FEASIBILITY REPORT AND ENVIRONMENTAL ASSESSMENT ON SHORE AND HURRICANE WAVE PROTECTION

WRIGHTSVILLE BEACH NORTH CAROLINA

Army Corps
Engineers
Wilmington District

SEPTEMBER 1982

SADPD-P (10 Dec 82) 1st Ind
SUBJECT: Wrightsville Beach, North Carolina - 13004

DA, South Atlantic Division, Corps of Engineers, 510 Title Bldg, 30 Pryor St., S.W., Atlanta, Georgia 30303 17 December 1982

TO: Resident Member, Board of Engineers for Rivers and Harbors, Kingman Building, Fort Belvoir, Virginia 22060

I concur in the recommendations of the District Engineer.

JAMES B. HALL
Colonel, CE
Acting Commander

DEPARTMENT OF THE ARMY
WILMINGTON DISTRICT, CORPS OF ENGINEERS
P. O. BOX 1890
WILMINGTON, NORTH CAROLINA 28402

IN REPLY REFER TO

FEASIBILITY REPORT
AND
ENVIRONMENTAL ASSESSMENT
ON SHORE AND HURRICANE WAVE PROTECTION

WRIGHTSVILLE BEACH
NORTH CAROLINA

SYLLABUS

This Feasibility Report presents the results of a study conducted to address the need for beach erosion control, hurricane protection, and related purposes at Wrightsville Beach, North Carolina.

Wrightsville Beach is located on the Atlantic Ocean in New Hanover County. It has a permanent population of about 3,000 and a peak summer population of about 25,000. The beach within the existing shore protection project is publicly owned and constitutes 20 percent of the beach area in the State that is readily accessible and open to free public access. Continued existence of the beach and dune system is of vital importance to the economic security and community stability of Wrightsville Beach.

There are records of many hurricanes dating back to the early 1700's that have caused severe damage in the Wrightsville Beach area. Most recently, heavy property damage resulted from hurricanes occurring in 1944, 1954, 1955, 1958, and 1960.

In 1965 the Federal Government, under authority contained in PL 82-874, constructed a shore and hurricane wave protection project along 14,000 feet of the ocean shoreline extending north from Masonboro Inlet. This project includes a dune and berm system that protects against hurricane wave action from a 35-year storm. Also included was Federal aid for periodic nourishment for a 10-year trial basis to determine the technical viability of periodic nourishment. The 10-year trial basis began in 1970 when the project was considered officially completed and was turned over to the local sponsor, the town of Wrightsville Beach. After the 10-year period, which ended after the most recent project restoration (November 1980 to April 1981), the project was reexamined in this study to determine if Federal participation in periodic nourishment is the most efficient and economic solution.

Since completion of this project, erosion has been about five times greater than anticipated. A shore processes analysis shows that about 46 percent is induced by the Masonboro Inlet navigation project. The remainder is due to natural causes, including the increased erosion induced by an anomaly in the beach alignment. Mitigation of the Masonboro Inlet navigation project damage has been performed under authority contained in Section 111 of PL 90-483. The remaining 54 percent deficit in the sand budget will result in gradual and continual deterioration in the effectiveness of the existing project to a point where a significant threat to life and property will exist.

Nonstructural and structural alternative solutions were considered and evaluated independently as well as in various combinations. This included extension of the authorized project, relocation of the building line, property acquisition, flood proofing, construction of small floodwalls, and Federal participation in beach nourishment for the project life. All plans, with the exception of continued Federal participation in beach nourishment, were found to lack economic feasibility.

Our reanalysis of the existing shore and hurricane wave protection project bears out continued Federal interest since it is the most efficient and economic solution. Therefore, the recommended plan is for continued Federal aid for periodic nourishment throughout the life of the project. The plan is also considered environmentally acceptable. Impacts to significant resources will be minor and temporary in nature.

Average annual costs are estimated at $668,000. Maintenance costs consisting of periodic beach nourishment will be shared evenly by the Federal Government and local sponsor. The Federal share is estimated at $311,000 and the non-Federal share is estimated at $311,000. Maintenance costs consisting of periodic berm and dune maintenance will be the responsibility of the local sponsor and are estimated at $46,000. Therefore, the total share for the Federal Government is $311,000 and $357,000 for the local sponsor. The average annual benefits are estimated at $910,300. The recommended plan has a benefit-to-cost ratio of 1.36 and is, therefore, considered economically justified.

FEASIBILITY REPORT

WRIGHTSVILLE BEACH, N.C.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

LIST OF APPENDIXES

SECTION I - INTRODUCTION

Study Authorization

The authority for this study is contained in a resolution of the Committee on Public Works of the U.S. House of Representatives, dated 2 December 1970. The resolution was initiated by Congressman Alton Lennon, and requested the Secretary of the Army to direct the Office of the Chief of Engineers to make a survey of "Wrightsville Beach, North Carolina and adjacent beaches in the interest of beach erosion control, hurricane protection and related purposes, including oceanic and lagoonal shores and interconnected tidal channels."

A notice of this resolution was forwarded to the Chief of Engineers, Washington, D.C., 2 December 1970. On 5 December 1970 the Chief of Engineers assigned the study to the South Atlantic Division (SAD) which, in turn, assigned the study to the Wilmington District, 18 February 1971. Funds to initiate the study were made available 1 October 1977.

Scope of the Study

The scope of the study, in accordance with the study authority, will address the identification of needs and development of plans related to beach erosion control and hurricane protection at Wrightsville Beach. The scope of the study will also encompass the range of economic, environmental, and other impacts associated with implementation of shore protection improvements.

Study Participation and Coordination

A public meeting was held on 18 April 1978 at Wrightsville Beach to provide the public an opportunity to express their views concerning the need for shore protection at Wrightsville Beach.

Also, during the course of preparation of this Feasibility Report, coordination has been carried out with the United States Department of the Interior, Fish and Wildlife Service; the North Carolina Department of Natural Resources and Community Development: and other Federal and State agencies having responsibilities and interest related to this study.

In addition to studies conducted by the Wilmington District, an analysis of the project was submitted by the U.S. Fish and Wildlife Service and is attached as appendix E of this report.

The Report and Study Process

This document is basically structured in accordance with the four functional planning tasks: (1) Problem Identification, (2) Formulation of Alternatives, (3) Impact Assessment, and (4) Evaluation. The report consists of a main report and supporting appendixes. The environmental assessment is included in the main report.

SECTION II - PROBLEM IDENTIFICATION

Problem identification is the first of four planning tasks described in the preceding paragraph. This task is undertaken to determine what problems exist and should be addressed by the Federal Government, what geographic study area will be affected, and what the ultimate goals of the study should be.

This section includes (1) a statement of National Objectives, which describes the Federal interest in Wrightsville Beach; (2) identification of public concerns; (3) analysis of resource management problems; (4) delineation of the study area; and (5) development of planning objectives.

National Objective

The Chief of Engineers, under authority contained in a resolution of the Committee on Public Works of the U.S. House of Representatives, dated 2 December 1970, has authority to undertake studies related to shore protection. The Federal objective in water resources planning is the enhancement of the National economic development. Projects formulated under this objective must be cost effective, environmentally sound, and in the best public interest with National Economic Development as the principle objective.

Public Concern

Local interests have expressed a need for shore protection at Wrightsville Beach, consisting of continued Federal participation in the existing shore protection project, extension of the existing project northward 2,800 feet, and erosion control along the estuarine shoreline.

Resource Management Problems

Wrightsville Beach has had a history of erosion problems and experienced heavy property damages as a result of hurricanes occurring in 1944, 1954, 1955, 1958, and 1960. The beach and adjacent waters represent many natural values which should be preserved or enhanced. This is the basis of the resource management problems which this Feasibility Report will address.

Study Area

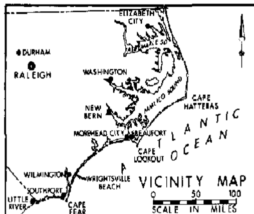
The specific area included in this study, as authorized by the 2 December 1970 congressional resolution, consists of "Wrightsville Beach and adjacent beaches ... including oceanic and lagoonal shores and interconnected tidal channels." The actual physical boundaries of the study area are: the Atlantic Ocean on the east, the Atlantic Intracoastal Waterway (AIWW) on the west, Mason Inlet on the north, and Masonboro Inlet on the south. With the exception of the northernmost 1,600 feet of the barrier beach island south of Mason Inlet, the entire study area is also within either the corporate limits of the town of Wrightsville Beach or the immediately adjacent zone of "extraterritorial jurisdiction." Figure 1 shows the study area and the referenced physical features and boundaries. The problems and needs of the study area are also viewed in the broader context of the southeastern region of the State which, in addition to New Hanover County, includes Brunswick, Bladen, Columbus, and Pender Counties.

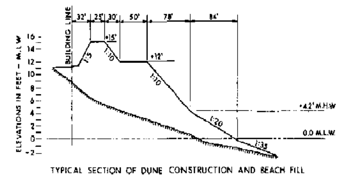
Existing Conditions

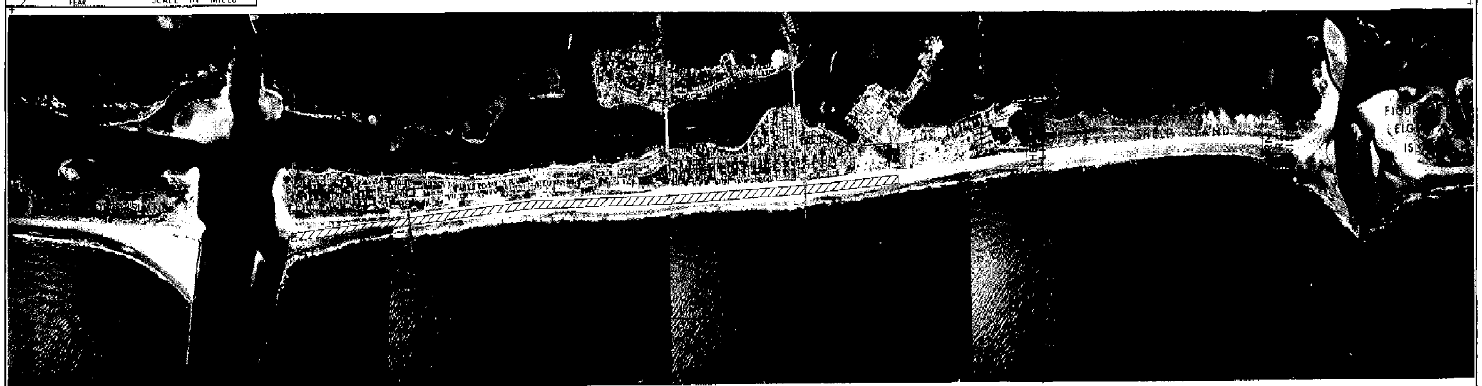
The purpose of this report section is to provide a general overview of the study area, prior corrective actions, other studies, and a discussion of significant resources identified therein.

General Overview and Prior Corrective Actions

The town of Wrightsville Beach is comprised of two units, the estuarine island known as Harbor Island and the barrier island of Wrightsville Beach. The former has an area of 293 acres, with 3.5 miles of shoreline exposed to current and wave activity. The latter has an area of 354 acres, with 16,800 feet (3.2 miles) of oceanic shoreline and 16,000 feet (3.0 miles) of estuarine shoreline within the town's corporate limits. The total length of ocean shoreline along the barrier island is about 23,000 feet (4.5 miles).







WRIGHTSVILLE BEACH, N.C. AND VICINITY

STUDY AREA

AERIAL PHOTOGRAPHY SEP 81

FIGURE 1

Adjacent bodies of water include the Atlantic Ocean on the east, Banks and Mott Channels and the Atlantic Intracoastal Waterway (AIWW) on the west, Mason Inlet on the north, and Masonboro Inlet on the south. Shinn Creek on the south forms a hydraulic connection between the AIWW and Masonboro Inlet. To the north of Mason Inlet is Figure Eight Island; to the south of Masonboro Inlet is Masonboro Island.

Wrightsville Beach has evolved into an important recreational resource of the State of North Carolina since the latter part of the 19th century. In 1889, a link between the mainland and the barrier island was established with the completion of a trolley route spanning over a mile of wetlands and estuarine channels, and extending south along the beach. This system was the only means of access to the barrier island, other than by boat or foot bridge, until the completion of a passenger car bridge to the island in 1935. The final trolley run took place in 1939.

Today Wrightsville Beach is accessible by two U.S. highway routes. It has a permanent population of about 3,000 and a population on peak summer days which has been estimated to approach 25,000, including day visitors. The 14,000 feet of beach within the shore protection project limits are publicly owned and constitute 20 percent of the State and municipal ocean beach frontage in North Carolina readily accessible and open to free public access. Continued existence of this beach in a stable and esthetically pleasing condition is of vital importance to the economic security and community stability of the town of Wrightsville Beach. The shore protection project directly provides a large measure of recreational and protective benefits to the town, as well as a recreational resource to a far greater number of people from the adjoining region and beyond.

Wrightsville Beach has had a history of erosion problems dating from the earliest attempts to build within this dynamic barrier island zone. Local interests began attempts to control erosion in 1923 when the town, with assistance from New Hanover County and the Tidewater Power Company, constructed five timber groins along the middle 6,400 feet of the ocean shoreline. In 1925, six reinforced concrete groins were added, with three to the north and three to the south of the timber groins. The wooden groins functioned satisfactorily until about 1928, by which time attacks by marine borers had partially destroyed them. The concrete groins were temporarily successful at the southern end of the island, but those at the northern end were eventually flanked and destroyed. Then in 1939 the town, with the assistance of PWA funds, constructed 16 creosoted timber groins, each about 325 feet long and spaced about 800 feet apart. In addition, 700,000 cubic yards (cu.yds.) of sand fill were placed on the beach to replace some of that lost to erosion.

Wrightsville Beach experienced heavy property damages as a result of hurricanes occurring in 1944, 1954, 1955, 1958, and 1960. Erosion caused by these hurricanes necessitated the placement of a total of about 500,000 cu.yds. of sand dredged from Banks Channel in four separate operations between 1955 and 1959.

The involvement of the Federal Government in providing long-term beach stabilization began in 1962 when Congress (P.L. 87-874) authorized the construction of a combined beach erosion control/hurricane protection project along the 14,000 feet of ocean shoreline extending north from Masonboro Inlet, which corresponded to the then-existing town limits. The project was constructed in 1965. The dune section had a design width of 25 feet at the crest at an elevation of +15 feet mean low water datum (MLW), with the landward toe of the dune on or near the town building line. The berm section had a design width of 50 feet at an elevation of +12 feet MLW. A total of about 2,993,000 cubic yards of sand from Banks Channel was used in the initial construction, which included both the closure of Moore Inlet, located at about C.E. baseline station 150+00, and advance nourishment along a 2,800-foot section of beach north of the authorized project limit. Following closure of the inlet, Wrightsville Beach extended its town limits northward to include this 2,800 feet of beach. This action created the present situation in which the town limits include 16,800 feet of beach north of Masonboro Inlet (to Station 168+00), whereas the Federal shore protection project limits include only 14,000 feet of beach north of the inlet (to Station 140+00).

Construction of the northern of the two Masonboro Inlet jetties, which were authorized in 1949, took place between July 1965 and June 1966. During the period 1965 to 1970, the shore protection project suffered an unexpectedly high rate of erosion of the sand fill, particularly along the northern 7,000 feet of the project shoreline. This erosion could not be totally accounted for in terms of slope adjustments or sorting action on the fill. Continued severe erosion necessitated the dredging and placement of about 1.4 million cubic yards of fill on the shore protection project in the spring of 1970, after which the project was considered officially completed and was turned over to the local sponsor, the town of Wrightsville Beach. No additional fill was placed on the project until April 1980. At that time, an emergency fill, consisting of approximately 500,000 cubic yards of sand, was placed along the northern 7,000 feet of project shoreline under Public Law 84-99 authority. Upon completion of this work in May 1980, the northern half of the project still offered only a portion of the protection for which it was designed.

Between December 1980 and April 1981, a complete restoration of the authorized shore protection project was performed, returning it to the design configuration and level of protection for which it was authorized. This restoration required the dredging and placement of about 1.25 million cubic yards of sand, obtained from Masonboro Inlet and distributed along the northern 7,000 feet of project shoreline. The restoration was completed using a combination of funds, including:

o Federal Construction, General funds for periodic nourishment of the project shoreline. (Under existing authority, this nourishment represented the last time that the Federal Government could participate in the cost-sharing of nourishment. The question of modifying existing authority to allow continued Federal participation for the project life is addressed as a part of this study.)

o Non-Federal cash contribution.

o Section 111 funds (to mitigate erosion damage of the Wrightsville Beach shoreline judged to have been caused by the Federal navigation project at Masonboro Inlet).

o Masonboro Inlet Navigation Project Operation and Maintenance (O&M) funds (for restoration of project depths and channel alignment).

Prior to construction of the project in 1965, it was anticipated that periodic nourishment of the berm and dune would be essential to achieve expected benefits of hurricane flood protection and beach erosion control In fact, the Feasibility Report and subsequent Design Memorandum for the project stipulated an estimated annual beach nourishment rate of 1.8 cubic yards of sand per lineal foot of beach, for a net annual volume of 25,200 cubic yards. In addition, maintenance of the berm at +12 feet MLW would require 0.4 cubic yard per lineal foot, or a net 5,600 cubic yards annually along with about 1,000 cubic yards annually for dune maintenance. Thus, an annual requirement of about 32,000 cubic yards of fill material was anticipated prior to project implementation.

The actual erosion rate experienced along the project shoreline was about five times greater than the estimated 32,000 cubic yards per year. The determination of an average annual erosion quantity of 167,000 cubic yards per year was made as part of an analysis of shore processes for a 19-mile segment of coast including Wrightsville Beach and Masonboro Inlet. This analysis was submitted in October 1977 as a technical appendix to the General Design Memorandum (GDM) for the Masonboro Inlet south jetty. The GDM was approved by SAD in February 1978. The analysis indicated that 155,000 of the 167,000 cubic yards of annual erosion losses were the result of the Masonboro Inlet north jetty reducing natural sand bypassing at the inlet. To mitigate this jetty-induced erosion, a plan was developed in which material would be dredged from the deposition basin adjacent to the north jetty and placed along the affected reach of Wrightsville Beach shoreline at an average rate of 155,000 cubic yards per year. Masonboro Inlet navigation project O&M funds would be utilized to perform this work. The balance of 12,000 cubic yards per year was identified as the historic, natural erosion component. Replacing this portion of the computed 167,000 cubic yards per year sand deficit at Wrightsville Beach would be a cost allocated to the shore protection project.

The shore processes analysis in the Masonboro Inlet South Jetty GDM was limited in that the assumptions dictated that all the erosion losses off Wrightsville Beach were attributed to either the navigation project at Masonboro Inlet or historical losses. However, recognition was given to the possible existence of other factors which could be contributing to the erosion, specifically, the anomalous convex shape of the Wrightsville Beach shoreline.

The convex shape of the Wrightsville Beach ocean shoreline, as shown by figure 1, is primarily due to Moore Inlet which was closed during the initial placement of the hurricane and shore protection fill in 1965. Moore Inlet, which was located between Station 140+00 and the present northern town limits of Wrightsville Beach (see figure 1), had existed as the northern boundary of the town since the mid-1800's and characteristically had caused the shorelines immediately north and south to curve seaward. When development began to spread northward along Wrightsville Beach, roads and houses were built more or less parallel to the shoreline existing at that time. Also, the town building line was established seaward of the development and parallel to the shoreline. Consequently when the hurricane and shore protection project was constructed, the fill was placed seaward of the development and the town building line thus producing the present convex or bulbous shoreline configuration.

Since the normal shape of barrier islands in the vicinity of Wrightsville Beach is concave, there is a natural tendency for normal shore processes to reshape the beach planform to an alignment more compatible with prevailing waves, currents, and inlet positions. In appendix D, a detailed examination was made of the effects of the bulbous shoreline shape on erosion losses off Wrightsville Beach, as well as a complete reexamination of the historical losses and losses attributable to the Masonboro Inlet navigation project. The results of this analysis were as follows:

(a) Total rate of erosion . . . . 130,000 cu yds/yr

(b) Historical losses, i.e., losses occurring prior to project construction. . . . . 29,000 cu yds/yr

(c) Losses due to the bulbous shoreline . . . . . 41,000 cu yds/yr

(d) Losses due to the navigation project at Masonboro Inlet . . . . 60,000 cu yds/yr

Most of the erosion losses on Wrightsville Beach are occurring north of Station 50+00 (see figure 1), while the southern 5,000 feet, which constitutes the accretion fillet adjacent to the north jetty at Masonboro Inlet, only experienced minor losses during the time period selected for the shore processes analysis. Even though the fillet did experience some erosion, this trend will not continue indefinitely due to the stabilizing effect of the Masonboro Inlet north jetty. The north jetty has a low weir section which allows southward moving littoral sediments to pass over and deposit in a deposition basin from which they will be removed during sand bypassing operations. Since the north jetty does not present a complete littoral barrier, minor fluctuations in the position of the fillet shoreline are to be expected. Over a long period of time, however, the fillet will remain stable both in width and length north of the jetty.

The stability of the fillet is independent of Wrightsville Beach receiving any artificial nourishment. For example, the minor erosion of the fillet that was computed for the shore processes analysis occurred between 1968 and 1979. However, in 1970, Wrightsville Beach was nourished with 1,377,000 cu. yds. of fill which was placed north of Station 50+00. Since the fillet did not buildup following this nourishment operation, it was obvious that material moving south out of the fill area and onto the fillet was being carried past the fillet and into Masonboro Inlet by normal shore processes. Also, in evaluating the effects of the bulbous shoreline on erosion rates, a normal shoreline configuration was obtained for Wrightsville Beach by analyzing the shape of natural barrier islands in the general vicinity of the study area. This normal shoreline, which was assumed to represent the ultimate quasi-equilibrium planform of the entire beach between Masons Inlet and Masonboro Inlet, coincided with the existing alignment and position of the shoreline along the 5,000-foot fillet. Therefore, even if Wrightsville Beach does not receive any additional nourishments, the southernmost 5,000 feet of the project shoreline will remain in essentially its present location.

The long-term costs of replacing erosion losses induced by the north jetty will be allocated to the navigation project. The long-term costs of replacing erosion losses related to project alignment and natural erosion will be allocated to the shore protection project.

Other Studies

Section 111 Report, Wrightsville Beach, N.C.: This report, approved 2 Oct 1980, recommended the application of Section 111, PL 90-483, to mitigate shoreline damages at Wrightsville Beach caused by the Federal navigation project at Masonboro Inlet. Mitigation would be accomplished by placement of dredged sand fill on the affected shoreline in conjunction with the restoration of the shore protection project and the Masonboro Inlet channel presently underway.

PL 84-99 Report, Wrightsville Beach, N.C.: This report, approved 17 January 1980, recommended application of PL 84-99 authority to provide emergency rehabilitation to the shore protection subsequent to erosion damage suffered during Hurricane David 4-5 Sep 1979. Rehabilitation was cost-shared with non-Federal interests.

Masonboro Inlet, South Jetty GDM: This memorandum, approved 1 February 1978, contained an analysis of shore processes for a 19-mile segment of the North Carolina coast from Wrightsville Beach south to Kure Beach. This analysis specifically identified the north jetty at Masonboro Inlet as inducing a net sand deficit at Wrightsville Beach of 155,000 cubic yards per year, and 184,000 cubic yards per year along Masonboro Island, and raised the issue of possible applicability of Section 111 (PL 90-483) authority to Wrightsville Beach.

Unfavorable Report: A report on hurricane protection, Bogue Inlet to Moore Inlet, North Carolina (House Document No. 480/89/2) transmitted to Congress in August 1966, found hurricane protection to be of no public benefit along the undeveloped islands within the study area. However, there has been an increase in residential and commercial development (Holiday Inn Motel constructed at location of Moore Inlet which was closed in 1965 by private developers and Islander Condominium constructed just south of old Moore Inlet). The increased development and increased recreational activity have caused the public interests in seeking remedial measures for the study area.

Wrightsville Beach Hurricane Protection Project: The report on a hurricane protection study of Wrightsville Beach, North Carolina (House Document No. 511/87/2) transmitted to Congress in August 1962 recommended the authorized and completed berm and dune project at Wrightsville Beach. This project extends from Masonboro Inlet to the northern town limit, a distance of 14,000 feet. Since completion of the project, the northern town limit has been extended 2,800 feet which has prompted the request by locals for an extension of the berm and dune project.

Masonboro Inlet and Connecting Channels: The report on a navigation study of Masonboro Inlet and Connecting Channels (HD 341/81/1) transmitted to Congress Sep 1949 recommended the currently authorized project. The north jetty was completed in 1966. The south jetty was completed in 1980.

Socioeconomic Resources

The following is an overview of economic and social conditions of New Hanover County, the socioeconomic study area. Both Wrightsville Beach and the city of Wilmington, North Carolina's largest coastal city and port, are situated in New Hanover County. With its largely urban character, New

Hanover County is the primary market for Wrightsville Beach day use.

Base Socioeconomic Conditions. The population of New Hanover County grew at an annual rate of 2.2 percent during the period 1970-1980, reaching 103,471 in 1980, and having a population density of 559.3 per square mile. For the period 1970-1975, net migration was +10.8 percent. In 1970, the percentage of urbanization in New Hanover County was 69.5, less than the United States average of 73.5, but greater than the North Carolina average of 45.0.

In 1970, the median education level for persons 25 years old and over in New Hanover County was 12.0. The percentage of high school graduates in the group was 50.

In 1978, per capita income in New Hanover County was $6,728, slightly higher than the North Carolina per capita income of $6,640. During the period 1970-1978, real per capita income increased at an annual rate of 2.81 percent. In 1979, the civilian labor force numbered 46,490, of which 43,690 persons were employed and 2,800 persons, or 6 percent were unemployed. During the period 1970-1979, employment in New Hanover County grew at an annual rate of 3.45 percent, a growth rate higher than the 2.2 percent for population. In 1979, 24 percent of all employed persons in New Hanover County worked in manufacturing industries. Of the 76 percent in nonmanufacturing industries, one-third worked in the trade industry, and one-fourth worked for a government.

The 1980 permanent population of Wrightsville Beach was 2,910, a 71.1 percent increase over the 1970 permanent population. In 1980, the estimated summer population was 8,024, excluding day visitors.

Natural Resources

During the course of this study, significant resources were identified and evaluated as follows:

Seashore Area.

Within the town limits of Wrightsville Beach, there are many acres of high quality seashore area available for recreation activities, i.e., sunbathing, surf fishing, walking, jogging, bird watching, shell collecting, etc. This intertidal zone also serves as habitat for an invertebrate community adapted to the high energy sandy beach environment. The organisms which make up this community, i.e., mole crabs, coquina clams, amphipods, isopods, and polychaetes, are an important food source for surf feeding fish populations such as flounder, croaker, red drum, black drum, spot, northern kingfish, and pompano.

Invertebrate Species Occurring in Borrow Areas.

Masonboro Inlet and the portions of Banks Channel south of channel marker 14 are considered to be prime borrow sites because of the excellent composition of the sediment and sparse populations of benthic invertebrates. Both of these sites were used to obtain the nourishment material for the restoration project undertaken during the winter of 80/81. Prior to that dredging, common macroinvertebrates inhabiting these areas included the hemichordate worms, Balanoglossus auranticus and Saccoglossus kowlevskii, the razor clam Ensis directus, the bivalves Dosinia, Tellina, and Mercenaria mercenaria (U.S. Fish and Wildlife Service, 1979). Sampling of these areas has not occurred since the dredging took place; however, it can be safely assumed that populations of benthic invertebrates have begun to recolonize the areas although they may have different levels of abundance and different community structures. Due to the shifting sand bottom and past history of disturbance at these sites (for maintenance dredging of navigation projects as well as for beach nourishments), it is unlikely that they have been able to establish stable benthic communities in recent years.

Water Quality.

The water quality in the vicinity of the borrow sites is good. Banks Channel has a classification of SB (suitable for bathing). Masonboro Inlet has a classification of SA (suitable for shell fishing for market purposes). The high quality of the water in these areas can be attributed to tidal flushing and distance from any major pollution sources. The town of Wrightsville Beach prohibits the use of septic tanks.

Nonpoint pollution sources on Wrightsville Beach are not considered to be a major problem. Storm water from the community is removed by a separate storm drainage system which drains into the surrounding waters. Each storm water drain inlet structure has a trap for silt, grit, and trash, which is periodically cleaned and the debris treated as solid waste. Less than 10 percent of the rainfall that falls on the town enters the system due to the high absorptive capacity of the soils.

Fisheries Resources.

Recreational and commercial fishing in the vicinity of Masonboro Inlet and Banks channel are significant. These areas support both sport and commercial fisheries for such common saltwater finfish as black drum, croaker, pigfish, red drum, flounder, spot, black seabass, and bluefish. In addition, blue crab and penaeid shrimp are fished for both commercial and recreational purposes. Among other sport fish in the surf zone, northern kingfish, pompano, and spot are actively fished for, both from the beach and the two fishing piers located at Wrightsville Beach. Nearshore waters support an abundance of king mackerel, Spanish mackerel, and cobia.

Endangered Species.

Informal consultation as delineated in Section 7(c) of the Endangered Species Act of 1973, as amended, has been concluded with the Fish and Wildlife Service and National Marine Fisheries Service. The following list of species was considered in the biological assessment process:

Brown pelican (Pelicanus occidentalis)-E
Florida manatee (Trichechus manatus)-E
Blue whale (Balaenoptera musculus)-E
Finback whale (Balaenoptera physulus)-E
Humpback whale (Megaptera novaeangliae)-E
Right whale (Eubalaena spp)-E
Sei whale (Balaenoptera borealis)-E
Sperm whale (Physeter catadon)-E
Kemps ridley sea turtle (Lepidochelys kempi)-E
Hawksbill turtle (Eretmochelys imbricata)-E
Leatherback turtle (Derimochelys coriacea)-E
Shortnose sturgeon (Acipenser brevirostrum)-E
Loggerhead turtle (Caretta caretta)-T
Green turtle (Chelenia mydas)-T

Cultural Resources.

A cultural resources survey of Masonboro Inlet and Masonboro Island was conducted in connection with the construction of the South Jetty at Masonboro Inlet. During the exploratory phase of this survey (October through November 1977), five major magnetic anomalies were recorded. Two of the five are located in the vicinity of the Masonboro Inlet borrow area. During April and May 1978, the N.C. Division of Archives and History made additional examinations of these two sites using a hydraulic probing device. By this method, it was determined that one of the sites is probably the remains of a relatively modern vessel lying below a plane of -14 feet m.l.w, although it is possible that the modern vessel is positioned over a site of earlier vintage. The other site was probed to a depth of -20 feet m.l.w. without encountering the anomaly (Watts et. al.).

The Banks Channel borrow site is not considered to offer any potential for submerged cultural resources as it was dredged below the depths which will be required for continued maintenance during initial project construction; therefore, all of the sediments in the area are of recent origin.

Terrestrial Resources.

Within the study area, the most significant terrestrial resources occur on the undeveloped portion of Shell Island and on the manmade and natural estuarine islands which occur in Wrightsville Sound. These areas offer the only significant sites of natural vegetation communities available for terrestrial wildlife.

An extensive, stable dune system comprises the undeveloped portions of Shell Island. Vegetated principally with grasses, its value to some species of wildlife is limited. Data on wildlife utilization of the area is sparse; however, the data which does exist indicates that Shell Island offers good habitat for many species of birds and small mammals.

Most of the manmade and natural estuarine islands of the area are heavily vegetated with shrubs and small trees. These islands are heavily used by marsh foraging mammals and birds. Unvegetated manmade islands have been heavily used in the past by colonially nesting seabirds; however, this use has tapered off in recent years due to the confinement of dredged material disposal to just a few locations, thereby permitting most of the previously bare sand islands to vegetate.

Wetlands.

Wetlands are extremely abundant in the study area with about 70 percent of its 2,800 acres being salt marsh and tidal creeks. The marshes of the area are comprised principally of *Spartina alterniflora*. The transition zone between the salt marsh and upland areas is dominated by *Spartina patens* with interspersed patches of *Distichlis spicata*, *Salicornia virginica*, and *Borrichia frutescens*. These wetlands are very important to the marine resources and wildlife of the study area due to their high primary productivity and refuge/foraging value. While no studies are known to have been done on the productivity of the salt marshes of the study area, the productivity for such marshes generally falls in the range of 329 to 1,296 dry wt/m^2/yr (Keefe 1972). When this is combined with the additional productivity of approximately 100g carbon/m^2/yr for phytoplankton (Thayer 1971) and approximately 200g carbon/m^2/yr for benthic microalgae (Peterson and Peterson 1979), the high productivity of these systems becomes apparent.

Condition if no Federal Action is Taken

The purpose of this report section is to examine the differences between the base condition of the study area's significant resources and future conditions, based on existing trends, scientific judgments, and economic projections. This report section provides a basis of comparison for evaluating the impact of any plans of improvement which ultimately emerge from the study.

The base condition for analyzing the authorized Shore and Hurricane Wave Protection project is that the project, as originally requested, was for Federal aid for periodic nourishment for a 10-year trial basis. At the end of the 10 years the project would be reexamined to determine the technical viability of periodic nourishment and to determine if Federal participation in periodic nourishment is the most efficient and economic solution. The future condition of the project is described below.

Future Condition at Masonboro Inlet

Estimates indicate that the 60,000 cubic yards of sand, as determined in the shore processes analysis to be a navigation project responsibility, will be placed along the shoreline of Wrightsville Beach on an average annual basis by the Federal Government. (See plate 8 for details on the navigation project.)

Future Condition of Natural Resources

It is estimated that the Shore and Hurricane Wave Protection project will suffer an average annual deficit of 70,000 cubic yards of sand. This deficit will equal the total annual erosion rate minus the annual rate of material placed as a navigation project responsibility. It is important that the design profile for the berm and dune be maintained to provide maximum storm protection. The authorized Shore and Hurricane Wave Protection project was formulated for storm protection. It was designed to protect against wave action from a 35-year storm. This berm width is in excess of what is needed to support recreational benefits claimed.

Future Condition of Socioeconomic Resources

Accompanying the annual deficit of sand on Wrightsville Beach will be an annual decrease in the remaining level of shore protection, and a corresponding decrease in the width of public beach available for recreation. Thus, damages associated with the existing conditions can be expected to occur in the future. However, as discussed below, beach use demand in the Planning Area is projected to increase.

The 1990 through 2035 projections of populations, employment, and per capita income presented below are based on draft (1982) county disaggregations of State OBERS projections for North Carolina.

TABLE 1

New Hanover County

Year	1990	2000	2010	2020	2030	2035
Population	117,588	129,814	140,359	149.658	157,520	161,658
Employment	57,582	63,701	68,075	69,245	70,552	71,221
Per Capita Income (in 1972 dollars)	6,246	7,905	9,869	11,817	14,323	15,842

Wrightsville Beach

Year	1990	2000	2010	2020	2030	2035
Beach Day Visitation (Annual User Days)	593,200	878.000	1,299,700	1,512,900	1,512,900	1,512,900

Problems, Needs, and Opportunities

Based on the public concerns identified previously, there exists a need for shore protection improvements in the form of continued beach nourishment at Wrightsville Beach. This need has been verified through the analysis of existing conditions described briefly in the previous report section.

The concerns of agencies and individuals having interests and responsibilities related to environmental quality have also been verified. Studies by the Wilmington District, as well as the U.S. Fish and Wildlife Service indicates that the area does indeed possess significant natural resources which are important to the Nation's continued environmental quality.

Planning Objective

Based on the public concerns identified previously, and verified through an analysis of existing and probable future conditions, there is a need for shore protection at Wrightsville Beach. Therefore, shore protection at Wrightsville Beach is the planning objective.

The problem of estuarine shoreline erosion was a Stage I planning objective that was evaluated during Stage II, resulting in the following findings: a field survey showed that 71 percent of the shoreline bordering development was stabilized by some form of structure; the shoreline is privately owned; erosion of the unstabilized portions of the shoreline has largely been attributable to the effects of boat wakes; the Wildlife Resource Commission of North Carolina has the enforcement authority for no-wake zones; model studies at Masonboro Inlet indicated that velocities in Banks Channel were not increased enough by channel dredging to account for erosion experienced. Therefore, this planning objective was dropped during Stage II.

Future Condition of Natural Resources

It is estimated that the Shore and Hurricane Wave Protection project will suffer an average annual deficit of 70,000 cubic yards of sand. This deficit will equal the total annual erosion rate minus the annual rate of material placed as a navigation project responsibility. It is important that the design profile for the berm and dune be maintained to provide maximum storm protection. The authorized Shore and Hurricane Wave Protection project was formulated for storm protection. It was designed to protect against wave action from a 35-year storm. This berm width is in excess of what is needed to support recreational benefits claimed.

Future Condition of Socioeconomic Resources

Accompanying the annual deficit of sand on Wrightsville Beach will be an annual decrease in the remaining level of shore protection, and a corresponding decrease in the width of public beach available for recreation. Thus, damages associated with the existing conditions can be expected to occur in the future. However, as discussed below, beach use demand in the Planning Area is projected to increase.

The 1990 through 2035 projections of populations, employment, and per capita income presented below are based on draft (1982) county disaggregations of State OBERS projections for North Carolina.

TABLE 1

New Hanover County

Year	1990	2000	2010	2020	2030	2035
Population	117,588	129,814	140,359	149.658	157,520	161,658
Employment	57,582	63,701	68,075	69,245	70,552	71,221
Per Capita Income (in 1972 dollars)	6,246	7,905	9,869	11,817	14,323	15,842

Wrightsville Beach

Year	1990	2000	2010	2020	2030	2035
Beach Day Visitation (Annual User Days)	593,200	878.000	1,299,700	1,512,900	1,512,900	1,512,900

Problems, Needs, and Opportunities

Based on the public concerns identified previously, there exists a need for shore protection improvements in the form of continued beach nourishment at Wrightsville Beach. This need has been verified through the analysis of existing conditions described briefly in the previous report section.

The concerns of agencies and individuals having interests and responsibilities related to environmental quality have also been verified. Studies by the Wilmington District, as well as the U.S. Fish and Wildlife Service indicates that the area does indeed possess significant natural resources which are important to the Nation's continued environmental quality.

Planning Objective

Based on the public concerns identified previously, and verified through an analysis of existing and probable future conditions, there is a need for shore protection at Wrightsville Beach. Therefore, shore protection at Wrightsville Beach is the planning objective.

The problem of estuarine shoreline erosion was a Stage I planning objective that was evaluated during Stage II, resulting in the following findings: a field survey showed that 71 percent of the shoreline bordering development was stabilized by some form of structure; the shoreline is privately owned; erosion of the unstabilized portions of the shoreline has largely been attributable to the effects of boat wakes; the Wildlife Resource Commission of North Carolina has the enforcement authority for no-wake zones; model studies at Masonboro Inlet indicated that velocities in Banks Channel were not increased enough by channel dredging to account for erosion experienced. Therefore, this planning objective was dropped during Stage II.

SECTION III - FORMULATION OF PRELIMINARY PLANS

Formulation of plans to address the planning objective is the second of the four functional planning tasks described in the introductory section of this report. This section consists of three parts: (1) Management Measures, which describes the general approaches which might be used in addressing the planning objective; (2) Plan Formulation Rationale, which describes the basic assumptions and procedures used; and (3) Analysis of Preliminary Plans, which analyzes the plans considered and identifies those which should be retained for future consideration.

Management Measures

There are essentially two categories of management measures available to address the need for shore protection improvements at Wrightsville Beach. These consist of (1) structural alternatives, and (2) nonstructural alternatives.

The preliminary plans described in the following report sections include both structural and nonstructural alternatives, as well as a display of the economic advantages and disadvantages of each.

Plan Formulation Criteria

As noted previously, there exist two basic categories of management measures to address the planning objective: structural and nonstructural improvements. Preliminary plans based on these measures were developed and evaluated within a framework of Plan Formulation Criteria. These are set out below, followed by a description of the preliminary plans considered.

Technical Criteria.

1. Berm and dune designs were based on the design used for the existing shore protection project which was just recently renourished (April 1981) and is at the design level of protection.

Economic Criteria.

1. Plans 1A, 1B, 2, 3, 3A, and 4 were not updated from Stage II development because their benefit-cost ratios were far below unity (0.44 or less).

2. For Plan 5, an interest rate of 7-7/8 percent and a period of analysis of 50 years were used for computation of benefits and costs. The base year is 1987 and October 1982 price levels were used. As explained previously, the southern 5,000 linear feet of the authorized berm and dune project is projected to remain stable even if Wrightsville Beach does not receive any additional artificial nourishment.

3. Any alternative, to be considered implementable, must produce economic benefits which exceed economic costs.

Environmental and Other Criteria.

No commitment of resources will be made until required permits and entitlements have been obtained.

Description of Preliminary Plans

The preliminary plans presented in this report section were formulated utilizing both categories of management measures described previously: structural and nonstructural alternatives. Also, the preliminary plans varied in scope in that one plan included an evaluation of the existing shore protection project, another plan included a nonstructural analysis for Wrightsville Beach, while the remaining plans included both structural and nonstructural analysis for protection along the northern 2,800 feet of Wrightsville Beach which is presently unprotected. In all cases, the plan formulation criteria described previously were utilized in determining the economic, environmental, and technical feasibility of each plan.

Plans 1A, 1B, 2, 3, and 3A - Extension of the Authorized Shore Protection Project Northward.

Plan 1-A provides for the extension of the authorized shore protection project northward, a distance of about 2,800 feet, to protect the developed area immediately north of the existing project limits. The berm and dune fill would be constructed seaward of the present town building line along that section of shore (see plates 1 and 3). The benefit-to-cost ratio for this plan is 0.23, therefore, this plan is not economically feasible and is not recommended for further consideration.

Plan 1-B extends the authorized project northward the same distance as Plan 1-A, but requires the relocation of the building line and the oceanfront row of structures. This action would result in a less bulbous shoreline configuration, reducing erosion losses relative to Plan 1-A. In both Plans 1-A and 1-B, the proposed dune extension would tie into the existing natural dune to the north (see plates 2 and 3). The benefit-to-cost ratio for this plan is 0.24, therefore, this plan is not economically feasible and is not recommended for further consideration.

Plan 2. This plan combines the basic features of Plans 1-A and 1-B, with a requirement that any future development in the presently undeveloped section of the barrier island be required to locate landward of a proposed building line for the area. (See plate 4.) This plan was formulated with the intent that by proper planning and land management, the development of the rest of the Shell Island section could occur in a manner which maximized the available natural shore protection offered by the stable beach and large primary dunes, and thus precluded the need to consider further extension of the authorized shore protection project. This plan would have required that the Town of Wrightsville Beach, through its planning and zoning jurisdiction, establish the recommended building line as a condition for the project extension considered in Plan 1. If the regulatory approach to this question was found to be contrary to Corps policy, then an alternate approach would be considered. In this approach, an alternate site development plan would be formulated and evaluated to demonstrate that the site could be developed to the same or greater density (and profit) as envisioned by the owner/

developers, and yet in a manner which did not encroach on the large dunes which provide the last line of defense during storm events.

Since Plans 1-A and 1-B were found not to be economically feasible, Plan 2 will not be considered further in this investigation. However, all technical information developed by the Wilmington District in the course of formulating and evaluating Plan 2 will be presented to the town of Wrightsville Beach. If the town is successful in efforts to establish the recommended building line, no future need of extension of the authorized project will occur.

Plan 3. This plan combines the basic features of Plans 1-A and 1-B, with a recommendation that the entire presently undeveloped section of Shell Island be acquired for preservation in its natural state. (See plate 5.) Like Plan 2, Plan 3 was formulated to fulfill a planning objective, namely protection and enhancement of environmental and esthetic qualities of the remaining undeveloped section of barrier island in the study area. This objective derived from local citizen concerns, as well as from specific guidelines applicable to the conduct of Federal water resource planning investigations. In particular, 33 CFR, Part 239, "Implementation of E.O. 11988 on Floodplain Management" states in Section 239.6, "Objectives of the Order" that:

> "the Executive Order has as an objective the avoidance. . . of long and short term adverse impacts associated with the occupancy and modification of the base floodplain. . . whenever there is a practicable alternative. The Corps is required to provide leadership and take action to:
> [a] avoid development in the base floodplain unless it is the only practicable alternative.
> [b] reduce the hazard and risk associated with floods.
> [c] minimize the impact of floods on human safety, health and welfare.
> [d] restore and preserve the natural and beneficial values of the base floodplain." [underlining added for emphasis]

Additionally, it was considered that a scheme such as Plan 3 would be directly responsive to meeting the National objective of Environmental Quality, and thus be a candidate EQ plan for this investigation. In this regard, the acquisition of the remaining undeveloped barrier island would be considered a "separable EQ measure to meet established planning objectives," as outlined in ER 1165-2-28. This ER further states that "such separable EQ measures for Corps implementation must be related to, or take advantage of, opportunities created by a water resource development to be recommended for implementation by the Corps of Engineers." Had the authorized project extension considered in Plans 1-A or 1-B been found feasible and thus "a water resource development. . . for implementation by the Corps," then the preservation of Shell Island could have been evaluated as a "separable EQ measure" of the overall plan. However, because Plans 1-A and 1-B were found to be infeasible, the linkage between the "recommended water resource development" and the "separable EQ feature" no longer existed. Therefore, this plan will not be considered further in this investigation.

Plan 3-A. This plan was developed as an alternative to total preservation, which presumes a minimum level of disturbance and human activity in the area. (See plate 5.) Under Plan 3-A, the undeveloped Shell Island area would be acquired and managed for recreation use, which provides NED benefits not obtained in Plan 3. The estimated annual recreation benefit could then be compared to the equivalent annual cost of acquiring the land and managing it for recreational use. The benefit-to-cost ratio for this plan is 0.44; therefore, this plan is not economically feasible and is not recommended for further consideration.

Plan 4 - Nonstructural Flood Damage Reduction Measures

Plan 4. This plan involves the application of nonstructural flood damage reduction measures to existing development within the study area. The plan was formulated with the intent of providing protection against inundation damages accompanying up to a 100-year flood for every structure in Wrightsville Beach. The basic stage frequency relationship used in developing this plan is the N.O.A.A. curve of total tide height (feet m.s.l.) versus return period in years (see Plate 6). The still water elevation accompanying the 100-year storm is 13.1 feet m.s.l. The development of this plan as one of the major areas of study effort is directly responsive to the increasing National emphasis in water resource planning for the consideration of nonstructural approaches to flood damage problems. The benefit-to-cost ratio for this plan is 0.36; therefore, this plan is not economically feasible and is not recommended for further consideration.

Plan 5 - Evaluation of the Completed Shore Protection Project

Evaluation of Completed Shore Protection Project. This evaluation was added as a study objective during the latter part of this investigation, in view of the fact that authority for further Federal contribution toward the cost of project nourishment expired with the recently completed (April 1981) restoration. This expiration was in accordance with the terms of project cost sharing as specified in the original authorization (H.D. 511, PL 87-874, 22 October 1962) but inconsistent with Federal shore protection projects authorized after 1975. Since that date, Federal participation in the cost of beach nourishment has been authorized for project life. This is an analysis of the existing Wrightsville Beach shore protection project with respect to two basic areas, namely:

o Study Area Shore Processes - specifically, a determination of the present erosion rate at Wrightsville Beach and the relative magnitudes of the factors which contribute to the erosion problem.

o Economic feasibility of continued beach nourishment for project life.

Economic Evaluation: Costs. As indicated earlier, the primary purpose of the shore processes analysis is to establish a better quantification of the causative factors related to the erosion of the shore protection fill, namely:

(1) Erosion attributable to the effects of the Masonboro Inlet navigation project (specifically, the jetties) in reducing the rate of natural sand bypassing to Wrightsville Beach. The placement of this 60,000 cubic yards of sand onto Wrightsville Beach will be considered an annual cost in the operation of the navigation project.

(2) Erosion attributable to the previously described unstable, convex-seaward alignment of the shore protection project which is estimated to be 41,000 cubic yards of sand per year.

(3) Erosion attributable to natural processes. This will be equal to the historic erosion rate prior to man-induced changes at Masonboro Inlet and Wrightsville Beach which is estimated to be 29,000 cubic yards of sand per year.

The total of the erosion rates determined for items (1), (2), and (3) is 130,000 cubic yards and the average annual quantity of sand required to maintain the shore protection project at the design level of protection. Item (1) will be a navigation project cost. The sum of items (2) and (3), the alignment-related and natural erosion components, respectively, will represent the average annual quantity of sand allocated as a responsibility of the shore protection project. The cost of replacing the latter quantity of sand will then represent the equivalent average annual cost of nourishment for the project life. Discussion of the average annual costs to be allocated to the shore protection project will be presented first, followed by a discussion and summary of the benefits derived from continued project nourishment.

There are two additional terms used in the following discussion which should be defined to avoid confusion. The "with project" condition is defined as the continued existence and nourishment of the authorized shore protection project for project life. The completion of the recent restoration effort (April 1981) is considered the start of the period for this analysis. The project is presently considered to be at its full authorized level of protection. The "with project" condition assumes that all erosion losses will be replaced.

The "without project" condition is defined as that which would occur in the absence of future nourishment allocated to the shore protection project. This condition assumes that:

o The authorized project is at the design level of protection at the completion of the most recent beach renourishment (April 1981).

o 60,000 cubic yards of sand, as determined in the shore processes analysis to be a navigation project responsibility, will be placed along the shoreline of Wrightsville Beach on an average annual basis.

o The shore protection project will suffer an average annual deficit of 70,000 cubic yards of sand. This deficit will equal the total annual erosion rate minus the annual rate of material placed as a navigation project responsibility.

Accompanying the annual deficit of sand on Wrightsville Beach will be an annual decrease in the remaining level of shore protection, and a corresponding decrease in the width of public beach available for recreation. The difference between the average annual damages with project and the average annual damages without project (in which damages increase with time as the remaining level of protection decreases) is the annual damage reduction benefit for continued project nourishment. Similarly, the difference between recreational use with project and use without project is the basis for determining the average annual recreation benefit.

The annual cost of nourishment allocated to the shore protection project was determined in the following manner:

o Determine the cost of the first sand bypassing operation from Masonboro Inlet to Wrightsville Beach (1987).

o Determine the cost of future sand bypassing operations from Masonboro Inlet to Wrightsville Beach.

o Determine the number of such operations required for the remaining project life.

o Discount the cost of each future sand bypassing operation to arrive at present worth.

o Separate out those costs associated with maintenance of the hurricane flood protection portion of the project.

o Multiply the total present worth of future bypassing by the appropriate I&A factor to determine the equivalent average annual cost.

o Apply the appropriate percentage to determine that portion of the gross average annual cost of sand replacement allocated to the shore protection project. The balance is thus allocated as the average annual cost of bypassing to be charged to Masonboro Inlet navigation project.

TABLE 2A

Cost Estimate, First Sand Bypassing at Masonboro Inlet in 1987

Criteria:		
Annual gross erosion rate: 130,000 cubic yards/year		
Years to first bypassing operation: 6		
Bypassing charged to Masonboro Inlet navigation project is being accomplished and one will be scheduled concurrently with shore protection project bypassing in 1987		
Quantity to be dredged, first operation:		
Assigned to shore protection project: (140,000 CY + 280,000 cy)[1]		420,000 cy
Assigned to navigation project:		120,000 cy
Total		540,000 cy
Dredge: 18 inch		
Maximum length pipeline: 20,000 feet		
Unit Cost: $4.28/cubic yard inplace[2]		
Dredging Cost: (540,000 cubic yards @ $4.28)	$2,311,000	
Vegetative Maintenance	8,000	
Mob. & Demob. (l.s.)	259,000	
Subtotal	$2,578,000	
Contingencies (20%)	516,000	
Subtotal	$3,094,000	
E&D	37,000	
S&A	173,000	
Total	$3,304,000	

Rev 2/22/83

1/ The first operation assigned to the shore protection project will include the initial placement of 140,000 cubic yards required at 2-year intervals and all periods of maintenance missed since project restoration in 1981.

2/ Unit cost is based on the contract cost (24 October 1980) for the 1981 beach restoration at Wrightsville Beach updated to October 1982 price levels using programming price level update factors for contract dredging (pipeline) which includes beach erosion control projects. Factor for 1980 to 1981 is 1.15 and 1.07 for 1981 to 1982.

Annual costs for maintenance of the hurricane flood protection portion of the project is based on values reported in the Design Memorandum for the original project (see page 8 of this report) and are:

Hurricane Flood Protection Maintenance Costs

Annual berm maintenance: 5,600 cy @ $4.28 =	$24,000
Annual dune maintenance: 1,000 cy @ $4.28 =	4,000
Annual vegetative maintenance:	4,000
Total	$32,000
Total for 2-year intervals	$64,000

The cost allocation for the first bypassing operation is:

Navigation Project (120,000 cy/540,000 cy X $3,304,000)	=	$ 734,000
Hurricane Flood Protection ($32,000 X 6 yrs)	=	192,000
Beach Erosion (remaining costs)	=	2,378,000
Total		$3,304,000

TABLE 2B

Cost Estimate, Future Sand Bypassing at Masonboro Inlet		
Criteria:		
Annual gross erosion rate: 130,000 cubic yards/year		
Bypassing operation interval: 2 years		
Quantity to be dredged, each operation:		260,000 cy
Dredge: 18 inch		
Maximum length pipeline: 20,000 feet		
Unit Cost: $4.28/cubic yard inplace		
Dredging Cost: (260,000 cubic yards @ $4.28)	$1,113,000	
Vegetative Maintenance	8,000	
Mob. & Demob. (l.s.)	259,000	
Subtotal	$1,380,000	
Contingencies (20%)	276,000	
Subtotal	$1,656,000	
E&D	37,000	
S&A	93,000	
Total	$1,786,000	

The cost allocation for future bypassing operations is:

Navigation Project (60,000 cy/130,000 cy X $1,786,000)	=	$ 824,000
Hurricane Flood Protection ($32,000 X 2 yrs)	=	64,000
Beach Erosion (remaining costs)	=	898,000
Total		$1,786,000

It was estimated that a total of 25 sand bypassing operations to Wrightsville Beach would be required at 2-year intervals during the project life. Finally, the average annual cost allocated to the authorized shore protection project for hurricane flood protection and beach erosion is:

TABLE 3

Summary - Annual Cost of Nourishment
Allocated to Shore and Hurricane Wave Protection Project

Hurricane Flood Protection		@ 7-7/8% Interest
($192,000 + ($64,000)(5.948078))(0.08057)	=	$ 46,000
Beach Erosion		
($2,378,000 + ($898,000)(5.948078))(0.08057)	=	622,000
Total		$668,000

Economic Evaluation: Benefits. The three basic categories of benefits generated by the shore protection project and evaluated in this investigation are beach erosion control, flood damage reduction, and recreation.

Beach Erosion Control. Benefits for beach erosion control include the value of land and improvements that would be lost to erosion. The average annual value of the land losses would be $225,700. The average annual value of structures lost to erosion would be $209,300.

Flood Damage Reduction. Flood damages as a function of storm return interval were computed for the preproject shoreline condition and for the Authorized Project with continued maintenance (1981) condition. The results are shown below:

Average Annual Damages for Preproject Shoreline Condition	$575,400
Average Annual Damages for Authorized Project With Continued Maintenance Condition	$300,400
Average Annual Flood Damage Reduction with Authorized Project and Continued Maintenance	$275,000

If the authorized project is not maintained, and after considering the average annual erosion rate and the resulting losses, the average annual flood damage reduction benefits for the 50-year period of analysis would be $169,500.

The increased real value of damageable residential contents in the future was projected using the projected growth rate of per capita income. After considering the residential structures lost to erosion during the 50-year period of analysis, the average annual flood damage reduction benefits related to the projected increased value of residential contents would be $35,300. Total flood damage reduction benefits would be $204,800 ($169,500 + 35,300).

Recreation. The unit day value evaluation procedure for determining recreation benefits was selected, and a unit day value of $3.20 was established. A maximum daily capacity of 22,500 was determined, and the total number of days used in a beach season was 90. Beach use demand was projected to exceed parking capacity in the year 2011. Benefits were projected to begin in the year 2003, when projected beach use demand would first exceed the capacity of the southern 5,000 linear feet of beach projected to remain stable. Benefits would increase yearly as demand increases until the year 2011 when parking capacity is reached. From that point through the remainder of the 50-year period, benefits would remain the same. Recreational visitations and values are shown below:

Year	Unit Day Value	Visitations	Recreational Value
2003	$3.20	3,754	$ 12,013
2010	$3.20	360,365	$1,153,168
2011	$3.20	387,900	$1,241,280

The average annual value of the recreation benefits would be $270,500.

Table 4 presents a summary of the benefits and costs associated with continued maintenance of the authorized berm and dune project.

TABLE 4

Benefit-Cost Summary
Continued Maintenance of Wrightsville Beach
Berm and Dune Project
50-Year Period of Analysis, 7-7/8 Percent Interest Rate

Benefit Category	Average Annual Benefits
Beach Erosion Control: Land	$225,700
Structures	209,300
Flood Damage Reduction	169,500
Increase in Value of Residential Contents	35,300
Recreation	270,500
Total Average Annual Benefits	$910,300
Total Average Annual Costs	$668,000
Benefit-to-Cost Ratio	1.36

Rev 2/22/83

SECTION IV - ASSESSMENT AND EVALUATION OF DETAILED PLANS

Based on the economic analysis summarized in the preceding report section, Plan 5 is the only plan retained for detailed considerations. This section of the report consists of impact assessment and evaluation of the detailed plan.

Impact assessment, task three of the four functional planning tasks described in the introductory section of this report, is primarily an objective analysis conducted to identify and measure the likely economic, social, and environmental impacts expected to result from implementation of the detailed plan.

Evaluation, task four of the functional planning tasks, involves an analysis of the acceptability of the plan to the concerned public, and its contribution to fulfillment of the planning objective. Also, the plan's contribution to the national economic development, the national environmental quality, and other considerations of national importance must be evaluated.

Impact Assessment

The impact of Plan 5 on each of the study area's significant resources, identified in the earlier section of the "Existing Conditions," is described below.

Impact to Socioeconomic Resources.

Continued maintenance of the existing shore protection project at Wrightsville Beach will have a favorable impact on the regional economy due to recreation and prevention of land loss and loss to property. Those categories of benefits, which were used for economic analysis in the preceding evaluation of preliminary plans are described below.

Flood Damage Reduction - Physical damages from water action will be reduced. Flood damages to increased real value of residential contents in the future will be reduced to the extent that residential structure damages are reduced and residential structures lost to erosion are prevented by the continued maintenance of the project.

Beach Erosion Control - Physical loss of land and improvements due to erosion will be prevented by the continued maintenance of the project.

Recreation - reduction in beach area available for recreation will be prevented by the continued maintenance of the project.

Impact on Natural Resources.

The impact of Plan 5 to each of the area's significant natural resources is described in the "Existing Conditions" section as well as in the "Environmental Assessment" section of this report. Based on the impact analysis presented in Section 4.01 of the "Environmental Assessment," it was determined that the impacts to the aforementioned significant resources will be minor and temporary in nature.

Evaluation of Detailed Plan

The purpose of this report section is to evaluate the effectiveness of the detailed plan in meeting the planning objectives for shore protection at Wrightsville Beach. Also, under current water resource planning authorities and related laws, certain other effects must also be evaluated.

Contribution to Planning Objective.

The Detailed Plan described in this study, Plan 5, would provide continued shore protection at Wrightsville Beach.

Public Views.

Public views were obtained through the 18 April 1978 meeting, as well as numerous informal contacts with the concerned public during plan formulation. Also, coordination has been accomplished with the Federal and State agencies having specific interests in the resources likely to be impacted by Plan 5. Coordination of this project will continue through distribution of this draft Feasibility Report and Environmental Assessment.

Local interests support Plan 5 and Federal and State agencies consulted during plan formulation are considered to regard the plan as environmentally acceptable.

Summary Comparison of Alternative Plans.

Table 5 on the following pages presents a "Summary Comparison of Alternative Plans." This table presents an analysis of Plan 5 and the "No Action" condition.

Included in table 5 are the "Four Accounts" which current water resources planning guidelines required be appraised for any plan considered for implementation. These accounts are: National Economic Development (NED); Environmental Quality (EQ); Regional Economic Development (RED); and Other Social Effects (OSE). These four accounts encompass all significant effects of a plan on the human environment as required by the National Environmental Policy Act of 1969. They also encompass social well being as required by Section 122 of the Flood Control Act of 1970. Each account shows particular effects on the human environment. The EQ account shows effects on ecological, cultural, and esthetic attributes of significant natural and cultural resources. The OSE account shows community impacts and effects on life, health, and safety. The NED account shows effects on the national economy. The RED account shows the regional incidence of NED effects, income transfers, and employment. Contributions to, and detractions from, these four accounts are shown in table 5 on the following pages.

TABLE 5

SUMMARY COMPARISON OF ALTERNATIVE PLANS

	PLAN 5	NO ACTION
A. PLAN DESCRIPTION	Continued maintenance of the existing Shore Protection Project.	Assume no Federal or local action is taken at Wrightsville Beach.
B. SIGNIFICANT IMPACTS	Maintain the present level of shore protection.	Annual decrease in the remaining level of shore protection.
	Maintain the present design beach as it presently exists for maximum recreation benefits.	Annual decrease in the width of public beach available for recreation.
C. PLAN EVALUATION		
1. CONTRIBUTION TO PLANNING OBJECTIVE	Provides required shore protection.	None
2. RELATIONSHIP TO FOUR NATIONAL ACCOUNTS		
NATIONAL ECONOMIC DEVELOPMENT		
Beneficial Contributions		
a. Beach Erosion Control		0
Land	$225,700	
Structures	209,300	0
Flood Damage Reduction	169,500	0
Increase in Value of Residential Contents	35,300	0
Recreation	270,500	0
Total Average Annual Benefits	$910,300	0

SUMMARY COMPARISON OF ALTERNATIVE PLANS--continued

	PLAN 5	NO ACTION
NATIONAL ECONOMIC DEVELOPMENT (Cont.)		
Adverse Contributions		
a. Annual Project Costs	$668,000	0
b. Benefit Cost Ratio	1.36	
ENVIRONMENTAL QUALITY		
Beneficial Contributions	None	None
Adverse Contributions	None	None
OTHER SOCIAL EFFECTS		
Beneficial Contributions		
a. Enhancement of health, safety, and community well-being.	Protection against flooding and erosion.	None
b. Educational, cultural, and recreational opportunities.	Increased water-oriented recreational opportunities.	None
Adverse Contributions		
a. Enhancement of health, safety, and community well-being.	None	Future potential flood and erosion damages.
b. Educational, cultural, and recreational opportunities	None	Future water-oriented recreational opportunities will be constrained.
REGIONAL ECONOMIC DEVELOPMENT		
Beneficial Contributions		
a. Increased Income	None	Future decrease in beach area and recreational use will affect income from recreational related activities.
b. Increased Employment	No significant increase.	None
Adverse Contributions		
a. Increased Income	None	None
b. Increased Employment	None	None

Rationale for Designation of NED Plan and LED Plan

Based on the contribution to the four accounts presented in table 5, the plan must be identified which produces the maximum net benefit to National Economic Development (NED Plan) and the maximum net benefit to Environmental Quality (EQ Plan). If no plan can be identified which produces a net positive effect on environmental quality, the plan which is the least environmentally damaging (LED Plan) should be designated.

In this case, Plan 5 was the only detailed plan developed, due to economic infeasibility of the other alternatives considered. This plan has a positive benefit-to-cost ratio of 1.36. Since there is no space available for additional parking along the project area due to the full level of development, recreational benefits claimed are the maximum to be achieved for the recommended plan. Therefore, the recommended plan is designated the NED plan. Also, while Plan 5 contains no measures to enhance environmental quality, its adverse environmental impacts are considered to be minor and to be outweighed by economic benefits associated with the improvements. Therefore, Plan 5 is also designated the LED Plan.

Rationale for Selected Plan

As established in the previous sections of this report, Plan 5 is the only plan which would address the need for shore protection in a manner which is economically feasible. Also, the environmental impacts of this plan are considered to be minor. Therefore, Plan 5 is designated the Selected Plan.

SECTION V - THE SELECTED PLAN

The purpose of this section is to summarize information, from the main report and supporting appendixes, related to the Selected Plan. Information is presented as related to the economic justification and environmental impacts of the Selected Plan. A summary of Cost Allocation and Design and Construction procedures is also included.

Economic Justification

Economic justification is based on the determination that economic benefits exceed economic costs. A summary of economic costs for the Selected Plan follows.

Economic Costs - Selected Plan.

Annual Costs.

Periodic Nourishment: $668,000.

