SECTION 933 EVALUATION REPORT

THIMBLE SHOAL AND ATLANTIC OCEAN CHANNELS

SANDBRIDGE BEACH

VIRGINIA BEACH, VIRGINIA

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ɹgust 1989

SANDBRIDGE BEACH
SANDBRIDGE, VIRGINIA
SECTION 933 STUDY

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INTRODUCTION

STUDY AUTHORITY

The study contained herein was authorized by Section 145 of the Water Resources Development Act of 1976 (Public Law 94-587) dated October 22, 1976 which states in part:

> "The Secretary of the Army, acting through the Chief of Engineers, is authorized upon request of the State, to place on the beaches of such State beach-quality sand which has been dredged in constructing and maintaining navigation inlets and channels adjacent to such beaches, if the Secretary deems such action to be in the public interest and upon payment of the increased cost thereof above the cost required for alternative methods of disposing of such sand."

This authority was amended by Section 933 of the Water Resources Development Act of 1986 (Public Law 99-662) dated November 17, 1986, by the insertion of "... by such State of 50 percent" after "upon payment." The Commonwealth of Virginia in correspondence dated April 7, 1988 (see appendix D), requested that a Section 933 study be initiated for the placement of sand dredged from either the Thimble Shoal Channel or Atlantic Ocean Channel onto the beach at Sandbridge in Virginia Beach, Virginia.

STUDY PURPOSE AND SCOPE

The purpose of this study is to determine the Federal interest in participating in the cost of placing suitable material from Thimble Shoal Channel and/or Atlantic Ocean Channel (see plate 1) on the beach at Sandbridge in Virginia Beach rather than depositing it in an offshore disposal area. The evaluation report will consider only that material to be provided from the 55-foot-deep outbound channel which is part of the Norfolk Harbor and Channels, Virginia, project.

STUDY AREA

The study area is located within the city of Virginia Beach which contains almost 260 square miles of predominantly low-lying and flat terrain including 28 miles of oceanfront and 10 miles of bay front. The specific area addressed by this study is the 4.6 miles of beach between that area south of the U.S. Naval Fleet Anti-Air Warfare Training Center at Dam Neck, hereinafter referred to as Dam Neck, and north of the Back Bay National Wildlife Refuge. Sandbridge, located on the Atlantic oceanfront approximately 5 miles south of the "resort strip" in Virginia Beach is a residential community of approximately 1,200 homes. The shoreline has a small irregular dune line with a narrow beach varying from about 75 feet at mean high water to virtually no beach at all along some portions of the study area. The backshore areas were formerly protected by foredunes. Prior development and previous storms have leveled the dunes in many areas. Approximately 120 of the 247 oceanfront properties have been bulkheaded as a measure to combat the effects of continued erosion. The city of Virginia Beach and the Sandbridge study area are shown on plate 2.

PRIOR STUDIES, REPORTS, AND EXISTING PROJECTS

There have been a number of previous reports prepared chiefly by the Corps of Engineers dealing with beach erosion control and/or hurricane protection for the Atlantic coastline in Virginia Beach. Others were prepared by local, state, and private interests and their consultants. These reports are described briefly in the following paragraphs. It should be noted that the majority of the reports have dealt with the evaluation of protection measures for the "resort strip" which is located some 5 miles north of Sandbridge.

In 1952, the Corps of Engineers, in cooperation with the city of Virginia Beach, prepared a report on a beach erosion control study for Virginia Beach. The report, printed in House Document 186, 83rd Congress, 1st Session, concluded that artificial placement of sand on the beach between Rudee Inlet and 49th Street was justified. In his report, the Chief of Engineers recommended authorizing Federal participation in an amount equal to the cost of protecting the Federally owned frontage, plus one-third of the first cost of measures for the restoration and protection of the other publicly owned portions of the shores of Virginia Beach. The plan of protection included (a) artificial placement on the ocean shore of approximately 1,100,000 cubic yards of suitable sand fill to widen the beach berm to a minimum width of approximately 100 feet at elevation 7 feet above mean low water or elevation 5.4 National Geodetic Vertical Datum (NGVD), and (b) construction of a system of approximately 21 groins as deferred construction when experience indicates the need therefor. The total cost of the work was estimated at $2,024,500 at November 1951 price levels, and in accordance with the provisions of Public Law 727, 79th Congress, approved August 13, 1946, the Federal share was estimated at $675,000. The project was adopted by the River and Harbor Act of September 3, 1954 (Public Law 780, 83rd Congress, 2nd Session), as recommended by the Chief of Engineers. In an effort to expedite construction, beach restoration, in accordance with the recommended plan, was completed by local interests in 1953. The groins have not been constructed to date. Protection for the Sandbridge area was not considered as a part of this report.

In 1962, a brief review report on a beach erosion control study for Virginia Beach was made by the Corps of Engineers in cooperation with the Virginia Beach Erosion Commission. Protection for the Sandbridge area was not considered as a part of this report. The report, printed in House Document 382, 87th Congress, 2nd Session, was a review of the project for beach erosion control at Virginia Beach authorized by the River and Harbor Act of 1954. The review was made to determine the extent, if any, of Federal participation in the cost of periodic beach nourishment. The initial project was authorized prior to the passage of Public Law 826, 84th Congress, which provides a policy of Federal assistance for periodic nourishment. In this report, the Chief of Engineers recommended modification of the existing Federal project for Virginia Beach to authorize Federal participation in the amount of one-third of the costs of periodic nourishment of the shore. This participation was for a period of 25 years from the placement of an initial quantity of nourishment material equal to the deficiency in the design beach at that time. This was done generally in accordance with the plan of the District and Division Engineers with such modifications as deemed necessary by the Chief of Engineers. Authorization was contained in the River and Harbor Act of 1962. Local interests acquired their own dredging plant and borrow areas and replenished the beach. In accordance with Section 103 of the 1962 River and Harbor Act, the Federal Government was responsible for payment of one-half of the cost for this program. Federal participation in beach nourishment expired in February 1987.

A brief hurricane survey report on Virginia Beach, Virginia was prepared in 1965 in compliance with Public Law 71, 84th Congress, 1st Session. Protection for the Sandbridge area was not considered as a part of this report.

The report on the hurricane problem, printed in House Document 268, 89th Congress, 1st Session, recommended that no Federal expenditure be made and that the report be distributed to local interests for use in establishing flood plain regulatory measures and evacuation procedures.

A feasibility report for beach erosion and hurricane protection was completed in 1970 and published in House Document 96-365, 92nd Congress, 2nd Session. It encompassed the entire shoreline of Virginia Beach from the North Carolina line to Little Creek Inlet in Chesapeake Bay. The feasibility report recommended that the existing project for beach erosion control in the city of Virginia Beach, Virginia be modified to provide for the construction of a Federal project for beach erosion control and hurricane protection between Rudee Inlet and 89th Street, a distance of about 6 miles. The report determined that a plan considered for hurricane protection, consisting of 24,300 feet of sand dune and berms designed to protect against a tidal flood stage equal to that produced by the 420-year design storm, was not economically justified for the Sandbridge area.

As a result of the above recommendation, a Phase I report on Virginia Beach was prepared in partial response to Section 1(a) of the 1974 Water Resources Development Act. In this report, the Chief of Engineers recommended the construction of a new seawall from Rudee Inlet to 57th Street, the raising and/or widening of the existing sand dune from 57th Street to 89th Street, and the maintenance of a beach berm with minimum width of 100 feet between 49th Street and 89th Street. A Phase II General Design Memorandum (leading to construction plans) has been completed for this project. Based on a lack of economic justification, it was determined that no Federal interest existed in protection for the Sandbridge area. It was as a result of this authority that the basis for a reanalysis effort was established. Local homeowners, acting through the Sandbridge Restoration Association (SBRA), hired a consultant to review the conclusions reached in the Phase I Sandbridge effort. The consultant indicated that feasible plans of improvement existed based on a number of cost and benefit considerations. The Board of Engineers for Rivers and Harbors considered the negative findings of the Norfolk District and North Atlantic Division for Sandbridge as well as the SBRA report and issued its own findings in a December 1986 report. The report concluded that a beach erosion plan exhibited the most likely engineeringly feasible plan, although the report concluded that none of the plans were economically feasible. Subsequent to the Board of Engineers for Rivers and Harbors report, the Office of the Chief of Engineers conducted a national survey of dredging costs and determined that revised lower unit sand costs might indicate that an economically justified plan existed. As a result of this national survey of dredging costs, a reanalysis report has been conducted by the Norfolk District for the Office of the Chief of Engineers. That report is currently under review by the Office of the Chief of Engineers.

A study of Rudee Inlet was initiated in connection with an investigation of Virginia Beach Streams authorized by the Committee on Public Works of the House of Representatives on June 21, 1965. In view of the close relationship of Rudee Inlet to the beach erosion and hurricane protection project, the Chief of Engineers approved inclusion of Rudee Inlet as part of the Phase I study authorized for Virginia Beach. However, a separate report was prepared on the inlet since any plan selected for Rudee Inlet would require that the proposed project bypass the same amount of littoral drift to the downdrift area as would naturally bypass if there were no inlet present. Furthermore, the effect on the beach would be as if there were no inlet or no Federal navigation project at Rudee Inlet.

Rudee Inlet is now a Federal navigation project having been approved in December 1983. A Local Cooperation Agreement was signed in April 1986 with the local sponsor, the city of Virginia Beach. The authorized plan of improvement consists of a 10-foot-deep entrance channel from the Atlantic Ocean through the inlet; a 7-foot-deep inner channel, safety area, and turning basin; and an 18-foot-deep sand trap. Annual maintenance dredging is performed in the entrance channel and sand trap, all of which is used for beach nourishment of the resort strip. The maintenance schedule for the interior areas is based on a 10-year cycle, and will average approximately 3,000 cubic yards annually. Construction is scheduled for 1990.

In December 1987, the district completed a reevaluation report under authority of Sections 933 and 934 of the Water Resources Development Act of 1986 (P.L. 99-662) for the reach of beach between Rudee Inlet and 49th Street.

Under the Section 933 authority, it was determined that a volume of 964,000 cubic yards of sand would be dredged from the Cape Henry Channel (a part of the Baltimore Harbor and Channels, Maryland and Virginia project) to provide a construction berm containing 360,000 cubic yards of sand with a width of about 100 feet. The effectiveness of the berm would last an estimated 2 to 3 years. Construction of this project was completed in August 1989.

The reevaluation report concluded that, under Section 934 authority, Federal participation is warranted in the cost of nourishing the beach between Rudee Inlet and 49th Street with artificial placement of suitable sand fill to provide and maintain a berm having a width of approximately 100 feet at elevation 5.4 feet NGVD for an additional 10-year period. This project in effect extends the beach nourishment project authorized by the River and Harbor Act of 1962 which expired in February 1987. Funds for extending the project, however, will not be budgeted until such time as the effectiveness of the Section 933 sand supplied to the beach from the Cape Henry Channel has been diminished to a level where further nourishment is needed. Section 934 authority applies only to existing Federal projects and therefore is not applicable to Sandbridge.

NAVIGATION PROJECT

The Norfolk Harbor and Channels project provides for deepening the existing 45-foot channels to 55 feet, constructing a new 60-foot-deep channel off Virginia Beach's oceanfront referred to as the Atlantic Ocean Channel, deepening the existing 40-foot portion of the Elizabeth River and its Southern Branch to 45 feet, and deepening the existing 35-foot portion of Southern Branch to 40 feet up to the Gilmerton Bridge (River Mile 17.5) and providing an 800-foot turning basin at that point. Deepening of the Thimble Shoal Channel to a depth of 50 feet was completed in 1988. Further deepening of Thimble Shoal Channel from 50 to 55 feet and construction of the Atlantic Ocean Channel is scheduled to be initiated in the fall of 1990. It is the deepening of these two channels which would provide the source of material for beach deposition at Sandbridge.

RESOURCES AND ECONOMY OF THE STUDY AREA

INTRODUCTION

Virginia Beach is a part of the Norfolk-Virginia Beach-Newport News Metropolitan Statistical Area, or MSA, a group of economically and socially integrated cities and counties in southeastern Virginia. These cities surround the port of Hampton Roads, one of the largest and finest harbors in the world. The classification of this area as a MSA occurred after 1980 when almost all of the cities and counties located in the two separate but adjacent Standard Metropolitan Statistical Areas (SMSA's) were combined into one large area for census classification purposes.

The city of Virginia Beach was formed in 1963 by the merger of Princess Anne County with the former Virginia Beach City. The city is bordered by the Atlantic Ocean on the east, the Chesapeake Bay on the north, the cities of Norfolk and Chesapeake on the west, and Currituck County, North Carolina on the south. Virginia Beach has a total land area of 258.7 square miles, which includes 28 miles of oceanfront and 10 miles of shoreline along the Chesapeake Bay.

ENVIRONMENTAL SETTING

Virginia Beach is a city of environmental contrasts, including beaches, lakes, woodlands, large agricultural and livestock areas, and a concentrated development of hotels, motels, restaurants, night clubs, and tourist shops which stretch northward along the oceanfront from Rudee Inlet for about 40 city blocks. The Sandbridge area is characterized by residential development consisting of approximately 3,871 housing units, of which 86 percent are single family. A small strip of commercial development exists at the entrance to the study area.

The northern end of Virginia Beach's oceanfront shoreline begins at Fort Story adjacent to 89th Street. It then extends southward, uninterrupted, for about 6 miles where Rudee Inlet connects Lakes Rudee and Wesley with the Atlantic Ocean. From Rudee Inlet to the North Carolina state line (a distance of about 16 miles) the beach front is occupied by the public beach at Croatan, the military reservations at Camp Pendleton and Dam Neck, Sandbridge, Back Bay National Wildlife Refuge, and False Cape State Park. Sandbridge, centrally located on this section of beach, lies between Dam Neck and the Back Bay refuge. The Back Bay refuge itself contains some 4,600 acres of beach, dunes, marsh, and woodland. Much of the productive marshland consists of small islands which together with the open waters of the bay form excellent waterfowl habitat supporting thousands of overwintering ducks, geese, and swans. Resident wildlife consists of many species of mammals, birds, reptiles, and amphibians.

Enhancing the marsh's abundance of life forms is its close association with Back Bay itself whose shallow, brackish waters intermingle with the wetlands along numerous channels, bays, and coves which create an interchange of nutrients producing a very productive ecosystem. At one time, Back Bay was known for its submerged aquatic vegetation which supported one of the East Coast's finest waterfowl wintering habitats. In addition to the main Back Bay National Wildlife Refuge, there are several other waterfowl management areas in the vicinity which are managed jointly by Federal and state agencies.

At Sandbridge, the beach is normally characterized by a small irregular dune lying seaward of the oceanfront cottages. The dune is vegetated with sparse stands of beachgrass (Ammophila) and sea oats (Uniola). Normally, the emergent portion of the beach, above mean high water, varies between 0 and 75 feet. During storm events, wave scour usually alters the beach profile considerably, removing sand from the dune and from beneath the cottages. As would be expected, much of the fauna associated with the beach at Sandbridge is either transient in nature or sufficiently mobile to escape the sometimes drastic changes that occur due to erosive forces.

Virtually the whole oceanfront beach from Fort Story southward through Sandbridge is known for recreation. The famous resort strip of Virginia Beach runs generally from Rudee Inlet north to 49th Street. Most of this area is backed by hotel/motel development and other tourist-related businesses. The Sandbridge area is not developed for tourists, but rather individual homes or summer homes. There are only a limited number of commercial establishments, all located 1 to 2 blocks from the oceanfront. The city has made the beach available for the public by dedicating pedestrian access lanes at the ends of numerous streets intersecting and running perpendicular to the shoreline. On-street parking is provided in several locations along the beach front. There are also public beaches on the northern and southern portions of the study area. These areas have limited public parking facilities. In addition to these beaches, there is a public fishing pier. Recreational use of the beach at Sandbridge during the summer months is a result of overcrowded conditions at the resort beach further north, or as a chosen alternative destination for area residents not requiring hotel or motel accommodations.

Tides at Virginia Beach are semi-diurnal. The mean range is 3.4 feet with a spring mean range of 4.1 feet. Swells reaching Virginia Beach are predominantly from the southeast during the summer and from the northeast during the winter. The greatest yearly percentage of swells arrive from the east-northeast and range in height between 1 and 6 feet. Calm conditions prevail approximately 19 percent of the time.

Thimble Shoal is considered to be an excellent source of beach-compatible sand, if the sand is extracted below the 50-foot mean low water depth. The sand source for this evaluation includes this area as well as the Atlantic Ocean Channel.

According to the U.S. Fish and Wildlife Service (appendix E), the project area is located between the U.S. Naval Fleet Anti-Air Warfare Training Center and the Back Bay National Wildlife Refuge where a permanent and summer residential neighborhood has developed between Back Bay and the ocean. The wildlife species of concern in this area is the loggerhead turtle. In spite of the rather heavy recreational use of the Sandbridge beach in summer, a nest of the loggerhead turtles was found in the area in 1980 and again in 1989.

CULTURAL RESOURCES

The Virginia Research Center for Archaeology headquartered in Richmond, Virginia has stated that there are no known archaeological sites in the area specific to the beach itself at Sandbridge. The beach is highly subject to change due to erosive forces; therefore, archaeological sites would be wanting. However, there could be vessels which were lost off the coast. The Atlantic Ocean along Virginia Beach was the location of a coastal trade route between the ports of the Chesapeake Bay southward and, thus, is a prime area for the location of past shipwrecks. A survey of the proposed Atlantic Ocean Channel, which is located off the coast of Virginia Beach, was accomplished in connection with the Norfolk Harbor and Channels Deepening and Disposal Project. However, no significant cultural resources were discovered in this area.

HUMAN RESOURCES

Population

Virginia Beach is the largest city in the state and one of the most rapidly growing ones as well. According to U.S. census figures, the city had a 1980 population of 262,199. The most recent estimate by the state (Tayloe Murphy Institute) showed a figure of 350,100 for 1987, a 34 percent increase since 1980. By contrast, Norfolk's population is estimated to have increased only 5 percent during the same time period. Much of Virginia Beach's growth has been fueled by a high inmigration rate. It is estimated that two-thirds of the city's growth between 1980 and 1987 can be attributed to inmigration with the remainder the result of births.

Projections for Virginia Beach's future population show continued growth through the year 2040. Although this growth will be substantial, the average annual rate of growth is projected to decline from the 3.3 percent projected for the 1980-1990 decade to 1.1 percent for the 2030-2040 decade. The following table shows past and projected population growth for Virginia Beach and the surrounding area.

The population in the census tract which encompasses the study area has grown considerably faster than the citywide population from 1980 to 1987, based on data from the Virginia Beach Planning Department. According to the city's projections, the growth rate should continue to outpace the citywide growth rate as development spreads into the Courthouse-Sandbridge area. The area encompassed in the Sandbridge census tract is projected to be the largest growing area in the city between 1990 and 2010, both in terms of numbers of people and in percentage growth.

Census data show that the city's population tends to be younger and more educated than that of the region and the state as a whole. The city seems to be attracting large numbers of younger residents, most of whom are relatively well educated. With continued growth and maintenance of its positive image, this trend should continue into the next century. Virginia Beach and the Hampton Roads area in general have a high transient rate due, in part, to the high percentage of military employment in the labor force.

Table 1. NORFOLK-VIRGINIA BEACH-NEWPORT NEWS MSA POPULATION DATA

Location	1970	1980	1987	1990	2000	2010	2020	2030	2040(a)
SOUTHSIDE HAMPTON ROADS									
Chesapeake	89,580	114,486	141,500	143,000	163,000	183,000	203,000	223,000	245,000
Norfolk	307,951	266,979	280,800	274,700	280,000	285,300	290,600	295,900	301,300
Portsmouth	110,963	104,577	110,100	114,800	117,100	119,400	121,700	124,000	126,300
Suffolk	45,024	47,621	52,200	55,500	64,500	73,500	82,500	91,500	101,500
Virginia Beach	172,106	262,199	350,100	362,600	426,200	489,800	553,400	617,000	687,900
NORTH SIDE HAMPTON ROADS(b)									
TOTAL	333,140	364,449	411,400	421,800	459,700	497,600	535,500	573,400	614,000
TOTAL MSA	1,058,764	1,160,311	1,346,100	1,372,400	1,510,500	1,648,600	1,786,700	1,924,800	2,076,000

(a) Projections based on continuation of trend from 2020 to 2030.
(b) Includes the cities of Hampton, Newport News, Poquoson, and Williamsburg along with Gloucester County, James City County, and York County.

Sources: Virginia Dept. of Planning and Budget
(1987 population figures are provisional estimates from Tayloe Murphy Institute)

Housing

The number of housing units has increased even faster than the population because of the decrease in household size that has been occurring in recent years. Much of the new home construction has been taking place in the Kempsville and Holland Road areas. In the past few years, residential construction has slowed near the northern stretches of the city's oceanfront since this area has become highly developed. Projections by the Virginia Beach Planning Department show that the area of greatest development in the next 20 years will be the central portion of the city immediately south of the Oceana Naval Air Station, including the Courthouse-Sandbridge area.

Between 1980 and 1988, the rate of increase in housing construction for the census tract encompassing the Sandbridge area occurred at three and one-half times that of the citywide total. Projections for the period from 1990 to 2010 show a continuation of growth in number of dwelling units concomitant to the growth in population.

In the Sandbridge census tract, housing is a mixture of single-family dwellings (85%), duplex (2%), townhouses (5%), and multifamily (8%). The single-family dwellings consist of permanent residences as well as rental cottages. By contrast, for the city as a whole, 58 percent of the housing units are single-family structures, 2 percent are duplexes, 13 percent are townhouses, and 26 percent are multifamily units.

Because of all of the residential construction in Virginia Beach, housing as a whole tends to be newer than in the older, more established cities of Norfolk and Portsmouth. Housing values and rents also tend to be higher in Virginia Beach than for the area as a whole.

DEVELOPMENT AND ECONOMY

Employment and Income

Virginia Beach's economy is highly dependent on the Federal Government, which is the largest single employer in the city as well as the entire metropolitan area. Most of this employment is concentrated in the four Federal military bases located in the city: Little Creek Amphibious Base, U.S. Navy

Training Center Dam Neck, Oceana Naval Air Station, and the U.S. Army's Fort Story. In addition to these bases, there are several other military facilities in the region which employ many Virginia Beach residents. Traditionally, Virginia Beach has served as a bedroom community for Norfolk and still does to some extent, although increasing numbers of jobs are being created in Virginia Beach as the population grows.

The largest number of jobs in the city are in the services and trade sectors, which account for over half the employment located in Virginia Beach. Job creation in these areas will continue as long as the city's population keeps expanding. Associated with the growing population is the construction industry, which is an important component of the city's economy. Employment in this industry fluctuates more than most other segments of the economy because of changing interest rates and general economic conditions. Manufacturing employs a smaller segment of the population here than in the state as a whole, although several foreign firms have recently located in the city, thereby increasing employment in the city. Agriculture plays an important role in the rural sections of the city, but it has been declining as residential development spreads into these areas.

One of the most important segments of Virginia Beach's economy is tourism, which generated employment for 11,637 people in 1985 (Virginian-Pilot and the Ledger-Star). Tourism provides significant employment in the service and retail trade segments of the city's economy and is a major source of revenue for the city. Tax receipts from tourist-related activities totaled $17.5 million in 1986, an amount which enables the city to have the lowest real estate tax rate in the southside Hampton Roads area. The U.S. Travel Data Center estimated that tourists spent $432 million in Virginia Beach in 1986, a significant contribution to the city's economy.

As would be expected with the higher educational and income levels for city residents, the occupational structure shows a higher percentage of white-collar jobs and fewer blue-collar jobs than the surrounding area and the state as a whole. Unemployment rates traditionally are lower, with a rate of 3.5 percent in 1988, for example. Per capita income figures published by the Bureau of Economic Analysis for 1983 show Virginia Beach with $13,488 compared to Norfolk with $11,207. Median family income showed a similar pattern with Virginia Beach being the highest in the local area, followed by Chesapeake. Projections of future per capita income by the Bureau of Economic Analysis show Virginia Beach maintaining the highest levels of per capita income within southside Hampton Roads. However, these same projections show the city's per capita income declining as a percentage of the national figure from a high of 109 percent in 1983 to a low of 99 percent in 2015 and 2035 as shown in the following table.

Table 2. PROJECTED PER CAPITA INCOME FOR VIRGINIA BEACH AND THE COMMONWEALTH OF VIRGINIA (1984 CONSTANT DOLLARS)

	Area	
Item	Virginia Beach	Com. of Virginia
1978	$12,524	$10,401
% of U.S.	106	97
1983	$13,488	$12,882
% of U.S.	109	104
1990	$15,105	$14,921
% of U.S.	103	102
2000	$16,891	$17,059
% of U.S.	101	102
2015	$19,127	$19,581
% of U.S.	99	102
2035	$22,779	$23,470
% of U.S.	99	102

Source: Bureau of Economic Analysis, "County-level Projections of Economic Activity and Population, Virginia 1990-2035."

Land Use

Although land use in Virginia Beach is fairly well diversified, there is a strong trend toward development of vacant and agricultural land to accommodate the rapidly expanding population. Residential and commercial development predominates in the northern and western parts of the city while the southeastern section is still heavily rural. The majority of the industrial development has occurred in the nine industrial parks in the city, three of which are municipally owned. As vacant land becomes scarce in the northern and western sections of Virginia Beach, pressure will shift to the southeastern part of the city for future construction. A decline in the amount of agricultural acreage is inevitable as development continues.

As of December 1987, land use in the Sandbridge area was about 39 percent residential, 7 percent water, 40 percent undeveloped, 1 percent commercial, and 13 percent marsh and miscellaneous. These figures contrast with those for the city as a whole, where almost one-third of the land is zoned either agricultural or public use and only about one-fifth is zoned residential.

PROBLEMS, NEEDS, AND OPPORTUNITIES

THE STORM AND BEACH EROSION PROBLEMS

The location and orientation of the study area shoreline along the Atlantic ocean shoreline has made this area readily accessible to damages associated with storm activity. Storm tides, created by high winds and low barometric pressure, accompanied by wave action have impinged on developed areas and have caused property damage and endangered health and safety.

The most severe storms to which the study area is subjected are hurricanes which originate principally during the months of August, September, and October. A hurricane is characterized by an intense cyclone, low barometric pressure, high winds (over 74 m.p.h.), heavy rainfall, large waves, and tidal surges. The most severe hurricane affecting the study area was that of August 1933.

In addition to hurricanes, there are storms called "northeasters" which affect the study area. Northeasters are characterized by onshore winds predominantly from the the northeast and occur periodically throughout the fall, winter, and spring months along the Atlantic coast. Winds accompanying these storms are not of hurricane force, but are usually persistent enough to cause the elevation of nearshore waters for extended periods of time. The most severe northeaster to affect the study area occurred in March 1962.

Beach erosion is another problem associated with the study area. Erosion of the beach reduces the area available for recreation and permits storm waves to break further onshore. Erosion results principally from storm-induced wave action that spurs alongshore currents. A more detailed investigation of the hydrology, hydraulics, and coastal engineering is found in appendix C of this report.

DREDGING AND PLACING OFFSHORE SAND ON BEACH

The following two basic dredges are available for removing sand from either the Thimble Shoal Channel or Atlantic Ocean Channel and placing it on the beach at Sandbridge. One is a large cutterhead suction dredge which cuts up the material and pumps it continuously through a long pipeline to the shore. The diameter of the discharge line can be up to 42 inches. The Atlantic Ocean Channel is the nearer of the two. Booster pumps and jack-up barges (DeLong Piers) raised above wave action would be required. The main problem with this system is keeping the submerged line connection with the dredge and booster pump intact in a possibly rough ocean environment.

Any offshore borrow site contains a certain percentage of silt-size material. When more granular material is dredged, enough of the fine material will be mixed to yield a relatively easy pumping slurry. The pipeline dredge will handle this slurry without modifying it and will deliver it to the beach. The dredge can be located farther away than a hopper dredge and still achieve good results. Some of the difference in quality of the fill material can be compensated for by the shore crew. By allowing more of the fine material to flow into the surf from the pipeline by using shorter training dikes in the ponding and settlement area, much of the silt-size material can be eliminated without damage to the new beach section.

The second type of dredge that can be used is the hopper dredge. This dredge stores the material in its hoppers or bins, travels to the shoreline, and then pumps the nourishment material (sand) ashore through one or more booster pumps depending on the distance from the ship's mooring facility to the beach. A hopper dredge cannot dredge and pump ashore in a continuous operation as does the pipeline dredge. Consequently, a substantial portion of the working time is spent traveling and pumping out its hoppers. A connection between the target beach dumping system and the hopper dredge requires an offshore hookup such as a DeLong Pier jacked up above wave action as an intermediary discharge plant. Such a system was used in 1975 when sand was pumped to a beach at Fort Story from Thimble Shoal Channel. The stockpiled material was later transported by trucks to the beach at Virginia Beach.