As shown above, average annual costs for the Selected Plan are $668,000. Average annual benefits must equal or exceed this amount if the plan is to be considered implementable. A summary of economic benefits follows:

Economic Benefits - Selected Plan.

Benefit Categories	Average Annual Benefits
Beach Erosion Control	
Land	$225,700
Structures	209,300
Recreation	270,500
Flood Damage Reduction	169,500
Increase in Value of Residential Contents	35,300
Total Average Annual Benefits	$910,300

Rev. 2/22/83

As shown above, total average annual benefits equal $910,300. With average annual costs of $668,000, the benefit-to-cost ratio is 1.36.

Allocation and Apportionment of Costs

Costs for Plan 5 will be shared by the Federal Government and the local sponsor. However, the current Administration is reviewing project cost sharing and financing across the entire spectrum of water resource development functions and has submitted proposed legislation to Congress for navigation projects. The basic principle governing the development of specific cost-sharing policies is that whenever possible the cost of services produced by water projects should be paid for by direct beneficiaries. It is also recognized that the Federal Government can no longer bear the major portion of the financing of water projects. New sources of project financing, both public and private, will have to be found.

While specific policies applicable for specific flood control projects have not yet been established, non-Federal interest can expect that, under the Administration's financing and cost-sharing principles, the level of their financial participation could be significantly greater than in the past. Accordingly, actual apportionment of project cost will be subject to modified cost-sharing and financing arrangements which are satisfactory to the President and to Congress.

However, under traditional guidelines applicable to beach erosion control projects, periodic beach nourishment costs are shared with the Federal Government and local sponsor each paying 50 percent, whereas the cost of maintenance of hurricane flood protection projects is the sole responsibility of the local sponsor. If the traditional methods of apportioning project cost are followed, apportionment of project first cost would be as shown below.

Cost Allocation - Selected Plan.

	Average Annual Cost
Hurricane Flood Protection	$ 46,000
Beach Erosion Control	622,000
Total	$668,000

Cost Apportionment - Selected Plan.

	Average Annual Cost	
	Federal Government	Local Sponsor
Hurricane Flood Protection	$ 0	$ 46,000
Beach Erosion Control	311,000	311,000
Total	$311,000	$357,000

Environmental Impacts

The environmental impacts are discussed in the "Environmental Assessment" section of this report. Based on the impact analysis presented in Section 4.01, impacts to environmental resources in the study area will be minor and temporary in nature.

Design and Construction

The Selected Plan is to continue Federal participation in the Wrightsville Beach Erosion Control and Hurricane Protection Project. This will consist of placing 70,000 cubic yards of sand on Wrightsville Beach on an average annual basis. This material will be obtained from the Masonboro Inlet complex.

Rev 2/22/83

Recommendations

I recommend that the existing shore and hurricane wave protection project for Wrightsville Beach, N.C., described in House Document No. 511, 87th Congress, be modified to extend Federal participation in periodic nourishment for the life of the project. This recommendation is subject to such modifications thereof as in the discretion of the Chief of Engineers may be advisable.

The total erosion rate is 130,000 cubic yards and is the average annual quantity of sand required to maintain the shore and hurricane wave protection project at the design level of protection. The erosion attributable to the effects of the Masonboro Inlet navigation project (specifically, the jetties) in reducing the rate of natural sand bypassing to Wrightsville Beach is 60,000 cubic yards per year. The placement of this 60,000 cubic yards of sand onto Wrightsville Beach will be considered an annual cost in the operation of the navigation project. The remaining 70,000 cubic yards represents the average annual quantity of sand allocated as a responsibility of the shore and hurricane wave protection project which is being recommended in this report. The recommended nourishment is estimated to cost $668,000 on an average annual basis.

It is further recommended that authorization of continued nourishment for Wrightsville Beach be contingent on the project sponsor giving written assurances satisfactory to the Secretary of the Army that it will:

a. Provide without cost to the United States all lands, easements, and rights-of-way, including borrow areas, necessary for implementation of the project.

b. Accomplish all relocations and alterations of sewerage and drainage facilities, buildings, streets, utilities, and other structures made necessary by the construction.

c. Hold and save the United States free from damages that may result due to the maintenance of the project other than damages due to the fault or negligence of the United States or its contractors.

d. Contribute its proportionate share of the cost of the periodic nourishment to be performed by the United States.

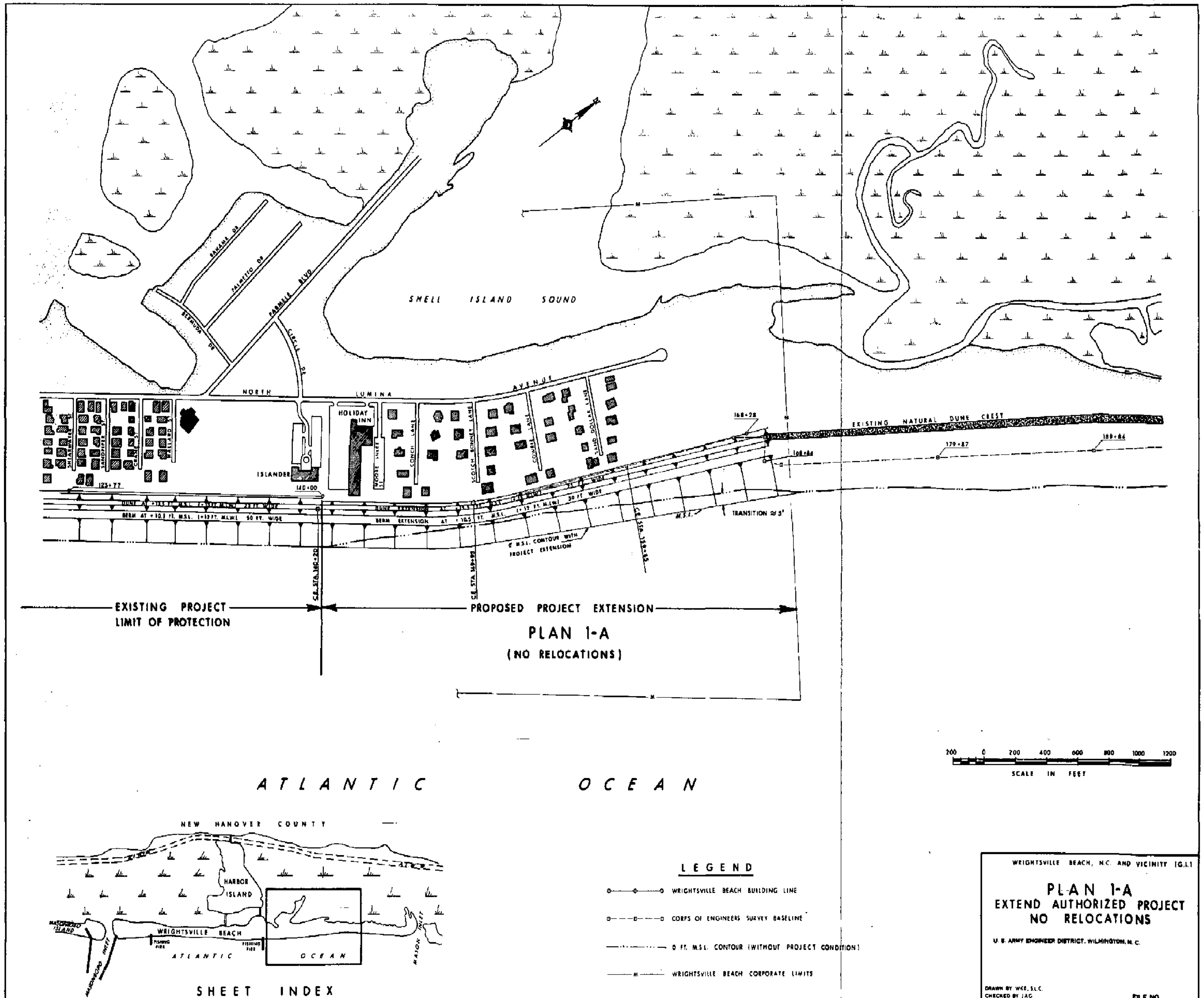
e. Maintain, during the economic life of the project, continued public ownership of the publicly-owned shore upon which the Federal participation is based.

f. Adopt and enforce appropriate ordinances to provide for the preservation of the improvement and its protective vegetation.

g. Continue to enforce flood plain regulations that comply with Federal Emergency Management Agency (FEMA) guidelines.

It is also recommended that construction authorization of the recommended modifications be subject to cost-sharing and financing arrangements with the non-Federal agencies supporting the project which are satisfactory to the President and the Congress.

Robert K. Hughes
ROBERT K. HUGHES
Colonel, Corps of Engineers
Commanding



WRIGHTSVILLE BEACH, N.C. AND VICINITY (G.I.)

PLAN 1-A
EXTEND AUTHORIZED PROJECT
NO RELOCATIONS

U. S. ARMY ENGINEER DISTRICT, WILMINGTON, N. C.

DRAWN BY WKE, SLC
CHECKED BY JAG

FILE NO.

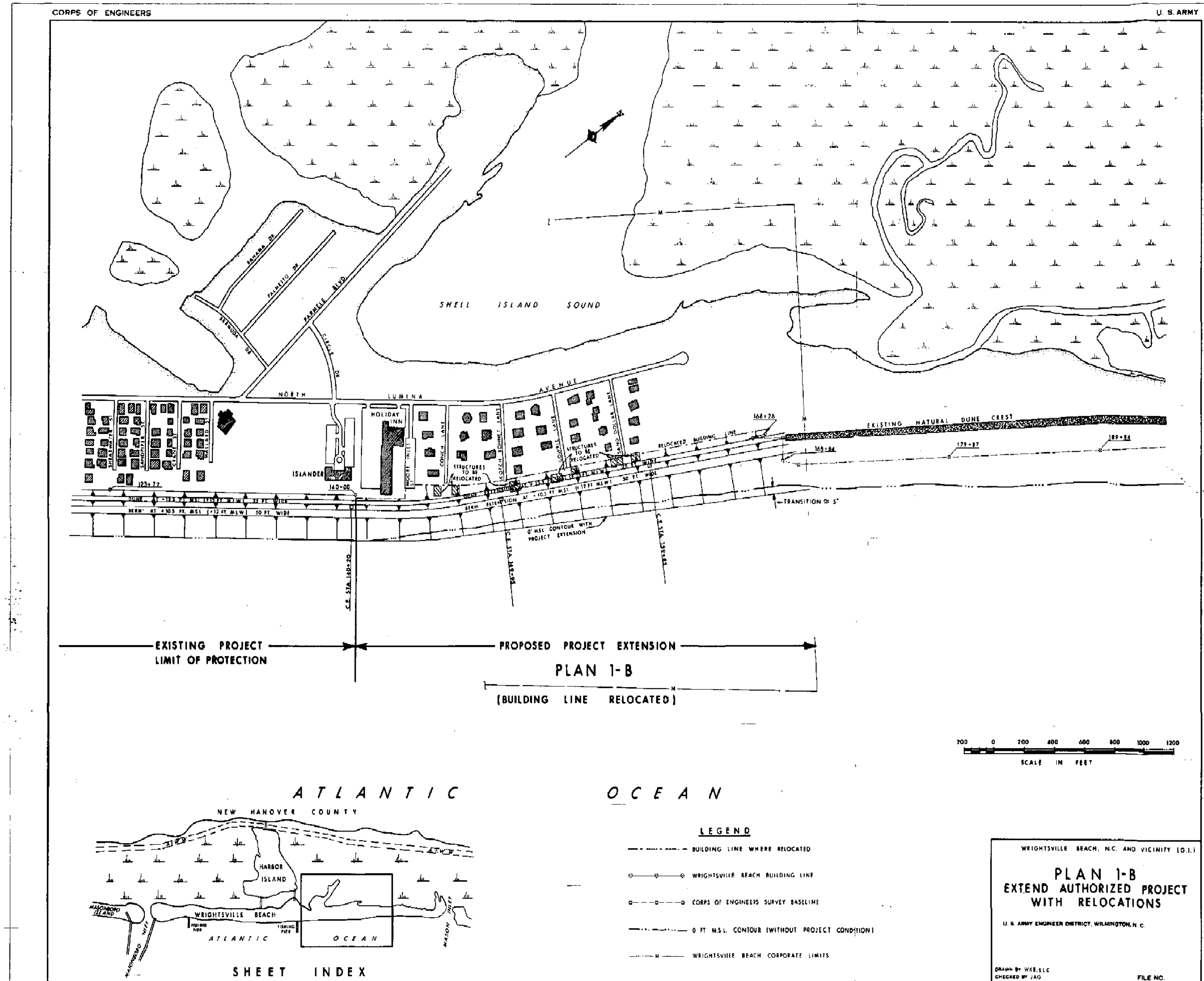
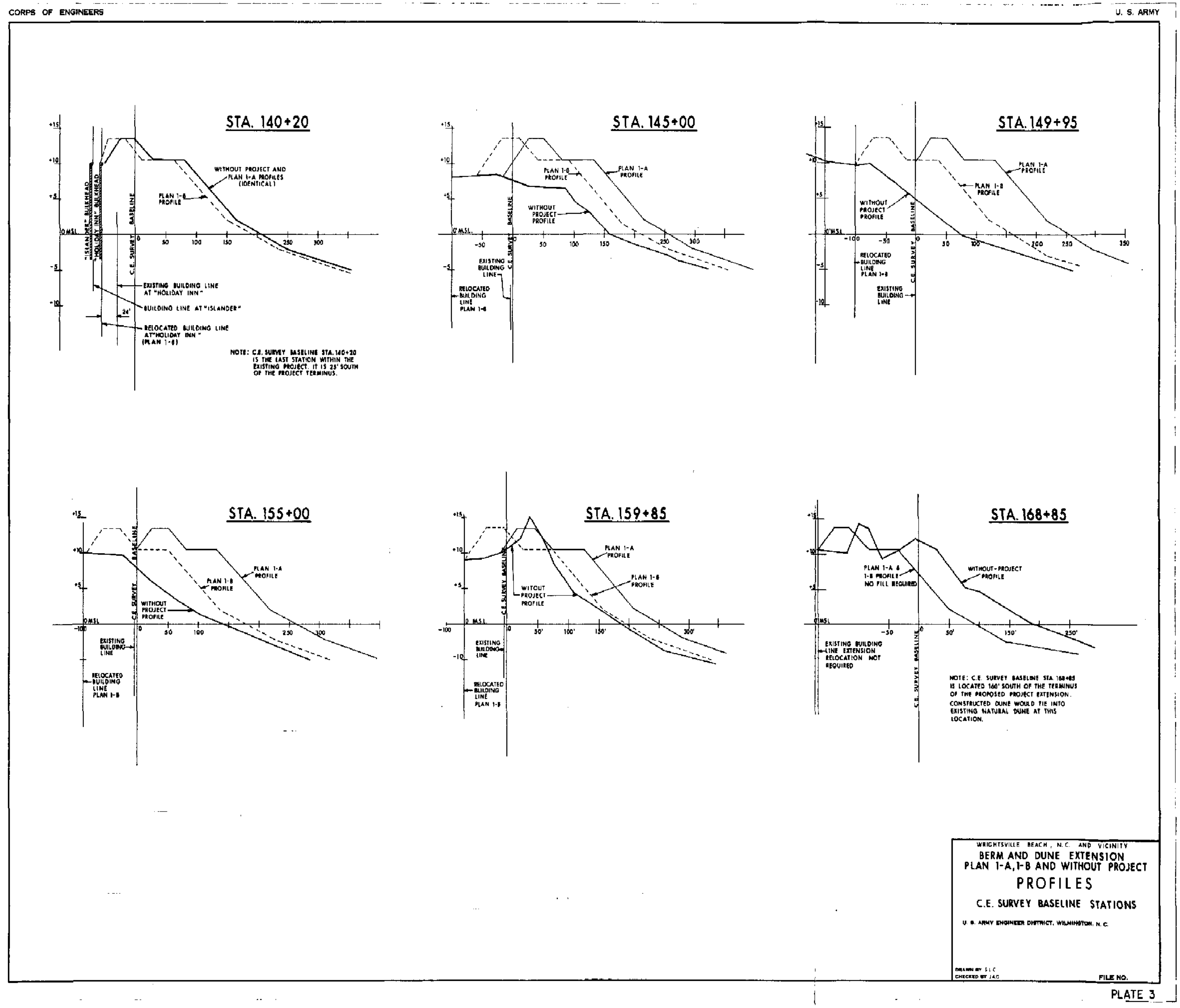
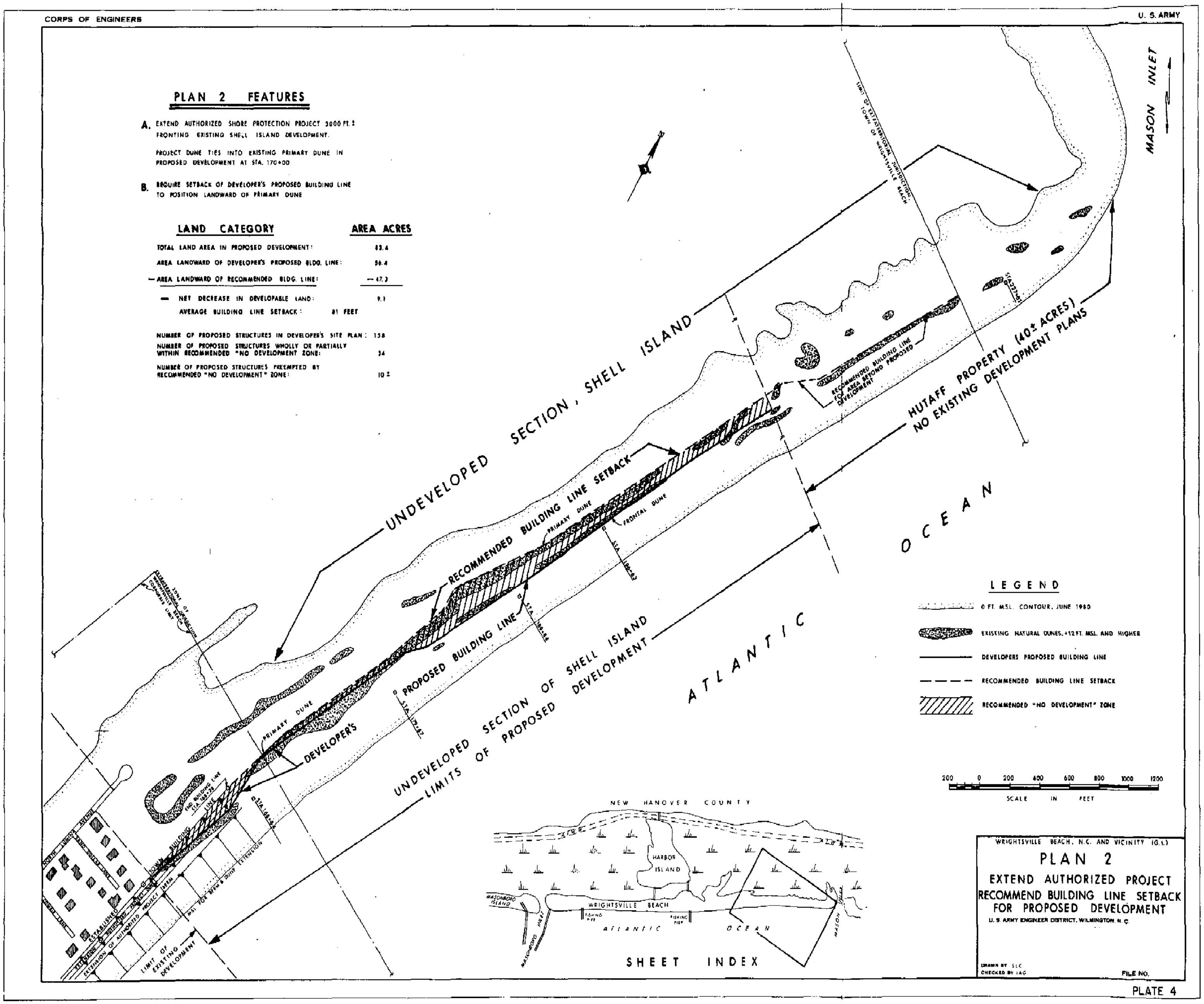
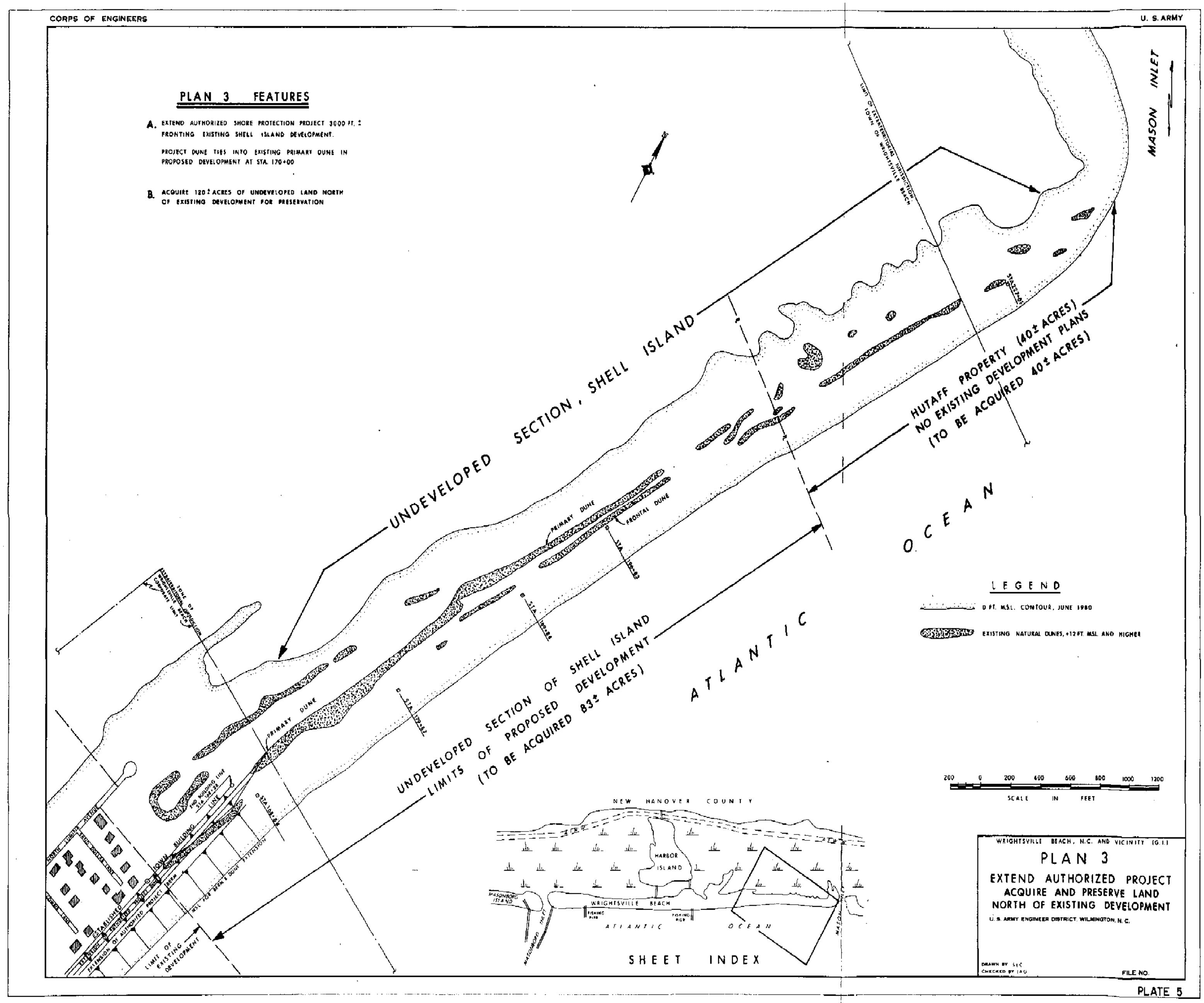

CORPS OF ENGINEERS
U. S. ARMY
SHELL ISLAND SOUND
NORTH LUMINA AVENUE
PARMELE BLVD
PALMETTO DR
BAHAMA DR
BERMUDA DR
CIRCLE DR
HOLIDAY INN
ISLANDER
MOORE INLET ST
CONCH LANE
SCOTCH BONNET LANE
LOURIE LANE
SAND DOLLAR LANE
STRUCTURES TO BE RELOCATED
RELOCATED BUILDING LINE
EXISTING NATURAL DUNE CREST
TRANSITION 1 ON 5
0' MSL CONTOUR WITH PROJECT EXTENSION
BERM EXTENSION
BERM AT +10.5 FT. MSL (+12 FT. MLW) 50 FT. WIDE
125+77
160+00
168+26
168+84
179+87
189+84
C.E. STA 160+20
EXISTING PROJECT LIMIT OF PROTECTION
PROPOSED PROJECT EXTENSION
PLAN 1-B
(BUILDING LINE RELOCATED)
SCALE IN FEET
200 0 200 400 600 800 1000 1200
ATLANTIC OCEAN
NEW HANOVER COUNTY
HARBOR ISLAND
WRIGHTSVILLE BEACH
MASONBORO ISLAND
MASON INLET
SHEET INDEX
LEGEND
BUILDING LINE WHERE RELOCATED
WRIGHTSVILLE BEACH BUILDING LINE
CORPS OF ENGINEERS SURVEY BASELINE
0 FT M.S.L. CONTOUR (WITHOUT PROJECT CONDITION)
WRIGHTSVILLE BEACH CORPORATE LIMITS
WRIGHTSVILLE BEACH, N.C. AND VICINITY (O.I.)
PLAN 1-B
EXTEND AUTHORIZED PROJECT
WITH RELOCATIONS
U. S. ARMY ENGINEER DISTRICT, WILMINGTON, N. C.
DRAWN BY WKB, SLC
CHECKED BY JAG
FILE NO.

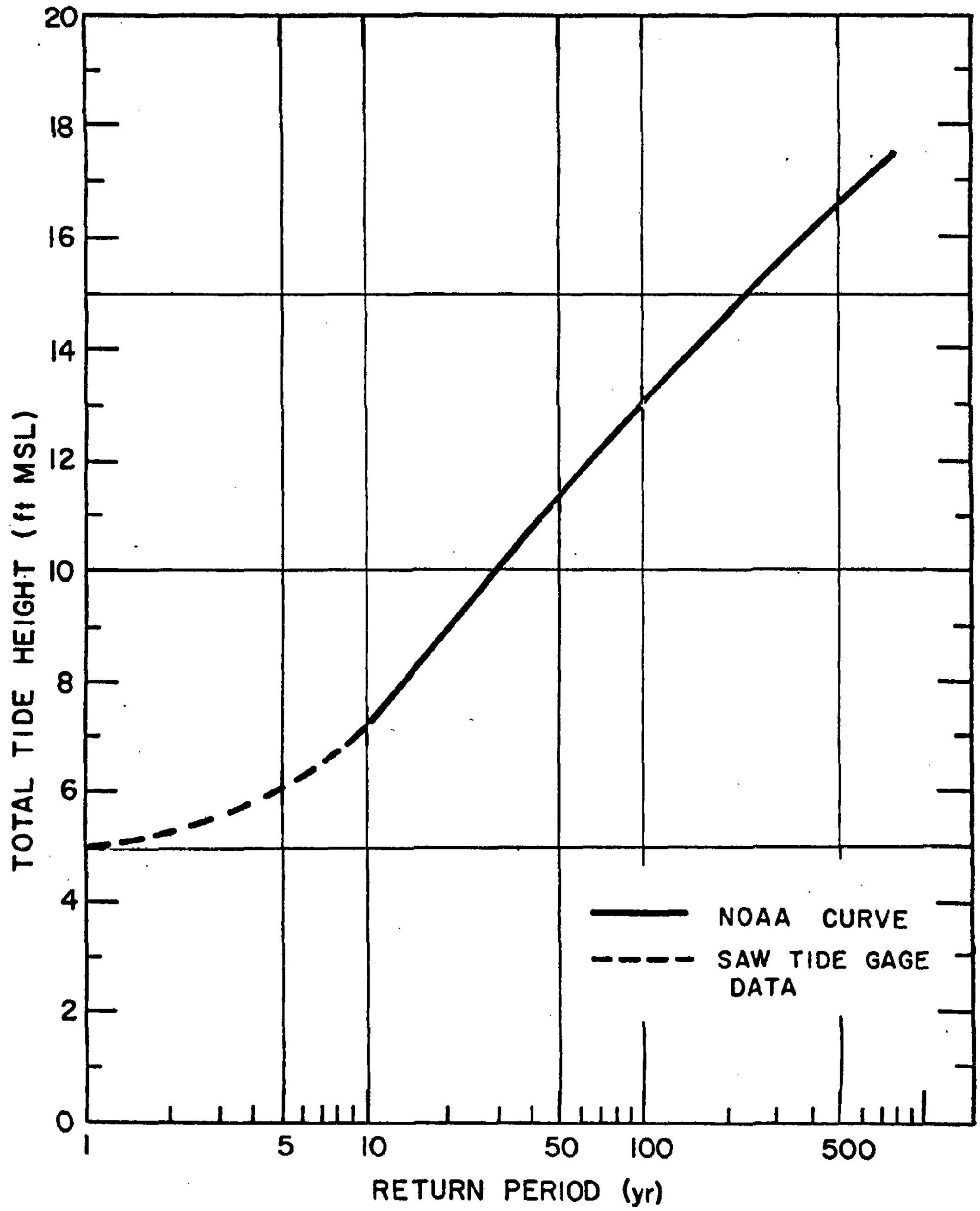
PLATE 2


CORPS OF ENGINEERS
U. S. ARMY
STA. 140+20
"ISLANDER" BULKHEAD
"HOLIDAY INN" BULKHEAD
C.E. SURVEY BASELINE
WITHOUT PROJECT AND PLAN 1-A PROFILES (IDENTICAL)
PLAN 1-B PROFILE
EXISTING BUILDING LINE AT "HOLIDAY INN"
BUILDING LINE AT "ISLANDER"
RELOCATED BUILDING LINE AT "HOLIDAY INN" (PLAN 1-B)
NOTE: C.E. SURVEY BASELINE STA. 140+20 IS THE LAST STATION WITHIN THE EXISTING PROJECT. IT IS 23' SOUTH OF THE PROJECT TERMINUS.
STA. 145+00
PLAN 1-B PROFILE
PLAN 1-A PROFILE
WITHOUT PROJECT PROFILE
EXISTING BUILDING LINE
RELOCATED BUILDING LINE PLAN 1-B
STA. 149+95
PLAN 1-A PROFILE
PLAN 1-B PROFILE
WITHOUT PROJECT PROFILE
RELOCATED BUILDING LINE PLAN 1-B
EXISTING BUILDING LINE
STA. 155+00
PLAN 1-A PROFILE
PLAN 1-B PROFILE
WITHOUT PROJECT PROFILE
EXISTING BUILDING LINE
RELOCATED BUILDING LINE PLAN 1-B
STA. 159+85
PLAN 1-A PROFILE
PLAN 1-B PROFILE
WITOUT PROJECT PROFILE
EXISTING BUILDING LINE
RELOCATED BUILDING LINE PLAN 1-B
STA. 168+85
WITHOUT-PROJECT PROFILE
PLAN 1-A & 1-B PROFILE NO FILL REQUIRED
EXISTING BUILDING LINE EXTENSION RELOCATION NOT REQUIRED
NOTE: C.E. SURVEY BASELINE STA. 168+85 IS LOCATED 160' SOUTH OF THE TERMINUS OF THE PROPOSED PROJECT EXTENSION. CONSTRUCTED DUNE WOULD TIE INTO EXISTING NATURAL DUNE AT THIS LOCATION.
WRIGHTSVILLE BEACH, N.C. AND VICINITY
BERM AND DUNE EXTENSION
PLAN 1-A, 1-B AND WITHOUT PROJECT
PROFILES
C.E. SURVEY BASELINE STATIONS
U. S. ARMY ENGINEER DISTRICT, WILMINGTON, N. C.
DRAWN BY S.L.C.
CHECKED BY J.A.C.
FILE NO.
PLATE 3

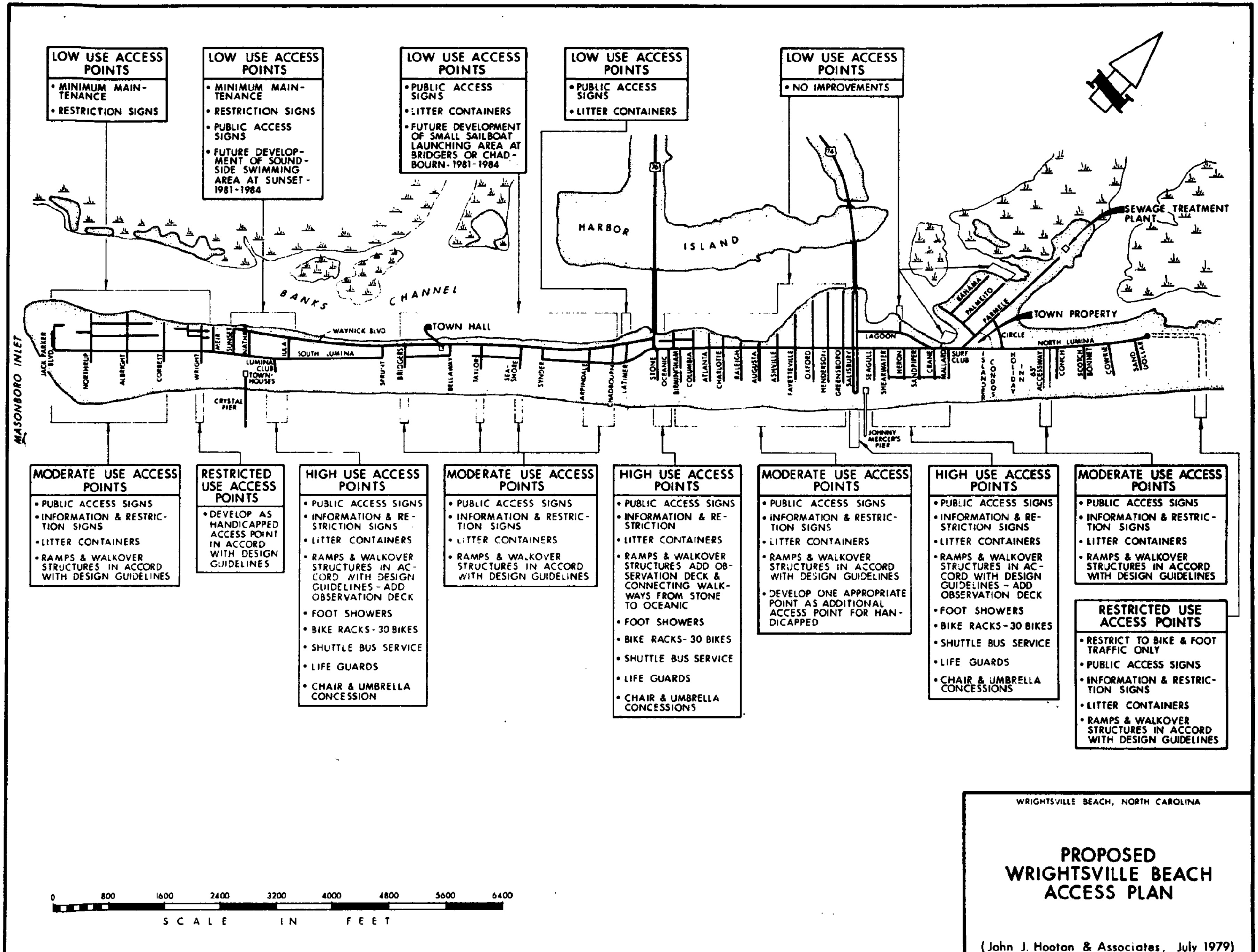


CORPS OF ENGINEERS
U. S. ARMY
PLAN 2 FEATURES
A. EXTEND AUTHORIZED SHORE PROTECTION PROJECT 3000 FT. ± FRONTING EXISTING SHELL ISLAND DEVELOPMENT.
PROJECT DUNE TIES INTO EXISTING PRIMARY DUNE IN PROPOSED DEVELOPMENT AT STA. 170+00
B. REQUIRE SETBACK OF DEVELOPER'S PROPOSED BUILDING LINE TO POSITION LANDWARD OF PRIMARY DUNE
LAND CATEGORY
AREA ACRES
TOTAL LAND AREA IN PROPOSED DEVELOPMENT: 83.4
AREA LANDWARD OF DEVELOPER'S PROPOSED BLDG. LINE: 56.4
— AREA LANDWARD OF RECOMMENDED BLDG. LINE: — 47.3
— NET DECREASE IN DEVELOPABLE LAND: 9.1
AVERAGE BUILDING LINE SETBACK: 81 FEET
NUMBER OF PROPOSED STRUCTURES IN DEVELOPER'S SITE PLAN: 158
NUMBER OF PROPOSED STRUCTURES WHOLLY OR PARTIALLY WITHIN RECOMMENDED "NO DEVELOPMENT ZONE: 34
NUMBER OF PROPOSED STRUCTURES PREEMPTED BY RECOMMENDED "NO DEVELOPMENT" ZONE: 10 ±
UNDEVELOPED SECTION, SHELL ISLAND
RECOMMENDED BUILDING LINE SETBACK
PRIMARY DUNE
FRONTAL DUNE
DEVELOPER'S
PROPOSED BUILDING LINE
UNDEVELOPED SECTION OF SHELL ISLAND
LIMITS OF PROPOSED DEVELOPMENT
HUTAFF PROPERTY (40± ACRES)
NO EXISTING DEVELOPMENT PLANS
ATLANTIC
OCEAN
MASON INLET
LIMIT OF EXISTING DEVELOPMENT
LEGEND
0 FT. MSL. CONTOUR, JUNE 1980
EXISTING NATURAL DUNES, +12 FT. MSL. AND HIGHER
DEVELOPERS PROPOSED BUILDING LINE
RECOMMENDED BUILDING LINE SETBACK
RECOMMENDED "NO DEVELOPMENT" ZONE
200 0 200 400 600 800 1000 1200
SCALE IN FEET
NEW HANOVER COUNTY
HARBOR ISLAND
WRIGHTSVILLE BEACH
ATLANTIC OCEAN
SHEET INDEX
WRIGHTSVILLE BEACH, N.C. AND VICINITY (G.L.)
PLAN 2
EXTEND AUTHORIZED PROJECT
RECOMMEND BUILDING LINE SETBACK
FOR PROPOSED DEVELOPMENT
U. S. ARMY ENGINEER DISTRICT, WILMINGTON, N. C.
DRAWN BY SLC
CHECKED BY JAG
FILE NO.
PLATE 4


CORPS OF ENGINEERS
U. S. ARMY
PLAN 3 FEATURES
A. EXTEND AUTHORIZED SHORE PROTECTION PROJECT 3000 FT. ± FRONTING EXISTING SHELL ISLAND DEVELOPMENT.
PROJECT DUNE TIES INTO EXISTING PRIMARY DUNE IN PROPOSED DEVELOPMENT AT STA. 170+00
B. ACQUIRE 120± ACRES OF UNDEVELOPED LAND NORTH OF EXISTING DEVELOPMENT FOR PRESERVATION
MASON INLET
UNDEVELOPED SECTION, SHELL ISLAND
HUTAFF PROPERTY (40± ACRES)
NO EXISTING DEVELOPMENT PLANS
(TO BE ACQUIRED 40± ACRES)
UNDEVELOPED SECTION OF SHELL ISLAND
LIMITS OF PROPOSED DEVELOPMENT
(TO BE ACQUIRED 83± ACRES)
PRIMARY DUNE
FRONTAL DUNE
LIMIT OF EXISTING DEVELOPMENT
ATLANTIC OCEAN
LEGEND
0 FT. MSL. CONTOUR, JUNE 1980
EXISTING NATURAL DUNES, +12 FT. MSL AND HIGHER
200 0 200 400 600 800 1000 1200
SCALE IN FEET
NEW HANOVER COUNTY
HARBOR ISLAND
WRIGHTSVILLE BEACH
ATLANTIC OCEAN
SHEET INDEX
WRIGHTSVILLE BEACH, N.C. AND VICINITY (G.I.)
PLAN 3
EXTEND AUTHORIZED PROJECT
ACQUIRE AND PRESERVE LAND
NORTH OF EXISTING DEVELOPMENT
U. S. ARMY ENGINEER DISTRICT, WILMINGTON, N. C.
DRAWN BY SLC
CHECKED BY JAG
FILE NO.
PLATE 5



STAGE-FREQUENCY CURVE
WRIGHTSVILLE BEACH, N.C.



LOW USE ACCESS POINTS
• MINIMUM MAIN-TENANCE
• RESTRICTION SIGNS
LOW USE ACCESS POINTS
• MINIMUM MAIN-TENANCE
• RESTRICTION SIGNS
• PUBLIC ACCESS SIGNS
• FUTURE DEVELOPMENT OF SOUND-SIDE SWIMMING AREA AT SUNSET - 1981-1984
LOW USE ACCESS POINTS
• PUBLIC ACCESS SIGNS
• LITTER CONTAINERS
• FUTURE DEVELOPMENT OF SMALL SAILBOAT LAUNCHING AREA AT BRIDGERS OR CHAD-BOURN - 1981-1984
LOW USE ACCESS POINTS
• PUBLIC ACCESS SIGNS
• LITTER CONTAINERS
LOW USE ACCESS POINTS
• NO IMPROVEMENTS
HARBOR ISLAND
BANKS CHANNEL
SEWAGE TREATMENT PLANT
TOWN PROPERTY
TOWN HALL
WAYNICK BLVD
SOUTH LUMINA
NORTH LUMINA
LAGOON
CIRCLE
MASONBORO INLET
JACK PARKER BLVD
NORTHRUP
ALBRIGHT
CORBETT
WRIGHT
MEIR
SUNSET
NATHAN
LUMINA CLUB
TOWN-HOUSES
CRYSTAL PIER
IUKA
SPRUNT
BRIDGERS
BELLAMY
TAYLOR
SEA-SHORE
SYNDER
ARPINDALE
CHADBOURN
LATIMER
STONE
OCEANIC
BIRMINGHAM
COLUMBIA
ATLANTA
CHARLOTTE
RALEIGH
AUGUSTA
ASHVILLE
FAYETTEVILLE
OXFORD
HENDERSON
GREENSBORO
SALISBURY
SEAGULL
SHEARWATER
HERON
SANDPIPER
CRANE
MALLARD
SURF CLUB
JOHNNY MERCER'S PIER
ACCESSWAY
CONCH
SCOTCH BONNET
COWRIE
SAND DOLLAR
MODERATE USE ACCESS POINTS
• PUBLIC ACCESS SIGNS
• INFORMATION & RESTRIC-TION SIGNS
• LITTER CONTAINERS
• RAMPS & WALKOVER STRUCTURES IN ACCORD WITH DESIGN GUIDELINES
RESTRICTED USE ACCESS POINTS
• DEVELOP AS HANDICAPPED ACCESS POINT IN ACCORD WITH DESIGN GUIDELINES
HIGH USE ACCESS POINTS
• PUBLIC ACCESS SIGNS
• INFORMATION & RE-STRICTION SIGNS
• LITTER CONTAINERS
• RAMPS & WALKOVER STRUCTURES IN AC-CORD WITH DESIGN GUIDELINES - ADD OBSERVATION DECK
• FOOT SHOWERS
• BIKE RACKS - 30 BIKES
• SHUTTLE BUS SERVICE
• LIFE GUARDS
• CHAIR & UMBRELLA CONCESSION
MODERATE USE ACCESS POINTS
• PUBLIC ACCESS SIGNS
• INFORMATION & RESTRIC-TION SIGNS
• LITTER CONTAINERS
• RAMPS & WALKOVER STRUCTURES IN ACCORD WITH DESIGN GUIDELINES
HIGH USE ACCESS POINTS
• PUBLIC ACCESS SIGNS
• INFORMATION & RE-STRICTION
• LITTER CONTAINERS
• RAMPS & WALKOVER STRUCTURES ADD OB-SERVATION DECK & CONNECTING WALK-WAYS FROM STONE TO OCEANIC
• FOOT SHOWERS
• BIKE RACKS - 30 BIKES
• SHUTTLE BUS SERVICE
• LIFE GUARDS
• CHAIR & UMBRELLA CONCESSIONS
MODERATE USE ACCESS POINTS
• PUBLIC ACCESS SIGNS
• INFORMATION & RESTRIC-TION SIGNS
• LITTER CONTAINERS
• RAMPS & WALKOVER STRUCTURES IN ACCORD WITH DESIGN GUIDELINES
• DEVELOP ONE APPROPRIATE POINT AS ADDITIONAL ACCESS POINT FOR HAN-DICAPPED
HIGH USE ACCESS POINTS
• PUBLIC ACCESS SIGNS
• INFORMATION & RE-STRICTION SIGNS
• LITTER CONTAINERS
• RAMPS & WALKOVER STRUCTURES IN AC-CORD WITH DESIGN GUIDELINES - ADD OBSERVATION DECK
• FOOT SHOWERS
• BIKE RACKS - 30 BIKES
• SHUTTLE BUS SERVICE
• LIFE GUARDS
• CHAIR & UMBRELLA CONCESSIONS
MODERATE USE ACCESS POINTS
• PUBLIC ACCESS SIGNS
• INFORMATION & RESTRIC-TION SIGNS
• LITTER CONTAINERS
• RAMPS & WALKOVER STRUCTURES IN ACCORD WITH DESIGN GUIDELINES
RESTRICTED USE ACCESS POINTS
• RESTRICT TO BIKE & FOOT TRAFFIC ONLY
• PUBLIC ACCESS SIGNS
• INFORMATION & RESTRIC-TION SIGNS
• LITTER CONTAINERS
• RAMPS & WALKOVER STRUCTURES IN ACCORD WITH DESIGN GUIDELINES
0 800 1600 2400 3200 4000 4800 5600 6400
SCALE IN FEET
WRIGHTSVILLE BEACH, NORTH CAROLINA
PROPOSED WRIGHTSVILLE BEACH ACCESS PLAN
(John J. Hooton & Associates, July 1979)

PLATE 7

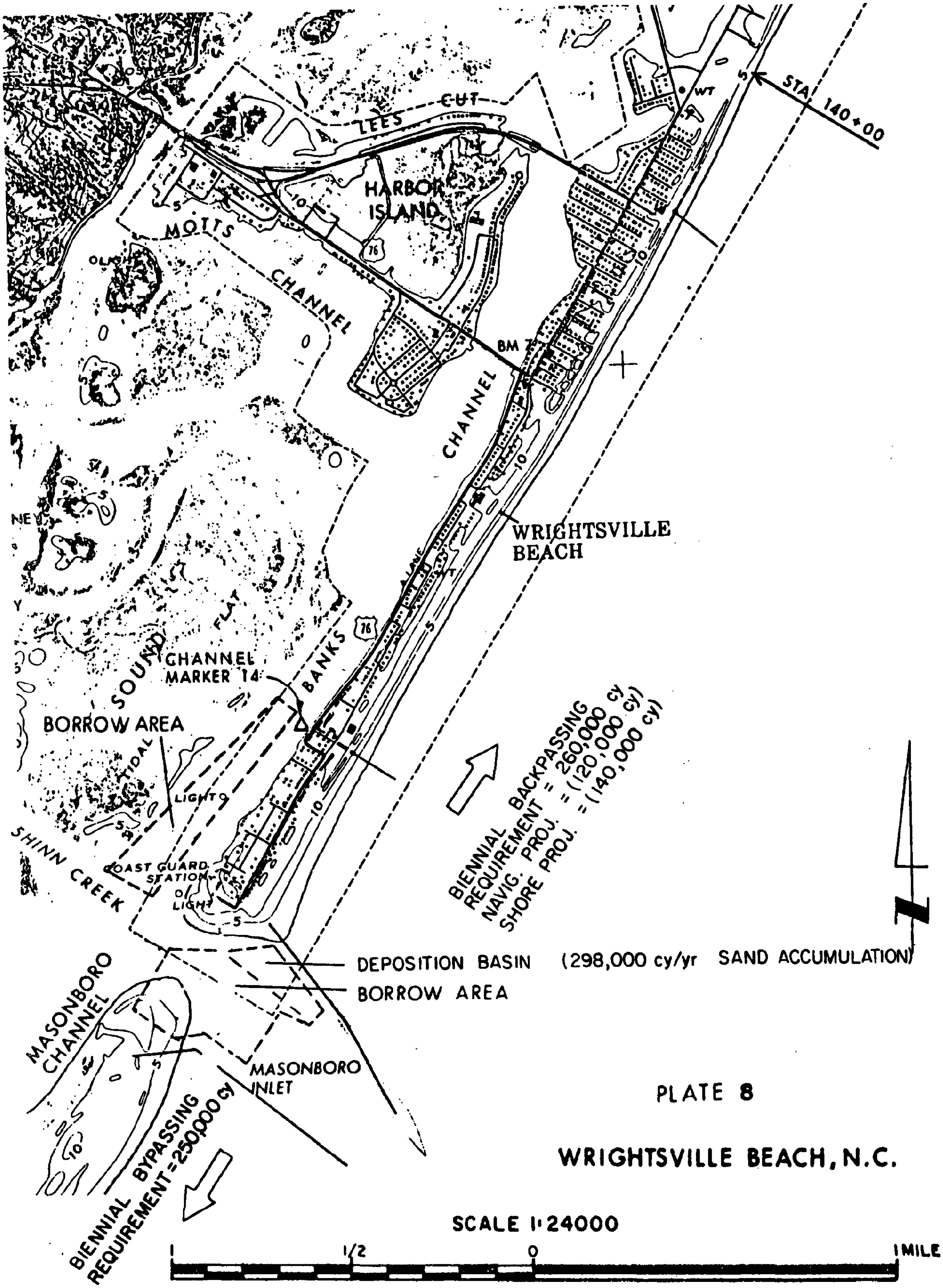


PLATE 8

WRIGHTSVILLE BEACH, N.C.

ENVIRONMENTAL ASSESSMENT
FOR THE
CONTINUED FEDERAL PARTICIPATION
IN THE
WRIGHTSVILLE BEACH SHORE AND
HURRICANE WAVE PROTECTION
PROJECT
NEW HANOVER COUNTY, NORTH CAROLINA

TABLE OF CONTENTS

TABLE OF CONTENTS (Cont'd)

ATTACHMENTS

Introduction

A. History of the Existing Project.

Wrightsville Beach has had a history of erosion problems dating from the earliest attempts to build on the oceanfront. Local interests began attempts to control erosion in 1923 when five timber groins were constructed along the middle 6,400 feet of the towns ocean shoreline. More groins were added in 1925, 1928, and again 1939. In addition, 700,000 cubic yards (cu. yds.) of sandfill were placed on the beach in 1939 to replace some of the sand lost to erosion.

Wrightsville Beach experienced heavy property damages as a result of hurricanes occurring in 1944, 1954, 1955, 1958, and 1960. Erosion caused by these hurricanes necessitated the placement of a total of about 500,000 cu. yds. of sand dredged from Banks Channel in four separate operations between 1955 and 1959.

The Federal Government became involved in providing long-term beach stabilization in 1962 when Congress authorized (P.L. 87-974) the construction of a beach erosion control and hurricane protection project along the 14,000 feet of ocean shoreline extending north from Masonboro Inlet, which corresponded to the then existing town limits. The project was constructed in 1965.

The dune section had a design width of 25 feet at the crest at an elevation of +15 feet mean low water (m.l.w.), with the landward toe of the dune on or near the town building line. The berm section had a design width of 50 feet at an elevation of +12 feet m.l.w. A total of about 2,993,000 cubic yards of sand from Banks Channel was used in the initial construction, which included both the closure of Moore Inlet, located at about C.E. baseline station 150+00, and advance nourishment along a 2,800- foot section of beach north of the authorized project limit. Following closure of the inlet, Wrightsville Beach extended its town limits northward to include this 2,800 feet of beach. This action created the present situation in which the town limits include 16,800 feet of beach north of Masonboro Inlet (to Station 168+00); whereas, the Federal shore protection project limits include only 14,000 feet of beach north of the inlet (to Station 140+00).

Construction of the northern of the two Masonboro Inlet jetties, which were authorized in 1949, took place between July 1965 and June 1966. During the period of 1965 to 1970, the shore protection project suffered an unexpectedly high rate of erosion of the sand fill, particularly along the northern 7,000 feet of the project shoreline. This erosion could not be accounted for in terms of slope adjustments or sorting action on the fill. Continued severe erosion necessitated the dredging and placement of about 1.4 million cubic yards of fill on the shore protection project in the spring of 1970, after which the project was considered officially completed and was turned over to the local sponsor, the town of Wrightsville Beach. No additional fill was placed on the project until April 1980. At that time, an emergency fill, consisting of approximately 500,000 cubic yards of sand, was placed along the northern 7,000 feet of project shoreline under Public Law 84-99 authority. Upon completion of this work in May 1980, the northern half of the project still offered only a portion of the protection for which it was designed.

Between December 1980 and April 1981, a complete restoration of the authorized shore protection project was performed, returning it to the design configuration and level of protection for which it was authorized. This restoration required the dredging and placement of about 1.25 million cubic yards of sand, obtained from the Masonboro Inlet complex and Banks Channel and its distribution along the northern 7,000 feet of project shoreline. The restoration was completed using a combination of funds, including:

1. Federal Construction-General funds for periodic nourishment of the project shoreline. (Under existing authority, this nourishment represented the last time that the Federal Government could participate in the cost sharing of nourishment. The question of modifying existing authority to allow continued Federal participation for the project life is addressed in this study.)

2. Non-Federal cash contribution.

3. Section 111 funds (to mitigate erosion damage of the Wrightsville Beach shoreline judged to have been caused by the Federal navigation project at Masonboro Inlet).

4. Masonboro Inlet Navigation Project O&M funds (for restoration of project depths and channel alignment).

B. Purpose of this Assessment.

This environmental assessment discusses the environmental aspects of the current proposal to continue Federal cost sharing in the existing beach erosion control/hurricane protection project at Wrightsville Beach. This proposal resulted from a general investigation study authorized by a resolution of the Committee on Public Works of the U.S. House of Representatives, dated 2 December 1970. During the course of the investigation and subsequent report preparation, it became apparent that the preparation of a detailed environmental impact statement would be inappropriate due to the past history of disturbance on the beach and the lack of any known major environmental impacts associated with any of those events. Accordingly, attached to this environmental assessment is a signed Finding of No Significant Impact (FONSI).

1.00 SUMMARY

1.01 Major Conclusions and Findings.

It has been concluded that continued Federal participation in the authorized Wrightsville Beach erosion control/hurricane protection project is warranted and that impacts to the natural resources of the area will be minor and temporary in nature. Methods to be used will be similar to those used during initial construction and subsequent maintenance events. The basic elements of this method are outlined in Section 2.03. Borrow sites to obtain the necessary sand will be located in the Masonboro Inlet complex and in Banks Channel south of channel marker 14. These sites were selected due to the quality of the material they contain; the lower diversity of benthic organisms that they contain (as compared to surrounding areas); and the fact that dredging of these areas will naturally be required to maintain the navigation channels they contain. It is projected that nourishment of Wrightsville Beach will be performed at 2-year intervals during the project life. Nourishment activities will be performed during the winter months.

1.02 Areas of Controversy.

There are no known areas of controversy concerning this proposal.

1.03 Unresolved Issues.

There are no major unresolved issues.

1.04 Relationship of Plans to Environmental Requirements.

Federal Policies	Plans: Continued Federal Participation	Plans: No Action
National Historic Preservation Act of 1966, as amended	Full compliance	Not applicable
National Environmental Policy Act	Full compliance	Not applicable
Clean Water Act of 1977	Full compliance	Not applicable
Coastal Zone Management Act of 1972, as amended	Full compliance	Not applicable
Endangered Species Act of 1973, as amended	Full compliance	Not applicable
E.O. 11990, Protection of Wetlands	Full compliance	Not applicable
Fish and Wildlife Coordination Act	Full compliance	Not applicable
E.O. 11988, Flood Plain Management	Full compliance	Not applicable
State and Local Policies		
Coastal Area Management Act of 1974	Full compliance	Not applicable
N.C. Dredge and Fill Law N.C. General Stat. 113-229	Full compliance	Not applicable
Local Land Use Plans		
Town of Wrightsville Beach, N.C. CAMA Land Use Plan	Full compliance	Not applicable

2.00 PLAN FORMULATION AND EVALUATION

2.01 Study Authorization.

The authority for this study is contained in a resolution of the Committee on Public Works of the U.S. House of Representatives, dated 2 December 1970. The resolution was initiated by Congressman Alton Lennon, and requested the Secretary of the Army to direct the Office of the Chief of Engineers to make a survey of "Wrightsville Beach, North Carolina, and adjacent beaches in the interest of beach erosion control, hurricane protection and related purposes, including oceanic and lagoonal shores and interconnected tidal channels."

A notice of this resolution was forwarded to the Chief of Engineers, Washington, DC, on 2 December 1970. On 5 December 1970 the Chief of Engineers assigned the study to the South Atlantic Division which in turn assigned the study to the Wilmington District on 18 February 1971. Funds to initiate the study were made available on 1 October 1977.

2.02. Authorization of Existing Project.

Authorization of the existing Wrightsville Beach, NC, project was provided by Public Law 84-874, 87th Congress, H. R. 13273 23 October 1962 (House Document 511, 87th Congress, 2nd session).

2.03 Description of Existing Project.

The authorized project consists of a dune with a landward toe at or near the town building line, with a crown width of 25 feet at an elevation of 15 feet above mean low water (m.l.w.) and a 50-foot-wide berm at an elevation of 12 feet above m.l.w. The project extends 14,000 feet from Masonboro Inlet on the south to the location of the northern town limit existing in 1965. Initial construction included the closure of Moore Inlet, which previously separated Wrightsville Beach from Shell Island to the north, and placement of advance nourishment along 2,700 feet of beach north of the authorized project limit.

The current proposal is to continue Federal participation in maintaining this project, as original authorization provided for only 10 years of Federal involvement after original project construction.

As erosion of the existing project is attributable to two sources, natural erosion (53.8%) and erosion caused by the jetties at Masonboro Inlet (46.2%), the costs of maintaining the project will be divided accordingly. The Federal Government will bear 100% of the project maintenance costs attributable to erosion induced by the navigation project at Masonboro Inlet, while the project maintenance costs associated with natural erosion will be cost shared with the local project sponsor (Town of Wrightsville Beach) according to terms laid out in the authorizing document (50% Federal, 50% local).

Erosion of the shore protection project at Wrightsville Beach occurs at a rate of 130,000 cubic yards (cu. yds.) per year. The first sand bypassing operation is planned for 1987 and approximately 540,000 cu. yds. of sand will be placed on the project. (See table 2A of the main report.) Thereafter, nourishment of the project will occur once every two years and approximately 260,000 cu. yds. of sand will be placed with each nourishment event. In order to avoid dredging and disposal during periods of high biological and recreational activity, nourishment work will be performed during the established dredging window (October through March).

Two borrow areas will be used to obtain the nourishment material. These borrow areas were used previously during the reconstruction of the project which occurred during the winter of 80/81. One area is located in Banks Channel between Masonboro Inlet and Channel Marker 14. This site will be dredged to a plane of -30 feet mean low water (MLW) during maintenance events. The other area is located in Masonboro Inlet. The Masonboro Inlet site will only be dredged to a depth of -20 feet MLW in order to avoid impacting submerged cultural resources. The boundaries of both of these sites can be seen on plate 8.

Material excavated by the dredge in the borrow areas will be pumped through a submerged pipeline in Banks Channel and, with the aid of a floating booster station, transported to the beach. Short sand dikes will be used on the beach to delay the return of the effluent to the ocean. This will aid in the retention of sand and reduce the amount of turbidity introduced into the surf zone. Bulldozers will be used for spreading and shaping the sand placed on the beach.

2.04 Review of Planning Performed in this Study.

In Stage I of this study, a set of planning objectives was developed which responded to the specific request of the congressional resolution authorizing the investigation, and to the resource management problems and needs identified, and the expressed public concerns. The Stage I planning objectives are summarized below:

(1) Evaluate the feasibility of reducing and/or controling erosion of the estuarine and oceanic shoreline of Wrightsville Beach.

(2) Evaluate the feasibility of reducing the potential for hurricane wave and flood damage along northern 2,800 feet of the town's ocean shoreline and other developed areas.

(3) Develop basic data and guidelines for protecting and enhancing the environmental and esthetic quality of undeveloped sections of estuarine and barrier beach islands and adjacent waters.

(4) Develop and evaluate basic data and guidelines to assist in producing a rational program of land use for undeveloped Shell Island area.

(5) Develop guidelines for providing additional parking facilities to reduce traffic congestion and assist in improving public utilization of existing beach area.

During Stage 2 of this investigation, information and analyses were developed which led to a refinement of the original planning objectives. Certain concerns, such as the reduction or control of estuarine shoreline erosion, and the development of guidelines for providing additional parking and reducing traffic congestion, were eliminated from further consideration.

One significant addition was made to the set of planning objectives. This involved the reevaluation of the functional and economic aspects of the existing shore protection project in the following areas: revising the study area shore processes analysis and evaluating the future benefits and costs of the project to determine if terms of project cost sharing should be modified to extend Federal participation in beach nourishment for the project life. Existing authority for Federal cost sharing of nourishment expired with the restoration completed in April 1981. The set of planning objectives addressed in Stage 2 was as follows:

(1) Evaluate the feasibility of extending the limits of authorized shore protection northward to include the area developed since initial project construction.

(2) Develop data and recommendations to insure that if the northern end of the barrier island is developed, it is done in a manner which utilizes the high level of protection offered by the existing stable dune areas.

(3) Develop basic data and guidelines for protecting and enhancing the environmental and esthetic qualities of the remaining undeveloped section of barrier island.

(4) Evaluate the feasibility of implementing nonstructural measures to reduce storm-related inundation damages.

(5) Evaluate the existing shore protection project with a view toward more cost effective operation and possible extension on the period of Federal participation in the cost sharing of beach nourishment.

2.05 ALTERNATIVES

During Stage 2 planning an array of alternatives was developed which met the aforementioned objectives. These alternatives were analyzed in greater detail during Stage 2 planning and, as a result of this analysis, the current proposal was determined to be the only one feasible from an economic standpoint. The following presentation summarizes all of the alternatives considered in Stage 2. A complete discussion of the alternatives considered can be found in the Stage 2 report dated June 1981.

- Plan 1-A provides for the extension of the authorized shore protection project northward, a distance of 2,800 feet, to protect the developed area immediately north of the existing project limits. The berm and dune fill would have been constructed seaward of the present town building line along that section of shore.

- Plan 1-B extends the authorized project northward the same distance as Plan 1-A, but requires the relocation of the building line and the oceanfront row of structures. This section would have resulted in a less bulbous shoreline configuration, reducing erosion losses relative to Plan 1-A. In both Plans 1-A and 1-B, the proposed dune extension would have tied into the existing natural dune to the north.

- Plan 2 combines the basic features of Plans 1-A and 1-B with a requirement that any future development of the undeveloped section of the barrier island be located landward of a proposed building line. The location of this proposed line was generally at the landward toe of a large primary dune ridge, and would have insured the preservation of a high level of natural shore protection for future development.

- Plan 3 combines the basic features of Plans 1-A and 1-B with a proposal that the presently undeveloped section of the barrier island be acquired for preservation of its environmental and esthetic values. Plan 3-A was similar to Plan 3 except that the acquired barrier island area would be managed for recreation uses rather than preservation.

- Plan 4 is an entirely nonstructural plan for the reduction or elimination of inundation damages to existing development in the study area. This plan involved the application of a variety of nonstructural measures, including raising in place, relocating the building or contents out of the flood hazard zone, and constructing small floodwalls.

- Plan 5 is to continue Federal participation in beach nourishment for the project life.

- The no action alternative would end the Federal Government's participation in maintaining the authorized beach erosion/hurricane protection project at Wrightsville Beach. Under this alternative, that percentage (53.8%) of the beach erosion occurring which is not attributable to the jetties at Masonboro Inlet would not be compensated for by cost shared beach nourishment actions. This would allow a gradual and continual deterioration of the effectiveness of the project unless local interests assume 100% of the costs for its maintenance. Based on past performance, it is felt that this is unlikely, and that the project would deteriorate to a point where a significant threat to life and property will exist.

3.00 AFFECTED ENVIRONMENT

3.01 Geographic Setting.

The Town of Wrightsville Beach is comprised of two units, the estuarine island known as Harbor Island and the barrier island of Wrightsville Beach.

The former has an area of 293 acres, with 3.5 miles of estuarine shoreline exposed to current and wave activity. The latter has an area of 354 acres, with 3.2 miles of oceanic shoreline and 3.0 miles of estuarine shoreline. Adjacent bodies of water include the Atlantic Ocean on the east; Banks Channel, Motts Channel, and the Atlantic Intracoastal Waterway (AIWW) on the west; Masons Inlet on the north; and Masonboro Inlet on the south. Shinn Creek forms a hydraulic connection between the AIWW and Masonboro Inlet. To the north of Masons Inlet is Figure 8 Island; to the south of Masonboro Inlet is Masonboro Island.

Prior to the construction of the existing beach erosion control/hurricane wave protection project, Wrightsville Beach was an island extending 15,400 feet north from Masonboro Inlet to the then existing Moores Inlet. The 14,000 feet of oceanic shoreline within the town limits at that time was the portion of the island for which Congress authorized the Wrightsville Beach, N.C. project in Public Law 87-874, 23 October 1962. The 1,400 feet of beach between the northern town limits and Moores Inlet were undeveloped and privately owned. However, upon completion of the existing project, surplus project funds were used to close Moores Inlet in order to improve the littoral transport in the area. This action connected Wrightsville Beach to Shell Island, an undeveloped, privately-owned barrier island extending 8,000 feet northeast. The town of Wrightsville Beach then annexed the 1,400 feet of beach immediately north of the original town limits, including a 600-foot section formerly occupied by Moores Inlet, and the southern 800 feet of Shell Island, thus, extending the length of the town's ocean shoreline to 16,800 feet (to Station 168+00). This section, referred to as Shell Island, has developed into a predominantly residential area.

3.02 Population and Economics.

The preliminary results of a special 1976 census conducted by the town of Wrightsville Beach show 2,521 persons permanently residing in the town. As the following analysis from the town of Wrightsville Beach CAMA Land Use Plan indicates, the total population that may be present in the town during a peak period is considerably larger than that shown in this 1976 special census. On a peak day, such as the Fourth of July, a total of nearly 25,000 persons may be present in the town at one time.

Total Population of Wrightsville Beach

Permanent Population	2,521
Summer Residents	3,291
Overnight Visitors	6,566
Day Visitors	12,447
Total	24,825

Thus, instead of providing services and facilities for the 2,521 permanent population, the town must provide for a seasonal population up to 10 times that size.

The economy of Wrightsville Beach is tourist oriented with most of its residents being either retired persons or commuters who work in areas outside Wrightsville Beach. There are three major nontourist oriented employers within the corporate limits of Wrightsville Beach. These are the town government, the Saline Water Research Plant, and International Nickel Company. The remainder of the economy, with the exception of a few real estate agencies, exists to serve day visitors and overnight visitors. Restaurants, lounges, retail stores, fishing piers, motels, hotels, and specialty shops are the base of Wrightsville Beach's economy.

3.03 Significant Resources.

Seashore Area.

Within the town limits of Wrightsville Beach, there are many acres of high quality seashore area available for recreation activities, i.e., sunbathing, surf fishing, walking, jogging, bird watching, shell collecting, etc. This intertidal zone also serves as habitat for an invertebrate community adapted to the high energy sandy beach environment. The organisms which make up this community, i.e., mole crabs, coquina clams, amphipods, isopods, and polychaetes, are an important food source for surf feeding fish populations such as flounder, croaker, red drum, black drum, spot, northern kingfish, and pompano.

Invertebrate Species Occurring in Borrow Areas.

Masonboro Inlet and the portions of Banks Channel south of channel marker 14 (see plate 1) are considered to be prime borrow sites because of the excellent composition of the sediment and sparse populations of benthic invertebrates. Both of these sites were used to obtain the nourishment material for the restoration project undertaken during the winter of 80/81. Prior to that dredging, common macroinvertebrates inhabiting these areas included the hemichordate worms, *Balanoglossus auranticus* and *Saccoglossus kowlevskii*, the razor clam *Ensis directus*, the bivalves *Dosinia*, *Tellina*, and *Mercenaria mercenaria* (U.S. Fish and Wildlife Service, 1979). Sampling of these areas has not occurred) since the dredging took place; however, it can be safely assumed that populations of benthic invertebrates have begun to recolonize the areas although they may have different levels of abundance and different community structures. Due to the shifting sand bottom and past history of disturbance at these sites (for maintenance dredging of navigation projects as well as for beach nourishments), it is unlikely that they have been able to establish stable benthic communities in recent years.

Water Quality.

The water quality in the vicinity of the borrow sites is good. Banks Channel has a classification of SB (suitable for bathing). Masonboro Inlet has a classification of SA (suitable for shell fishing for market purposes). The high quality of the water in these areas can be attributed to tidal flushing and distance from any major pollution sources. The town of Wrightsville Beach prohibits the use of septic tanks.

Nonpoint pollution sources on Wrightsville Beach are not considered to be a major problem. Storm water from the community is removed by a separate storm drainage system which drains into the surrounding waters. Each storm water drain inlet structure has a trap for silt, grit, and trash, which is periodically cleaned and the debris treated as solid waste. Less than 10 percent of the rainfall that falls on the town enters the system due to the high absorptive capacity of the soils.

Fisheries Resources.

Recreational and commercial fishing in the vicinity of Masonboro Inlet and Banks channel are significant. These areas support both sport and commercial fisheries for such common saltwater finfish as black drum, croaker, pigfish, red drum, flounder, spot, black seabass, and bluefish. In addition, blue crab and penaeid shrimp are fished for both commercial and recreational purposes. Among other sport fish in the surf zone, northern kingfish, pompano, and spot are actively fished for, both from the beach and the two fishing piers located at Wrightsville Beach. Nearshore waters support an abundance of king mackerel, Spanish mackerel, and cobia.

Endangered Species.

Informal consultation as delineated in Section 7(c) of the Endangered Species Act of 1973, as amended, has been concluded with the Fish and Wildlife Service and National Marine Fisheries Service. The following list of species was considered in the biological assessment process:

Brown pelican (Pelicanus occidentalis)-E
Florida manatee (Trichechus manatus)-E
Blue whale (Balaenoptera musculus)-E
Finback whale (Balaenoptera physulus)-E
Humpback whale (Megaptera novaeangliae)-E
Right whale (Eubalaena spp)-E
Sei whale (Balaenoptera borealis)-E
Sperm whale (Physeter catadon)-E
Kemps ridley sea turtle (Lepidochelys kempi)-E
Hawksbill turtle (Eretmochelys imbricata)-E
Leatherback turtle (Derimochelys coriacea)-E
Shortnose sturgeon (Acipenser brevirostrum)-E
Loggerhead turtle (Caretta caretta)-T
Green turtle (Chelenia mydas)-T

Cultural Resources.

A cultural resources survey of Masonboro Inlet and Masonboro Island was conducted in connection with the construction of the South Jetty at

Masonboro Inlet. During the exploratory phase of this survey (October through November 1977), five major magnetic anomalies were recorded. Two of the five are located in the vicinity of the Masonboro Inlet borrow area. During April and May 1978, the N.C. Division of Archives and History made additional examinations of these two sites using a hydraulic probing device. By this method, it was determined that one of the sites is probably the remains of a relative modern vessel lying below a plane of -14 feet m.l.w, although it is possible that the modern vessel is positioned over a site of earlier vintage. The other site was probed to a depth of -20 feet m.l.w. without encountering the anomaly (Watts et. al.).

The Banks Channel borrow site is not considered to offer any potential for submerged cultural resources as it was dredged below the depths which will be required for continued maintenance during initial project construction; therefore, all of the sediments in the area are of recent origin.

Terrestrial Resources.

Within the study area, the most significant terrestrial resources occur on the undeveloped portion of Shell Island and on the manmade and natural estuarine islands which occur in Wrightsville Sound. These areas offer the only significant sites of natural vegetation communities available for terrestrial wildlife.

An extensive, stable dune system comprise the undeveloped portions of Shell Island. Vegetated principally with grasses, its value to some species of wildlife is limited. Data on wildlife utilization of the area is sparse; however, the data which does exist indicates that Shell Island offers good habitat for many species of birds and small mammals.

Most of the manmade and natural estuarine islands of the area are heavily vegetated with shrubs and small trees. These islands are heavily used by marsh foraging mammals and birds. Unvegetated manmade islands have been heavily used in the past by colonially nesting seabirds; however, this use has tapered off in recent years due to the confinement of dredged material disposal to just a few locations, thereby permitting most of the previously bare sand islands to vegetate.

Wetlands.

Wetlands are extremely abundant in the study area with about 70 percent of its 2,800 acres being salt marsh and tidal creeks. The marshes of the area are comprised principally of Spartina alterniflora. The transition zone between the salt marsh and upland areas is dominated by Spartina patens with interspersed patches of Distichlis spicata, Salicornia virginica, and Borrichia frutescens. These wetlands are very important to the marine resources and wildlife of the study area due to their high primary productivity and refuge/foraging value. While no studies are known to have been done on the productivity of the salt marshes of the study area, the productivity for such marshes generally falls in the range of 329 to 1,296 dry wt/m^2/yr (Keefe 1972). When this is combined with the additional productivity of approximately 100g carbon/m^2/yr for phytoplankton (Thayer 1971) and approximately 200g carbon/m^2/yr for benthic microalgae (Peterson and Peterson 1979), the astonishing productivity of these systems becomes apparent.

4.00 ENVIRONMENTAL EFFECTS

4.01 Effects on Significant Resources.

Seashore Area.

The disposal and shaping of sand for the maintenance of the berm and dune at Wrightsville Beach will normally occur between 1 October and 31 March in order to avoid adverse impacts to summer oriented tourism and disruption of the estuary and nearshore ocean during times of high biological productivity. Even with this time restriction, the following impacts can be expected to occur:

A. Esthetics - The esthetics of the beach will be diminished by the presence of pipeline and heavy equipment on the beach during nourishment activity. Since the nourishment work would occur in the "off" season, this impact will be felt principally by the beaches' resident population. Overall, the esthetics of the beach will be enhanced through maintaining the project, as the manmade berm and dune will provide a more pleasing prospect to the eye than a heavily eroded beach.

B. Turbidity - Beach nourishment activities normally elevate levels of turbidity in the surf zone due to the presence of silts and clays in the nourishment material. High levels of such turbidity are suspected of causing temporary displacement of various species of sport fish although this effect has not been documented. Equally possible would be a concentrated effect on sport fishes due to the presence of fragmented marine organisms from the dredge slurry being present in the surf zone (high food availability). During the last nourishment action undertaken on Wrightsville Beach, nourishment related turbidity did not appear to be a problem, as none was visible from the beach or from the air. This lack of noticeable turbidity was likely related to the following factors:

1) The use of short sand dikes between the outfall and the surf zone;

2) The coarseness of the material being used for nourishment and an overall lack of silts and clays; and

3) The natural turbidity in the surf zone.

Since the same borrow sites and construction techniques will be used in the future maintenance of the project, turbidity related impacts are expected to be minor.

C. Intertidal macrofauna - Disposal operations may have negative impacts on the intertidal macrofauna through various mechanisms. Changes in beach profile or grain size, direct burial, or the adverse effects of increased turbidity can singlehandedly or, in combination, radically change the faunistic composition of a beach. At Fort Macon, NC, beach disposal performed during the winter of 1977 essentially destroyed existing intertidal macrofauna (Reilly and Bellis, 1978). Investigators of that nourishment event concluded that turbidity was the principal agent involved in changing the community. Other studies (Hayden and Dolan, 1974) indicate that beach nourishment actions with coarse sands can have virtually no impact on intertidal macrofauna causing only temporary shifts in the distribution of the population. Due to the coarseness of the sands which have been and will continue to be used for nourishment of Wrightsville Beach, turbidity induced change in intertidal macrofauna will probably be slight. While no disposal effect studies have been performed at Wrightsville Beach which would corroborate this, random samples taken on the beach less than 2 months after the last nourishment action ended found that all life stages of the mole crab, Emerita talpoida, a key community species, were present.

Invertebrate Species Located in Borrow Areas.

The hydraulic dredging of sand from the borrow areas to maintain the design profile berm and dune at Wrightsville Beach will result in a total loss of all sedentary or slow-moving organisms in the borrow areas during each maintenance event. The effects of these types of impacts are difficult to assess but should be of minor significance as the habitat value of the borrow areas is low due to the instability of the bottoms and the areas to be dredged are small in relation to the amount of subtidal habitat available in the study area. Both borrow areas have been used for previous beach nourishment work. Benthic organisms will begin the recolonization of these borrow areas after each use; however, with the planned repeated use, they will not achieve any community stability during the remainder of the project life.

Water Quality in the Vicinity of Masonboro Inlet.

The dredging of the borrow areas will change bottom configuration and slightly alter current velocities at and adjacent to the borrow areas. This alteration may prove to increase the tidal flushing capacity of Masonboro Inlet, possibly improving water quality in the area to a slight degree. Turbidity caused by the dredging operations could cause a short term decrease in light penetration and dissolved oxygen but, due to the coarseness of the material to be dredged, these effects should be minimal and of short duration.

Fisheries Resources.

The continued maintenance of the project may cause minor adverse impacts to the fisheries of the area. Impacts would occur principally through the disruption of sources of food organisms and through direct mortality of juvenile fishes taken by the dredge. Impacts from turbidity are expected to be minimal. These impacts will be temporary, but recurring. Therefore, a semi-permanent decline in the fisheries of the area may occur; however, due to the small size of the areas to be dredged and the rapidness of the beach's invertebrate community's recovery, the decline is not expected to be noticeable or measurable.

Endangered Species.

Through the biological assessment process, the District has determined that continued Federal participation in the Wrightsville Beach project will not effect any threatened or endangered species. Confirmation of this finding by the Fish and Wildlife Service and National Marine Fisheries Service has been received.

Cultural Resources.

No impacts to cultural resources will result from the continued maintenance of the project as proposed. The Banks Channel borrow area has been dredged to the proposed limits and depths on two previous occasions. Therefore, the sediments which have accumulated in that area are recent and offer no potential for submerged cultural resources.

Two sites are known to occur in the vicinity of the Masonboro Inlet borrow area. One site, actually within the limits of the borrow area, lies deeper than the proposed dredging limit of -20 feet MLW and; therefore, will not be affected. Another site is located 400 feet seaward of the outer border of the borrow area. Strict limits have been placed on the Masonboro Inlet borrow area so that neither of these sites will be impacted.

Disposal of beach fill is considered to be of no consequence to cultural resources as it will simply replace material that has already washed away. If any sites remain buried on the portions of the beach to be affected by the project, they will simply be buried deeper, an action which has already occurred several times.

Terrestrial Resources.

The impacts of the project will be confined to the borrow areas and the ocean shoreline fronting the Town of Wrightsville Beach. The beach to the north of the authorized project limit will also gain some sand through longshore transport; however, this process is so gradual that it will have no discernable impact on natural resources. The extensive dune system on Shell Island will be unaffected.

Wetlands.

The vast salt marshes of the study area will be unaffected by the project. As the dredge pipeline exits Banks Channel and crosses the beach strand, it may be necessary to lay it across the marsh fringe bordering the east side of Banks Channel. If this occurs, its impact will be minor, as no permanent disruption of the marsh will occur.

5.00 PUBLIC INTEREST

5.01 Public Involvement Program.

Since the initiation of the study, two public meetings have been held. The first, in April 1978, was held for the purposes of informing the public of the start of the General Investigation Study of the Wrightsville Beach area, and to elicit public response on identification of water resources problem areas. The second meeting, held in December 1979, was held for the purpose of informing the public of the restoration work which was to be performed during the winter of 80/81. In addition to these public meetings, the District has been in frequent contact with Wrightsville Beach officials and other interested State and Federal agencies. A scoping letter seeking public input into Stage II of the planning process was sent out in March 1981. The principal result of this involvement has been to establish a high level of public support for the authorized project.

5.02 Required Coordination.

Concurrent with the circulation of this environmental assessment, a Section 404(b) (Public Law 92-500) Public Notice and evaluation was circulated, and a consistency determination was furnished to the North Carolina Office of Coastal Management and their concurrence was obtained. The Corps has completed the Section 7(c) endangered species consultation, and a Section 401 (Public Law 92-500) certificate has been received from the State of North Carolina. A final Fish and Wildlife Coordination Act Report was received in March 1982.

5.03 Recipients of the Assessment.

This assessment has been circulated for review and comment to the following concerned agencies and public for 30 days. After reviewing the comments received, the District Engineer may sign the Finding of No Significant Impact and proceed with the proposed action.

Environmental Protection Agency, Region IV
Department of Housing and Urban Development, Greensboro Area Office
U.S. Department of Commerce
Federal Energy Administration
Fifth Coast Guard District
Department of Health, Education, and Welfare, Region IV
League of Women Voters

N.C. Wildlife Federation
Sierra Club
The Coastland Times
Soil Conservation Service, USDA
Forest Service, USDA
Environmental Defense Fund, Inc.
Conservation Council of North Carolina
Federal Highway Administration
Mayor, Wrightsville Beach, NC
Clearinghouse and Information Center of North Carolina
Chairman, New Hanover County Commission
U.S. Fish and Wildlife Service

REFERENCES

Hayden, B., and R. Dolan. 1974. Impact of Beach Nourishment on Distribution of Emerita talpoida, the Common Mole Crab. Journal of the Waterways, Harbors, and Coastal Engineering Division ASCE 100:WWZ pp. 123-132.

Keefe, C. W. 1972. Marsh production: A Summary of the Literature. Contrib. Mar. Sci. 16:163-181.

Peterson, C. H., and N. M. Peterson. 1979. The Ecology of Intertidal Flats of North Carolina: A community profile. U.S. Fish and Wildlife Service, Office of Biological Services. FWS/OBS-79/39. 73 pp.

Reilly, F.J. Jr., and V. J. Bellis. 1978. A Study of the Ecological Impact of Beach Nourishment with Dredged Materials on the Intertidal Zone. Institute for Coastal and Marine Resources Technical Report No. 4. 107 pp.

Thayer, G. W. 1971. Phytoplankton Production and the Distribution of Nutrients in A Shallow Unstratified Estuarine System Near Beaufort, NC. Chesapeake Science 12:240-253.

U.S. Army Corps of Engineers. 1981. Wrightsville Beach, North Carolina, Stage II report. Wilmington District. 61 pp.

U.S. Fish and Wildlife Service. 5 October 1979. Letter from David Rackley, Acting Field Supervisor, to Col. Adolph Hight, District Engineer, Wilmington District, Corps of Engineers.

Watts, G. P. Jr., R. W. Lawrence, D. B. Hill, and J. A. Pleasants. 1978. Final Report on the Investigation of Magnetic Anomalies at Masonboro Island and Masonboro Inlet. Corps of Engineers Contract, SAWEN-E-78F0176.

Attachment A

FINDING OF NO SIGNIFICANT IMPACT

The Corps of Engineers proposes to continue Federal participation in the authorized beach erosion control/hurricane protection project at Wrightsville Beach for the project life. Dimensions of the project and the methods to be used in maintaining it are outlined in section 2.03, page EA-7. Maintenance work will occur approximately once every 2 years and will be performed during the winter months.

Alternatives to continuing Federal participation in the authorized project are discussed in section 2.05, page EA-9.

Significant resources discussed in the assessment include:

a. Seashore Area, 3.03, page EA-12.

b. Invertebrate Species Occurring in the Borrow Area, 3.03, page EA-12.

c. Water Quality, 3.03, page EA-12.

d. Fisheries Resources, 3.03, page EA-13.

e. Endangered Species, 3.03, page EA-13.

f. Cultural Resources, 3.03, page EA-13.

g. Terrestrial Resources, 3.03, page EA-14.

h. Wetlands, 3.03, page EA-14.

I have determined, based on the impact analysis presented in Section 4.01, page EA-15, that the impacts to the aforementioned significant resources will be minor and temporary in nature and that the preparation of an environmental impact statement will not be required. The alternatives analyzed are either economically infeasible or, in the case of no action, would permit deterioration of the effectiveness of the existing project at Wrightsville Beach, leaving the community vulnerable to the hazards associated with hurricanes and unchecked beach erosion.

A. A. KOPCSAK
LTC, Corps of Engineers
Acting District Engineer

ATTACHMENT B

COMMENT/RESPONSE

ENVIRONMENTAL ASSESSMENT ON
SHORE AND HURRICANE WAVE PROTECTION
WRIGHTSVILLE BEACH, N.C.

FEDERAL AGENCIES

A. Letter from Fifth Coast Guard District dated 24 August 1982.

COMMENT: The Fifth Coast Guard District offers no comments concerning the subject DEIS.

RESPONSE: Noted

B. Letter from the U.S. Fish and Wildlife Service dated 1 September 1982.

COMMENT: Generally, we believe the report is adequate with the exception of specific concerns addressed herein. The Service participated fully in the planning process for this project, and we provided comments and recommendations during that period. We are pleased that the Corps has utilized, and will apparently continue to utilize, borrow sites which we identified as having relatively low population densities of benthic organisms. Since it appears that beach nourishment and sand bypassing will occur every two years, we recommend that project maintenance be in accordance with Service recommendations contained in our Final Fish and Wildlife Coordination Act Report of March 2, 1982.

RESPONSE: The schedule recommended by the Service is infeasible as it only allows 60 days (1 October through 30 November) for beach nourishment activities. In order to accommodate Fish and Wildlife concerns as much as possible, the nourishment activities will be restricted to the established dredging window (October through March).

COMMENT: Although we generally concur with your assessment of anticipated project impacts, we do not believe that the impacts of periodic placement of sand in the littoral zone of the ocean beach are known. These impacts range in magnitude from minor short-term losses of near shore fauna to prolonged reductions in the population size of these species. Since any major long-term reductions in near shore populations could adversely affect local recreational and commercial fisheries, we continue to recommend that the effects of periodic disposal of dredged materials in the ocean littoral zone be studied further.

RESPONSE: Impacts of beach nourishment on resident benthic fauna is an issue of national concern and is currently being considered as a research topic by the Coastal Engineering Research Center at Fort Belvoir, Virginia. Two studies performed to date illustrate the wide divergence in results which can be obtained, depending on the nature of the material being placed on the beach. At Cape Hatteras, N.C., studies showed little effect when coarse grained material is deposited; at Fort Macon, N.C., significant adverse effects were noted when silty material was deposited. In neither case were long-term impacts analyzed. After the last beach nourishment at Wrightsville Beach, Corps biologists sampling the beach found little evidence of any severe impacts on benthic fauna. If the Coastal Engineering Research Center performs studies on the effects of beach nourishment on benthic communities, they will be designed to address long-term impacts.

COMMENT: Page 23, paragraph 1: Clarification is needed to explain why the preservation of Shell Island cannot be linked to the selected alternative. We assume that Corps regulations prohibit the expansion of project's boundaries when non-structural features are involved; however, this is not clear in the draft report.

RESPONSE: The measure referred to was an EQ feature which was linked to Plans 1-A and 1-B. When these plans were found to be infeasible, the linkage between the "recommended water resource development" and the separable "EQ feature" no longer existed.

A nonstructural measure (Plan 4) was evaluated for every structure on Wrightsville Beach, but was found to be economically infeasible (benefit-cost ratio = 0.36 to 1.0).

C. Letter from United States Environmental Protection Agency dated 29 September 1982.

COMMENT: We have reviewed the draft Feasibility Report and Environmental Assessment on the Hurricane Protection and Beach Erosion Control Project at Wrightsville Beach, New Hanover County, North Carolina. Our evaluation of the document revealed it to be well prepared and that the proposed action should cause little in the way of long-term and/or significant adverse environmental consequences over which this Agency has mandated authority.

RESPONSE: Noted.

COMMENT: However, we do observe that while the selected alternative may provide some temporary increase in the actual extent of the beach, it actually may foster the potential for future increased property losses there. For example, using excess project funds from a previous authorization, Moore's Cut was filled in and Shell Island connected to Wrightsville Beach. The subsequent development to the north including a Holiday Inn were seriously threatened until another emergency nourishment was undertaken (see inclosed photographs). Hence, it has been our experience that beach nourishment often engenders improvident development. This development in turn creates the demand for even more protection at ever increasing Federal cost.

RESPONSE: The beach area behind the existing berm and dune project is fully developed at the present time. If the project is not maintained considerable erosion damage to the existing development would occur. Nourishment is a planned part of the maintenance of the project. It has been performed in the past to insure the designed protection along the authorized project. In the case of future protection, the plan to extend the existing project northward 2,800 feet was found not to be economically feasible. Therefore, at this time, more protection is not being recommended. Plan 5, which is the recommended plan, is to continue Federal participation in the maintenance of the existing project for the life of the project.

STATE AGENCIES:

A. Letter dated 17 September 1982 from North Carolina Department of Natural Resources and Community Development.

COMMENT: Plan Number Five (5) has been the chosen alternative for continued maintenance of the beach renourishment project. The same borrow areas are proposed including that area south of Marker #14 in banks channel and the inlet weir collection reservoir. The Office of Coastal Management's major agency concerns are not centered on the continued use of these borrow areas which are highly disturbed deep water, sandy bottom sites but are the timing of the dredging activities. As stated before, it is very important in order to protect juvenile shrimp and finfish populations that no excavation or filling occur between April 1 and September 30 of any given year. The Office of Coastal Management would recommend that the winter months be considered for such operations to lessen impacts to ocean surf feeding fish as well.

RESPONSE: The nourishment activities will be restricted to the established dredging window (October through March).

COMMENT: The Wrightsville Beach Land Use Plan heavily concentrates its biggest problem as finding funds to continue the maintenance of the renourishment project. It states ..."That the preferred alternative for erosion control be renourishment, supplemented by land use controls, access planning and vegetation maintenance." It is hoped that the Corps' recommendation would also include a note that explains the specific land use and flood proofing recommendations described in Plans #2 and #4 to be implemented as much as feasible. Even though the benefit-to-cost ratios were found to be not favorable for these two plans, it should be recognized that emergency phases of future maintenance north of the defined project limits (Shell Island) are inevitable and that the town should acquire public beach access easements along these private streets. The final Corps' recommendation should be emphatically clear about Federal participation contingent upon provision of beach access through the existing Shell Island private development.

RESPONSE: All technical information developed in the course of formulating and evaluating Plans 2 and 4 will be presented to the Town of Wrightsville Beach. Implementation of these plans would be at the discretion of the local government and property owners.

Since the recommended project does not extend along Shell Island, the Corps cannot require provision of beach access through the existing Shell Island private development.

COMMENT: The rest of the Plan #5 appears to be consistent with the Land Use Plan and CAMA guidelines.

RESPONSE: Noted.

A. Letter from New Hanover County Planning Department dated 3 September 1982.

COMMENT: Impacts to the environment should be minor and of short duration. When combined with the maintenance objective of Masonboro Inlet this dual approach of dredging and beach nourishment seems quite acceptable.

RESPONSE: Noted.

COMMENT: In regard to the Feasibility Report several questions arise concerning the cost benefit analysis. Potential loss to land and structures includes damages to private property. Direct benefits to these properties are actually private rather than public. Since these individual landowners represent the greatest amount of benefit in any public expenditure, a more equitable comparison might be the potential annual tax value of the property. Certainly, that loss would have a broader impact on the community.

RESPONSE: The benefit-cost analysis was accomplished in accordance with guidelines and policies for Federal water resources agencies which attempt to measure potential project effects to the national economy, and public vs. individual ownership is not a criterion for determining acceptability of benefits from reducing or eliminating damages. Generally, individual property owners are considered as members of the public at large. Lost revenues to property taxing agencies are not considered to be losses from the national standpoint because the decreases in tax revenues become increased discretionary income to the owners of the lost property. Actually, lost tax revenues would probably be offset by increasing taxes of other property owners.

COMMENT: Continued funding of beach nourishment projects should be a burden of those who utilize the beaches. This could be accomplished through special district taxes or certain excise taxes.

RESPONSE: This would be a decision that the Town of Wrightsville Beach, New Hanover County, and the State of North Carolina would have to make concerning the non-Federal share of project costs.

COMMENT: Maximum setback requirements should be a condition of further funding. Adequate setbacks can take advantage of the natural shoreline and large primary dunes that act as barriers and offer protection for inland development.

RESPONSE: The Town of Wrightsville Beach has established an adequate building line setback along the authorized shore protection project.

COMMENT: Is the proposed plan consistent with the Department of Interior and FEMA's classification of Shell Island as "Undeveloped?"

RESPONSE: The proposed plan is continued Federal cost-sharing in the existing shore protection project located along Wrightsville Beach for the life of the project. Therefore, the plan has nothing to do with the classification of Shell Island as "Undeveloped."

B. Letter from Town of Wrightsville Beach dated 27 September 1982.

COMMENT: We are in receipt of and have reviewed the draft Feasibility Report and Environmental Assessment Document. While we are perhaps disappointed in the benefit-to-cost ratios developed in preliminary plans 1A, 1B, 2, 3, 3A and 4, the findings were not totally unexpected.

It is the position of the Town that the conclusions drawn and the recommendations made are in order and should be supported by the Town. We further totally agree that there is no necessity for an EIS, and the Finding of No Significant Impact statement should be signed.

RESPONSE: Noted.

APPENDIX A

HISTORY OF HURRICANES

HISTORICAL RECORDS

1. Lists of Hurricanes. The following tables present a chronological list of tropical hurricanes which have likely affected the Wrightsville Beach area. However, many of them caused no appreciable damage and others prior to 1871, which caused some damage, may not be listed:

Records of 18th and 19th Century Hurricanes
Affecting the North Carolina Coastal Area

Date Year, Month, and Day		
18th Century		
1700	September	16
1713	September	16
1728	August	-
1728	September	14
1752	September	15
1753	September	15
1757	October	-
1758	August	23
1761	June	1
1761	September	23
1770	June	6
1781	August	10
1783	-	-
1785	September	22-24
1797	September	-
19th Century		
1804	September	7
1811	September	10
1813	August	27
1814	July	1
1815	September	28
1821	September	2
1822	August	-
1822	September	27
1827	July	30
1827	August	24-25
1830	August	16
1837	August	1
1837	August	20
1837	October	9
1838	November	26-28
1842	August	24

Date Year, Month, and Day		
19th Century (cont'd)		
1844	September	14
1846	August	16
1853	September	7
1854	September	8
1857	September	12
1861	October	-
1871	August	18-19
1871	November	14
1873	September	22-24
1873	October	6-8
1873	November	17
1874	September	28
1874	November	22
1875	October	13
1876	September	17
1877	November	2
1878	September	12
1878	October	22
1879	August	19
1880	August	15
1881	August	27
1881	September	9
1883	September	11
1885	August	24-25
1888	October	11
1893	August	28
1893	October	13
1894	September	27
1894	October	9
1896	September	20
1897	November	7
1898	October	2
1899/	October	30

Records of 20th Century Hurricanes Affecting New Hanover County, N.C., Beach Areas

Year	Month and Day	Notes, Severity, Damage Areas, etc.
		Major and Moderate
[1]1904	September 14	Moderate, S.E.N.C.
1904	November 13	Moderate, N.C. coast
[1]1906	September 17	Severe, S.E.N.C. Barometer at Wilm., 27.90
1910	October 19	Moderate, Wilmington area - inland
[1]1913	September 2-3	Hatteras - major, N.E.N.C.
1916	July 19-20	Moderate, N.E.N.C. Heavy rainfall
1918	August 24	Hatteras, moderate, small, N.E.N.C.
1924	August 25	Moderate, skirted N.C. at Hatteras
[1]1925	December 2	Moderate, N.E.N.C. Unusual storm Barometer 28.90 near Wilmington
1930	September 12	Hatteras and vicinity - moderate. Barometer 29.71 at Wilmington.
[1]1933	September 16	Severe N. of New Bern to Va. Capes, moderate to minor elsewhere. Barometer at Hatteras, 28.25 inches.
1934	July 21-25	Very minor in vicinity of Wilmington
[1]1944	August 1-2	Wilmington - severe, S.E.N.C. Barometer at Wilmington, 29.41
[1]1944	September 14	Hatteras - severe. Barometer at Hatteras, 27.97.
1945	September 15-16	Beaufort area - moderate.
1954	August 30	Moderate to light - whole coast - "Carol" Barometer 29.41 at Wilmington.
[1]1954	October 15	Very severe, S.E.N.C. "Hazel." Barometer, 27.70 at Little River, S.C.

[1] Storms actually striking or entering N.C. coast with destructive force.

Records of 20th Century Hurricanes Affecting New Hanover County, N.C., Beach Areas

Year	Month and Day	Notes, Severity, Damage Areas, etc.
		Major and Moderate -- Cont'd
[1]1955	August 11-12	Severe, E.N.C., heavy rains - "Connie." Barometer, 28.40 at Fort Macon, N.C.
[1]1955	August 17	Moderate in Wilmington Area - "Diane." Barometer, 29.13 at Wilmington, N.C.
[1]1955	September 19	Severe, E.N.C., excessive precipitation. Barometer, 28.35 at Morehead City, N.C. "Ione."
[1]1958	September 27	"Helene." Severe in Cape Fear area. Maximum 5-minute wind, 69 mph. Minimum barometer 28.80 inches - both at Wilm., N.C.
[1]1960	September 11-12	"Donna." Severe in Cape Fear area, worse in vicinity of Morehead City, N.C. Maximum 1-minute wind velocity in Wilmington, 53 mph, NW; minimum barometer 28.41 inches.
		Minor
1901	September 18	
1902	June 16	
1903	September 16	Very minor - delayed flight of Wright Brothers
1908	August 31	Cape Lookout damaged - very unusual storm.
1916	July 14	Heavy rain in interior.
[1]1920	September 20	Cape Fear River area - small storm - little damage.
1923	October 23	
1924	September 16-17	
1924	September 30	Minor in Wilmington area.
1928	September 18	S.E.N.C. Barometer, 29.12 at Wilmington, N.C.

Records of 20th Century Hurricanes Affecting
New Hanover County, N.C., Beach Areas

Year	Month and Day	Notes, Severity, Damage Areas, etc.
		Minor -- Cont'd
1929	September 1-2	Very minor
1934	September 7-8	Barometer at Hatteras, 28.56
1935	September 5-6	
1937	July 31	Minor, not a hurricane in N.C.
1937	August 2-8	Minor, not a hurricane in N.C.
1937	September 26-30	Minor, not a hurricane in N.C.
1938	September 21	Hatteras and vicinity
1938	October 23-24	Minor, not a hurricane in N.C.
1940	August 15	Very minor, heavy rain
1940	September 1	Heavy rains
1942	October 11-12	Very minor, not a hurricane in N.C.
1944	October 20	
1945	June 24	
1945	November 5	Very minor
1946	July 6	Very minor
1946	September 19	Minor
1947	October 12-13	
1950	August 19-20	
1951	October 4	
1952	August 30	Very minor "Able."
1953	August 13	"Barbara" Cape Lookout area.

Records of 20th Century Hurricanes Affecting New Hanover County, N.C., Beach Areas

Year	Month and Day	Notes, Severity, Damage Areas, etc.
		Minor -- Cont'd
1954	September 10	"Edna"
1973	February 17	Erosion and some property damage
1979	September 5	"David" 1-year frequency storm

18th CENTURY HURRICANES

General. In the following narrative account of hurricanes affecting the beach areas of New Hanover County, North Carolina, it will be noted that not all hurricanes listed in tables B-1 and B-2 are discussed. Those not discussed caused very little damage in the study area, or very little record of their characteristics or damages is available. In some cases the damage a storm caused outside the study area may be cited as background information.

1752 - September 15. A severe hurricane destroyed the Onslow County seat which was rebuilt in a new location. This new location was around 40 miles east of Wilmington. In Charleston this storm was described, in part, as follows:

"The wind blew so hard that it stemmed the Gulf Stream in its northern course and threw it on the shores. At 9 o'clock the flood came rolling in with great impetuousity and in a short time the tide rose ten feet above high water mark of the highest tide."

Among the ships involved was: "The Hornet, sloop-of-war, with seven anchors, drifted ashore where Gadsden's Wharf now stands. She was the only vessel in the harbor which rode out the storm." This hurricane was probably one of the great hurricanes of the century.

1761 - September 23. "A London magazine of 1761 reports that a storm occurred in North Carolina, which began on Monday, the 20th of September, and continued until friday, but raged with most violence on the 23d. Many houses were thrown down, and all vessels, except one, in the Cape Fear River, were driven ashore. It forced open a new channel at a place called the Haul-Over, between the Cedar House and Bald Head. This new channel was found on sounding to be eighteen feet at high water, and was near half-a-mile wide." (Wilmington Directory for 1865-66 by Frank D. Smaw, Jr.)

"The Greatest Hurricane. - The year 1761 was quite an eventful one in the history of Brunswick. It was in that year that the fearful hurricane along the coast occurred which did great damage, throwing down many houses including the roof of the church, and forcing open New Inlet - which remained for a hundred years until after the War between the States." (History of New Hanover County by Waddell.)

The records indicate that this also was one of the great hurricanes of North Carolina and considered by some historians to be the most violent to occur along the North Carolina coast.

19th CENTURY HURRICANES

General. Prior to 1871, few records have been found in North Carolina pertaining to hurricanes. By comparison of old shipwreck data with records of hurricanes kept in adjoining states, it is the opinion of this office that a number of the shipwrecks resulted from the effects of hurricanes. Records of a total of 38 hurricanes affecting the coastal area of North Carolina have been found and are briefly discussed in the following paragraphs.

1804 - September 7. This hurricane struck the Atlantic coast near Charleston, S.C., then passed northward through North Carolina. Although this storm was well inward of the North Carolina coast, it was so severe that its effects were felt along the entire North Carolina coast.

1821 - September 2. This hurricane, commonly known as the "Long Island Hurricane," hit the coast of North Carolina near Morehead City and passed close to New Bern and Washington into Virginia, near Norfolk. Although this was a very severe hurricane, there are no records of shipwrecks or other losses in North carolina.

1822 - August. The only available information states that this hurricane struck the North Carolina coast.

1822 - September 27 or October 27. Conflicting records indicate that this hurricane struck the coast of North Carolina on either September 27 or October 27. Records indicate that the schooner ENTERPRISE was a victim of the tropical storm by being wrecked near Rodanthe, N.C., on October 27.

1827 - July 30. This was considered as one of three hurricanes recorded as afecting the North Carolina coast in the year 1827. Records have been found for one other of these hurricanes. In all probability this was not a very intense storm.

1827 - August 24-25. Records indicate that this hurricane, known as the "St. Kitts Hurricane," passed close offshore from Cape Hatteras. Tearing the Diamond Shoals Lightship from its anchorage and wrecking it on Ocracoke Island, this hurricane was probably quite severe along the northeastern coast of North Carolina from Beaufort to the Virginia line; probably minor in the Wilmington area.

1830 - August 16. This tropical storm, the "Atlantic Coast Hurricane," hit the South Carolina coast near Charleston on August 1st, then moved up through North Carolina and out to sea near Currituck on the 16th.

1837 - August 1. This tropical hurricane, "The Barbados Hurricane," moved in a continuous arc through the eastern tip of Florida, up to a point southeast of Wilmington, and then out to sea. Damages from this storm were relatively light in North Carolina.

1837 - August 20. "Calypso," as this tropical storm was named, passed close off the shore from Cape Hatteras. While in all probability this hurricane had sufficient destructive powers, there are no records of loss or damage in North Carolina.

1837 - October 9. "Racer's Storm" first appeared southeast of Jamaica. There were very high winds, and for 2 days (September 27-28) the Kingston streets were flooded. The sloop RACER ran head-on into the hurricane in the Yucatan peninsula and the Bay of Campeche. The hurricane destroyed the town of Brazos, Santiago, on October 3-4. It then curved north, flooded the Texas coast, and struck Galveston on the 5th. Curving more to the east it hit New Orleans on the 6th, Mobile on the 7th, and Charleson on the 8th. It was on the North Carolina coast on the 9th where it was credited with taking around 90 lives in one of the worst marine disasters in North Carolina history, the wreck of the proud new steamboat HOME.

1842 - August 24. At least three ships were known to have been wrecked and others were reported aground. This storm took a terrific toll in shipping, lives, and property along the North Carolina coast.

1853 - September 7 - Cape Verde - Hatteras hurricane (Tannehill). No specific data are available on this memorable storm, but weather records in 1893 mention this day as a day of previous high flood on the Cape Fear River.

1854 - September 8. This hurricane of great violence has been recorded as passing near Charleston on September 8 and Norfolk on the 9th. Therefore, it must have pased directly over eastern North Carolina, although no records have been found proving this.

1857 - September 12. Conflicting data make it difficult to determine whether this hurricane occurred in 1856 or 1857. It was reported that this September storm, or "Northeaster" as they were called in the middle 1800's, was very severe in southeastern North Carolina. A German farmer, Mr. Charlie Teigen, who lived about 6 or 7 miles east of Wilmington, related that the wind blew for 2 days and then shifted to southeast to southwest. He further related that Wrightsville Beach at that time contained many live oak trees. These trees, with the exception of a few which died soon after the storm, were washed away. He also related that fishing shacks were washed away and that debris floated across the sound into his yard which was some 30 feet above sea level. Other reports tell of the hurricane passing off Hatteras, and of a new inlet resulting south of Federal Point. If this is a true account, there is little doubt but that this was one of the great storms of the 19th century in North Carolina.

1861 - October. Very little information is available pertaining to this storm. However, records indicate that a terrific gale scattered a fleet of 75 ships enroute from Norfolk to South Carolina. It is felt that in all probability this storm was of sufficient strength to be classified as a hurricane, although there are no definite records to this effect.

1871 - August 18-19. "The cyclone, after striking Savannah and Charleston seems to have taken a more easterly course, as only moderately high winds were felt here.

"August 21. Reports have been received that a very severe gale was raging at Smithville (Southport) some 30 miles south of Wilmington, on the mouth of the Cape Fear River, on Saturday night, August 19. (Data from journal of Wilmington Weather Station.)

1871 - November 14. "The order UP SIGNALS was received at 1 p.m. Rain continued thru the night, the wind was blowing very fresh with signs of increasing force. The barometer kept falling rapidly until 10:50 a.m. (lowest was 29.49). The wind velocity up to that time had increased to 36 mph blowing strong gusts, the force of which could only be estimated. A comparative lull of a few minutes was succeeded by a very heavy blast, at least 45 mph. At that time the wind veered to southwest and the barometer began to rise." (Wilmington data.)

1873 - October 6-8. Village of Punta Rassa, Florida, destroyed. There were reports of damage at Jacksonville and Charleston and destructive gales off Cape Henry. Winds from the west produced a maximum 5-minute velocity of 38 miles per hour at Wilmington.

1873 - November 17. The Wilmington Weather Bureau reported winds from the northwest, producing a maximum 5-minute velocity of 36 miles per hour. Detailed information is not available on this hurricane.

1874 - September 28. The Wilmington Weather Bureau recorded the following:

"During the nights of the 27th and 28th the center passed northeasterly over upper Florida to the coast of Georgia, pursuing a track similar to the storms of 1873. It passed along the Carolina coast on the 28th developing a force that has been generally compared to the hurricane of 1854. The center of this storm passed a short distance east of Charleston and west of Wilmington and Norfolk, crossing Chesapeake Bay on the morning of the 29th. The lowest barometric pressures reported were: Charleston 29.06, Wilmington 29.15, Norfolk 29.41. The maximum 5-minute velocities were: Savannah, N.W., 36 miles; Charleston, E., and N.W., 48; Wilmington, S.E., 45, and S.W., 50; Cape Hatteras, S.E., 75."

"----The 2 p.m. observation showed a fall in the barometer of .189, the wind from southeast and oscillating to southwest with a velocity of 28 mph. At 5 p.m. the wind oscillated continually between the east and west point blowing in heavy gusts of which some were 45 mph. At 5:15 the rain ceased. At 6:15 p.m. the center of the storm was immediately near, the minimum height of the barometer occurred which read 29.149. The wind blowing in heavy gusts from the east, southeast, and south and the anemoscope oscillating from the east via south to the west several times to the northwest. At 7:15 p.m. the barometer read 29.234 the wind blowing in heavy gusts almost uniformly from southwest some of which attained a velocity of 48 to 50 mph....The destruction was very great in the Cape Fear area, uprooting large trees and carrying them at a considerable distance. In many places along Water Street (Wilmington) the waves of the Cape Fear River were above the wharf and the business section was entirely deserted. The storm at Smithville (Southport), 30 miles from Wilmington, was very disastrous. Several houses were blown down, the warehouses on the Grrison wharf were completely destroyed and the Oceanhouse was also demolished. The Spanish Barque "Arrina" lying in the roads was blown over in ten fathoms of water. The rice crop along the river was injured to the extent of 33 percent. The telegraph lines were blown down; several railroad bridges were destroyed. The corner of the new Post Office was blown down."

<u>1874 - November 22.</u> This is another tropical storm which was considered of hurricane force, although there are no records to substantiate it. Records do report that the schooner HENRIETTA of Saco, Maine, captained by James H. Sampson, lost both of her masts during a sudden blow on November 18. Wilmington Weather Bureau records indicate that a maximum 5-minute wind velocity was recorded blowing from the southwest at 38 miles per hour.

<u>1875 - October 13.</u> This hurricane passed off the North Carolina coast. The only records available state that the brig NELLIE ANTRIM was damaged by a northwest gale off Cape Fear. Damage to the North Carolina coast was probably light.

<u>1876 - September 17.</u> This hurricane, moving up from the Bahamas, struck the Atlantic coast near the North Carolina-South Carolina State line and then continued north, passing over Washington, D.C., between 4 and 6 p.m. on the 17th. Generally, the path of this hurricane coincided with that of Hurricane Hazel in 1954, although this hurricane was not as severe a hurricane as "Hazel." The anemometers at both Wilmington and Cape Lookout were disabled at the height of the storm after recording, respectfully, north, 60 miles per hour; and southwest, 73 miles per hour. The lowest pressures were: Smithville (Southport), 29.24; Wlmington, 29.32; Cape Lookout, 29.46. Records indicate that there was considerable wind damage in Wilmington and that at least one ship, the British bark EXCELSIOR, was driven ashore near Wilmington. Reports also tell of a camp being washed away at New River near Swansboro, N.C., and two lives being lost due to drowning.

1877 - November 2. This hurricane is another of the many which have affected the coast of North Carolina, for which few records have been found. The Wilmington Weather Bureau, however, has a record which shows that a maximum 5-minute velocity of 38 miles per hour was recorded from the southwest.

1878 - September 12. This hurricane moved almost due north from the Florida Keys to Lake Erie. Reports relate that a great many ships were disabled and wrecked and that the lighthouse on St. John's Bar near Jacksonville, Florida, was blown down. The steamer CITY OF NEW YORK reported that the hurricane lasted 40 hours between Charleston and Cape Hatteras. Maximum winds recorded were: Smithville (Southport), 48 miles per hour; and Cape Lookout, 75 miles per hour from the southeast.

1878 - October 22. The chart in the Annual Report of the Chief Signal Officer indicates that this hurricane passed directly over Cape Fear. "The storm commenced at Wilmington at 3 p.m., wind E.; at 10:20 p.m. wind suddenly shifted from N.E. to N.W.; at 10:40 p.m. maximum velocity 36, N.W. occurred and at 11:56 p.m. the lowest pressure, viz., 29.12. Cape Lookout barometer 29.05 wind S.E. 68 maximum velocity since 4:37 p.m., 100 miles. Portsmouth reported wind S.E. 82; Smithville E. 32 and Charleston N.E., 30. The steamer JUANITA, at Wilmington on the 22d, reported terrific N.E. gale between Charleston and Tybee. The steamer CITY OF HOUSTON was lost on Frying Pan Shoals. A great many ships damaged or lost all along the Atlantic Coast." This was a very destructive storm along the coast.

1879 - August 19. This hurricane seemed to have followed a path resembling those of "Carol" (1954) and "Connie" (1955). It apparently struck the coast between Cape Lookout and Cape Fear, probably in the Swansboro vicinity. There are many accounts of this hurricane in old books, records, and newspaper clippings. One account reads as follows:

A TERRIBLE STORM August 19, 1879

The worst storm every to have visited our coast took place today. It was particularly terrific at Beaufort and Morehead City. The old Atlantic Hotel was the first to go, and it was blown down completely, the guests being forced to flee hurriedly. Next to go was the Ocean View Hotel. Scores of buildings were blown down and several people lost their lives. At least a dozen yachts also were smashed to pieces. The Atlantic and North Carolina railroad tracks were torn up for about a thousand yards. In Wilmington dozens of houses also were unroofed and it is reported that great damage took place elsewhere along the coast."

At 5 a.m. (18th) the wind reached its greatest velocity, 37 miles NW, at Smithville, and at 5 a.m. at Wilmington W, 68 miles. At that time (5 a.m., 18th) at Cape Lookout, the wind had increased to SE, 80 miles, the rain fell in torrents, and a fearful sea swept away the stable and outbuildings. The schooner SECCHELLE came ashore as wind veered to southwest; and, although drawing 12 feet, was carried, a total wreck, above the highest tidemark, over ground never remembered to have been overflowed before. After 5 a.m. the wind and rain abated at Smithville, with 2.10 inches rainfall in the preceding 10 hours. At 6"30 a.m. (18th) at Macon, the anemometer registered 80 miles and then the electrical connections failed. At 6:30 a.m. the barometer at Cape Lookout, which at 6 a.m. was 29.22, had fallen to 29.15 and the anemometer cups were blown away, the wind then blowing at the rate of 138 miles per hour. The barometer remained at 29.15 until 7 a.m., the wind and sea still increasing. By 7:30 a.m. the barometer had risen to 29.18, with wind at its greatest force - an estimated velocity of SW, 165 miles. At 8:45 a.m. the wind at Portsmouth, N.C., was SE, 97 miles, when the recording apparatus became temporarily disabled. At Macon the wind veered to SW at 8 a.m. (18th) and the tide rose 4 feet above the ordinary tide. At 8:30 a.m. the wind reached its maximum recorded velocity at Cape Hatteras, S.E., 74, when the cups were blown away; and at Kitty Hawk at 9:50 a.m., S.E., 100 miles. The gale continued at Wilmington until 10 a.m., with a total rainfall of 4.60 inches in 6-1/2 hours.

The damage done by this storm cannot be enumerated. The damage to maritime property must have been enormous; reports at hand show that over 100 large vessels were shipwrecked or suffered serious injury, while the number of yachts and smaller vessels which were destroyed or seriously damaged must certainly exceed 200. The journal of the Wilmington Weather Office gives a detailed account of the destruction in the city and to ships in the vicinity. This was most certainly one of the great hurricanes that have struck the southeastern North Carolina coast.

<u>1881 - August 27.</u> This hurricane hit the Atlantic coast near Savannah, Georgia, where there were over 335 casulaties. It then continued westward into the United States. Relatively little damage occurred in North Carolina. Reports from Masonboro Sound near Wilmington tell of a heavy gale on the night of the 27th, with heavy seas and unusually high tides. Heavy rains were experienced, and winds were recorded at 27 miles per hour from the east. Undoubtedly, this was one of the very minor hurricanes affecting North Carolina.

<u>1881 - September 9.</u> A report at the Weather Bureau office in Wilmington reads as follows:

"Brisk NE winds and light rain early in the morning, and at 7:30 a.m. accompanied by thunder and lightning. At 9:45 a.m. 'UP SIGNALS' received. At 10 a.m. the wind increased to a gale (35 miles). The lowest barometer reading was 29.302 at 1 p.m. The center passed station at 1 p.m. when wind veered to the SW and to the west at 1:15 p.m. when the wind suddenly increased to a hurricane blowing at the rate of 90 miles for 4 minutes when the wires of the anemometer were carried away. At this hour the roof of the Purcell House was blown off. Bark LIVE OAK blown ashore, small schooner capsized in the river. Freight houses blown down, several vessels dragged anchor in the river and were more or less damaged. Houses were unroofed, shade trees, brick walls, fences, telegraph and telephone wires prostrated. The damage done is immense and estimated at $60,000." A report on

September 10, 1881, estimated the damage at $100,000. A maximum 5-minute velocity of 65 miles per hour from the west was recorded at Wilmington. This is the highest ever recorded at this station. This hurricane is considered as one of the great hurricanes in North Carolina history, and probably of greater intensity than Hurricane Hazel.

1883 - September 11. This tropical storm moved inland in the vicinity of the North Carolina-South Carolina State line and spread over North Carolina. Wind velocities along the North Carolina coast were recorded as 93 miles per hour, SE, at Southport; 39 miles per hour, SE, at Wilmington; 60 miles per hour, NE, at Fort Macon and Cape Lookout; and 48 miles per hour, NE, at Hatteras. Wilmington barometer read 29.41 inches. Reports at Wilmington tell of little damage except to the telephone exchange and to one ship which broke loose from her mooring. The greatest damage caused by high water was sustained by the rice crop.

1885 - August 24-25. This severe storm moved inland in the vicinity of the South Carolina-Georgia State line on the 24th, passed landward of the coast, and emerged into the Atlantic Ocean on the 25th near Kitty Hawk, N.C. Maximum wind velocities recorded were: SW, 98 miles per hour at Southport; SW, 52 miles per hour at Wilmington; SW, 92 miles per hour at Fort Macon; and S, 52 miles per hour at Hatteras. The anemometer cups blew away at Southport before the peak of the storm arrived. At the peak, winds were estimated at 125 miles per hour. The Wilmington barometer read 29.36 inches. Property damage at Southport and surrounding locations approached $1 million.

1888 - October 11. Records of this hurricane are very sketchy regarding damage inflicted or path of travel. The records at the Wilmington Weather Bureau, however, show a maximum 5-minute velocity of 47 miles per hour from the NE and that the fastest mile recorded was 60 miles per hour, also from the NE. The lowest barometric pressure reading was 29.454.

1893 - August 28. This seems to have been one of the great hurricanes of the 19th century. The storm came from the Atlantic, passed north of the usual track (north of the West Indies and Bahama Islands), and struck the coast between Savannah and Charleston. Islands along the South Carolina coast were submerged. At least 1,000 leves were lost in Charleston and the property loss was $10 million. The maximum wind velocity at Charleston was reported as 96 miles per hour for 5 minutes, with an extreme 1-minute velocity of 120 miles per hour. The lowest barometer recorded was 29.076. Entries in the Wilmington station journal read in part as follows:

"Wind continued to increase in force during early a.m. hauling to SE. Pressure decreased to a reduced reading of 29.60 at 9:30 a.m. At 10:15 a.m. wind was blowing at the terrific rate of 49 mph from SE, veering to S & SW and moderating towards midnight. The damage in this immediate vicinity was very slight from wind, but considerable damage (probably amounting to several thousand) was done to merchandise in storms along river front. The river tide was highest ever known there. All the wharves being submerged.

The greatest damage was to shipping. The Norwegian bark 'Bonita' was blown ashore in Cape Fear River near Southport and a number of vessels wrecked on the coast."

The marine losses were much greater than the station journal indicates. Four ships were wrecked between Lockwoods Folly and Cape Fear. Eight more were lost on Frying Pan Shoals. There were other wrecks along the coast between Cape Fear and Cape Lookout. One old newspaper report states that 36 ships were lost in the storm between Lockwoods Folly and Ocracoke Island. The sea washed across Wrightsville Beach Island and Carolina Beach. For Wilmington and the Cape Fear area this hurricane seems to have been the most severe since records began in 1871. However, the old log books and newspaper clippings state that the hurricane that followed in October was even more severe.

Other maximum wind velocities recorded were 72 miles per hour from the south at Southport and 50 miles per hour from the south at Kitty Hawk.

<u>1893 - October 13</u>. The following is from the station journal at Wilmington:

"Rain continued from yesterday, becoming heavy at times. NE gale set in during early morning. Barometer fell steadily all night and until 12:15 p.m. today, reaching 29 inches even, the lowest on record at this station. The wind held steadily from NE until about 10:35 a.m. when it shifted to SE blowing from that direction until 2 p.m. when it began to work around to SW, increasing very regularly until 12:25 p.m. at which time the highest velocity (56 mph) was attained. The wind was remarkable for the very regular rate of speed maintained, the instrument recording 45 to 48 mph for several hours. Very heavy gusts, of only a few seconds duration, caused extreme velocity of 60 mph several different times extreme for the day 68, and the high puffs doubtless reached as much as 75 or 80 miles. The wind so steady from SE caused the highest tide in the memory of the oldest river men, exceeding the previous highest tide (that of 1853) by 16 inches. The water in the river was forced upstream by the tide and wind until it rose over the docks, flooding Water Street and destroying great quantities of stores, cotton, hay, flour, etc. Great damage was done to rice fields and river docks.

"The storm had been heralded by the Weather Bureau and no doubt much loss and greater disasters were avoided by the public heeding the warnings. About 12:45 p.m. the barometer began to rise and it went up nearly as fast and steadily as it had gone down. The wind began to slacken very slowly about sundown, and by 8 p.m. the most severe storm that has visited this station in its history of 23 years was over."

(This hurricane evidently was very destructive in the southeastern North Carolina area, but there were fewer ships wrecked. The Charleston records make no mention of the storm and it is barely mentioned in Tannehill's list. This hurricane may have been similar to the one in 1961; perhaps it was small in diameter but of great intensity. The numerous newspaper clippings in the station journal indicate a very severe hurricane, worse than the one that struck in August. The path of this hurricane is not known here.)

1894 - September 27. This hurricane passed up through Haiti, Cuba, and Florida before causing high winds in North Carolina. The Wilmington Weather Bureau office recorded a maximum 5-minute velocity of 35 miles per hour from the northeast. No other information is available.

1894 - October 9. This hurricane moved northeastward along the Atlantic coast states inside the coastline. At Wilmington, N.C., the storm was accompanied by heavy rainfall and high tides, with very little damage in that area. There are no other records of any value on this hurricane.

1898 - October 2. High east winds along the coast were reported. Hurricane signals were received at Wilmington at 11 a.m. This hurricane appears to have been much more severe along the coast than indicated by observations at Wilmington, since other reports state that a Navy lookout station at Carolina Beach was destroyed by a heavy surf.

1899 - October 30. Following is the record of this storm as written up in the Wilmington station journal:

"Inappreciable showers during night. Light rain began at 8:20 a.m., became heavy toward evening and continued at midnight. Generally cooler and rapidly decreasing pressure after 10 a.m. The wind gradually increased in force from the NE reaching a gale velocity at 3 p.m. and became very severe during evening. Max. vel. of wind to midnight 42 mph from the NE. The gale continued very severe during the night and forenoon accompanied by heavy rain till 4:50 a.m. and light showers from 8:10 a.m. to 3:30 p.m. Rapid and decided fall in barometer till 5 a.m. when it reached 28.90 (actual). After this time it began to rise sharply. The wind gradually veered from NE to SE during the night, blowing with increased force, reaching a maximum velocity of 43 miles from the SE at 4:30 a.m. The wind came in great gusts at times, reached extreme velocities of 50 to 55 miles. Toward noon the wind began to shift to SW'ly becoming steady from that direction at 4 p.m. and gradually decreasing in force. Gale ended at 8:07 p.m. Much higher temperatures after midnight, falling slowly during the day. The amount of damage done in Wilmington and vicinity is enormous, not so much by the high winds but by the tremendously high tide accompanying. The tide reached nearly the highest point in the history of the port, and much damage was due to submerged wharves and warehouse floors. At many points the overflow covered Water and Nutt Streets. In the city proper only a few other minor damages were done. Such as trees, signs, and awnings blown down and a section of the north wall of the Masonic Temple in course of erection.

"At the summer resort beaches - Wrightsville Beach 10 miles due east and Carolina Beach, 18 miles southeast - the wind and tide played havoc. Sixteen cottages were washed away at Wrightsville Beach and the remainder more or less damaged. A large section of the railway trestle connecting the beach with the mainland and the track on the beach was washed away.

"At Carolina Beach the devastation was about as great and but few of the cottages remain. From Southport only meager reports are to be had as the telegraph wires are down. Such reports as received indicate much damage. The steamer SOUTHPORT was thrown up on the shore 100 feet above high water mark. The tug BLANCHE was thrown high and dry on the beach. The launch NAPTHA costing $1,800 was smashed and is a total wreck. All wharves excepting the Government dock were demolished. Several houses near the water edge were washed away. The most conservative estimates place the known damage at and near Wilmington as $200,000."

Records pertaining to damages in other areas of North Carolina are not available.

20TH CENTURY HURRICANES

General. While there have been numerous hurricanes which have passed northward along the Atlantic coast, some skirting close to Hatteras, only those which have shown a decided destructive force along the southeastern North Carolina tidal areas, or those of unusual occurrences, are discussed in the following paragraphs.

1904 - September 14. This tropical hurricane entered the Atlantic coast near the North Carolina-South Carolina State line on the 14th, then recurved northeastward, passing into Virginia. The Wilmington Weather Bureau office recorded a maximum 5-minute velocity of 36 miles per hour from the south. There was considerable damage to seaside property and many seagoing vessels were wrecked.

1904 - November 13. This hurricane was born off the northern coast of South America, moved in a northerly direction, and skirted the coast of North Carolina. It was accompanied by heavy rains along the coast and snow in the northern latitudes. The observed central pressures were not usually low, but the storm was fairly intense and caused considerable damage along the coast.

1906 - September 17. This very severe hurricane entered North Carolina in the vicinity of Southport, passing almost due west into the United States. The record in the Wilmington Weather Bureau office reads as follows:

"September 17. Rapid fall of barometer during night with wind shifting from north to northeast, increasing to a severe gale, and reaching a maximum 5-minute velocity of 50 mph at 8:55 a.m. Wind blew a gale for several hours diminishing towards noon and veering to east and southeast. Considerable damage was done in the city and on the beaches. Trees and wires were blown down in all directions and trestle on the trolley line to the beach badly damaged. At the beaches a number of houses were washed away by the unusually high water. No lives were lost.

"September 18. Reports continue to come in of damage by yesterday's storm. (Note - There seemed to be a reluctance to use the word 'Hurricane' in the old days.) Many small boats were driven ashore in the river and sounds but no loss of life is so far reported in these waters. Steamer NAVAHOE from New York and the PENTUNIA from Savannah arrived today. Both encountered the storm of Monday off the mouth of the Cape Fear and reported it very severe and that the beaches are covered with wreckage. The Captain of the NAVAHOE reported the unusually low barometer reading of 27.95 at 9:30 a.m. Monday about 13 miles southeast of the mouth of the Cape Fear. The fall became very rapid with great oscillation and hurricane from southeast. A calm of about 15 minutes ensued followed by a southwest hurricane. Officers of the vessel estimate the velocity as much as a hundred miles per hour. The barometer observations taken during the storm preclude all possibility of an error being made in the lowest reading. The vessel barometer, an aneroid, was carefully compared on the 22nd and found to read .05 too high. (Note - This would give a reading of 27.90 when corrected.)"

Of this storm the Charleston record reads:

"A tropical storm entered the S.C. coast near Georgetown moving generally WNW up through SC. An unofficial 28.72 inches was recorded at Goergetown. No reports were received from the immediate vicinity of the storm center as it moved inland, although it caused considerable loss to shipping."

<u>1908 - July 30.</u> This storm of marked intensity moved northwestward through the Bahamas, skirted the east coast of Florida, passed over Hatteras, then moved out to sea. Records at the Weather Bureau office at Wilmington show that the maximum 5-minute velocity recorded was 48 miles per hour from the NE and that the barometer reached a low of 29.14. Winds reaching a velocity of 58 miles per hour from the northwest were recorded at Hatteras. This storm was rather severe along the coast where much damage was done. Records tell of the flooding of Wrightsville Beach, and of the many homes which were washed away.

<u>1908 - August 31 - September 1.</u> There was something very puzzling about this weak tropical storm. It is not listed in any record of hurricanes or tropical storms and is barely mentioned in the Monthly Weather Review. It apparently passed over the Weather Station at Cape Lookout. A letter from the light house keeper says:

"I have respectfully to inform you that the Hurricane of Aug. 31st and Sep. 1st, 1908, blew down the Storm tower at this place; the lower section is badly twisted, bent and broken."

There was no mention of a waterspout or tornado. The CO in Washington was very much interested as this is the only instance of a regular storm-warning tower being destroyed in a hurricane. The old letters do not explain the mystery. The storm was not felt in southeastern North Carolina.

1910 - October 19-20. This hurricane developed in the Caribbean, moved northward, made a loop over western Cuba, crossed Florida, and then moved northward along the Atlantic coastline and out to sea at Hatteras. Reports indicate that this hurricane was of great violence along the North Carolina coast, causing high tides and heavy seas at the beaches near Wilmington, where a steel pier was partially washed away.

1913 - September 2. This hurricane moved north from the Bahamas to Cape Hatteras, then curved west across central North Carolina where it dissipated. Wind velocities recorded were: Norfolk, Virginia, 50 miles per hour E; Hatteras, N.C., 74 miles per hour SE; Raleigh, N.C., 37 miles per hour NE; and Wilmington, N.C., 30 miles per hour W. Although the storm caused only a few marine disasters, it did great damge in eastern North Carolina, particularly in Pamlico and Beaufort Counties. Belhaven reported damages to be approximately $350,000, while reports indicated that damages in Beaufort County exceeded $2 million. Winds at Washington, N.C., were estimated as being 90 to 100 miles per hour. The Neuse River at New Bern rose 11 feet above mean low water, and along the Pamlico County coast the tide was considered to be as high as that experienced in 1933 and 1955. Five lives were lost in eastern North Carolina, and the total property loss was estimated between $4 and $5 million. This hurricane was very minor in the vicinity of Wilmington.