The self-propelled hopper dredges have a capacity of several thousand cubic yards and a speed of about 13 knots when loaded. An effective pump ashore system is a single-point mooring which utilizes an anchored buoy that holds the open end of the submerged shoreline pipe to which the dredge attaches its pumpout system. The hopper dredge when attached to the buoy is free to pivot with its head into the wind, thus riding as at anchor and achieving the best possible stability. A loaded hopper dredge draws 20 or more feet of water; therefore, the vessel must be located offshore where sufficient depth is available.

The hopper dredge sorts material in its hopper causing the silt to be suspended and lost overboard during the loading process. The resulting material, while superior for beach fill, will be more difficult to transport through a pipeline. The hopper dredge transfer point, therefore, should be as close to the beach as safety will permit. Of the two types of dredges, the hopper dredge will be used for placing sand on the beach at Sandbridge.

WITHOUT PROJECT CONDITION

The "without project" condition is the land use and related conditions likely to occur under existing improvements, laws, and policies. For the purpose of this evaluation, it is assumed that no other beach nourishment would occur in the absence of the sand placement from the dredging of the outbound 55-foot-deep Thimble Shoal and Atlantic Ocean Channels. Hurricanes and northeasters will continue to subject the Sandbridge Beach area to wave attack and erosion. Benefits and costs are based on the assumption that the historical average erosion rate of 6 feet per year will continue into the future. The beach is highly developed with homes built on 210 of the 247 oceanfront properties. Currently 120 of the 247 oceanfront properties are protected by bulkheads. These bulkheads provide protection to the improvements located behind them; however, recent inspections have indicated that the presence of bulkheads increases the rate of storm-induced sand loss to adjacent properties which are not bulkheaded. This evaluation will examine the effects of recent efforts to stabilize properties through bulkheading.

PLAN EVALUATION

PLANNING OBJECTIVES

The Federal objective in water and related land resources planning is to contribute to the National Economic Development (NED) consistent with protection and enhancement, wherever possible, of the Nation's environment pursuant to Federal, state, and local environmental statutes, executive orders, and other planning requirements. Contributions to the NED account are increases in the net value of the National output of goods and services expressed in monetary units. Contributions are the direct net benefits that accrue in the planning area as well as in the rest of the Nation.

The planning objective of this study is to determine the Federal interest in cost sharing in the placement of sand from Norfolk Harbor Channels on the beach at Sandbridge, thereby reducing storm and erosion damages based on the projected life of the various berms under consideration. In addition, much of the information generated as a result of this study may be useful in identifying longer term solutions to the problems being experienced at Sandbridge.

PLANNING CONSTRAINTS

Planning constraints are any consideration that has the capacity to restrict or otherwise impact the planning process. Typical constraints include existing laws, policies, regulations, and the authorizing document; state-of-theart technology; money; and time. More specific constraints include the following:

a. The dynamic nature and inherent uncertainty of coastal processes which act on the study area shoreline and potential offshore borrow sites.

b. The necessity of expediting the completion and approval of this report so appropriate local, state, and Federal decisions can be made prior to construction of the navigation project.

c. The limitation of this nourishment to a one-time event which includes no renourishment and no maintenance. Longer term solutions to the problems being experienced at Sandbridge are being examined under authority of Section 1(a) of the Water Resources Development Act of 1974.

d. The limitation of the quantity and quality of the source material to that dredged from Norfolk Harbor Channels.

COSTS

The least costly, acceptable disposal alternative is Dam Neck Ocean Disposal Site. Costs for this study are based on the difference in cost for placing sand onto Sandbridge Beach versus disposal in Dam Neck. Details concerning the cost estimates for disposing of material from the Thimble Shoal and Atlantic Ocean Channels into the Dam Neck Ocean Disposal Site and onto the beach at Sandbridge are shown in appendix A. The least costly alternative is based on disposing all 16 million cubic yards of dredged material into the Dam Neck Ocean Disposal Site. The following two tables show the additional cost associated with placing the material on the beach in lieu of disposal into the Dam Neck Ocean Disposal Site. The Sandbridge beach berm dimensions include a length of 24,300 feet, a height of 6 feet NGVD, and a width varying from 50 to 150 feet. Costs are shown for utilizing both the Thimble Shoal and the Atlantic Ocean Channels as sources of sand.

Table 3. ADDITIONAL COSTS FOR BEACH PLACEMENT

Item	Cost
Least costly alternative for Thimble Shoal Channel material:	
6,400,000 cubic yards to Dam Neck Ocean Disposal Site	
(6,400,000 cubic yards) X ($3.75 per cubic yard) =	$24,000,000
50-foot berm	
419,000 cubic yards to Sandbridge Beach	
(419,000 cubic yards) X ($10.10 per cubic yard) =	$ 4,232,000
5,981,000 cubic yards to Dam Neck Ocean Disposal Site	
(5,981,000 cubic yards) X ($3.75 per cubic yard) =	$22,429,000
Total cost	$26,661,000
Least costly alternative	$24,000,000
Added cost	$ 2,661,000
75-foot berm	
691,000 cubic yards to Sandbridge Beach	
(691,000 cubic yards) X ($9.36 per cubic yard) =	$ 6,468,000
5,709,000 cubic yards to Dam Neck Ocean Disposal Site	
(5,709,000 cubic yards) X ($3.76 per cubic yard) =	$21,466,000
Total cost	$27,934,000
Least costly alternative	$24,000,000
Added cost	$ 3,934,000
100-foot berm	
1,097,000 cubic yards to Sandbridge Beach	
(1,097,000 cubic yards) X ($8.87 per cubic yard) =	$ 9,730,000
5,303,000 cubic yards to Dam Neck Ocean Disposal Site	
(5,303,000 cubic yards) X ($3.78 per cubic yard) =	$20,045,000
Total cost	$29,775,000
Least costly alternative	$24,000,000
Added cost	$ 5,775,000
150-foot berm	
1,991,000 cubic yards to Sandbridge Beach	
(1,991,000 cubic yards) X ($8.64 per cubic yard) =	$17,202,000
4,409,000 cubic yards to Dam Neck Ocean Disposal Site	
(4,409,000 cubic yards) X ($3.81 per cubic yard) =	$16,798,000
Total cost	$34,000,000
Least costly alternative	$24,000,000
Added cost	$10,000,000

Table 3. ADDITIONAL COSTS FOR BEACH PLACEMENT (Cont'd)

Item	Cost
Least costly alternative for Atlantic Ocean Channel material:	
9,600,000 cubic yards to Dam Neck Ocean Disposal Site	
(9,600,000 cubic yards) X ($1.96 per cubic yard) =	$18,816,000
50-foot berm	
468,000 cubic yards to Sandbridge Beach	
(468,000 cubic yards) X ($7.76 per cubic yard) =	$ 3,632,000
9,132,000 cubic yards to Dam Neck Ocean Disposal Site	
(9,132,000 cubic yards) X ($1.96 per cubic yard) =	$17,899,000
Total cost	$21,531,000
Least costly alternative	$18,816,000
Added cost	$ 2,715,000
75-foot berm	
772,000 cubic yards to Sandbridge Beach	
(772,000 cubic yards) X ($7.16 per cubic yard) =	$ 5,528,000
8,828,000 cubic yards to Dam Neck Ocean Disposal Site	
(8,828,000 cubic yards) X ($1.96 per cubic yard) =	$17,303,000
Total cost	$22,831,000
Least costly alternative	$18,816,000
Added cost	$ 4,015,000
100-foot berm	
1,226,000 cubic yards to Sandbridge Beach	
(1,226,000 cubic yards) X ($6.74 per cubic yard) =	$ 8,263,000
8,374,000 cubic yards to Dam Neck Ocean Disposal Site	
(8,374,000 cubic yards) X ($1.96 per cubic yard) =	$16,413,000
Total cost	$24,676,000
Least costly alternative	$18,816,000
Added cost	$ 5,860,000
150-foot berm	
2,224,000 cubic yards to Sandbridge Beach	
(2,224,000 cubic yards) X ($6.53 per cubic yard) =	$14,523,000
7,376,000 cubic yards to Dam Neck Ocean Disposal Site	
(7,376,000 cubic yards) X ($1.96 per cubic yard) =	$14,457,000
Total cost	$28,980,000
Least costly alternative	$18,816,000
Added cost	$10,164,000

Average annual equivalent costs are very sensitive to the length of time the sand placement will remain on the beach and provide beneficial impacts. A wide range of erosion rates have been evaluated and are discussed in the sensitivity section of this report. However, the annual costs shown in the following table are based on the most likely erosion rates expected to be experienced with the various berm widths under consideration for both the Thimble Shoal and Atlantic Ocean Channels. Most likely erosion rates are estimated to be 1.5 times the existing rate of 6 feet per year for proposed berm widths of 50, 75, and 100 feet, and 2.0 times the existing rate for a berm width of 150-feet.

Table 4. AVERAGE ANNUAL EQUIVALENT COSTS

Berm width (feet)	Added costs ($)	Estimated life of placement (years)	Equivalent annual costs ($)
		Thimble Shoal Channel	
50	2,661,000	0.9	3,206,000
75	3,934,000	1.5	2,916,000
100	5,775,000	2.4	2,777,000
150	10,000,000	3.3	3,627,000
		Atlantic Ocean Channel	
50	2,715,000	1.0	2,956,000
75	4,015,000	1.7	2,647,000
100	5,860,000	2.7	2,535,000
150	10,164,000	3.7	3,342,000

BENEFITS

The following paragraphs discuss the beneficial impacts which would result from the one-time placement of up to a maximum of 2.2 million cubic yards of sand dredged from the Norfolk Harbor navigation channels onto the Sandbridge Beach. The beneficial impacts from the initial placement of the dredged sand are (a) reduced tangible primary flood damages, (b) the delay in the loss of land and structure loss due to erosion, (c) the delay of storm damages to bulkheads and related losses of sand behind existing bulkheads, and (d) the beneficial effects on downdrift areas. Estimates of monetary benefits are based on October 1988 price levels, a base year of 1990, and an interest rate of 8-7/8 percent.

A wide range of erosion rates has been evaluated and is discussed in the sensitivity section of this report. However, the annual benefits shown in the following tables are based on the most likely erosion rates expected to be experienced with the various berm widths under consideration for both the Thimble Shoal and Atlantic Ocean Channels. It is necessary to evaluate the flood damage reduction benefits for four alternative beach berm widths--50, 75, 100, and 150 feet. Most likely erosion rates are estimated to be 1.5 times the existing rate for berm widths of 50, 75, and 100 feet, and 2.0 times the existing rate for a berm width of 150 feet. Obviously, the wider berm widths will have longer physical lives and provide beneficial effects over a longer span of time. The life of the berm is also influenced by the sand source and the anticipated erosion rate. It is noted that as the berm width is increased, erosion rates tend to accelerate. Details relative to the estimation of benefit values are shown in appendix B.

Flood Damage Reduction

Primary tangible flood damage reduction benefits are the equivalent average annual tidal flood damages prevented and represent the difference between average annual tidal flood losses without protection and residual annual losses after providing protection. The without project condition assumes no sand nourishment over the period of analysis.

Average annual flood damages for a given condition were obtained by combining the total damage at various tidal flood stages with the corresponding frequency of flooding to those stages to obtain a damage-frequency relationship. The damage-frequency relationship is utilized to determine the average annual damages for the given condition. This is done for natural conditions without protection and conditions which would exist with the sand placement, the difference being the average annual flood prevention benefits attributable to the project.

The following table shows the average annual benefits based on the indicated berm widths and the most likely erosion rates expected with the sand placement. When evaluated on a total present value basis, the accumulated present value increases as the berm width increases. The impacts of alternative erosion rates are shown in the sensitivity section of this report.

Table 5. AVERAGE ANNUAL EQUIVALENT STORM DAMAGE REDUCTION BENEFITS

Berm width (feet)	Estimated life of placement (years)	Amount ($)
	Thimble Shoal Channel	
50	0.9	87,000
75	1.5	132,000
100	2.4	152,000
150	3.3	183,000
	Atlantic Ocean Channel	
50	1.0	86,000
75	1.7	130,000
100	2.7	150,000
150	3.7	180,000

Delayed Land and Structure Losses From Erosion

In addition to storm damage to structures along the beach, a significant number of beach front properties are subject to erosion under the without project condition. Historically, erosion along the 24,300-foot stretch of beach in the study area has averaged about 6.0 feet per year. Of the 247 oceanfront properties, 120 have been fortified by bulkheads. The one-time placement of sand on the beach would not prevent future losses to the 127 non-bulkheaded properties, but would delay losses by pushing them further into the future. Each proposed berm configuration would protect existing land and structure values for the period that the berm is in place. Accordingly, the annual loss under existing conditions would be delayed from 0.7 to 7.4 years depending upon the berm width, the sand source, and the rate of erosion. The present value of the losses to non-bulkheaded properties, both with and without sand placement, was computed for various berm configurations. The difference in these values represents the benefits to the various berm configurations under consideration. Values were annualized by capitalizing at an 8-7/8 percent discount rate over the appropriate life of the sand placement. When evaluated on a total present value basis, the accumulated present value increases as the berm width increases. The following table shows the average annual equivalent benefits attributable to delaying land and structure losses from the one-time placement of sand on the beach at Sandbridge.

Table 6. AVERAGE ANNUAL EQUIVALENT LAND AND STRUCTURE BENEFITS

Berm width (feet)	Estimated life of placement (years)	Amount ($)
	Thimble Shoal Channel	
50	0.9	87,000
75	1.5	109,000
100	2.4	172,000
150	3.3	274,000
	Atlantic Ocean Channel	
50	1.0	86,000
75	1.7	118,000
100	2.7	202,000
150	3.7	329,000

Reduction of Storm Damages to Bulkheads and Storm Sand Losses

During recent years, 120 of the 247 oceanfront lots have been fortified with bulkheads in an attempt to control the existing erosion problem. The severely eroded condition of the beach leaves structures vulnerable to storm damage. The sand located behind the line of protection is also threatened during coastal storm events. The tangible benefit from these two items is the equivalent average annual damages prevented and represents the difference between average annual damages without beach nourishment and residual damages remaining after beach nourishment. The without project condition assumes no sand nourishment over the period of analysis. The following table details the average annual equivalent benefit from protecting these bulkheads and the sand behind them.

Table 7. AVERAGE ANNUAL EQUIVALENT BENEFIT FOR STORM DAMAGE REDUCTION TO BULKHEADS AND SAND LOSSES

Beach width (ft.)	Bulkheads ($)	Sand loss ($)	Total ($)
	Thimble Shoal Channel		
50	1,098,000	994,000	2,092,000
75	1,131,000	1,023,000	2,154,000
100	1,201,000	1,065,000	2,266,000
150	1,267,000	1,100,000	2,367,000
	Atlantic Ocean Channel		
50	1,080,000	978,000	2,058,000
75	1,113,000	1,007,000	2,120,000
100	1,184,000	1,050,000	2,234,000
150	1,251,000	1,086,000	2,337,000

Beneficial Effects on Downdrift Areas

Sandbridge Beach serves as a feeder beach to downdrift areas. Available evidence indicates that an average of approximately 300,000 cubic yards of sand are eroded from the Sandbridge beaches annually. Of this amount, a range of 104,000 to 215,000 cubic yards of material is transported along the shore to the sand bypass operation at Rudee Inlet. This material is used as beach nourishment for the resort beach between Rudee Inlet and 49th Street. The introduction of additional material as a result of a beach nourishment project at Sandbridge can be expected to push the shoreline out of equilibrium due to profile disturbance resulting from placement of the project fill. A seaward bulge with respect to adjacent beaches will be created. The further a fill extends offshore, the more sediment loss can be expected. As a result, sediment transported parallel to the shore will be increased in comparison to pre-fill transport rates. An estimate of equivalent annual erosion losses was made based on a with project erosion rate 1.5 times the existing erosion rate. This would indicate that a range of 156,000 to 323,000 cubic yards of material could be made available for bypassing to the resort beach. A measure of the amount of increased material available to the resort beach is therefore a range of between 52,000 and 108,000 cubic yards of sand per year subject to the life of the potential with project berms at Sandbridge.

Sand bypass records were obtained from the Virginia Beach Erosion Council to determine the long-term historical average material transported to the resort beach as a result of the bypass operation. The results indicated that over the most recent 10-year period of record (fiscal years 1978-1987), an average of 184,000 cubic yards of material was bypassed from Rudee Inlet to the resort beach. The highest recorded bypass of material to the resort beach occurred in fiscal year 1986 when 246,000 cubic yards of material were by-passed. An estimate of capacities of existing plant to move material to the resort beach was developed based on a range containing two scenarios. The first scenario is that the fiscal year 1986 bypass effort is a minimum measure of capacity. The second scenario is based on estimates of the dredge Rudee Inlet II operating in a more efficient manner than the previous dredge-eductor system which was discontinued in 1987. The estimated minimum capacity of the dredge Rudee Inlet II is 300,000 cubic yards of material annually. Given the increase in production rates based on historical development and use of this type dredge, it is estimated that the minimum bypass capacity of the existing plant is 300,000 cubic yards annually. Given the potential for capacity constraints, the material available for downdrift benefits would be reduced to a range of between 52,000 and 85,000 cubic yards of material per year subject to the life of the potential with project berms at Sandbridge.

Recent records of the Virginia Beach Erosion Council were researched to determine unit costs for truck haul to the resort beach as this is the most likely alternative source of sand. These records indicate that the truck haul rate would be approximately $6.10 per cubic yard. An estimate of the cost per cubic yard to bypass an additional 52,000 to 85,000 cubic yards of material per year is $2.10. This was determined based on audited Virginia Beach Erosion Council records used in the determination of the Corps of Engineers participation in the long-term beach nourishment program for the resort beach. Based on the parameters discussed above, the downdrift benefit would be $4.00 per cubic yard of sand bypassed. The average annual equivalent savings to the downdrift resort beach from this operation would range from $208,000 to $340,000. Given the uncertainties as to the timing of the receipt of sand to downdrift areas, the actual capacity of the dredge bypass operations, and the need for sand at the resort beach, it is believed that an equivalent annual benefit of $208,000 is appropriate for each of the berms under consideration.

Summary

The following table shows a summary of average annual equivalent benefits attributable to the one-time sand placement on the beach at Sandbridge in the city of Virginia Beach.

Table 8. SUMMARY OF BENEFITS

Beach width (ft)	Flood damage reduction ($)	Reduced erosion damages ($)	Reduction in bulkhead and sand losses ($)	Benefit to downdrift areas ($)	Total ($)
			Thimble Shoal Channel		
50	87,000	87,000	2,092,000	208,000	2,474,000
75	132,000	109,000	2,154,000	208,000	2,603,000
100	152,000	172,000	2,266,000	208,000	2,798,000
150	183,000	274,000	2,367,000	208,000	3,032,000
			Atlantic Ocean Channel		
50	86,000	86,000	2,058,000	208,000	2,438,000
75	130,000	118,000	2,120,000	208,000	2,576,000
100	150,000	202,000	2,234,000	208,000	2,794,000
150	180,000	329,000	2,337,000	208,000	3,054,000

ENVIRONMENTAL EFFECTS

The Commonwealth of Virginia proposes that beach-compatible material dredged from either the Thimble Shoal Channel or Atlantic Ocean Channel during the deepening of Norfolk Harbor navigation project be placed along the Sandbridge Beach to assure a greater amount of protection to the existing beach and to adjacent properties. Impacts and effects of offshore dredging associated with new work and/or maintenance dredging of any channel or basin associated with a Federal navigation project is approved through the environmental documentation process for each individual project. Additionally, numerous independent studies on the effects of offshore dredging and beach nourishment have been conducted by Federal and state governmental agencies as well as academic institutions. Below are appropriate passages from Corps of Engineers environmental documents addressing the direct placement of sand on the beach at Virginia Beach from nearby Federal navigation channels during either routine maintenance dredging or new work construction. These documents are applicable to the Sandbridge area of Virginia Beach.

Virginia Beach, Virginia, Beach Erosion Control and Hurricane Protection, FEIS, September 1972. "Possible sources of suitable material include... the Chesapeake Bay bottoms off the Lynnhaven River, and the potential supply from ocean bottom offshore." It also adds, "The nearshore borrow areas in the Chesapeake Bay off Lynnhaven Inlet are part of a highly significant crab wintering ground as well as a relatively important finfish zone, both of which might be affected by dredging operations. Accordingly, the timing and methods of sand extraction at any area would be coordinated with the appropriate Federal and state agencies before a borrow source is selected and during project construction to minimize effects."

Supplement 1, Virginia Beach Beach Erosion and Hurricane Protection, FEIS, February 1985. "With the provision that the material meets the suitability requirements, one borrow option that remains under consideration is the use of material removed during construction and maintenance of the Norfolk Harbor Deepening and Disposal Project."

Final Supplement 1, Norfolk Harbor and Channels,Virginia, Deepening and Disposal, FEIS, June 1985. After a discussion of needs within the Hampton Roads area for supplemental sand supplies, the document continued with, "The planned Atlantic Ocean Channel and the eastern end of Thimble Shoal Channel are known to contain sand which could be placed on area beaches. To the maximum extent practicable, the Norfolk District will recommend the placement of suitable quantities and types of dredged material on nearby shorelines, the creation of stockpiles, and other such beneficial uses ... consistent with all project engineering, environmental, economic, legal, local cooperation, and cost-sharing requirements."

Impacts of Channel Deepening. Two major types of impacts would result from the removal of sand from the Atlantic Ocean Channel. First would be the direct loss of benthic infauna within the dredged area. Inspections of core samples from beach surfaces, immediately after nourishment material has been pumped onto beaches, have verified that benthic sediments are defaunated following pumping at high pressures through mechanical impeller booster pumps. Such cores are totally and repeatedly devoid of live organisms. Remains of motile epibenthic forms, such as fish and crustaceans, are rarely found in pumped sediments. These would be expected to temporarily leave the dredging area and should not be significantly impacted.

The second impact associated with offshore dredging would be an increase in turbidity levels. Due to the sandy substrate and location of the channel in a dynamic ocean environment, it is not anticipated that there would be any release of pollutants or significant lowering of dissolved oxygen levels resulting from dredging activities. Surface sediments may have a percentage of silt which would be released in the water column; however, with use of a hydraulic pipeline dredge, turbidity increases should be below the lethal limit of most estuarine and marine organisms. Hopper dredging may result in higher surface turbidity levels due to the practice of allowing the hopper to overflow with finer material and water until a full load of coarser material is obtained. In channel areas where silt content is high, the material will be placed in the Dam Neck Ocean Disposal Site. It is anticipated that the dynamic wave and current conditions offshore from Virginia Beach would rapidly dissipate any suspended solids which might be released.

Impacts of Beach Nourishment. Impacts associated with placement of material on the beach would be loss of beach organisms by covering and nearshore organisms by high turbidity. Liquefaction of indigenous sediments often occurs during deposition, allowing for the possibility of escape from burial by motile species (amphipods, decapods, etc.).

During 1987, the Norfolk District conducted a study along the Virginia Beach shoreline to determine the effects of beach nourishment on beach fauna. The findings are appropriate to the Sandbridge area. The data indicated that the nourished area did not undergo population changes that differed significantly from a similar control area at the north end of Virginia Beach. In three quarterly samplings, both the fill and control areas experienced the usual seasonal decline in the number of mole crabs (*Emerita talpoida*) and other species of beach fauna from the high spring populations. A second control area, located along the Croatan shoreline of Virginia Beach, experienced some extraordinary changes in population, elevating after nourishment at the fill area, and then, by fall, showing the greatest overall decline from the spring counts. It is believed the data for Croatan was highly affected by the pockets of gravel and coarse shell material along this area. Seasonal population change comparisons between the control areas and the nourished beach were almost identical (one percent variance).

Other separate and independent studies have concluded that the greatest influencing factor on beach fauna populations appears not to be the introduction of additional material onto the beach, but the composition of the introduced material. Deposited sediments, when similar in composition (grain size and other physical characteristics) to existing beach material (whether indigenous or introduced by an earlier nourishment or construction event), do not appear to have the potential to reduce the numbers of species or individuals of beach infauna.

The effects of change in profile could also be significant. Beach zones are defined faunistically and in relation to water levels--above high tide, intertidal, and always submerged. Altering the slope of the profile would alter the proportion of surface available for each zone, hence altering the proportion of fauna typifying each zone. Beach slope is determined by a number of variables including wave period, wave amplitude, water table height, and composition of the material. Introduction of new material comparable to existing material, regardless of orientation at the time of deposition, also minimizes changes in beach slope.

Impacts of nourishment activities have been ongoing at Virginia Beach for the past quarter of a century in association with nourishment activities occurring on an annual basis. Impacts associated with sunbather usage are seasonal, but, when in effect, can be very intense, especially on ghost crab populations. The baseline conditions are, therefore, not comparable to those of an undisturbed beach system such as those on Virginia's Eastern Shore. There are no foreseeable adverse effects on threatened or endangered species that would result from the anticipated project impacts. However, the U.S. Fish and Wildlife Service cautions that in the Sandbridge area, the endangered loggerhead turtle may occasionally nest and that placing sand on the eroded beach at that time could cause adverse impacts upon turtle hatchlings. A more descriptive account may be found in appendix E, the Fish and Wildlife Coordination Act Planning Aid Report.

JUSTIFICATION

With respect to the justification for the deposition of sand dredged from either Thimble Shoal or Atlantic Ocean Channels onto the beach at Sandbridge, it is Corps policy to participate in the additional costs for placing clean sand or other suitable material, dredged by the Corps during construction or maintenance of Federal navigation projects, onto adjacent beaches or nearshore waters subject to the following:

(1) Placement of the material on a beach or beaches and Federal (Corps) participation in the costs must be requested by the state in which the beach or beaches are located;

(2) The added cost of such disposal must be justified by the benefits associated with protection of such beach or beaches;

(3) The storm damage reduction benefits resulting from the beach protection must exceed 50 percent of the total benefits, unless the placing of the dredged material is economically justified based on storm damage reduction benefits alone, or on the combination of storm damage reduction benefits and an equivalent amount of incidental recreation benefits if incidental recreation benefits exceed 50 percent of total benefits;

(4) The beaches involved must be open to the public;

(5) The placement must be environmentally acceptable, pursuant to all applicable statutes and regulations;

(6) Local interests must pay 50 percent of the added cost of disposal above the alternative least costly and environmentally sound method of disposal; and,

(7) Local interests must provide (without cost sharing) any necessary additional lands, easements, or rights-of-way, and relocations.

The following table shows a comparison of the various plans under consideration for placing sand dredged from the Thimble Shoal and Atlantic Ocean Channels onto the beach at Sandbridge.

The above conditions have been satisfied in connection with the placing of sand dredged from the Thimble Shoal Channel or Atlantic Ocean Channel onto the beach at Sandbridge. The following table shows that benefits from the provision of a 100-foot berm using Thimble Shoal Channel sand or Atlantic Ocean Channel sand are sufficient to justify the additional costs of disposing of the sand on the beach in lieu of ocean disposal.

Table 9. PLAN EVALUATION AND JUSTIFICATION

Item	Berm Width (feet) 50	75	100	150
Thimble Shoal Channel				
Construction volume (c.y.)	289,000	476,000	757,000	(a)
Dredged from channel (c.y.)	419,000	691,000	1,097,000	
Life of placement (year)	0.9	1.5	2.4	
First cost (added cost)	2,661,000	3,934,000	5,775,000	
Annual costs	3,206,000	2,916,000	2,777,000	
Annual benefits	2,474,000	2,603,000	2,798,000	
Net benefits	(732,000)	(313,000)	21,000	
Benefit-cost ratio	0.77	0.89	1.01	
Atlantic Ocean Channel				
Construction volume (c.y.)	289,000	476,000	757,000	1,373,000
Dredged from channel (c.y.)	468,000	772,000	1,226,000	2,224,000
Life of placement (years)	1.0	1.7	2.7	3.7(b)
First cost (added cost)	2,715,00	4,015,000	5,860,000	10,164,000
Annual costs	2,956,000	2,647,000	2,535,000	3,342,000
Annual benefits	2,438,000	2,576,000	2,794,000	3,054,000
Net benefits	(518,000)	(71,000)	259,000	(288,000)
Benefit-cost ratio	0.83	0.97	1.10	0.91

(a) 100-foot berm is the largest available for construction using sand dredged from Thimble Shoal Channel.