1916 - July 14. This is another example of an odd storm. The Monthly Weather Review says:

"The hurricane is believed to have been one of the most severe that has visited this coast since the Weather Bureau was established."

The storm apparently moved northwest, passed near Frying Pan Shoals, and struck the coast in the area near the North Carolina-South Carolina boundary. It was hardly noticeable at Cape Fear, but as it moved inland it was accompanied by the heaviest rainfall on record for North Carolina. At Altapass, N.C., the rainfall in 24 hours totaled 22.22 inches.

1918 - August 24. This small tropical hurricane moved inland just north of New River Inlet, N.C., passed over the sound area of southeastern North Carolina and into the Atlantic Ocean between Hatteras and Manteo. The storm, while severe on the immediate coast, did not extend more than 50 miles inland. Maximum wind velocities recorded were 34 miles per hour NE at Wilmington and 64 miles per hour SW at Hatteras. Considerable damage resulted to beach resorts and towns along the North Carolina coast. A steel pier was destroyed at Wrightsville Beach near Wilmington.

1920 - September 22-23. This hurricane is unique in that it originated comparatively near an offshore area, north of the Bahamas. It crossed the coast near the mouth of the Cape Fear River, about 25 miles south of Carolina Beach. It was rather weak and caused little damage. The maximum 5-minute wind at Wilmington was 33 miles per hour NE, and the minimum barometric pressure was 29.93 inches.

1924 - August 25. The storm center moved up over Puerto Rico along the Atlantic coast and passed a short distance east of Hatteras, where highest winds were recorded as 72 miles per hour from the northwest. The Weather Bureau at Hatteras rates this tropical storm as one of the greatest hurricanes, both in intensity and extent, ever experienced off the Atlantic coast.

The station journal at Wilmington reports as follows:

"Very heavy swells from the east rolled in at the beach...The wind was considerably stronger at the beach than at Wilmington, the estimated maximum velocity being 45 mph. The maximum velocity at Wilmington during the storm was 28 mph...No damage was done in the vicinity of Wilmington. Residents at Wrightsville Beach were considerably alarmed and several hundred people came to the mainland in the afternoon."

1924 - September 20. This disturbance originated in the east Gulf area, moved inland over northern Florida, skirted the Atlantic coast to the North Carolina-South Carolina State line where it moved inland, passing just north of Wilmington, N.C., and struck the Atlantic coast again just north of Cape Henry, Virginia. Wind velocities recorded were as follows: Wilmington, N.C., 40 miles per hour SW; Hatteras, 52 miles per hour S; and Norfolk, Virginia, 65 miles per hour W. Easterly gales were experienced along the entire coast, but no reports of damages have been found.

1925 - December 2. This storm is of interest due to the late date of occurrence. This hurricane passed through eastern North Carolina, hitting the coast near Cape Lookout. Highest wind recorded was 40 miles per hour SW at Atlantic City. A ship 100 miles SSE of Wilmington reported a barometer reading of 28.90 inches. Unusually high tides were reported, but damages were light.

1928 - September 18. This hurricane originated near the Cape Verde Islands, moved to central Florida where it recurved to follow the coastline of the United States, then passed inward to the Great Lakes. This storm, said to be one of the most violent and destructive of the century, was most destructive in Florida where the barometer at West Palm Beach fell to a low of 27.43. As this storm moved northward from Florida it decreased in intensity and was not too severe in the coastal areas of North Carolina; however, the heavy rains which accompanied it caused considerable flooding at Fayetteville. Maximum wind recorded at Wilmington was 24 miles per hour SE, with a barometer reading of 29.12 inches.

1930 - September 12. This tropical disturbance passed about 50 miles southeastwardly from Hatteras and continued generally east into the ocean. The Weather Bureau office at Wilmington reported the maximum wind as NE, 15 miles per hour, with a barometer reading of 29.71 inches. Reports tell of heavy seas at Wrightsville Beach but little damage. No other information is available.

1933 - September 16. This tropical hurricane moved up the Atlantic coast and pased slightly to the west of Hatteras, N.C. Wind velocities recorded were 42 miles per hour NW at Wilmington and 76 miles per hour at Hatteras, where the low barometer reading was 28.25 inches. While this storm was not particularly severe in the Cape Fear area, it caused extensive damage in the Hatteras area. Record high water was reported all along the western shore of Pamlico Sound. At Oriental and Arapahoe the water was reported to be about 8 inches higher than during "Ione" in 1955. Atlantic also reported higher water than that which occurred in 1955. Old residents of Beaufort, N.C., delcare it was the worst storm they ever experienced. Twenty-one lives were lost, and the property damage along the North Carolina coast was estimated at more than $3 million. Heaviest damages occurred from Carteret County to the Virginia line.

1934 - July 21-25. This hurricane was hardly noticeable in the Wilmington area, but it is noteworthy because of its unusual origin and path. It originated off Cape Hatteras and, moving southwest, it crossed into the Gulf of Mexico and struct Corpus Christi, Texas.

1935 - September 5. This hurricane caused minor wind damage in Wilmington and practically none at nearby beaches. It passed inland, about 100 miles west of Wilmington, where the maximum 5-minute wind was recorded at 48 miles per hour S, and the minimum barometric pressure was 29.63 inches.

1944 - August 1. Originating several hundred miles north of Haiti, this storm moved into North Carolina after striking the coast a short distance south of the State line, went northward through North Carolina and Virginia, then northeastward into the Atlantic with diminishing force. The winds at Wilmington reached an extreme velocity of 52 miles per hour from the south, with gusts estimated as high as 72 miles per hour. A maximum 5-minute velocity of 46 miles per hour S was also recorded at Wilmington, where the barometer fell to 29.41 inches. No exact data on wave heights were obtained.

Wrightsville Beach suffered heavy damages. Two piers were partially wrecked and many roofs were damaged, Total damage in southeastern North Carolina was estimated at $1,600,000. However, there were no fatalities.

1944 - September 14. The center of this storm, known as the Great Atlantic Hurricane, passed almost directly over Hatteras, traveling about due north. Highest wind velocities recorded in North Carolina were: 90 miles per hour W at Hatteras; 70 miles per hour NNW at Elizabeth City; and 27 miles per hour NW at Wilmington. The storm had little effect on the Wilmington area; 67 mile-per-hour winds were reported in the Morehead City-Beaufort area. A low pressure of 27.97 inches was reported at Hatteras, the lowest reading in over 70 years. Along the North Carolina coast, property damage was estimated to exceed half a million dollars, while damages to crops were estimated at over $1 million.

1945 - September 16-17. This tropical storm moved north-northeast from Richmond County in southern North Carolina to Person County in the northern part of North Carolina. Although the loss of life and livestock was small, chiefly because of adequate warning service, the economic losses were very large. The heavy rains in the interior of North Carolina caused record floods on many rivers. The Cape Fear River at Fayetteville reached a stage of 68.9 feet on the 21st. No estimate of the total damage caused by this hurricane has been made. The maximum 5-minute wind velocity at Wilmington was only SSE, 32 miles per hour. Practically no damage was caused along the coast.

1946 - July 6. This tropical disturbance crossed the coast in the vicinity of Charleston, then moved north-northeastward, pasing approximately 20 miles west of Wrightsville Beach. Barometric pressure was read at 29.71 at Wilmington, and gusts to 60 miles per hour were experienced at Wrightsville and Carolina Beach. This storm was considered as being of moderate intensity, and property damage was of a minor nature.

1947 - October 12-13. This hurricane moved northeastward off the coast, causing high tides and heavy rain all along the southeastern coast. High tides flooded much of the lowlands and forced residents to evacuate some homes in Morehead City. The waterfront in Wilmington suffered some damage to stock, due to high water in the street.

1953 - August 13. Hurricane Barbara, as this tropical disturbance was labeled, moved northward offshore of southeastern North Carolina on the 12th, moved inland above Cape Lookout on the 13th, and then passed oceanward just south of the Virginia line early on the 14th. Property damage along the shore was estimated at about $100,000, mostly to beach houses and warehouse roofs, with most of the damage resulting from vulnerable construction. One death was attributed to this hurricane when a man was swept from a pier at Wrightsville Beach and presumedly drowned.

1954 - August 30 ("Carol"). This tropical storm moved from the Caribbean to a position about 400 miles off the coast of South Carolina on August 25. The storm developed into full hurricane force, but moved very slowly. In fact, it was still well off the Carolina coast 4 days later. On the evening of the 30th the hurricane moved suddenly north-northeastward, grazing the coast of North Carolina. The beaches were pounded by high tides and heavy rains, but winds of hurricane force failed to reach shore. The effect of Hurricane Carol on the North Carolina coast was not severe and the property damage in any given locality was light, but there was considerable erosion of the shoreline. Over the length of the coast, however, damages totaled an estimated $250,000, consisting of approximately $225,000 damage to piers, roofs, television antennas, and about 1,000 feet of paved highway which was undermined on the outer banks by high tides. The remaining $25,000 damage was to crops, which resulted from corn and soybeans being blown down in the fields. Considerable erosion was experienced along the entire North Carolina coast. The waterfront section of the town of New Bern experienced some flooding. A peak gust of 78 miles per hour was observed at Hatteras.

1954 - October 15. Hurricane Hazel, the most destructive and damaging storm that has struck the North Carolina coast in over 50 years, originated a short distance south of Barbados on the morning of October 5. The center was first located about 50 miles east of Grenada. The storm maneuvered through the Caribbean and Atlantic Ocean, causing much damage in Haiti and the Bahamas, and reached the coast of the United States on October 15. The tropical cyclone crossed the coast in the vicinity of the North Carolina-South Carolina State line. It quickly passed east of Whiteville and Clinton, west of Goldsboro, Wilson, and Nashville, and across the Virginia line. This hurricane took a toll of 19 lives in North Carolina. Total damages throughout the State have been estimated at $125,309,000, of which an estimated $31,190,300 occurred in the coastal and tidal areas.

1955 - August 12. Hurricane Connie, the first of three moderately severe hurricanes to strike North Carolina during 1955, originated on August 5 near latitude 18°-30'N., longitude 55°-15'W. The center moved northwestward until the afternoon of the 10th when it recurved northward, crossing the coast of North Carolina on the 12th in the vicinity of Cape Lookout. It then moved across Hyde and Tyrrell Counties, passing just east of Elizabeth City before passing into Virginia. Most of the damages were attributed to flooding. Total damages throughout the State were estimated at $50 million as a result of this tropical storm.

1955 - August 17. Hurricane Diane, the second tropical hurricane of 1955, followed closely behind Hurricane Connie. Hurricane Diane developed into a tropical storm on August 10 near latitude 22°N., longitude 60°W., and intensified to hurricane force that night. The course was rather erratic, traveling northwestward, northward, and north-northeastward until it abruptly turned westward on the 12th. On the 13th the storm traveled west-southwestward for a short time, then established a steady west-northwest course for 3 days. On the 16th it recurved northwestward, and crossed the North Carolina coast near Wilmington on the 17th. It passed over Durham and then headed toward Lynchburg, Virginia. Hurricanes Connie and Diane came so close together that separate damage estimates for the entire State were impossible. The combined loss, however, is estimated to exceed $90 million, with an estimated $25,682,400 agricultural damages occurring in the tidal areas.

1955 - September 19. Hurricane Ione, the third and most severe hurricane of 1955, originated on September 14-15 near latitude 19.5°N., longitude 62.6°W. From there "Ione" pursued a northwesterly course toward the North Carolina coast. The greatest intensity was reached late on the 17th, with a central pressure of 27.70 inches and maximum winds of 125 miles per hour. The center moved northward off the South Carolina coast and crossed the North Carolina coast approximately over Morehead City on the morning of the 19th. The center passed west of Cherry Point, between Oriental and New Bern, and then northeastward to the coast near the Virginia line. Principal damage occurring from "Ione" was due to water. Total damages throughout North Carolina were estimated at $88 million, with an estimated $22,317,200 occurring in the tidal area. Agricultural damages were the largest suffered.

1958 - September 27. Hurricane Helene was a severe hurricane, more so because of its high winds than because of induced wave and tide action. It formed as a tropical storm in an "easterly wave" in the Atlantic Trade Wind Belt on September 23, 1958, about 300 miles northeast of Hispaniola. It continued to increase in severity as it approached the coast in a northwestward direction.

Veering from a predicted landfall at Myrtle Beach, S.C., during the night of the 26th, it turned north towards the Cape Fear. The hurricane apparently reached maximum intensity early Saturday, September 27th, with a lowest reported central pressure of 27.55 inches at a point south-southeast of Cape Fear. Its center passed to the east of Wrightsville Beach near noon, September 27th, giving the highest winds recorded at Wilmington since the Weather Bureau station was established in 1871; a maximum 5-minute wind velocity of 69 miles per hour north and a peak gust of 135 miles per hour were attained. The minimum barometric pressure recorded at Wilmington was 28.80 inches. It is estimated that damages were $221,800 at Wrightsville Beach.

1960 - September 11-12. Hurricane Donna was a severe hurricane at Wrightsville Beach, and would have caused even more damage if it had struck about 3 hours later, so as to coincide with a lunar high tide. Its early path through the straits of Florida indicated a landfall on the gulf coast, but it suddenly turned north, traversed the Florida peninsula, went to sea, and made a second landfall in the Cape Fear area. It subsequently struck in the Morehead City-Beaufort, N.C., area, causing great water damage.

The center of the eye is reported to have passed a few miles east of Wrightsville Beach, although Wilmington and Wrightsville Beach were in the eye for about an hour. At Wilmington airport the lowest barometer reading was 28.41 inches and the maximum 1-minute wind velocity was 53 miles per hour, northwest, with a peak gust of 97 miles per hour. Total damages at Wrightsville Beach were estimated at $338,000, of which $222,000 were attributed to wave action and tidal flooding.

1964 - September 1. Hurricane Cleo passed over Bodie Island, moving easterly. Hatteras observed windspeeds up to 45 miles per hour. The minimum pressure observed was 29.56 inches. There was no damage reported on the North Carolina coast.

1964 - September 13. Hurricane Dora passed over Hatteras Island, moving northeasterly. Hatteras fastest 1-mile windspeed was 35 miles per hour, north-northeast. Gusts of 41 miles per hour were recorded. The minimum pressure observed was 29.50 inches. Tides of 2.52 feet above normal were recorded in Pamlico Sound. There was no damage reported in North Carolina.

1964 - October 16. Hurricane Isbell passed over Morehead City, N.C., moving north-northwest. Hatteras Weather Station recorded the fastest 1-mile windspeed as 36 miles per hour. The minimum pressure observed was 29.42 inches. There was no damage reported in North Carolina.

1967 - September 16. Hurricane Doria dropped to tropical storm intensity just before making landfall at the Virginia-North Carolina border. Hatteras Weather Station recorded the fastest 1-mile windspeed as 26 miles per hour. There was no damage reported in North Carolina.

1971 - August 27. Tropical storm Doria passed over the North Carolina coast west of Morehead City. Hatteras fastest 1-mile windspeed was 41 miles per hour, south-southwest. Gusts of 54 miles per hour were recorded. The minimum pressure observed was 29.61 inches. Tides were 1 to 2 feet above normal in Pamlico Sound. Damage throughout North Carolina was minor, and total property and crop estimates were set at about $150,000.

1971 - September 30. Hurricane Ginger passed over Morehead City moving northward. Hatteras Weather Station recorded the fastest 1-mile windspeed as 44 miles per hour, southeast. Gusts of 70 miles per hour were recorded. The minimum pressure observed was 29.43 inches. Tides on Pamlico Sound were 4 to 7 feet above normal. Rainfall was heaviest along the shores of Pamlico Sound, 10 to 13 inches. Damage throughout North Carolina was estimated at $10 million. Agricultural damages were the largest suffered.

1973 - February 17. The most damaging winter coastal storm of the present generation was on February 17, 1973. The following newspaper quote succintly describes the storm:

"North Carolina's land mass is smaller by several hundred acres this week as a result of a severe coastal storm which gnawed away at beaches from Corolla to Cape Fear.

"During the two days following a freak storm that frosted the state's eastern lowlands with up to 15 inches of snow, savage 56-knot winds and powerful 40-foot waves hauled tons of sand from the shore.

"The wind-whipped sea toppled large buildings in resort communities on the Outer Banks, nearly bisected at least two offshore islands, ripped up highways, filled roadbeds with sand and carved away large chunks of sandy beach.

"The worst of the storm's fury was directed at Buxton, Kitty Hawk, and Nags Head, but severe erosion and some property damage occurred at the more southerly resort communities of Wrightsville Beach, Carolina Beach and Topsail Beach." (Raleigh News and Observer, February 19, 1973.)

A typical description of local damage, from the same source, is "At Kitty Hawk four beach cottages were washed away, nine were toppled by the waves but left partially standing, 12 others received structural damage from the pounding surf and dozens of others are left standing so near the encroaching sea that another storm would undermine them."

1979 - September 5. This storm originated as a zone of disturbed weather about 1,200 miles west of the coast of Africa on 25 August, and developed strength as it moved west across the South Atlantic. The storm attained hurricane status on Monday, 27 August, at which point it was 700 miles east of the Lesser Antilles. By noon on 28 August, Hurricane David was accompanied by sustained 150 mph winds. From Tuesday, 28 August, to Monday, 3 September, Hurricane David proceeded on a course north of west, skirting the southern coasts of Puerto Rico and Hispaniola, heading toward southern Florida. At 0200 EDT on 2 September, David was 85 miles east-southeast of Miami. Hurricane warnings were posted for southern Florida on Monday, 3 September, and by 0400 on Tuesday, 4 September, warnings were in effect as far north as southeast North Carolina. At approximately 2000 hours EDT on 4 September, Hurricane David went ashore near Savannah, Georgia, with maximum winds of 90 mph and an ocean storm surge of about 6 feet. Once over land, David weakened to tropical storm status by 0300 EDT, 5 September, and to gale status by 1800 EDT, 5 September, while continuing on a generally north-northeast course through North Carolina and Virginia on into New York State and New England.

The effects of storm David were first experienced in the vicinity of Wrightsville Beach during the afternoon and evening of Tuesday, 4 September. Sustained winds of 30 to 40 mph out of the south and southeast and higher than average spring (astronomical) tides resulted in a maximum ocean water level (stage) of +5.2 fet MSL (+7.0 local MLW) as recorded by the SAW tide gage on Cyrstal Pier, located about 3,000 feet north of Masonboro Inlet. This maximum water level occurred at 1830 EDT Tuesday, and was 2.0 feet above the predicted high tide elevation. The following low tide at about 0100 EDT Wednesday was 1.7 feet above the predicted tide. Thereafter, the difference between predicted tide height and observed tide height decreased to about 0.6 foot during Wednesday, 5 September, and to about 0.3 foot by 0100 EDT Thursday, 6 September.

Highest wind speeds recorded by the National Weather Service and U.S. Coast Guard wind gages during this same period were: Wilmington Airport, 51 knots from the southeast at 0332 EST, 5 September; Wrightsville Beach Coast Guard Station, sustained 38-knot winds from the southeast, gusts to 52 knots, 0425 EDT, 5 September; Oak Island Coast Guard Station, gusts to 53 knots, 0300 EDT, 5 September; and Holden Beach, 60-knot gusts, 0400 EDT, 5 September.

There were no wave gages operating in this vicinity during the passage of storm David. Additionally, the Frying Pan Shoals Light Tower was evacuated because of the storm threat. Consequently, only an estimated wave height of 10 to 12 feet is available from visual observations of the surf at Wrightsville Beach on 4 and 5 September.

Comparison of the maximum recorded stage during David of 5.2 feet above MSL (7.0 feet MLW) to the stage-frequency curve presented in the authorizing document for the Wrightsville Beach project (H.D. 511, Plate E-1; this report, figure 1) suggests a recurrence interval of one event per 3.5 years for a stage comparable to that from storm David. However, a review of Crystal Pier tide gage records for the period January 1976 to the present showed that, although the +5.2-foot MSL stage during storm David was the maximum for this period, there were no less than 7 occurrences of stages within 0.5 foot of the David maximum (two occurrences at 5.1, one at 5.0, one at 4.9, and three at 4.8 feet MSL). It was, therefore, deemed appropriate to adjust the stage-frequency curve such that a 5.0-foot MSL (6.8 feet MLW) stage corresponded to a one-year recurrence interval, rather than a 3.0-year interval.

The following paragraph is extracted from a field damage report for Wrightsville Beach and is a portion of Report Number RR052020Z Sept 79, SITREP No. 1 - Hurricane David, which was sent via teletype to DAEN-CWO-E on 5 September 1979.

> Additional erosion to the dune line on island of approx 2 to 3 ft. The bulkhead on the north side of the Holiday Inn has experienced some minor erosion. The fill located between the sandbags and the Garrabrant House on Shell Island has washed out. The fill behind the NE corner of the bulkhead at the house on the NE end of Scotch Bonnet Lane has washed out and 20 ft of sidewalk has washed away. Red house on the southeast end of Cowrie Lane has had a minor washout to the north end of the bulkhead. On the north end of Shell Island 3 to 4 feet of the southerly dune has washed away from Cowrie Lane north. There is an overwash area approx 100 ft wide on the south side of the Islander extending to within 5-75 ft of the main road. There is roughly 22 ft of erosion to the dune from Mallard Street to the Islander. One bent of Mercer's Pier has been damaged and the pier is sagging on the south side approx 50 ft from the end of the pier. There has been a washout of the dunes between Augusta and Raleigh Streets. The house on the south end of Augusta Street has water partially underneath it. And at this time a temporary dune is being constructed at the end of Raleigh Street at a house on the south-southeast end. A porch roof on Stone Street has been blown away.

CORPS OF ENGINEERS U.S. ARMY

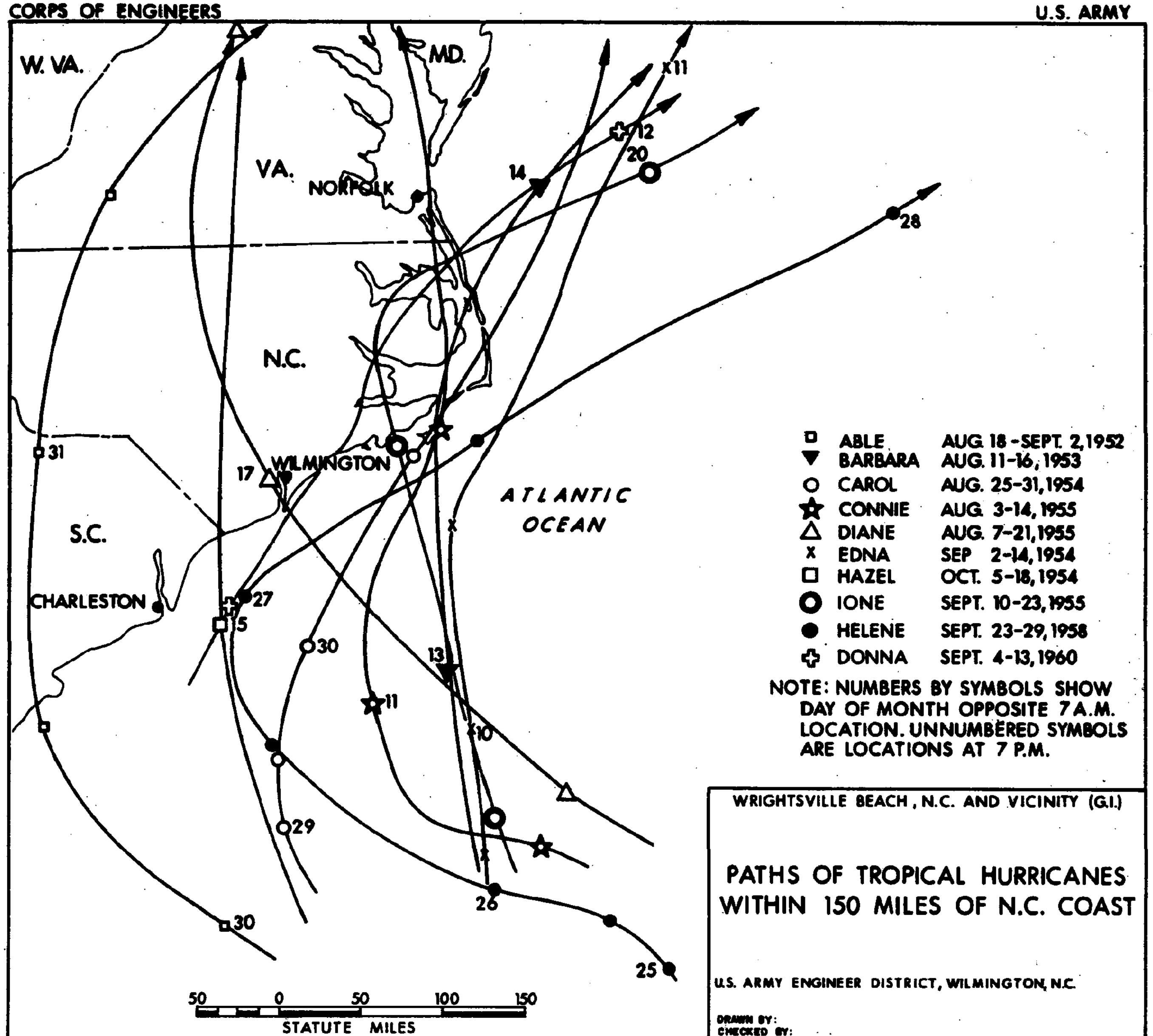


PLATE A-1

APPENDIX B

SOCIOECONOMIC CONDITIONS

APPENDIX B

Socioeconomic Conditions

The following is an overview of economic and social conditions of New Hanover County, the socioeconomic study area. Both Wrightsville Beach and the city of Wilmington, North Carolina's largest coastal city and port, are situated in New Hanover County. With its largely urban character, New Hanover County is the primary market for Wrightsville Beach day use.

Base Socioeconomic Conditions. The population of New Hanover County grew at an annual rate of 2.2 percent during the period 1970-1980, reaching 103,471 in 1980, and having a population density of 559.3 per square mile. For the period 1970-1975, net migration was +10.8 percent. In 1970, the percentage of urbanization in New Hanover County was 69.5, less than the United States average of 73.5, but greater than the North Carolina average of 45.0.

In 1970, the median education level for persons 25 years old and over in New Hanover County was 12.0. The percentage of high school graduates in the group was 50.

In 1978, per capita income in New Hanover County was $6,728, slightly higher than the North Carolina per capita income of $6,640. During the period 1970-1978, real per capita income increased at an annual rate of 2.81 percent. In 1979, the civilian labor force numbered 46,490, of which 43,690 persons were employed and 2,800 persons, or 6 percent were unemployed. During the period 1970-1979, employment in New Hanover County grew at an annual rate of 3.45 percent, a growth rate higher than the 2.2 percent for population. In 1979, 24 percent of all employed persons in New Hanover County worked in manufacturing industries. Of the 76 percent in non-manufacturing industries, one-third worked in the trade industry, and one-fourth worked for a government.

The 1980 permanent population of Wrightsville Beach was 2,910, a 71.1 percent increase over the 1970 permanent population. In 1980, the estimated summer population was 8,024, excluding day visitors.

Projected Socioeconomic Conditions. The 1990 through 2035 projections of populations, employment, and per capita income presented below are based on draft county disaggregations of State OBERS projections for North Carolina.

TABLE 1
New Hanover County

Year	1990	2000	2010	2020	2030	2035
Population	117,588	129,814	140,359	149,658	157,520	161,658
Employment	57,582	63,701	68,075	69,245	70,552	71,221
Per Capita Income (in 1972 dollars)	6,246	7,905	9,869	11,817	14,323	15,842

TABLE 1 (Cont'd)

Wrightsville Beach

Year	1990	2000	2010	2020	2030	2035
Beach Day Visitation* (Annual User Days)	593,200	878,000	1,299,700	1,512,900	1,512,900	1,512,900

*Parking capacity of 1,512,900 reached in the year 2011.

APPENDIX C

ECONOMIC ANALYSIS

APPENDIX C

Economic Appendix

Introduction

The evaluation of the shore processes, presented in detail in appendix D and summarized in the main report, indicates that the total rate of volume loss off Wrightsville Beach is 130,000 cu yds/yr. Of this total, 60,000 cu yds/yr was attributed to the Masonboro Inlet navigation project while the remaining 70,000 cu yds/yr is due to historic losses and the anomalous convex shape of the Wrightsville Beach ocean shoreline. The 60,000 cu yds/yr deficit due to the Masonboro Inlet navigation project will be placed on Wrightsville Beach at 100 percent Federal expense as part of the O&M cost of this navigation project. Therefore, in evaluating the without project condition, only the effects of the 70,000 cu yds/yr deficit on the beach and its development was considered.

Most of the erosion of Wrightsville Beach is occurring north of Station 50+00 which lies 5,000 feet north of the north jetty. South of this point, the beach is considered to be stable even though some erosion was measured in this area during the time period used in the shore processes analysis. Moreover, the southern 5,000 feet is expected to remain stable whether or not Wrightsville Beach receives any additional artificial nourishment.

The movement of the shoreline within the 9,000-foot section associated with the 70,000 cu yd/yr deficit varies from a low of 1.2 feet of erosion per year at Station 50+00 to a high of 14.8 feet of erosion per year at Station 130+00 which is 1,000 feet south of the northern limits of the authorized project. Rather than deal with a variable rate of erosion, an average erosion rate of 8.9 ft/yr, was determined from 10 profile stations within the 9,000-foot reach, was adopted.

Based on the evaluation of the shore processes at Wrightsville Beach, the economic benefit analysis considers the southern 5,000 linear feet of beach stable and uses the average erosion rate of 8.9 feet per year for the remaining 9,000 linear feet of beach. An October 1982 price level applies to all values. An interest rate of 7-7/8 percent and a period of analysis of 50 years are used. The base year is 1987. The "without" condition in the economic benefit analysis is the authorized berm and dune project fully in place in 1981 but not maintained thereafter. The "with" condition is continued maintenance of the authorized berm and dune project beginning in 1987, the base year, by fully restoring the project and maintaining it throughout the period of analysis.

Beach Erosion and Flood Damage Reduction

Benefits for beach erosion control include the value of land and improvements that would be lost to erosion if the authorized berm and dune project were not maintained. The assumption that the structures would be lost to erosion is based on the fact that the structures could not be moved without sustaining severe damage and the fact that there is no place to move the structures except the mainland. A 125-foot width of beach used in the recreation analysis was not included in the land lost to erosion. The 87-foot width of dune was not included either. At the average annual erosion rate of 8.9 feet, 2005 is the first year that erosion takes place landward of the 125 feet of recreation beach and 87 feet of dune. For each year 2005 through 2023, land valued at $1,001,250 would be lost to erosion. This amount is based on ocean front lots 160 feet deep being valued at $2,000 per linear foot in October 1982 or $554,500 per acre. With an eroding beach 9,000 feet long, 1.83884 acres of land are lost annually. For each year 2024 through 2037, land valued at $667,499 would be lost to erosion. This amount is based on second and third row lots of 60 feet by 80 feet average size being valued at approximately $40,000 each or $363,000 per acre. The erosion rate and length of eroding beach are assumed to remain the same throughout the 50-year period. The average annual value of these land losses would be $225,700.

A structure was assumed lost when approximately one-half the lot on which it was built was lost to erosion. The values of the structures lost by year of assumed loss are shown below.

Rev 2/22/83

Year of Loss	Value of Structures Lost
2010	$ 1,500,000
2016	8,224,000
2022	18,441,000
2027	1,220,000
2030	1,684,000

The average annual value of these structure losses would be $209,300.

Flood damages as a function of storm return interval were computed for the condition of "preproject shoreline" and for the full project in place condition existing in 1981. With the full project in place, the dune has a top elevation of 13.5 feet m.s.l. and provides protection from ocean flooding up to and including the 35-year storm. Table 1 is a summary of numbers of units and damageable property values for the areas subject to benefit from the project. Average annual flood damages for preproject shoreline conditions, for authorized project and continued maintenance conditions, and the resulting flood damage reduction benefits are shown in table 2. Figure C-1 shows the "without" condition of the authorized project fully in place in 1981 but without continued maintenance, thereby resulting in the project and flood damage reduction benefits eroding away to preproject condition by the year 2005. Without maintenance, erosion would continue throughout the 50-year period of analysis resulting in structure loss as well as land loss. In order to not claim flood damage reduction benefits on structures after their loss to erosion during the 50-year period of analysis, the following procedure was taken. The values of the lost structures were converted to percents of the total value of damageable structures. Those percents were then applied to and deducted from the flood damage reduction benefits computed for the applicable years.

Figure C-2 shows the average annual flood damage reduction benefits for the "with" condition of fully restoring the authorized project in 1987 and maintaining it thereafter. The decline in the average annual flood damage reduction benefits after 2005 reflects the loss of structures that would occur in the absence of continued maintenance of the project. The total average annual value of these flood damage reduction benefits would be $169,500.

TABLE 1

Damageable Property Summary*

Zone	Type	Number of Units	Damageable Property Value (Structures & Contents, Oct 1982 Price Level)
Oceanfront	Residential	122	$13,772,800
Oceanfront	Commercial	9	2,511,700
Mid-island	Residential	347	30,434,300
Mid-island	Commercial	38	3,997,400
Total		516	$50,716,200

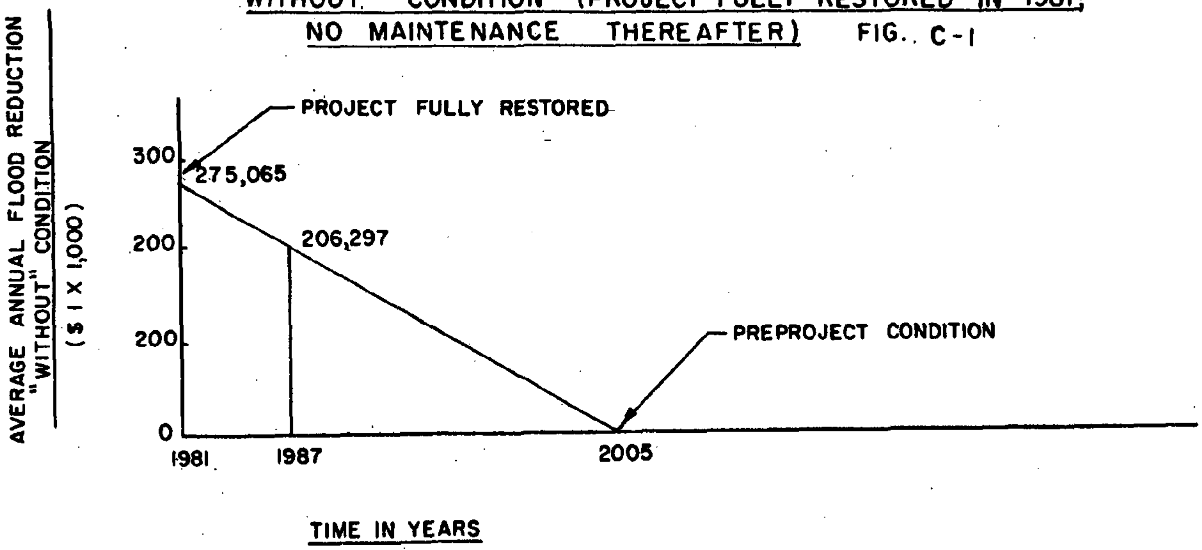
*Includes only property within the 9,000 linear feet subject to benefit from continued maintenance.

TABLE 2

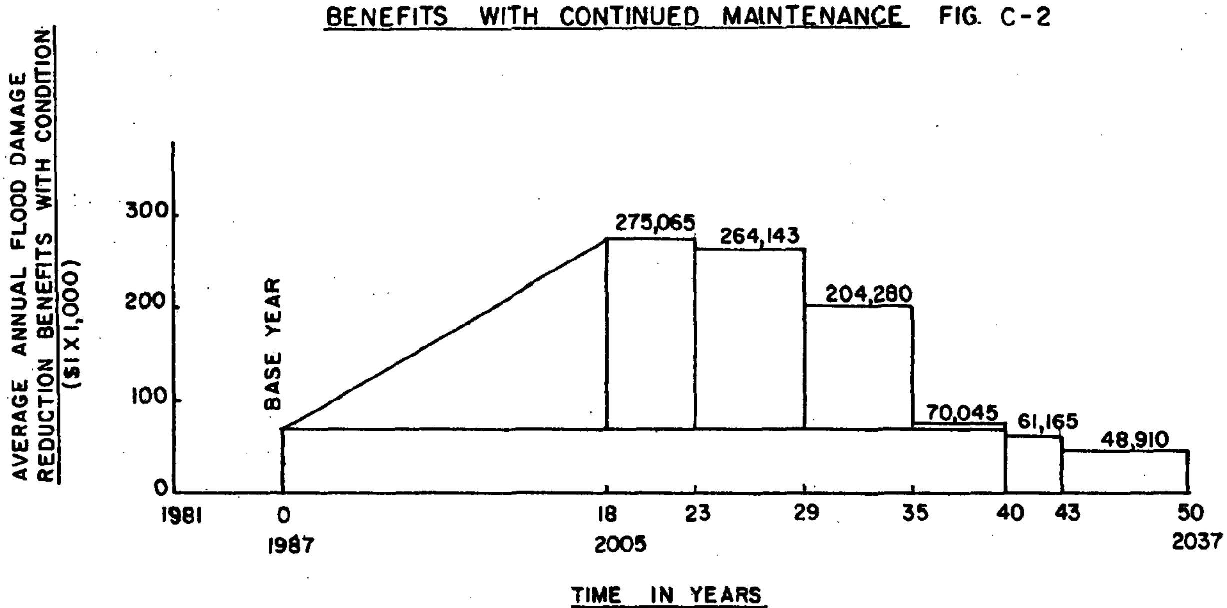
Average Annual Flood Damages and Flood Damage Reduction Benefits, Authorized Project and Continued Maintenance

Zone	Type	Average Annual Damages for Preproject Shoreline Condition	Average Annual Damages with Authorized Project and Continued Maintenance	Average Annual Flood Damage Reduction Benefits With Project and Continued Maintenance
Oceanfront	Residential	$120,516	$ 70,454	$ 50,062
Oceanfront	Commercial	48,633	26,890	21,743
Oceanfront	Utilities	6,428	3,699	2,729
Oceanfront	Transportation	335	114	221
Mid-island	Residential	276,373	142,776	133,597
Mid-island	Commercial	106,508	48,329	58,179
Mid-island	Utilities	14,549	7,262	7,287
Mid-island	Transportation	2,105	860	1,245
		$575,447	$300,384	$275,063

AVERAGE ANNUAL FLOOD DAMAGE REDUCTION BENEFITS "WITHOUT" CONDITION (PROJECT FULLY RESTORED IN 1981; NO MAINTENANCE THEREAFTER) FIG. C-1



AVERAGE ANNUAL FLOOD DAMAGE REDUCTION BENEFITS WITH CONTINUED MAINTENANCE FIG. C-2



The increase in value of residential contents in the future was projected using the projected growth rate of per capita income for New Hanover County as shown in the draft County disaggregations of State OBERS projections for North Carolina. Projections were limited to 75 percent of the value of the residential structures. As residential structures were assumed to be lost due to erosion, commensurate deductions were made from content values. The average annual benefits related to projected increasing value of residential contents would be $35,300.

Recreation

General. Applying the criteria in ER 1105-2-40, Subpart K - NED Benefit Evaluation Procedures: Recreation, 8 January 1982, figure 703.903-1, the unit day value evaluation procedure was selected. No applicable regional model is available. Uses affected do not involve specialized recreation activities. Estimated annual visits affected do not exceed 500,000. Expected recreation specific costs affected do not exceed 25 percent of expected total project costs.

Using the table K-3-2 Guidelines for Assigning Points for General Recreation and table K-3-1 (FY 1983) Conversion of Points to Dollar Values in ER 1105-2-40, 8 January 1982, a total of 45 points were assigned and converted to a unit day value of $3.20.

This evaluation is based on a projected growth in demand for beach use, and takes into consideration the limits imposed on maximum daily and maximum seasonal use by available parking capacity. Parking capacity was found to be the limiting factor on total seasonal beach use. Existing bridge access and traffic flow capacity were found to exceed parking capacity. Beach use and demand were developed for all of Wrightsville Beach. However, since the southern 5,000 linear feet is projected to remain stable, benefits are taken on the remaining beach only after total Wrightsville Beach demand exceeds total capacity of the stable 5,000 linear feet. Approximately 1,000 linear feet of beach north of the Wrightsville Beach project limit, within the transitional zone, is accessible to the public for recreation. This length of beach has an erosion rate similar to that of the 9,000 linear feet south of it. Therefore, any possible recreational area would be lost to erosion before total recreational demand exceeded the capacity of the stable southern 5,000 linear feet of Wrightsville Beach. Recreational benefits developed and attributed to the Wrightsville Beach project area include recreational use of the 1,000 linear feet of beach north of the project limit in the transitional zone.

Beach Capacity. The beach area per person used in this analysis was 100 square feet. The authorized project design cross section offers a 125-foot width of usable beach. Along the 5,000 feet of stable shoreline, this represents 625,000 square feet with an instantaneous capacity of 6,250 persons and, using a turnover rate of 2, a maximum daily capacity of 12,500. Along the remaining 9,000 feet of shoreline, this represents 1,125,000 square feet with an instantaneous capacity of 11,250 persons and, using a turnover rate of 2, a maximum daily capacity of 22,500.

Length of Season. The total number of days in the beach use season was determined to be 90. The following table presents the derivation of this value. The number of inclement days is based on monthly averages presented in the Wilmington, N.C., 30-year climatological summary.

TABLE 2A

Beach Use Season, Wrightsville Beach

Month	Weekend Days	Holidays	Weekdays	Inclement Days	Net Beach Use Days
April	4	0	0	1	3
May	10	1	9	3	17
June	8	0	22	7	23
July	7	1	23	11	20
August	10	0	21	10	21
September	2	1	4	1	6
Total	41	3	79	33	90

Beach Use and Demand. Statistics on present beach use were derived from nine head counts of beach users made during the 1979 season. Both low altitude aerial photographs and in-person head counts were used as a data base. Counts were made between the hours of 12:30 and 2 p.m., EDT, and are assumed to equal peak use for each occasion. The average weekday peak use value (4 counts) was 1,851 persons. The average weekend day peak use value (3 counts) was 3,303. The single holiday peak use value (4 July) was 5,193. The assumption was made that the ratio of total daily use to peak use was 2 to 1. The numbers of weekdays, weekend days, and holidays for the 1979 season (corrected for inclement weather days), as well as the turnover rate of 2, were then applied to the average peak use values in each category. The resulting value for the total 1979 beach use was 440,352.

The projected growth rate of the total seasonal use was determined from an analysis of hourly traffic statistics for the AIWW drawbridge for the period 1975 to 1980. Three categories of traffic statistics were examined: average daily traffic, average summer weekday traffic (includes June, July, and August), and average Saturday traffic, high month (July). The annual growth rate for the three categories, for the 1975 to 1980 period, was determined to be 6.0 percent, 4.0 percent, and 3.0 percent, respectively. The rate of 4.0 percent per year was thus adopted as the projected annual growth rate for beach use demand, with a base year (1979) value of 440,352.

Parking. Existing parking capacity adjacent to the shore protection project was evaluated using the 4 July 1979 aerial photography. All parked cars were counted. The breakdown of public versus private parking was based on a public parking survey developed for the town of Wrightsville Beach. That survey stated that there were 2,018 public parking spaces. Because the island is relatively narrow, no parking space is more than 1/4-mile from the authorized project beach. A turnover rate of 2, with 2.5 persons per car, was assumed for the public parking spaces. Maximum daily use utilizing public parking was determined to be 10,090 persons. The parking available on private property was determined by subtracting the public parking value (2,018) from the total number of cars parked on 4 July 1979 (4,706). The resulting value was 2,688, which is considered a conservative estimate because of the number of cars parked in garages and carports and thus not visible on aerial photography. The turnover rate and number of persons per car utilizing private parking spaces were estimated at 1 and 2.5, respectively. This yields a maximum daily use of 6,720 persons utilizing private parking. The maximum total daily use limited by parking is thus 10,090 plus 6,720, for a total of 16,810 users. For the 90-day season derived earlier in this section, the total seasonal use is thus limited to 1,512,900 users. Using the demand growth rate developed in the preceding section, it was determined that existing seasonal parking capacity is exceeded by seasonal beach use demand in the year 2011.

Benefit Analysis. The southern 5,000 linear feet of beach, with an annual visitation capacity of 1,125,000, are projected to remain stable throughout the 50-year period of analysis. The remaining 9,000 linear feet of beach are projected to erode at an average annual rate of 8.9 feet per year. The recreational beach width loss of 125 feet by 1995 was assumed to represent the point at which there was no remaining recreational value. It is not until 2003, however, that demand exceeds capacity of the southern 5,000 linear feet of beach projected to remain stable. Benefits begin in 2003 and increase yearly until 2011 when parking capacity is reached. From that point through the remainder of the 50-year period, benefits remain the same. The average annual value of these recreation benefits would be $270,500. Table 3 presents recreational visitations and values for the 9,000 linear feet of beach being considered.

Table 3

Recreational Visitations and Values for the 9,000
Linear Feet of Wrightsville Beach Under Consideration

Year	Unit Day Value	Visitations	Recreational Value
2003	$3.20	3,754	$ 12,013
2010	3.20	360,365	1,153,168
2011	3.20	387,900	1,241,280

Benefit - Cost Summary

Table 4 presents a summary of the benefits and costs associated with continued maintenance of the authorized berm and dune project.

*

TABLE 4

Benefit-Cost Summary
Continued Maintenance of Wrightsville Beach
Berm and Dune Project
50-Year Period of Analysis, 7-7/8 Percent Interest

Benefit Category	Average Annual Benefit
Beach Erosion Control: Land	$225,700
Structures	209,300
Flood Damage Reduction	169,500
Increase in Value of Residential Contents	35,300
Recreation	270,500
Total Average Annual Benefits	$910,300
Total Average Annual Costs	$668,000
Benefit-to-Cost Ratio	1.36

Rev 2/22/83

APPENDIX D

REEVALUATION OF SHORE PROCESSES AT WRIGHTSVILLE BEACH

APPENDIX D

EVALUATION OF SHORE PROCESSES AT WRIGHTSVILLE BEACH

Table of Contents

List of Tables

List of Tables - Cont'd

List of Figures

Table of Contents - Cont'd

List of Figures - Cont'd

List of Plates

APPENDIX D

REEVALUATION OF SHORE PROCESSES AT WRIGHTSVILLE BEACH

INTRODUCTION

In the spring of 1965, a hurricane and shore protection project was constructed along Wrightsville Beach. This project involved the placement of 2,993,000 cu. yd. of material along 14,000 feet of ocean shoreline from Masonboro Inlet to the then northern town limits of Wrightsville Beach. In addition, Moore Inlet, which at the time of construction separated Wrightsville Beach from Shell Island, was closed. The fill was shaped into a 25-foot-wide dune at elevation 15 feet above mean low water (mlw) which sloped down to a 50-foot-wide storm berm at elevation 12 feet mlw. The material for this fill was borrowed from Banks Channel. Between June 1965 and July 1966, the north jetty at Masonboro Inlet was constructed. Associated with this inlet stabilization project was the excavation of 319,000 cu. yd. of sand adjacent to the inlet side of the north jetty to form a sediment trap for future sand bypassing around the inlet. This material, which was dredged in July 1966, was distributed on Wrightsville Beach between the two fishing piers. In October 1966, an additional 42,000 cu. yd. of material was placed along the northernmost 2,000 feet of the authorized project. This material was obtained from the lagoon behind the presently developed section of Shell Island. Thus, between the spring of 1965 and the fall of 1966, a total of 3,294,000 cu. yd. of fill had been placed on Wrightsville Beach.

Erosion of the northern most 8,000 feet of this fill (i.e., between baseline stations 60+00 and 140+00 shown on plate D-1) occurred rapidly due in part to hydraulic sorting and winnowing of the fill and initial slope adjustments. On the other hand, the southern 6,000 feet experienced a large initial accretion due to the formation of an accretion fillet updrift of the Masonboro Inlet north jetty. The erosion of the northern 8,000 feet was so severe that by 1970 the protective value of the project had been substantially reduced. Therefore, in the spring of 1970, the northern 8,000 feet of the project was renourished with 951,000 cu. yd. of material obtained from Banks Channel and 426,000 cu. yd. from the lagoon behind Shell Island. Included in this renourishment was a 2,000-foot transition section between stations 140+00 and 160+00 (i.e., outside the authorized project limits) which provided a gradual return of the fill shoreline back to the natural beach on Shell Island.

In October 1977, a General Design Memorandum (GDM) for the south jetty at Masonboro Inlet (1) was published and contained an evaluation of shore processes along 19 miles of shoreline from Wrightsville Beach to Kure Beach. In this shore processes analysis, inlet sediment accumulation data and shoreline change information dating from 1966 to 1975 was used in combination with wave refraction studies, to develop a sediment budget for the entire 19-mile area. In this analysis, an attempt was made to adjust the shoreline change rates observed between 1966 and 1975 on Wrightsville Beach for sorting and winnowing losses and initial profile slope adjustments for both the initial fill material and the 1970 renourishment fill. However, due to the nature of this analysis, other factors that could have had a substantial impact on the erosion of Wrightsville Beach were not identified. As a result, approximately 92.8 percent of the erosion was attributed to navigation improvements at Masonboro Inlet, specifically, the construction of the north jetty. The shortcomings of this earlier evaluation were recognized and a statement made to the effect that a more detailed evaluation of the shore processes along Wrightsville Beach would have to be made to differentiate the magnitude of the erosion associated with various possible causes. The analysis that follows is such an evaluation.

Prior to the initiation of this present reevaluation, erosion had again essentially removed all but a minimum amount of the protective value of the northernmost 8,000 feet of the authorized project and the 2,000-foot northern transition. In the most severely eroded section (located between baseline station 110+00 and 130+00), the shoreline had almost returned to its preproject position and posed a serious threat to development in the area. This prompted the placement of 500,000 cu. yd. of emergency beachfill along the northern segment of the project during April and May 1980. The borrow area used for this emergency fill was a shoal in Banks Channel located opposite the U.S. Coast Guard Station. This emergency fill was followed by a complete restoration of the authorized project between December 1980 and April 1981. This latest restoration required 1.25 million cu. yd. of sand, with the material being dredged from Masonboro Inlet and placed along the northern 8,000 feet of the project, i.e., between stations 60+00 and 140+00. Due to fund limitations, the 2,000-foot transition was not rebuilt. However, shortly following renourishment, natural processes had spread the fill northward forming a gradual transition.

SHORE PROCESSES REEVALUATION

General. One of the apparent causes of the erosion of Wrightsville Beach is the shape of the present day shoreline. Figure D-1 is an oblique aerial photograph of Wrightsville Beach looking toward the north from Masonboro Inlet. As is evident from this photo, there is a large protuberance in the shoreline beginning in the vicinity of the Blockade Runner Motel, baseline station 70+00, and extending northward to a point beyond the developed section on Shell Island. This protuberance, or bulge as it will be referred to later in this analysis, is primarily associated with the former Moore Inlet which, as mentioned above, was closed in 1965 during the initial placement of the hurricane and shore protection fill. Moore Inlet had existed as the northern boundary of Wrightsville Beach since the mid-1800's and characteristically had caused the shoreline immediately to the north and south to curve seaward. Since Moore Inlet had been a persistent feature of Wrightsville Beach, when the northern end of the island began to develop,

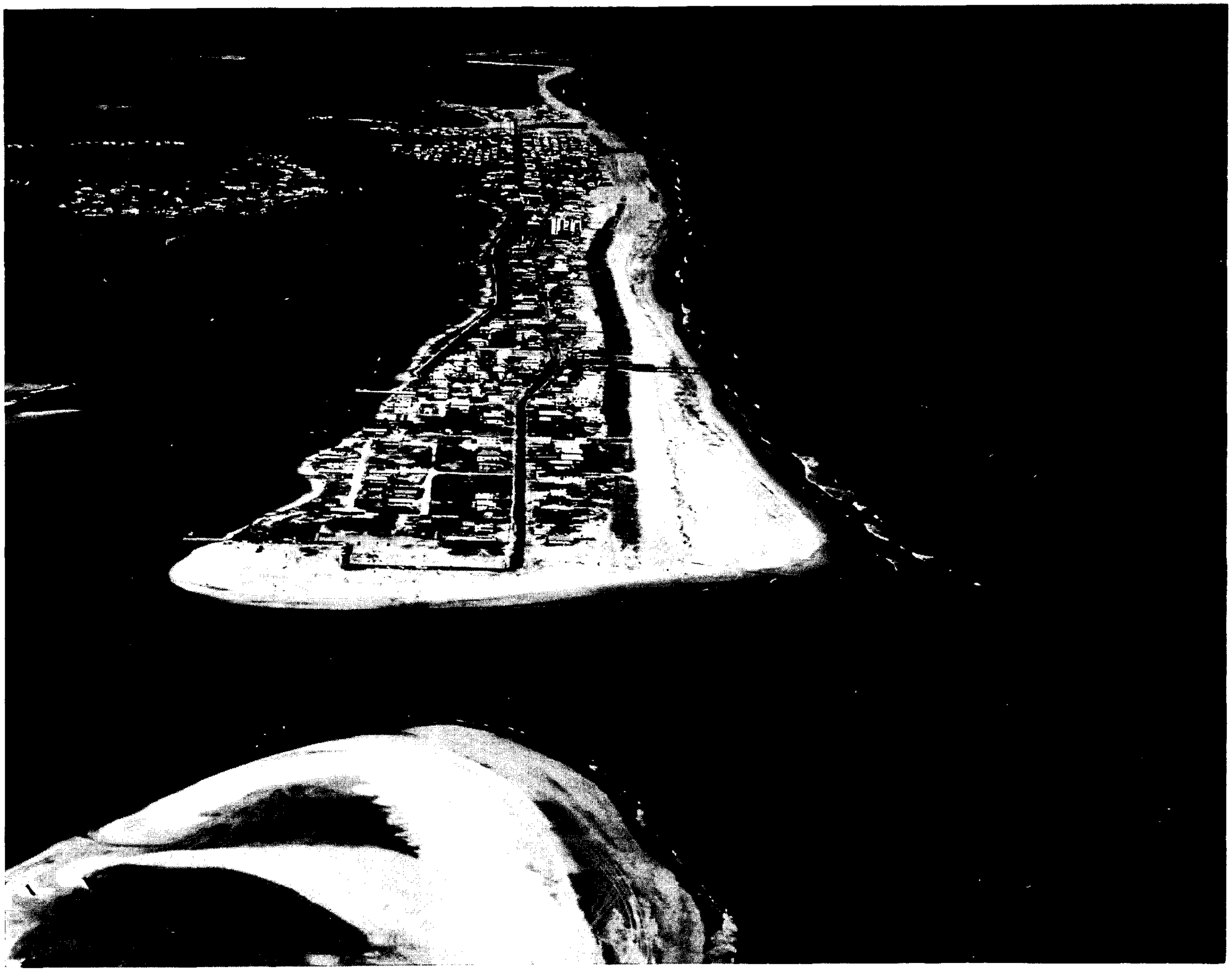


FIGURE D-1. WRIGHTSVILLE BEACH. MAR 1971.

roads and houses more or less paralled the general shore alignment. Consequently, when the hurricane and shore protection project was constructed, the fill was placed seaward of the development, thus producing the present bulge.

Since the closure of Moore Inlet stopped the interaction between inlet tidal flow, longshore currents, and sediment transport, which were the factors responsible for the preproject shoreline shape, the planform of Wrightsville Beach is now anomalous compared to other barrier islands in the vicinity. It appears that the natural tendency for normal shore processes is to reshape the beach planform to an alignment more compatible with prevailing waves, currents, and inlet positions. An estimate of the effects of the bulge on shoreline change rates is given below.

Other factors which have contributed to the high rates of erosion include: (a) sorting and winnowing losses from the artificial fill material; (b) beach profile slope adjustments following fill placement; (c) historical deficits caused by sand entrapment in the inlets, offshore sand transport, and sea level rise; and (d) the impact of the navigation improvements at Masonboro Inlet. An evaluation of the effects of each of these factors is given below. First the magnitude of the erosion problem is presented by examining the recent shoreline history of Wrightsville Beach and Shell Island.

Recent History of the Wrightsville Beach and Shell Island Shorelines. Beach profile surveys of Wrightsville Beach were initiated in 1965 after the completion of the first phase of fill placement. These surveys were performed quarterly (i.e. every 3 months) until August 1970, at which time the survey program was changed to a bimonthly basis which continued until February 1974. After February 1974, no surveys were made until April 1978. The April 1978 survey was followed by two more, one in July 1979 and one in December 1979. The December 1979 was the last survey that covered all of Wrightsville Beach and Shell Island prior to the latest renourishment.

The August 1970 and July 1979 surveys covered the entire beach profile to depths of about 32 feet below m.s.l., whereas the other surveys extended only to approximately mean low water (-2 feet, m.s.l.). Also, detailed coverage of Shell Island northward to Masons Inlet was not begun until October 1970.

As previously stated, the largest amount of erosion on Wrightsville Beach occurred between stations 60+00 and 160+00. South of station 60+00 to the north jetty at Masonboro Inlet, the shoreline experienced a rapid buildup during and immediately following the construction of the north jetty as a result of the formation of an accretion fillet. The growth of the accretion fillet continued until about February 1968 at which time the shoreline became fairly stable. This stable condition continued until at least February 1974. By April 1978, however, the survey data indicated that some erosion of the fillet had occurred as the shoreline position at most stations was landward of the February 1968 shoreline. Between April 1978 and December 1979, the fillet accreted slightly, but overall, the net change on the fillet from February 1968 to December 1979 was erosion as indicated by the shoreline change rates from stations 3+50 to 50+00 in table D-2. During the entire period following the construction of the north jetty, the portion of the beach landward of the berm crest built up as a result of aeolian sand transport and associated dune formation. Although the recent shoreline trend of the fillet has been erosion, this is not expected to continue indefinitely due to the stabilizing effect of the north jetty.

For this reevaluation of the Wrightsville Beach shore processes, the analysis of shoreline changes within the severely eroding area, that extends from station 60+00 to 160+00, was limited to the August 1970 to July 1979 period, which is a period sandwiched between the 1970 and 1980-81 renourishments of Wrightsville Beach. This period was selected primarily because detailed information was available on the characteristics of the borrow material used for the 1970 fill, thus allowing for an estimate of sorting and winnowing losses.

Changes in the position of the mean sea level contour at each profile station within the severely eroding area were measured and graphs drawn of the cumulative shoreline change over time. The graphs for each of these profiles are shown on figures D-2 to D-4. A notable characteristic of these shoreline change graphs is that extremely rapid shoreline retreat rates were experienced between stations 70+00 and 140+00 immediately following the fill placement, and that after an initial period, the rate of shoreline change diminished and became relatively uniform over time. The initial period of rapid shoreline retreat appeared to extend to about December 1971. Interestingly, the total amount of erosion between stations 70+00 and 140+00 was, by December 1971, generally equal to or greater than the added width of beach provided by the 1970 fill. This is illustrated in table D-1. The significance of this is that approximately all of the 1970 fill material had been exposed to the hydraulic sorting and winnowing action of the waves by this date. Also, the initial beach profile slope adjustments had occurred by December 1971.

Since the changes in the position of the m.s.l. contour between February 1972 and July 1979 were rather uniform and relatively unaffected by sorting and winnowing losses, lines of best fit were computed through this portion of the shoreline change curves for each profile station within the severely eroding area (i.e. stations 60+00 to 160+00). The slope of these best fit lines were interpreted to represent steady state trends in the shoreline behavior. These trends, given in terms of feet of shoreline change per year, are summarized in table D-2.

Shoreline change rates for Shell Island north of the fill to Masons Inlet, applicable to this reevaluation of shore processes, were based on the longest period available which was from October 1970 to December 1979. These rates are also given in table D-2.