SELECTED PLAN

As discussed in the "Justification" section of this report, the disposal of 1,097,000 cubic yards of material dredged from the Thimble Shoal Channel or 1,226,000 cubic yards of material dredged from the Atlantic Ocean Channel and placed onto the beach at Sandbridge is estimated to be in the Federal interest. Based on an overfill ratio of 1.45 for Thimble Shoal Channel material and an overfill ratio of 1.62 for Atlantic Ocean Channel material, the berm widths indicated above would provide useful lives for the sand placement of 2.4 years and 2.7 years, respectively, using Thimble Shoal Channel sand Atlantic Ocean Channel sand. These quantities of sand when placed on the beach would create a berm approximately 24,300 feet long, 100 feet wide, and 6 feet high (NGVD). As shown in table 9, benefits are maximized with a 100-foot berm. The criteria discussed previously regarding requirements for Federal participation in the additional cost of placing sand on the beach, in lieu of the least costly acceptable disposal alternative, have been satisfied. The following table summarizes the economic evaluation of the selected plan.

Table 10. ECONOMIC EVALUATION OF SAND PLACEMENT

Item	Atlantic Ocean Channel	Thimble Shoal Channel
Annual costs	$2,535,000	$2,777,000
Annual benefits	$2,794,000	$2,798,000
Net benefits	$259,000	$21,000
Benefit-cost ratio	1.10	1.01

RISK AND UNCERTAINTY

Risk and uncertainty refer to the unpredictable variability of future events. This unpredictability is addressed as it specifically relates to the placement of sand dredged from Norfolk Harbor navigation channels onto the beach. The key variable with respect to the sand placement is the length of time the material will stay on the beach and provide beneficial effects. Both average annual costs and benefits are sensitive to the estimated placement life. Accordingly, project justification, and, therefore, the Federal interest, can be very sensitive to this variable. The following tables show the impact of varying the useful life of the sand placement on the average annual costs, average annual benefits, net benefits, and benefit-cost ratios. As indicated in the tables, the life of the sand placement has a substantial effect on annual costs, reducing them significantly as the life is extended. However, as the estimates of the sand placement life are increased, the likelihood of the estimate being accurate decreases.

Accordingly, shorter life estimates contain less risk and uncertainty and are believed to be more applicable to project evaluation and selection.

Table 11. ECONOMIC SENSITIVITY TO LIFE OF SAND PLACEMENT, THIMBLE SHOAL CHANNEL SAND

Item	Life of sand placement (years)			
50-foot berm	0.7	0.9	1.1	1.4
Annual costs ($000)	4,087	3,206	2,645	2,104
Annual benefits ($000)	2,333	2,474	2,415	2,492
Net benefits ($000)	(1,754)	(732)	(230)	388
Benefit-cost ratio	0.57	0.77	0.91	1.18
75-foot berm	1.2	1.5	1.8	2.3
Annual costs ($000)	3,579	2,916	2,460	1,965
Annual benefits ($000)	2,520	2,603	2,665	2,711
Net benefits ($000)	(1,059)	(313)	205	746
Benefit-cost ratio	0.70	0.89	1.08	1.38
100-foot berm	1.8	2.4	2.9	3.7
Annual costs ($000)	3,612	2,777	2,345	1,899
Annual benefits ($000)	2,756	2,798	2,859	2,958
Net benefits ($000)	(856)	21	514	1,059
Benefit-cost ratio	0.76	1.01	1.22	1.56

Table 12. ECONOMIC SENSITIVITY TO LIFE OF SAND PLACEMENT, ATLANTIC OCEAN CHANNEL SAND

Item	Life of sand placement (years)			
50-foot berm	0.8	1.0	1.2	1.6
Annual costs ($000)	3,664	2,956	2,484	1,894
Annual benefits ($000)	2,521	2,438	2,396	2,462
Net benefits ($000)	(1,143)	(518)	(88)	568
Benefit-cost ratio	0.69	0.83	0.96	1.30
75-foot berm	1.3	1.7	2.1	2.6
Annual costs ($000)	3,405	2,647	2,179	1,797
Annual benefits ($000)	2,645	2,576	2,635	2,704
Net benefits ($000)	(760)	(71)	456	907
Benefit-cost ratio	0.78	0.97	1.21	1.50
100-foot berm	2.0	2.7	3.3	4.1
Annual costs ($000)	3,326	2,535	2,125	1,767
Annual benefits ($000)	2,728	2,794	2,934	3,042
Net benefits ($000)	(598)	259	809	1,275
Benefit-cost ratio	0.82	1.10	1.38	1.72
150-foot berm	3.7	4.9	5.9	7.4
Annual costs ($000)	3,342	2,648	2,287	1,931
Annual benefits ($000)	3,054	3,342	3,618	4,044
Net benefits ($000)	(288)	694	1,331	2,113
Benefit-cost ratio	0.91	1.26	1.58	2.09

COORDINATION

Coordination has been maintained during the course of the study with appropriate Federal, state, regional, and local agencies. Key agencies specifically involved with the conduct of the evaluation include the Virginia Port Authority, Virginia Commission on the Conservation and Development of Public Beaches, the city of Virginia Beach, and the U.S. Fish and Wildlife Service. Pertinent correspondence is contained in appendix D.

LOCAL COOPERATION

Federal participation in the cost of placing sand dredged from the 55-foot outbound Norfolk Harbor Channels on the beach at Sandbridge is based on the Commonwealth of Virginia ensuring the Chief of Engineers that:

a. The state will pay 50 percent of the added cost of placement of the sand on the beach above that cost for placement in the Dam Neck Ocean Disposal Site. Furthermore, the state will pay 100 percent of the added cost for that quantity of sand exceeding the amount determined to be in the Federal interest.

b. The state will provide all necessary lands, easements, rights-of-way, and relocations.

c. The state will hold and save the United States free from damages that may result from the placement of sand on the beach except where such damages are due to the fault or negligence of the United States or its contractors.

d. The state will ensure that the beach involved will be open to the public.

CONCLUSIONS

Based on this report, it is concluded that the added cost of the placement of 1,097,000 cubic yards of sand dredged from the Thimble Shoal Channel or 1,226,000 cubic yards of sand dredged from the Atlantic Ocean Channel on the beach at Sandbridge between the 4.6 miles of beach between that area south of the U.S. Naval Fleet Anti-Air Warfare Training Center at Dam Neck and north of the Back Bay National Wildlife Refuge is justified by the benefits associated with the placement of sand. The additional cost of placing 1,097,000 cubic yards of sand from the Thimble Shoal Channel is estimated at $5,775,000. The additional cost of placing 1,226,000 cubic yards of sand on the beach from the Atlantic Ocean Channel source is estimated at $5,860,000. However, due to the unpredictability of coastal processes, the inherent difficulties in determining an exact quantity of sand placement to be in the public interest, and the need for flexibility in the physical placement of dredged sand on the beach, it is recommended that a range of dredged sand from 1,000,000 cubic yards to 1,300,000 cubic yards be considered in the Federal interest for cost-sharing purposes.

RECOMMENDATIONS

It is recommended that the Federal Government participate in the additional cost of placing from 1.0 million to 1.3 million cubic yards of sand on the beach at Sandbridge along the 4.6 miles of beach between that area south of the U.S. Naval Fleet Anti-Air Warfare Training Center at Dam Neck, hereinafter referred to as Dam Neck, and north of the Back Bay National Wildlife Refuge, from the Atlantic Ocean Channel. The recommendation is contingent upon non-Federal interests, in this case, the Commonwealth of Virginia, providing the required items of local cooperation as stated previously in this report.

J. J. THOMAS
Colonel, Corps of Engineers
Commanding

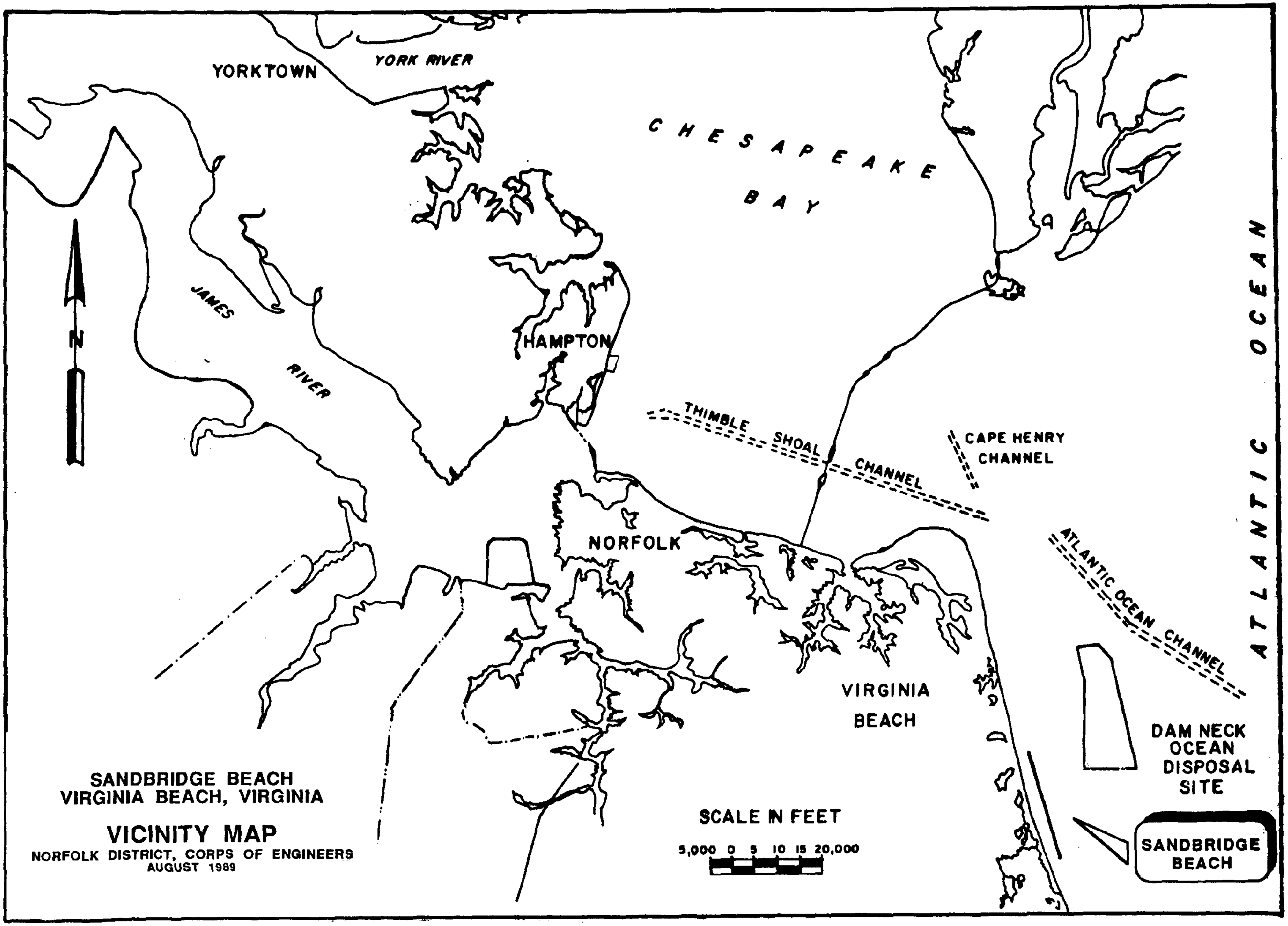
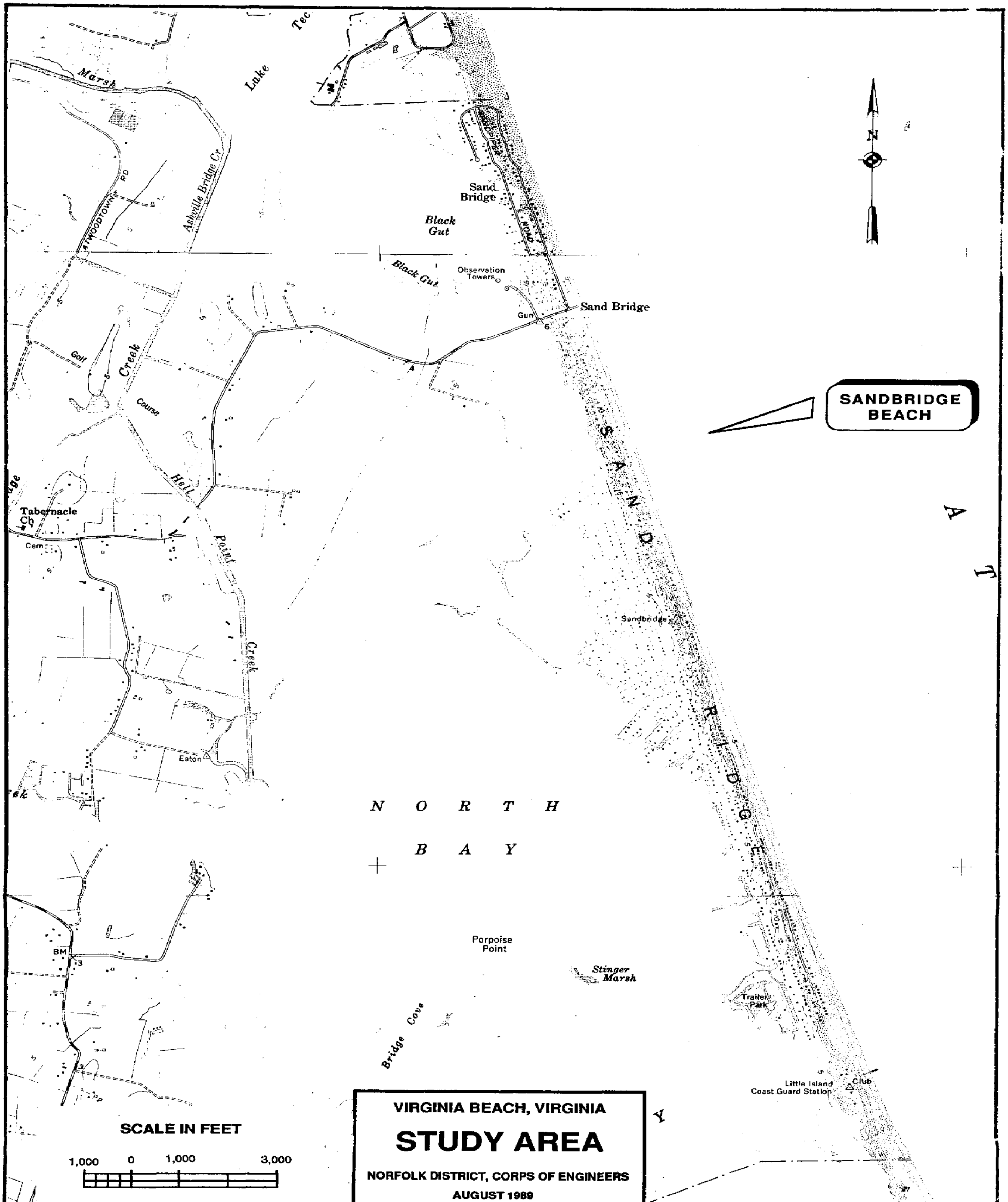

YORKTOWN
YORK RIVER
CHESAPEAKE
BAY
JAMES
RIVER
N
HAMPTON
THIMBLE SHOAL CHANNEL
CAPE HENRY CHANNEL
ATLANTIC OCEAN
ATLANTIC OCEAN CHANNEL
NORFOLK
VIRGINIA BEACH
DAM NECK OCEAN DISPOSAL SITE
SANDBRIDGE BEACH
SCALE IN FEET
5,000 0 5 10 15 20,000
SANDBRIDGE BEACH
VIRGINIA BEACH, VIRGINIA
VICINITY MAP
NORFOLK DISTRICT, CORPS OF ENGINEERS
AUGUST 1989

PLATE 1



Marsh
Lake
Ashville Bridge Cr.
ATWOODTOWN RD
Sand Bridge
Black Gut
Black Gut
Observation Towers
Gun
Sand Bridge
Golf
Creek
Course
Hell Point Creek
Tabernacle Ch
Cem
SANDBRIDGE BEACH
S A N D R I D G E
A T
Sandbridge
Eaton
N O R T H
B A Y
BM
Porpoise Point
Stinger Marsh
Bridge Cove
Trailer Park
Little Island Coast Guard Station
Club
SCALE IN FEET
1,000 0 1,000 3,000
VIRGINIA BEACH, VIRGINIA
STUDY AREA
NORFOLK DISTRICT, CORPS OF ENGINEERS
AUGUST 1969

PLATE 2

APPENDIXES

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B BENEFIT EVALUATION

C HYDROLOGY AND HYDRAULICS

D PERTINENT CORRESPONDENCE

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APPENDIX A

COST ESTIMATES

PURPOSE

1. This section of the appendix presents the methodology and assumptions used in estimating the costs of placement of sand dredged from the Thimble Shoal and Atlantic Ocean Channels onto Sandbridge Beach. Costs are based on October 1988 price levels.

LITTORAL TRANSPORT

2. Littoral transport is the movement of sedimentary material (littoral drift) by waves and currents in the littoral zone. As wave trains approach a shore at an angle, they generate an alongshore current that moves sediment that has been placed in suspension by wave action. This shore-parallel movement of sediment is called longshore transport. The direction of transport is dependent upon shoreline orientation, wind and wave directions, and nearshore bottom geometry. In addition, transport of material perpendicular to a shoreline is referred to as onshore-offshore transport; it is also influenced by the above factors.

3. Generally, beach compartments on either side of a divergent nodal point experience erosion because they are the source areas for littoral drift. Conversely, convergent nodal areas usually acrete. Sandbridge lies immediately north of a divergent nodal point in the littoral transport system. Immediately south of this nodal area, net littoral transport is to the south. To the north of this nodal area, from Sandbridge to Cape Henry, the net littoral transport is to the north.

THIMBLE SHOAL CHANNEL

4. The Thimble Shoal Channel is located in the southern portion of the Chesapeake Bay. It extends westward from the mouth of the Chesapeake Bay

to the mouth of the Hampton Roads Harbor. The channel is bounded on the north side by the submarine topographic features known as the Horseshoe and Tail of the Horseshoe. To the south, the channel is bounded by the submarine features referred to as Crumps Bank and Willoughby Bank. Thimble Shoal Channel is approximately 9.5 nautical miles long and 1,000 feet wide with auxiliary channels located on each side of the main channel. The auxiliary channels are 450 feet wide. The location of the channel is shown on plate 1 of the main report.

5. In May 1983, August 1984, and July 1985, the Norfolk District personnel supervised subsurface investigations for the Thimble Shoal Channel, Norfolk Harbor and Channels deepening project. The scope of work was fourfold; namely:

a. To determine substrata conditions to a minimum depth of minus 58 feet below mean low water. Detail was given to identifying areas where sediment changes occurred both vertically and horizontally.

b. To perform laboratory tests on soil identification, moisture content, natural density, and soil strength.

c. To determine the side slopes for the channel.

d. To identify areas within the project area which may have sand texturally suitable and available in appreciable quantities for mining.

6. Details from the above investigations are contained in appendix C of the General Design Memorandum dated June 1986.

7. The Corps recently completed the dredging of the channel to provide for a Congressionally authorized outbound channel 50 feet deep from Norfolk Harbor to the Atlantic Ocean. This dredging did not provide any satisfactory sand. However, a 55-foot channel has also been Congressionally authorized into Norfolk Harbor. Investigations indicate the 6.4 million cubic yards of total pay quantity material will be dredged from this channel, of which 1.2 million cubic yards is expected to be beach-quality sand. The mean grain size, based

on samples, ranges from 0.181 mm to 0.308 mm. The overfill ratio is estimated at 1.45, meaning that to obtain 1 cubic yard of this sand on the beach, 1.45 cubic yards must be dredged from the channel to account for placement losses between the dredge and the beach.

ATLANTIC OCEAN CHANNEL

8. The Atlantic Ocean Channel is located offshore of Virginia Beach, Virginia in the Atlantic Ocean. It extends southeastward from a point approximately 3.5 nautical miles offshore of Cape Henry to approximately 10 nautical miles offshore of Rudee Inlet, Virginia Beach, Virginia. Its northern end leads into one of the largest estuaries in the world, the Chesapeake Bay. Approximately 9 nautical miles of the channel was investigated in connection with the preparation of the General Design Memorandum for deepening the Norfolk Harbor Channels. The scope of work for this investigation was identical to that indicated previously for the Thimble Shoal Channel. The location of the channel is shown on plate 1 of the main report.

9. Investigations indicate that sand suitable for disposal on area beaches is found in the middle and outer reaches of the channel. It is estimated that 9.6 million cubic yards of total pay quantity material will be dredged from this channel, of which 5.2 million cubic yards is expected to be beach-quality sand. The mean grain size, based on samples, is estimated to be 0.25 mm. The overfill ratio is estimated at 1.62.

PLACEMENT OF OFFSHORE SAND ON BEACH

10. The following two basic dredges are available for deposition of sand from Thimble Shoal and Atlantic Ocean Channels onto Sandbridge Beach.

a. A large cutterhead suction dredge which cuts up the material and pumps it continuously through a long attached pipeline to the shore. The diameter of the discharge line can be as much as 42 inches. If the borrow area is such that the maximum length of pipe can be kept under about 18,000 feet, it is very likely that a large pipeline dredge working on swing wires from April through September could remove material and pump it onshore through a booster pumping plant located on a jack-up barge (or DeLong Pier) above wave action, though not at the surf zone. Another booster pump can be added onshore. However, a pipeline could not successfully compete with hopper dredge equipment if the summer months (when the beach is actively used by residents and tourists) were excluded from the dredging operation. The main problem with this system is keeping the submerged line connection with the dredge and booster pump intact in an ocean environment. With the borrow area located as much as 6 miles from the beach, additional booster pumps or a second dredge would be required, thereby doubling the problems and cost of pumping.

b. The hopper dredge stores the material in its hoppers, travels to the shoreline, and then pumps the sand onshore through one or more booster pumps, depending on the distance from its mooring facility to the beach. A hopper dredge cannot dredge and pump onshore in a continuous operation as does the pipeline dredge. Consequently, a substantial portion of the work time is spent traveling and pumping out its hoppers even if the travel distance is short. A connection between the beach pumping system and the hopper dredge requires an offshore hookup, such as use of a DeLong Pier barge partially jacked up above wave action as an intermediate discharge plant. It was used in the calmer waters of Chesapeake Bay when sand was pumped onshore from Thimble Shoal Channel to Fort Story. The self-propelled hopper dredges have a capacity of up to several thousand cubic yards and a speed of up to 13 knots when loaded. An effective offshore pump system is a single-point mooring which utilizes an anchored buoy that holds the open end of the submerged shoreline pipe to which the dredge attaches its pumpout system. The hopper dredge, when attached to the buoy is free to pivot with its head into the wind, thus riding as if at anchor and achieving the best possible stability.

11. Generally, the dredges draw 20 to 30 feet of water and must therefore be located offshore where this depth of water is available. Any offshore borrow site contains a percentage of silt-size material. When more granular material is dredged, enough of the fine material will be mixed to yield a relatively easy pumping slurry. The pipeline dredge will handle this slurry without modifying it and will deliver it to the beach. The hopper dredge, on the other hand, sorts the material in its hopper causing the silt to be suspended and lost overboard during the loading process. The resulting material, while superior for beach fill, will be more difficult to transport through a pipeline. The hopper dredge transfer point, therefore, should be as close to the beach as safety will permit. A pipeline dredge can be located farther away and still achieve good results. Some of the difference in quality of the fill material can be compensated for by the shore crew. By allowing more of the fine material to flow into the surf from the pipeline and by using shorter training dikes in the ponding and settlement area, much of the silt-size material can be eliminated without damage to the new beach section. However, in view of the distances involved from the Atlantic Ocean and/or Thimble Shoal Channels to the beach and the sensitivity of the hydraulic pipeline dredge to weather conditions, the hopper dredge is considered a more practical alternative for accomplishing the work.

SAND REQUIRED FOR VARIOUS BEACH BERMS

12. Based on past records and observations, the existing erosion rate of the beach is estimated at 300,000 cubic yards per year or about 6 feet per year. If the present beach is widened, the erosion rate can be expected to increase. This increase in erosion would be contributed to the beach not being in dynamic equilibrium with wave conditions, sediment characteristics, offshore topography, and slope as well as foreshore-backshore geometrics. This implies that erosion is expected to be accelerated until the portion of the active beach

out to closure depth is filled in with the required volume of sand. The closure depth is defined as the seaward limit of the extreme surf-related effect on the sediment movements. An important factor when increasing the subaerial portion of the beach seaward is the additional volume of material needed to fill in the area out to closure depth. For many beaches, the design beach does not include the volume of material needed to fill in the offshore zone. When this zone is not filled in, the beach is not in dynamic equilibrium. Erosion rates are expected to increase until this area is filled. It is estimated that with sand placement sufficient to increase the existing berm width in the range from 50 to 150 feet, erosion rates could increase up to twice their existing rates.

13. Sand requirements for beach berm widths of 50 feet to 150 feet at elevation 6 feet m.s.l. have been estimated and are shown in table A-1. The estimated volumes are based on closure depths, coastal processes, and shoreline recessions which were identified through analysis of profile cross sections developed from beach surveys completed in the spring of 1989. Required quantities of sand include overfill volumes estimated on the basis of the beach's native sediment characteristics and the characteristics of the material to be dredged from the Thimble Shoal and Atlantic Ocean Channels. The length of time the sand will remain on the beach for each proposed berm width has been estimated based upon normal shoreline retreat due to berm development and the resulting non-equilibrium beach profile.

14. Table A-1 summarizes the quantity of sand required by berm width for sand dredged from the Thimble Shoal and Atlantic Ocean Channels.

Table A-1. SUMMARY OF SAND REQUIREMENTS

Berm width (feet)	Construction volume (cu. yds.)	Dredged volume (cu. yds.)	Range of estimated life of placement (years)
		Thimble Shoal Channel	
50	289,000	419,000	0.7 - 1.4
75	476,000	691,000	1.2 - 2.3
100	757,000	1,097,000	1.8 - 3.7
150	1,373,000	1,991,000	3.3 - 6.6
		Atlantic Ocean Channel	
50	289,000	468,000	0.8 - 1.6
75	476,000	772,000	1.3 - 2.6
100	757,000	1,226,000	2.0 - 4.1
150	1,373,000	2,224,000	3.7 - 7.4

COST DATA

15. Cost estimates are based on using a Manhatten Class hopper dredge with pumpout capability. This dredge would load material, proceed to a mooring buoy, and connect to a submerged pipeline leading to shore. Pumping would be assisted by boosters as needed. It may not be efficient to spread some of the smaller quantity along the beach. Estimates assume that an efficient placement method will be used. Use of the hopper dredge, with the long periods of no pumping, would allow more time to switch the discharge pipe without losing efficiency.

16. Pertinent assumptions relative to the estimation of costs are shown in tables A-2 and A-3.

Table A-2. HOPPER DREDGE DATA

Item	Cubic yards						
	100,000	250,000	500,000	1,000,000	2,000,000	4,000,000	6,000,000
Cycle time in minutes							
Dredging	130	120	110	100	100	100	100
Turning	10	10	10	10	10	10	10
To disposal area							
Thimble Shoal Channel	72	72	72	72	72	72	72
Atlantic Ocean Channel	30	30	30	30	30	30	30
Discharge to beach	190	180	170	150	145	145	145
Discharge to Dam Neck	10	8	5	5	5	5	5
To dredging area							
Thimble Shoal Channel	60	60	60	60	60	60	60
Atlantic Ocean Channel	25	25	25	25	25	25	25
Operating days/month	21	22	23	23	23	23	23

Table A-3. OVERHEAD AND PROFIT FOR HOPPER DREDGE

Cubic yardage	Overhead and profit (percent)
250,000	26
500,000	25
1,000,000	24
2,000,000	23
4,000,000	21
6,000,000	20

17. In determining costs, all contract costs were increased by 6 percent for Engineering and Design and Supervision and Administration and by 10 percent for contingencies. Costs also include the requirement for one booster pump since the length of the line from the dredge to the beach is 3,000 feet.

18. Tables A-4, A-5, A-6, and A-7 show the computation of costs per cubic yard of sand based on 1 million cubic yards dredged from Atlantic Ocean and Thimble Shoal Channels and placed in Dam Neck Disposal Site and on Sandbridge Beach. Unit cost estimates for other quantities ranging from 250,000 to 6 million cubic yards were calculated in the same manner and are shown in table A-8.

Table A-4. UNIT COST, ATLANTIC OCEAN CHANNEL SAND TO DAM NECK DISPOSAL SITE
(1,000,000 C.Y.)