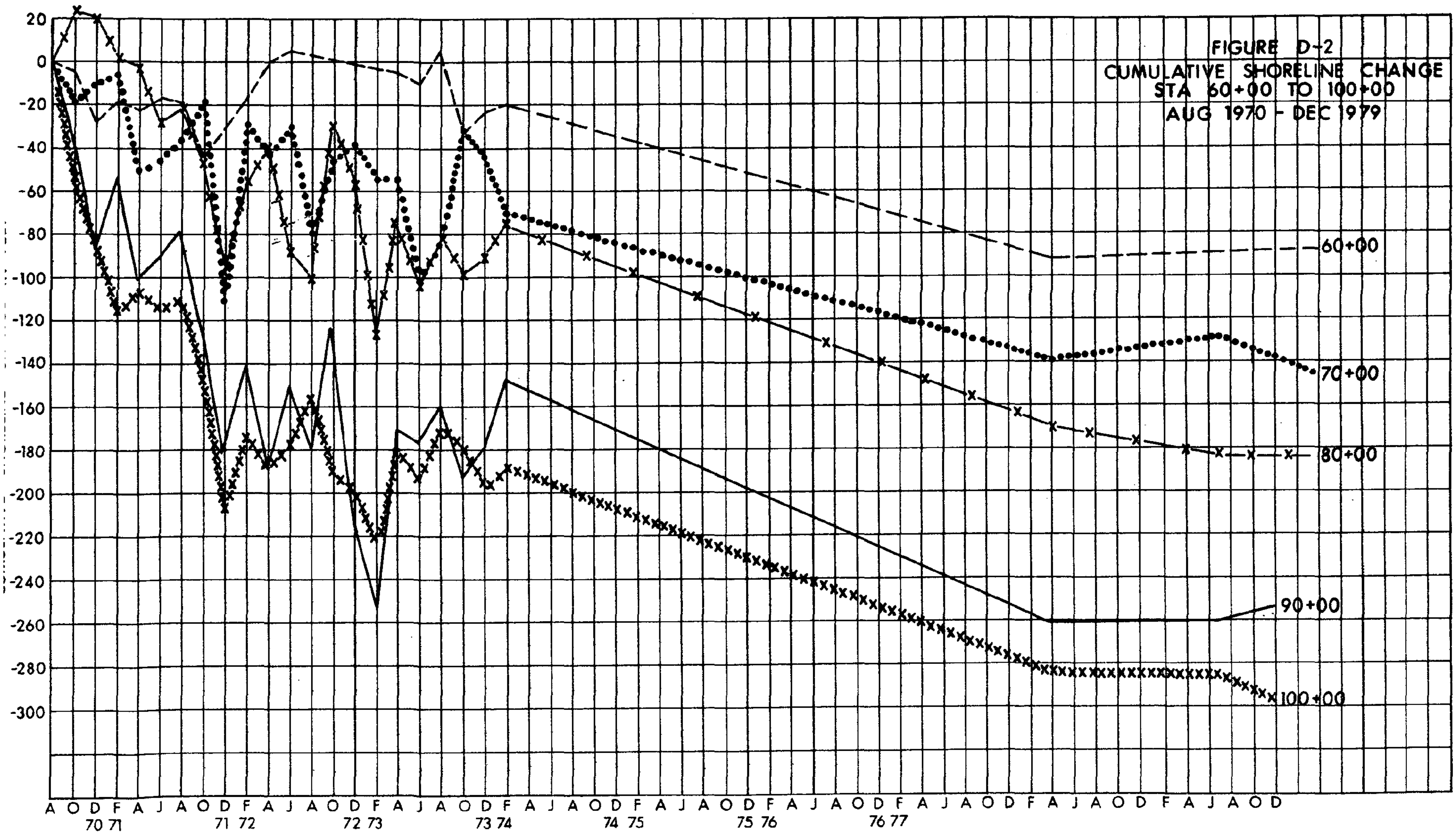


FIGURE D-2
CUMULATIVE SHORELINE CHANGE
STA 60+00 TO 100+00
AUG 1970 - DEC 1979
60+00
70+00
80+00
90+00
100+00
20
0
-20
-40
-60
-80
-100
-120
-140
-160
-180
-200
-220
-240
-260
-280
-300
A O D F A J A O D F A J A O D F A J A O D F A J A O D F A J A O D F A J A O D F A J A O D F A J A O D F A J A O D
70 71
71 72
72 73
73 74
74 75
75 76
76 77

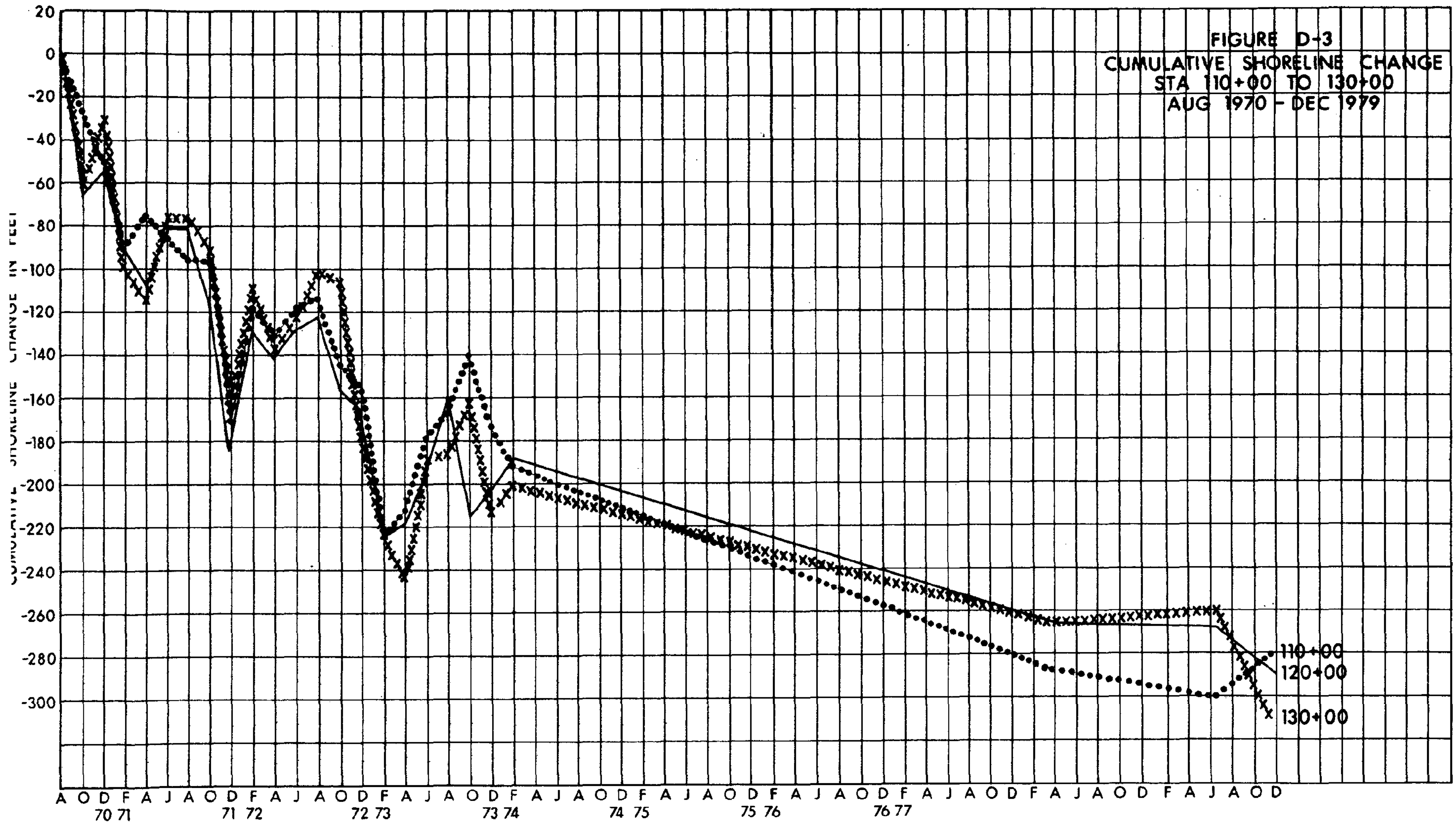


FIGURE D-3
CUMULATIVE SHORELINE CHANGE
STA 110+00 TO 130+00
AUG 1970 - DEC 1979
110+00
120+00
130+00
CUMULATIVE SHORELINE CHANGE IN FEET
20
0
-20
-40
-60
-80
-100
-120
-140
-160
-180
-200
-220
-240
-260
-280
-300
A O D F A J A O D F A J A O D F A J A O D F A J A O D F A J A O D F A J A O D F A J A O D F A J A O D F A J A O D F A J A O D
70 71
71 72
72 73
73 74
74 75
75 76
76 77

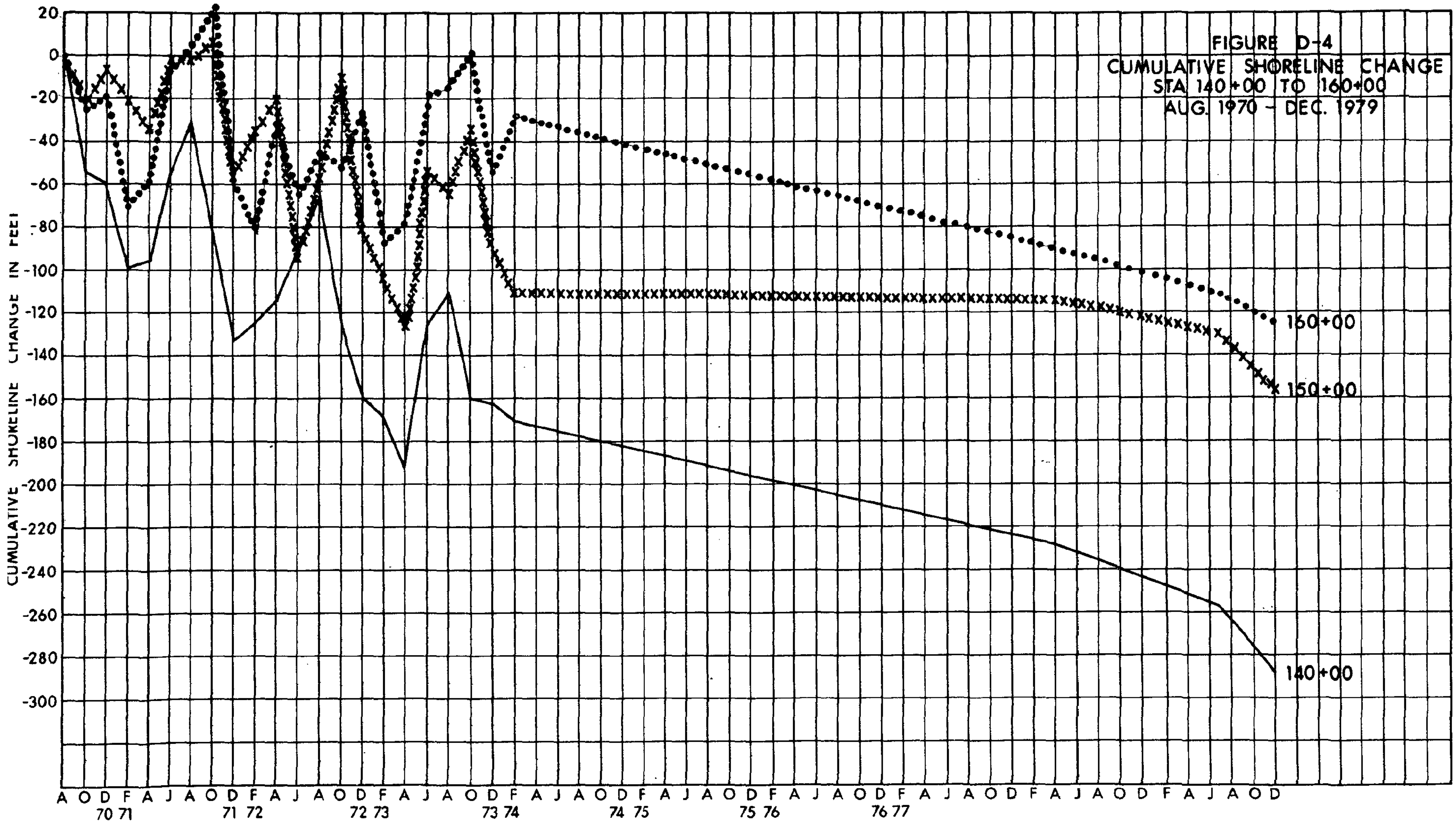


FIGURE D-4
CUMULATIVE SHORELINE CHANGE
STA 140+00 TO 160+00
AUG. 1970 - DEC. 1979
CUMULATIVE SHORELINE CHANGE IN FEET
20
0
-20
-40
-60
-80
-100
-120
-140
-160
-180
-200
-220
-240
-260
-280
-300
160+00
150+00
140+00
A O D F A J A O D F A J A O D F A J A O D F A J A O D F A J A O D F A J A O D F A J A O D F A J A O D F A J A O D
70 71
71 72
72 73
73 74
74 75
75 76
76 77

TABLE D-1

1970 Beach Fill Widths vs. Shoreline Retreat
as of December 1971

Station	Shoreline Advance by 1970 Fill (ft)	Shoreline Retreat as of Dec 1971 (ft)
60+00	74	-30
70+00	85	-108
80+00	113	-96
90+00	144	-180
100+00	166	-208
110+00	190	-172
120+00	176	-182
130+00	165	-160
140+00	84	-132
150+00	50	-56
160+00	14	-60

TABLE D-2

Wrightsville Beach - Shell Island
Shoreline Change Rates

Station	Measured Rate of Change[1] Outside 1970 fill area (ft/yr)	Computed Shoreline Trend within 1970[1] Fill Area (2/72-7/79 data) (ft/yr)	Deficit[2] x 0.54
3+50	-15.4*		
10+00	-9.6*		
20+00	-3.2*		
* 30+00	-0.6*		
40+00	+3.2*		
50+00	-2.3*	2.3	-1.2
60+00		-11.5	-6.2
70+00		-11.4	-6.2
80+00		-17.0	-9.2
90+00		-16.7	-9.0
100+00		-14.4	-7.8
110+00		-22.7	-12.2
120+00		-22.1	-11.9
130+00		-27.5	-14.8
140+00		-19.3	-10.4
150+00		-9.8	88.9/10=8.89
160+00		-6.2	
169+00	-6.5**		Say 8/9/yr.
180+00	-2.2**		
190+00	-1.3**		
197+00	0 **		
227+00	+1.3**		

1 Negative and positive signs represent erosion and accretion, respectively

2 Erosion rate adjusted to reflect placement of 60,000 cubic yards per year from Masonboro Inlet Navigation Project (70,000/130,000 = 0.54)

* February 1968 to December 1979 data
** October 1970 to December 1979 data

Volumetric Changes - Wrightsville Beach and Shell Island - August 1970 to July 1979. The two onshore-offshore surveys taken in August 1970 and July 1979 were used to estimate the volumetric changes on the beach profile between Masonboro and Masons Inlets. The results of the volume change estimate are given in table D-3. Since the August 1970 survey was taken immediately after the 1970 fill was completed, the total volume change within the fill area includes losses due to sorting and winnowing of the fill material along with the losses associated with the other effects being evaluated. Therefore, before an annual rate of loss of material from this area can be computed, an adjustment must be made for these sorting and winnowing losses.

Sorting and Winnowing Losses from the 1970 Fill Material. As mentioned earlier, the 1970 fill material was obtained from two sources, namely a shoal area in Banks Channel opposite the U.S. Coast Guard Station and from the lagoon behind Shell Island. The quality of these two sources of material were strikingly different; specifically, the Banks Channel sand was relatively coarse (mean grain size of 0.26 mm) and widely distributed in terms of grain size, whereas the Shell Island sand was fine (mean grain size of 0.17 mm) and poorly sorted. A total of 951,000 cu. yd. of material were removed from Banks Channel and placed between stations 60+00 and 110+00 while the Shell Island material, totaling 426,000 cu. yd., was spread between stations 110+00 and 160+00.

A considerable amount of grain size information was available for the two borrow areas from core borings taken prior to the placement of the fill. This grain size information was used along with the before and after dredging surveys of the borrow areas to estimate the composite grain size characteristics of the two borrow materials.

In the case of the Banks Channel borrow area, the before and after dredging cross sections were plotted along with the vertical distribution of the material characteristics obtained from the analysis of the boring samples. From these plots, the borrow area was separated into three sections in which the grain size characteristics were similar. Based on the volume of material removed from these three sections and the average grain size characteristics in the sections, a weighted composite grain size distribution was constructed for the Banks Channel borrow material. With respect to the Shell Island borrow area, there were no distinct variations in the quality of the material from one end of the borrow area to the other or from top to bottom. Therefore, the composite characteristics of this material was obtained by averaging the size distributions of 38 samples taken from 14 borings. The resulting composite size characteristics of the two borrow materials are summarized in table D-4.

TABLE D-3

Volume Changes - Wrightsville Beach & Shell Island
August 1970 - July 1979

Station	Volume Change Btwn Baseline Stas. (cubic yards)	
0+00*		
	-17,400	
3+50		
	-41,200	
10+00		
	-77,700	0+00 to 60+00
30+17*		Total Change = -125,700 CY
	+18,400	Rate = -14,000 CY/Yr
40+00		
	+17,000	
49+05*		
	-24,800	
60+00*		
	-66,100	
70+00		
	-105,300	
80+00		
	-311,300	60+00 to 160+00 (Fill Area)
100+00		Total Change = -1,474,900 CY
	-514,100	Rate = N/A**
130+00		
	-478,100	
160+00*		
	-56,600	
167+00		160+00 to 227+00
	+22,700	Total Change = +314,500 CY
197+00		Rate = +34,900 CY/Yr
	+348,400	
227+00		

* Interpolated - no offshore profiles taken at these stations
** Not applicable due to sorting and winnowing losses from fill

TABLE D-4

1970 Borrow Material Grain Size Characteristics

Borrow Area	Mean		Standard Deviation	% Silt
	φ units	mm	φ units	and Clay
Banks Channel	1.95	0.26	1.05	5.0
Shell Island	2.54	0.17	0.49	10.2

An estimate of the sorting losses from the borrow material is obtained by comparing the composite characteristics of the borrow material to that of the surficial sediments comprising the native beach profile. In the case of Wrightsville Beach, a truly native beach sand did not exist due to the placement of previous artificial fills. Therefore, the size characteristics of the beach material was based on samples collected from the profiles in early 1980 prior to the latest renourishment. In this case, the 1980 samples reflect the characteristics of the 1970 fill material that were retained on the active beach profile; and therefore should, when compared to the borrow material characteristics, give a reasonable estimate of sorting losses.

A total of 73 samples taken from profile stations 70+00, 90+00, 110+00, 130+00, and 150+00 to depths of 24 feet below m.s.l. were used to compute the composite characteristics of the beach material. Note that all of the sample stations are within the limits of the 1970 fill. The resulting composite distribution of the beach material had a phi mean of 2.31 (0.20mm) and a standard deviation of 0.66.

The procedure for computing a value known as the fill factor (R_A), which is a measure of the number of cubic yards of fill material needed to retain one cubic yard of sorted material on the beach profile, is given in the Shore Protection Manual (2). Based on this procedure, the Banks Channel material had an R_A value of 1.1, whereas the Shell Island material R_A was 3.0. Adjusting these two R_A values for the amount of silt and clay in the borrow areas which would be winnowed from the fill during placement, the final fill factors were 1.16 for Banks Channel and 3.34 for Shell Island. By applying these fill factors to the volume of material removed from each borrow area, the estimated sorting and winnowing loss from the Banks Channel material was 130,000 cu. yd. while the Shell Island material lost an estimated 298,000 cu. yd. This results in a total sorting and winnowing loss of 428,000 cu. yd. from the entire fill. Since the two borrow materials were spread along different sections of the beach, the estimated sorting losses were applied station by station to the fill area to arrive at an adjusted or net volumetric change on Wrightsville Beach between August 1970 and July 1979. This adjustment, shown in table D-5, resulted in a net rate of loss of material from the fill area of about 116,000 cu. yd./year. For the entire Wrightsville Beach fill area which extends from Masonboro Inlet northward to the end of the transition section (0+00 to 160+00), the

TABLE D-5

Adjusted Volumetric Changes - Wrightsville Beach & Shell Island
August 1970 - July 1979

Station	Observed Vol Change Btwn Stas (CY)	Est Vol 1970 Fill Placed Btwn Stas (CY)	Source of Fill	Est Sorting Losses Btwn Stas (CY)	Net Vol Change(CY)	
0+00						
	-17,400	0			-17,400	
3+50						
	-41,200	0			-41,200	
10+00						
	-77,700	0			-77,700	0+00 to 60+00 Total Change = -125,700 CY Rate = -14,000 CY/Yr
30+17						
	+18,400	0			+18,400	
40+00						
	+17,000	0			+17,000	
49+05						
	-24,800	0			-24,800	
60+00						
	-66,100	117,700	Banks Ch	16,100	-50,000	
70+00						
	-105,300	146,500	Banks Ch	20,000	-85,300	
80+00						
	-155,600	190,200	Banks Ch	26,000	-129,600	
90+00						
	-155,700	229,400	Banks Ch	31,300	-124,400	60+00 to 160+00 Total Change = -1,046,900 CY Rate = -116,000 CY/Yr
100+00						
	-171,400	267,200	Banks Ch	36,600	-134,800	
110+00						
	-342,700	261,700	Shell Is	183,000	-159,700	
130+00						
	-159,400	91,500	Shell Is	64,000	-95,400	
140+00						
	-318,700	72,800	Shell Is	51,000	-267,700	
160+00						
	-56,600				-56,600	
167+00						
	+22,700				+22,700	160+00 to 227+00 Total Change = 314,500 CY Rate = +34,900 CY/Yr
197+00						
	+348,400				+348,400	
227+00						

total rate of loss was 130,000 cu. yd./year. This total rate of volume loss is less than that reported in reference (1) which was 167,000 cu. yd./year.

As has been discussed, shoreline changes on Wrightsville Beach following the 1970 renourishment occurred rapidly during the initial 16 months (August 1970 - December 1971) as a result of sorting-winnowing losses and profile slope adjustments. However, the rate of shoreline change at each profile station within the fill area eventually developed into uniform rates after this initial period. It is assumed that this uniform rate of change was free of any sorting and winnowing losses. Accordingly, by applying this rate to the 9-year period corresponding to the time between the August 1970 and July 1979 offshore surveys, the difference between the volumetric erosion predicted by the uniform shoreline change rates and that measured from the comparison of the offshore profiles, gives an order of magnitude check of the computed sorting-winnowing losses given above. Since the uniform rate is given in terms of the linear change in the shoreline position per year (i.e. ft/yr), a volumetric equivalent factor had to be developed to convert the shoreline movements to volumetric change.

Repetitive soundings were made from Johnnie Mercers Pier, located near station 120+00, between March 1972 and July 1979, which approximately corresponds to the post slope adjustment--sorting/winnowing loss period. The depth of water at the end of the pier is around 18 feet below m.s.l., which is near the seaward limit of the active profile. Based on these soundings, the mean sea level contour at the pier moved landward 130 feet between March 1972 and July 1978 while the volume of material on the profile decreased by 99.3 cu. yd./linear foot of shoreline. Based on these measured changes, a volumetric equivalent factor obtains wherein every foot of lateral change in the position of the mean sea level contour results in a loss of 0.76 cubic yards from the profile per lineal foot of shoreline.

The 1970 fill was divided into three segments, namely: (1) the southern transition (stas. 60+00 to 80+00); (2) the main fill (stas. 80+00 to 140+00); and (3) the northern transition (stas. 140+00 to 160+00). The cumulative shoreline change at each station within the three segments were averaged for the period February 1972 to July 1979, and a single shoreline trend curve computed for each segment. A plot of these cumulative changes and associated trend curves are shown on figure D-5. The resulting trends in the three segments were: -13.8 ft./yr. for the southern transition; -18.4 ft./yr. for the main fill; and -9.7 ft./yr. for the northern transition. These shoreline trends along with the volumetric equivalent factor given above applied over the 9-year survey period from August 1970 to July 1979, convert to a total predicted volumetric loss of 1,077,00 cu. yd. The measure volumetric loss from the fill area between August 1970 and July 1979 was 1,479,000 cu. yd. which is 397,900 cu. yd. more than the erosion predicted from the uniform shoreline trends. Assuming that this difference was for the most part due to sorting and winnowing, the estimated 428,000 cu. yd. of sorting and winnowing losses computed from the material characteristics appears to be within the correct order of magnitude.

Historical Losses Off Wrightsville Beach (Preproject Losses). Wrightsville Beach has had a history of erosion problems dating from the earliest attempts to build within this dynamic barrier island zone. Local interests began attempts to control erosion in 1923 when the town, with assistance from New Hanover County and the Tidewater Power Company, constructed five timber groins along the middle 6,400 feet of the ocean shoreline. In 1925, six reinforced concrete groins were added, with three to the north and three to the south of the timber groins. The wooden groins functioned satisfactorily until about 1928, by which time attacks by marine borers had partially destroyed them. The concrete groins were temporarily successful at the southern end of the island, but those at the northern end were eventually flanked and destroyed. In 1939 the town, with the assistance of PWA funds, constructed 16 creosoted timber groins, each about 325 feet long and spaced about 800 feet apart. Also, between 1955 and 1959, four beach nourishment operations placed a total of 477,800 cu. yd. of fill on Wrightsville Beach. The timber groins were apparently effective for a while; however, the seaward ends of the groins deteriorated rapidly so that by 1957 their impact on the beach was negligible. In spite of these efforts by the town, the shoreline along Wrightsville Beach retreated between 1939 and 1965.

The magnitude of the preproject shoreline change was obtained by comparing onshore profiles (i.e. landward of the -2 foot, m.s.l. contour) made in 1939 with a preproject survey made in 1965. The measured change in the position of the m.s.l. contour at each profile station during this time is given in table D-6. The weighted average shoreline erosion along the entire beach was 60 feet. Since Wrightsville Beach was only 12,500 feet long during this period, the 60 feet of landward movement of the m.s.l. contour is equivalent to a volume loss of 562,000 cu. yd. over the 26-year period.

The four beach fills placed on Wrightsville Beach between 1955 and 1959 used Banks Channel as a borrow source. Since the quality of that material in terms of its compatibility with the native beach is not known, this fill material was assumed to have the same fill factor as the original hurricane and shore protection fill placed in 1965. The 1965 fill material had an estimated fill factor of 2.5 (1). Thus, the net volume of fill placed on the beach between the 1939 and 1965 surveys was approximately 191,000 cu. yd. If this fill volume is added to the net loss computed from the profile surveys, the total volume loss off Wrightsville Beach during the 26-year period was 753,000 cu. yd., corresponding to an average annual loss rate of 29,000 cu. yd. In terms of shoreline movement, a volumetric loss of 29,000 cu. yd./year is equivalent to a lateral movement of -3 ft./year at the m.s.l. contour.

IMPACT OF THE SHORELINE SHAPE ON EROSION RATES

The evaluation of the effects of the anomalous shape of the Wrightsville Beach shoreline was accomplished through a numerical simulation of sand transport along a shoreline bulge comparable to that of Wrightsville Beach.

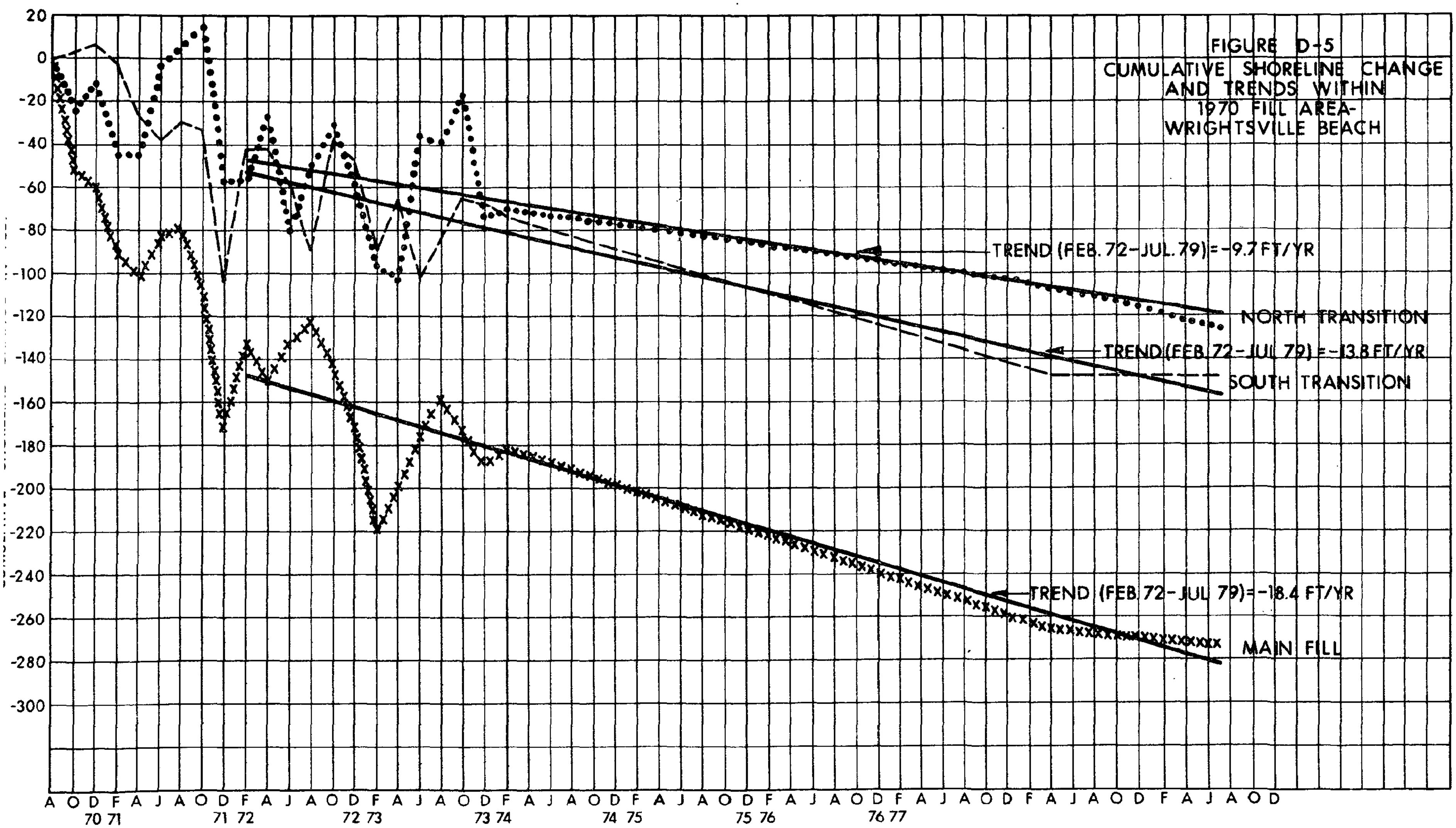


FIGURE D-5
CUMULATIVE SHORELINE CHANGE AND TRENDS WITHIN 1970 FILL AREA-WRIGHTSVILLE BEACH

TABLE D-6

Wrightsville Beach Shoreline Changes
1939 - 1965

CE Sta	Dist Btwn Stas (Ft)	m.s.l. Change (ft)	Area Change (ft^2)
1+00		-10	
	470		-12,925
5+70		-45	
	530		-11,925
11+00		0	
	530		-16,960
16+30		-64	
	525		-35,700
21+55		-72	
	480		-30,960
26+35		-57	
	377		-16,588
30+12		-31	
	208		-7,904
32+20		-45	
	880		-46,200
41+00		-60	
	1,000		-70,000
51+00		-80	
	900		-45,450
60+00		-21	
	1,100		-29,700
71+00		-33	
	850		-48,025
79+50		-80	
	1,280		-124,800
92+30		-115	
	810		-87,075
100+40		-100	
	1,000		-65,000
110+40		-30	
	603		-28,643
116+43		-65	
	387		-26,123
120+30		-70	
	390		-30,420
124+20		-86	

Total Area Change (ft^2) 734,398

Average MSL Change = 734,398/12,320 = -60 ft

The numerical longshore transport simulation had, as input, wave characteristics observed at Wrightsville Beach and normal longshore transport rates applicable to the area. The simulation of the physical characteristics of the bulge was based on the variation of the Wrightsville Beach shoreline from an average shape that is characteristic of barrier islands in the vicinity. Each of the features of this analysis, i.e., the evaluation of the magnitude of the shoreline anomaly, wave characteristics applicable to Wrightsville Beach, longshore sand transport rates, and the development of the longshore transport numerical simulation, are discussed below. This will be followed by a presentation of the results obtained from the analysis.

Magnitude of Shoreline Anomaly. The shape of most barrier islands in the vicinity of Wrightsville Beach, which are bounded on the updrift and downdrift sides by tidal inlets, is concave seaward. This concavity is normally sharpest immediately downdrift of the updrift inlet until a point of maximum indention occurs from which the degree of curvature decreases in the downdrift direction. A sketch of a typical barrier island, identifying terms to be referred to later, is shown on figure D-6.

Several barrier islands, both past and present, were selected for the purpose of determining an average ocean shoreline shape of islands in the area. These included the: 1857 Wrightsville Beach shoreline; 1887 Wrightsville Beach shoreline; 1938 Shell Island shoreline; 1949 Shell Island shoreline; 1970 shoreline between Old Topsail Inlet and Rich Inlet; 1970 Figure Eight Island shoreline; 1970 Lea Island shoreline; and 1970 Masonboro Island shoreline.

For each of these islands, a baseline was established connecting the protuberant shoulders of the updrift and downdrift inlets as shown on figure D-6. From this baseline the relative offset distance, Y/Ymax, was measured at various relative distance, X/L, along the baseline. These relative values were then plotted, as shown on figure D-7, and lines of best fit drawn through various segments of the data set to produce a relationship for the average shape of a barrier island.

In order to apply the shoreline shape relationship given by the curve on figure D-7 to Wrightsville Beach, the length of the island and maximum indenture had to be defined. With respect to the island length, a value of 17,700 feet was selected which is the distance from Masons Inlet to station 50+00 on Wrightsville Beach. South of station 50+00 to Masonboro Inlet the shoreline curvature approximates that of the average barrier island. A maximum indenture of 350 feet was also selected which is the average indenture of six of the eight barrier islands. The 1,200-foot indenture of Figure Eight Island and the 1,500-foot indenture of Masonboro Island were not included in this average as they were considered to be too large for Wrightsville Beach. The shape and position of the predicted shoreline relative to the 1970 shoreline is shown on figure D-8. This predicted shoreline is presumed to represent the eventual shoreline position and shape for Wrightsville Beach that would develop after some period of time if the

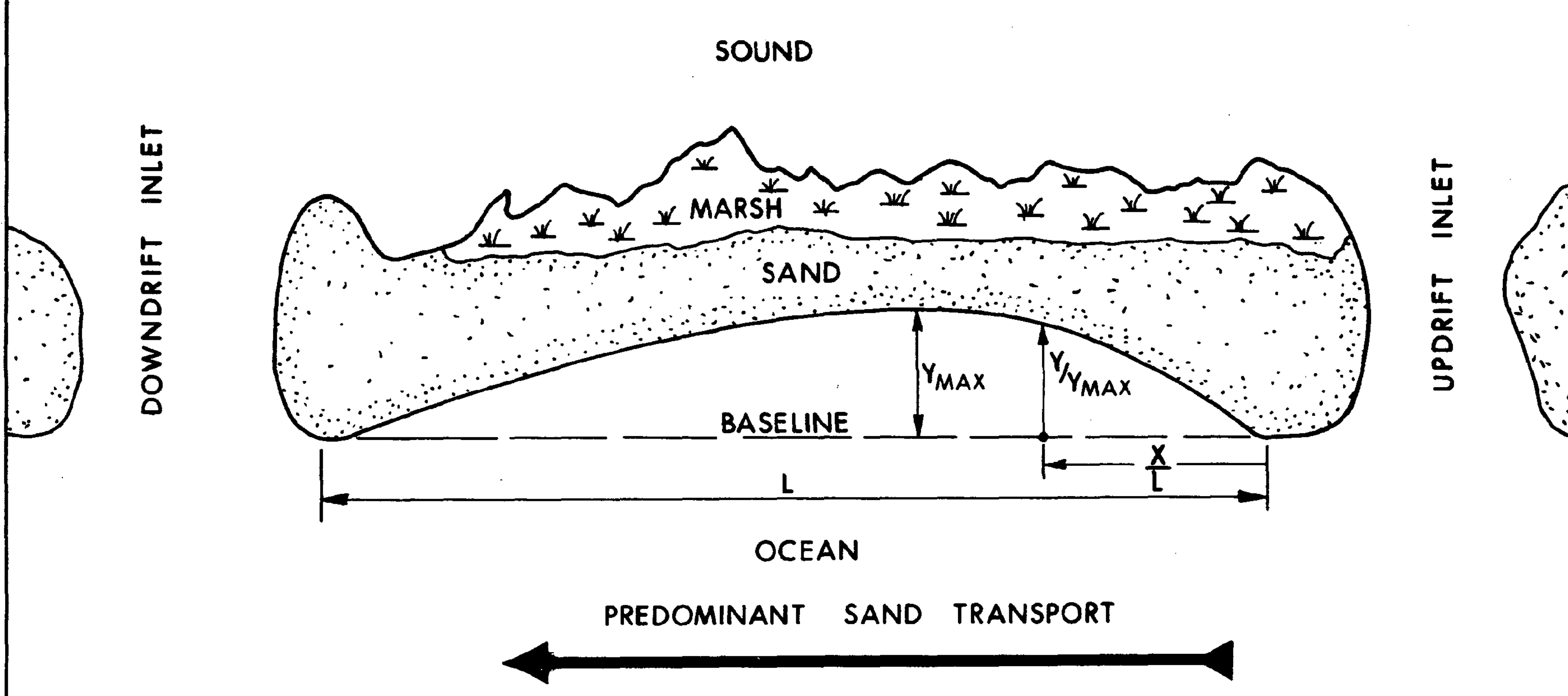


FIGURE D-6
DEFINITION SKETCH-BARRIER ISLAND
SHORELINE SHAPE

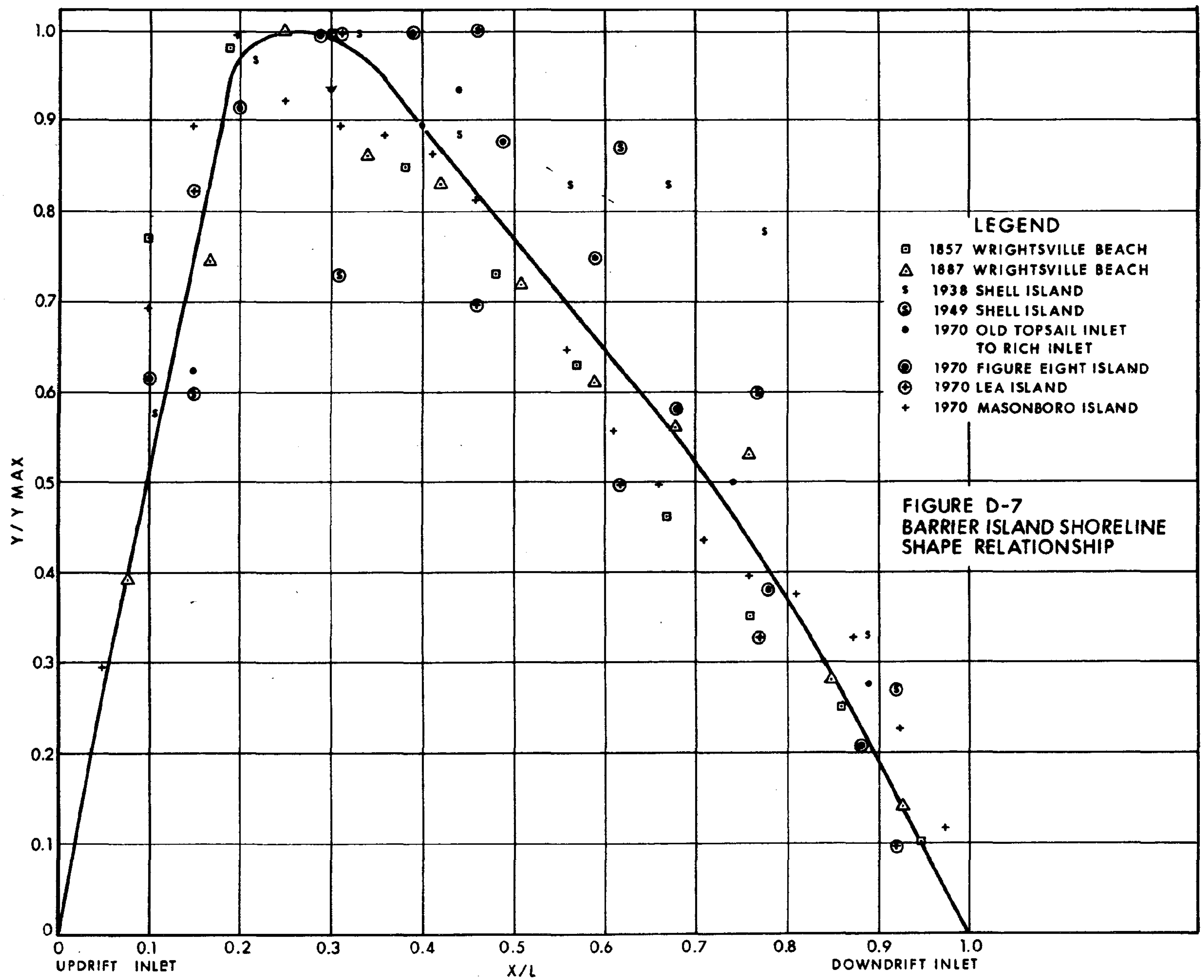
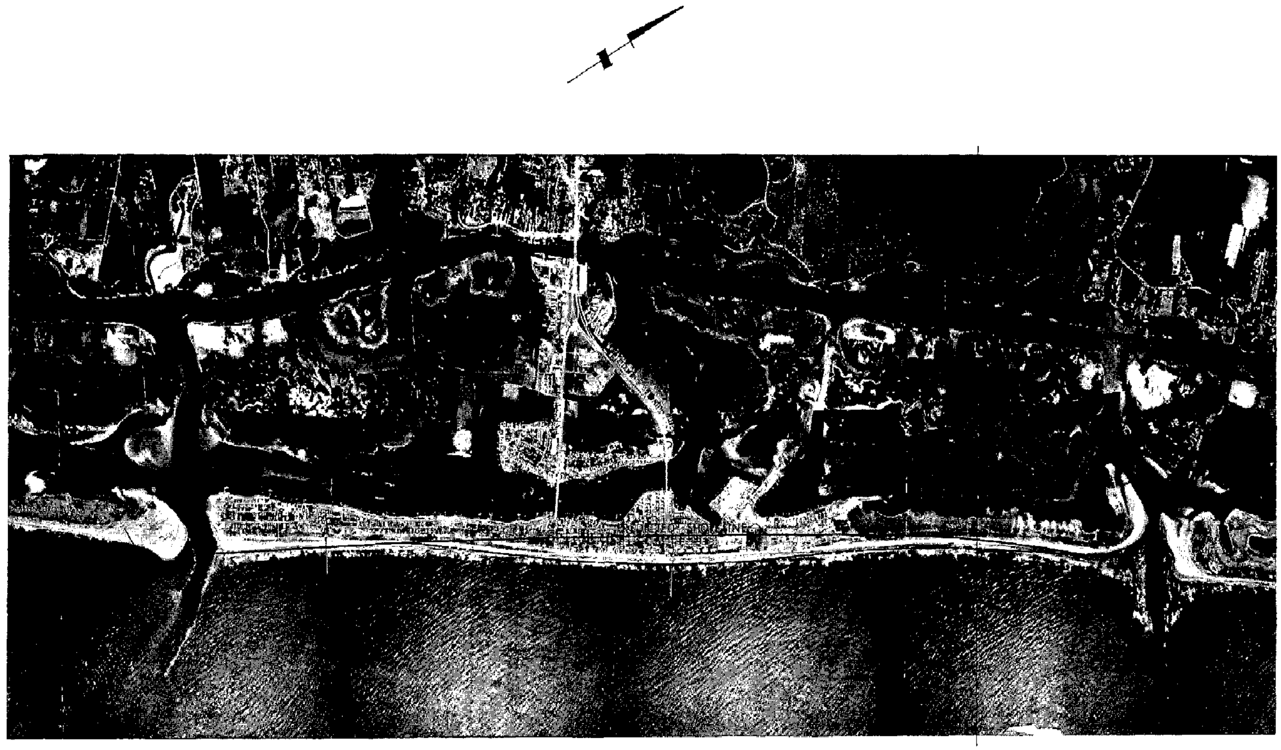


FIGURE D-7
BARRIER ISLAND SHORELINE SHAPE RELATIONSHIP



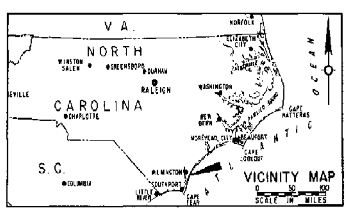


FIGURE D-8
PREDICTED SHORELINE
SHAPE FOR WRIGHTSVILLE
BEACH & SHELL ISLAND

beach were not maintained by artificial means and Masons Inlet remains in the same relative position.

The concave shape of the barrier islands is to a large extent the result of the interaction of tidal flow through the inlets with longshore sediment transport by waves. If this perturbation to sediment movement is removed, the shape of the shoreline would probably conform to that of the nearshore contours. For example, if the nearshore contours are straight and parallel, the shoreline would also be straight. This particular concept was used to develop the simulated offshore hydrography to be used in the numerical simulation of sand transport along the bulge shoreline.

The shape of the idealized shoreline bulge was determined from the difference between the 1970 Wrightsville Beach shoreline and the predicted average shape of this barrier island as shown on figure D-8. The maximum difference between these two shorelines occurred from station 100+00 to 140+00 and averaged approximately 600 feet. If the predicted average shoreline for Wrightsville Beach is normalized into a straight line, the angle between the point of maximum protuberance on the 1970 bulge shoreline and the normalized straight shoreline was estimated to be around 3.8°.

The idealized bulge shoreline used in this analysis is shown on figure D-9 and consists of: (1) two straight shoreline segments north and south of the bulge; (2) a north transition and a south transition with angles of 3.4° from the idealized straight shoreline; and (3) the main bulge section offset 600 feet from the straight shoreline. This idealized shoreline reasonably represents the relative shape of the 1970 Wrightsville Beach shoreline.

The offshore bathymetry of the bulge was developed by averaging the distance to various depth contours at 23 profile stations along Wrightsville Beach and Shell Island located between stations 40+00 and 196+84. Station 196+84 is approximately 3,000 feet south of Masons Inlet and is not affected by the inlet's ocean bar. These average distances between the contours are given in table D-7 and a plot of this average profile is shown on figure D-10. In constructing the offshore bathymetry, the depth contours out to -24 feet, m.s.l. were made parallel to the bulge shoreline, whereas the -30 feet, m.s.l. depth contour was maintained at a constant distance of 3,050 feet relative to the straight shoreline. Thus, in the vicinity of the bulge, the slope of the offshore profile between the 30- and 24-foot, m.s.l. depth contours was steeper than along the straight portion of the simulated ocean bottom. This appeared to be the actual case as reflected by both the 1970 and 1979 offshore surveys. The resulting offshore bathymetry used in this bulge analysis is also shown on figure D-9. From this offshore bathymetry, a depth grid with spacings in both the X (shore parallel) and Y (perpendicular to the shore) directions of approximately 208 feet was generated for use in the numerical simulation of longshore sand transport along the bulge.

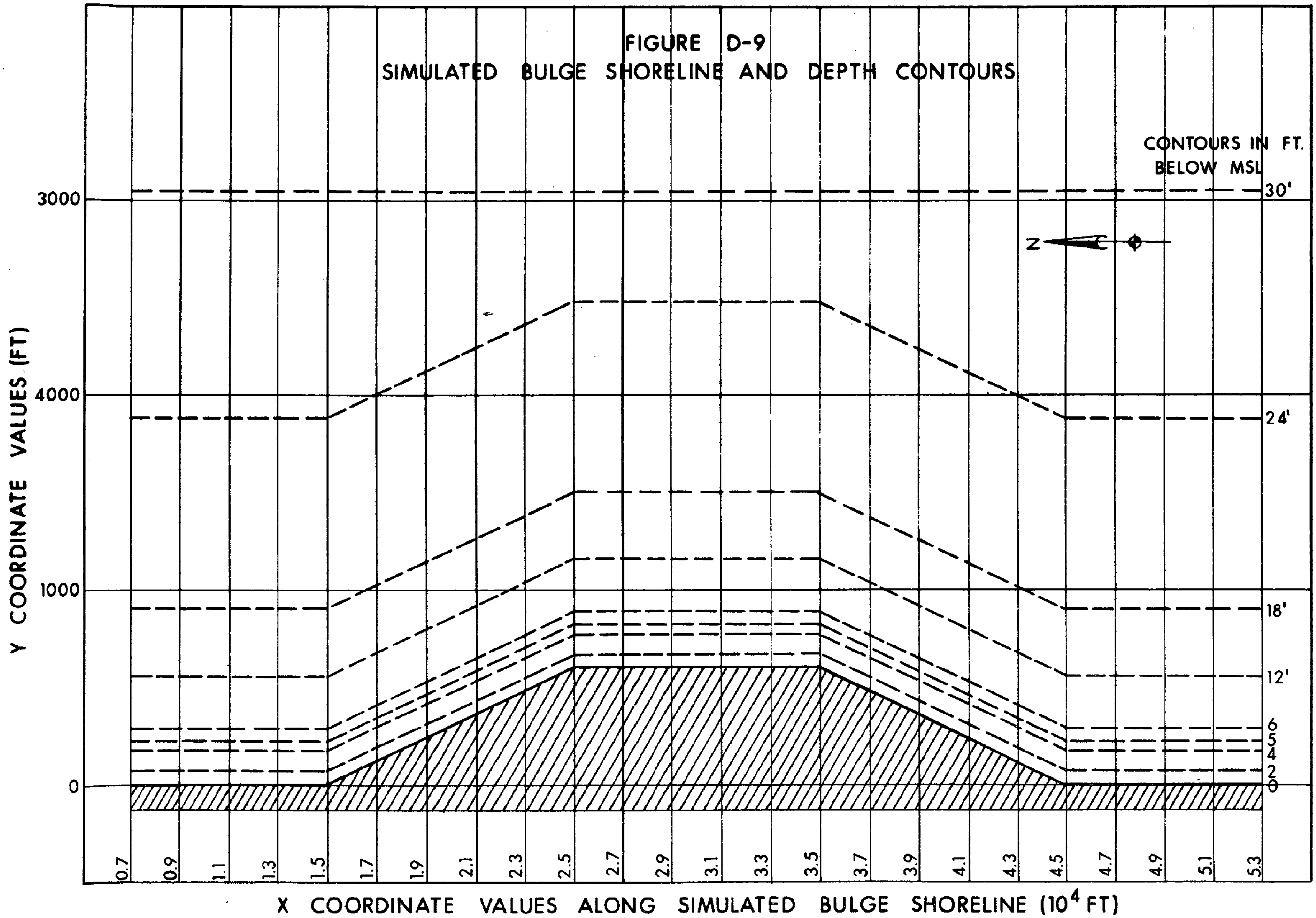
Longshore Sand Transport Rates - Wave Climatology. The annual rates of longshore sand transport to the north and south along Wrightsville Beach

TABLE D-7

Average Distance Between Depth Contours
Wrightsville Beach

Contour Interval (ft, m.s.l.)	Distance Between Contours (ft)	Cumulative Distance Betwn Controus (ft)
0-2	75	75
2-4	100	175
4-5	50	225
5-6	90	315
6-12	250	565
12-18	335	900
18-24	980	1,880
24-30	1,170	3,050

FIGURE D-9
SIMULATED BULGE SHORELINE AND DEPTH CONTOURS



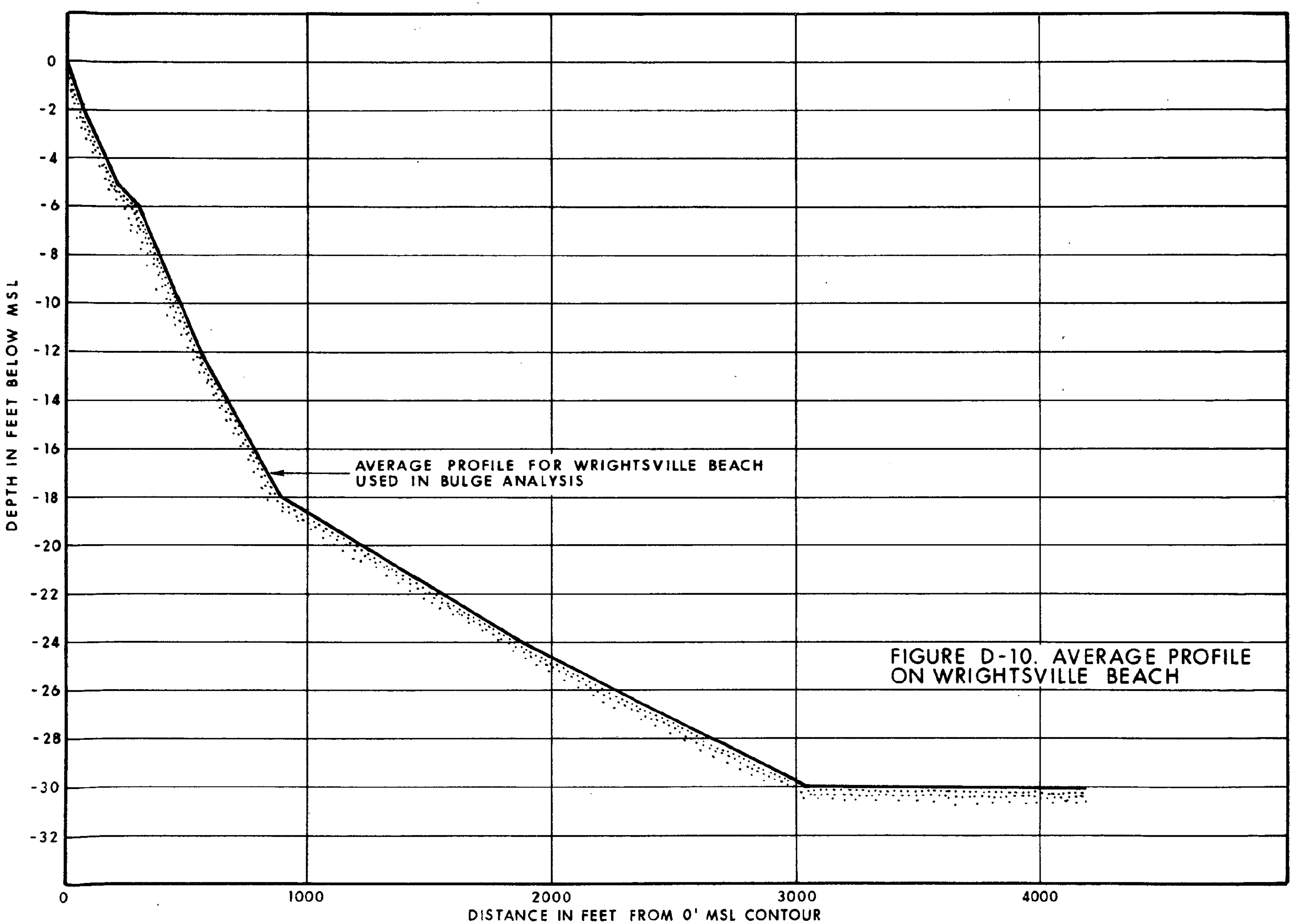


FIGURE D-10. AVERAGE PROFILE ON WRIGHTSVILLE BEACH were determined in reference (1). Since the computed rates varied along the Wrightsville Beach and Shell Island shorelines, the annual longshore transport rates to the north and south used in this study were averages of the rates computed between Masonboro Inlet and Masons Inlet. These rates are:

769,000	cu. yd./yr. to the south (70.2% of the gross drift)
326,000	cu. yd./yr. to the north (29.8% of the gross drift)
1,095,000	cu. yd./yr. gross drift

The gross annual longshore drift rate of 1,095,000 cu. yd./yr. was prorated to the months of the year based on the percentage of annual wave energy occurring in a given month. The monthly percentage of the annual wave energy was determined from recorded wave gage records collected at Johnnie Mercers Pier between 1971 and 1975. The monthly percentage of the annual wave energy and the prorated gross drift rate in each month are given in table D-8.

Visual wave observations made by U.S. Coast Guard personnel from the Frying Pan Light Tower, located off Cape Fear approximately 40 miles south-southwest of the study area (see figure D-11), were used to separate the monthly gross drift into north and south components. Due to the presence of Frying Pan Shoal, which has minimum depths of between 7 and 8 feet mlw, observed wave heights at the Light greater than 6 feet out of the south and south-southwest were not included in the directional wave energy distribution since waves larger than 6 feet would break on the shoal. In addition, average breaker angles for each wave direction, determined from the results of the extensive wave refraction analysis reported in reference (1), were used to adjust the wave energy to an alongshore component.

The gross monthly sand transport rates given in table D-8 were multiplied by the percentages of wave energy from the northern quadrants determined from the Frying Pan Light data. The resulting southward transport was 66.8 percent of the gross annual longshore transport. Since this percentage of the gross drift rate was less than the 70.2 percent southward transport given above, the monthly directional drift distributions were adjusted slightly to make the annual southward drift 70.2 percent of the gross. The final monthly distribution in sand transport to the south and north are given in table D-9.

As will be discussed below, the transport of sand along the simulated bulge shoreline was based on repetitive refraction analysis using various wave periods applicable to Wrightsville Beach. The wave periods used in the analysis were 4.5, 5.5, 6.5, 7.5, 8.5, 9.5, 11.0, and 13.0 seconds. In order to perform the analysis of the effects of the bulge shoreline on Wrightsville Beach erosion rates, the north and south monthly transport volumes were proportioned between the various wave periods. To do this, a value termed the relative longshore wave energy flux (Pr) was computed for each period in each month and the amount of transport for each period assigned on the basis of its percentage of the total monthly Pr. The relative longshore wave energy flux is defined as:

TABLE D-8

Monthly Wave Energy Percentage
and Gross Littoral Drift Rate

Month	Percent Annual Wave Energy	Gross Drift (CY)
Jan	9.8	107,000
Feb	9.4	103,000
Mar	8.8	96,000
Apr	8.8	96,000
May	8.7	95,000
Jun	5.8	64,000
Jul	5.8	64,000
Aug	7.1	78,000
Sep	7.6	83,000
Oct	7.9	87,000
Nov	8.1	89,000
Dec	12.2	133,000

TABLE D-9

Monthly Percentage and Volume of Littoral Drift
to the South and North Used in Bulge Analysis

Month	Southward Drift		Northward Drift	
	%	Vol (CY)	%	Vol (CY)
Jan	80	86,000	20	21,000
Feb	75	77,000	25	26,000
Mar	70	67,000	30	29,000
Apr	65	62,000	35	34,000
May	65	62,000	35	33,000
Jun	40	26,000	60	38,000
Jul	35	22,000	65	42,000
Aug	55	43,000	45	35,000
Sep	90	75,000	10	8,000
Oct	90	78,000	10	9,000
Nov	80	71,000	20	18,000
Dec	75	100,000	25	33,000

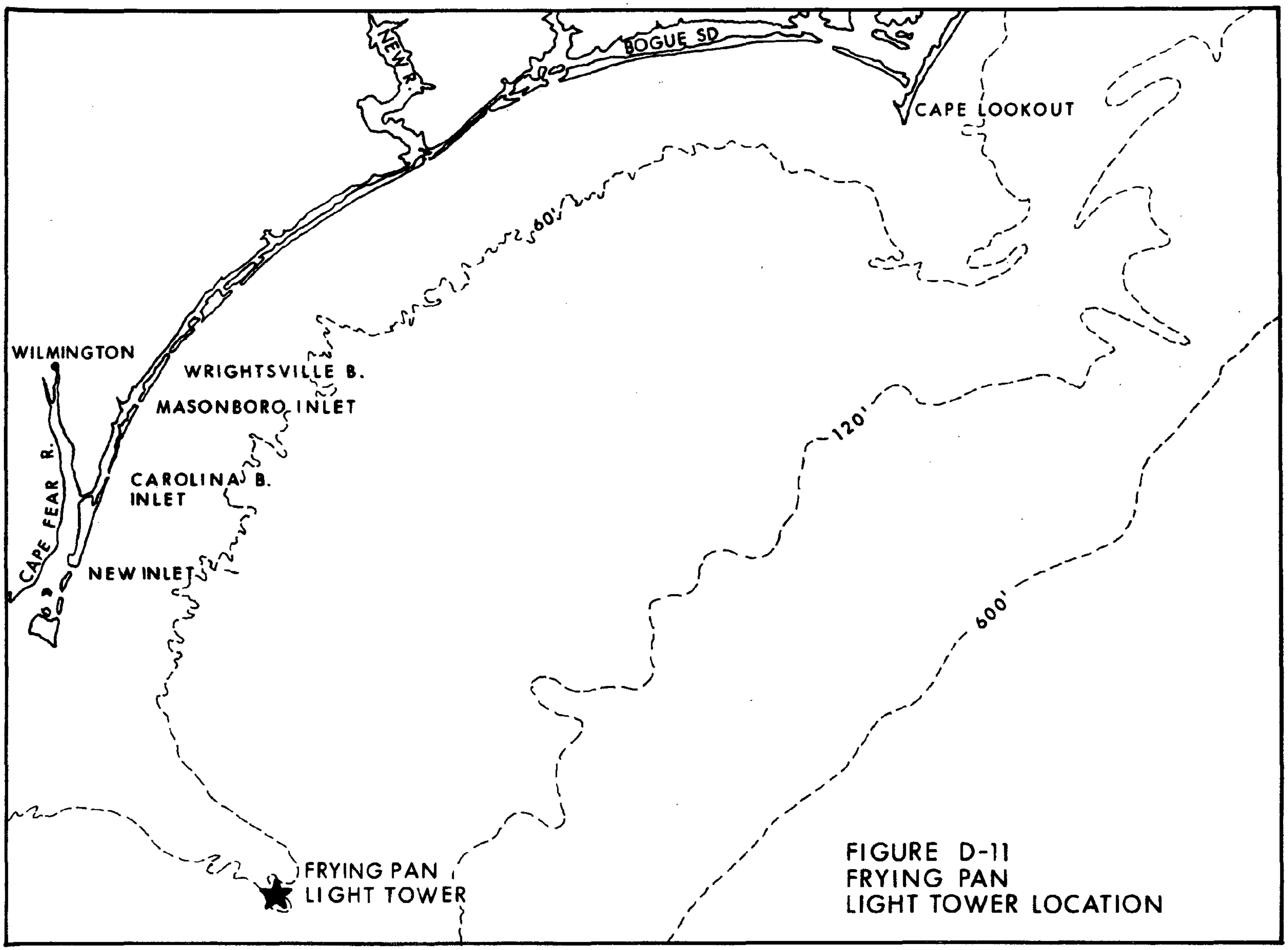


FIGURE D-11
FRYING PAN
LIGHT TOWER LOCATION

$$Pr = \Sigma\ (\%\ ObvsxH^2)_T (K_R)^2_T\ T\ \sin 2(\alpha_b)_T \qquad \text{(Eq. 1)}$$

where:

$\Sigma\ (\%ObvsxH^2)_T$ = Sum of the percentage of observations for a given wave height (H) and period (T) times the wave height squared

$(K_R)_T$ = Refraction coefficient for wave period T computed from the 30-foot depth contour to the point of breaking

T = wave period

$(\alpha_b)T$ = Average breaker angle for wave period T

Since Pr depends on the average breaker angle for each wave period, visual wave observations, made by employees of the Wilmington District from Johnnie Mercers Pier between May 1970 and December 1971, were used to develop relationships between wave period, breaker angle, and wave direction.

The visual observations of breaker angles from Johnnie Mercers Pier were made by sighting down a breaking wave crest with a hand-held compass. The wave periods and heights associated with the breaker angles were determined from the recorded wave records with supplemental data provided by visual estimates when the gage was not operating. A plot of the observed data relating breaker angle to wave period for waves from the northern and southern quadrants is shown on figure D-12. Also shown on this figure are the averages of the observed breaker angles associated with the wave periods used in this analysis. Although there is a considerable amount of scatter of the individual observations, the average breaker angles show a high degree of correlation with wave period for waves from both the north and south quadrants. Accordingly, linear regression lines were computed through the average breaker angle wave period points and resulted in the following two relationships:

waves from the north; $(\alpha_b) = 20.0 - 1.46T$ (Eq. 2)

waves from the south; $(\alpha_b) = 16.2 - 1.08T$ (Eq. 3)

Breaker angles determined from these two relationships were used in the computation of Pr.

The refraction coefficient for each wave period was determined from Snell's Law by computing the change in wave angle from the break point out to the 30-foot depth contour. Snell's Law is:

$$SIN(\alpha_{30}) = \frac{(C_{30})}{C_b} SIN(\alpha_b)$$

(Eq. 4)

where:

α_{30} = angle wave crest makes with the 30-foot depth contour
C_{30} = wave celerity in water depth of 30 feet
C_b = wave celerity at point of breaking
α_b = angle wave crest makes with the shoreline at point of breaking

From this $(K_R)_T$ is computed as:

$$(K_R)_T = \left(\frac{COS\alpha_{30}}{COS\alpha_b}\right)^{1/2} \quad \text{(Eq. 5)}$$

The longshore transport volumes associated with each period during each month computed on the basis of the above proportioning procedures are given in table D-10. In the analysis of the effects of the bulge shorline on longshore sediment transport rates, the values given in table D-10 were assumed to represent sand transport along a coast with straight and parallel bottom contours and a straight coastline (i.e. these transport values served as boundary conditions for the bulge analysis).

Numerical Simulation of Longshore Sand Transport. Longshore sediment transport is related to the longshore component of wave energy flux (P_s) by the general relationship:

where: $Q_s = \beta P\ell_s$

β = constant (Eq. 6)

$$P\ell_s = \frac{\rho g^2}{64\pi} T (Ho\ K_R)^2 SIN\ 2\alpha_b$$

in which:

ρ = mass density of seawater
g = acceleration due to gravity
T = wave period
H_o = deepwater wave height
K_R = refraction coefficient
α_b = breaker angle

Since sediment transport rates along a straight shoreline associated with a certain wave period are known (table D-10), the variation in the transport rate along the bulge shoreline for a given wave period depends on the difference in the breaker angle at a point on the bulge shoreline relative to the breaker angle on the straight shoreline and the difference in the refraction coefficient for those two shoreline conditions. This dependency is given by the following:

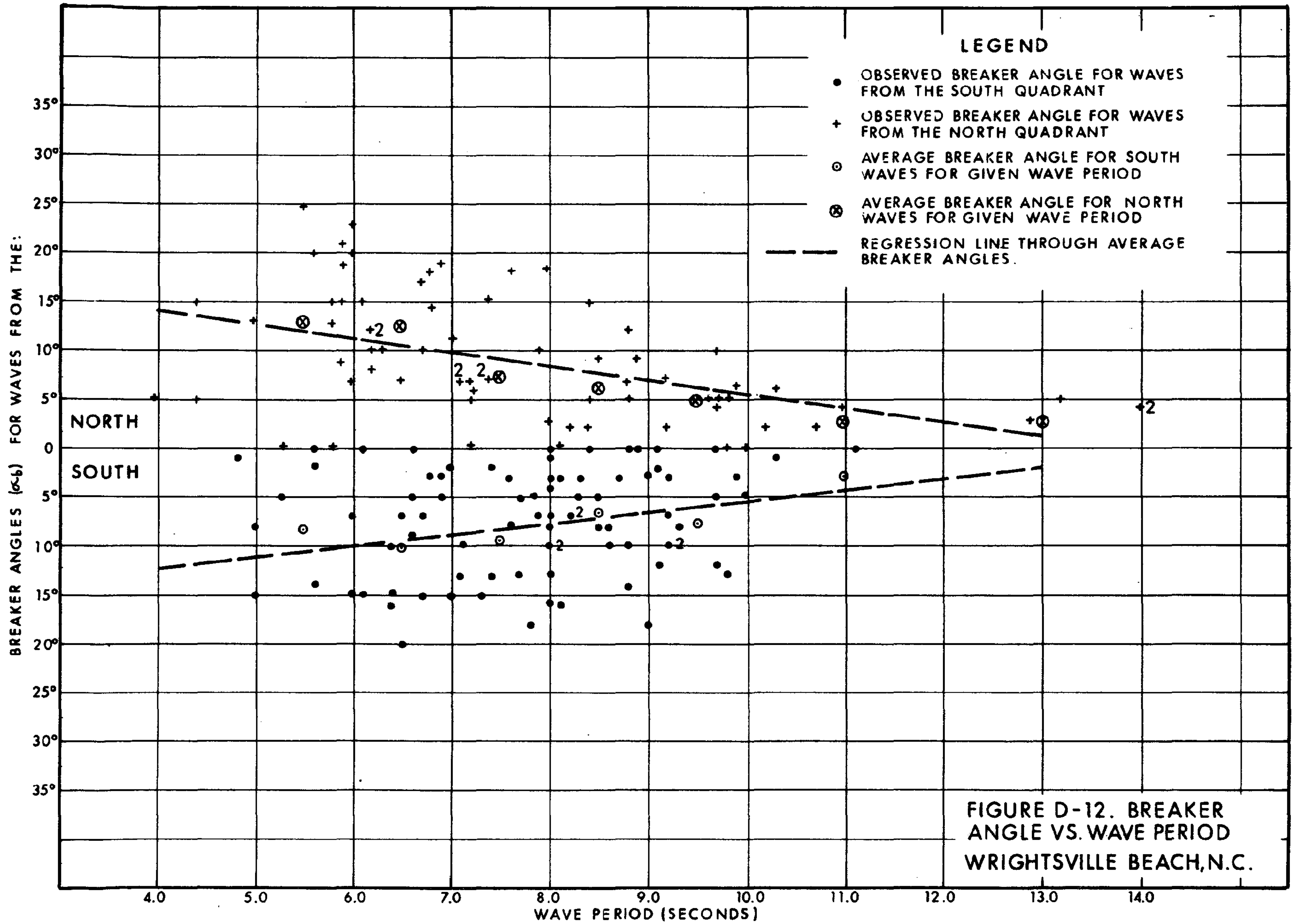


FIGURE D-12. BREAKER ANGLE VS. WAVE PERIOD WRIGHTSVILLE BEACH, N.C.