Plant: Manhatten Island Class Hopper Dredge
Channel Segment: Atlantic Ocean Channel
Disposal Area: Dam Neck Ocean Disposal Area
Haul Distance (Miles): 3

Cycle Time (In Minutes):		
Dredging		100
Turning		10
To Disposal Area	3 Miles @ 10 MPH	18
Discharging		5
To Dredging Area	3 Miles @ 12 MPH	15
Total Cycle Time (In Minutes):		148
Monthly Plant Cost:		
Dredge	20,000/Day X 30	$600,000
Mooring Barge or Buoy		
Shore Men and Equipment		
24" Submerged Pipe	LF @ 4.35/LF	
24" Shore Pipe	LF @ 3.00/LF	
Subtotal		$600,000
24% Overhead & Profit		120,000
Total Monthly Plant Cost		$720,000
Production and Cost Estimates:		
Loads Per Day	9.73	
Cubic Yards/Load	2,000	
Operating Days/Month	23	
Monthly Production (Cubic Yds):		447,580
Quantity of Material (Cubic Yds):		1,000,000
Dredging Time:	2.23 Mos.	
Dredging Cost:		$1,605,600
Mobilization/Demobilization:		420,000
Total Job Cost:		$2,025,600
Unit Cost/C.Y. Contract:		$2.03
E&D + S&A (6%):		0.12
Contingencies (10%):		0.22
Unit Cost/C.Y. Total:		$2.37

Table A-5. UNIT COST, THIMBLE SHOAL CHANNEL SAND TO DAM NECK DISPOSAL SITE
(1,000,000 C.Y.)

Plant: Manhatten Island Class Hopper Dredge
Channel Segment: Thimble Shoal Channel
Disposal Area: Dam Neck Ocean Disposal Area
Haul Distance (Miles): 15

Cycle Time (In Minutes):		
Dredging		100
Turning		10
To Disposal Area	15 Miles @ 10 MPH	90
Discharging		5
To Dredging Area	15 Miles @ 12 MPH	75
Total Cycle Time (In Minutes):		280
Monthly Plant Cost:		
Dredge	20,000/Day X 30	$600,000
Mooring Barge or Buoy		5,200
Shore Men and Equipment		16,000
24" Submerged Pipe	LF @ 4.35/LF	
24" Shore Pipe	LF @ 3.00/LF	
Subtotal		$621,200
24% Overhead & Profit		124,240
Total Monthly Plant Cost		$745,440
Production and Cost Estimates:		
Loads Per Day	5.14	
Cubic Yards/Load	2,000	
Operating Days/Month	23	
Monthly Production (Cubic Yds):		236,571
Quantity of Material (Cubic Yds):		1,000,000
Dredging Time (One Dredge):	4.23 Mos.	
Dredging Cost:		$3,153,211
Mobilization/Demobilization:		420,000
Total Job Cost:		$3,573,211
Unit Cost/C.Y. Contract:		$3.57
E&D + S&A (6%):		0.21
Contingencies (10%):		0.38
Unit Cost/C.Y. Total:		$4.16

Table A-6. UNIT COST, ATLANTIC OCEAN CHANNEL SAND TO SANDBRIDGE BEACH
(1,000,000 C.Y.)

Plant: Manhatten Island Class Hopper Dredge
Channel Segment: Atlantic Ocean Channel
Disposal Area: Sandbridge Beach
Haul Distance (Miles): 9
Pumping Distance: 6,000 feet

Cycle Time (In Minutes):		
Dredging		100
Turning		10
To Disposal Area	9 Miles @ 10 MPH	54
Discharging		150
To Dredging Area	9 Miles @ 12 MPH	45
Total Cycle Time (In Minutes):		359
Monthly Plant Cost:		
Dredge	20,000/Day X 30	$600,000
Mooring Barge or Buoy		5,200
Booster Pump	1 X 125,000	125,000
Shore Men and Equipment		16,000
24" Submerged Pipe	3,000 LF @ 4.35/LF	13,050
24" Shore Pipe	10,000 LF @ 3.00/LF	30,000
Subtotal		$789,250
24% Overhead & Profit		189,420
Total Monthly Plant Cost		$978,670
Production and Cost Estimates:		
Loads Per Day	4.01	
Cubic Yards/Load	2,000	
Operating Days/Month	23	
Monthly Production (Cubic Yds):		184,460
Quantity of Material (Cubic Yds):		1,000,000
Dredging Time (One Dredge):	5.42 Mos.	
Dredging Cost:		$5,304,391
Mobilization/Demobilization:		280,000
Total Job Cost:		$5,584,391
Unit Cost/C.Y. Contract:		$5.58
E&D + S&A (6%):		0.33
Contingencies (10%):		0.59
Unit Cost/C.Y. Total:		$6.50

Table A-7. UNIT COST, THIMBLE SHOAL CHANNEL SAND TO SANDBRIDGE BEACH
(1,000,000 C.Y.)

Plant: Manhatten Island Class Hopper Dredge
Channel Segment: Thimble Shoal Channel
Disposal Area: Sandbridge Beach
Haul Distance (Miles): 20
Pumping Distance: 6,000 feet

Cycle Time (In Minutes):		
Dredging		100
Turning		10
To Disposal Area	20 Miles @ 10 MPH	120
Discharging		150
To Dredging Area	20 Miles @ 12 MPH	100
Total Cycle Time (In Minutes):		480
Monthly Plant Cost:		
Dredge	20,000/Day X 30	$600,000
Mooring Barge or Buoy		5,200
Booster Pump	1 X 125,000	125,000
Shore Men and Equipment		16,000
24" Submerged Pipe	3,000 LF @ 4.35/LF	13,050
24" Shore Pipe	10,000 LF @ 3.00/LF	30,000
Subtotal		$789,250
24% Overhead & Profit		189,420
Total Monthly Plant Cost		$978,670
Production and Cost Estimates:		
Loads Per Day	3.00	
Cubic Yards/Load	2,000	
Operating Days/Month	23	
Monthly Production (Cubic Yds):		138,000
Quantity of Material (Cubic Yds):		1,000,000
Dredging Time (One Dredge):	7.25Mos.	
Dredging Cost:		$7,095,358
Mobilization/Demobilization:		280,000
Total Job Cost:		$7,375,358
Unit Cost/C.Y. Contract:		$7.38
E&D + S&A (6%):		0.44
Contingencies (10%):		0.78
Unit Cost/C.Y. Total:		$8.60

19. Table A-8 summarizes the estimated costs for offshore sand from Thimble Shoal and Atlantic Ocean Channels to be deposited in Dam Neck Disposal Site or on the beach at Sandbridge Beach.

Table A-8. COST SUMMARY FOR OFFSHORE SAND(a)

Yardage (c.y.)	Cost of sand from offshore site ($/c.y.)			
	Thimble Shoal to Dam Neck	Atlantic Ocean to Dam Neck	Thimble Shoal to Sb Beach	Atlantic Ocean to Sb Beach
250,000	6.35	4.32	11.07	8.90
500,000	4.94	2.94	8.31	7.59
1,000,000	4.16	2.37	8.90	6.80
2,000,000	4.02	2.17	8.64	6.55
4,000,000	3.83	2.01	8.43	6.37
6,000,000	3.75	1.96	7.95	6.21

(a) Costs shown for Sandbridge Beach include $0.30/c.y. for spreading material on the beach.

APPENDIX B

BENEFIT EVALUATION

APPENDIX B

BENEFIT EVALUATION

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APPENDIX B

BENEFIT EVALUATION

GENERAL

1. This section of the appendix evaluates the beneficial impacts associated with protection of 4.6 miles of Sandbridge beach between that area south of Dam Neck and north of the Back Bay National Wildlife Refuge by the placement of sand dredged from the 55-foot-deep outbound Norfolk Harbor Channels onto the beach. The beneficial impacts from the initial placement of the dredged sand are (a) reduced tangible primary flood damages, (b) the delay in the loss of land and structure loss due to erosion, (c) the delay of storm damages to bulkheads and related losses of sand behind existing bulkheads, and (d) the beneficial effects on downdrift areas. Estimates of monetary benefits are based on October 1988 price levels, a base year of 1990, and an interest rate of 8-7/8 percent. The existing beach area is sufficient to accommodate the expected recreational visitation to Sandbridge and therefore no benefits were claimed.

FLOOD DAMAGES

2. The first step in estimating average annual tidal flood damage is to obtain pertinent data through flood damage surveys. Detailed surveys were made in connection with the Phase I General Design Memorandum (GDM) for Virginia Beach completed in June 1984. These surveys were updated in 1988 based on development which has occurred since completion of the Phase I GDM. Following the compilation of the flood damage survey data, benefits were then estimated by evaluating damages under with and without project conditions over a range of alternative berm widths. The estimated life of the sand placement varies both within each berm width and between alternative berm widths.

3. Primary tangible flood damage reduction benefits for the sand placement are the equivalent average annual tidal flood damages prevented and represent the difference between average annual tidal flood losses without protection and residual average annual losses after providing protection. The without project condition assumes no sand nourishment over the period of analysis.

4. Average annual damages for a given condition were obtained by combining the total damage at various tidal flood stages with the corresponding frequency of flooding to those stages to obtain a damage-frequency relationship. The damage-frequency relationship is utilized to determine the average annual damages for each given condition. This is done for natural conditions without protection and conditions which would exist with the sand placement, the difference being the average annual flood prevention benefits attributable to the project.

DAMAGE SURVEYS

Purpose and Method

5. Investigations were made to determine the relationship between the tidal flood stage in the project area and the resulting damages to existing developments. Such a relationship, when compared with the probable frequency of recurring tidal flood stages, is a guide to the forecast of future flood losses. It also furnishes data required to determine the economic justification of depositing sand on the beach in lieu of open-water disposal areas.

6. A stage-loss relationship cannot be based entirely on the damages from tidal stages caused by past hurricanes or northeasters, as such data are not always available. Most of the occupants of business establishments in the areas at the time of the record 1933 hurricane are no longer in business. Records relative to structural, content, and indirect damage caused by floods are not always maintained by homeowners. Furthermore, recent development of the flood plain must be considered. The recent survey indicated that 68 new structures have been added to the flood plain since the information was collected for the Phase I GDM.

7. U.S. Geological Survey quadrangle sheets to a scale of 1:24,000 were used to delineate the limits of the area inundated by the March 1962 storm. City plat maps to a scale of 1 inch equals 200 feet showed the location and extent of each parcel of property. The ground-floor elevation for each structure in the area was obtained. Reliable high-water marks were established for the August 1933 and March 1962 storms. This facilitated a determination of the elevations to be expected from tidal flood stages of varying magnitude and the effect of wave heights in the area.

8. The stillwater level tidal flood stage was used as an index of the damage, since it could be expressed on a frequency basis. The wind-driven waves generated by prior storms have rushed up and over the beaches causing damage at elevations considerably higher than the stillwater level offshore. The probable damage associated with a given stillwater level was approximated by estimating the depth and extent of flooding in areas adjacent to the shore, using that experienced in March 1962 as a basis, and estimating the damage which would occur under those conditions. The stage-damage relationship was defined by determining the damages which would result in a recurrence of the tide levels reached in March 1962 and August 1933 and in a storm producing a tide level of elevation 12 feet.

Residential Damages

9. Damages were evaluated based on depth-damage functions with allowances for loss of market value when undermining occurs. Damages to structures which were undermined were estimated at 60 percent and 75 percent, respectively, for a repeat of the 1962 and 1933 events and at 90 percent for those structures that would be undermined with an equivalent stillwater level of 12 feet NGVD.

10. Although intangible damages are not adaptable to monetary measurement, they are of considerable importance in the flood plain area. Although no significant loss of life or epidemic diseases have been recorded as directly attributable to tidal flooding in recent years, the danger is ever present. Also of importance is the adverse effect of prolonged periods of inundation on the general welfare of the residents. During a major storm such as occurred in March 1962, communications are interrupted, utilities become inoperative, and

transportation routes are impassable. These breakdowns in communication and services result in delays in evacuation, prevent the rendering of needed assistance, and add to the already difficult problem of rehabilitation.

EXISTING STAGE-DAMAGE DATA

11. Based on the original damage survey, supplemented by the update to reflect current levels of development and based on October 1988 price levels, the data for damages to existing residential structures, contents and indirect damages were summarized and correlated. The without project damages were based on a stillwater level of 3.0 feet NGVD for non-bulkheaded properties and 4.5 feet NGVD for bulkheaded properties. Table B-1 presents the residential stage-damage relationships under without project conditions.

Table B-1. STAGE-DAMAGE DATA FOR SANDBRIDGE BEACH ($1,000s)

Stage ft., NGVD	Structure	Contents	Indirect	Total
12.00	10,234	4,062	529	14,825
11.50	9,453	3,745	496	13,694
11.00	8,655	3,420	461	12,536
10.73	8,226	3,232	441	11,899
10.00	6,947	2,722	393	10,062
9.50	6,035	2,353	388	8,776
9.00	5,110	1,985	308	7,403
8.70	4,500	1,753	280	6,533
8.60	4,305	1,685	272	6,262
8.50	4,100	1,595	256	5,951
8.00	3,243	1,207	204	4,654
7.50	2,463	895	152	3,510
7.00	1,743	612	104	2,459
6.70	1,299	455	79	1,833
6.50	1,156	401	70	1,627
6.00	756	275	47	1,078
5.70	597	179	34	810
5.40	419	128	24	571
5.00	230	57	12	299
4.50	35	0	0	35
3.00	0	0	0	0

AVERAGE ANNUAL DAMAGES

12. In order to convert the stage-damage data in the previous table to average annual values, it is necessary to relate them to stage-frequency data. This is accomplished in the following table which shows the frequency data, the corresponding stages, the damage at each stage, and the annualized damage values for Sandbridge under without project conditions.

Table B-2. AVERAGE ANNUAL FLOOD DAMAGES (WITHOUT CONDITION) ($1,000)

Frequency (years)	Stage (feet)	Damage at stage ($)	Avg. annual value ($)
0	12.0	14,825	692
500.0	11.0	12,536	664
256.4	10.0	10,062	643
125.0	9.0	7,403	607
54.1	8.0	4,654	547
20.4	7.0	2,459	443
6.7	6.0	1,078	287
2.0	5.0	299	76
1.05	4.5	35	1
1.0	3.0	0	0

FLOOD REDUCTION BENEFITS

13. The data presented previously relate to without project flood damages in the study area. The following section will quantify the average annual benefits attributable to the one-time placement of sand dredged from the outbound 55-foot-deep navigation channels.

14. The damages for the with project condition consist of four principal alternative berm width considerations of 50, 75, 100, and 150 feet, respectively. The following table shows the estimated stillwater level zero-damage points with the 50-foot, 75-foot, 100-foot, and 150-foot berm widths in place.

Table B-3. STILLWATER LEVEL ZERO-DAMAGE ELEVATIONS

Berm width (ft.)	Zero damage points, residential (ft. NGVD)
50	5.0
75	5.4
100	5.7
150	6.0

15. Tables B-4, B-5, B-6, and B-7 show average annual with project damages for berm widths of 50, 75, 100, and 150 feet, respectively.

Table B-4. AVERAGE ANNUAL FLOOD DAMAGES
50-FOOT BERM CONFIGURATION ($1,000)

Frequency (years)	Stage (feet)	Damage at stage ($)	Avg. annual value ($)
0	12.0	14,825	529
500.0	11.0	12,536	502
256.4	10.0	10,062	480
125.0	9.0	7,403	445
54.1	8.0	4,654	384
20.4	7.0	2,459	280
6.7	6.0	915	128
2.0	5.0	0	0
1.05	4.5	0	0
1.0	3.0	0	0

Table B-5. AVERAGE ANNUAL FLOOD DAMAGES
75-FOOT BERM CONFIGURATION ($1,000)

Frequency (years)	Stage (feet)	Damage at stage ($)	Avg. annual value ($)
0	12.0	14,825	443
500.0	11.0	12,536	416
256.4	10.0	10,062	394
125.0	9.0	7,403	359
54.1	8.0	4,654	299
20.4	7.0	2,459	194
6.7	6.0	715	53
2.0	5.0	0	0
1.05	4.5	0	0
1.0	3.0	0	0

Table B-6. AVERAGE ANNUAL FLOOD DAMAGES
100-FOOT BERM CONFIGURATION ($1,000)

Frequency (years)	Stage (feet)	Damage at stage ($)	Avg. annual value ($)
0	12.0	14,825	411
500.0	11.0	12,536	383
256.4	10.0	10,062	361
125.0	9.0	7,403	326
54.1	8.0	4,654	265
20.4	7.0	2,459	161
6.7	6.0	625	23
2.0	5.0	0	0
1.05	4.5	0	0
1.0	3.0	0	0

Table B-7. AVERAGE ANNUAL FLOOD DAMAGES
150-FOOT BERM CONFIGURATION ($1,000)

Frequency (years)	Stage (feet)	Damage at stage ($)	Avg. annual value ($)
0	12.0	14,825	358
500.0	11.0	12,536	331
256.4	10.0	10,062	309
125.0	9.0	7,403	274
54.1	8.0	4,654	213
20.4	7.0	2,459	109
6.7	6.0	0	0
2.0	5.0	0	0
1.05	4.5	0	0
1.0	3.0	0	0

16. Flood damage reduction benefits based on conditions that exist in the project area are derived from the previous tables. Damages eliminated correspond directly to the average annual value at the specified frequency and stages considered for protection. The difference between the damages for the with and without project conditions is defined as the benefit to the plan under consideration. These benefits are estimated to be $163,000, $249,000, $281,000, and $334,000 for the 50-foot, 75-foot, 100-foot, and 150-foot berm widths, respectively.

17. For comparative purposes, the average annual flood damages prevented are based on the berm width not being maintained and allowed to erode back to a level equal to the without project condition. Thus, the average annual equivalent benefits will vary depending on how long after the initial placement the beach reaches the without condition. The berm projects will have longer physical lives depending upon the width of the berm, the sand source from either the Thimble Shoal or the Atlantic Ocean Channels, and the anticipated erosion rate. Based on historical data, for example, the 100-foot berm with sand from Thimble Shoal Channel is estimated to extend the life of the beach about 1.8 to 3.7 years depending upon the estimated erosion rate. Whereas, if sand from the Atlantic Ocean Channel is used, the expected extended life of the

beach is estimated at 2.0 to 4.1 years. The following table shows estimates, based on normal and accelerated erosion rates, of the probable life of the 50-, 75-, 100-, and 150-foot berm projects with the placement of sand from Thimble Shoal and Atlantic Ocean Channels.

Table B-8. EXPECTED LIFE OF PROPOSED BERM PROJECTS WITH PLACEMENT OF SAND FROM THIMBLE SHOAL AND ATLANTIC OCEAN CHANNELS

Berm project (width)	Range of estimated life of placement	Most likely life of placement
Thimble Shoal Channel Sand		
50-foot	0.7 to 1.4	0.9
75-foot	1.2 to 2.3	1.5
100-foot	1.8 to 3.7	2.4
150-foot	3.3 to 6.6	3.3
Atlantic Ocean Channel Sand		
50-foot	0.8 to 1.6	1.0
75-foot	1.3 to 2.6	1.7
100-foot	2.0 to 4.1	2.7
150-foot	3.7 to 7.4	3.7

18. Based on the above table, the 50-foot berm would provide beneficial effects about 0.7 to 1.6 years; the 75-foot berm, 1.2 to 2.6 years; the 100-foot berm, 1.8 to 4.1 years; and the 150-foot berm, 3.3 to 7.4 years. The upper end of the ranges shown in the above table are theoretically possible but are considered very unlikely. ok Table B-9 shows the average annual equivalent benefits based on the ranges of estimated lives of the berm projects shown in the previous table and the most likely estimate of life of placement. The diff between damages for both the with and without condition over the expected life of each berm and were capitalized using an annual [illegible] to

Table B-9. AVERAGE ANNUAL EQUIVALENT BENEFITS

Project	Project life (yrs)	Amount ($)
Thimble Shoal Channel		
50-Foot Berm	0.7	81,000
	0.9	87,000
	1.1	85,000
	1.4	87,000
75-Foot Berm	1.2	128,000
	1.5	132,000
	1.8	135,000
	2.3	135,000
100-Foot Berm	1.8	153,000
	2.4	152,000
	2.9	153,000
	3.7	152,000
150-Foot Berm	3.3	183,000
	4.4	184,000
	5.3	187,000
	6.6	188,000
Atlantic Ocean Channel		
50-Foot Berm	0.8	89,000
	1.0	86,000
	1.2	84,000
	1.6	86,000
75-Foot Berm	1.3	135,000
	1.7	130,000
	2.1	132,000
	2.6	133,000
100-Foot Berm	2.0	150,000
	2.7	150,000
	3.3	154,000
	4.1	154,000
150-Foot Berm	3.7	180,000
	4.9	185,000
	5.9	187,000
	7.4	191,000

LAND AND STRUCTURES LOST TO EROSION

19. In addition to storm damage to structures along the beach, a significant number of beach front properties are subject to erosion under the without project condition. Historically, erosion along the 24,300 feet of beach in the study area has averaged about 6.0 feet per year. Of the 247 oceanfront properties, 120 have been fortified by bulkheads. The one-time placement of sand on the beach would not prevent future losses to the 127 non-bulkheaded properties, but would delay losses by pushing them further into the future. Each proposed berm configuration would protect existing land and structure values for the period that the berm is in place. Accordingly, the annual loss under existing conditions would be delayed from 0.7 to 7.4 years depending upon the berm width, the sand source, and the rate of erosion. The present value of the losses to non-bulkheaded properties, both with and without sand placement, was computed for various berm configurations. The difference in these values represents the benefits to the various berm configurations under consideration. Values were annualized by capitalizing at an 8-7/8 percent discount rate over the appropriate life of the sand placement. When evaluated on a total present value basis, the accumulated present value increases as the berm width increases. Table B-10 details a sample of the present value analysis for a berm width of 100 feet with an estimated life of 2.7 years.

Table B-10. PRESENT VALUE OF DAMAGES ATTRIBUTABLE TO LOSS OF LAND AND STRUCTURE VALUE WITH AND WITHOUT 100-FOOT BERM OVER THE LIFE OF THE BERM, ATLANTIC OCEAN CHANNEL SAND, 2.7-YEAR LIFE

		Without berm project		With berm project	
Year	Present value factor	Annul value of of existing loss ($)	Present value ($)	Annual value of of existing loss ($)	Present value ($)
1	0.918	1,060,000	973,000		
2	0.844	589,200	497,000		
2.7	0.795	1,009,610	803,000		
3.7	0.730			1,060,000	774,000
4.7	0.671			589,200	395,000
5.4	0.632			1,009,610	638,000
Total Loss			2,273,000		1,807,000

983,000

20. An average annual equivalent benefit was then determined based on the difference between the accumulated present value of loss under the with and without project conditions. For example, the difference in the accumulated present value of losses as shown in table B-10 is $466,000. When annualized based on a berm life of 2.7 years the equivalent annual loss prevented is $202,000. The following table shows the average annual equivalent benefits attributable to delaying land and structure losses from the one-time placement of sand on the beach at Sandbridge.

Table B-11. AVERAGE ANNUAL EQUIVALENT LAND AND STRUCTURE BENEFITS

Project	Project life (yrs)	Amount ($)
Thimble Shoal Channel		
50-Foot Berm	0.7	89,000
	0.9	87,000
	1.1	91,000
	1.4	105,000
75-Foot Berm	1.2	96,000
	1.5	109,000
	1.8	122,000
	2.3	162,000
100-Foot Berm	1.8	122,000
	2.4	172,000
	2.9	221,000
	3.7	329,000
150-Foot Berm	3.3	274,000
	4.4	452,000
	5.3	654,000
	6.6	975,000
Atlantic Ocean Channel		
50-Foot Berm	0.8	88,000
	1.0	86,000
	1.2	96,000
	1.6	114,000
75-Foot Berm	1.3	100,000
	1.7	118,000
	2.1	141,000
	2.6	192,000
100-Foot Berm	2.0	131,000
	2.7	202,000
	3.3	274,000
	4.1	389,000
150-Foot Berm	3.7	329,000
	4.9	550,000
	5.9	797,000
	7.4	1,177,000

REDUCTION OF STORM DAMAGES TO BULKHEADS AND STORM SAND LOSSES

bulkhead #13

21. During recent years, 120 of the 247 oceanfront lots have been fortified with bulkheads in an attempt to control the existing erosion problem. However the severely eroded condition of the beach berm leaves these protective structures vulnerable to storm damage. The sand located behind the line of protection is also threatened during coastal storm events. The tangible benefit from these two items is the equivalent average annual damages prevented and represents the difference between average annual damages without beach nourishment and residual damages remaining after beach nourishment. The without project condition assumes no sand nourishment over the period of analysis.

DAMAGE SURVEYS

22. Investigations were made during the course of this study to determine the relationship between the tidal flood stage in the project area and the resulting damages to the bulkheads and the quantity of material removed from behind the line of protection. In this effort, results from the 1985 Phase I GDM and the 1989 Supplemental Preauthorization Study were checked for applicability and incorporated into this analysis where appropriate.

23. Expected storm damages to bulkheads and associated storm sand loss is based on recent experiences with the effects of minor coastal storm events. During the recent March 1989 northeaster (s.w.l. of approximately 4.0 ft., NGVD), there was approximately 1,000 feet of bulkhead which was extensively damaged. Also during this event, storm sand losses as estimated in news articles exceeded $2 million. For the larger range of coastal storm events, estimated storm damages were developed for a recurrence of the tide levels reached in March 1962, August 1933, and in a storm with a tide level of elevation 12 ft., NGVD. These damages were based on historical records, experience with similar reaches of shoreline and analytical methods. The analytical method for determining storm-related sand losses was the method described by T. Edelmann in his work entitled "Dune Erosion During Storm Conditions" (11th conference on Coastal Engineering, London, England, September 1968).

EXISTING STAGE-DAMAGE DATA

24. Based on the procedures previously outlined, the without project storm damages to bulkheads and storm-related sand losses was summarized. These data are shown in table B-12.

Table B-12. STAGE-DAMAGE DATA - STORM DAMAGE TO BULKHEADS AND STORM RELATED SAND LOSSES FOR SANDBRIDGE BEACH ($1,000s)

Stage ft., NGVD	Bulkheads	Sand Losses	Total
12.00	5,000	9,479	14,479
11.50	5,000	9,364	14,364
11.00	5,000	9,180	14,180
10.73	5,000	9,058	14,058
10.00	5,000	8,692	13,692
9.50	5,000	8,326	13,326
9.00	5,000	7,899	12,899
8.70	5,000	7,594	12,594
8.60	5,000	7,479	12,479
8.50	5,000	7,381	12,381
8.00	5,000	6,771	11,771
7.50	5,000	5,978	10,978
7.00	5,000	4,941	9,941
6.70	5,000	4,215	9,215
6.50	5,000	3,904	8,904
6.00	5,000	3,020	8,020
5.00	2,475	1,708	4,183
4.50	1,550	1,220	2,770
3.00	0	0	0

AVERAGE ANNUAL DAMAGES

25. As previously discussed in the section on "Flood Damages," it is necessary to relate the stage damages to the stage-frequency relationship. This procedure will convert the stage-damage data in the previous table to average annual values. This is accomplished in the following table which shows the frequency data, the corresponding stages, the damage at each stage, and the annualized damage values for Sandbridge under without project conditions.

Table B-13. AVERAGE ANNUAL FLOOD DAMAGES (WITHOUT CONDITION) ($1,000)

Frequency (years)	Stage (feet)	Damage at stage ($)	Avg. annual value ($)
0	12.0	14,479	4,979
6.7	6.0	8,020	3,549
2.2	5.0	4,183	1,778
1.0	4.5	2,770	0
1.0	3.0	0	0

BENEFITS ATTRIBUTABLE TO THE REDUCTION OF STORM DAMAGES TO BULKHEADS AND STORM SAND LOSSES

26. The data presented previously relate to without project damages in the study area. The following section will quantify the average annual benefits attributable to the one-time placement of sand dredged from the outbound 55-foot-deep navigation channels.

27. The damages for the with project condition consist of four principal alternative berm width considerations of 50, 75, 100, and 150 feet, respectively. The following table shows the estimated stillwater level zero-damage points with the 50-foot, 75-foot, 100-foot, and 150-foot berm widths in place.

Table B-14. STILLWATER LEVEL ZERO-DAMAGE ELEVATIONS FOR SAND LOSSES AND BULKHEADS

Berm width (ft.)	Zero damage points, residential (ft. NGVD)
50	4.7
75	5.0
100	5.4
150	5.7

28. Tables B-15, B-16, B-17, and B-18 show average annual with project damages for berm widths of 50, 75, 100, and 150 feet, respectively.