TABLE D-10

LONGSHORE TRANSPORT VOLUMES BY MONTH AND WAVE PERIOD

Period	Southward Transport (CY)	Northward Transport (CY)	Southward Transport (CY)	Northward Transport (CY)	Southward Transport (CY)	Northward Transport (CY)	Southward Transport (CY)	Northward Transport (CY)
	JAN		FEB		MAR		APR	
4.5	4,500	1,000	5,300	1,600	5,200	2,400	6,900	3,700
5.5	15,200	3,600	13,900	4,400	13,600	6,600	12,900	7,200
6.5	13,900	3,300	10,900	3,500	15,600	3,800	10,200	5,800
7.5	13,700	3,300	9,100	2,400	8,000	2,500	7,800	4,400
8.5	26,600	6,500	19,900	6,500	13,500	6,800	17,400	10,100
9.5	9,000	2,400	11,900	4,200	6,400	3,500	3,800	1,200
11.0	2,900	800	3,800	1,500	3,200	1,900	2,500	1,000
13.0	200	100	2,200	1,400	1,500	1,500	500	600
	MAY		JUN		JUL		AUG	
4.5	6,300	3,200	2,400	3,100	2,500	4,500	8,500	6,600
5.5	13,300	6,900	3,100	7,100	4,700	8,700	8,000	6,300
6.5	8,400	4,400	6,800	9,000	3,800	7,100	7,000	5,600
7.5	9,500	5,000	4,200	5,700	1,900	3,600	4,400	3,600
8.5	19,400	10,500	7,900	10,800	7,600	14,800	10,400	8,600
9.5	4,500	2,600	1,500	2,100	1,100	2,200	2,700	2,300
11.0	400	200	100	200	200	300	1,800	1,600
13.0	800	200	0	0	200	800	200	400
	SEP		OCT		NOV		DEC	
4.5	12,100	1,200	7,500	800	8,700	2,100	4,600	1,400
5.5	14,500	1,500	15,900	1,800	16,300	4,000	17,400	5,600
6.5	12,700	1,300	15,100	1,700	11,900	2,900	18,700	6,000
7.5	6,200	600	7,800	900	7,700	1,900	13,700	4,400
8.5	15,700	1,700	23,000	2,700	18,200	4,600	31,500	10,400
9.5	5,800	600	6,300	800	5,300	1,500	10,000	3,500
11.0	5,900	700	1,700	200	1,800	500	3,800	1,500
13.0	2,100	400	700	100	1,100	500	300	200

$$(q_s)_x = (q_s)_N \frac{\text{SIN } 2\ (\alpha_b)_x}{\text{SIN } 2\ (\alpha_b)_N} \left(\frac{(K_R)_x}{(K_R)_N}\right)^2 \qquad \text{(Eq. 7)}$$

where:

$(q_s)_x$ = sand transport at point x on the bulge shoreline associated with a given wave period

$(q_s)_N$ = sand transport along a straight shoreline associated with the same wave period (table D-10)

$(\alpha_b)_N$ = breaker angle on a straight shoreline for the wave period

$(\alpha_b)_x$ = breaker angle at point x on the shoreline for the same period

$(K_R)_N$ = refraction coefficient for the wave period on a straight shoreline

$(K_R)_x$ = refraction coefficient at point x on the bulge shoreline for the same period

The initial variation in the breaker angles and refraction coefficients along the bulge shoreline for the various wave conditions were computed by refracting waves across the bottom bathymetry shown on figure D-9. Wave rays for each of the eight wave periods out of both the north and south quadrants were refracted shoreward from the 30-foot depth contour to the shoreline. Examples of these refraction diagrams are shown on figures D-13 to D-16. Angles at which the wave crests approached the 30-foot depth contour were determined by first computing the average breaker angles in accordance to eqs. 2 and 3, and then refracting the waves seaward from the break point over the straight-parallel bottom contours.

With the basic information provided by the refraction analysis, the computation of shoreline and offshore bottom changes proceeded as follows:

1. The simulated bulge shoreline was divided into cells equal in width to two grid spacings on the depth grid or approximately 416 feet as shown on the definition sketch in figure D-17.

2. Breaker angles and refraction coefficients for the various wave conditions were interpolated at each upcoast and downcoast boundary of the cells.

3. The monthly sediment transport quantities associated with each wave period and direction were arranged in a random order. The random order of the 16 wave events is shown in table D-11. This random order of wave input was repeated twice each month with one-half of the transport associated with a given wave condition in that month allowed to move along the simulated shoreline and the resulting shoreline changes computed before simulating the next sediment transport condition. Since there are 16 wave conditions, 32 such computations were carried out for each month resulting in a total of 384 shoreline change computations during a 1 year simulation.

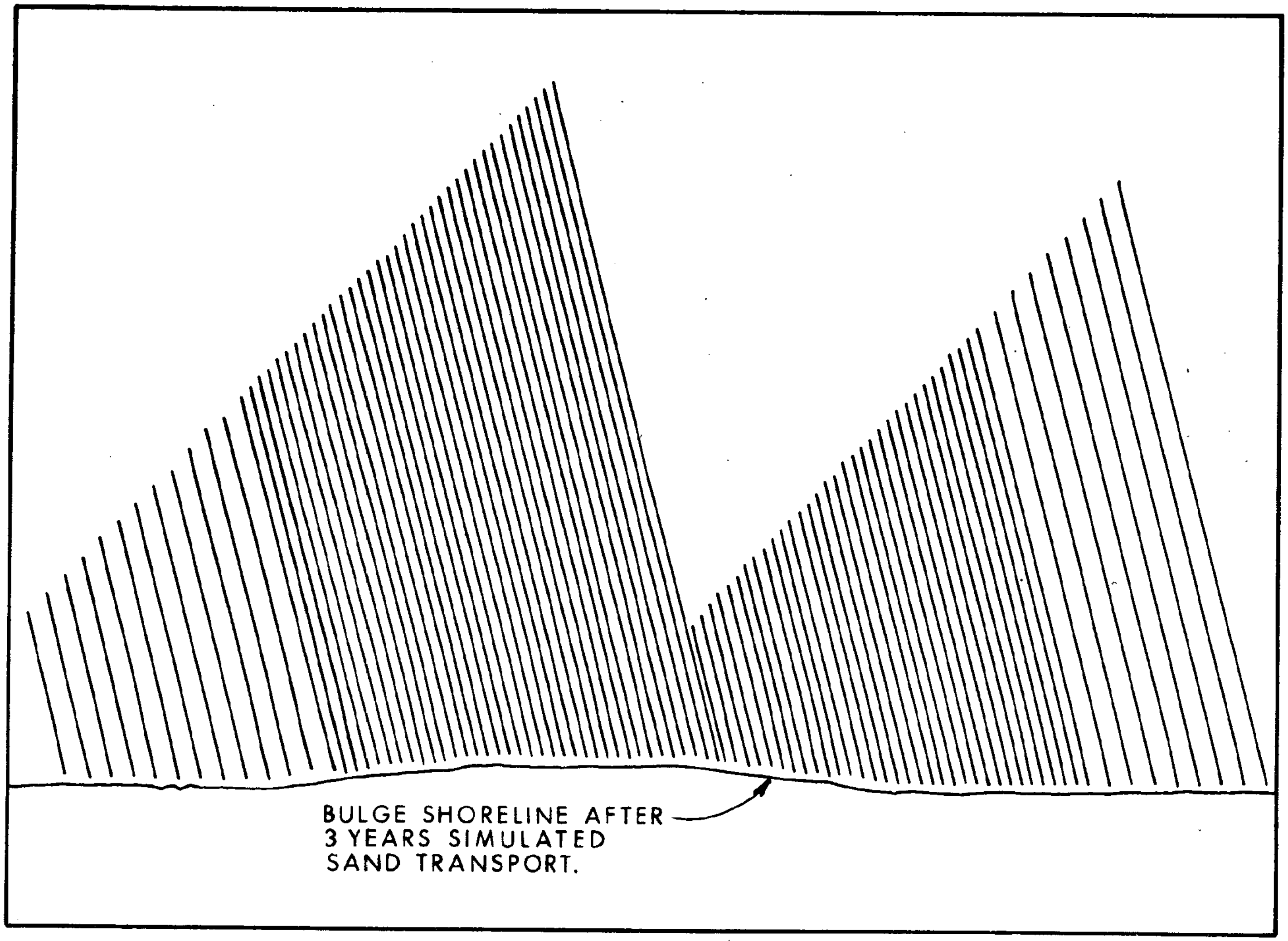


FIGURE D - 13
REFRACTION DIAGRAM
5.5 SEC. WAVE PERIOD.
WAVES FROM NORTH
QUADRANT.

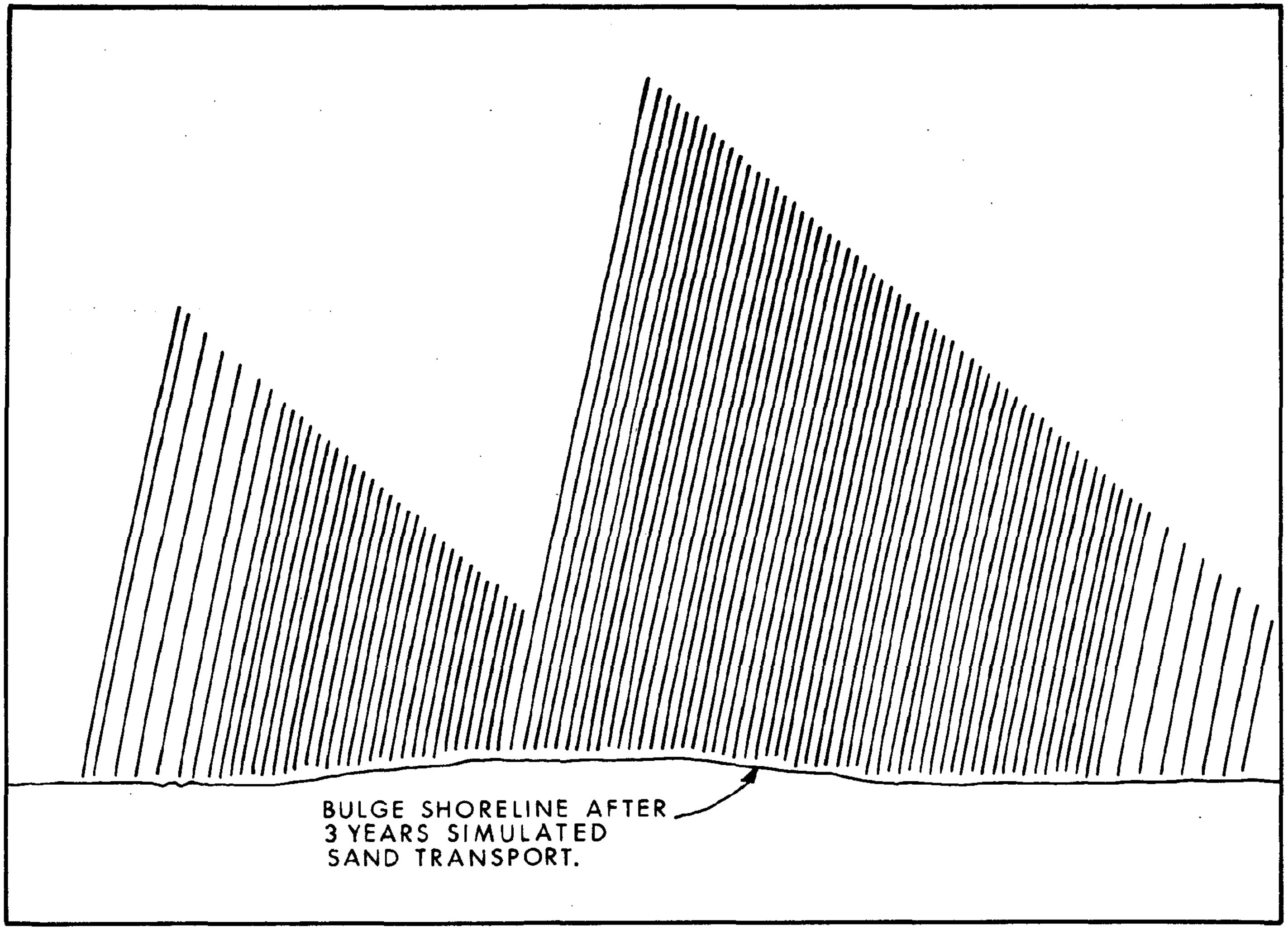


FIGURE D - 14
REFRACTION DIAGRAM
5.5 SEC. WAVE PERIOD.
WAVES FROM SOUTH
QUADRANT.

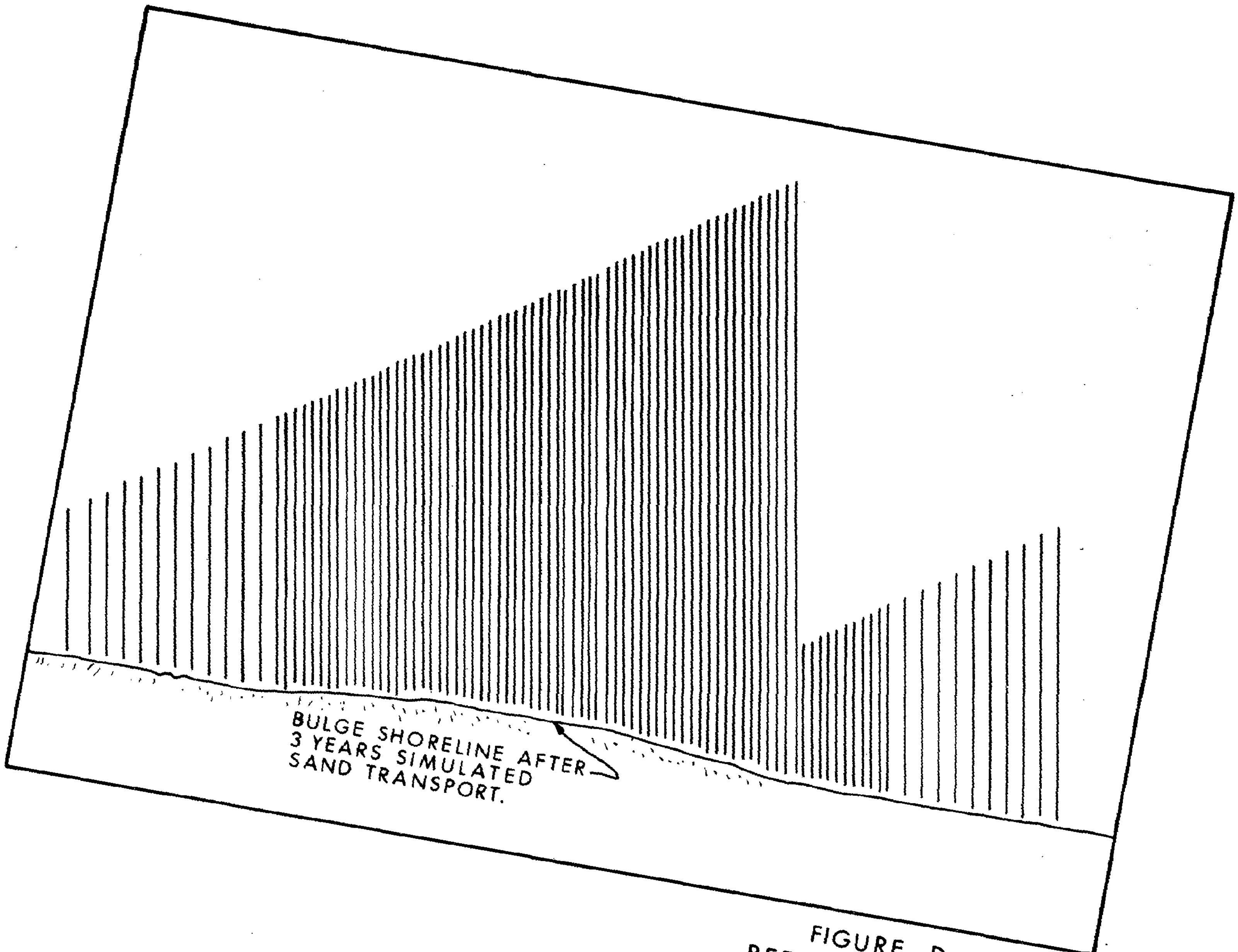


FIGURE D - 15
REFRACTION DIAGRAM
8.5 SEC. WAVE PERIOD.
WAVES FROM NORTH
QUADRANT.

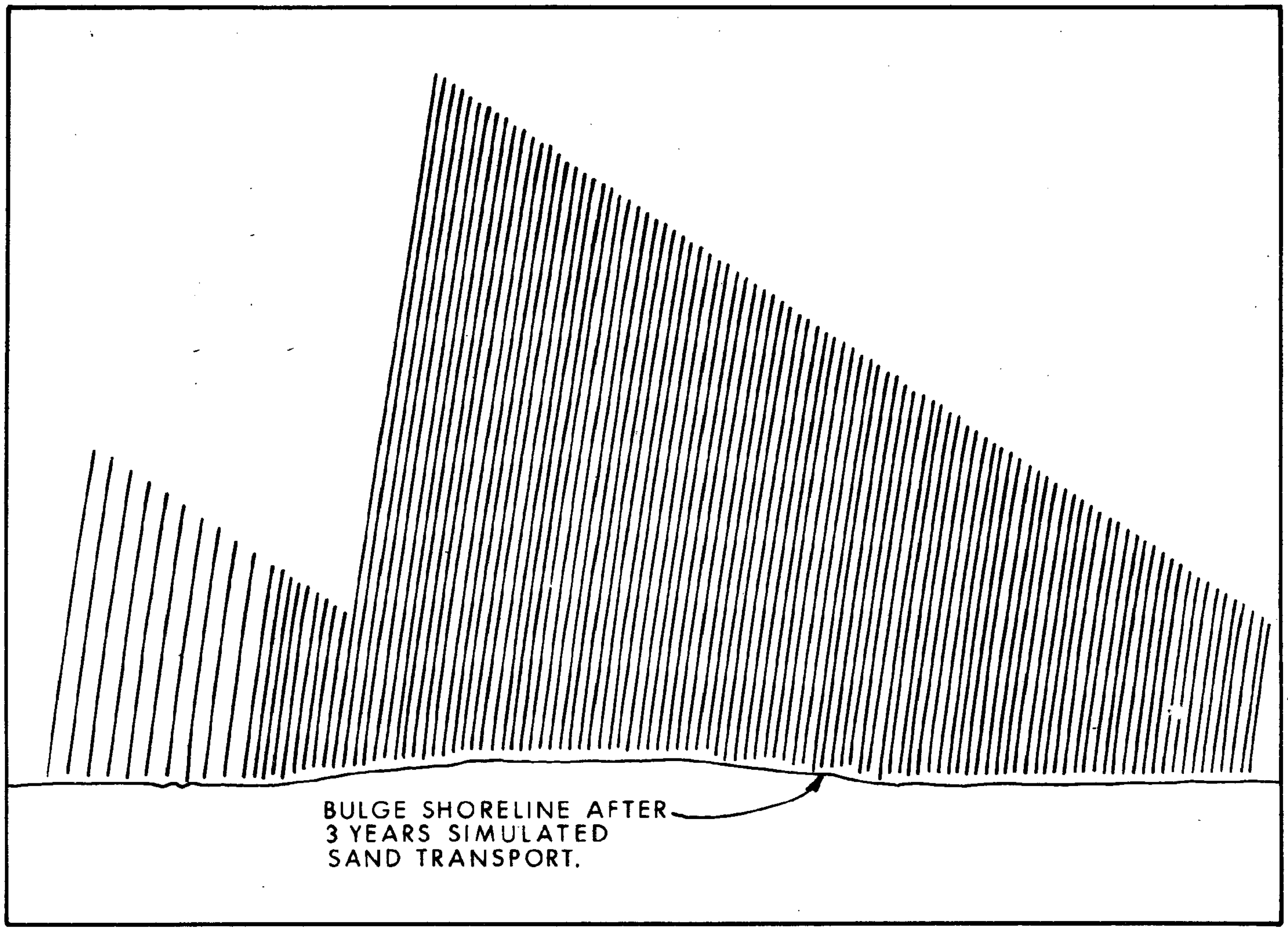


FIGURE D-16
REFRACTION DIAGRAM
8.5 SEC. WAVE PERIOD.
WAVES FROM SOUTH
QUADRANT.

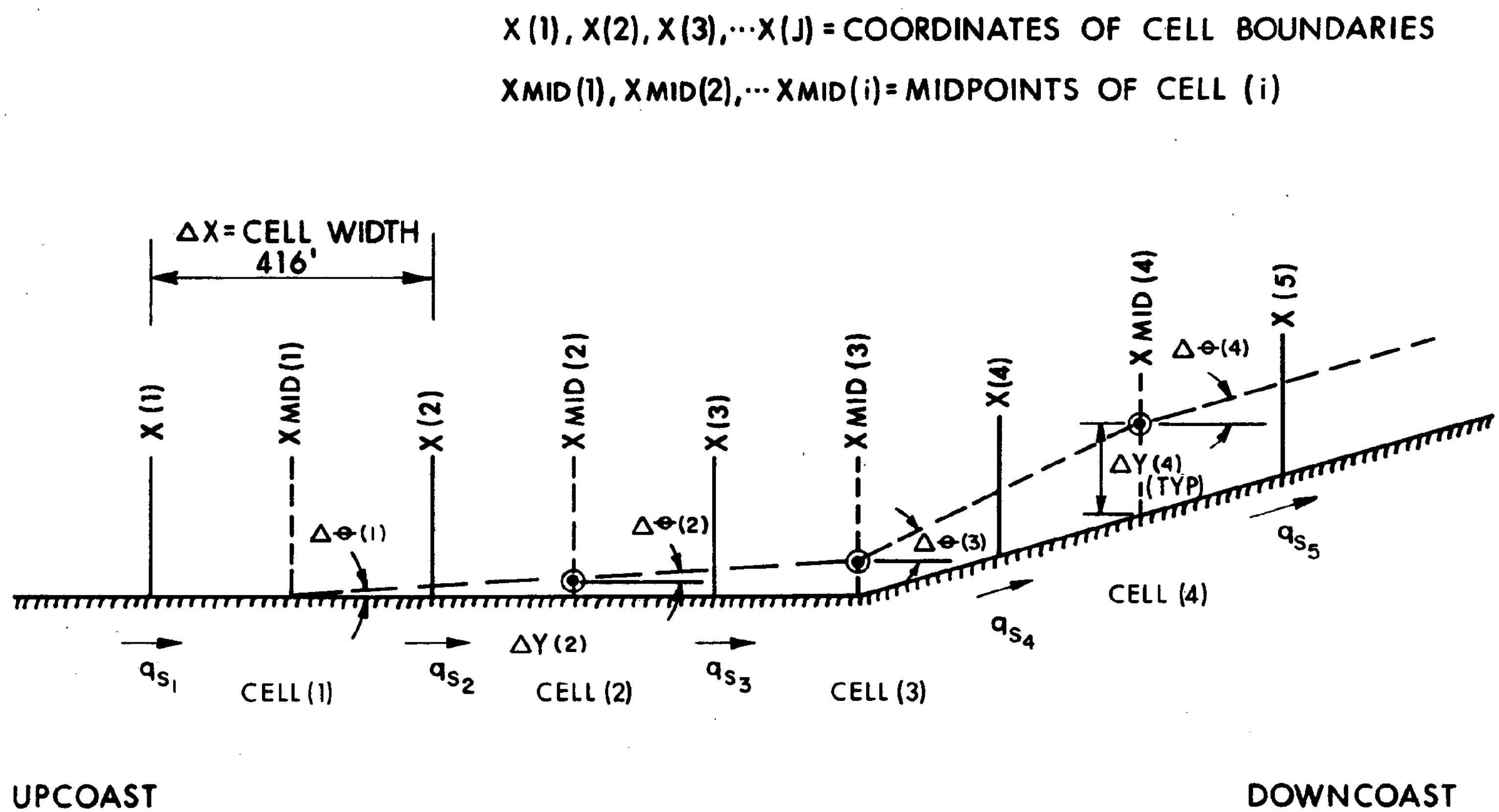


FIGURE D-17
DEFINITION SKETCH-SHORELINE
CHANGE COMPUTATIONS

TABLE D-11

Random Order of Wave Input to Bulge Analysis

Order	Wave Direction	Wave Period (sec)
1	north	11.0
2	south	13.0
3	north	8.5
4	north	5.5
5	north	7.5
6	south	7.5
7	north	13.0
8	south	4.5
9	south	8.5
10	south	5.5
11	south	11.0
12	north	6.5
13	north	4.5
14	south	9.5
15	south	6.5
16	north	9.5

4. The change in the shoreline position due to each sand transport episode was determined from the difference in the rate of sand transport at each cell boundary in accordance with the following equation:

$$\Delta Y(i) = \frac{\Delta VOL(i)}{\Delta X\ C} \qquad \text{(Eq. 8)}$$

in which:

$\Delta Y(i)$ = change in position of the shoreline at the midpoint of cell (i)

$\Delta VOL(i)$ = $(q_s(j+1))_k - (q_s(j))_k$ = difference in sand transport volume at the downdrift cell boundary (j+1) and upcoast cell boundary (j) for wave condition k(k=1 to 16)

$(q_s(j))_k$ = sediment transport at the cell boundary computed in accordance with eq. 7. Since only one refraction analysis was performed for each year's simulation, the refraction coefficient ratio in eq. 7 for a given wave condition remained the same at a given cell boundary during a year's simulation of sediment transport. Thus during the year's simulation only the breaker angle ratio changed for each sediment transport episode.

ΔX = length of the cell.

C = volumetric equivalent factor relating volume change on the profile to a linear change in the shoreline position.

5. The change in shoreline position, Y(i), applied to the midpoint of each cell results in a change in the shoreline angle across the cell boundaries (see figure D-17). This change in the shoreline angle between the midpoints of the cells is computed by:

$$\Delta\theta(i) = \mathrm{Tan}^{-1} \frac{\Delta Y(i+1) - \Delta Y(i)}{\Delta X} \qquad \text{(Eq. 9)}$$

6. This change in the shoreline angle across the cell boundary results in a new breaker angle at the cell boundary which is given by:

$$\alpha_b(j)_k = \alpha_{b0}(j) + \Delta\theta(i)$$

(Eq. 10)

where:

$\alpha_b(j)_k$ = new breaker angle at cell boundary (j) for wave condition k

$\alpha_{b0}(j)_k$ = initial breaker angle at cell boundary (j) for wave condition k computed from the wave refraction analysis, i.e., this is the breaker angle at the beginning of the 1 year simulation of sediment transport

$\Delta\theta$ (i) = change in shoreline angle between the midpoints of cell (i+1) and (i) given by eq. 9. (Note that when j=n, i=n+1)

7. Steps 4-6 are repeated for each cell until all 384 yearly transport episodes are completed. This yields the new shoreline position at each cell midpoint after 1 year.

8. Once this new shoreline position was found, an entirely new depth grid was generated by assuming that all depth contours out to -24 feet, m.s.l. remained parallel to the new shoreline. The -30-foot, m.s.l. contour was maintained 3,050 feet from the original straight shoreline throughout the analysis.

9. The wave refraction analysis, for the 16 wave conditions, was repeated using the new offshore depth grid. This resulted in a new set of initial breaker angles, $\alpha_{b0}(j)_k$, and refraction coefficients, $(K_R)_T$, which were used in the computation of shoreline changes during the second year of simulated longshore sediment transport.

10. The entire procedure was repeated until a total of 5 years of longshore transport and shoreline change had been simulated.

The above described numerical simulation of shoreline change was accomplished on the Wilmington District's Harris 120 Computer System and involved the use of seven computer programs. Table D-12 contains a list of the programs giving their file name and a general description of what each program does. Printouts of these programs can be made available upon request.

Results of Bulge Analysis. The computed theoretical rates of shoreline change along the bulge shoreline after 5 years of simulated littoral transport are shown on figure D-18(a). Figure D-18(b) shows a similar plot of the observed rates of shoreline change on Wrightsville Beach and Shell Island. The observed rates plotted on figure D-18(b) are those given in table D-2. Also plotted on figure D-18(b) is a curve of the difference between the observed rates of shoreline change and the theoretical rate computed at comparable points on the simulated bulge shoreline. As indicated by the shaded area on figure D-18(b), a large portion of the erosion that occurred within the limits of the 1970 fill, specifically from

TABLE D-12

Numerical Shoreline Change Simulation
Computer Program Listing

Program File Name	Description
1. NEWCTUR	Generates depth contours over the depth grid area based on a given shoreline position. (SAW)
2. GRDW4	Computes depth values at each X, Y grid point from the position of the depth contours generated by NEWCTUR. (SAW)
3. R1	Main wave refraction program. Computes the path of the individual wave rays over the depth grid. (CERC)
4. R2	Takes each wave ray pair and computes the value of the wave refraction coefficient and the angle the rays make the the X-axis at various points along the path of the ray pair. Input is from R1. (CERC-SAW)
5. R3	Computes the refraction coefficient and wave angle relative to the shoreline at the point of breaking of the wave. Input is from R2. (SAW)
6. SHOEVO	Data from R3 is used to compute the change in the shoreline position in accordance with the steps given in the text. (SAW)
7. SLCHG	Computes the rates of shoreline change from results of SHOEVO.

(SAW) - program written by Wilmington District
(CERC) - program written by the Coastal Engineering Research Center
(CERC-SAW) - program written by CERC and modified by SAW

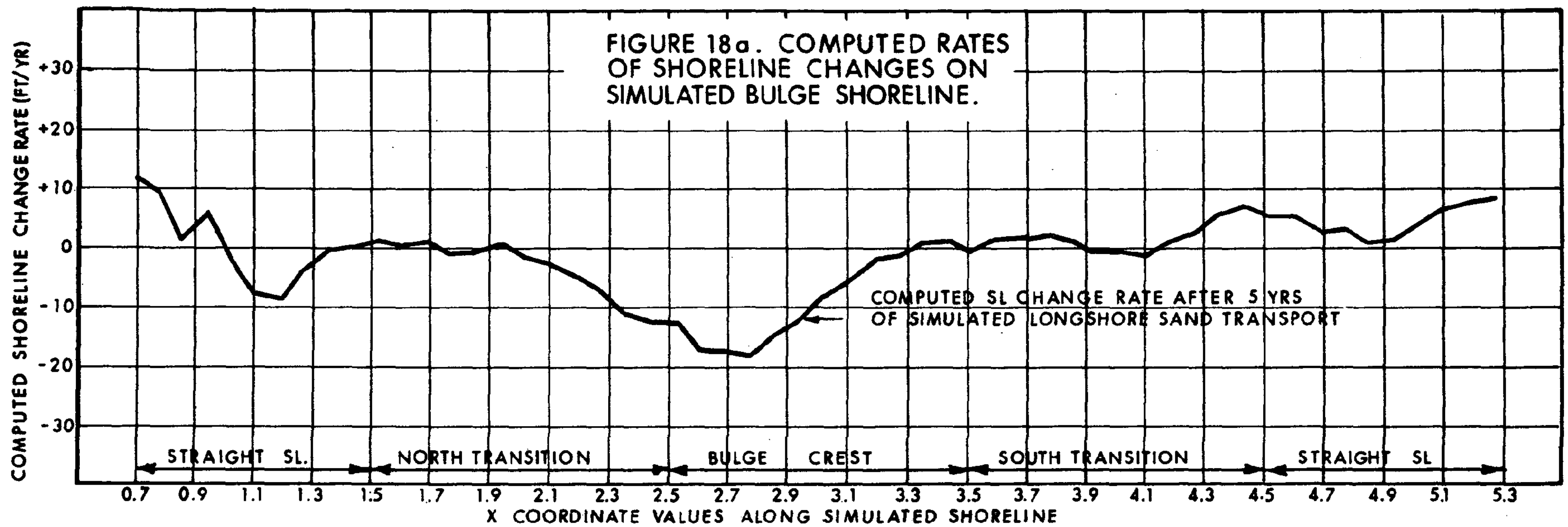


FIGURE 18a. COMPUTED RATES OF SHORELINE CHANGES ON SIMULATED BULGE SHORELINE.

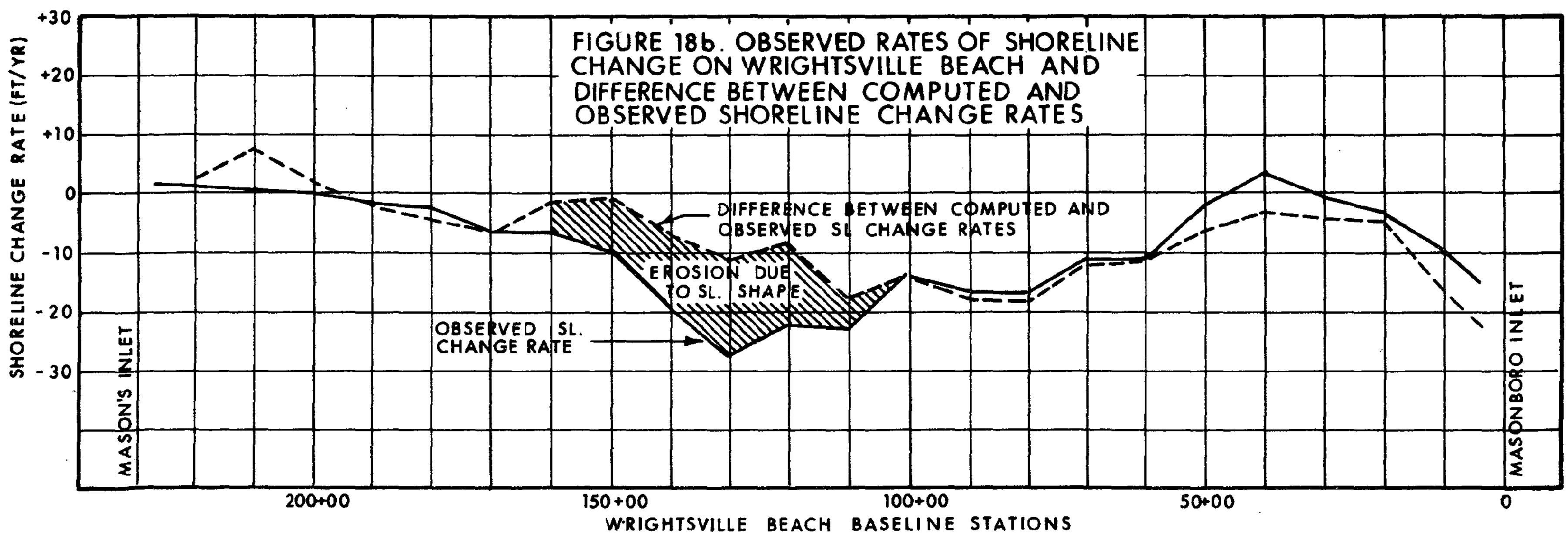


FIGURE 18b. OBSERVED RATES OF SHORELINE CHANGE ON WRIGHTSVILLE BEACH AND DIFFERENCE BETWEEN COMPUTED AND OBSERVED SHORELINE CHANGE RATES

station 100+00 to 160+00, can be explained by the effects that the bulbous shoreline has had on longshore transport along Wrightsville Beach. North and south of this particular reach the observed rates of shoreline change appear to be independent of the effects associated with the shoreline shape.

The average rate of shoreline change observed between stations 100+00 and 160+00 was -16.2 feet/yr. Over a comparable stretch of the simulated bulge shoreline, the average rate of shoreline change attributed to the bulge shoreline was -9.1 feet/yr. or 56.2 percent of the total observed rate. Within this 6,000-foot reach, the adjusted volume loss, as given in table D-5 over the 9-year period from August 1970 to July 1979 was 657,600 cu. yd. which is equivalent to an annual rate of 73,000 cu. yd./yr. Therefore, based on the theoretical bulge shoreline analysis, 56.2 percent of this volumetric loss, or 41,000 cu. yd./yr., was due to the protuberant shape of the shoreline.

Conclusions. The present estimate of the total rate of volumetric loss from the Wrightsville Beach project, adjusted for sorting and winnowing losses from the 1970 fill, is 130,000 cu. yd./yr. Of this total, 29,000 cu. yd./yr. is attributed to historical or long-term losses that were occurring before the construction of the hurricane/shore protection project and the stabilization of Masonboro Inlet. These historical losses included sediment entrapment in the inlets, storm induced erosion, and losses due to a gradual rise in sea level. In addition, the anomalous shape of the present shoreline of Wrightsville Beach, which is convex seaward rather than concave, has accelerated the natural loss from the project by 41,000 cu. yd./yr. In all, approximately 70,000 cu. yd./yr. of the erosion, or 53.8 percent, is attributed to factors other than the navigation improvements at Masonboro Inlet. Although it is not precisely clear whether or not the remaining 60,000 cu. yd./yr. loss, or 46.2 percent, is due entirely to the Masonboro Inlet navigation improvements, no other causes could be identified. Therefore, 46.2 percent of the total loss off Wrightsville Beach is assigned to the Masonboro Inlet navigation project.

Section 111 of the River and Harbor Act of 1968 (PL 90-483), requires the Federal Government to mitigate erosion caused by Federal navigation projects. In the case of Wrightsville Beach, 46.2 percent of the erosion from the beach project has been attributed to the navigation improvements at Masonboro Inlet. Therefore, this portion of any future renourishment of the beach would be paid for by Federal navigation funds. The remaining 53.8 percent of the cost required to rebuild the beach would be shared between Federal and non-Federal interest.

REVISION OF WRIGHTSVILLE BEACH SEDIMENT BUDGET

General. The current estimate of the volumetric erosion on Wrightsville Beach differs from that contained in the sediment budget presented in the Masonboro Inlet south jetty GDM (1). Also, 5 more years of survey information was available for both Masonboro Inlet and Masonboro Island compared to that used in the previous sediment budget. Therefore, the sediment budget applicable to Wrightsville Beach, Masonboro Inlet, and the north end of Masonboro Island was revised to reflect the latest information available for these areas.

Masonboro Island Volume Change. Beach profile surveys of Masonboro Island, which extended out to the -30-foot m.s.l. depth contour, were made in July 1969 and August 1979. From a comparison of these two offshore surveys, the northern 6,000 feet of Masonboro Island, which corresponds to the same area used in the GDM sediment budget, lost a total of 832,000 cu. yd. of sand, which is equivalent to an average annual rate of -83,000 cu. yd./yr. This volumetric erosion rate is down from the GDM estimate in which the loss rate was estimated to be 155,000 cu. yd./yr. The difference in the two rates can be explained in part by the difference in the quality of the survey data, in that the GDM estimate was only based on shoreline movements over a 4-year period from July 1969 to September 1973, whereas the current estimate included changes in the entire active profile over a 10-year period. Along the remainder of Masonboro Island the measured rate of volume change over the July 1969 to August 1979 survey period was -179,000 cu. yd./yr., which is also below the GDM estimate of -310,000 cu. yd./yr.

Masonboro Inlet. The revised rate of sand accumulation in Masonboro Inlet was based on survey of the ocean bar made between July 1970 and August 1980 and surveys of Banks Channel made in 1970 and 1978. The 1970 survey of Banks Channel was made following the 1970 beach renourishment in which this particular area was used as a borrow source for the fill material. The total rate of sand accumulation in the inlet complex computed from these surveys was 256,000 cu. yd./yr. of which 95,000 cu. yd./yr. was being trapped in Banks Channel and 161,000 cu. yd./yr. on the ocean bar. This total rate of sand accumulation in the inlet is also lower than the previous estimate of 435,000 cu. yd./yr. contained in the GDM. The one consistent trend between these old and new rates of volume change is that the newly computed rates are lower than the previous rates.

Revised Sediment Budget. The old sediment budget for the Wrightsville Beach -Masonboro Inlet area is shown on figure D-19(a). Figure D-19(b) is the revised sediment budget based on the new estimates of volume change. The revised sediment budget was derived from the old in the following manner:

(a) The longshore transport rates into and out of the Wrightsville Beach littoral cell were reduced by the ratio of the new rate of volumetric erosion to the old rate, i.e. 116,000/160,000 = .725.

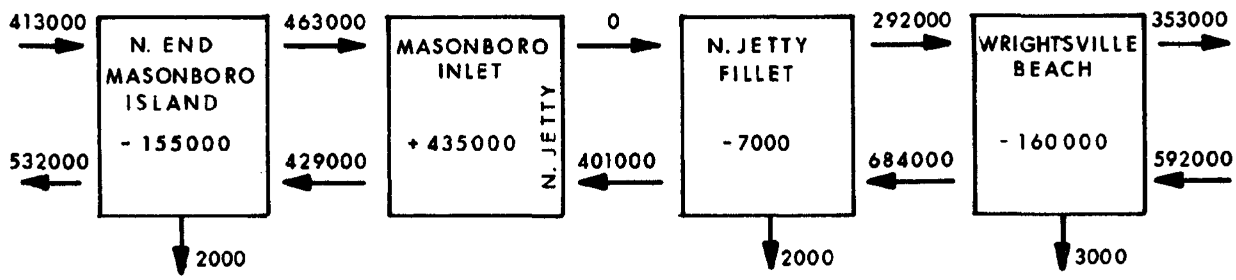


FIGURE D-19(a)
PREVIOUS SEDIMENT BUDGET (1966-1975)
WRIGHTSVILLE BEACH & VICINITY

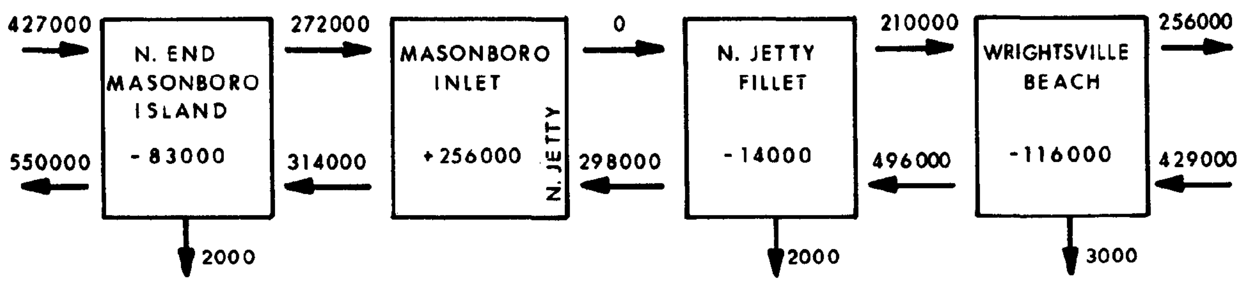


FIGURE D-19(b)
REVISED SEDIMENT BUDGET (1970 - 1980)
WRIGHTSVILLE BEACH & VICINITY

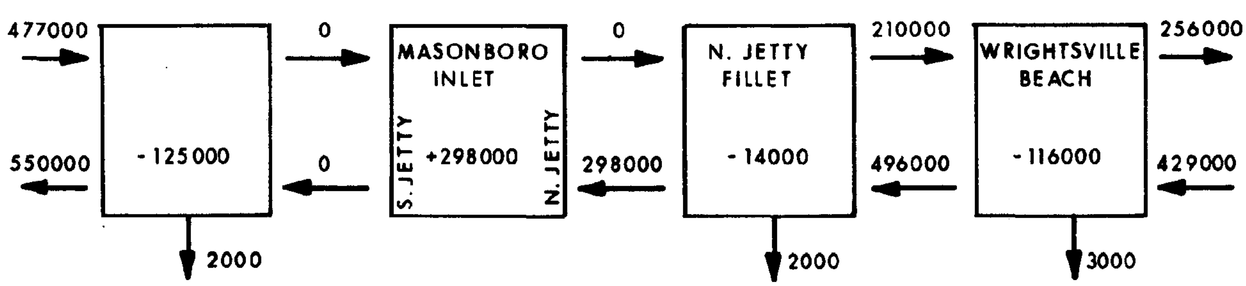


FIGURE D-19(c)
PRESENT SEDIMENT BUDGET WITH SOUTH
JETTY AT MASONBORO INLET

(b) As in the old sediment budget, natural sand movement across Masonboro Inlet to Wrightsville Beach was assumed to be zero. Based on this assumption, a total of 298,000 cu. yd./yr. must pass by the north jetty and enter Masonboro Inlet.

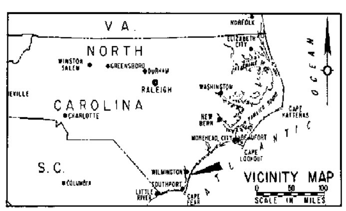
(c) Sand transport off the north end of Masonboro Island into Masonboro Inlet was reduced by the ratio of the new and old sand entrapment rates in the inlet which was 256,000/435,000 = .589. With this assumption, the natural sand bypassing from Masonboro Inlet to the north end of Masonboro Island (presouth jetty rate) was 314,000 cu. yd./yr.

(d) The relative rates of sand transport at the south boundary of the north end of Masonboro Island littoral cell was assumed to stay the same as in the old budget, i.e. if the northward transport at this boundary is taken as Q_N, the southward transport would be 1.288 Q_N. The revised transport rates at this particular boundary were within 3.3 percent of the old estimate.

Now that the south jetty at Masonboro Inlet has been completed, sand transport from Masonboro Inlet to Masonboro Island, and vice versa, has been stopped. As a result, sand accumulation in Masonboro Inlet should increase to around 298,000 cu. yd./yr. whereas erosion of the north end of Masonboro Island should be 125,000 cu. yd./yr. This present sediment budget is shown on figure D-19(c).

FUTURE SOURCE OF BEACH NOURISHMENT MATERIAL FOR WRIGHTSVILLE BEACH

In the south jetty GDM (1), a sand bypassing and backpassing scheme was developed in which material trapped in the inlet each year would have been placed on Masonboro Island and Wrightsville Beach during alternate years. This particular scheme was recommended since, at the time, the erosion on both beaches which was attributed to the inlet navigation improvements appeared to be equal. Based on the present sediment budget as shown in figure D-19(c), the total rate of erosion along the north end of Masonboro Island, which is 125,000 cu. yd./yr., is still essentially equal to the 130,000 cu. yd./yr. rate of loss off Wrightsville Beach. However, only 60,000 cu. yd./yr. of the Wrightsville Beach loss is now attributed to Masonboro Inlet. In any event, the bypassing-backpassing scheme developed in (1) still appears feasible since no adverse effects would be expected on Masonboro Island as a result of placing inlet trapped material back on to Wrightsville Beach. For example, the biennial requirement for Masonboro Island would be 250,000 cu. yd. whereas the Wrightsville Beach biennial requirements would be 260,000 cu. yd. Since 298,000 cu. yd. of sand is expected to accumulate in Masonboro Inlet each year, enough of this material should be available for placement on these two beaches.



WRIGHTSVILLE BEACH, N.C. AND VICINITY (T.G.)

GENERAL MAP

SCALE IN FEET

1000 0 1000 2000 3000

U. S. ARMY ENGINEER DISTRICT, WILMINGTON, N.C.

DRAWN BY
CHECKED BY

FILE NO.

PLATE D-1

APPENDIX E

REPORT BY U.S. FISH AND WILDLIFE SERVICE

United States Department of the Interior

FISH AND WILDLIFE SERVICE
PLATEAU BUILDING, ROOM A-5
50 SOUTH FRENCH BROAD AVENUE
ASHEVILLE, NORTH CAROLINA 28801

March 2, 1982

Colonel Robert K. Hughes
District Engineer
U.S. Army Corps of Engineers
P.O. Box 1890
Wilmington, North Carolina 28402

Dear Colonel Hughes:

Enclosed is the Service's Final Fish and Wildlife Coordination Act Report on the proposed Beach Erosion Control and Hurricane Protection project at Wrightsville Beach. Letters of concurrence from the North Carolina Wildlife Resources Commission and the North Carolina Office of Coastal Management and your letter reviewing the draft version of the report are contained in Appendix E of the report.

The Service appreciates the opportunity to provide this final report to you and your staff.

Sincerely,

William C. Hickling
Area Manager

Enclosure

cc:
Mr. Randy Cheek, National Marine Fisheries Service, Environmental Assessment Branch, Piver's Island, P.O. Box 570, Beaufort, NC 28516
Environmental Protection Agency - Region IV, 345 Courtland Street, N.E., Atlanta, GA 30308
Mr. Preston P. Pate, Jr., Office of Coastal Management, P.O. Box 769, Morehead City, NC 28557
Mr. Rich Carpenter, Division of Marine Fisheries, 7725 Wrightsville Avenue, Wilmington, North Carolina 28403
Mr. Frank Reilly, Department of Surgery, Trace Elements Lab, East Carolina University, Greenville, NC 27834
FWS, Washington, DC (ES--Attention Mr. Don Dobel, Branch Chief, Branch of Federal Projects)
Raleigh ES

UNITED STATES DEPARTMENT OF THE INTERIOR
U.S. FISH AND WILDLIFE SERVICE

FINAL FISH AND WILDLIFE COORDINATION ACT REPORT
WRIGHTSVILLE BEACH EROSION CONTROL AND HURRICANE PROTECTION STUDY
WRIGHTSVILLE BEACH, NORTH CAROLINA

Prepared by:
Ecological Services Division
U.S. Fish and Wildlife Service
Raleigh, North Carolina

Planning Agency: U.S. Army Corps of Engineers, Wilmington District

TABLE OF CONTENTS

INTRODUCTION

The following report addresses the Wrightsville Beach Erosion Control and Hurricane Protection Study being conducted by the Wilmington District Corps of Engineers. On December 2, 1970, the Committee on Public Works of the U.S. House of Representatives adopted a resolution requesting the Secretary of the Army to direct the Chief of Engineers to conduct a survey of Wrightsville Beach in New Hanover County, North Carolina including the adjacent beaches, oceanic and lagoonal shores and interconnected tidal channels. The survey was authorized in the interest of formulating measures for beach erosion control, hurricane protection and related purposes. The U.S. Army Corps of Engineers, Wilmington District, conducted a survey in accordance with that resolution which identified the principal problems at Wrightsville beach as: 1) potential hurricane flood damage as a consequence of low elevation; and 2) loss of land and structures as a consequence of erosion of estuarine and oceanic shorelines. In addition to evaluating the feasibility of reducing and/or controlling the principal problems, Corps planning objectives as stated in the Stage I report (U.S. Army Corps of Engineers 1978) were to:

*Develop basic data and guidelines for protecting and enhancing the environmental and esthetic quality of undeveloped sections of estuarine and barrier beach islands and adjacent waters.

*Develop and evaluate basic data and guidelines to assist in producing a rational program of land use for undeveloped Shell Island area.

*Develop guidelines for providing additional parking facilities to reduce traffic congestion and assist in improving public utilization of existing beach area.

Structural and non-structural measures to address the stated objectives were presented for consideration in the Stage I report (U.S. Army Corps of Engineers 1978). Alternative plans for alleviating the principal problems are presented and evaluated in the Corps' Stage II report (U.S. Army Corps of Engineers 1981).

This report is submitted under authority of Section 2 (b) of the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661 et seq.) and should be incorporated as an integral part of the Corps' Stage III report. This report was prepared in cooperation with the N.C. Department of Natural Resources and Community Development-Division of Marine Fisheries (DMF), the N.C. Wildlife Resources Commission (WRC), the National Marine Fisheries Service (NMFS), and the N.C. Office of Coastal Management (OCM) and the U.S. Environmental Protection Agency (EPA).

In addition to fulfilling our responsibility under the Fish and Wildlife Coordination Act, this document also serves to fulfill the Service's responsibility to provide comments to other Federal agencies regarding: 1) environmental impacts of projects wherein we have special expertise or jurisdiction by law (National Environmental Policy Act; 42 U.S.C. 4332 (c) (v)); 2) endangered or threatened species (Endangered Species Act of 1973, as amended, 16 U.S.C. 1536); 3) floodplains (Executive Order 11988, Floodplain Management, May 24, 1977); and 4) wetlands (Executive Order 11990, Protection of Wetlands, May 24, 1977).

The objectives of this report are to:

*Provide a brief description of the existing conditions at Wrightsville Beach.

*Summarize previous efforts in regard to controlling beach erosion and preventing hurricane damage at Wrightsville Beach;

*Describe the aquatic and wildlife resources present at Wrightsville Beach and in the vicinity;

*Summarize the alternatives considered for solving existing problems at Wrightsville Beach;

*Assess the impacts of each alternative upon aquatic and wildlife resources at and in the vicinity of Wrightsville Beach; and

*Make recommendations as to which alternative(s) would be most desirable from an environmental quality standpoint.

Previous reports were provided by the Service to the Corps for the present study and for a previous study concerning Wrightsville Beach. A survey report was provided February 26, 1960 in regard to proposed hurricane-tidal flood protection at Wrightsville Beach. Subsequent to that report, the Service provided a report to aid in the Corps' Stage II planning (U.S. Fish and Wildlife Service 1979) and a supplementary report dated March 18, 1981 (U.S. Fish and Wildlife Service 1981) as a consequence of the present Corps study.

DESCRIPTION OF THE AREA

General Description

The town of Wrightsville Beach is located on two islands, an estuarine island known as Harbor Island and the barrier island of Wrightsville Beach in New Hanover County, North Carolina about 25 miles northeast of Cape Fear and eight miles east of Wilmington, N.C. (Figure 1). A second barrier island, Shell Island, is now part of Wrightsville Beach Island as a result of the filling of Moore Inlet by the Corps in 1965 (U.S. Army Corps of Engineers 1978).

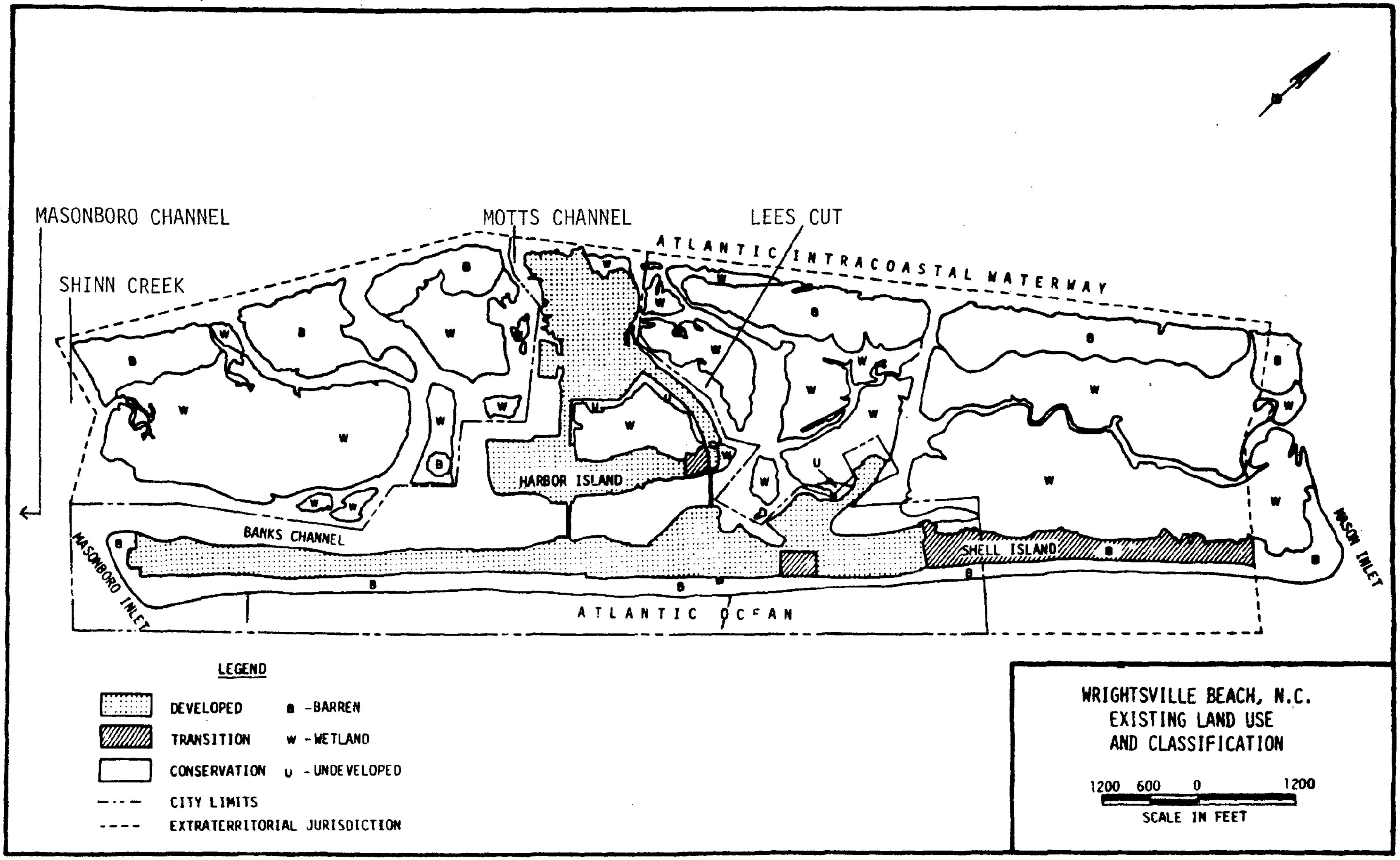


Figure 1. Wrightsville Beach, North Carolina and vicinity, indicating land use and classification in 1978 (U.S. Army Corps of Engineers, 1978). Present land use is essentially the same.

The island of Wrightsville Beach is oriented northeast-southwest and is bounded on the northeast by Mason Inlet, on the east by the Atlantic Ocean, on the southwest by Masonboro Inlet, and on the west by the Atlantic Intracoastal Waterway (AIWW). Access to Harbor Island and Wrightsville Beach is provided by US Highways 74 and 76.

The Wrightsville Beach-Shell Island complex is approximately 4.8 miles in length and its high ground area is only 0.25 mile wide at its widest point (Figure 1). There are approximately 4.5 miles of oceanic shoreline (U.S. Army Corps of Engineers 1981), and 3.2 miles are within the corporate limits of the town of Wrightsville Beach. Harbor Island's shoreline is entirely estuarine and encompasses 3.5 miles. There are an additional 3.0 miles of estuarine shoreline on the barrier island located within the Wrightsville Beach corporate limits.

Harbor Island has a total area of 293 acres. About 171 acres of the island are developed. The remaining acreage consists primarily of an expanse of salt marsh, tidal creeks and tidal flats located between US 74 and 76 in the central portion of the island. An additional undeveloped marsh and tidal creek area lies north of US 74-76 along the AIWW.

High ground areas with elevations in excess of five feet above mean sea level occupy approximately 477 acres on the Wrightsville Beach-Shell Island complex. The developed portions of the complex occupy 354 acres. An additional 123 acres located immediately north of the developed tract is presently undeveloped. Associated with the barrier island complex is an extensive area of salt marsh, intertwining tidal creeks and dredge spoil islands, located to the northeast and southwest of Harbor Island along the AIWW (Figure 1). The marsh and associated tidal creeks occupy approximately 1872 acres. There are approximately 179 acres of dredge spoil islands where elevations exceed 5 feet above mean sea level. Table 1 presents total acreages and acreages by landform and land-use classification for the project area.

The usual oceanic tidal range at Wrightsville Beach is approximately 4.0 feet, with spring tides ranging to 4.7 feet. The highest tides ever recorded at Wrightsville Beach occurred during Hurricane Hazel in 1954 and attained a level of approximately 12 feet above mean sea level. Elevations on Harbor Island and Wrightsville Beach are primarily between 0-10 feet above mean sea level. Some dunes in the undeveloped northern portion of the barrier island approach an elevation of 20 feet above mean sea level (U.S. Army Corps of Engineers 1978).

Table 1. Acreages by usage and/or landform for Harbor Island and the Wrightsville Beach-Shell Island Complex.

Island	Landform/Usage	Acres[1]
Harbor Island	High Ground[2], Developed	171
	High Ground, Undeveloped	22
	Marsh, Tidal Flats, Tidal Creeks	100
	Total Area	293*
Wrightsville Beach-Shell Island	High Ground, Developed	354*
	High Ground, Undeveloped	123*
	Marsh, Tidal Flats, Tidal Creeks (NE Harbor Island)	1147
	Marsh Tidal Flats, Tidal Creeks (SW Harbor Island)	725
	High Ground, Dredge Spoil Islands (NE Harbor Island)	105
	High Ground, Dredge Spoil Islands (SW Harbor Island)	74
	Total Area	2528

1*Acreages are approximate as determined by polar planimeter except for values followed by an asterisk which were cited in U.S. Army Corps of Engineers (1978; 1981).

2High ground is defined as any area greater than five feet above mean sea level in elevation.

Vegetation remaining on the undeveloped portions of Harbor Island and Wrightsville Beach is typical of that found on other barrier islands in the dune and shrub thicket communities. Upland areas on Harbor Island are almost completely developed with little natural vegetation remaining, but some shrub thicket exists bordering the remaining expanse of marsh.

The undeveloped northern portion of Wrightsville Beach contains an extensive dune community dominated by grasses with occasional shrubs interspersed. Principal species include sea oats (*Uniola paniculata*), spike grass (*Uniola laxa*), saltmeadow cordgrass (*Spartina patens*), broomsedge (*Andropogon virginicus*) and sea elder (*Iva imbricata*). Interspersed among the grasses, particularly in the swales between the dune ridges, are yucca (*Yucca filamentosa*), blanket flower (*Gaillardia pulchella*), prickley pear (*Opuntia* sp.), sea rocket (*Cakile edentula*) and sea lavender (*Limonium carolinianum*). The transition zone between the dune community and the extensive salt marshes to the west is dominated by saltmeadow cordgrass with interspersed patches of saltgrass (*Distichlis spicata*), glasswort (*Salicornia* sp.), scattered sea ox-eye (*Borrichia frutescens*), and silverling (*Baccharis halimifolia*). The marshes are composed of smooth cordgrass (*Spartina alterniflora*). Dredge spoil islands located along the AIWW which have remained undisturbed for a number of years have typical maritime shrub thicket communities.

Development is present along approximately 3 miles of the 4.5 miles of oceanfront beach on the barrier island. Development began in 1899 when a trolley which provided access from the mainland was established. Presently there are 1,161 structures located within the town of Wrightsville Beach, 66 of which are commercial (U.S. Army Corps of Engineers 1981). The remaining structures are residential. Approximately 80 percent of the high ground area on Harbor Island and Wrightsville Beach is currently developed (Table 1), largely with single-family frame dwellings which serve as vacation homes.

The resident population of Wrightsville Beach is approximately 3,000 and peak summer populations may approach 25,000 if day visitors are included (U.S. Army Corps of Engineers 1981). The currently undeveloped northern end of the barrier island is owned by the Shell Island Corporation (83 acres) and the Hutaff family (approximately 40 acres). There are no known plans for development of the Hutaff tract, but the Shell Island Corporation is planning to develop their tract which is adjacent to Wrightsville Beach.

Description of the Problem

Harbor Island and the Wrightsville Beach-Shell Island complex have historically been subjected to hurricane flood damage, overwash and erosion of both oceanic and estuarine shorelines. The barrier island is also subject to property loss from inlet migration. Hurricanes which occurred between the years of 1944 and 1960 caused physical property damage of about $4,000,000 in 1960 dollars (U.S. Army Corps of Engineers 1978) and caused erosion which necessitated the placement of a total of approximately 500,000 cubic yards of sand on four separate occasions between 1955 and 1959 (U.S. Army Corps of Engineers 1981).