Table B-15. AVERAGE ANNUAL DAMAGES 50-FOOT BERM CONFIGURATION ($1,000)

Frequency (years)	Stage (feet)	Damage at stage ($)	Avg. annual value ($)
0	12.0	10,179	1,076
6.7	6.0	1,596	306
2.2	5.0	299	28
1.0	4.5	0	0
1.0	3.0	0	0

Table B-16. AVERAGE ANNUAL DAMAGES
75-FOOT BERM CONFIGURATION ($1,000)

Frequency (years)	Stage (feet)	Damage at stage ($)	Avg. annual value ($)
0	12.0	9,740	920
6.7	6.0	1744	176
2.2	5.0	0	0
1.0	4.5	0	0
1.0	3.0	0	0

Table B-17. AVERAGE ANNUAL DAMAGES
100-FOOT BERM CONFIGURATION ($1,000)

Frequency (years)	Stage (feet)	Damage at stage ($)	Avg. annual value ($)
0	12.0	9,264	786
6.7	6.0	1,302	91
2.2	5.0	0	0
1.0	4.5	0	0
1.0	3.0	0	0

Table B-18. AVERAGE ANNUAL DAMAGES
150-FOOT BERM CONFIGURATION ($1,000)

Frequency (years)	Stage (feet)	Damage at stage ($)	Avg. annual value ($)
0	12.0	8,794	660
6.7	6.0	711	24
2.2	5.0	0	0
1.0	4.5	0	0
1.0	3.0	0	0

29. Flood damage reduction benefits based on conditions that exist in the project area are derived from the previous tables. Damages eliminated correspond directly to the average annual value at the specified frequency and stages considered for protection. The difference between the damages for the with and without project conditions is defined as the benefit to the plan under consideration. These benefits are estimated to be $3,903,000, $4,059,000, $4,193,000, and $4,319,000 for the 50-foot, 75-foot, 100-foot, and 150-foot berm widths, respectively.

30. Utilizing the same procedures and data that are discussed in paragraphs 17 and 18 and table B-8 , the average annual storm reduction benefits were reduced to an average annual equivalent benefit based on expected berm life. Table B-19 shows the average annual equivalent benefits based on the ranges of estimated lives of the berm projects shown in table B-8 and the most likely estimate of life of placement.

Table B-19. AVERAGE ANNUAL EQUIVALENT BENEFITS

Project	Project life (yrs)	Amount ($)
Thimble Shoal Channel		
50-Foot Berm	0.7	1,955,000
	0.9	2,092,000
	1.1	2,031,000
	1.4	2,092,000
75-Foot Berm	1.2	2,088,000
	1.5	2,154,000
	1.8	2,200,000
	2.3	2,206,000
100-Foot Berm	1.8	2,273,000
	2.4	2,266,000
	2.9	2,277,000
	3.7	2,269,000
150-Foot Berm	3.3	2,367,000
	4.4	2,385,000
	5.3	2,416,000
	6.6	2,436,000
Atlantic Ocean Channel		
50-Foot Berm	0.8	2,136,000
	1.0	2,058,000
	1.2	2,008,000
	1.6	2,054,000
75-Foot Berm	1.3	2,202,000
	1.7	2,120,000
	2.1	2,154,000
	2.6	2,171,000
100-Foot Berm	2.0	2,239,000
	2.7	2,234,000
	3.3	2,298,000
	4.1	2,291,000
150-Foot Berm	3.7	2,337,000
	4.9	2,399,000
	5.9	2,426,000
	7.4	2,468,000

BENEFICIAL EFFECTS ON DOWNDRIFT AREAS

31. Sandbridge Beach serves as a feeder beach to downdrift areas. Available evidence indicates that an average of approximately 300,000 cubic yards of sand are eroded from Sandbridge beaches annually. Of this amount, a range of 104,000 to 215,000 cubic yards of material is transported along the shore to the sand bypass operation at Rudee Inlet. This material is used as beach nourishment for the resort beach between Rudee Inlet and 49th Street. The introduction of additional material as a result of a beach nourishment project at Sandbridge can be expected to push the shoreline out of equilibrium due to profile disturbance resulting from placement of the project fill. A seaward bulge with respect to adjacent beaches will be created. The further a fill extends offshore, the more sediment loss can be expected. As a result, sediment transported parallel to the shore will be increased in comparison to pre-fill transport rates. An estimate of equivalent annual erosion losses was made based on a with project erosion rate 1.5 times the existing erosion rate. This would indicate that a range of 156,000 to 323,000 cubic yards of material could be made available for bypassing to the resort beach. A measure of the amount of increased material available to the resort beach is therefore a range of between 52,000 and 108,000 cubic yards of sand per year subject to the life of the potential with project berms at Sandbridge.

32. Sand bypass records were obtained from the Virginia Beach Erosion Council to determine the long-term historical average material transported to the resort beach as a result of the bypass operation. The results indicated that over the most recent 10-year period of record (fiscal years 1978-1987), an average of 184,000 cubic yards of material was bypassed from Rudee Inlet to the resort beach. The highest recorded bypass of material to the resort beach occurred in fiscal year 1986 when 246,000 cubic yards of material were by-passed. An estimate of capacities of existing plant to move material to the resort beach was developed based on a range containing two scenarios. The first scenario is that the fiscal year 1986 bypass effort is a minimum measure of capacity. The second scenario is based on estimates of the dredge Rudee Inlet II operating in a more efficient manner than the previous dredge-eductor system which was discontinued in 1987. The estimated minimum capacity of the dredge Rudee Inlet II is 300,000 cubic yards of material annually. Given the

increase in production rates based on historical development and use of this type of dredge, it is estimated that the minimum bypass capacity of the existing plant is 300,000 cubic yards annually. Given the potential for capacity constraints, the material available for downdrift benefits would be reduced to a range of between 52,000 and 85,000 cubic yards of material per year subject to the life of the potential with project berms at Sandbridge.

33. Recent records of the Virginia Beach Erosion Council were researched to determine unit costs for truck haul to the resort beach as this is the most likely alternative source of sand. These records indicate that the truck haul rate would be approximately $6.10 per cubic yard. An estimate of the cost per cubic yard to bypass an additional 52,000 to 85,000 cubic yards of material per year is $2.10. This was determined based on audited Virginia Beach Erosion Council records used in the determination of the Corps of Engineers participation in the long-term beach nourishment program for the resort beach. Based on the parameters discussed above, the downdrift benefit would be $4.00 per cubic yard of sand bypassed. The average annual equivalent savings to the downdrift resort beach from this operation would range from $208,000 to $340,000. Given the uncertainties as to the timing of the receipt of sand to downdrift areas, the actual capacity of the dredge bypass operations, and the need for sand at the resort beach, it is believed that an equivalent annual benefit of $208,000 is appropriate for each of the berms under consideration.

SUMMARY

34. The following table shows the average annual equivalent benefits applicable to beach berm widths of 50, 75, 100, and 150 feet with the placement of sand from the Thimble Shoal and Atlantic Ocean Channels under normal and accelerated erosion conditions.

Table B-20. SUMMARY OF BENEFITS

Beach width (ft)	Flood damage reduction ($)	Reduced erosion damages ($)	Reduction in bulkhead and sand losses ($)	Benefit to downdrift areas ($)	Total ($)
		Thimble Shoal Channel			
50	87,000	87,000	2,092,000	208,000	2,474,000
75	132,000	109,000	2,154,000	208,000	2,603,000
100	152,000	172,000	2,266,000	208,000	2,798,000
150	183,000	274,000	2,367,000	208,000	3,032,000
		Atlantic Ocean Channel			
50	86,000	86,000	2,058,000	208,000	2,438,000
75	130,000	118,000	2,120,000	208,000	2,576,000
100	150,000	202,000	2,234,000	208,000	2,794,000
150 (a)	180,000	329,000	2,337,000	208,000	3,054,000

(a) Based on an erosion rate 2.0 times the existing rate.

APPENDIX C

HYDROLOGY AND HYDRAULICS

APPENDIX C

HYDROLOGY AND HYDRAULICS

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APPENDIX C

HYDROLOGY AND HYDRAULICS

INTRODUCTION

1. This section provides information on the hydrology, hydraulic, and coastal engineering-related aspects of the study area under both existing and anticipated project conditions. More specifically, it includes discussions on natural forces, design criteria and assumptions, and the effects which may be expected for certain project features.

STUDY AREA

2. The study area, Sandbridge Beach, is located in the city of Virginia Beach, Virginia, as shown on plate C-1, and has a reach length of 4.6 miles. The study area currently is dependent on protection provided by the remnants of a natural dune line. Also, a number of the oceanfront property owners have constructed bulkheads which provide some limited protection for lower level storm events.

NATURAL FORCES

3. Knowledge of such physical phenomena as winds, waves, tides, storms, and their magnitudes is necessary in order to identify the many variable forces affecting the coastal waters and the adjacent beach. Establishment of these forces is necessary to analyze their effects on developments along the shoreline under existing conditions and also to consider the design and effects of possible protective measures.

CLIMATE

4. Virginia Beach is temperate with moderate, seasonal changes. Winters are generally mild, and summers, though long and warm, are frequently tempered by cool periods resulting from winds off the Atlantic Ocean. Occasionally,

during brief periods, the climatic conditions vary extremely from normal due to storms of both extra-tropical and tropical origin. The average annual precipitation is about 45 inches. It is fairly evenly distributed throughout the year, with average monthly amounts ranging from 5.74 inches in July to 2.62 inches in November. Measurable amounts occur on an average of about 1 day out of 3. Two general types of major storms affect the Sandbridge Beach area in the form of northeasters and hurricanes.

5. The term "hurricane" is applied to an intense cyclonic storm originating in the tropical and subtropical latitudes in the Atlantic Ocean north of the equator. These storms normally gain intensity as they move over water in the southern latitudes, and decay or decrease in intensity as they pass over land or move into the northern latitudes where conditions are such that the energy of the storm cannot be maintained. A hurricane is characterized by low barometric pressure, high winds (over 74 m.p.h.), heavy rainfall, large waves, and tidal surges. The most severe hurricane affecting the Sandbridge Beach area was that of August 1933. Pertinent information concerning this storm is shown on plate C-2.

6. "Northeaster" is the term given to a particular type of storm which seemingly occurs periodically throughout the fall, winter, and spring months along the Atlantic Coast. The Virginia Beach area, for some peculiar reason, appears to be the focal point or spawning ground for a disproportionately large number of these storms. A northeaster is characterized by high winds circulating around an essentially stationary low pressure area and producing high tides, large waves, and heavy rainfall along the coast. Like all cyclonic wind systems in the northern hemisphere, the wind direction is always rotating inward and counter-clockwise about the low pressure area. Winds, more often than not, are from the northeast quadrant relative to Virginia Beach, hence the term "northeaster." Northeasters sometimes develop into complex storms having more than one influencing pressure cell. The location of high pressure centers and low pressure centers with respect to each other may greatly intensify the wind speeds that would be expected from a single storm cell. Strong winds reaching almost hurricane strength may occur over many thousands of square miles. Northeasters may form with little or no advance warning and persist for as long as a week to 10 days. The average duration of a northeaster, however, is only

about 2 or 3 days. Noteworthy northeasters of recent years occurred in April 1956, March 1962, and April 1978. The most severe of these was the March 1962 storm, which caused serious tidal flooding and widespread damage along the Middle Atlantic Coast. Pertinent information about the March 1962 storm is shown on plate C-2.

WAVE CLIMATE

Winds

7. A study of recorded and possible wind velocities, duration, and direction is necessary to determine their effect on the characteristics of waves likely to be experienced in the study area. Wind-generated waves are the primary cause of loss of material from the beaches.

8. A compilation of wind velocities, durations, and directions was made from the records of the United States Weather Bureau Station at Cape Henry, Virginia, located 15 miles north of the study area. Wind data for the 16-year period, 1930 to 1945, inclusive, are shown on plate C-3. Destructive wave attack and elevated water levels are caused by winds which have components ranging from a north-northeast clockwise to a south-southeast direction. Analysis of the data on plate C-3 indicates that the prevailing local winds were from the southern quadrants, but that the velocities and total wind movement were greater from the northern quadrants. These data, along with the information available from the March 1962 storm, cover the most severe periods which have been experienced to date and are considered adequate for this study. Plate C-2 shows the direction and velocities of winds experienced at Norfolk, Virginia, during the hurricane of August 1933 and during the northeaster of March 1962.

Waves

9. Although there are other sources which will be mentioned, the pertinent published information which was of real value to this study included the following:

a. The Coastal Engineering Research Center's (CERC) T.R. 77-1 entitled "Wave Climate at Selected Locations Along U.S. Coasts" by Edward F. Thompson.

b. Atlantic Coast Hindcast, Shallow-Water, Significant Wave Information (WIS Phase III).

10. The configuration of the Atlantic coastline of Virginia Beach is such that only waves approaching it from the north-northeast through east to southeast can act upon the beach. It is interesting to note that deepwater waves greater than 60 feet in height have been reported by shipping traffic off the coast of Virginia Beach. As the storm waves approach the shoreline, however, their characteristics are altered by the friction of the bottom, the change in water depth, and local meteorological conditions such as wind or rain.

11. By using the "wave spectrum" method, wave characteristics were determined for a station just east of the mouth of Chesapeake Bay at 37°00' north latitude and 75°30' west longitude. These were based on weather maps from the U.S. Weather Bureau and the U.S. Coast Guard covering the 3-year period 1947-1949, using observed rather than computed winds. Details of the analysis are published in Beach Erosion Board's (BEB) T.M.-57. Wave roses indicating the average deepwater wave conditions to be expected during the winter, spring, summer, and fall are shown on plate C-4. Wave characteristics were also determined by the Bretschneider--revised Sverdrup-Monk Method for the same station using synoptic weather charts for the 3-year period, 1948-1950. These are published in BEB's T.M.-55 and show the characteristics for the significant wave. Duration of the deepwater significant waves is shown for the entire year and is reasonably consistent with data shown on plate C-4.

Surf

12. In planning shore protection projects and the ways and means by which shore erosion may be controlled, surf conditions are an important consideration. They consist of the characteristics of waves and currents in the vicinity of the normal low water line. From October 1954 through December 1957, a Virginia Beach Lifeboat Station located approximately 10 miles north of Sandbridge made daily observations of surf conditions during every 4-hour watch, unless there was poor visibility. The information obtained consisted of: the time in seconds for 10 complete breakers, a visual estimate of the significant height of the surf, the angle at which the wave broke on shore, and the direction of wave

approach 1/2 to 1 mile offshore. Observations included surf conditions experienced during hurricanes "Connie" and "Diane" of August 1955. All of the information obtained was included in BEB's T.M.-108. Plate C-5 indicates the wave heights and periods experienced in August 1955 and the cumulative frequency of surf from all directions at Virginia Beach, Virginia.

13. The swell diagram shown on plate C-6 was compiled from records of the United States Hydrographic Office. The swells are classified according to the height of the waves and are indicated on the diagram by the width of the lines weighted in proportion to the swell heights squared. The data from which the swell diagram was developed was obtained from ships operating within the 5° area immediately offshore of Virginia Beach. The data include swells moving away from the shore. These swells obviously can have no effect on the shore of the problem area. Waves and swells approaching the Virginia Beach shoreline from a due east direction make an angle of approximately 12° with the shoreline and tend to create a slight northward littoral transport. A study of the swell diagram indicates that the greatest percentage of low swells are from directions which would tend to produce northward transport; however, a predominance of medium and heavy swells are from directions which would tend to cause southward movement of littoral drift.

TIDES

14. Tides in the Atlantic Ocean at Virginia Beach are uniformly semidiurnal with the principal variations following the changes in the moon's distance and phase. The mean range of tide is 3.4 feet and the spring range is 4.1 feet. Variations in water surface elevations of more than 9 feet have resulted from storms.

SHORELINE AND VOLUMETRIC CHANGES

15. Generally, beach compartments on either side of a divergent nodal point experience erosion because they are the source areas for littoral drift. Conversely, convergent nodal areas usually acrete. Sandbridge lies immediately north of a divergent nodal point in the littoral transport system. Immediately south of this nodal area, net littoral transport is to the south. To the north of this nodal area, from Sandbridge to Cape Henry, the net littoral transport is to the north.

16. Historically, the Sandbridge area has experienced erosion. In evaluating shoreline (mean high water line) position maps from 1859 to 1980, the average shoreline retreat at Sandbridge over that period has been approximately 4 feet per year. During the BERH staff review of the March 1985 Phase I GDM for Sandbridge, a shoreline profile analysis for the period 1937 to 1984 was performed which determined an average annual erosion rate of between 5 and 6 feet per year. Guidance from the BERH report indicates that, for planning purposes, an annual erosion rate for the without project condition should be approaching 6 feet per year and has been selected for this analysis.

STORMS

17. Numerous northeasters occur each year, many of which cause moderately high tides and flooding. Hurricanes producing high tides are much less frequent but have been responsible for creating the two highest tides of record and six of the eight highest tides. The number of tropical storms of consequence recorded each year has been highly variable, ranging from a minimum of only 1 to a maximum of 21 storms. A study of the tracks of all tropical storms of record indicates that once a year on an average, a tropical storm of hurricane force passes within 250 miles of Virginia Beach, thus posing a threat to the study area of Sandbridge Beach. A summary of the paths of tropical storms is shown on plate C-7. Plate C-8 shows the number of occurrences and the azimuth distribution of paths followed by hurricanes which posed a threat to the Virginia Beach area between 1886 and 1966. While hurricanes may affect the Virginia Beach area from May through November, nearly 80 percent occur in the months of August, September, and October, and about 40 percent occur in September.

HURRICANE TIDES AND HIGH WATER MARKS

18. Ocean tide data has been recorded at Virginia Beach at irregular intervals from October 1959 to March 1971. Unfortunately, the maximum heights were not recorded for the three largest tide-producing storms during this period of

record because the gage malfunctioned. The problem stemmed from failure to find a suitable location to install the gage. In the past, quite frequently during severe storms, waves damaged or carried away parts of the pier to which the gage was attached. The maximum known tidal stillwater level occurred in August 1933. In contrast to the broken period of recorded gage data, high water marks (HWM), presumably the results of wave overlapping and ponding landward of streets and dunes, were 8 feet higher during the August 1933 storm and 3 to 9 feet higher during the March 1962 storm which endured for a much longer period. These HWMs are indicative of damage potential which may be caused by wave runup and overtopping. Virginia Beach gaged data which are available are shown in table C-1.

Table C-1. HIGHEST RECORDED GAGE READINGS
AT VIRGINIA BEACH (a)

Year	Gage readings in feet											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1959											8.4	8.6
1960	8.8	8.5	8.5	7.9	8.3	9.3	8.0	8.3	9.5			
1961					8.2	7.7	8.1	7.6	9.1	9.9	8.2	8.3
1962	7.6	8.1										
1963							8.0	7.5	9.1	8.5	8.7	8.0
1964	8.3	8.1	7.9	8.2	8.2	8.2	8.2	7.9	9.4	8.3	8.6	8.1
1965	9.7	8.4	7.8								8.4	
1966		8.0	7.9	8.0	8.2	7.9	8.4	7.8			8.7	8.2
1967	8.1			8.8	9.6	8.9	7.7	8.6	9.5	8.8	9.1	9.1
1968	8.8	8.2	7.9	8.7	9.2	8.7	8.1	8.2	8.0	8.7	9.2	8.3
1969	8.9	8.8	9.5	8.4	8.3	8.1	8.4	8.5	8.7	9.2		8.2
1970	9.1	8.1	8.5	8.3	8.2	7.8	7.7	8.4	7.8	9.5	9.1	8.9

(a) Latitude 36°51'; longitude 75°58' (broken record). Subtract 5.17 feet to refer heights to National Geodetic Vertical Datum (NGVD).

19. The following is a discussion of the development of a tidal frequency relationship determined for the 1984 Virginia Beach, Virginia, Beach Erosion Control and Hurricane Protection, Phase I GDM. Due to the close proximity of Sandbridge Beach to the Virginia Beach study area and the fact that both study areas are located on the open coast of the Atlantic Ocean, this tide-frequency

relationship is considered appropriate for the Sandbridge Beach area and was utilized in this study.

20. Tide records at Virginia Beach alone are considered inadequate to establish a reliable tide-frequency relationship. A tide-frequency relationship was obtained by correlation of available tide records and high water marks at Virginia Beach with the tide-frequency curve developed for the Norfolk Harbor gage located about 10 miles inside Chesapeake Bay. There are historical accounts of tidal flooding for nearly 300 years, but a reasonably accurate indication of the heights reached in Norfolk Harbor is available only since 1908 and a complete record since 1928.

21. There has been a gradual rise in sea level over the investigated period of record at Norfolk Harbor. Variation by epoch and allowances which must be made for all gage readings follows.

Table C-2. SEA LEVEL VARIATION AT NORFOLK HARBOR (a)

Epoch, years	NGVD, feet	Change, feet
1924-1942	4.87	-
1941-1959	5.15	+0.28
1960-1978	5.39	+0.24

(a) These changes are considered applicable to the lower Chesapeake Bay and the open coast area of Virginia Beach. For gage readings prior to 1942, add 0.52 foot. After 1941, reduce the 0.52 foot at the rate of 0.0137 ft./yr.

22. Since the Virginia Beach gage was only in operation from 1959 through 1971 (a portion of which was a broken record), there is a scarcity of recorded high water information. However, this lack of data has been supplemented by estimates determined from high water marks in the project area. Estimates at the time of the storm for August 1933, October 1957, September 1960, and March 1962 are 8.6 feet, 5.9 feet, 4.3 feet, and 6.5-7.0 feet NGVD, respectively.

Table C-3 provides the elevation of some of these extreme events if they were to occur under present conditions.

Table C-3. ESTIMATED CURRENT TIDAL STILLWATER LEVELS AS A RESULT OF A REPEATED HISTORICAL RECORD (a)

Date		Maximum elevations in NGVD (b) Norfolk Harbor	Virginia Beach
23	August 1933	8.05	9.12
18	September 1936	7.55	--
7	March 1962	7.06	6.73-7.23
16	September 1933	6.35	--
11	April 1956	6.34	--
12	September 1960	6.09	4.56
18	September 1928	5.85	--
27	April 1978	5.84	--
27	September 1956	5.74	--
6	October 1957	5.53	6.2
5	October 1948	5.35	--

(a) Additional correlations between Norfolk Harbor and Virginia Beach can be determined from plate C-10.
(b) Allowances for increase in sea level have been incorporated.

TIDAL FREQUENCY

23. The procedure to develop the Virginia Beach frequency curve using the Norfolk Harbor tidal data is defined as follows:

a. A Norfolk Harbor statistical analysis was performed in accordance with the procedures set forth in Hydrology Subcommittee, Guidelines for Determining Flood Flow Frequency Bulletin 17B, Revised September 1981, Editorial Corrections March 1982. The Pearson Type III methodology without the logs was incorporated for the selected period of record from 1928 through 1978. The Pearson Type III distribution without the logs was selected as a result of the following:

(1) The New England Division attempted to fit a number of different distributions to tidal elevation data. They found the Pearson Type III distribution without the logs provided the best fit of the data points.

(2) The Pearson Type III distribution without the logs was found to fit the Norfolk Harbor data fairly well.

(3) It was felt that a statistical analysis would produce a more reliable and reproducible result when compared to a graphical approach.

b. Consideration was given to separating hurricane and non-hurricane events. Although objective statistical approaches are available for incomplete samples (a hurricane-related tide exists for less than 50 percent of the years on record), they do not always provide reasonable results. Therefore, all tropical and extratropical events were included together in the analysis of the annual maximum tides.

c. The analysis of the 51 years of systematic record indicated that the 1933 and 1936 events could be high outliers. However, assuming that the true distribution is defined by the computed (non-adjusted) statistics, the value of 8.05 feet for the 1933 event has an exceedance probability of 0.010. It has been determined that, with 51 years of record, the probability of an event this rare being exceeded is 40 percent. Since this risk is so high and it is known that several events as large if not larger than the 1933 event have historically occurred, the 1933 event (and any smaller events) was not considered to be a high outlier.

d. Historical accounts indicate that tides have occurred in Norfolk Harbor at approximately 8.0 feet in 1667 and 1785 and approximately 7.9 feet in 1846. As noted earlier, there has been a gradual rise in sea level. There was some question as to the amount of adjustment that should be made to the historic events. To avoid overestimating the impact of sea level rise, the historic events were increased by only 0.50 foot (approximately the same adjustment for the 1924 to 1942 period). The analysis, based on a historical period of 312 years, resulted in a slight move to the left of the upper portion of the frequency curve when compared to the systematic record. Since the adjustment was not very large and there is some question as to the reliability of the historical data, the district has accepted the computed statistics based on the 51 years of systematic record.

e. The upper portion of the statistical curve was adjusted to include expected probability.

f. The lower portion of the statistical curve was adjusted with a partial duration analysis using plotting positions in accordance with Weibull. It included all elevations above 4.26 feet NGVD.

g. The following table is a summary of the analysis based on the 51 years of systematic record at the Norfolk Harbor gage. The Norfolk Harbor curve is shown on plate C-9. This curve was then translated to Virginia Beach by a correlation relationship of known tidal elevations. This correlation relationship and the Virginia Beach curve (by CENAO) are shown on plate C-10.

Table C-4. FINAL RESULTS OF FREQUENCY CURVE FOR NORFOLK HARBOR

Tidal elevation (a)			Confidence limits	
Computed	Expected probability	Exceedance probability	0.05 limit	0.95 limit
9.4	9.9	0.002	10.3	8.7
8.6	8.9	0.005	9.4	8.0
8.0	8.2	0.010	8.7	7.5
7.4	7.6	0.020	8.0	7.0
6.8	6.9	0.040	7.3	6.4
6.0	6.0	0.100	6.3	5.7
5.4	5.4	0.200	5.6	5.1
4.5	4.5	0.500	4.7	4.2
4.0	4.0	0.800	4.2	3.7
3.8	3.8	0.900	4.1	3.5
3.7	3.7	0.950	4.0	3.4
3.6	3.6	0.990	3.9	3.3

FREQUENCY CURVE STATISTICS		STATISTICS BASED ON	
MEAN	4.7345	HISTORIC EVENTS	0
STANDARD DEVIATION	0.9521	HIGH OUTLIERS	0
COMPUTED SKEW	1.7014	LOW OUTLIERS	0
GENERALIZED SKEW	-99.0000	ZERO OR MISSING	0
ADOPTED SKEW	1.7014	SYSTEMATIC EVENTS	51

(a) All elevations are annual events in feet, NGVD.

24. Information on tidal frequency studies in the Virginia Beach area by others includes T.M. NWS HYDRO-32 by NOAA. In this analysis, tropical and extratropical events were studied separately. The annual frequencies from each at a given tide level were then summed to obtain the overall annual frequency of that level. The resulting curve is plotted on plate C-10. OCE was concerned about the differences between the frequency analysis which CENAO developed using the Norfolk Harbor data and that presented by NOAA. The adopted frequency curve for Virginia Beach, which is shown on plate C-10, was selected during conversations between OCE, CENAD, and CENAO. It basically

was a compromise of the CENAO and NOAA analyses. Estimated stillwater levels and associated frequencies are presented in the following table.

Table C-5. ADOPTED FREQUENCY OF STILLWATER LEVELS (SWL)

SWL	Exceedance frequency in percent	Remarks
5.13	40	
5.8	20	Plate C-10 shows the entire range of probable frequencies for the adopted curve. The correlation analysis is not considered applicable to the adopted curve.
6.32	10	
7.9	2	
8.75	1	
11.0	0.2	
12.2	0.1	

DESIGN CONSIDERATIONS

25. Proper planning for and evaluation of erosion control and hurricane protection projects requires that attention be devoted to other factors such as shoreline profile changes, wave heights, ensuing runup, and associated characteristics.

26. The procedures used in this study were generally those used for the Virginia Beach, Beach Erosion Control and Hurricane Protection Phase I, GDM published as House Document 99-216, May 8, 1986. Deviations from those procedures came as a result of physical model testing for irregular wave overtopping and pressure measurements conducted in support of the Phase II BEC & HP GDM for Virginia Beach. The major deviation consisted of the use of a smaller value for wave setup in determining the zero points of damage.

SHORELINE PROFILE CHANGES

27. Storm erosion losses both on a with and without project basis were computed utilizing procedures developed by T. Edelmann, "Dune Erosion

During Storm Conditions," 11th Conference on Coastal Engineering, London, England, September 1968. Edelmann assumed that the material eroded from the dune and berm system would be deposited offshore within the limits of the surf zone, i.e., landward of the breaking point of the storm waves. In this procedure, it is assumed that all materials eroded from the dune and foreshore are transported and deposited offshore. Sand deposition is determined by the breaking depth of the wave associated with a particular storm. In the absence of suitable wave data for various storms, Edelmann suggests using a storm height equal to 1.5 times the storm surge level measured from NGVD. Also, the breaking depth of the storm wave, relative to the prestorm profile, was assumed to equal 1.3 times the storm-wave height in accordance with the solitary wave theory.

28. The degree of erosion for both with and without project conditions involved using computations based on Edelmann's procedures as a base condition and then adjusting the eroded profile based on experience gained through engineering investigations of the area and coordination with OCE on similar previous studies.

WAVE HEIGHTS AND RUNUP

29. The determination of wave heights that might be experienced within the project area that would be appropriate for use in runup computations was based on the methodology of the solitary wave theory as contained in the 1984 edition of the Shore Protection Manual (SPM), Volume I, Chapter 2, Section II - 7 contained on pages 2 - 55 through 2 - 59. Wave runup computations were performed on the eroded profile, discussed previously, in accordance with procedures contained in the SPM.