Historically, overwashes have occurred on the northern end of the Wrightsville Beach-Shell Island complex although none have occurred in the last 20 years since hurricane activity has been minimal. The Shell Island Corporation tract was overwashed on several occasions prior to 1938, but there is no indication that overwashes have occurred subsequent to that year. The Hutaff tract is generally lower in elevation and has been overwashed twice since 1938 (U.S. Army Corps of Engineers 1981).

Inlet migration is a likelihood only at Mason Inlet on the northern end of the barrier island. Mason Inlet is migrating south at a long-term average rate of 84 feet per year, and if that rate continues, will migrate through the Hutaff tract and encroach on the Shell Island Corporation tract within 25 years (U.S. Army Corps of Engineers 1981). The southern inlet, Masonboro Inlet, is stable by virtue of two jetties which were constructed by the Corps in 1965-66 and 1979-80 respectively.

Erosion problems have existed at Wrightsville Beach since the first attempts to build structures there. Groins were constructed in 1923, 1925 and 1939 by local interests but all were ultimately destroyed by marine borers and/or the sea (U.S. Army Corps of Engineers 1981). Federal involvement began in 1962 when Congress authorized construction of 14,000 feet of dune and berm along the Wrightsville Beach ocean shoreline. That project, completed in 1965, included the closure of Moore Inlet and nourishment of 2,800 feet of beach north of the authorized project limits (U.S. Army Corps of Engineers 1978). The project has been maintained by periodic renourishment and was essentially rebuilt in 1970 and more recently in 1981.

Plan of Development

Consideration of the Stage II Corps planning objectives led to the development of four plans, several of which have options associated with them. The plans fall into essentially two categories: plan 4, which would reduce or eliminate inundation damages, is a nonstructural measure; plans 1, 2, 3 and the variations thereof are plans which would require some structural measures in conjunction with nonstructural ones. In addition, the Corps also conducted an analysis of the existing Wrightsville Beach shore protection project which may include structural measures if it is implemented.

Plan 1

Plan 1 would extend the authorized shore protection project northward by 3,000 feet to protect the developed portion of the barrier island which is adjacent to the existing project.

Plan 1 is under consideration to alleviate ocean beach erosion and to minimize hurricane damage potential immediately north of the existing project. The convex shoreline created at the junction of the existing project with the natural beach has eroded at a rapid rate and jeopardized the Holiday Inn motel and four residences to the extent that bulkheading is required to prevent undermining of the structures. Plan 1-A would require construction of a 50-foot-wide berm and 25-foot-wide dune system seaward of the present building line along that shoreline. The dune would have an elevation of +15 feet above mean low water (mlw) and the berm would be +12 mlw. The dune extension would tie in to the existing natural dune to the north. In addition, Plan 1-B would require the relocation of the building line and the oceanfront row of structures. This additional action would create a more stable shoreline configuration and would reduce erosion losses relative to Plan 1-A.

Plan 2

Plan 2 combines the features of Plans 1-A and 1-B with the requirement that any future development within the Shell Island portion of the barrier island be landward of a proposed building line which follows the landward edge of the existing primary dune ridge. This additional requirement would insure a high level of natural shore protection for any future development.

Plan 2 is under consideration to insure that subsequent development employs existing natural shore protection and alleviates the need for future extension of the existing shore project.

Plan 3

Plan 3 combines the provisions of Plans 1-A and 1-B with a proposal that the undeveloped northern portion of the island be acquired for preservation of its environmental and aesthetic value. Plan 3-A calls for managing the area for recreational uses rather than for preservation.

Plan 3 was considered largely in response to Executive Order No. 11988 relative to floodplain management and expressions of concern by local citizens over the possible development of the only remaining undeveloped section of barrier island within the study area.

Plan 4

Plan 4 is an entirely nonstructural plan which would employ a variety of measures to reduce or eliminate damage to structures within the study area. Such measures would include elevating the structures on pilings, constructing small floodwalls, and relocating buildings out of the flood hazard zone.

This plan was included for consideration as a means of providing protection, against damages accompanying up to a 100-year flood, for every structure within Wrightsville Beach.

Evaluation of Existing Shore Protection Project

Because authority for further Federal contributions toward nourishment of Wrightsville Beach expired in April, 1981 and nourishment for projects funded subsequent to 1975 has been authorized for the full 50 years of project life, this evaluation was added as an additional Corps Stage II study objective. The Corps has identified three areas for consideration:

(1) Study Area Shore Processes - Specifically, a determination of the present erosion rate at Wrightsville Beach and the relative magnitudes of the factors which contribute to the erosion problem.

(2) Economic feasibility of continued beach nourishment for the remaining 40 years of project life.

(3) Possible improvement of project cost effectiveness through use of shoreline stabilization structures. These would reduce the annual quantity of beach nourishment required to maintain the authorized level of protection.

EXISTING RESOURCES

Aquatic Resources

Commercial and recreational fishery resources at Wrightsville Beach are of primary importance from an economic standpoint to those who fish for them and to local merchants who depend on revenue generated by visiting fishermen. The highly varied and diverse marine invertebrate fauna of Banks Channel and surrounding area waters and intertidal flats also serve as an important teaching resource for nearby academic institutions (Dr. Anne McCrary, University of North Carolina at Wilmington, personal communication). The waters surrounding Wrightsville Beach constitute a third important resource since they serve as nursery areas for many species of ecological, economic and academic interest.

Commercial and Recreational Fisheries

Significant commercial and recreational fisheries exist at and in the vicinity of Wrightsville Beach. Both sport and commercial fishermen fish Mason Inlet, Masonboro Inlet, Masonboro Channel, Banks Channel and Lees Cut for common marine fish species as well as shrimp and blue crabs. Several marinas and landings on Harbor Island or in the vicinity provide access to the waters adjacent to Wrightsville Beach. Pedestrian recreational fishing occurs from two fishing piers (Figure 1), the ocean beach, the US 74 and US 76 bridges, and the banks of Banks Channel (Dixon 1978).

Lees Cut and Banks Channel are the site of much of the commercial fishery activity near Wrightsville Beach. As many as 20 commercial vessels fish the area daily during brown shrimp (Penaeus aztecus) and pink shrimp (P. duorarum) seasons. The cut is also fished commercially by gill-netters seeking weakfish (Cynoscion regalis), spot (Leiostomus xanthurus) and pigfish (Orthopristis chrysoptera) and by pot fishermen seeking blue crabs (Callinectes sapidus). Lee and Banks Channels are also important crabbing areas. An area south of the US 76 bridge is the sole site where commercial fishing for hard clams (Mercenaria mercenaria) occurs.

A survey of fishermen conducted in 1978 indicates that recreational fishing in Wrightsville Beach occurs principally from piers, in the surf and from private small craft (Dixon 1978). Masonboro Channel, Masonboro Inlet and Mason Inlet are the primary sites for sport fishing and provide excellent fishing for flounder (Paralichthys sp.), bluefish (Pomatomus saltatrix), pigfish, weakfish, croaker (Micropogonias undulatus) and spot. Fishermen surveyed indicated that they fished primarily for spot and flounder in the summer and for bluefish in the fall (Dixon 1978). The N.C. Division of Marine Fisheries trawl data indicate that Banks Channel is heavily utilized by many other species of economic importance (Table 2).

Species of commercial and recreational fishery importance contribute significantly to the economy of Wrightsville Beach and vicinity. The dockside value of commercial landings from areas adjacent to Wrightsville Beach exceeded three quarters of a million dollars in 1980 (Table 3). A survey of recreational fishermen done by Dixon (1978) indicated that an average value of approximately $270 was spent by each fisherman visiting Wrightsville Beach. No data are available which indicate the value of the recreational catch.

Table 2. Economically important finfish and crustaceans found in Banks Channel based on North Carolina Division of Marine Fisheries trawl sampling (Rich Carpenter, N.C. Division of Marine Fisheries, personal communication).

Family	Species	Common Name	Seasonality
Clupeidae	Brevoortia tyrannus	Atlantic menhaden	Spring, summer
	Opisthonema oglinum	Atlantic thread herring	Summer
Gadidae	Urophysis floridanus	Southern hake	Spring
	U. regius	Spotted hake	Spring
Serranidae	Centropristis philadelphica	Rock sea bass	Year round
	Centropristis striata	Black sea bass	Year round
	Mycteroperca microlepis	Gag	Fall, spring
Pomatomidae	Pomatomus satatrix	Bluefish	Spring, summer, fall
Carangidae	Trachinotus carolinus	Florida pompano	Summer
Lutjanidae	Lutjanus griseus	Gray snapper	Fall
	L. mahogoni	Mahogany snapper	Fall
Pomadasyidae	Orthopristis chrysoptera	Pigfish	Spring, summer, fall
Sparidae	Archosargus probatocephalus	Sheepshead	Spring, summer
	Lagodon rhomboides	Pinfish	Year round
	Stenotomus caprinus	Longspine porgy	Summer

Table 2 (cont'd).

Scianidae	*Bairdiella chrysura*	Silver perch	Year round
	Cynoscion nothus	Silver sea trout	Spring
	C. regalis	Weakfish	Spring, summer, fall
	Leiostomus xanthurus	Spot	Year round
	Micropogonias undulatus	Atlantic croaker	Year round
	Pogonias cromis	Black drum	Winter
Mugilidae	*Mugil cephalus*	Striped mullet	Winter, spring, summer
	M. curema	White mullet	Summer
Stromateidae	*Peprilus triacanthus*	Butterfish	Spring
Bothidae	*Ancylopsetta quadrocellata*	Ocellated flounder	Spring, summer
	Paralichthys albiqutta	Gulf flounder	Fall
	P. dentatus	Summer flounder	Winter
	P. lethostigma	Southern flounder	Spring, summer, fall
	Scophthalmus aquosus	Windowpane	Spring
Tetraodontidae	*Sphoeroides maculatus*	Northern puffer	Summer

Table 3. Commercial landings and dockside values of the catch from Masonboro Sound and the Atlantic Intracoastal Waterway near Wrightsville Beach, 1980 (Katie West, N.C. Division of Marine Fisheries, personal communication).

Species	Pounds		Value	
	MASONBORO SOUND (lbs.)	AIWW (lbs.)	MASONBORO SOUND ($)	AIWW ($)
Bluefish (*Pomatomus saltatrix*)	26,136	3,405	4,498	562
Atlantic croaker (*Micropogonias undulatus*)	33,542	5,456	10,505	1,756
Red drum (*Scianops ocellata*)	220	166	54	50
Flounders (*Bothidae*)	31,487	5,600	25,983	4,466
Kingfishes (*Menticirrhus* spp.)	125	-----	34	-----
Striped mullet (*Mugil Cephalus*)	32,877	12,159	8,357	3,449
Weakfish (*Cynoscion regalis*)	36,367	6,255	9,451	1,590
Spotted seatrout (*Cynoscion nebulosus*)	40	1,215	40	1,278
Spanish mackeral (*Scomberomorus maculatus*)	279	-----	140	-----
Spot (*Leiostomus xanthurus*)	49,746	17,675	14,693	5,582
Striped bass (*Morone saxatilis*)	------	250	------	250
Blue crab (*Callinectes sapidus*)	59,119	4,000	11,488	800
Shrimp (*Penaeus* spp.)	115,244	49,327	181,213	86,074

Table 3 (cont'd).

Clams (_Mercenaria mercenaria_)	72,881	17,918	276,124	70,646
Oysters (_Crassostrea virginica_)	25,291	8,668	37,307	14,359
Totals	483,361	132,104	579,887	190,862

Marine Invertebrates

Little information is available regarding invertebrate fauna inhabiting Masonboro and Mason Inlets, Shinn Creek, Motts Channel, Lees Cut and the AIWW (U.S. Fish and Wildlife Service 1979). There are viable populations of hard clams (Mercenaria mercenaria) in Masonboro and Mason Inlets and Lees Cut but harvesting is not allowed in much of the area as a consequence of pollution (N.C. Dept. Natural Resources and Comm. Devel. 1981). Hosier and Parnell (1979) reported the existence of significant assemblages of benthic organisms both in and adjacent to the AIWW north and south of the bridge to Harbor Island (sites 1-B, 2-B, 3-B, 4-B, 5-B, 7-B and 11-B; John Baden, U.S. Army Corps of Engineers, personal communication). Sites were also reported in Mason Inlet (8-B) and on the south side of Motts Channel (14-B). It is likely that all the relatively protected, higher salinity areas of Shinn Creek, Motts Channel, Lees Cut and the AIWW have diverse, abundant invertebrate benthic fauna.

Banks and Masonboro Channels are extremely rich in benthic invertebrate fauna (U.S. Fish and Wildlife Service 1979; Dr. Anne McCrary, University of North Carolina, Wilmington, personal communication). Among the invertebrates recorded from the area are a number of uncommon and/or disjunct species. Consequently, these areas are highly important collection and investigation sites for several publicly owned and supported academic institutions in North Carolina, especially UNC-Wilmington. Banks Channel and its richly diverse micro- and macro- invertebrate populations have been studied by nationally known experts in the field of marine invertebrate zoology. The area offers the advantage of being readily accessible and close to laboratory facilities. With the possible exception of estuaries located in the vicinity of Beaufort, North Carolina, no other area in the state is as ideally suited for marine and estuarine studies. Because there have been few substantial changes in the status of the marine invertebrate fauna subsequent to the Service's Stage II Planning Aid Report (U.S. Fish and Wildlife Service 1979) to the Corps, the section of that report dealing with marine invertebrate fauna is included herein by reference.

Nursery Areas

The waters surrounding Wrightsville Beach serve as nursery areas for the larval and juvenile stages of many of the economically important fish and shellfish. The perpetuation of the commercial and recreational fisheries is totally dependent upon the continued maintenance of suitable nursery habitat and sufficient water quality within the habitat. Numerous other species of ecological importance as prey items also use nursery areas adjacent to Wrightsville Beach. A list of fish which have occurred or probably do occur at Wrightsville Beach is attached as Appendix A.

The State of North Carolina has designated as primary nursery areas several expanses of salt marsh with intertwining tidal creeks adjacent to Wrightsville Beach. Those areas designated are the expanses of salt marsh and intertwining tidal creeks northwest of Shell Island and north of Shell Island Sound and the area lying between Motts Channel and Masonboro Inlet west of Wrightsville Beach.

Recent studies in the Cape Fear River estuary have shown that concentrations of larval and juvenile organisms within such salt marsh habitat far exceed concentrations in adjacent open water habitat (Hodson 1979; Weinstein 1979) and that access to such habitats is often a prerequisite for growth in several economically and ecologically important species (Hodson, Hackman and Bennet, in press; Weisburg and Lotrich 1981). A study of larval fishes near Wrightsville Beach indicates that the salt marsh habitat in the area is utilized as a nursery area by a variety of species and does contribute significantly to the perpetuation of commercial and recreational fisheries (Dr. Gil Bane, UNC-W, unpublished data).

Wildlife Resources

The beaches, dunes, maritime shrub thickets, salt marshes, intertidal flats and subtidal open water areas and associated vegetation on and near Wrightsville Beach provide habitat, food, and cover for a number of wildlife species (Table 4). Though habitat diversity is lower on Wrightsville Beach than on other North Carolina barrier islands, extensive areas of both estuarine and oceanic shoreline are present on the barrier island and its associated tidal creeks, marshes and dredge spoil islands.

An extensive, stable dune system is present on the northern end of the island. Maritime shrub thickets are present on dredge spoil islands and to some extent on Harbor Island, and extensive expanses of salt marsh lie between the barrier island and the AIWW.

Wrightsville Beach offers suitable habitat for a limited number of reptiles and amphibians. With the exception of the loggerhead sea turtle which is discussed under the Endangered Species section of this report, the only reptile documented from Wrightsville Beach is the six-lined racerunner (Cnemidophorus sexlineatus (Dr. P. Hosier, Dr. J. Parnell, Mr. D. Webster, UNC-Wilmington, personal communications). However, the black racer (Coluber constrictor), coachwhip (Masticophis flagellum), rough green snake (Opheodrys aestivus), glass lizard (Ophisaurus spp.), skink (Eumeces spp.) anole (Anolis carolinensis) and diamond back terrapin (Malaclemys terrapin) may also occur but have not been recorded from Wrightsville Beach. Many of these latter species have been recorded from Figure Eight Island to the north and Masonboro Island to the south (D. Webster, UNC-W, personal communication; Hosier and Cleary, 1977). No amphibians have been recorded from Wrightsville Beach (N.C. State Museum of Natural History, unpublished data) but toads (Bufo sp) may occur there.

Table 4. A partial list of vegetation occurring on Wrightsville Beach and its relative value to wildlife (compiled from: Martin, Zim and Nelson 1951; Pierce 1977; and Potter, Parnell and Teulings 1980).

Species	Value
Blanket flower (Gaillardia pulchella)	No data; seeds probably eaten by birds.
Broomsedge (Andropogon virginicus)	Seeds eaten by songbirds; seeds and leaves by small mammals; rootstalk by muskrats.
Cordgrass, saltmeadow (Spartina patens)	Seeds important to ducks, especially black ducks; seaside and sharptailed sparrows; shore and marsh birds; stems eaten by muskrats.
Cordgrass, smooth (Spartina alterniflora)	Seeds eaten by ducks; marsh, shore and song birds; and Virginia, sora, and black rails; used for nesting by clapper and black rails, long-billed marsh wrens and seaside sparrows.
Glasswort (Salicornia sp.)	Seed-bearing stem tips eaten by ducks in the fall.
Prickley pear (Opuntia sp.)	Birds and small mammals eat the seeds and fruit.
Salt grass (Distichlis spicata)	Used by waterfowl for nesting; seeds, young plants and roots used as food by ducks, marsh and shore birds and small mammals.
Sea elder (Iva imbricata)	Used for nesting by songbirds.
Sea lavender (Limonium carolinianum)	No data.
Sea oats (Uniola paniculata)	Seeds eaten by birds and small mammals.
Sea ox-eye (Borrichia frutescens)	Used for nesting by songbirds.
Sea rocket (Cakile edentula)	No data.
Silverling (Baccharis halimifolia)	Used for nesting by songbirds.
Spike grass (Uniola laxa)	Seeds eaten by birds and small mammals.
Yucca (Yucca filamentosa)	No data.

Numerous waterfowl, wading birds, shorebirds and songbirds use the available habitats, though no data are available specifically for Wrightsville Beach. The variety of birds which may use Wrightsville Beach is considerable based upon those using other barrier islands in the southeastern U.S. (Appendix B). Appendix C contains bird species which may occur within specific habitats on Wrightsville Beach based on those appearing in the same habitats on Bogue Banks, Smith Island and the sea-islands of South Carolina and Georgia. Birds recorded at and in the vicinity of Wilmington, North Carolina during the winter of 1979-80 (Heilbrun et al. 1980) are also included in Appendix C. Additional information on species recorded at Wrightsville Beach which have not been reported in the published literature may be obtained from Dr. James Parnell (Dr. J. Parnell, Univ. North Carolina - Wilmington, personal communication).

In addition to the large number of species listed which may use the various habitats for resting or foraging, some birds may also nest within them. Fussell (1978) records mourning doves, Carolina wrens, mockingbirds, catbirds, brown thrashers, prairie warblers, cardinals, painted buntings and rufous-sided towhees as nesting in maritime shrub thickets. Marsh nesters may include meadowlarks, red-winged black birds, boat-tailed grackles, pied-billed grebes, least bitterns, clapper rails, laughing gulls, long-billed marsh wrens, sharp-tailed sparrows and seaside sparrows. Colonial nesting seabirds may use a variety of habitats on dredge spoil islands adjacent to Wrightsville Beach (U.S. Army Corps of Engineers 1978). Least terns were nesting on the southernmost dredge spoil island adjacent to Masonboro Inlet in 1976 and 1977 (Parnell and Soots 1979).

Mammals which may occur at Wrightsville Beach or in the vicinity are presented in Table 5. It is likely that mammalian fauna on Wrightsville Beach is sparse and most comparable to that of Masonboro Island (Hosier and Cleary 1977) due to extensive development.

Endangered Species

In accordance with Section 7 (c) of the Endangered Species Act, as amended, the Corps requested a list of species that may be present within the study area. The Service's response dated June 27, 1979 indicated that the brown pelican, manatee (*Trichechus manatus*), hawksbill turtle (*Eretmochelys imbricata*), Kemp's ridley turtle (*Lepidochelys kempii*), leatherback turtle (*Dermochelys coriacea*), loggerhead turtle (*Caretta caretta*) and green turtle (*Chelonia mydas*) may be present. A biological assessment was prepared and by letter dated February 12, 1980, the Service concurred with the Corps' conclusion of no impact on the species for which we are responsible (Appendix D). However, consideration of any alternative not related to the maintenance of the existing beach erosion control project at Wrightsville Beach, listing of any new species which may be affected, or the availability of new information which indicates a listed species may be affected will require that consultation between the Corps and the Service be reinitiated.

Although a determination of no effect was made for the loggerhead sea turtle, that species does use the northern end of Wrightsville Beach for

Table 5. Mammals which may occur on or in the vicinity of Wrightsville Beach based on those occurring in similar habitat on other N.C. barrier islands (Parnell and Adams 1970; Hosier and Cleary 1977; Fussell 1978).

Common Name	Scientific Name	Bogue Banks	Masonboro Island	Smith Island
Opossum	*Didelphis marsupialis*	X		X
Least shrew	*Cryptotis parva*	?		X
Eastern mole	*Scalopus aquaticus*	X		X
Raccoon	*Procyon lotor*	X	X	X
River otter	*Lutra canadensis*	X		X
Mink	*Mustela vison*			X
Gray fox	*Urocyon cinereoargenteus*	X		X
Cotton mouse	*Peromyscus gossypinus*	X		X
Rice rat	*Oryzomys palustris*	X		X
Cotton rat	*Sigmodon hispidus*		X	X
Norway rat	*Rattus norvegicus*	X		X
House mouse	*Mus. musculus*	X	X	X
Eastern cottontail	*Sylvilagus floridanus*		X	X
Marsh rabbit	*Sylvilagus palustris*	X	X	
Atlantic bottlenose dolphin	*Tursiops truncatus*	X		X

nesting to a limited extent (Debby Crouse, N.C. Dept. of Parks and Recreation, personal communication). Since the survey conducted by the N.C. Wildlife Resources Commission (Barick and Crouse 1980) sampled only twice weekly, use of the Shell Island portion of Wrightsville Beach may have been underestimated (D. Crouse, personal communication). Any aspect of future Corps activities at Wrightsville Beach which may occur during the loggerhead turtle nesting season should be evaluated in light of the most recent nesting data available.

FUTURE CONDITIONS

Without the Proposed Action

Aquatic Resources. The future quality of aquatic resources in the vicinity of Wrightsville Beach is dependent upon management practices employed by State agencies, the amount of fishing and collecting pressure upon the resources, and the quality of nursery and nearshore habitats. Commercial and recreational fishing pressure will undoubtedly increase in the future. Overfishing could become a serious problem on a regional basis if entry into commercial fisheries is not limited and competition for the resource continues to increase. Competion and fishing pressure will increase in recreational and sports fisheries as development facilitates access to more coastal areas and increases population densities within and near Wrightsville Beach. If management decisions which regulate creel, season and size limits are not reevaluated and updated in a systematic manner, fishery resources will decline as coastal use increases. Fishing pressure on all coastal stocks could ultimately increase to such an extent that non-reproductive age individuals comprise a majority of the harvest. Such pressure upon young age classes can potentially result in complete loss of the fishery due to reproductive failure.

Habitat quality may or may not decline in the future, depending upon the regulation of future development on and in the vicinity of Wrightsville Beach. Pollution from the Wrightsville Beach Sewage Treatment Plant has already resulted in the closure of much of the adjacent area to shellfish harvesting (N.C. Department of Natural Resources and Community Development 1981) and will increase as development proceeds, contributing to further contamination of estuarine areas and potential closure of more estuarine shellfish areas. If water quality near Wrightsville Beach continues to decline as a consequence of increasing development and increased input of pollutants, the usefulness of estuarine nursery areas to juvenile fishes, shellfish and the public will decrease. The technology is presently available to reduce contamination from sewage outfalls and, if applied, could enhance future water quality and benefit fishery resources. Nearshore and estuarine fishery resources may potentially be affected by periodic events, such as oil spills, particularly if increases occur in offshore shipping traffic. This will be especially true at Wrightsville Beach if an oil refinery is ever built within the Cape Fear River estuary.

Increasing evidence suggests that, in regard to salt marsh nursery areas, habitat quantity may be as critical, or more so, than habitat quality. Turner (1977) and Hodson and Hackman (In review) present data which strongly suggest that production of penaeid shrimp, spot and mullet are directly related to the areal extent of intertidal vegetation. Any reduction of marsh acreage in or near the vicinity of Wrightsville Beach is therefore likely to cause further declines in estuarine productivity. As long as stringent regulations are in force which prevent marsh alteration or elimination, such declines should not occur.

Marine invertebrates, especially epibenthic ones which are relatively immobile, are more susceptible in many instances to overharvest and declining water quality than mobile fish and crustaceans. While fish and crustaceans can often avoid poor water quality, benthic invertebrates may be totally eliminated by declining water quality. The least change which would occur if water quality at Wrightsville Beach declines would be a decrease in diversity and a shift in numbers as pollution-tolerant species become more abundant. Because invertebrates are generally less mobile, they are more susceptible to overharvest of local populations, especially those species which have clumped distributions. Because they are at present essentially unregulated, perpetuation of their numbers is somewhat dependent upon the exercise of restraint by those using them as a resource to insure that overharvesting does not occur.

Wildlife Resources

Although there will undoubtedly be some decrease in wildlife resources at Wrightsville Beach if the northern end of the barrier island is developed, population levels of most species should remain at or near present levels or decline slightly.

Development of the northern end of Wrightsville Beach will eliminate some dune habitat presently used by the six-lined racerunner and various birds and mammals. The extent of any decrease in utility to terrestrial wildlife will be dependent upon the manner in which development occurs. Development which gives consideration to maintaining as much of the existing dune system as possible and minimizing the impact of the human population by keeping densities at reasonable levels will tend to minimize disturbance of the natural system. Wildlife can continue to coexist with man under these circumstances. If, however, high density development occurs which requires clearing of the maximum amount of habitat, resident terrestrial wildlife population levels will decline or be completely eliminated. Since the town of Wrightsville Beach exercises some control, through extraterritorial jurisdiction, over the development of the northern section, the potential exists for environmentally responsible development to occur.

Changes in population levels of wildlife, primarily birds, which use the beaches, marshes, dredge islands and waters around Wrightsville Beach should be slight. Oil spills or other periodic events could drastically reduce bird populations on beaches and in open waters if they occurred when populations were at a peak during winter. Deterioration of estuarine water quality to such an extent that prey species were eliminated could also cause declines in bird populations. Appropriate enforcement of existing legislation and regulations, however, should preclude water quality declining to such levels.

Marshes can be expected to support the same levels of wildlife which they presently support provided there is no further decrease in available habitat. Existing legislation and regulations, if enforced, should preclude further losses of marsh habitat and thereby insure their continued productivity.

Dredge islands should continue to support about the same levels of wildlife which presently exist if proper management techniques are employed. Techniques such as scheduling deposition between August and May to avoid impacts on colonial nesting seabirds, limiting island size and height, and careful placement of new material should insure optimum conditions for use of dredge islands by wildlife (U.S. Fish and Wildlife Service 1979).

While deposition of new material upon old islands may eliminate habitat for some species, it creates new habitats for others (Parnell and Soots 1975). As long as the total area of different habitat types present on dredge islands within the vicinity of Wrightsville Beach remains relatively constant, wildlife population levels should stay the same in the absence of any other changes.

With the Proposed Action

Plan 1-Aquatic Resources.

The principle impacts on fishery and marine and estuarine invertebrate resources from Plan 1 would be temporary losses in water quality associated with dredging operations and beach nourishment and short- or long-term reductions in littoral and benthic invertebrate populations. Secondary impacts would be short- or long-term disruptions to marine and estuarine food chains in the area as a consequence of reduced invertebrate populations (Reilly and Bellis 1978; Reilly, Cobb and Bellis 1980). For the purpose of discussion, we define short-term reductions and disruptions as localized, temporary decreases in population density and localized, temporary shifts in dietary habits. These are usually alleviated by recruitment of new benthos from adjacent areas as a consequence of reproduction and/or by a return to pre-project levels of water quality and substrate composition. Recovery may be complete within one to two years (Reilly et al. 1980). Long-term reductions and disruptions are defined as those impacts which impose semi-permanent decreases in population density or cause semi-permanent dietary shifts. In this specific instance, frequent (every two years) nourishment of Wrightsville Beach could result in a decrease in mole crab and coquina populations for the 50-year life of the project. From the perspective of birds and fishes with much shorter life spans than mans', such changes are essentially permanent. We choose to call such changes semi-permanent because they are reversible upon project completion. The magnitude and duration of adverse impacts, both short- or long-term, is somewhat dependent upon the scheduling of dredging and nourishment operations and the quality of material employed.

If sufficient time intervals between nourishments are provided to allow the system to recover, the likelihood of long-term impacts would be greatly reduced.

Water quality decreases due to dredging and beach nourishment usually occur as a consequence of increased turbidity and accompanying siltation. Siltation may clog the gills and/or feeding apparatus of benthic invertebrates in nearby areas not being dredged. Turbidity may reduce or temporarily eliminate larval recruitment of littoral (Reilly and Bellis 1978) and benthic fauna and may inhibit feeding of duirnally active fishes and nocturnally active decapod predators (Reilly et al. 1980). Larval stages of commercially important estuarine dependent fish and crustaceans would also be impacted by increased turbidity levels if the dredging site is located near or within migration routes and work is performed concurrent with recruitment. The degree of siltation is to some degree a consequence of the sediment composition of the material used in nourishment. Material used for previous nourishment activity at Wrightsville Beach was coarse material and produced little turbidity (Col. H. Hughes, personal communication, January 6, 1982). If such material is employed for future nourishments and nourishment activity is confined to the winter months, adverse impacts should be minimal.

Initial project construction may temporarily eliminate or reduce populations of mole crabs, coquinas, ghost crabs and other littoral and sublittoral fauna. Deposition of dredged material upon Wrightsville Beach would adversely impact fauna in localities where the material is deposited. Fauna may be killed outright or leave the affected areas (Reilly and Bellis 1978; Hayden and Dolan 1974). Such impacts should be considerably reduced if nourishment occurs during the winter months when many organisms have moved offshore to deeper waters. Biologists of the U.S. Army Corps of Engineers, Wilmington District, conducted a cursory, one-day investigation of mole crab abundance on Wrightsville Beach following nourishment in 1981 (U.S. Army Corps of Engineers, unpublished data). Although mole crabs were collected, which may imply that recovery was taking place, samples were not obtained quantitatively, therefore densities cannot be calculated to allow comparisons with densities on undisturbed beaches.

Impacts which adversely affect mole crab and coquina populations at Wrightsville Beach will have indirect effects on ghost crabs, shorebirds and surf-zone fish and decapod predators. Ghost crabs feed primarily upon mole crabs and coquinas (Wolcott 1978). If nourishment encompasses a long stretch of beach and occurs during the time when larval recruitment of mole crabs and coquinas normally occurs, prey populations could conceivably be locally eliminated or much-reduced and consequently either force a temporary dietary shift for ghost crabs or severely reduce their abundance by eliminating their principal food source. The same scenario is applicable to shorebirds and several commercially and recreationally important fishes. Shorebirds (Sandifer et al. 1980), pompano (Fields 1962), and kingfish (Bearden 1963) have been reported to prey upon mole crabs and coquinas. Reilly and Bellis (1978) reported that every fish stomach they examined contained identifiable amounts of mole crabs and/or coquinas. Species which they collected included kingfish, summer flounder, Florida pompano, Atlantic croaker, spot and crevalle jack, the majority of which are of great importance to the recreational fishery at Wrightsville Beach.

Both Plans 1A and 1B would require approximately 300,000 to 670,000 cubic yards of material initially with annual nourishment quantities of 27,600 to 46,000 cubic yards. Areas from which material is taken for beach nourishment may require from one to two years to recolonize if substrate quality is relatively unaltered. It is possible that permanent alteration of the benthic community will result even if substrate and other environmental conditions are restored. Diaz and Boesch (1978) found that preproject population composition and densities had not been re-established in borrow areas after one year. Any permanent changes could cause localized long-term changes in predator diversity because of alterations in food webs. If borrow sites are confined to inlet areas or to trap sites adjacent to the jetties at Masonboro Inlet, semi-permanent changes would probably be less likely. These areas are already inherently unstable and provide less suitable benthic habitat than sheltered areas in channels, tidal creeks and the AIWW.

Plan 1-Wildlife Resources

Impacts to wildlife resources from implementation of Plan 1 would be slight. Some decrease could be expected as a consequence of loss or deterioration of benthic prey items used by diving waterfowl and littoral infauna preyed upon by shorebirds. Additional losses would be incurred if protection of the shoreline spurred further development on Wrightsville Beach. Impacts of Plan 1 on aquatic and wildlife resources are summarized in Figure 2.

Plan 2-Aquatic Resources

Plan 2 impacts upon aquatic resources would be identical to those described for Plan 1, since it incorporates the same provisions (see Figure 2).

Plan 2-Wildlife Resources

Plan 2 would have less impact upon wildlife resources than Plan 1 since it requires that a building setback line be implemented to restrict future development on the undeveloped northern end of Wrightsville Beach. Such a requirement would insure that the dune system which presently exists would remain essentially intact, preserving its usefulness as habitat to the six-lined racerunner, birds and small mammals which live or forage there. Impacts of Plan 2 upon wildlife using littoral or open water areas would be the same as Plan 1 (see Figure 2).

Plan 3-Aquatic Resources

Plan 3 would have impacts upon aquatic resources identical to those described for Plan 1, since it incorporates the same provisions (see Figure 2).

Plan 3-Wildlife Resources

Plan 3 would have a beneficial impact upon terrestrial wildlife resources since it would effectively eliminate or highly reduce any development of

POSSIBLE AQUATIC IMPACTS PLAN	1	1A	1B	2	3	3A	4	Continue Exist. Proj.
Temporary turbidity at borrow and deposition sites	X	X	X	X	X	X		X
Temporary reduction in benthos at borrow sites	X	X	X	X	X	X		X
Semi-permanent reduction in benthos at borrow sites								X
Temporary reduction in littoral and benthic fauna at deposit site	X	X	X	X	X	X		X
Semi-permanent reduction in littoral and benthic fauna at deposit site								X
Temporary disruption in aquatic food chain	X	X	X	X	X	X		X
Semi-permanent disruption in aquatic food chain								X
Temporary inhibition of larval recruitment	X	X	X	X	X	X		X
Temporary inhibition of larval migration	X	X	X	X	X	X		X
Permanent local disruption of longshore larval transport and migration*								X
Temporary degradation of foraging habitat for benthos predators	X	X	X	X	X	X		X
Semi-permanent degradation of foraging habitat for benthos predators								X
Creation of additional intertidal habitat	X	X	X	X	X	X		X
Creation of hard, stable substrate habitat in inter-tidal zone*								X

Figure 2. Matrix of possible beneficial and detrimental impacts on aquatic and wildlife resources associated with each alternative plan of development, Wrightsville Beach, North Carolina.

POSSIBLE AQUATIC IMPACTS	PLAN	1	1A	1B	2	3	3A	4	Continue Exist. Proj.
Temporary degradation of foraging habitat for littoral predators		X	X	X	X	X	X		X
Semi-permanent degradation of foraging habitat for littoral predators									X
Preservation of dune habitat by establishing setback line				X	X	X			
Creation of additional dune habitat			X	X	X				
Preservation of additional dune habitat by extending setback line					X				
Temporary disruption of dune habitat due to groin construction*									X
Preservation of terrestrial habitat by acquisition						X	X		
Elimination of some terrestrial habitat for parking and recreational needs							X		
Upgrade terrestrial habitat by removing structures								X	
Eliminate some terrestrial habitat through location of structures upon								X	

*These impacts would only be associated with groin construction. Groin construction is not included in the Corps' recommended alternative at this time.

Figure 2 (cont'd). Matrix of possible beneficial and detrimental impacts on aquatic and wildlife resources associated with each alternative plan of development, Wrightsville Beach, North Carolina.

the presently undeveloped northern end of Wrightsville Beach. Preservation of the northern end would effectively create a sanctuary for wildlife. Plan 3A, which would acquire the northern end as a recreational area, would allow maximum development in the form of access roads, beach access points and a bathhouse. It is less desirable from a wildlife standpoint because it would require some land area for parking, access and bathhouse facilities, but it would still preserve the majority of terrestrial habitat for use by wildlife. Impacts of Plan 3 upon aquatic wildlife would be the same as those described for Plan 1 (see Figure 2).

Plan 4-Aquatic Resources.

Plan 4 would have no adverse impact upon aquatic resources.

Plan 4-Wildlife Resources.

Plan 4 might temporarily displace small mammal populations or birds associated with human dwellings, but should have no substantial impact on wildlife resources on Wrightsville Beach (see Figure 2).

Evaluation of Existing Shore Protection Project-Aquatic Resources

Continuation of the existing shore project would have essentially the same impacts on aquatic resources as described for Plan 1 (see Figure 2). The longevity of those impacts would be dependent upon the scheduling of nourishment activity at Wrightsville Beach. If nourishment is repeated every two years as a consequence of sand-bypassing operations at Masonboro Inlet, locally severe long-term impacts on littoral infauna and their intertidal and surf-zone predators could result. Benthic and littoral systems may require from one to two years to recover from the effects of dredging and beach nourishment (Reilly and Bellis 1978; U.S. Fish and Wildlife Service 1979).

If such a recovery period is necessary, benthic invertebrates in borrow areas and deposition areas at Wrightsville Beach might not have sufficient time between dredging or bypassing operations and nourishment operations to ever fully stabilize to pre-project levels. Severe local reductions or possible local elimination of littoral infauna as a consequence of relatively continual disturbance could have, in turn, a locally severe impact upon the surf and pier fisheries at Wrightsville Beach. If the principal food source of the species which comprise the fisheries is locally reduced, then declines in local catches could be anticipated, producing attendant economic losses. Some indication that such a decline in local catch could occur is given by Reilly et al. (1980) who noted a decline in utilization of a nourished beach and adjacent areas by nocturnal decapod predators. Such losses should not occur if sufficient time is allowed between nourishments for fauna to completely recover.

If groins are added to the project, additional impacts on aquatic resources will occur. Additional turbidity will occur in the nearshore zone as a consequence of construction. Benthic organisms located on the updrift side of groins will be buried if they cannot move away and scouring and filling of areas adjacent to groins will keep production low until the shoreline stabilizes. Other impacts which may occur as a result of groin construction are increased sand surface for benthic and littoral organisms, new hard substrate for the attachment of epibenthic fauna and attraction of fishes (Mulvihill, Francisco, Glad, Kaster and Wilson 1980).

Evaluation of Existing Shore Protection Project - Wildlife Resources

Continued maintenance of the existing project would have only slight impacts upon wildlife. Some decrease in utilization of the littoral habitat by shorebirds and gulls would occur as a consequence of nourishment activities. Such decreased use should be short-term in nature if littoral infauna are allowed to sufficiently recover from each nourishment effort. Any diving birds using habitat in borrow areas would also be temporarily displaced and suffer a temporary reduction in their food supply.

The impact of groin construction and maintenance on wildlife would probably be slight, although little information exists concerning biological impacts (Mulvihill et al. 1980). Some terrestrial habitat in the dunes may be temporarily disrupted as a consequence of construction activities, but there should be no long term adverse impact. Groin construction will create new habitat for resting and/or foraging for several species of gulls and for purple sandpipers.

DISCUSSION

Although the Corps has determined that Plans 1-4 are not cost efficient and will not be given further consideration at the present time, the Service would like to emphasize the benefits which would result from two of the provisions of those plans. Plan 2 calls for establishment of a setback line to regulate beach front development on the undeveloped portion of Wrightsville Beach, and Plan 3 calls for preservation of the undeveloped portion. Both options would not only insure perpetuation of wildlife resources to varying degrees, but also would insure that future storm-related damage to any development would be minimal or totally eliminated. From a fish and wildlife perspective, and from the standpoint of environmental quality, Plan 3 is the most desirable option.

The remaining possibility, that the existing shore project will be continued for a period of 40 to 50 years, will have adverse impacts upon benthic and nektonic fauna in the vicinity of borrow areas and upon littoral and nearshore fauna on Wrightsville Beach. If renourishment occurs at two-year intervals, it is possible that long-term reductions in benthic and littoral fauna could occur. Some studies indicate that benthic and littoral systems take from one to two year's time to recover from dredging and beach nourishment operations (Diaz and Boesch 1978; Reilley and Bellis 1978). It is possible that the benthic fauna in borrow areas near Wrightsville Beach and littoral fauna on Wrightsville Beach may not ever completely recover from initial nourishment operations because of the short time interval between subsequent nourishment activities. Such an impact would lessen future use of Wrightsville Beach by diving waterfowl and shorebirds because of the reduced food supply and have negative impacts upon the recreational fishery. These adverse impacts can be considerably minimized by appropriately scheduling dredging and nourishment activities to avoid seasonal biological activity and by allowing longer intervals between nourishments.

Other impacts associated with the dredging and nourishment aspects of proposed project, such as turbidity, would be short-term and have little impact upon fish and wildlife resources as long as nourishment is conducted at a time when biological activity is at a minimum.

Groins placed along Wrightsville Beach to further stabilize the system would have both short- and long-term impacts. Short-term impacts of construction would have little impact upon fish and wildlife resources. From a long-term perspective, groins substantially affect littoral drift resulting in downdrift beach erosion, scour on the lee side, and accretion of sand landward of the groins. They do provide fishing access and a hard, stable substrate for attachment by benthic epifauna and attract reef-associated fishes inshore. They may also interfere with fish spawning areas or migratory routes (Persaud and Wilkins 1976).

In general, the Service will continue to recommend against initial or periodic sand borrowing in areas we have previously defined as being productive or important estuarine study areas (U.S. Fish and Wildlife

Service 1979). These areas are Lees Cut, Banks Channel and the southwest portion of the proposed Mason Inlet borrow area.

RECOMMENDATIONS

In order to lessen the projects' impacts on fish and wildlife resources, the Service recommends the following:

1. Borrow sites shall be restricted to the immediate vicinity of Masonboro and/or Mason Inlets with materials preferably obtained from maintenance of the inlets and from Masonboro Inlet sand bypassing operations. If insufficient material is obtained from these sites, the Service encourages consideration of the following sources of additional material: unstable bottoms and tidal sand flats located along the southwest corner of Figure Eight Island; unstable bottoms and tidal sand flats located along the northern portion of the channel connecting Mason Inlet and the AIWW; unstable bottoms at the confluence of the AIWW and Mason Inlet Channel; material from AIWW maintenance dredging; material from large dredged material islands along the eastern shore of the AIWW.

2. Studies should be implemented to assess the impact of borrowing and nourishment upon benthic and littoral infauna since times for recovery of those communities have not been definitively established by previous studies. Such a study would be especially beneficial, if nourishment is proposed every two years, in order to assess the impact of frequent disturbance. Studies should also be concurrently conducted to assess the secondary impacts of nourishment upon shorebird and waterfowl use of the area, upon surf and pier recreational fisheries, and upon recreational use. The proximity of this project to Wilmington makes it suitable as a potential before, during and after study by the Corps, the U.S. Fish and Wildlife Service, the State, and/or an independent contractor.

3. Dredging and nourishment should preferably be conducted between October 1 and November 30. Studies of larval recruitment in the nearby Cape Fear River estuary clearly indicate that any project activities occurring during the months of December through March would be concurrent with the peak period of larval recruitment for spot, croaker, flounders (Bothidae) menhaden, mullets (Mugilidae), and brown shrimp (Copeland, Hodson and Monroe 1979). Dates for scheduled activity should be closely coordinated with the Office of Coastal Management and the Division of Marine Fisheries.

4. Any dune vegetation destroyed during construction shall be replanted in order to provide stabilization.

Literature Cited

Barick, F. and D. Crouse. 1980. Sea turtle nesting surveillance in North Carolina, 1980. Annual Rep. 1 October 1979-30 September 1980. N.C. Wildlife Resources Commission, Raleigh, N.C. 28 pp.

Bearden, C. M. 1963. A contribution to the biology of the king whitings, genus Menticirrhus, of South Carolina. Contrib. Bears Bluff Lab. No. 38. Wadmalaw Island, S.C. 27 pp.

Birkhead, W. S., B. J. Copeland and R. G. Hodson. 1979. Ecological monitoring in the lower Cape Fear River estuary. Report 79-1 to Carolina Power and Light Co., Raleigh, N.C. 292 pp.

Carolina Power and Light Company. 1979. Impingement studies at the Brunswick Steam Electric Plant, Southport, North Carolina, 1974-1978. Environmental Technology Section, Shearin Harris Environmental and Energy Center, New Hill, N.C. 139 pp. + appendices.

Copeland, B. J., R. G. Hodson and R. J. Monroe. 1979. Larvae and post-larvae in the Cape Fear River Estuary, N.C. during operation of the Brunswick Steam Electric Plant 1974-1978. Rep. 79-3 to Carolina Power and Light Co., Raleigh, N.C.

Diaz, R. J. and D. F. Boesch. 1978. Environmental effect of subaqueous sand fill acquisition on the benthic communities of Hampton Bar, James River, Virginia. Final Rep. to Newport News Shipbuilding and Dry Dock Co. 73 pp.

Dixon, R. D. 1978. Wrightsville Beach recreational fishing: a study of attitudes and behaviors. Technical Report to University of North Carolina Sea Grant Program, N.C. State University, Raleigh, N.C. 67 pp.

Fields, H. M. 1962. Pompanos (Trachinotus spp.) of South Atlantic coast of the United States. Fish. Bull. 62 (207): 189-222.

Fussell, J. O., III. 1978. Bogue Banks, North Carolina: a description of vegetative communities and annotated lists of amphibians, reptiles, birds, mammals and endangered and threatened species. Report to U.S. Fish and Wildlife Service, Division of Ecological Services, Raleigh, North Carolina. 115 pp.

Hayden, B. and R. Dolan. 1974. Impact of beach nourishment on distribution of Emerita talpoida, the common mole crab. J. Waterways, Harbors Coast. Engineering Division ASCE 100:WW2 pp. 123-132.

Heilbrun, L. H. and the CBC Regional Editors. 1980. The eightieth Audubon Christmas bird count. Amer. Birds. 34:327-681.

Hodson, R. G. 1979. Utilization of marsh habitats as primary nursery areas by young fish and shrimp, Cape Fear Estuary, North Carolina. Report 79-5 to Carolina Power and Light Company, Raleigh, N.C.

Hodson, R. G. and J. O. Hackman. In review. Evidence for marsh residence in some estuarine-dependent species. Dept. of Zoology, N.C. State University. Raleigh, N.C.

Hodson, R. G., J. O. Hackman and C. R. Bennet. 1981. Food habits of young spots in nursery areas of the Cape Fear River Estuary, North Carolina. Trans. Amer. Fish. Soc. 110:495-501.

Hosier, P. E. and W. J. Cleary. 1977. A resource inventory of Masonboro Island, North Carolina, Draft Report. University of North Carolina at Wilmington, Wilmington, N.C. 35 pp.

Hosier, P. E. and J. F. Parnell. 1979. Aquatic resources associated with the Atlantic Intracoastal Waterway, Wilmington District North Carolina. Final Contract Rep. to U.S. Army Corps of Engineers, Wilmington District. Contract DACW54-78-C-0055. 21 pp. + Appendices.

Huish, M. T. and J. P. Geaghan. 1979. A study of adult and juvenile fishes of the lower Cape Fear River near the Brunswick Steam Electric Plant, 1975-1976. Report 79-4 to Carolina Power and Light Company, Raleigh, N.C. 148 pp.

Martin, A. C., H. S. Zim and A. L. Nelson. 1951. American wildlife and plants: a guide to wildlife food habits. McGraw-Hill Book Company, Inc. New York, New York. 500 pp.

Mulvihill, E. L., C. A. Francisco, J. B. Glad, K. B. Kaster and R. E. Wilson. 1980. Biological impacts of minor shoreline structures on the coastal environment: state of the art review. Vol. I. U.S. Fish and Wildlife Service, Office of Biol. Serv. FWS/OBS-77/51. 156 pp.

N. C. Department of Natural Resources and Community Development. 1981. North Carolina Fisheries Regulations for Coastal Waters, 1981. N.C.D.N.R.C.D., Division of Marine Fisheries, Morehead City, N.C. 88 pp.

Parnell, J. F. and D. A. Adams. 1970. Smith Island: a resource capability study, interim report. Report to Univ. of North Carolina Sea Grant Program. 83 pp.

Parnell, J. F. and R. F. Soots. 1975. Proceedings of a conference on management of dredge islands in North Carolina estuarines. Rep. UNC-SG-75-01. UNC Sea Grant Program, N.C. State University, Raleigh, N.C. 142 pp.

Parnell, J. F. and R. F. Soots, Jr. 1979. Atlas of colonial waterbirds of North Carolina estuaries. Sea Grant Pub. UNC-SG-78-10, Univ. of North Carolina Sea Grant Program, N.C. State University, Raleigh, N.C. 269 pp., 2 appendices.

Persaud, D. and W. D. Wilkins. 1976. Evaluating construction activities impacting on water resources. Canada Ministry of the Environment. Planning and Co-ordination Section, Water Resources Branch.

Pierce, R. J. 1977. Wetland plants of the eastern United States. U.S. Army Corps of Engineers, North Atlantic Division, New York, New York.

Potter, E. F., J. F. Parnell and R. P. Teulings. 1980. Birds of the Carolinas. Univ. North Carolina Press, Chapel Hill, N.C. 408 pp.

Reilly, F. J., Jr., D. M. L. Cobb and V. J. Bellis. 1980. Biological implications of beach replenishment. pp 269-280 in N. P. Psuty and D. McArthur (eds.). Utilization of science in the decision-making process. Proc. Sixth Annual Conference. The Coastal Society. Arlington, Virginia. 330 pp.

Reilly, F. J., Jr., and V. J. Bellis. 1978. A study of the ecological impact of beach nourishment with dredged materials on the intertidal zone. Tech. Rep. No. 4, Institute for Coastal and Marine Resources, East Carolina University, Greenville, N.C. 107 pp.

Robins, C. R., R. M. Bailey, C. E. Bond, J. R. Brooker, E. A. Lachner, R. N. Lea and W. B. Scott. 1980. A list of common and scientific names of fishes from the United States and Canada. Amer. Fish. Soc., Spec. Pub. No. 12: 1-174.

Sandifier, P. A., J. V. Miglarese, D. R. Calder, et al. 1980. Ecological characterization of the sea island coastal region of South Carolina and Georgia. Vol. III: Biological features of the characterization area. U.S. Fish and Wildl. Serv., Ofc. Biol. Serv., Washington, D.C. FWS/OBS-79/42. 620 pp.

Schwartz, F. J., P. Perschbacher, L. Davidson, K. Sandoy, J. Tate, M. McAdams, C. Simpson, J. Duncan, and D. Mason. 1979. An ecological study of fishes and invertebrate macrofauna utilizing the Cape Fear River estuary, Carolina Beach Inlet and adjacent Atlantic Ocean. Annual Report to Carolina Power and Light Co., Raleigh, N.C. 326 pp.

Turner, R. E. 1977. Intertidal vegetation and commercial yields of penaeid shrimp. Trans. Amer. Fish. Soc. 106:411-416.

U. S. Army Corps of Engineers. 1978. Plan of study, Wrightsville Beach, North Carolina. Wilmington District, Wilmington, N.C. 95 pp.

U. S. Army Corps of Engineers. 1981. Wrightsville Beach, North Carolina, Stage II report. Wilmington, N.C. 62 pp., 8 plates.

U. S. Fish and Wildlife Service. 1979. Report of the U.S. Fish and Wildlife Service on the study of beach erosion and hurricane protection at Wrightsville Beach by the U.S. Army Corps of Engineers, Wilmington District. Division of Ecological Services, Raleigh Field Office, Raleigh, N.C. 23 pp. 2 tables.

U. S. Fish and Wildlife Service. 1981. Planning aid report of the U.S. Fish and Wildlife Service (FWS) on the study of beach erosion and hurricane protection (BEHP) at Wrightsville Beach by the Wilmington District, U.S. Army Corps of Engineers. Division of Ecological Services, Raleigh Field Office, Raleigh, N.C. 7 pp.

Weinstein, M. P. 1979. Shallow marsh habitats as primary nurseries for fishes and shellfish, Cape Fear River, North Carolina. Fish. Bull. 77:339-357.

Weisburg, S. B. and V. A. Lotrich. 1981. The importance of the intertidal marsh surface as an energy source for the mummichog, Fundulus heteroclitus: an experimental approach. Paper presented at the joint Atlantic Estuarine Research Society and Southeastern Estuarine Research Society meeting March 13, 1981, Wrightsville Beach, N.C.

Wolcott, T. G. 1978. Ecological role of ghost crabs, Ocypode quadrata (Fabricius) on an ocean beach: scavengers or predators? J. Exp. Mar. Biol. Ecol. 31:67-82.

APPENDIX A.

FISHES WHICH MAY OCCUR IN WRIGHTSVILLE BEACH AND THE IMMEDIATE VICINITY BASED ON SAMPLING AT WRIGHTSVILLE BEACH AND IN THE CAPE FEAR RIVER (Birkhead, Copeland and Hodson 1979; Carolina Power and Light Company 1979; Huish and Geaghan 1979; Schwartz et al. 1979).[1,2]

Family	Common Name	Scientific Name
Petromyzontidae	Sea lamprey	Petromyzon marinus
Carcharhinidae	Silky shark	Carcharhinus falciformis
	Blacktip shark	C. limbatus
	Dusky shark	C. obscurus
	Sandbar shark	C. plumbeus (formerly milberti)
	Smooth dogfish	Mustelus canis
	Lemon shark	Negaprion brevirostris
	Atlantic sharpnose shark	Rhizoprionodon terraenovae
Sphyrnidae	Scalloped hammerhead	Sphyrna lewini
	Bonnethead	S. tiburo
Squalidae	Spiny dogfish	Squalus acanthias
Rhinobatidae	Atlantic guitarfish	Rhinobatos lentiginosus
Torpedinidae	Lesser electric ray	Narcine brasiliensis
Rajidae	Clearnose skate	Raja eglanteria
Dasyatidae	Southern stingray	Dasyatis americana
	Roughtail stingray	D. centroura
	Atlantic stingray	D. sabina
	Bluntnose stingray	D. sayi
	Smooth butterfly ray	Gymnura micrura
Myliobatidae	Spotted eagle ray	Aetobatus narinari
	Bullnose ray	Myliobatus freminvillei
	Cownose ray	Rhinoptera bonasus
Acipenseridae	Atlantic sturgeon	Acipenser oxyrhynchus
Elopidae	Ladyfish	Elops saurus
	Tarpon	Megalops atlanticus

Anquillidae	American eel	Anquilla rostrata
Congridae	Conger eel	Conger oceanicus
Ophichthidae	Speckled worm eel	Myrophis punctatus
	Shrimp eel	Ophichthus gomesi
	Palespotted eel	Ophichthus ocellatus
Clupeidae	Blueback herring	Alosa aestivalis
	Hickory shad	A. mediocris
	Alewife	A. pseudoharengus
	American shad	A. sapidissima
	Yellowfin menhaden	Brevoortia smithi
	Atlantic menhaden	B. tyrannus
	Gizzard shad	Dorosoma cepedianum
	Threadfin shad	D. petenense
	Atlantic thread herring	Opisthonema oglinum
	Spanish sardine	Sardinella aurita (formerly anchovia)
Engraulidae	Striped anchovy	Anchoa hepsetus
	Bay anchovy	A. mitchilli
	Longnose anchovy	A. nasuta
Synodontidae	Inshore lizardfish	Synodus foetens
Ariidae	Hardhead catfish	Arius felis
	Gafftopsail catfish	Bagre marinus
	Atlantic midshipmen	Porichthys plectrodon
Gobiesocidae	Skilletfish	Gobiesox strumosus
Antennariidae	Ocellated frogfish	Antennarius ocellatus
	Sargassum fish	Histrio histrio

Ogcocephalidae	Shortnose batfish	*Ogcocephalus nasutus*
Gadidae	Carolina hake	*Urophycis earlli*
	Southern hake	*U. floridana*
	Spotted hake	*U. regia*
Ophidiidae	Bearded brotula	*Brotula barbata*
	Blotched cusk-eel	*Ophidion grayi*
	Crested cusk-eel	*Ophidion welshi*
Exocoetidae	Flyingfish	*Cypselurus* sp.
Belonidae	Atlantic needlefish	*Strongylura marina*
Cyprinodontidae	Sheepshead minnow	*Cyprinodon variegatus*
	Marsh killifish	*Fundulus confluentus*
	Mummichog	*F. heteroclitus*
	Spotfin killifish	*F. luciae*
	Striped killifish	*F. majalis*
Poeciliidae	Mosquitofish	*Gambusia affinis*
	Sailfin molly	*Poecilia latipinna*
Atherinidae	Rough silverside	*Membras martinica*
	Tidewater silverside	*Menidia beryllina*
	Atlantic silverside	*M. menidia*
Fistulariidae	Bluespotted cornetfish	*Fistulari tabacaria*
Syngnathidae	Lined seahorse	*Hippocampus erectus*
	Oppossum pipefish	*Oostethus brachyurus*
	Dusky pipefish	*Syngnathus floridae*
	Northern pipefish	*S. fuscus*
	Chain pipefish	*S. louisianae*
Centropomidae	Snook	*Centropomus undecimalis*

Percichthyidae	Striped bass	_Morone saxatilis_
Serranidae	Bank sea bass	_Centropristis ocyurus_
	Rock sea bass	_C. philadelphica_
	Black sea bass	_C. striata_
	Sand perch	_Diplectrum formosum_
	Red grouper	_Epinephelus morio_
	Warsaw grouper	_E. nigritus_
	Nassau grouper	_E. striatus_
	Black grouper	_Mycteroperca bonaci_
	Gag	_M. microlepis_
	Scamp	_M. phenax_
Priacanthidae	Bigeye	_Priacanthus arenatus_
	Short bigeye	_Pristigenys alta_
Pomatomidae	Bluefish	_Pomatomus saltatrix_
Rachycentridae	Cobia	_Rachycentron canadum_
Echeneidae	Sharksucker	_Echeneis naucrates_
Carangidae	Yellow jack	_Caranx bartholomaei_
	Blue runner	_C. crysos_
	Crevalle jack	_C. hippos_
	Horse-eye jack	_C. latus_
	Atlantic bumper	_Chloroscombrus chrysurus_
	Leatherjacket	_Oligoplites saurus_
	Atlantic moonfish	_Selene setapinnis_
	Lookdown	_S. vomer_
	Florida pompano	_Trachinotus carolinus_
	Permit	_T. falcatus_
	Rough scad	_Trachurus lathami_

Lutjanidae	Mutton snapper	Lutjanus analis
	Gray snapper	L. griseus
	Dog snapper	L. jocu
	Lane snapper	L. synagris
Lobotidae	Tripletail	Lobotes surinamensis
Gerreidae	Irish pompano	Diapterus auratus
	Spotfin mojarra	Eucinostomus argenteus
	Silver jenny	E. gula
	Yellowfin mojarra	Gerres cinereus
Haemulidae	Pigfish	Orthopristis chrysoptera
Sparidae	Sheepshead	Archosargus probatocephalus
	Spottail pinfish	Diplodus holbrooki
	Pinfish	Lagodom rhomboides
	Longspine porgy	Stenotomus caprinus
Sciaenidae	Silver perch	Bairdiella chrysoura
	Spotted seatrout	Cynoscion nebulosus
	Silver seatrout	C. nothus
	Weakfish	C. regalis
	Banded drum	Larimus fasciatus
	Spot	Leiostomus xanthurus
	Southern kingfish	Menticirrhus americanus
	Gulf kingfish	M. littoralis
	Northern kingfish	M. saxatilis
	Atlantic croaker	Micropogonias undulatus
	Black drum	Pogonias cromis
	Red drum	Scianops ocellatus
	Star drum	Stellifer lanceolatus

Ephippidae	Atlantic spadefish	*Chaetodipterus faber*
Labridae	Tautog	*Tautoga onitis*
Mugilidae	Striped mullet	*Mugil cephalus*
	White mullet	*M. curema*
Sphyraenidae	Great barracuda	*Sphyraena barracuda*
	Northern sennet	*S. borealis*
	Guaguanche	*S. guanchancho*
Uranoscopidae	Northern stargazer	*Astroscopus guttatus*
	Southern stargazer	*A. y-graecum*
Blenniidae	Striped blenny	*Chasmodes bosquianus*
	Crested blenny	*Hypleurochilus geminatus*
	Feather blenny	*Hypsoblennius hentzi*
	Freckled blenny	*H. ionthas*
Eleotridae	Fat sleeper	*Dormitator maculatus*
	Spiny cheek sleeper	*Eleotris pisonis*
Gobiidae	Darter goby	*Gobionellus boleosoma*
	Sharptail goby	*G. hastatus*
	Freshwater goby	*G. shufeldti*
	Marked goby	*G. stigmaticus*
	Naked goby	*Gobiosoma bosci*
	Seaboard goby	*G. ginsburgi*
	Green goby	*Microgobius thallassinus*
Microdesmidae	Pink wormfish	*Microdesmus longipinnis*
Trichiuridae	Atlantic cutlassfish	*Trichiurus lepturus*
Scombridae	King mackeral	*Scomberomorus cavalla*
	Spanish mackeral	*S. maculatus*
Stromateidae	Harvestfish	*Peprilus alepidotus*

	Gulf butterfish	*P. burti*
	Butterfish	*P. triacanthus*
Scorpaenidae	Barbfish	*Scorpaena brasiliensis*
Triglidae	Northern searobin	*Prionotus carolinus*
	Striped searobin	*P. evolans*
	Blackwing searobin	*P. salmonicolor*
	Leopard searobin	*P. scitulus*
	Bighead searobin	*P. tribulus*
Dactylopteridae	Flying gurnard	*Dactylopterus volitans*
Bothidae	Ocellated flounder	*Ancylopsetta quadrocellata*
	Spotted whiff	*Citharichthys macrops*
	Bay whiff	*C. spilopterus*
	Fringed flounder	*Etropus crossotus*
	Gulf flounder	*Paralichthys albigutta*
	Summer flounder	*P. dentatus*
	Southern flounder	*P. lethostigma*
	Broad flounder	*P. squamilentus*
	Windowpane	*Scophthalmus aquosus*
Soleidae	Hogchoker	*Trinectes maculatus*
Cynoglossidae	Blackcheek tonguefish	*Symphurus plagiusa*
Balistidae	Orange filefish	*Aluterus schoepfi*
	Gray triggerfish	*Balistes capriscus*
	Planehead filefish	*Monacanthus hispidus*
Ostraciidae	Spotted trunkfish	*Lactophrys bicaudalis*
	Honeycomb cowfish	*L. polygonia*
Tetraodontidae	Smooth puffer	*Lagocephalus laevigatus*
	Northern puffer	*Sphoeroides maculatus*

	Bandtail puffer	S. spengleri
Diodontidae	Striped burrfish	Chilomycterus schoepfi

[1]Predominantly freshwater species which occurred in the Cape Fear River estuary periodically are not included in the list.

[2]Common and scientific names are based on Robins et al. 1980.

APPENDIX B

COMMON AND SCIENTIFIC NAMES OF BIRDS WHICH MAY OCCUR ON OR IN THE VICINITY OF WRIGHTSVILLE BEACH AND THEIR RESIDENCE AND NUMERICAL STATUS BASED ON THOSE OCCURRING ON OTHER SOUTHEASTERN BARRIER ISLANDS. (Compiled from: Parnell and Adams 1970; Fussell 1978; Heilbrun et al. 1980; Potter et al. 1980).