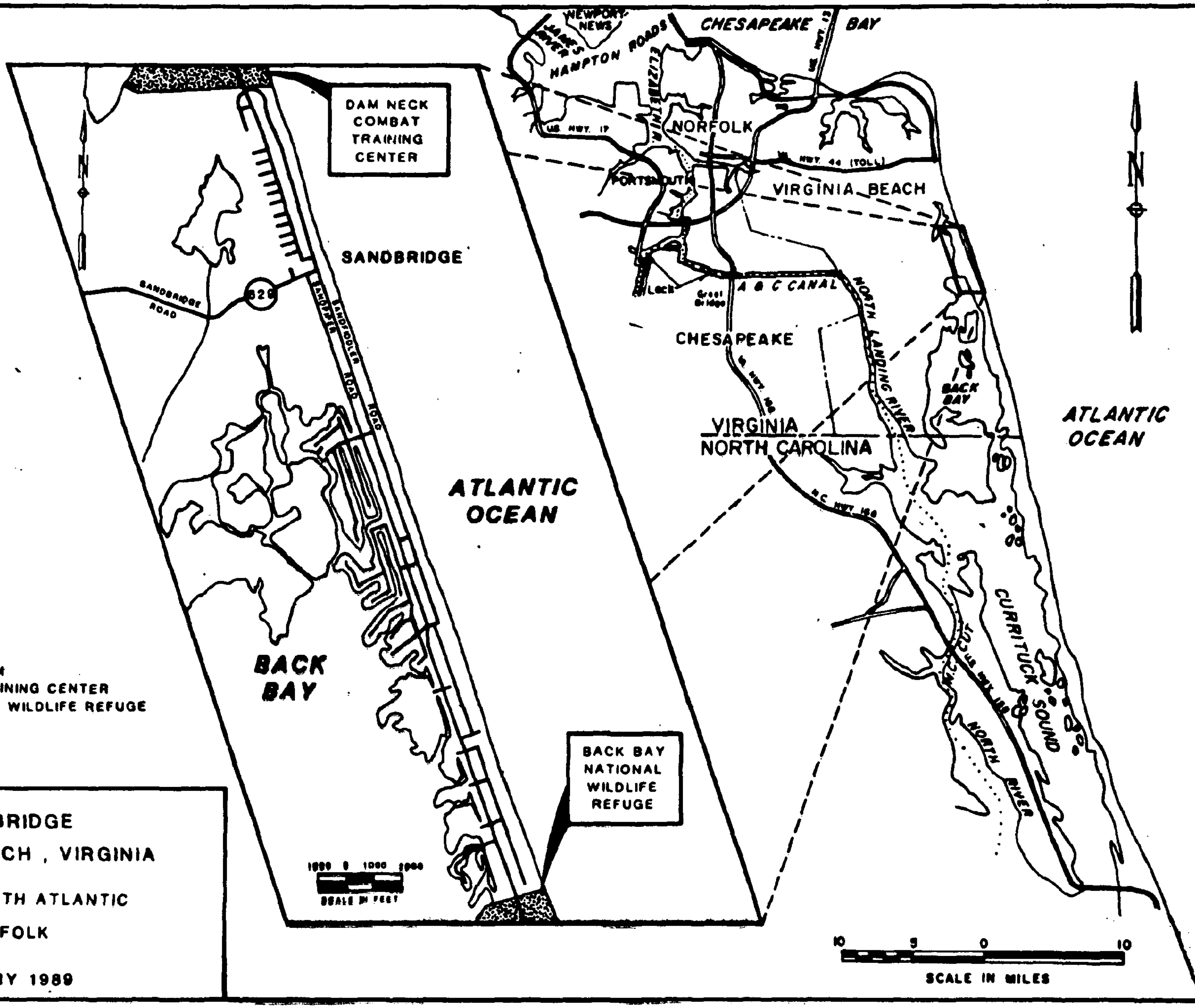
30. The following table provides a summary of stillwater levels at which the berm and structures would be lost or damages would begin to occur (e. g., points of zero damage), for various berm conditions.

Table C-6. SUMMARY OF POINTS OF ZERO DAMAGE
FOR BERM ONLY PLANS

Item	Without condition	Top width of berm, ft 50	75	100	150
Berm Elevation (ft., NGVD)	---	6.0	6.0	6.0	6.0
Zero Damage SWL (ft., NGVD)	3.0	5.0	5.4	5.7	6.0

SEA LEVEL RISE

31. Due to the short life of this one-time placement, no allowance for sea level rise was incorporated into this project other than the incorporation of historic sea level rise into the tide-frequency analysis.



LEGEND

STUDY LIMITS ARE FROM
DAM NECK COMBAT TRAINING CENTER
TO BACK BAY NATIONAL WILDLIFE REFUGE

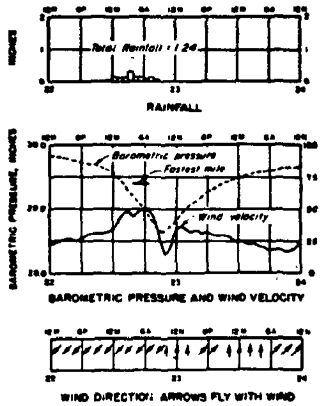
SANDBRIDGE

VIRGINIA BEACH , VIRGINIA

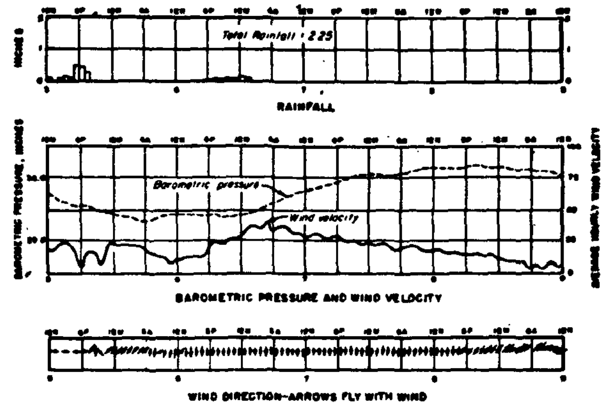
DIVISION: NORTH ATLANTIC

DISTRICT: NORFOLK

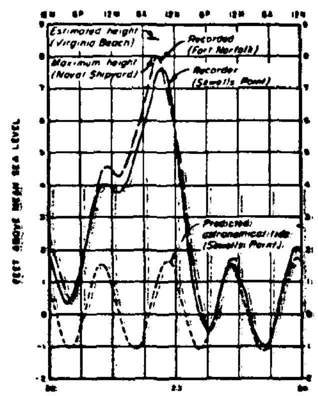
1 JANUARY 1989



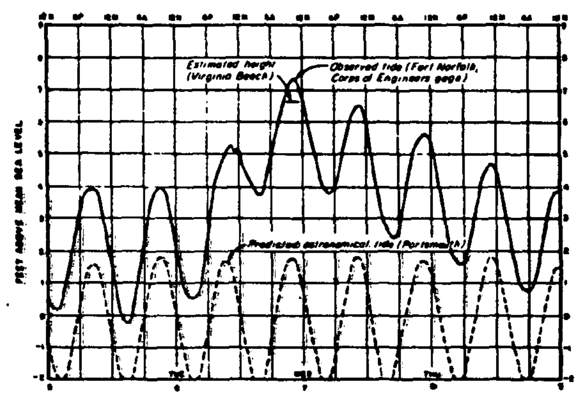
CLIMATOLOGICAL DATA



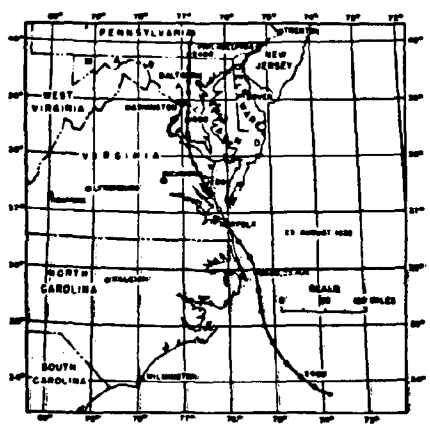
CLIMATOLOGICAL DATA



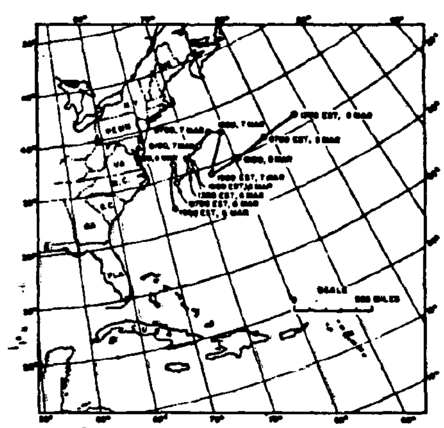
TIDE RECORD



TIDE RECORD



TRACK OF HURRICANE
AUGUST 1933



TRACK OF STORM
MARCH 1962

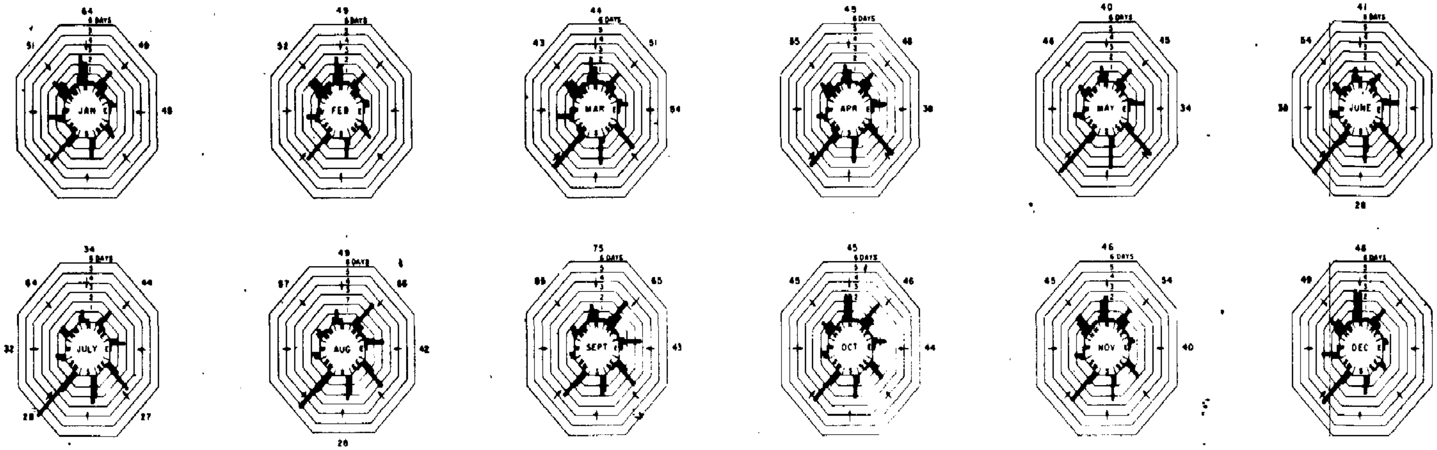
VIRGINIA BEACH, VIRGINIA

METEOROLOGIC AND HYDROLOGIC DATA

STORMS OF AUGUST 1933 AND MARCH 1962

NORFOLK DISTRICT, CORPS OF ENGINEERS

JUNE 1969 FILE: H-31-10-41



DIRECTION AND VELOCITY OF WINDS

Direction is indicated by arrows, velocity by widths, and frequency by length of shaded lines.

Length of shaded lines indicates number of days duration in an average month.

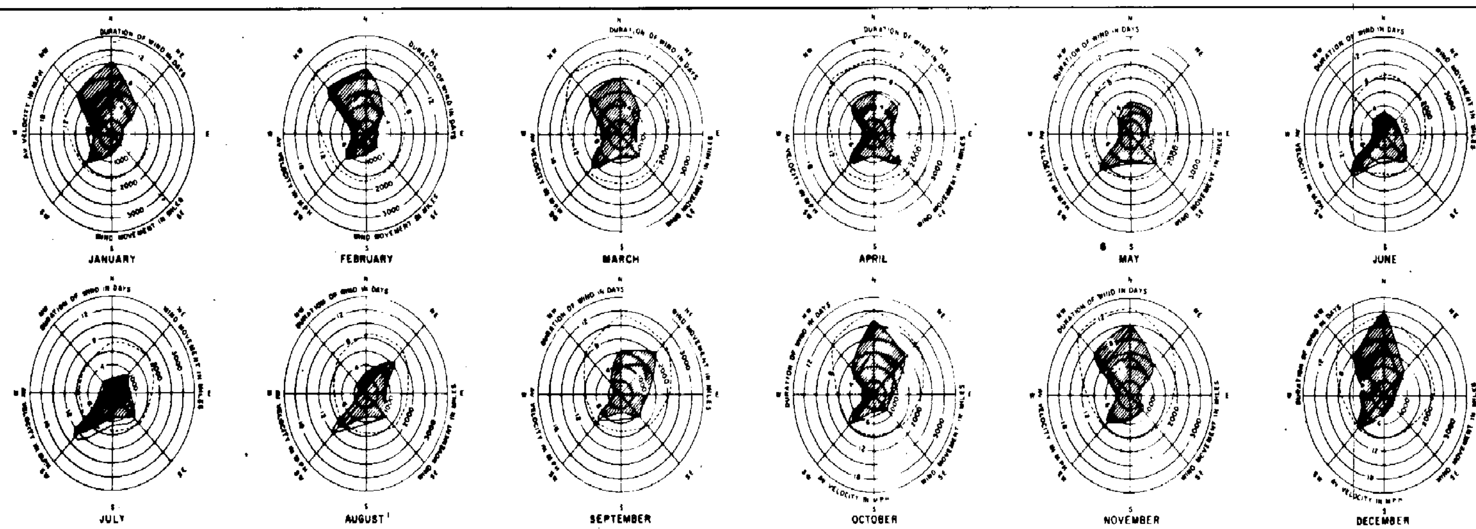
Data obtained from U.S. Weather Bureau, Cape Henry, Va.

Figures outside diagrams denote maximum wind velocities recorded during period 1930-1945.

LEGEND

Velocity Range M.P.H.	Force Beaufort Scale
0 to 7	0 to 2
8 to 18	3 & 4
19 to 31	5 & 6
over 31	7 & over

DIRECTIONAL-DURATION WIND ROSES
MONTHLY LONG-TERM AVERAGE
16 YEARS 1930-1945



Dynamic wind roses shown hereon represent average monthly values based on 16 years of record of the U.S. Weather Bureau's Cape Henry Station for the period 1930-1945.

LEGEND

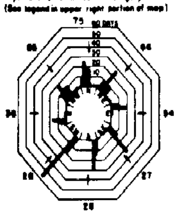
Average velocity in M.P.H.

Duration of wind in days

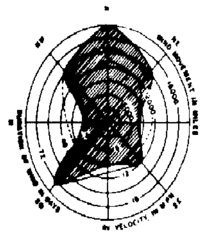
Wind movement in miles

DYNAMIC WIND ROSES
MONTHLY LONG-TERM AVERAGE
16 YEARS 1930-1945

Length of shaded lines indicates number of days duration of winds in average year (See legend in upper right portion of map)



DIRECTIONAL-DURATION WIND ROSE
AVERAGE YEAR
16-YEAR PERIOD 1930-1945



DYNAMIC WIND ROSE
AVERAGE YEAR
16-YR PERIOD 1930-1945

FREQUENCY IN DAYS PER 100 YEARS OF WINDS OVER 45 M.P.H.

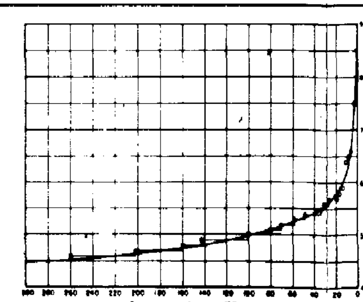
Velocity in M.P.H.	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	64	65	66	75	85
Number of observed days	17	22	19	6	17	7	4	5	4	6	1	2	4	1	1	1	1	1	1	1
Number of days wind velocity equalled or exceeded velocity shown on top line	121	104	82	63	57	40	33	29	24	20	14	13	11	7	6	5	4	3	2	1
Frequency in days per 100 years	297	228	184	142	120	98	78	62	90	42	33	27	23	20	16	9	8	7	3	1

FREQUENCY BY MONTHS OF WINDS OVER 45 M.P.H.

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Number of observed days	21	17	16	8	3	6	8	11	10	6	7	10
Frequency in days per 100 years	53	41	37	20	7	15	15	27	25	15	17	25

FREQUENCY BY DIRECTIONS OF WINDS OVER 45 M.P.H.

Direction	N	NE	E	SE	S	SW	W	NW
Number of observed days	36	28	5	0	0	0	0	52
Frequency in days per 100 years	88	68	12	0	0	0	0	128

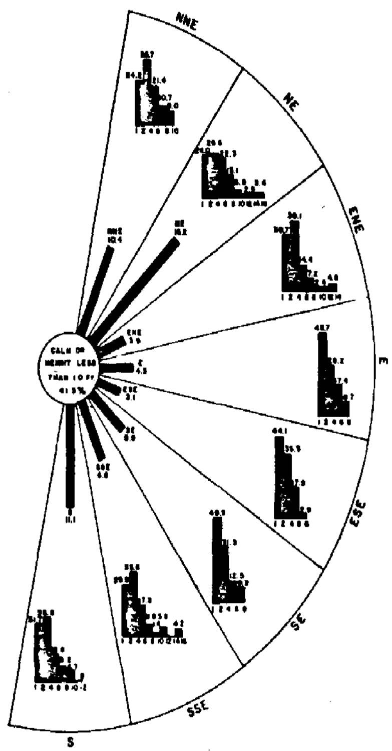


NOTE

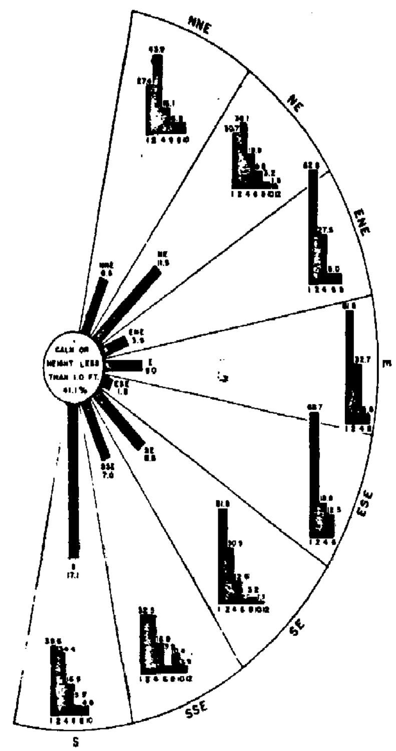
Wind frequencies shown hereon were developed from 40 years of record covering the period 1906-1945, incl.

VIRGINIA BEACH, VIRGINIA
WIND ROSE DATA

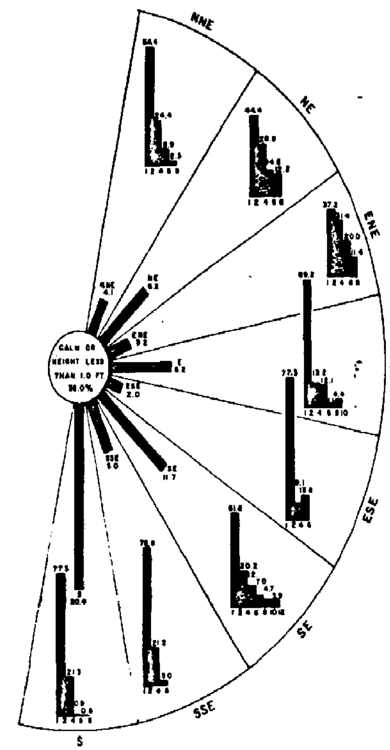
NORFOLK DISTRICT, CORPS OF ENGINEERS
JANUARY 1983



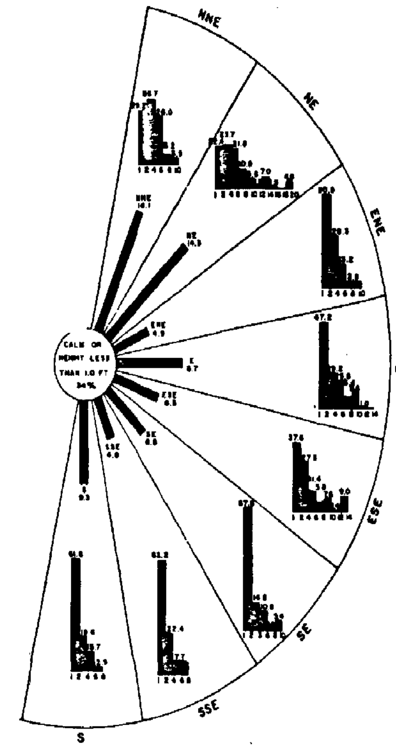
WINTER



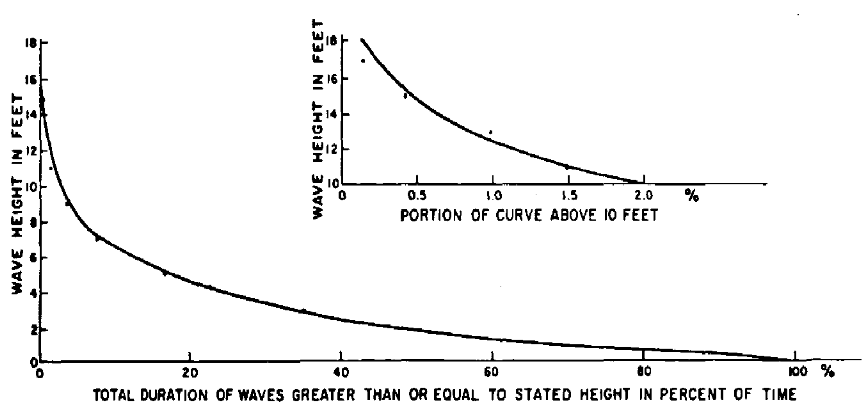
SPRING



SUMMER



FALL



NOTES:

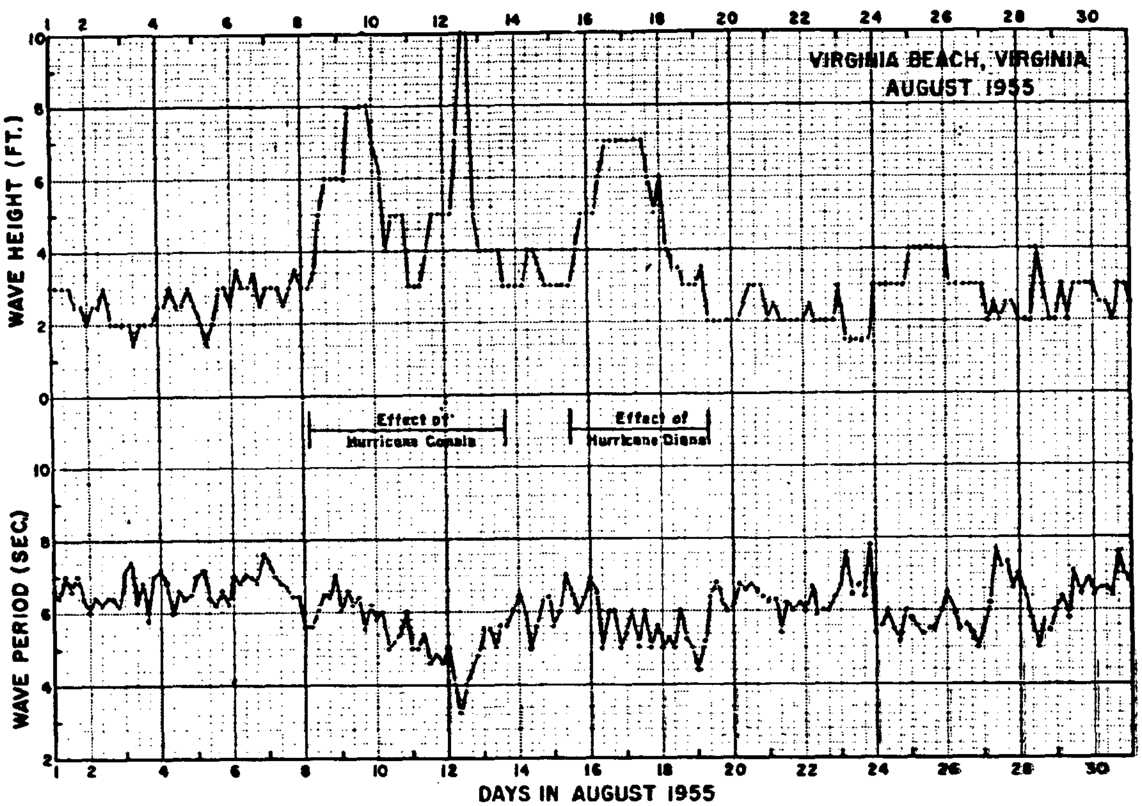
1. Data hereon based on data contained in BEB Technical Memorandum No.57, "North Atlantic Coast Wave Statistics Hindcast by the Wave Spectrum Method," Appendix D, Wave Statistics for Station D off Chesapeke Bay Entrance."
2. Wind data over a 3-year period, 1947-1949 inclusive, was used as a basis for the hindcast study.
3. Wave roses show percentage frequency of wave direction and percentage frequency distribution of significant wave height for each direction.

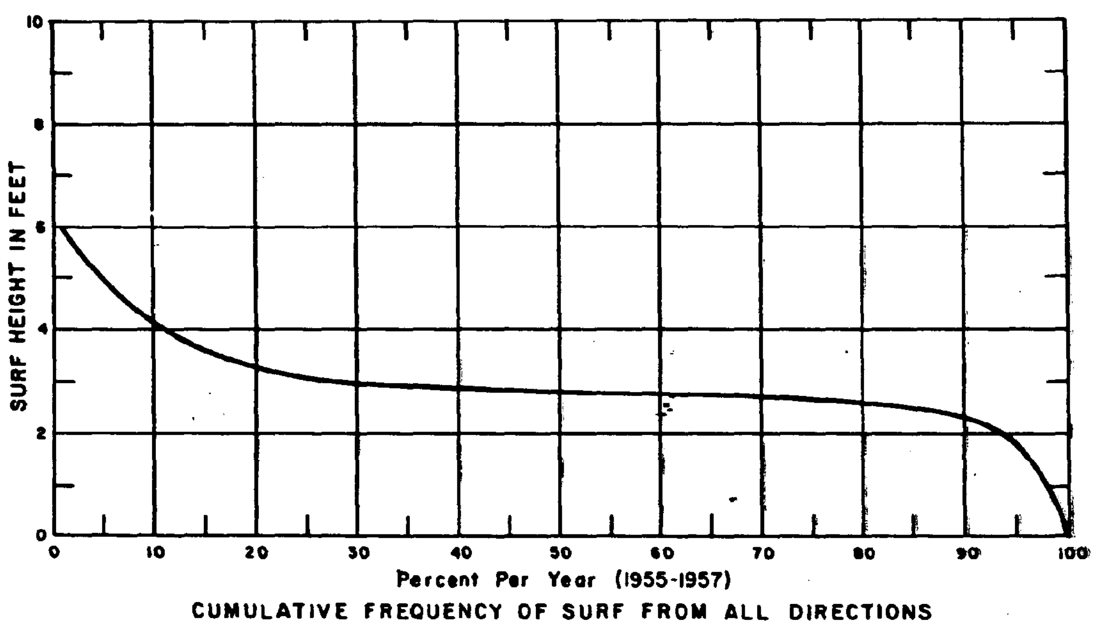
VIRGINIA BEACH, VIRGINIA

WAVE ROSE DATA BY SEASONS

NORFOLK DISTRICT, CORPS OF ENGINEERS

JANUARY 1983





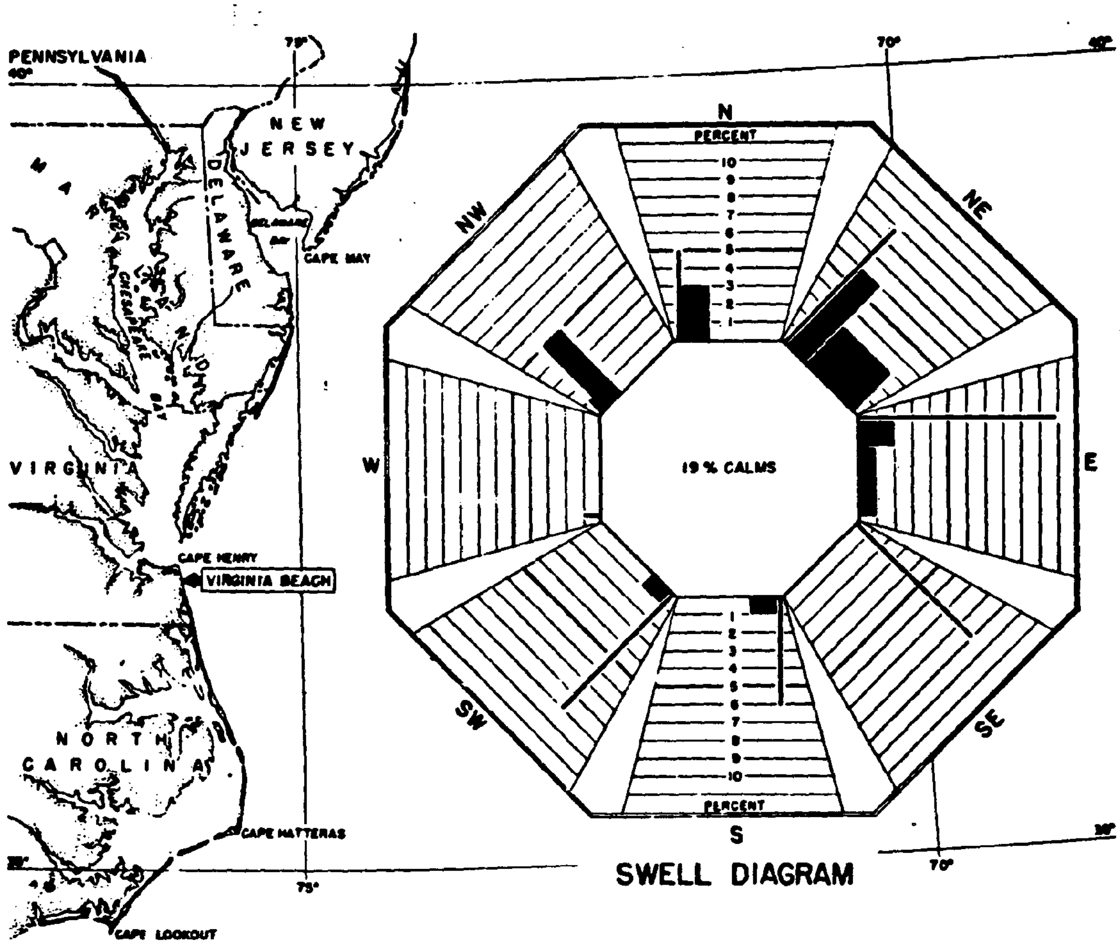
CUMULATIVE FREQUENCY OF SURF FROM ALL DIRECTIONS

NOTE:
Data obtained from CERC's T.M. No. 108, "Surf Statistics for the Coasts of the United States."

VIRGINIA BEACH, VIRGINIA

SURF DATA

JANUARY 1983
NORFOLK DISTRICT, CORPS OF ENGINEERS



IN THE SWELL DIAGRAM THE LENGTH OF THE BAR DENOTES THE PERCENT OF THE TIME THAT SWELLS OF EACH TYPE HAVE BEEN MOVING FROM OR NEAR THE GIVEN DIRECTION. THE FIGURE IN THE CENTER OF THE DIAGRAM INDICATES THE PERCENT OF CALMS.

WIDTH OF BARS HAVE BEEN WEIGHTED IN PROPORTION TO THE SWELL HEIGHT SQUARED.

THE SWELL DIAGRAM SHOWN ABOVE APPLIES TO THAT PORTION OF THE ATLANTIC OCEAN BETWEEN LATITUDE 36° AND 39° NORTH AND FROM THE SHORE EASTWARD TO THE 70 TH MERIDIAN WEST.

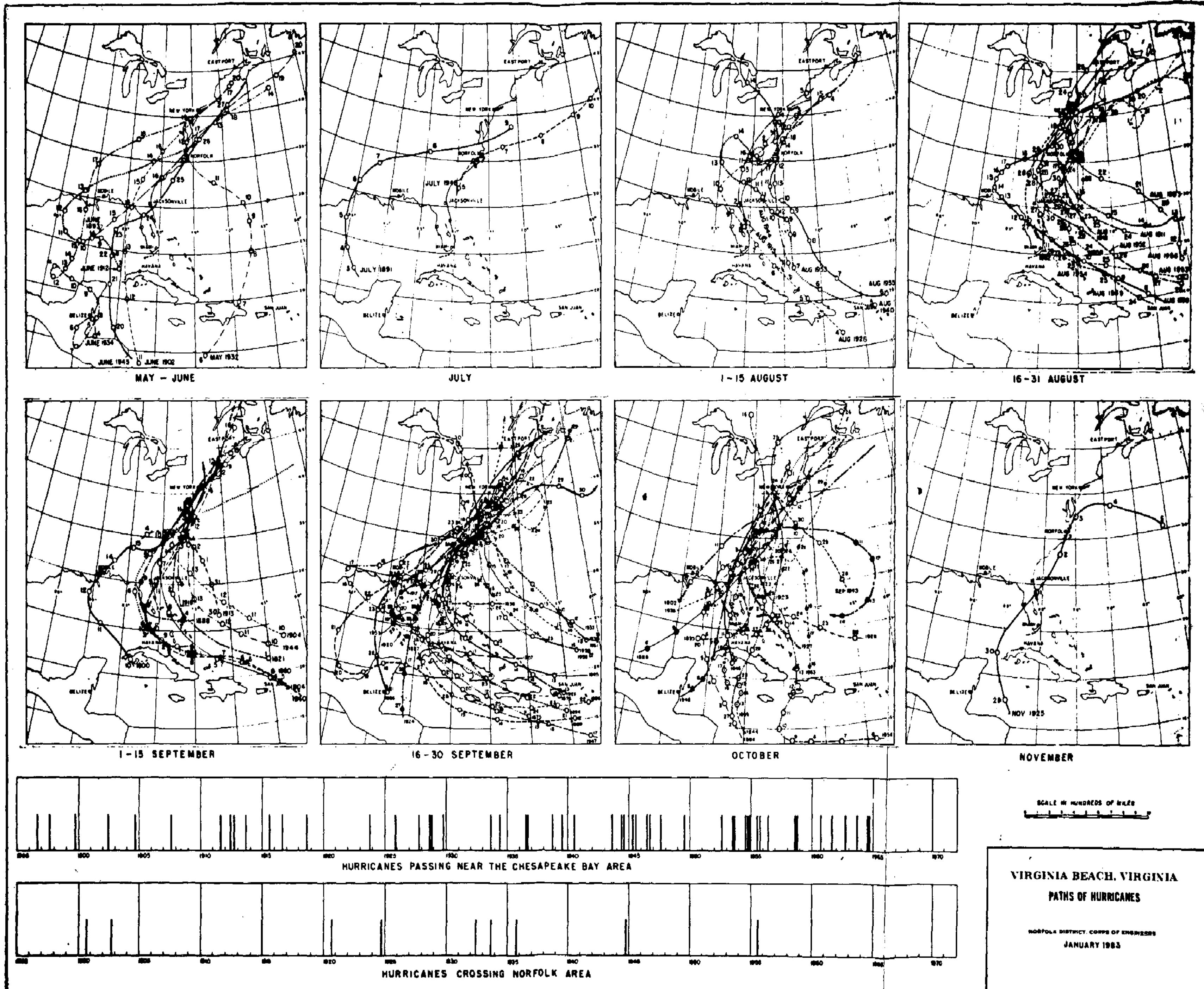
VIRGINIA BEACH, VIRGINIA

SWELL DIAGRAM

NORFOLK DISTRICT, CORPS OF ENGINEERS

JUNE 1969

FILE: H-31-10-44

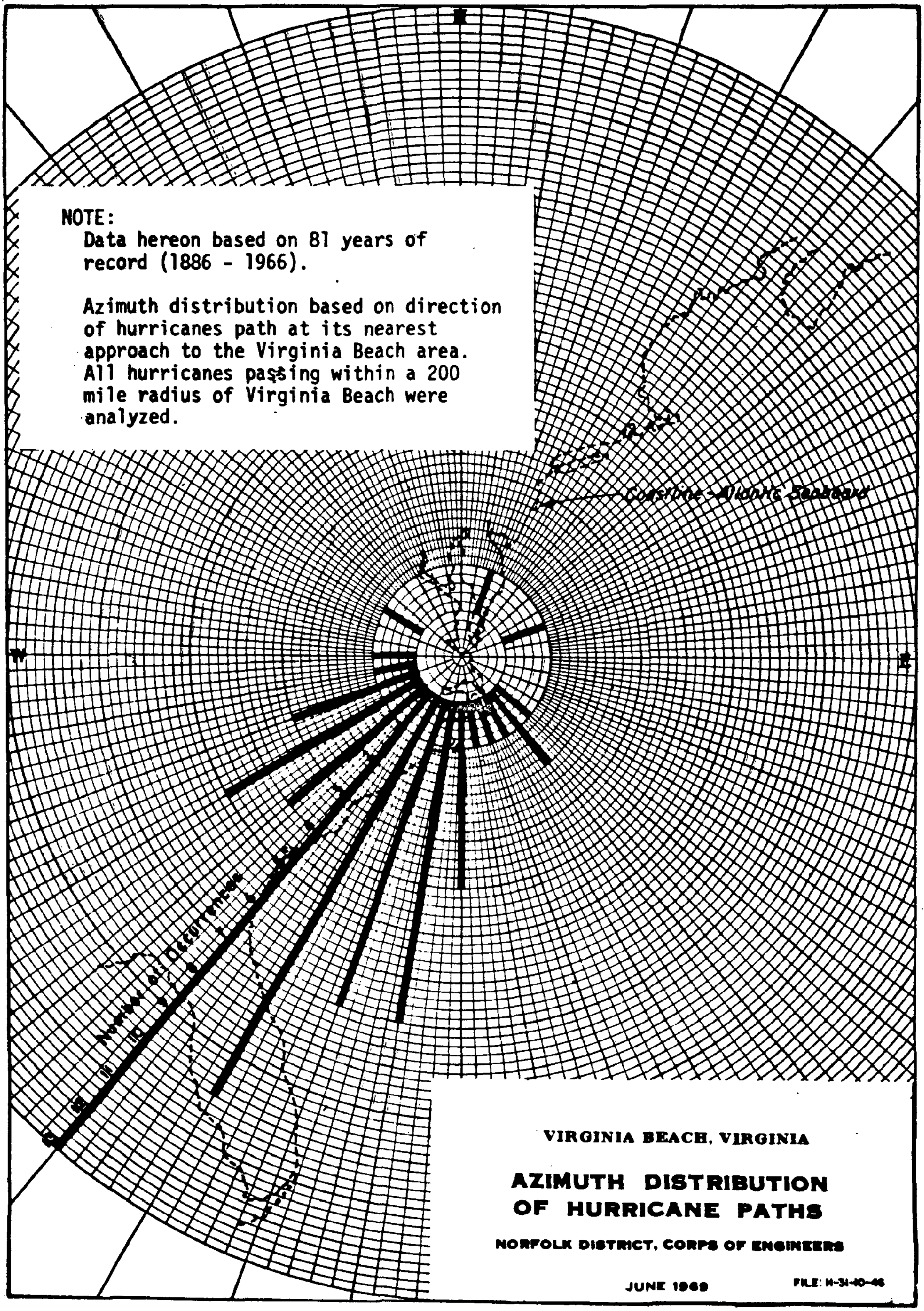


VIRGINIA BEACH, VIRGINIA

PATHS OF HURRICANES

NORFOLK DISTRICT, CORPS OF ENGINEERS

JANUARY 1983



NOTE:
Data hereon based on 81 years of record (1886 - 1966).

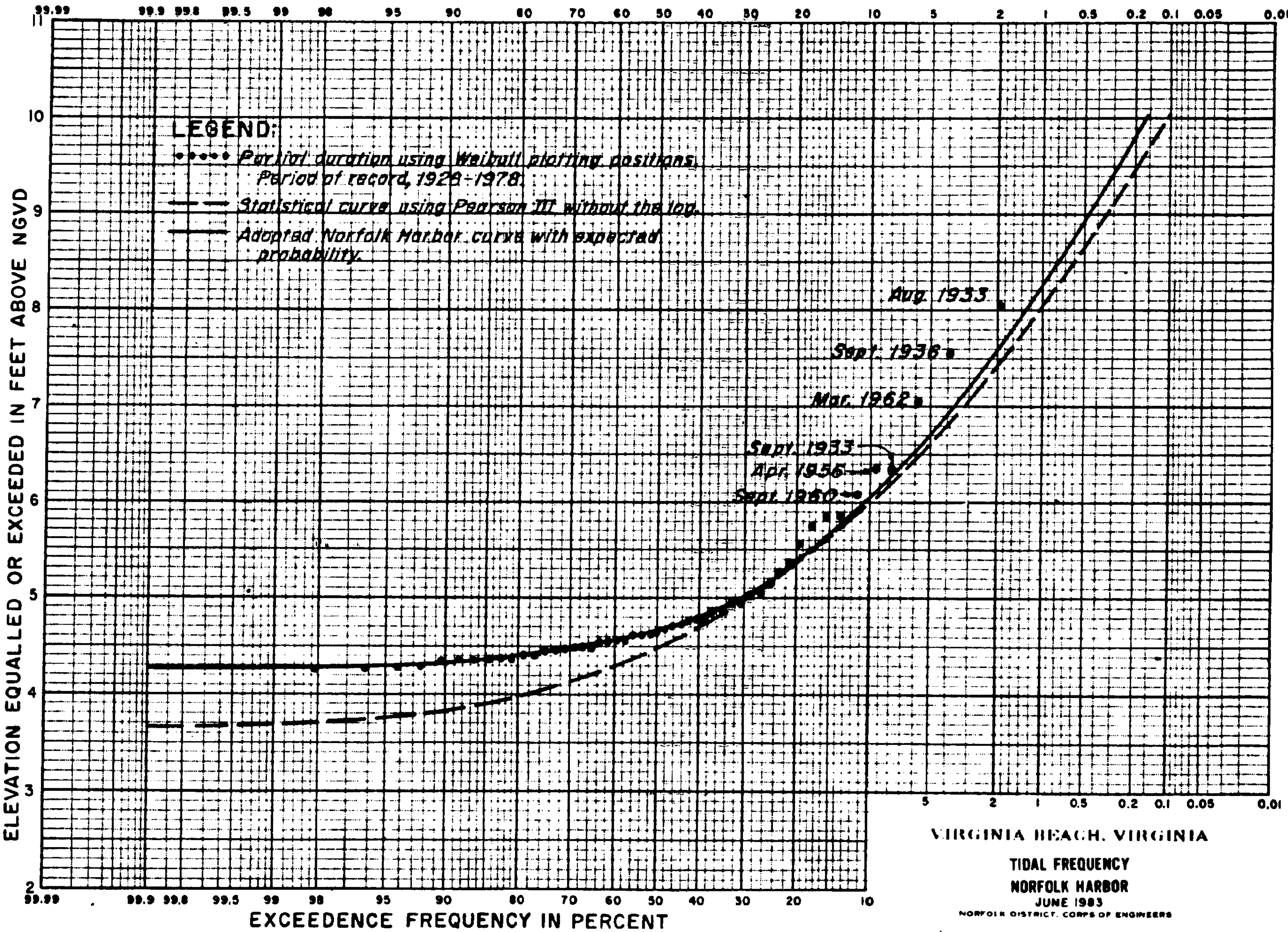
Azimuth distribution based on direction of hurricanes path at its nearest approach to the Virginia Beach area. All hurricanes passing within a 200 mile radius of Virginia Beach were analyzed.

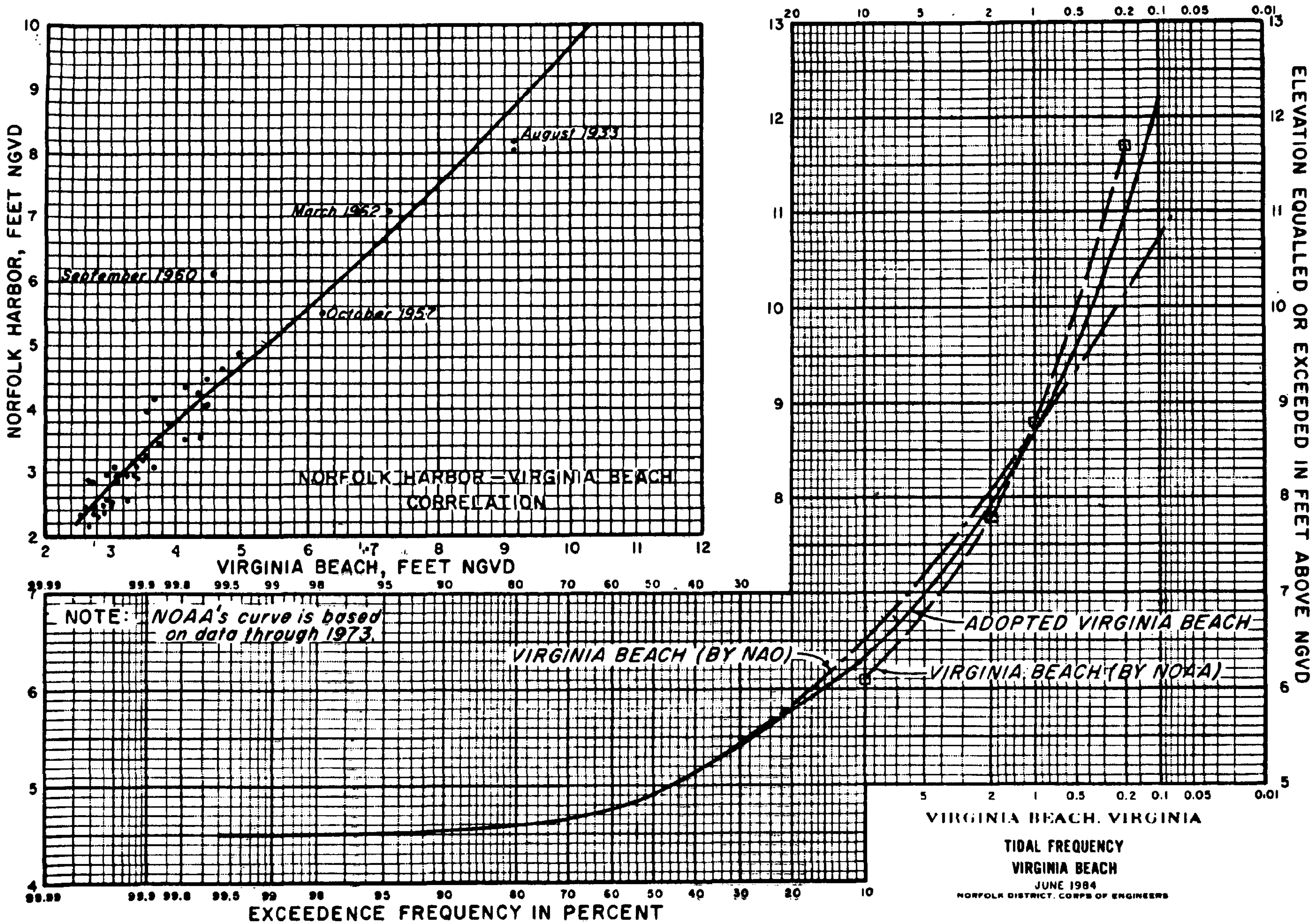
VIRGINIA BEACH, VIRGINIA

AZIMUTH DISTRIBUTION OF HURRICANE PATHS

NORFOLK DISTRICT, CORPS OF ENGINEERS

JUNE 1969 FILE: H-31-40-46


LEGEND:
Partial duration using Weibull plotting positions. Period of record, 1928-1978.
Statistical curve using Pearson III without the log.
Adopted Norfolk Harbor curve with expected probability.
Aug. 1933
Sept. 1936
Mar. 1962
Sept. 1933
Apr. 1956
Sept. 1960
ELEVATION EQUALLED OR EXCEEDED IN FEET ABOVE NGVD
EXCEEDENCE FREQUENCY IN PERCENT
VIRGINIA BEACH, VIRGINIA
TIDAL FREQUENCY
NORFOLK HARBOR
JUNE 1983
NORFOLK DISTRICT, CORPS OF ENGINEERS



VIRGINIA BEACH, VIRGINIA

TIDAL FREQUENCY
VIRGINIA BEACH
JUNE 1984
NORFOLK DISTRICT, CORPS OF ENGINEERS

APPENDIX D

PERTINENT CORRESPONDENCE

APPENDIX D

PERTINENT CORRESPONDENCE

TABLE OF CONTENTS

COMMONWEALTH *of* VIRGINIA

Virginia Port Authority
600 World Trade Center
Norfolk, Virginia 23510
Cable Address Vastports
Telephone (804) 623-8000
Telecopier (804) 623-8500
TWX 710 8811231

J. Robert Bray
Executive Director

April 12, 1988

Colonel J. J. Thomas
District Engineer
U.S. Army Corps of Engineers
803 Front Street
Norfolk, Virginia 23510-1096

Dear Colonel Thomas:

Based on correspondence received on April 7, 1988, from the City of Virginia Beach, I hereby request, on behalf of the Virginia Port Authority and the Commonwealth of Virginia, that Section 933 (of the Water Resources Development Act of 1986) studies be initiated for the placement of sand as requested by the City, as part of the 55-foot Outbound Channel Project. I would ask that you evaluate Thimble Shoal Channel as the sand source for the beach west of Ocean Park, the Resort Strip and the Fort Story stockpile site and the Atlantic Ocean Channel as the sand source for the Resort Strip, Sandbridge Beach and the Fort Story stockpile site.

It is my understanding you will provide a cost and time analysis for each proposed study site so that Virginia Beach may consider whether to proceed with any or all of the studies.

Sedimentological and survey data is available for most of the Virginia Beach sites. Jack Frye shall forward the most current data shortly.

If you have any questions, please feel free to call.

Sincerely,

J. Stanley Payne, Jr.
Deputy Executive Director
and General Counsel

cm

City of Virginia Beach

OFFICE OF THE CITY MANAGER
(804) 427-4242

MUNICIPAL CENTER
VIRGINIA BEACH, VIRGINIA 23456-9002

June 27, 1988

Mr. Jack E. Frye
Shoreline Programs Manager
Post Office Box 1024
Glouster Point, Virginia 23062

Dear Jack,

Thank you for your recent letter concerning Section 933 evaluations. The City wishes the Corps of Engineers to proceed with the three studies mentioned in your letter. These are as follows:

Beach Segment	Estimated Study Costs
Resort Strip	$ 43,000
Sandbridge Beach	$213,000
Chesapeake Bay Bridge-Tunnel to Ocean Park	$176,000

As your letter stated, Section 933 of the Water Resources Development Act 1986 and Corp's policies and regulations would allow for Corps participation in 50% of the cost of sand placement on these beaches. This would be in lieu of overboard disposal, and the cost would be the incremental cost above overboard disposal. Further, we understand if the studies do not result in placement of material on the beach, study costs will be absorbed by the Federal Government.

I believe under the current schedule, the studies will take approximately eighteen months and it will be 1990-1991 before the dredging begins.

Thank you for your assistance in rebuilding the beaches of the City. Please contact me if I can provide you with any further information.

Your truly,

Aubrey V. Watts, Jr.
City Manager

AVW/RRM:pah

cc: The Honorable Mayor
Members of Council
Robert Matthias
E. Dean Block
C. Oral Lambert
Carl Thoren
Don Williams

COMMONWEALTH of VIRGINIA

Virginia Port Authority
600 World Trade Center
Norfolk, Virginia 23510
Cable Address Vastports
Telephone (804) 623-8000
Telecopier (804) 623-8500
TWX 710 8811231

J. Robert Bray
Executive Director

June 30, 1988

Colonel J. J. Thomas
District Engineer
U. S. Army Corps of Engineers
803 Front Street
Norfolk, Virginia 23510-1096

Dear Colonel Thomas:

Based on the enclosed letter received June 29, 1988 from the City of Virginia Beach, I hereby request, on behalf of the Commonwealth of Virginia, that Section 933 (of the Water Resources Development Act of 1986) studies be initiated for the placement of sand on the Resort Strip, Sandbridge Beach and on the beach between the Chesapeake Bay Bridge-Tunnel and Ocean Park.

Please feel free to call me if anything further is required.

Sincerely,

Jack E. Frye
Shoreline Programs Manager

enclosure

cc: Aubrey V. Watts, Jr., City Manager,
City of Virginia Beach
Robert R. Matthias, Intergovernmental Relations Coordinator,
City of Virginia Beach
J. Stanley Payne, Deputy Executive Director and General Counsel,
Virginia Port Authority
B. C. Leynes, Jr., Director,
Department of Conservation and Historic Resources
Roland B. Geddes, Director,
Division of Soil and Water Conservation
Suzette M. Kimball, Marine Scientist,
Virginia Institute of Marine Science

APPENDIX E

FISH AND WILDLIFE COORDINATION ACT PLANNING AID REPORT

FISH AND WILDLIFE COORDINATION ACT

PLANNING AID REPORT

ENVIRONMENTAL EFFECTS OF BEACH NOURISHMENT AT NINE SELECTED VIRGINIA BEACHES

ANALYSIS OF THE ARMY CORPS OF ENGINEERS PLANS

Prepared for:

U.S. Army Corps of Engineers
Norfolk District
Norfolk, Virginia 23510

Prepared by:
Elizabeth Block, Wildlife Biologist

Under Supervision of:

John P. Wolflin, Supervisor
Annapolis Field Office
U.S. Fish and Wildlife Service
Annapolis, Maryland
and
Karen Mayne, Assistant Supervisor
Gloucester Point Field Office
U.S. Fish and Wildlife Service
White Marsh, Virginia

July 1989

Title: **Fish and Wildlife Coordination Act Planning Aid Report, Environmental Effects of Beach Nourishment at Nine Selected Virginia Beaches, Analysis of the Army Corps of Engineers Plans**

Elizabeth Block
July 1989

Abstract: The Army Corps of Engineers plans to dredge the Thimble Shoal and Atlantic Ocean Channels, Virginia between October 1990 and September 1993. The Commonwealth of Virginia has requested that suitable beach quality material be placed on up to nine Virginia beaches under Section 933 of the Water Resources Development Act of 1986. This act creates provisions for one-time use of dredged material for beach nourishment. The purpose of this report is to assess potential impacts of nourishment at these beaches to fish and wildlife resources and to make recommendations which would reduce impacts.

The nine beaches are located on the western shore of the mouth of Chesapeake Bay and on the Atlantic coast, south of the Bay, Virginia. Existing information was used to document past and current conditions and uses of beaches, and likely impacts to fish and shellfish resources, endangered species, and the nearshore ecosystem in general.

Probable impacts to nearshore biota include burial, lethal or sublethal effects of increased turbidity (reduction of dissolved oxygen, light penetration, and photosynthesis; disruption of predator-prey interaction; and clogging of gills and filter feeding structures), possible exposure to contaminants in dredged material, and changes in physical conditions such as beach slope, and particle size. Previous research indicates that most negative effects of beach nourishment are temporary, and the community would be expected to recover within a few years. Bioassay tests showed that toxicity of sediment from the two channels is not a concern. In general, effects to fish and wildlife at several of the proposed nourished beaches is of less concern because the beaches have been periodically nourished in the recent past.

Effects to endangered species are of concern for a few of the beaches. Loggerhead and Atlantic ridley turtles are summer residents of Chesapeake Bay. Loggerhead nesting is known to occur infrequently at two of the beaches. A nesting colony of piping plovers is adjacent to another proposed nourishment beach.

Times of year and specific nourishment methods were recommended for reducing effects to nearshore biota. We also recommended that one beach, Grandview Natural Preserve, not be nourished so that the ecological integrity of this natural area can be maintained.

Key words: Beach nourishment, dredging, turbidity, loggerhead turtles, piping plovers, Sandbridge Beach, Virginia Beach, Ocean Park Beach, Willoughby Beach, Buckroe Beach, Salt Ponds Beach, White Marsh Beach, Grandview Natural Preserve, Yorktown Beach, Thimble Shoals Channel, Atlantic Ocean Channel.

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INTRODUCTION

The Commonwealth of Virginia has requested that the U.S. Army Corps of Engineers (Corps) place dredged material on nine Virginia beaches to reestablish beach area lost to erosion and to provide storm protection for coastal developments. This report outlines the U.S. Fish and Wildlife Service's (Service) concerns for impacts to fish and wildlife resources which can be expected as a result of beach nourishment. This planning aid report has been prepared in accordance with provisions of the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661 et seq.) which requires the Service to assess potential impacts of proposed Federal projects on fish and wildlife resources. Impacts were assessed based on existing information and qualitative on-site examination.

Dredged material for beach nourishment will come from the deepening of the Thimble Shoal and Atlantic Ocean Channels (Figure 1), and dredging is scheduled to occur between October 1990 and September 1993. Probable impacts of dredging for borrow material to fish and wildlife resources in the vicinity of the Atlantic Ocean Channel have been documented by U.S. Fish and Wildlife Service (1982), and similar impacts would occur during dredging of the Thimble Shoal Channel. Effects to aquatic resources at dredge sites will not be considered in this report.

Much of the dredged material will be released at the Dam Neck Ocean Disposal Site (Figure 1). The Commonwealth of Virginia has requested that dredged material of suitable beach quality be placed on nine Virginia beaches under Section 933 of the Water Resources Development Act of 1986. This act creates provisions for one-time use of dredged materials for beach nourishment with the following stipulations. The project must be requested by the State, be environmentally acceptable, and the beach must be open to the public. The added cost of beach disposal must be justified by the benefits associated with protection of the beach, and 50% of the added cost must be paid for by local interests. The nine beaches are (from south to north, Figure 1):

- Sandbridge Beach - Dam Neck Naval Station to Back Bay National Wildlife Refuge
- Virginia Beach (Resort Strip) - Rudee Inlet to 49th Street
- Ocean Park Beach - Chesapeake Bay Bridge Tunnel to Lynnhaven Inlet
- Willoughby Beach - Mason Creek Road to Lea View Avenue
- Buckroe Beach - Buckroe Fishing Pier to Pilot Avenue
- Salt Ponds Beach - private property line north to Salt Ponds Inlet
- White Marsh Beach - Salt Ponds Inlet to Grandview Fishing Pier
- Grandview Natural Preserve - private property line north to Factory Point
- Yorktown Beach - Post Office 1,330 feet to existing stone breakwater

The first section of this report gives background information on the dredge sites. As the nearshore habitats at all of these beaches are similar, the next two sections consider impacts from beach nourishment activities in general, and impacts to fisheries specifically. The sections following give specific information on each beach considered for nourishment including special considerations such as endangered species. The final

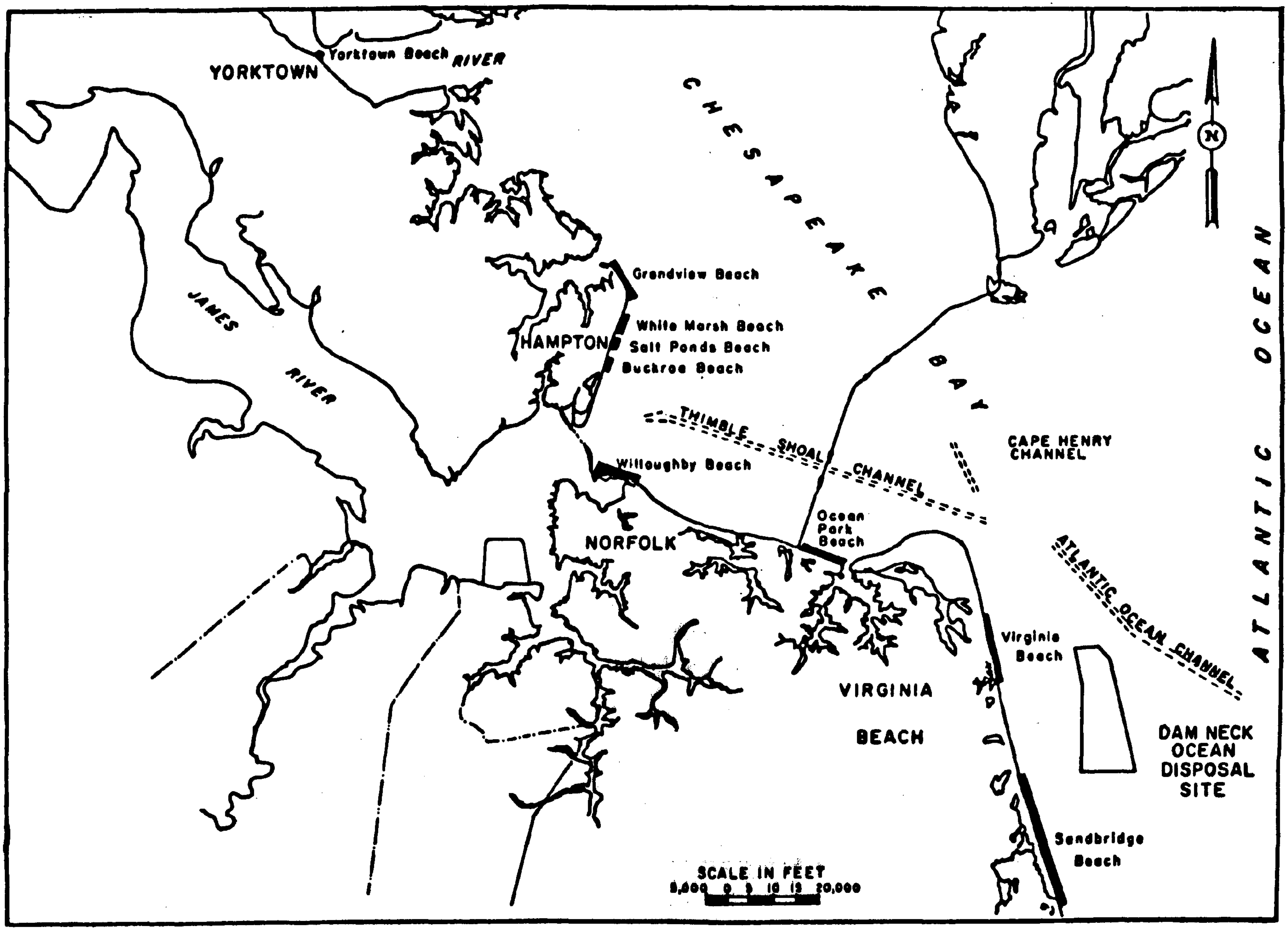

Figure 1. Location of nine beaches proposed to receive one-time nourishment during dredging of Atlantic Ocean and Thimble Shoal Channels.

section gives recommendations for reducing or avoiding impacts to wildlife resources.

DREDGE SITES

Channel deepening will proceed under the U.S. Army Corps of Engineers, Norfolk District, Norfolk Harbor and Channels Project scheduled to take place between October 1990 and September 1993. The Atlantic Ocean Channel will be constructed to a depth of 60 feet. Preliminary investigation of the sediments show that sand suitable for beach nourishment projects are located in the eastern two-thirds of the channel. The area was recommended as one of the most likely borrow areas in a previous study (U.S. Army Corps of Engineers 1984). Fines contained in the coarse grained sediment vary from 0.8 to 38.0 percent with an average of 12.4 percent. It is estimated that over 10,000,000 cubic yards of sandy material is located in this area of the channel (Swean 1986a). Geotechnical investigations have determined that the Atlantic Ocean Channel material has a high degree of similarity to the material on the berm and nearshore areas of the Virginia Beach oceanfront. Information on the degree of similarity with sand at other proposed locations is unavailable at this time.

The Thimble Shoal Channel was deepened to 50 feet in 1988 and may be further deepened to 55 feet under the Norfolk Harbor and Channels project. During an earlier maintenance dredging of this channel, dredged material from the eastern portion was stockpiled at Fort Story in 1974 and then hauled to Virginia Beach oceanfront. Later channel maintenance did not remove sufficient quantities of beach quality sand for economically feasible nourishment, and dredged material was taken to the Dam Neck Disposal Site. Swean (1986b) estimated that 3,000,000 cubic yards of suitable material is located in the eastern portion of the channel containing an average of 29.3 percent fines. Sand from the east end of the Thimble Shoal Channel (east of the Chesapeake Bay Bridge Tunnel) is exceptionally compatible with original material from Ocean Park, Virginia Beach, Sandbridge, Buckroe, and Ocean View (near Willoughby) beaches (Suzette Kimball, personal communication). The extreme eastern area of the channel is characterized by fine grained sediments (Swean 1986b) and is not appropriate for beach nourishment.

IMPACTS OF BEACH NOURISHMENT

The sandy beach is an inherently unstable system. The face of the beach is constantly changing in response to the ebb and flow of tides. Changes in current, wind, and wave energy or direction can move sand to or from any part of the beach and offshore area. Natural beaches are generally backed by dune systems which are said to stabilize the beach. However, the dunes are also part of the shifting equilibrium of sand on a longer time scale.

Sandy beaches and associated nearshore areas are quite inhospitable. Living creatures in these habitats can be exposed to wide ranges of temperature, moisture, and salinity in addition to the mechanical impacts of pounding surf. Cover is limited, and the sandy substrate is unstable. These areas were once considered to be relatively devoid of life. While the number of species is low, the organisms which have adapted to the difficult conditions often occur in high numbers.

The sandy beach can be divided into three habitats on the basis of physical conditions. The beach zone is above the reach of the high tide and inhabitants include ghost crabs (Ocypode quadrata) and sand fleas (Talitridae). The area of the beach zone habitat would be most extended by nourishment activities.

The surf zone starts at the high tide mark and includes the areas of breaking waves. Dominant organisms are mole crabs (Emerita talpoida) and coquina clams (Donax spp.). Species are generally small and well adapted to burrowing or digging. One of the physical characteristics of this habitat, the profile (slope), is created by wave and tide energy and direction. The profile is perhaps most susceptible to alteration by beach nourishment. Filling activities should attempt to recreate the profile to maintain similar habitat areas. More natural beach profiles can also be maintained by reducing or avoiding the use of heavy earth moving equipment and allowing the material to redistribute naturally.

The nearshore zone beyond the surf is more stable and supports a correspondingly greater diversity of organisms including those that migrate from deeper water to feed. Sport fish and shellfish can be abundant, and the area is used for migration by some species of juvenile fish. Organisms in this zone are less well adapted to disturbances, so may be more adversely impacted by beach nourishment.

The immediate effect of beach nourishment would be burial by transported sand. Fish and other more mobile creatures would probably leave the area and so would be less affected. As most of the surf zone species are adapted to burrowing, effects of burial would be somewhat minimized. Maurer et al. (1978) found that some benthic animals were able to migrate vertically through more than 30 cm of sediments. The smaller organisms and interstitial dwellers would be most affected by burial. As these creatures form the base of the detrital food chain in this area, reduction of higher order consumers is also a possibility. Effects from burial can be minimized by applying dredged material in the winter after adult clams and mole crabs have migrated offshore (Reilly and Bellis 1978).

Increases in turbidity are a major concern for the health of the biota. The effects of turbidity will depend on the mechanical methods used to spread sand on beaches, the amount of fines in the dredged material, and other conditions which modify settling rates including water currents. Increased turbidity has been shown to have several effects on physical conditions in the water column. Reduction in light penetration will affect photosynthetic organisms. Results from studies with phytoplankton have ranged from no effect to both reduced and increased photosynthesis, the latter can possibly be attributed to increased nutrient availability (Priest 1981). Most previous research found that drastic reduction in primary productivity was seldom observed and was short-lived in duration (reviewed in Morton 1977). Changes in light penetration may also change the temperature of the water column.

Decreases in dissolved oxygen in the water column result from physical rearrangement of sediment from a deposited to a suspended state (U.S. Fish and Wildlife 1987) and from the exposure of previously buried anoxic sediments. Suspension of organically rich sediments may also decrease dissolved oxygen. At open ocean dredge disposal sites, decreases in dissolved oxygen due to turbidity have been found to be small and relatively short-lived, but some studies reported substantial decreases of 1-2 milligrams per liter which might affect species with a narrow tolerance range (Priest 1981). During beach nourishment, wave action and dispersion by currents and tides will quickly reduce effects of depleted oxygen.

Resuspension of sediment and organic matter in the dredged material will result in increased nutrient levels in the water column. Increased nutrient availability can result in biotic stimulation or overstimulation and associated problems such as plankton blooms. Changes in physical conditions of the water column can produce synergistic effects. In a worst case scenario, dissolved oxygen could be reduced by suspended sediments, further decreased by the biological oxygen demand of bacteria stimulated by excess nutrients, and not replenished by photosynthetic organisms inhibited by reduced light penetration.

Turbidity may affect organisms in several ways. Settling of sediments may bury sedentary nonburrowing species. Suspended matter can clog gills and filter feeding structures which could directly cause death or reduce energy efficiency and cause indirect effects such as reduced reproduction or ability to avoid predation (Sherk 1971). The migration of larvae from the planktonic to the benthic community is disrupted by high turbidity (Reilly and Bellis 1978). Post-nourishment community recovery time would be slowed and possible effects to higher order consumers may occur. Suspended or settled sediments may also adversely impact spawning of certain commercial and recreational fish species. Turbidity could affect predator/prey behavior by reducing effectiveness of vision and other senses. The Federally threatened loggerhead turtles (Caretta caretta) may have an increased likelihood of becoming entangled and drowned in pound nets in high turbidity conditions. The loggerhead is a summer resident to Chesapeake Bay and the Atlantic coast. The Federally endangered Atlantic ridley turtle (Lepidochelys kempi) is also a summer resident and may be adversely affected by increased turbidity.

Tests with several life stages of oysters (Crassostrea virginica) and hard clams (Mercenaria mercenaria) indicate that lethal levels of suspended solids are much greater than levels found during most dredging projects (Haven et al. 1981). Four species of fish were exposed to high levels of turbidity. The effects to adults were minimal, eggs experienced a slight delay in hatching, and the lethal concentration of suspended particles for fish larvae were in excess of anticipated dredging levels (Priest 1981). In studies reviewed by Morton (1977), fish tolerance to turbidity varied widely by species.

Effects from increased turbidity will be less for a beach nourishment project than for open ocean disposal, as material suitable for placement on the beach is necessarily larger grained and contains fewer fines. During beach nourishment, dispersal by currents and tides act to reduce effects of turbidity. Water quality effects are generally quickly diluted, but Naqvi and Pullen (1982) caution that cellular circular patterns in nearshore areas may extend recovery time. Several authors believe that turbidity effects will be short-term and of minor impact (Thompson 1973, Naqvi and Pullen 1982).

An additional consideration in resuspension of sediments is increased bioavailability of metals and a variety of other persistent contaminants. Very low levels of contaminants may not directly and immediately affect adults but could cause chronic problems. Developmental stages of all organisms are especially sensitive. Rule (no date) tested sediment samples from the Thimble Shoal Channel for metals (Cd, Co, Cr, Cu, Fe, Mn, Ni, Pb, and Zn). Levels of all metals were below or only slightly above average crustal abundance, although the inner channel did have consistently slightly higher levels than the outer channel. Bioassay tests have been performed with sediment from the Thimble Shoal Channel by Alden and Young (1984), and results indicated that toxicity was not a concern.

Changes in grain size and makeup as a result of beach nourishment may affect substrate specific species, possibly resulting in community level changes, particularly of the interstitial community. Currently, little is known about how sand quality affects the loggerhead turtle's choice of nesting beaches. Naqvi and Pullen (1982) suggested that compactibility of sand may be important, and Keinath (personal communication) believes that sand which is too coarse or too fine would discourage nesting. A study in Imperial Beach, California found that sediments were rapidly sorted and that grain-size distribution was comparable to pre-nourishment conditions after about four months (Parr et al. 1978).

Recovery of the communities of nearshore organisms will depend on factors such as time of year, size of the nourishment project, amount of time between subsequent nourishment projects, and type of community. Naqvi and Pullen (1982) stated that communities are likely to recover rapidly due to high reproductive potential and recruitment from planktonic larvae and mobile macrofauna from nearby unaffected areas. However, Reilly and Bellis (1979) found that recovery was affected by failure of adult intertidal organisms to return from offshore overwintering areas, reductions in organism densities on adjacent unnourished beaches, and inhibition of pelagic larval recruitment. Reports on recovery rates vary from several tidal cycles to up to 18 years for small, nonmotile meiofauna (Rogers and Darnell 1973). Hayden and Dolan (1974) found that the mole crab population at a nourishment site recovered within a few tidal cycles. However, mole crabs are perhaps the best adapted of the beach community to recover from such disturbances. Reilly and Bellis (1979) concluded that recovery should take place within one or two seasons. Several studies found that no long-term damage to fauna had occurred after four to seven years of recovery time (reviewed in Naqvi and Pullen 1982). The community might not recover but change type, from a filter-feeding community to a deposit-feeding community or vice-versa. Repeated nourishment will prevent communities from ever fully recovering.

IMPACTS TO FISH AND SHELLFISH RESOURCES

The Chesapeake Bay, like other estuaries, is very productive, and a variety of finfish, clams, and crabs are harvested commercially according to season and size limits. The area also supports extensive recreational fisheries from public fishing piers, and private and charter boats. Species, numbers, and estimated catch levels for the Hampton Roads area and the lower Chesapeake Bay have been previously reported for the area (Mayne 1979, Hedgepeth et al. 1981, Birdsong no date, Birdsong et al. 1984, no date).

Currently, there are two permanent shellfish closures associated with sewage treatment plants. Little Creek, east of the Willoughby Beach site, is closed for marketing of all shellfish except blue crabs (Callinectes sapidus). Closure extends in a one-mile radius into the Bay. Two square miles off the coast at the U.S. Naval Fleet Anti-Air Warfare Training Center, north of Sandbridge Beach, is closed to shellfish marketing due to effluent from the Atlantic sewage treatment plant. The lower portion of the Chesapeake Bay is closed to crabbing between mid-May and mid-September due to the large number of spawning females in the area.

The nearshore area is important to fish for a variety of reasons. For some species, it provides a nursery area and migration route for juveniles. Anadromous fish also migrate through to reach upstream spawning grounds. Many species come in from deeper water to feed. While fish probably escape the more direct effects of beach nourishment, longer term disruptions to life cycles or movement patterns may take place. Beach nourishment will remove a segment of the prey population for a short time. This could be especially damaging to resident species with specific dietary requirements. Effects to fish resources would be minimized if nourishment took place on smaller segments of beach over a longer time period.

Hard clams are one of the important commercial species in southernmost Chesapeake Bay. Clam beds off the coast of Buckroe Beach had a reported value of $90 per acre at 1981 market prices (Hobbs et al. 1982). Clams could be detrimentally affected by beach nourishment if turbidity was prolonged over the clam beds or if substrate surface conditions were altered to affect larval clam settlement.

PROPOSED BEACH NOURISHMENT PROJECTS

The following sections give the location, description, beach nourishment history, estimated area and volume of added material (provided by the Corps), and specific biological considerations and recommendations for each project location. Previous beach nourishment periods and sources of material have been reported as available, and should not be considered to be complete.

Sandbridge Beach

The project area is located south of Virginia Beach, Virginia between the U.S. Naval Fleet Anti-Air Warfare Training Center and Back Bay National Wildlife Refuge (Figure 1). A permanent and summer residential neighborhood has developed on the narrow neck of land between Back Bay and the Atlantic Ocean. Dunes were destroyed during housing construction or by storms, and current storm protection includes a narrowing beach, and bulkheads and riprap placed by individual homeowners. Recreational use of the beach is fairly heavy during summer months.

Sandbridge Beach has been "nourished" periodically by the bulldozing of sand from the intertidal zone and beach face. Material was placed to rebuild the shoreline after the March 1962 storm. The volume and design of beach nourishment at this area has yet to be determined.

A species of concern in this area is the loggerhead turtle. A nest was found in the Sandbridge area in 1980 and in 1989. The Virginia Beach section below contains more detailed information on concerns for the turtle.

Virginia Beach, Resort Strip

The project area is located in the City of Virginia Beach, Virginia along the Atlantic Coast (Figure 1). The specific area to be nourished is 3.3 miles of oceanfront between Rudee Inlet and 49th Street. The area has a high density of commercial and recreation-oriented development including many high rise hotels, restaurants, and specialty shops catering to a large tourist trade. The beach is heavily used in the summer.

Artificial placement of sand to protect publicly owned portions of Virginia Beach was deemed justifiable as early as 1952. The Corps plan involved placing approximately 1,100,000 cubic yards of sand to widen the beach berm approximately 100 feet at an elevation of seven feet above mean low water and to construct a groin system. Beach restoration was accomplished by local interests in 1953 but the groins have not been constructed to date. The shoreline was also rebuilt after the March 1962 storm. The River and Harbor Act of 1962 authorized Federal participation in the form of one-half of the cost for periodic nourishment of the beach. Local interests acquired dredging equipment and borrow areas, and the beach was nourished annually between Rudee Inlet and 49th Street (U.S. Army Corps of Engineers 1984). Rudee Inlet has also been dredged annually since 1968, and sand bypassed to the downdrift side of the jetties. In 1970, a Corps feasibility report recommended extending protection to include the area between 49th and 89th Streets. Federal participation in this project expired in 1987 and was subsequently extended another 10 years.

The nourishment design calls for 900,000 to 1,200,000 cubic yards of sand to be used to extend the width of the beach berm 100 feet. Biological impacts of nourishment are not a strong concern at this location, as adding material will only continue previous periodic disturbances. Also, the very heavy summer recreational use of the area greatly reduces its value to wildlife.

A species of concern in this area is the federally threatened loggerhead turtle. Virginia Beach is at the northern edge of the breeding beach distribution. The 60-mile stretch of Virginia Atlantic Ocean coastline has an average of two or three nests per nesting season, and two turtles have nested right in front of the hotels on Resort Strip (Musick, personal communication). If material is to be added to beaches during the turtle nesting period, beaches should be examined carefully by trained experts to locate and remove eggs to more suitable beaches. As mentioned previously, sand quality may also be important in maintaining breeding beaches. This is a concern for the Atlantic coastline rather than just at the nourishment sites, as material will be moved with the currents. As with all species, developing turtle eggs are especially sensitive to contaminants which may occur in small amounts in the dredged material. Also, adult loggerheads are particularly sensitive to hydrocarbons, which could be resuspended in the water column during dredging or nourishment activities.

Ocean Park

The project area is located east of U.S. Navy Little Creek Amphibious Base in Norfolk, Virginia (Figure 1). Nourishment would take place along the shoreline between the Chesapeake Bay Bridge Tunnel and the Lynnhaven Inlet. The area is mostly residential with a few small commercial establishments, and the beach is used fairly heavily for recreational purposes in the summer months. Structural protection is provided by a groin system built in 1939. Information on previous nourishment activities was not located for this site. The nourishment design calls for 100,000 to 700,000 cubic yards of material to be placed to create a beach berm 50 to 150 feet wide.

Willoughby Beach

The project area is in the westernmost coastal part of Norfolk, Virginia (Figure 1). The residential area is located on a neck of land extending westward between Chesapeake Bay and Willoughby Bay. Nourishment will take place between Mason Creek Road and Lea View Lane.

Material was first placed on the beach in 1928 during the dredging of the Little Creek Inlet when over 800,000 cubic yards from the Little River was placed to the east and southeast of the new channel. Almost all material placed on the beach has come from dredging of the Little Creek entrance and forebay area with the exception of 20,000 cubic yards of sand from an upland site placed just west of the jetties (Hobbs et al. 1982). A recent city-initiated small fill project was conducted at the eastern extreme of the project area where 22,000 cubic yards of fill was placed in front of a public parking lot threatened with undermining. The volume and design of beach nourishment for this project has yet to be determined.

A location of concern is Sarah Constant Park, to the east of the project area. This preserved natural dune area contains the locally rare live oak (Quercus virginiana) and the only remaining extensive stand of the Virginia pinweed (Lechea maritima var. virginia) in the state. The park probably provides habitat for a variety of nesting birds and other wildlife as well. Beach nourishment would help protect the dunes from storm damage.

Buckroe Beach

The project area is in the City of Hampton and extends from the Buckroe Beach Fishing Pier to Pilot Avenue. Surrounding development is residential with apartment buildings and single family homes. Historically, recreational use was once augmented by an amusement park which was torn down several years ago. This area receives heavy use by beachgoers during the summer.

Buckroe Beach has been nourished periodically in the past. Sand dredged from Willoughby Bank adjacent to Fort Wool was placed here after it was no longer needed for the construction of the second Hampton Roads tunnel (Hobbs et al. 1982). The City of Hampton was issued a permit to place lines of sandbags below the mean low tide in 1983 to facilitate sand accretion and has recently been issued a permit (Army Corps of Engineers Permit #88-1787-12) to place sand along 7,950 feet of beach including Buckroe, Salt Ponds, and Grandview Beaches between 1989 and 1992. The nourishment design considered in this report calls for placing 40,000 to 140,000 cubic yards of sand along a distance of 3,470 feet of beach to create a berm 50 to 150 feet wide.

Salt Ponds

The project area is in the City of Hampton and extends from the Salt Ponds Inlet south to the private property line (Figure 1). Current development consists of single family homes, and future development is restricted by the limited area of the neck of land between the Salt Ponds and Chesapeake Bay. Commercial use consists of a few small fishing boats moored in the Salt Ponds.

The Salt Ponds area has been improved previously with the construction of jetties and the dredging of an inlet. Modification and maintenance of the inlet has involved placing sediment dredged from the inlet on surrounding beaches and bypassing sand from above the updrift jetty to below the downdrift jetty. The currently considered beach nourishment design calls for 50,000 to 250,000 cubic yards of sediment to be placed along 3,330 feet of beachfront to create a berm 50 to 150 feet wide.

White Marsh

The project area is in the City of Hampton and extends between the Salt Ponds Inlet and the Grandview Fishing Pier to the north (Figure 1). This stretch of beach is undeveloped along the proposed nourishment area. Recreational facilities to the north are the fishing pier and a campground. Low density single family homes are found beyond the pier. The wetlands just inland provide substantial wildlife habitat. Beach nourishment of White Marsh would involve the placement of 25,000 to 300,000 cubic yards of material along 4,500 feet of beachfront to create a berm 50 to 150 feet wide.

Grandview Natural Preserve

The project area is in the City of Hampton to the south of the mouth of the Back River. Nourishment would take place along a stretch of 15,350 feet between Factory Point to the north and the private property line to the south and would include the majority of the Preserve shoreline. The Preserve is currently undeveloped, with no parking facilities. Access to the beach is by a mile-long dirt road. Plans are under consideration by the City of Hampton to improve public access to the beach.

The Grandview Natural Preserve contains a wide variety of relatively undisturbed wetlands, beach/dune habitats, and associated wildlife species. It is one of the few remaining examples of undeveloped Chesapeake Bay shoreline. The U.S Fish and Wildlife Service has placed the Grandview area in Resource Category 1, meaning that the habitat is high value, unique, and irreplaceable in the ecoregion and nationally. The Service's goal for Resource Category 1 is no loss of existing value. In addition to many uncommon birds which can be observed, several colonial shorebirds nest at the northern tip of the peninsula, including the Federally threatened piping plover (Charadrius melodus). The Virginia listed endangered Wilson's plover (Charadrius wilsonia) was observed foraging on the beach in May 1989. The northern beach tiger beetle (Cicindela dorsalis dorsalis), a Category 1 Federal candidate, was observed here in July 1989. The Service is currently in the process of preparing documentation for proposing endangered status for this species. The area is used by numerous waterfowl and songbirds during migration or for overwintering. The beach is backed by a substantial dune system which will provide sand so that the beach will reach equilibrium with the physical conditions, such as sea level and wave energy. The beach is an example of a healthy, dynamic system. In the absence of development, beach nourishment would provide only minor benefits while disrupting a food web which supports the piping plover and many other wildlife species.

Yorktown

The project area is in Yorktown, York County just to the east of George P. Coleman Memorial Bridge (Figure 1). The historical area contains several museums, restaurants, and other tourist-oriented concessions. Nourishment would extend from in front of the post office southeast to an existing stone breakwater. The nourishment design consists of placing 11,000 to 17,000 cubic yards of material along 1,330 feet of shoreline to create a beach width of 40 to 60 feet.

RECOMMENDATIONS

Beach nourishment will initially cause extensive damage to the shoreline invertebrate community and less extensive effects to the offshore inhabitants due to turbidity. The damage is expected to be temporary, and recolonization and recovery of the communities should take place rapidly. The following recommendations will help minimize damage, specifically to invaluable wildlife habitat and endangered species.

1. The biological quality of most of the sites has previously been compromised by heavy recreational use and periodic nourishment and is less of a concern. However, this is not true of Grandview Natural Preserve. We strongly recommend that nourishment not take place on the Grandview Natural Preserve so that the integrity of the habitat and the food web will be maintained.

2. If nourishment is to take place on Grandview Natural Preserve, it should be scheduled to avoid the piping plover nesting period (mid-March through the end of July).

3. If nourishment is to take place on Virginia Beach and Sandbridge during the loggerhead turtle nesting season (June to August, but incubation can last until October), beaches should be searched for nests by trained professionals with appropriate permits (Virginia Institute of Marine Science staff under Jack Musick or Service personnel at Back Bay National Wildlife Refuge) so that eggs can be removed before material is placed on the beach.

4. Nourishment should only be conducted using material that is compatible in grain size with the original material on the beach. Fine grained material from the extreme eastern area of the Thimble Shoal Channel should not be used.

5. Material should be placed on the beach so that the profile created on the seaward side of the berm is similar to the original profile to maintain habitat types in similar proportions.

6. As much as possible, reduce or avoid the use of heavy earth moving equipment and allow waves, tides, and currents to distribute the material. The more natural habitats created will allow accelerated recolonization of species. Avoid excessive mounding of the material by moving the discharge pipe at appropriate intervals.

7. The beginning and end of the widened nourished area should be tapered gradually to the unnourished area to reduce erosion.

8. As much as possible, schedule dredging and nourishment for fall and winter months to reduce impacts during the time of year with higher levels of biological activity.

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