Family	Common Name	Scientific Name	Residence[1]/Abundance[2,3]
Gaviidae	Common loon	*Gavia immer*	RW/C
	Red-throated loon	*G. stellata*	RW/FC-C
Podicipedidae	Horned grebe	*Podiceps auritus*	RW/C
	Pied-bill grebe	*Podilymbus podiceps*	RP/C
Procellariidae	Greater shearwater	*Puffinus gravis*	TS/FC
	Sooty shearwater	*P. griseus*	TS/FC
	Audubon's shearwater	*P. lherminieri*	TS/FC
	Wilson's storm petrel	*Oceanites oceanicus*	RS/C
Pelicanidae	Brown pelican	*Pelecanus occidentalis*	RP/FC-C
Sulidae	Gannet	*Morus bassanus*	RW/C
Phalacrocoracidae	Double-crested cormorant	*Phalacrocorax auritus*	RW/C
Ardeidae	Great blue heron	*Ardea herodias*	RP/FC-C
	Green heron	*Butorides striatus*	RS/C
	Little blue heron	*Florida caerulea*	RP/C
	Great egret	*Casmerodius albus*	RP/C
	Snowy egret	*Egretta thula*	RP/C
	Louisiana heron	*Hydranassa tricolor*	RP/C
	Black-crowned night heron	*Nycticorax nycticorax*	RP/C
	Yellow-crowned night heron	*Nyctanassa violacea*	RP/FC
	Least bittern	*Ixobrychus exilis*	RS/FC-C

	American bittern	Botaurus lentiginosus	RW/FC
Ciconiidae	Wood stork	Mycteria americana	TF/U
Threskiornithidae	Glossy ibis	Plegadis falcinellus	RP/U-C
	White ibis	Eudocimus albus	RP/FC-C
Anatidae	Whistling swan	Olor columbianus	RW/R-U
	Canada goose	Branta canadensis	RW/U
	Brant	B. bernicla	TW/R
	Snow goose	Chen caerulescens	RW/R
	Mallard	Anas platyrhynchos	RW/C
	Black duck	A. rubripes	RW/FC
	Gadwall	A. strepera	RW/U-FC
	Pintail	A. acuta	RW/C
	Green-winged teal	A. crecca	RW/C
	Blue-winged teal	A. discors	T-WSp/FC-C
	American wigeon	A. americana	RW/C
	Northern shoveler	A. clypeata	RW/C
	Redhead	Aythya americana	RW/U
	Ring-necked duck	A. collaris	RW/C
	Canvasback	A. valisineria	RW/U-FC
	Greater scaup	A. marila	RW/U-FC
	Lesser scaup	A. affinis	RW/FC

	Common goldeneye	Bucephala clangula	RW/U
	Bufflehead	B. albeola	RW/FC-C
	Oldsquaw	Clangula hyemalis	RW/U
	White-winged scoter	Melanitta deglandi	TW/U
	Surf scoter	M. perspicillata	RW-TSp/FC-C
	Black scoter	M. nigra	RW-TSp/FC-C
	Ruddy duck	Oxyura jamaicensis	RW/C
	Hooded merganser	Lophodytes cucullatus	RW/FC
	Red-breasted merganser	Mergus serrator	RW/C
Cathartidae	Turkey vulture	Cathartes aura	RP/FC-C
	Black vulture	Coragyps atratus	RP/C
Accipitridae	Sharp-shinned hawk	Accipiter striatus	TF-RW/U-FC
	Red-tailed hawk	A. cooperii	RP/FC
	Marsh hawk	Circus cyaneus	RW/C
Pandionidae	Osprey	Pandion haliaetus	RS/FC
Falconidae	Peregrine falcon	Falco peregrinus	TF-RW/R-U
	Merlin	F. columbarius	TF/U-FC
	American kestrel	F. sparverius	RW/FC-C
Rallidae	Clapper rail	Rallus longirostris	RP/C
	Virginia rail	R. limicola	RW/FC-C
	Sora	Porzana carolina	TF-Sp/C

	American coot	Fulica americana	RW/C
Haematopidae	American oystercatcher	Haematopus palliatus	RP/FC
Recurvirostridae	American avocet	Recurvirostra americana	T/R
Charadriidae	Semipalmated plover	Charadrius semipalmatus	TF-Sp/FC-C
	Wilson's plover	C. wilsonia	RS/FC
	Killdeer	C. vociferus	RP/C
	Piping plover	C. melodus	RW/FC
	Black-bellied plover	Pluvialis squatarola	TWSpSF/R-C
Scolopacidae	Marbled godwit	Limosa fedoa	TF-RW/FC-C
	Whimbrel	Numenius phaeopus	TFSp/FC-C
	Long-billed curlew	N. americanus	RW/R
	Greater yellowlegs	Tringa melanoleuca	TW/FC
	Lesser yellowlegs	T. flavipes	TFSp-RW/U-FC
	Willet	Catoptrophorus semipalmatus	RP/C
	Spotted sandpiper	Actitis macularia	RP/C
	Ruddy turnstone	Arenaria interpres	RP/FC-C
	Northern phalarope	Phalaropus lobatus	T-SpF/C
	American woodcock	Scolopax minor	RP/FC
	Common snipe	Gallinago gallinago	RW/C
	Short-billed dowitcher	Limnodromus griseus	TFSp/FC-C
	Long-billed dowitcher	L. scolopaceus	TF-RW/R-U

	Red Knot	Calidris canutus	
	Sanderling	C. alba	RP/C
	Semipalmated sandpiper	C. pusilla	
	Western sandpiper	C. mauri	
	Least sandpiper	C. minutilla	
	Purple sandpiper	C. maritima	
	Dunlin	C. alpina	
	Buff-breasted sandpiper	Tryngites subruficollis	
Stercorariidae	Pomarine jaeger	Stercorarius pomarinus	RP/U
	Parasitic jaeger	S. parasiticus	RFW/C
Laridae	Great black-backed gull	Larus marinus	RW/FC
	Herring gull	L. argentatus	RP/C
	Ring-billed gull	L. delawarensis	RP/C
	Laughing gull	L. atricilla	RP/C
	Bonaparte's gull	L. philadelphia	RW/FC-C
	Gull-billed tern	Gelochelidon nilotica	RS/FC
	Forster's tern	Sterna forsteri	RW/C
	Common tern	S. hirundo	RS/C
	Least tern	S. albifrons	RS/FC
	Royal tern	S. maxima	RP/C

	Sandwich tern	S. sandvicensis	RS/FC
	Caspian tern	S. caspia	T-SpF/FC
	Black tern	Chlidonias niger	T-SpF/U-C
Rynchopidae	Black skimmer	Rynchops niger	RP/C
Columbidae	Rock dove	Columba livia	RP/C
	Mourning dove	Zenaida macroura	RP/C
	Ground dove	Columbina passerina	RP/FC
Cuculidae	Yellow-billed cuckoo	Coccyzus americanus	RS/FC-C
Tytonidae	Barn owl	Tyto alba	RP/R-U
Strigidae	Great horned owl	Bubo virginianus	RP/U-FC
	Short-eared owl	Asio flammeus	T-SpF/U
Caprimulgidae	Common night hawk	Chordeiles minor	RS/U-FC
Apodidae	Chimney swift	Chaetura pelagica	RS/C
Alcedinidae	Belted kingfisher	Megaceryle alcyon	RP/FC
Picidae	Common flicker	Colaptes auratus	RP/C
	Red-headed woodpecker	Melanerpes erythrocephalus	RP/U-FC
	Yellow-bellied sapsucker	Sphyrapicus varius	RW/C
Tyrannidae	Eastern kingbird	Tyrannus tyrannus	RS/U
	Eastern phoebe	Sayornis phoebe	R-FW/FC
	Least flycatcher	Empidonax minimus	T/R

Hirundinidae	Tree swallow	Iridoprocne bicolor	T-SpF/C
	Bank swallow	Riparia riparia	T-SpF/U-FC
	Rough-winged swallow	Stelgidopteryx ruficollis	RS/FC
	Barn swallow	Hirundo rustica	R-SpS/C
	Purple martin	Progne subis	RS/FC-C
Corvidae	Blue jay	Cyanocitta cristata	RP/C
	Common crow	Corvus brachyrhynchos	RP/C
	Fish crow	C. ossifragus	RP/C
Paridae	Carolina chickadee	Parus carolinensis	RP/C
Sittidae	Red-breasted nuthatch	Sitta canadensis	TW/R-C
Troglodytidae	House wren	Troglodytes aedon	RW/C
	Winter wren	T. troglodytes	RW/FC
	Carolina wren	Thryothorus ludovicianus	RP/C
	Long-billed marsh wren	Cistothorus palustris	RP/C
	Short-billed marsh wren	C. platensis	RW/FC-C
Mimidae	Mockingbird	Mimus polyglottos	RP/C
	Gray catbird	Dumetella carolinensis	RP/U-C
	Brown thrasher	Toxostoma rufum	RP/C
Turdidae	American robin	Turdus migratorius	RW/C
Sylviidae	Golden-crowned kinglet	Regulus satrapa	RW/C
Motacillidae	Water pipit	Anthus spinoletta	RW/C

Bombycillidae	Cedar waxwing	Bombycilla cedrorum	TW/U
Laniidae	Loggerhead shrike	Lanius ludovicianus	RP/U-FC
Sturnidae	Starling	Sturnus vulgaris	RP/C
Vireonidae	Red-eyed vireo	Vireo olivaceus	RS/C
Parulidae	Orange-crowned warbler	Vermivora celata	RW/FC
	Northern parula	Parula americana	RS/FC-C
	Yellow warbler	Dendroica petechia	T/U
	Magnolia warbler	D. magnolia	T-SpF/R-U
	Cape May warbler	D. tigrina	T-SpF/R-U
	Black-throated blue warbler	D. caerulescens	T-SpF/U
	Yellow-rumped warbler	D. coronata	RW/C
	Blackpoll warbler	D. striata	T-Sp/FC
	Prairie warbler	D. discolor	RS/C
	Palm warbler	D. palmarum	T-SpF/C
	Northern waterthrush	Seirurus noveboracensis	T-SpF/FC
	Common yellowthroat	Geothlypis trichas	RSpSF/C
	Yellow-breasted chat	Icteria virens	RS/U
	American redstart	Setophaga ruticilla	T-SpF/U-FC
Ploceidae	House sparrow	Passer domesticus	RP/C
Icteridae	Bobolink	Dolichonyx oryzivorus	T-SpF/FC-C
	Eastern meadowlark	Sturnella magna	RP/C

	Red-winged blackbird	_Agelaius phoeniceus_	RP/C
	Boat-tailed grackle	_Quiscalus major_	RP/C
	Common grackle	_Q. quiscula_	RP/C
	Brown-headed cowbird	_Molothrus ater_	RW/C
Fringillidae	Cardinal	_Cardinalis cardinalis_	RP/C
	Rose-breasted grosbeak	_Pheucticus ludovicianus_	T/R-U
	Blue grosbeak	_Guiraca caerulea_	RS/FC-C
	Indigo bunting	_Passerina cyanea_	RS/C
	Painted bunting	_P. cirus_	RS/C
	Purple finch	_Carpodacus purpureus_	RW/C
	Pine siskin	_Carduelis pinus_	RW/U-C
	American goldfinch	_C. tristis_	RW/C
	Rufous-sided towhee	_Pipilo erythrophthalmus_	RP/C
	Savannah (Ipswich) sparrow	_Passerculus sandwichensis_	RW/C
	Sharp-tailed sparrow	_Ammospiza caudacuta_	RW/C
	Seaside sparrow	_A. maritima_	RW/C
	Lark sparrow	_Chondestes grammacus_	TF/U
	Dark-eyed junco	_Junco hyemalis_	RW/C
	Chipping sparrow	_Spizella passerina_	RP/U-C
	Field sparrow	_S. pusilla_	RP/C
	White-crowned sparrow	_Zonotrichia leucophrys_	RW/FC

White-throated sparrow	_Z. albicollis_	RW/C
Fox sparrow	_Passerella iliaca_	RW/FC
Swamp sparrow	_Melospiza georgiana_	RW/C
Song sparrow	_M. melodia_	RW/C

[1]Residence: F=fall; P=permanent; R=resident; S=summer; Sp=spring; T=transient; and W=winter.

[2]Abundance: C=common; FC=fairly common; R=rare; U=uncommon

[3]All residence/abundance designations are based on the information contained in Potter et al. 1980 and pertain as nearly as possible to the immediate vicinity of Wrightsville Beach.

APPENDIX C

BIRDS LIKELY TO OCCUR WITHIN SPECIFIC HABITATS OF WRIGHTSVILLE BEACH, N.C., AND VICINITY, BASED ON STUDIES AT OTHER SOUTHEASTERN U.S. BARRIER ISLANDS AND AT WILMINGTON, N.C. (Parnell and Adams 1970; Heilbrun et al. 1980; Sandifer et al. 1980).

PELAGIC (may approach shore)

	Smith Island	Bogue Banks	SC-GA	Wilmington
Greater shearwater		X	X	
Sooty shearwater		X		
Audubon's shearwater		X	X	
Wilson's storm petrel		X	X	
Northern phalarope			X	
Pomarine jaeger		X		
Parisitic jaeger	X	X		

NEARSHORE OCEAN

	Smith Island	Bogue Banks	SC-GA	Wilmington
Sandwich tern	X	X	X	
Black tern	X	X	X	
Black skimmer		X	X	X
Greater scaup	X			X
Lesser scaup	X		X	X
Caspian tern	X		X	
Horned grebe	X		X	X
Canvasback			X	
Common goldeneye			X	
Ruddy duck		X	X	X
Mallard	X			X
Pintail	X			X
Blue-winged teal	X			X
Bufflehead	X			X
Red-breasted merganser	X			X
Osprey	X			

NEARSHORE OCEAN

	Smith Island	Bogue Banks	SC-GA	Wilmington
Common loon	X	X	X	X
Red-throated loon	X	X	X	X
Brown pelican	X	X	X	X
Gannet	X	X	X	X
Double-crested cormorant	X	X	X	X
White-winged scoter	X	X		
Unidentified scoter				X
Surf scoter	X	X	X	
Black scoter	X	X	X	X
Oldsquaw		X		
Great black-backed gull	X	X	X	X
Herring gull	X	X	X	X
Ring-billed gull	X	X	X	X
Laughing gull	X	X	X	X
Bonaparte's gull	X	X	X	X
Gull-billed tern	X	X	X	
Forster's tern	X	X	X	X
Common tern	X	X	X	
Least tern	X	X	X	
Royal tern	X	X	X	X

INTERTIDAL BEACH

	Smith Island	Bogue Banks	SC-GA	Wilmington
Wilson's plover	X		X	
Semipalmated plover	X	X		X
American oyster catcher	X		X	
Piping plover	X	X	X	X
Black-bellied plover	X	X	X	X
Brown pelican	X			
Ruddy turnstone	X	X	X	X
Willet	X	X	X	X
Whimbrel	X	X		X
Red knot	X	X	X	
Purple sandpiper (jetties)		X		
Least sandpiper	X	X	X	
Dunlin	X	X	X	X
Short-billed dowitcher	X	X	X	X
Semipalmated sandpiper	X	X	X	
Western sandpiper	X	X	X	X
Buff-breasted sandpiper	X			
Marbled godwit	X	X		X
Sanderling	X	X	X	X
Great black-backed gull	X	X	X	X
Herring gull	X	X	X	X
Ring-billed gull	X	X	X	X
Laughing gull	X	X	X	X
Bonaparte's gull		X	X	X
Sandwich tern	X		X	
Common tern	X	X	X	
Gull-billed tern	X	X	X	

INTERTIDAL BEACH

	Smith Island	Bogue Banks	SC-GA	Wilmington
Least tern	X	X	X	
Forster's tern	X		X	X
Royal tern	X		X	X
Caspian tern	X		X	
Black skimmer			X	X
Black tern	X		X	
Fish crow		X	X	X
Boat-tailed grackle	X	X	X	X
Snowy egret	X		X	X
Scaup			X	X
Turkey vulture			X	X
Black vulture			X	X
Peregrine falcon	X		X	
Common crow			X	X
Merlin	X		X	
Lesser yellowlegs	X			X
Water pipit	X			X

DUNES

	Smith Island	Bogue Banks	SC-GA	Wilmington
Sharp-shinned hawk			X	X
Red-tailed hawk		X		X
American kestrel	X	X	X	X
Mourning dove	X	X	X	X
Marsh hawk	X			X
Ground dove	X	X	X	X
Barn owl		X		
Short-eared owl		X		
Common flicker		X		X
Lark sparrow	X			
Bank swallow		X		
Tree swallow	X	X	X	X
Barn swallow	X	X	X	
Palm warbler		X	X	X
Yellow-rumped warbler		X	X	X
Red-winged blackbird	X	X	X	X
Pine siskin		X		
Dark-eyed junco			X	X
American goldfinch	X	X	X	X
Ipswich sparrow	X	X	X	
Savannah sparrow	X	X	X	X
Field sparrow			X	X
Least tern			X	
Common night hawk			X	
Fish crow			X	X
Boat-tailed grackle	X		X	X

DUNES

	Smith Island	Bogue Banks	SC-GA	Wilmington
American oyster catcher			X	X
Wilson's plover	X		X	
Willet			X	X
Gull-billed tern			X	
Chimney swift			X	
Common crow			X	X
Eastern meadowlark	X		X	X
Common grackle			X	X
Cardinal			X	X
Painted bunting			X	
Song sparrow			X	X
Great horned owl			X	X
Rough-winged swallow			X	
Purple martin			X	
Bobolink			X	

MARITIME SHRUB THICKET

	Smith Island	Bogue Banks	SC-GA	Wilmington
Sharp-shinned hawk		X	X	X
Red-tailed hawk		X		X
American kestrel	X	X	X	X
American woodcock		X		X
Willet		X		X
Gull-billed tern		X		
Mourning dove		X		X
Ground dove	X	X	X	X
Barn owl	X	X		
Common night hawk		X		
Common flicker	X	X		X
Red-headed woodpecker		X		X
Yellow-bellied sapsucker		X		X
Least flycatcher	X			
Eastern kingbird		X	X	
Eastern phoebe		X		X
Tree swallow		X	X	X
Bank swallow		X		
Chimney swift			X	
Barn swallow		X	X	
Blue jay		X		X
Common crow				X
Fish crow	X	X		X
Red-breasted nuthatch		X		
House wren	X	X		X

MARITIME SHRUB THICKET

	Smith Island	Bogue Banks	SC-GA	Wilmington
Winter wren	X			X
Carolina wren		X		X
Mockingbird	X	X	X	X
Gray catbird	X	X	X	X
Brown thrasher	X	X	X	X
American robin		X		X
Golden crowned kinglet		X		X
Cedar waxwing		X		X
Red-eyed vireo		X		
Orange-crowned warbler	X	X		X
Northern parula		X		
Yellow warbler		X		
Magnolia warbler		X		
Cape May warbler		X		
Black-throated blue warbler		X		
Yellow-rumped warbler	X	X	X	X
Blackpoll warbler		X		
Prairie warbler	X	X	X	
Palm warbler	X	X	X	X
Northern water thrush	X	X		
Common yellowthroat	X	X	X	
Yellow-breasted chat		X	X	
American redstart		X	X	
Red-winged blackbird		X	X	X

MARITIME SHRUB THICKET

	Smith Island	Bogue Banks	SC-GA	Wilmington
Boat-tailed grackle	X	X	X	X
Common grackle		X		X
Cardinal	X	X	X	X
Rose-breasted grosbeak		X		X
Painted bunting	X	X	X	
Pine siskin		X		
American goldfinch	X	X		X
Rufous-sided towhee	X	X	X	X
Dark eyed junco		X		X
Savannah sparrow	X			
Chipping sparrow		X		X
Field sparrow	X	X		X
White-crowned sparrow	X	X		
White-throated sparrow	X	X		X
Fox sparrow		X		X
Swamp sparrow	X	X		X
Song sparrow	X	X		X
Bobolink			X	
Blue grosbeak			X	
Indigo bunting	X		X	
Yellow-billed cuckoo	X			

SALT MARSH (high and low)

	Smith Island	Bogue Banks	SC-GA	Wilmington
Great blue heron	X	X	X	X
Green heron	X	X	X	X
Little blue heron	X	X	X	X
Great egret	X	X	X	X
Snowy egret	X	X	X	X
Louisiana heron	X	X	X	X
Black-crowned night heron	X	X	X	X
Yellow-crowned night heron	X	X	X	X
Least bittern		X	X	
American bittern	X	X	X	
Glossy ibis	X		X	
White ibis	X	X	X	X
Mallard		X		X
Black duck		X	X	X
Bufflehead			X	
Gadwall		X		X
Ruddy duck			X	
Pintail		X		X
Lesser scaup			X	
Green-winged teal		X		X
Blue-winged teal		X		X
American wigeon		X	X	X
Common goldeneye			X	
Northern shoveler		X		X
Red-breasted merganser			X	X
Hooded merganser		X	X	X

SALT MARSH (high and low)

	Smith Island	Bogue Banks	SC-GA	Wilmington
Sharp-shinned hawk			X	X
Red-tailed hawk	X	X		X
American kestrel			X	X
Marsh hawk	X	X	X	X
Osprey			X	
Clapper rail	X	X	X	X
Virginia rail	X	X	X	X
Sora	X	X	X	X
Common snipe		X		X
Spotted sandpiper			X	
Whimbrel		X		X
American oyster catcher			X	X
Greater yellowlegs		X	X	X
Lesser yellowlegs		X	X	X
Caspian tern		X	X	
Barn owl		X		
Long-billed marsh wren	X	X	X	X
Short-billed marsh wren		X	X	X
Bobolink	X	X	X	
Yellow warbler	X			
Eastern meadowlark	X	X		X
Palm warbler	X			X
Red-winged blackbird	X	X	X	X
Common yellow throat	X			
Boat-tailed grackle	X	X	X	X

SALT MARSH (high and low)

	Smith Island	Bogue Banks	SC-GA	Wilmington
Song sparrow	X			X
Sharp-tailed sparrow	X	X	X	X
Savannah sparrow	X			X
Seaside sparrow	X	X	X	
Swamp sparrow	X			X
Herring gull			X	X
Ring-billed gull			X	X
Laughing gull			X	X
Forster's tern			X	X
Least tern			X	
Black skimmer			X	X
Belted kingfisher			X	X
Tree swallow			X	X
Barn swallow			X	
Fish crow			X	X
Semipalmated plover			X	X
Black-bellied plover			X	X
Ruddy turnstone			X	X
Whimbrel			X	X
Willet			X	X
Least sandpiper			X	
Dunlin			X	X
Dowitcher			X	X
Semipalmated sandpiper			X	
Western sandpiper			X	X
Gull-billed tern	X		X	
Common tern			X	

SALT MARSH (high and low)

	Smith Island	Bogue Banks	SC-GA	Wilmington
Royal tern			X	X
Sandwich tern			X	
Black tern			X	
Rough winged swallow			X	
Common grackle	X		X	X
Wood stork			X	
Merlin			X	
Peregrine falcon	X		X	
American coot			X	X

INTERTIDAL FLATS

	Smith Island	Bogue Banks	SC-GA	Wilmington
American oyster catcher	X	X	X	X
Piping plover	X			X
Black-bellied plover	X	X	X	X
Wilson's plover	X			
Least sandpiper	X	X	X	
Dunlin	X	X	X	X
Short-billed dowitcher	X	X	X	X
Spotted sandpiper		X	X	
Semipalmated sandpiper	X	X	X	
Western sandpiper	X	X	X	X
Buff-breasted sandpiper	X			
Great blue heron	X	X	X	X
Little blue heron		X	X	X
Louisiana heron	X	X	X	X
Great egret	X	X	X	X
Snowy egret	X	X	X	X
Semipalmated plover	X		X	X
Ruddy turnstone	X		X	X
Willet	X		X	X
Herring gull	X		X	X
Ring-billed gull	X		X	X
Laughing gull	X		X	X
Forster's tern	X		X	X
Least tern	X		X	
Black tern	X			
Royal tern	X		X	X
Black skimmer	X		X	X

INTERTIDAL FLATS

	Smith Island	Bogue Banks	SC-GA	Wilmington
Peregrine falcon	X			
Boat-tailed grackle	X		X	X
Brown pelican			X	X
Double-crested cormorant			X	X
Yellow-crowned night heron			X	X
Glossy ibis		X	X	
Killdeer			X	X
Long-billed curlew	X	X		
Whimbrel	X	X	X	X
Greater yellowlegs	X	X	X	X
Lesser yellowlegs	X	X	X	X
Marbled godwit	X	X	X	X
Red Knot	X	X		
Bonaparte's gull			X	X
Gull-billed tern	X		X	
Common tern	X		X	
Sandwich tern	X		X	
Caspian tern	X		X	
Fish crow			X	X
Green heron		X	X	X
Black-crowned night heron		X	X	X
Wood stork			X	
White ibis		X	X	X
American avocet			X	
Pintail	X			X
Green-winged teal	X			X

ESTUARINE SUBTIDAL

	Smith Island	Bogue Banks	SC-GA	Wilmington
Horned grebe	X	X	X	X
Pied-bill grebe	X	X	X	X
Brown pelican	X	X	X	X
Great blue heron	X	X		X
Green heron	X			X
Little blue heron	X	X		X
Black-bellied plover	X			X
Great egret	X	X		X
American oystercatcher	X			X
Snowy egret	X	X		X
Dunlin	X			X
Louisiana heron	X	X		X
Short-billed dowitcher	X			X
Black-crowned night heron	X	X		X
Yellow-crowned night heron	X			X
Whistling swan		X		X
Lesser yellowlegs	X			X
Canada goose		X		X
Tree swallow	X			X
Barn swallow	X			
Brant		X		
Snow goose		X		
Gadwall	X			X
Mallard	X	X		X
Green winged teal	X			X
Blue winged teal	X			X
Black duck	X	X		X

ESTUARINE SUBTIDAL

	Smith Island	Bogue Banks	SC-GA	Wilmington
Pintail	X	X		X
Spotted sandpiper	X			
Red head		X	X	X
Ring-necked duck			X	X
Canvasback		X	X	
Greater scaup		X		X
Lesser scaup		X	X	X
Common goldeneye	X	X	X	X
Bufflehead	X	X	X	X
American wigeon	X			X
American coot	X			X
Surf scoter		X	X	X
Black scoter		X	X	X
Ruddy duck	X	X	X	X
Hooded merganser	X		X	X
Red-breasted merganser	X	X	X	X
Belted kingfisher	X			X
Osprey	X	X	X	
Great black-backed gull		X		X
Herring gull	X	X	X	X
Ring-billed gull	X	X	X	X
Laughing gull	X	X	X	X
Bonaparte's gull	X	X	X	X
Forster's tern	X	X	X	X
Common tern	X	X	X	
Least tern	X	X	X	
Royal tern	X	X	X	X

ESTUARINE SUBTIDAL

	Smith Island	Bogue Banks	SC-GA	Wilmington
Sandwich tern		X	X	
Caspian tern	X	X	X	
Black tern	X	X	X	
Black skimmer	X	X	X	X
Double crested cormorant	X		X	X
Common loon	X		X	X
Red-throated loon			X	X
Gull-billed tern	X		X	
Glossy ibis	X			
White ibis	X			X

URBAN AND RESIDENTIAL

	Smith Island	Bogue Banks	SC-GA	Wilmington
Killdeer		X		X
Rock dove		X		X
Loggerhead shrike		X		X
Starling		X		X
House sparrow		X		X
Common grackle		X		X
Brown-headed cowbird		X		X
Purple finch		X		X

APPENDIX D

U.S. FISH AND WILDLIFE SERVICE CORRESPONDENCE WITH THE CORPS REGARDING ENDANGERED OR THREATENED SPECIES.

February 12, 1980

Colonel Adolph A. Hight
District Engineer
Department of the Army
Wilmington District Corps of Engineers
P.O. Box 1890
Wilmington, North Carolina 28402

Re: 4-2-79-A-285

Dear Colonel Hight:

We have reviewed the biological assessment on the proposed Wrightsville Beach erosion control and hurricane wave protection project for several listed and/or proposed endangered and threatened species in New Hanover County, North Carolina, submitted February 8, 1980.

The biological assessment is adequate and supports the conclusion of no impact, with which we concur. In view of this, we believe that you have satisfied the requirements of Section 7 of the Endangered Species Act.

Your interest and initiative in enhancing endangered and threatened species is appreciated.

Sincerely yours,

/S/ William C. Hickling

WILLIAM C. HICKLING
Area Manager

cc: Director, Fish and Wildlife Service, Washington, D.C. (AFA/OES)

Regional Director, Fish and Wildlife Service, Atlanta, Georgia (AFA/SE)

Field Supervisor, Ecological Services, Raleigh, N.C.

Murdock:WCHickling:lr:2/11/80

APPENDIX E

CORRESPONDENCE FROM THE NORTH CAROLINA WILDLIFE RESOURCES COMMISSION, THE NORTH CAROLINA OFFICE OF COASTAL MANAGEMENT AND THE U.S. ARMY CORPS OF ENGINEERS, WILMINGTON DISTRICT PROVIDING COMMENTS ON THE DRAFT FWCA REPORT FOR THIS PROJECT.

North Carolina
Wildlife
Resources Commission
Archdale Building, 512 N. Salisbury Street, Raleigh, North Carolina 27611, 919-733-3391

December 11, 1981

Mr. William C. Hickling
U. S. Fish & Wildlife Service
Plateau Building, Room A-5
50 South French Broad Avenue
Asheville, N C. 28801

Dear Mr. Hickling:

We have reviewed the U. S. Fish & Wildlife Service's Draft Fish and Wildlife Coordination Act Report on the Corps of Engineers proposed beach erosion control and hurricane protection project at Wrightsville Beach, N. C. and vicinity. We concur in the general findings and recommendations concerning fish and wildlife impacts and proposed mitigation and enhancement.

We wish to call to your attention a minor duplication of data in Appendix I for the fishery Family Bothidae. It appears that a page should be deleted from the report in order to correct this duplication.

Sincerely,

Vernon Bevill

W. Vernon Bevill

TSC/dlp

cc: Mrs. Mike Gantt

US DOI, FWS
ASHEVILLE AO
RECEIVED
DEC 14 1981

ALL ____ SE/T ____
AM ____ SE/T ____
ARW ____ AO ____
ARW ____ YA ____
AE ____ CS ____
AE ____ CS ____
AF ____ CS ____
SE ____ Selv ____
SE/T ____

North Carolina Department of Natural Resources & Community Development
James B. Hunt, Jr., Governor
Joseph W. Grimsley, Secretary

OFFICE OF COASTAL MANAGEMENT
Kenneth D. Stewart
Director
Telephone 919/733-2293

Field Services Section
7225 Wrightsville Avenue
Wilmington, NC 28403
919/256-4161

January 12, 1982

Ms. Mike Gantt, Field Supervisor
U. S. Fish and Wildlife Service
310 New Bern Avenue
Raleigh, North Carolina 27601

Dear Ms. Gantt:

Thank you for allowing us the opportunity to comment on the "Draft Fish and Wildlife Coordination Act Report of the Wrightsville Beach Erosion Control and Hurricane Protection Study". I agree with the Service's general assessment of the current situation and potential impacts from the various proposed alternatives. In addition, I agree with the four recommendations in the end of the report. Our dredging moritorium is somewhat less, extending from April 1 through the end of September of any given year.

This office has processed a Major Development CAMA application for the development plans encompassing the northern section of Shell Island. A conditional permit #44-81 was issued on March 20, 1981 to the Shell Island Development Corporation. Our permit requires two major objectives that appear to be consistent with your recommendations:

(1) That all development be kept landward from the crest of the primary dune; and

(2) That three public access points be provided with no less than 390 public parking spaces distributed among these three points.

A copy of our major development permit is attached for your files.

At present the Shell Island Development Corporation is contesting our public assess conditions and a civil hearing proceeding is pending. Should you have any other questions about the project or need other assistance, please advise.

Sincerely,

Rob Moul
Field Consultant

RM/cfp
Enclosure

JAN 1 8 1982

DEPARTMENT OF THE ARMY
WILMINGTON DISTRICT. CORPS OF ENGINEERS
P. O. BOX 1890
WILMINGTON, NORTH CAROLINA 28402

IN REPLY REFER TO
SAWEN-EA

6 January 1982

Mr. William C. Hickling, Area Manager
U.S. Fish and Wildlife Service
Plateau Building, Room A-5
50 South French Broad Avenue
Asheville, NC 28801

Dear Mr. Hickling:

I have reviewed the Draft Fish and Wildlife Coordination Act Report on the Wrightsville Beach Erosion Control and Hurricane Protection Study, Wrightsville Beach, NC, and have varied impressions of the document. The description of the existing resources presented in the report is excellent, and the Service is to be commended on the thoroughness of its presentation. Gathering data from unpublished sources is a difficult task which the Service has performed well. I had some difficulty with the report's analysis of potential impacts, however, and our general comments on this matter follow. Our specific comments are clearly marked on the attached photocopy of the text.

a. Many impacts are referred to which could occur, but the likelihood of their occurrence is not discussed. Certainly, some impacts are more likely to occur than others and this distinction should be sharpened. Also, the significance of the impacts on the intertidal benthic fauna to the region is left unclear. Considering that Wrightsville Beach is only one part of a much larger regional littoral/estuarine system, it is questionable that even a worst case condition, consisting of total loss of intertidal benthic fauna on the beach, would seriously affect regional populations of birds and fishes. These potential losses, of undetermined significance, must be weighed by the Corps against the real benefits (such as recreation and aesthetics) which would result from the continued maintenance of the project. It is, therefore, very important that the likelihood of occurrence and significance of the impacts be as clearly defined as possible.

b. Use of the 1978 report of Reilly and Bellis in determining impacts for the Wrightsville Beach nourishment project should be done very carefully due to differences in the areas being discussed. At Fort Macon, where the studied nourishment took place, sediments came from a reducing

JAN 12 1982

environment and contained significant amounts of silt and clay. In fact, after nourishment, clay balls were present on the beach for weeks after nourishment. This contrasts very sharply with Wrightsville Beach where nourishment material has been, and will continue to be, principally coarse sand and with very little fine material. Reilly and Bellis theorize that it was nourishment related turbidity which had such a dramatic adverse impact on offshore overwintering Emerita, resulting in no adults appearing on the nourished beach during the normal recruitment period. During the nourishment of Wrightsville Beach during the winter of 80/81, there was no turbidity visible in the surf from the ground or air. More significantly, during a field sampling effort conducted by Corps biologists on 6/18/81, all sizes of Emerita were found ranging from adult to post-megalops larvae, indicating that offshore overwintering adults survived. This contrasts sharply with what Reilly and Bellis found at Fort Macon where early recruitment was entirely lacking in adult Emerita.

I hope that these comments, as well as those contained in the attached copy of the draft report, will be given careful consideration during the preparation of the final report. If you have any questions regarding any of these comments, please feel free to contact me.

Sincerely

ROBERT K. HUGHES
Colonel, Corps of Engineers
District Engineer

1 Incl
As stated

CF w/Incl:
Ms. Mike Gantt
U.S. Fish and Wildlife Service
310 New Bern Avenue, Room 468
Raleigh, NC 27601

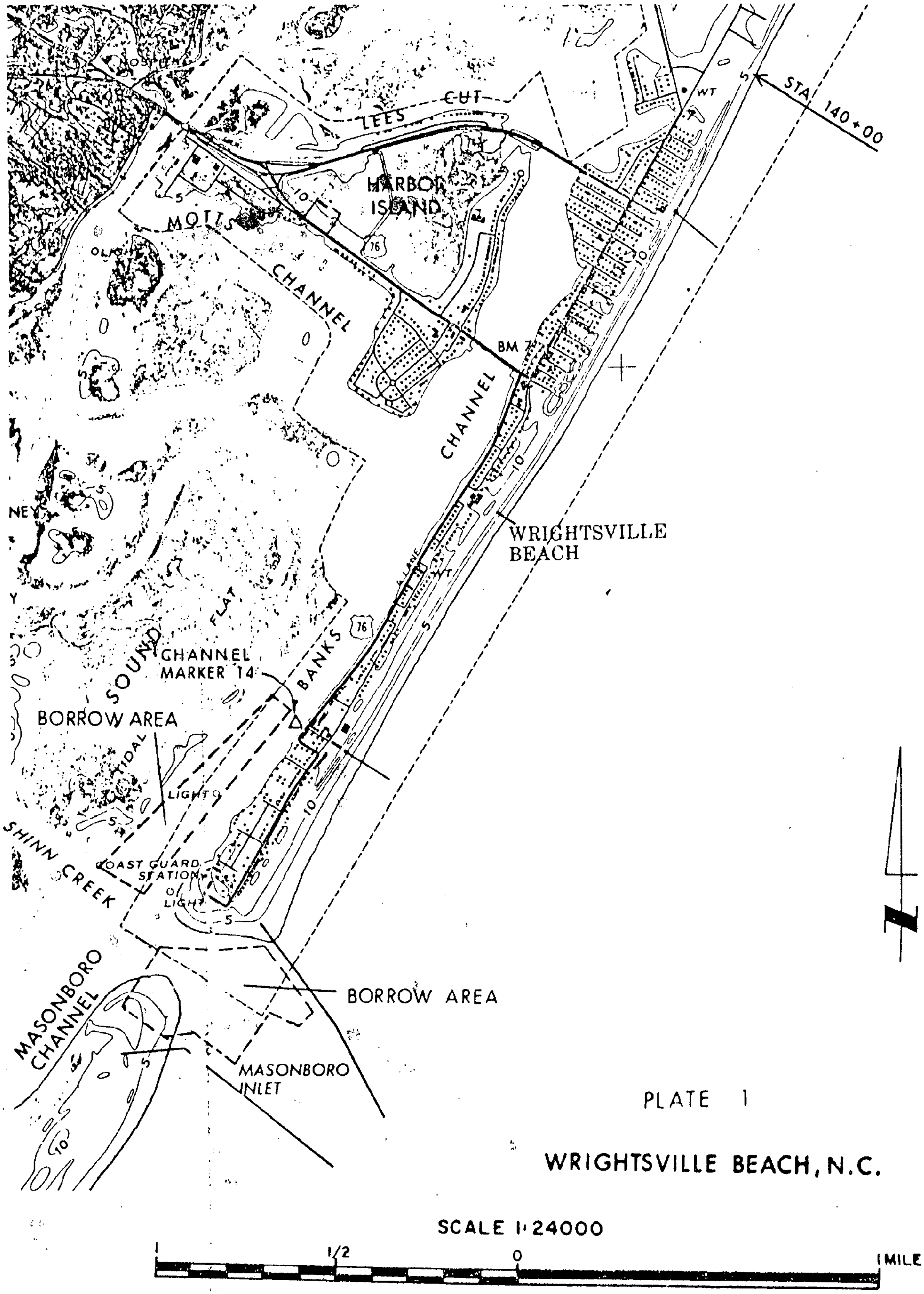


PLATE 1

WRIGHTSVILLE BEACH, N.C.

APPENDIX F

CONSISTENCY DETERMINATION

CONSISTENCY DETERMINATION
CONTINUED FEDERAL PARTICIPATION
IN THE
WRIGHTSVILLE BEACH SHORE
AND HURRICANE WAVE PROTECTION
PROJECT
NEW HANOVER COUNTY, NORTH CAROLINA

Project Description: The current proposal is to continue Federal participation in maintaining the existing shore and hurricane wave protection project, as original authorization provided for only 10 years of Federal involvement after original project construction.

The authorized project consists of a dune with a landward toe at or near the town building line, with a crown width of 25 feet at an elevation of 15 feet above mean low water (MLW) and a 50-foot-wide berm at an elevation of 12 feet above m.l.w. The project extends 14,000 feet from Masonboro Inlet on the south to the location of the northern town limit existing in 1965. Initial construction included the closure of Moore Inlet, which previously separated Wrightsville Beach from Shell Island to the north, and placement of advance nourishment along 2,700 feet of beach, north of the authorized project limit.

As erosion of the existing project is attributable to two sources, natural erosion (53.8%) and erosion caused by the jetties at Masonboro Inlet (46.2%), the costs of maintaining the project will be divided accordingly. The Federal Government will bear 100% of the project maintenance costs attributable to erosion induced by the navigation project at Masonboro Inlet, while the project maintenance costs associated with natural erosion will be cost shared with the local project sponsor (Town of Wrightsville Beach) according to terms laid out in the authorizing document (50% Federal, 50% local).

Erosion of the authorized project at Wrightsville Beach occurs at a rate of 130,000 cubic yards (cu. yds.) per year. Nourishment of the project will occur once every two years; therefore, approximately 260,000 cu. yds. of sand will be placed with each nourishment event. In order to avoid dredging and disposal during periods of high biological and recreational activity, nourishment work will be performed during the established dredging window (October through March).

Two borrow areas will be used to obtain the nourishment material. These borrow areas were used previously during the reconstruction of the project which occurred during the winter of 80/81. One area is located in Banks Channel between Masonboro Inlet and Channel Marker 14. This site will be dredged to a plane of -30 feet mean low water (MLW) during maintenance events. The other area is located in Masonboro Inlet. The Masonboro Inlet site will only be dredged to a depth of -20 feet MLW in order to avoid impacting submerged cultural resources. The boundaries of both of these sites can be seen on plate 1.

Material excavated by the dredge in the borrow areas will be pumped through a submerged pipeline in Banks Channel and, with the aid of a floating booster station, transported to the beach. Short sand dikes will be used on the beach to delay the return of the effluent to the ocean. This will aid in the retention of sand and reduce the amount of turbidity introduced into the surf zone. Bulldozers will be used for spreading and shaping the sand placed on the beach.

The proposed continued Federal participation in the "Wrightsville Beach Erosion Control/Hurricane Protection Project, New Hanover County, North Carolina," is consistent with the Coastal Management Program of the State of North Carolina. The following information supports the consistency determination:

A. Areas of environmental concern (AEC's): The proposed dredging will take place in the estuarine system, and the proposed disposal will take place in the ocean hazard system. The following AEC's will be affected:

ESTUARINE SYSTEM

Estuarine Waters: The proposed dredging in the estuarine system will maintain navigability of the area and will provide borrow material for the maintenance of the berm and dune at Wrightsville Beach.

Public Trust Areas: The dredging operations will not have any significant adverse effects on the biological and physical functions of the estuary.

OCEAN HAZARD SYSTEM

Ocean Erodible Area: The discharge of dredged material will not have any significant adverse effects on ocean beaches, primary dunes, or frontal dunes. The proposed beach disposal will maintain the berm and primary dune at Wrightsville Beach.

High Hazard Flood Areas: The maintenance of the berm and primary dune will provide protection for the high hazard flood areas. The restoration of the berm and dune at Wrightsville Beach would be a direct, significant, beneficial effect to the ocean hazard system.

With respect to general and specific use standards for estuarine system AEC's (15 NCAC 7H .0208):

1. The project is water dependent. (a)(1)

2. The need for the project has been documented in numerous reports, most recently in the "Environmental Assessment for the Continued Federal Participation in the Wrightsville Beach Project," dated April 1982. (a)(2)(A)

3. The project will have minimal effects on important natural resources. (a)(2)(B)

4. The project will not violate any applicable water and air quality standards. (a)(2)(C)

5. The project will not cause any major or irreversible damages to documented archeological, scientific, prehistoric, or historic resources. (a)(2)(D)

6. The dredging will cause a temporary increase in siltation immediately adjacent to the areas being dredged. (a)(2)(E)

7. The dredging will not create stagnant water bodies. (a)(2)(F)

8. Maintenance of the project is currently planned to be performed during the dredging window (October through March). (a)(2)(G)

9. The dredging will promote navigation and use of public trust or estuarine waters. (a)(2)(H)

10. The project will be consistent with the standards for the ocean hazard system AEC's defined in 15 NCAC 7H .0300. (a)(2)(I)

11. The dredging for borrow material will not alter or affect productive shellfish beds, submerged vegetation or regularly or irregularly flooded marsh areas. (b)(1)

12. (b)(2)(A) - N/A

13. The material dredged by pipeline will be taken from the estuarine system and will be deposited on Wrightsville Beach (i.e., ocean hazard system) for the purpose of beach nourishment. (b)(2)(B)

14. (b)(2)(C-F) - N/A

15. Dredging will occur in the estuarine system, and disposal will occur in the ocean hazard system. Although unconfined disposal is inconsistent with standard (b)(2)(B), it is recognized as a viable disposal alternative for beach restoration. Specific exclusion from confinement requirements is provided by standard (b)(2)(G), where overall public benefit dictates departure from confined disposal. (b)(2)(G)

16. Dredge spoil and effluent from open shellfish waters in the estuarine system shall be deposited on Wrightsville Beach (i.e., ocean hazard system). No impact to shellfish areas is anticipated. (b)(2)(H)

With respect to general and specific use standards for ocean hazard system AEC's (15 NCAC 7H .0306):

1. The proposed disposal is for maintenance of a beach erosion control project and, as such, is permitted seaward of the crest of the primary dune. (a)

2. The proposed disposal will reinforce the primary dune at Wrightsville Beach. (b)

3. The proposed disposal involves national and State interests in beach erosion control and hurricane flood protection and, as such, will provide public economic benefits and assure public access to the beach. (c)(1)

4. The proposed disposal will not aggravate existing hazards or damage natural buffers. (c)(2)

5. The proposed disposal will prevent erosion related damage. (c)(3)

6. Since Wrightsville Beach's ocean hazard system has been developed to its potential, the discharge of dredged material for beach restoration will not promote any further development. (c)(4)

7. Disposal will not cause major or irreversible damage to valuable documented historic, architectural, or archeological resources. (d)

8. 15 NCAC 7H .0306 (e): Not applicable. (e)

9. 15 NCAC 7H .0306 (f): Not applicable. (f)

10. The disposal is consistent with the general management objective for ocean hazard areas set forth in 15 NCAC 7H .0303. (g)

11. The terms of local cooperation are documented in House Document 511, 87th Congress, 2nd Session, dated 22 March 1962, "Interim Hurricane Survey of Wrightsville Beach, N.C.," authorized by PL 71, 84th Congress, approved 15 June 1955. One of those terms is as follows:

> "a. Assure continued public ownership of the shore upon which the amount of Federal participation in the beach-protection phase is based, and its administration for public use during the economic life of the project."

Therefore, legal access to and use of public resources is assured throughout the life of the project. (h)

12. The proposed disposal incorporates all reasonable means and methods to minimize adverse impacts. (i)(1-3)

With respect to general and specific use standards for ocean hazard system (15 NCAC 7H .0308):

1. The proposed disposal will not have any significant adverse impacts on wildlife habitats, as set forth in Rule .0306 (i) (15 NCAC 7H .0306) of this determination. (a)(1)

2. The proposed disposal is timed to have minimum significant adverse effects on biological activity. (a)(2)

3. 15 NCAC 7H .0308 (a)(3): Not applicable. (a)(3)

4. The proposed maintenance is designed for erosion control and hurricane wave protection. (a)(4)

5. Beach maintenance is the most effective erosion control measure for the site. (a)(5)

6. 15 NCAC 7H .0308 (a)(6): Not applicable (a)(6)

7. 15 NCAC 7H .0308 (a)(7): The proposed beach maintenance at Wrightsville Beach is excluded from this specific use standard. (a)(7)

8. The proposed disposal will maintain the dune and berm at Wrightsville Beach at its current alignment and configuration. (b)(1)

9. 15 NCAC 7H .0308 (b)(2): The proposed beach maintenance at Wrightsville Beach is excluded from this specific use standard. (b)(2)

10. The proposed disposal will be accomplished in such a manner as to limit adverse impacts to existing vegetation. Dune vegetation will be replanted as necessary. (b)(3)

11. The proposed "borrow" material will be excavated from the estuarine system (see attached map) and is of the same nature as the sand in the disposal area. (b)(4)

12. No new dunes will be created in the inlet hazard area. (b)(5)

13. 15 NCAC 7H .0308 (c)(1-3): Not applicable. (c)(1-3)

14. 15 NCAC 7H .0308 (d)(1-10): Not applicable. (d)(1-10)

B. Land Use Plans: The project is located entirely in New Hanover County. Wrightsville Beach land classification maps indicate that the dredging and disposal portions of the project are in an area designated as "conservation." The conservation class identifies lands that are fragile, present hazards to development, or are necessary to maintain a balanced environment. Existing Wrightsville Beach land use maps indicate that the disposal portion of the project is in an area designated as "barren," and that the dredging portion of the project is in an area designated as "water." Such areas will be maintained basically in their natural state.

Impacts on the conservation, barren, and water areas are expected to be minimal.

C. State Guidelines:

1. For AEC's: See paragraph A.

2. For Land Use Plan: See paragraph B.

3. General Policy (15 NCAC 7M) Section .0202 - Shoreline Erosion Policies:

(a) No losses to North Carolina's natural heritage are anticipated. (a)

(b) The proposed action at Wrightsville Beach will maintain the existing project at its congressionally authorized dimensions. The maintenance will be conducted in a manner designed to minimize impacts on the estuary, the barrier island, and the nearshore zone, while still providing erosion control and hurricane flood protection. (b)

(c) 15 NCAC 7M .0202 (c): Not applicable. (c)

(d) The continued maintenance of the Wrightsville Beach, N.C., project has been coordinated with the appropriate planning agencies, affected governments, and the interested public. (d)

(e) 15 NCAC 7M .0202 (e): Not applicable. (e)

4. General Policy (15 NCAC 7M) Section .0303 - Shorefront Access Policies:

a. 15 NCAC 7M .0303 (a, b, c, d, e, and h): The public will have adequate access to public trust resources, the ocean, sounds, rivers, and tributaries. The proposed beach maintenance will enhance public use of Wrightsville Beach. The proposed disposal will not interfere with the public's right of access to the shorefront (see paragraph 11 under 15 NCAC 7H .0306 of this determination) since public access is required as part of the terms of local cooperation for the project.

b. 15 NCAC 7M .0303 (f): Not applicable. (f)

c. The proposed disposal is designed to maintain the dune and berm at Wrightsville Beach at its authorized dimensions. (g)

D. Other State Policies: Review of the State policies found in chapter 3 of the Coastal Management Program document indicates that the project is in accordance with policies on navigation, water and air, recreational and tourism resources, Federal consistency and national interest.

The major policies and laws of the State that were specifically reviewed were the following:

1. The Coastal Area Management Act of 1974.

2. The Dredge and Fill Law (See paragraphs A-C of this determination.)

The proposed method of unconfined pipeline disposal does not conform to the requirement for confined disposal as stated in the Dredge and Fill Law. However, if the maintenance of Wrightsville Beach is to be accomplished, no other viable alternatives are practicable. (See paragraph A.13 under 15 NCAC 7H .0208 of this determination.)

3. The N. C. Sedimentation Pollution Control Act.

With respect to control of sedimentation and erosion, the proposed project is designed to promote sedimentation and reduce erosion. It was determined that, due to the current persistent erosion of the beach, the proposed beach maintenance would aid in erosion control.

4. Water quality regulations. A Section 401 Water Quality Certificate has been requested concurrent with this consistency determination.

The proposed maintenance of the Wrightsville Beach, N.C., project (New Hanover County, North Carolina) is consistent with the Coastal Management Program of the State of North Carolina.

Robert K. Hughes

ROBERT K. HUGHES
Colonel, Corps of Engineers
District Engineer

1 Incl:
Map
DATE: 28 July 82

APPENDIX G

SECTION 404(b) (PL 95-217) EVALUATION REPORT

SECTION 404(b) (PL 95-217) EVALUATION REPORT
CONTINUED FEDERAL PARTICIPATION
IN THE
WRIGHTSVILLE BEACH SHORE
AND HURRICANE WAVE PROTECTION
PROJECT
NEW HANOVER COUNTY, NORTH CAROLINA

I. PROJECT DESCRIPTION

a. Location. Wrightsville Beach, New Hanover County, North Carolina.

b. General Description.

The authorized project consists of a dune with a landward toe at or near the town building line, with a crown width of 25 feet at an elevation of 15 feet above mean low water (MLW) and a 50-foot-wide berm at an elevation of 12 feet above MLW. The project extends 14,000 feet from Masonboro Inlet on the south to the location of the northern town limit existing in 1965. Initial construction included the closure of Moore Inlet, which previously separated Wrightsville Beach from Shell Island to the north, and placement of advance nourishment along 2,700 feet of beach north of the authorized project limit.

The current proposal is to continue Federal participation in maintaining this project, as original authorization provided for only 10 years of Federal involvement after original project construction.

As erosion of the existing project is attributable to two sources, natural erosion (53.8%) and erosion caused by the jetties at Masonboro Inlet (46.2%), the costs of maintaining the project will be divided accordingly. The Federal Government will bear 100% of the project maintenance costs attributable to erosion induced by the navigation project at Masonboro Inlet, while the project maintenance costs associated with natural erosion will be cost shared with the local project sponsor (Town of Wrightsville Beach) according to terms laid out in the authorizing document (50% Federal, 50% local).

Erosion of the shore and hurricane wave protection project at Wrightsville Beach occurs at a rate of 130,000 cubic yards (cu. yds.) per year. Nourishment of the project will occur once every two years; therefore, approximately 260,000 cu. yds. of sand will be placed with each nourishment event. In order to avoid dredging and disposal during periods of high biological and recreational activity, nourishment work will be performed during the established dredging window (October through March).

Two borrow areas will be used to obtain the nourishment material. These borrow areas were used previously during the reconstruction of the project which occurred during the winter of 80/81. One area is located in Banks Channel between Masonboro Inlet and Channel Marker 14. This site will be dredged to a plane of -30 feet mean low water (MLW) during maintenance events. The other area is located in Masonboro Inlet. The Masonboro Inlet site will only be dredged to a depth of -20 feet MLW in order to avoid impacting submerged cultural resources. The boundaries of both of these sites can be seen on plate 1.

Material excavated by the dredge in the borrow areas will be pumped through a submerged pipeline in Banks Channel and, with the aid of a floating booster station, transported to the beach. Short sand dikes will be used on the beach to delay the return of the effluent to the ocean. This will aid in the retention of sand and reduce the amount of turbidity introduced into the surf zone. Bulldozers will be used for spreading and shaping the sand placed on the beach.

c. Authority and Purpose.

Authorization of the existing Wrightsville Beach, NC, project was provided by Public Law 84-874, 87th Congress, H. R. 13273 23 October 1962 (House Document 511, 87th Congress, 2nd session).

The authority for this study is contained in a resolution of the Committee on Public Works of the U.S. House of Representatives, dated 2 December 1970. The resolution was initiated by Congressman Alton Lennon, and requested the Secretary of the Army to direct the Office of the Chief of Engineers to make a survey of "Wrightsville Beach, North Carolina, and adjacent beaches in the interest of beach erosion control, hurricane protection and related purposes, including oceanic and lagoonal shores and interconnected tidal channels."

d. General Description of Dredged or Fill Material.

(1) General Characteristics of Material: The material to be discharged is predominantly sand, with minor amounts of shell fragments and silt and/or clay.

(2) Quantity of Material: Approximately 260,000 cubic yards of material will be discharged during each maintenance event.

(3) Source of Material: The material proposed for discharge is naturally occurring sands which have been deposited in Banks Channel and Masonboro Inlet.

e. Description of the Proposed Discharge Site.

(1) Location: The location of the discharge site is shown on figure 1.

(2) Size: The discharge area extends northward from Masonboro Inlet 16,700 feet (14,000 feet project length, 2,700 feet transition).

(3) Type of Site: The discharge will be on the beach at Wrightsville Beach, NC.

(4) Type of Habitat: Beachfront and nearshore ocean habitat will be affected.

(5) Timing and Duration of Discharge: Discharge will occur approximately once every two years for the project life. The discharges will occur between 1 October and 31 March.

f. Description of Disposal Method. Sand will be pumped from the borrow sites and discharged onto the beach by a pipeline dredge. Short sand dikes will be used on the beach to delay the return of the effluent to the ocean. Bulldozers will be used for spreading and shaping the sand placed on the beach.

II. FACTUAL DETERMINATIONS

a. Physical Substrate Determinations.

(1) Substrate Elevation and Slope: All of the discharged material will be placed on the beach and will decrease the bathymetry of the area.

(2) Sediment Type: Material placed on the beach will be similar to that which is covered.

(3) Dredged/Fill Material Movement: Material placed on the beach will be subject to normal wave action and will undergo substantial movement.

(4) Physical Effects on Benthos: Benthic populations on the beach will be disrupted by the discharge. Populations should reestablish quickly as the new substrate will be similar in nature to that which existed prior to the discharge.

(5) Other Effects: Not applicable.

(6) Actions Taken to Minimize Impacts: None.

b. Water Circulation, Fluctuation, and Salinity Determinations.

(1) Water:

(a) Salinity. No effect.

(b) Water chemistry. No effect.

(c) Clarity. Some turbidity may result from deposition of sand; however, due to the coarseness of the material, this effect is expected to be limited.

(d) Color. No effect.

(e) Odor. Not applicable.

(f) Taste. Not applicable.

(g) Dissolved Gas Levels. Not applicable.

(h) Nutrients. No effect.

(i) Eutrophication. No effect.

(j) Others as Appropriate. Not applicable.

(2) Current Patterns and Circulation:

(a) Current Patterns and Flow. No effect.

(b) Velocity. No effect.

(c) Stratification. No effect.

(d) Hydrologic Regime. No effect.

(3) Normal Water Level Fluctuations: No effect.

(4) Salinity Gradients: No effect.

(5) Actions That Will Be Taken to Minimize Impacts: None.

c. <u>Suspended Particulate/Turbidity Determinations</u>.

(1) Expected Changes in Suspended Particulates and Turbidity Levels in Vicinity of Disposal Site: Little turbidity should be associated with project maintenance as the disposal material will be principally coarse sand taken from Masonboro Inlet and Banks Channel. Previous nourishment events using materials from this location have not produced significant turbidity levels.

(2) Effects on Chemical and Physical Properties of the Water Column:

(a) Light penetration. Reduction in light penetration should be slight as turbidity levels are expected to be low.

(b) Dissolved Oxygen. No significant effect.

(c) Toxic Metals and Organics. Not applicable.

(d) Pathogens. Not applicable.

(e) Esthetics. Turbidity will not be of sufficient magnitude to detract from the esthetics of the area.

(f) Other. Not applilcable.

(3) Effects on Biota:

(a) Primary production, photosynthesis. Effects should be slight, as turbidity levels will be low.

(b) Suspension/filter feeders. Deposition of sands will disturb sedentary organisms occurring in the disposal site. Effects of turbidity are expected to be slight.

(c) Sight feeders. Turbidity is not expected to be serious enough to significantly affect sight feeding organisms.

(4) Actions Taken to Minimize Impacts: Short sand dikes will be used to delay the return of effluent to the surf zone.

d. Contaminant Determinations. Due to the coarseness of the material to be disposed and the fact that it is from noncontaminated sources, deposition will not introduce, relocate, or increase contaminants.

e. Aquatic Ecosystem and Organism Determinations.

(1) Effects on Plankton: Effects should be slight, as turbidity levels will be low.

(2) Effects on Benthos: Benthic communities within the project area will be disrupted with each nourishment event. Due to the similarity of the fill material to that already occurring on the beach, reestablishment of stable benthic communities should occur rapidly after each nourishment event.

(3) Effects on Nekton: No significant adverse impacts on nekton are anticipated, as losses of benthic organisms will be temporary.

(4) Effects on Aquatic Food Web: Temporary disturbance of benthic communities will disrupt energy flow from lower to higher trophic levels. This impact will be limited in scope and duration, and is not considered significant.

(5) Effects on Special Aquatic Sites:

(a) Sanctuaries and refuges. Not applicable.

(b) Wetlands. No wetlands will be affected by the proposed discharge.

(c) Mud flats. Not applicable.

(d) Vegetated shallows. Not applicable.

(e) Coral reefs. Not applicable.

(f) Riffle and pool communities. Not applicable.

(6) Threatened and Endangered Species: A "no effect" determination has been reached through the biological assessment process.

(7) Other Wildlife: Wildlife of the beachfront should be unaffected.

(8) Actions to Minimize Impacts: None.

f. Proposed Disposal Site Determination.

(1) Mixing Zone Determination: The mixing zone will be minimal due to the coarse and uncontaminated nature of the material to be deposited.

(2) Determination of Compliance with Applicable Water Quality Standards: A Section 401 Water Quality Certificate has been applied for from the State of North Carolina.

(3) Potential Effects on Human Use Characteristics:

(a) Municipal and private water supply. No effect.

(b) Recreational and commercial fisheries. Fishing should be unaffected by the project due to the minor affects on natural resources and the timing of the disposal activities.

(c) Water related recreation. Recreation should be enhanced by the project, as the existing heavily used beach will be kept from eroding. Since disposal will be performed during the off-season (October through March), direct impacts on beach goers will be limited.

(d) Esthetics. By maintaining the existing beach profile, the high quality esthetics of the beach will be retained.

(e) Parks, national and historic monuments, national seashores, wilderness areas, research sites, and similar preserves. Not applicable.

g. Determination of Cumulative Effects on the Aquatic Ecosystem. The project should not contribute to any adverse cumulative impacts, as it is relatively isolated from other areas where beach construction activity has occurred or will occur. Biennial disruption of beach invertebrate macrofauna is not expected to have any significant long-term effects.

h. Determination of Secondary Effects on the Aquatic Ecosystem. No secondary effects on the aquatic ecosystem are anticipated.

FINDING OF COMPLIANCE
FOR
CONTINUED FEDERAL PARTICIPATION
IN THE
WRIGHTSVILLE BEACH SHORE
AND HURRICANE WAVE PROTECTION
PROJECT
NEW HANOVER COUNTY, NORTH CAROLINA

1. No significant adaptations of the guidelines were made relative to this evaluation.

2. All alternatives, except flood proofing and no action, would require the placement of fill material. Of all the alternatives considered, only the proposed continued Federal participation in the project is economically feasible and environmentally acceptable; therefore, there is no practicable alternative to the proposed discharges which would have less adverse effect on the aquatic ecosystem.

3. A Section 401 Water Quality Certificate has been requested from the State of North Carolina. Project construction will not violate the Toxic Effluent Standards of Section 307 of the Clean Water Act.

4. Continued maintenance of the existing project will not harm any endangered species or their critical habitat or violate the protective measures for any marine sanctuaries.

5. The proposed placement of fill material will not result in significant adverse effects on human health and welfare, including municipal and private water supplies, recreational and commercial fishing, plankton, fish, shellfish, wildlife, and special aquatic sites. The life stages of aquatic and other wildlife will not be adversely affected. Significant adverse effects on aquatic ecosystem diversity, productivity and stability, and recreational, esthetic, and economic values will not occur.

6. Appropriate steps to minimize potential adverse impacts of the discharge on aquatic systems include timing the nourishment actions to occur during periods of low biological activity and using short sand dikes on the beach to maximize retention of effluent.

7. On the basis of this analysis, the proposed fill site is specified as complying with the requirements of the guidelines.

Robert K. Hughes

ROBERT K. HUGHES
Colonel, Corps of Engineers
District Engineer

DATE: 4 October 1982

APPENDIX H

PERTINENT CORRESPONDENCE

APPENDIX H

PERTINENT CORRESPONDENCE

Table of Contents

U.S. Department of Transportation
United States Coast Guard

Commander
Fifth Coast Guard District

Federal Building
431 Crawford Street
Portsmouth, VA 23705
Staff Symbol: (dpl)
Phone: (804) 398-6270

16000
Ser 2135

24 AUG 1982

From: Commander, Fifth Coast Guard District
To: Department of the Army, Wilmington District, Corps of Engineers, P.O. Box 1890, Wilmington, North Carolina 28400 (Attn: SAWPD-EA)

Subj: Draft Feasibility Report and Environmental Assessment on Hurricane Protection and Beach Erosion Control at Wrightsville Beach, North Carolina

1. The Fifth Coast Guard District offers no comments concerning the subject DEIS.

H. A. TAWNEY
By direction

United States Department of the Interior
FISH AND WILDLIFE SERVICE
Division of Ecological Services
310 New Bern Ave. Room 466
Raleigh, North Carolina 27601-1470

3 SEP 1982

September 1, 1982

Colonel Robert Hughes
District Engineer
U.S. Army Corps of Engineers
P.O. Box 1890
Wilmington, North Carolina 28402

Dear Colonel Hughes:

In response to your letter of August 19, 1982, the Service has reviewed the Draft Feasibility Report and Environmental Assessment prepared for the Hurricane Protection and Beach Erosion Control Project at Wrightsville Beach, New Hanover County, North Carolina (SAWPD-EA), and we offer the following comments for your consideration. This is the report of the Service and the Department of the Interior and is submitted in accordance with provisions of the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C., 661 et seq.).

Generally, we believe the report is adequate with the exception of specific concerns addressed herein. The Service participated fully in the planning process for this project, and we provided comments and recommendations during that period. We are pleased that the Corps has utilized, and will apparently continue to utilize, borrow sites which we identified as having relatively low population densities of benthic organisms. Since it appears that beach nourishment and sand bypassing will occur every two years, we recommend that project maintenance be in accordance with Service recommendations contained in our Final Fish and Wildlife Coordination Act Report of March 2, 1982.

Although we generally concur with your assessment of anticipated project impacts, we do not believe that the impacts of periodic placement of sand in the littoral zone of the ocean beach are known. These impacts range in magnitude from minor short-term losses of near shore fauna to prolonged reductions in the population size of these species. Since any major long-term reduction in near shore populations could adversely affect local recreational and commercial fisheries, we continue to recommend that the effects of periodic disposal of dredged materials in the ocean littoral zone be studied further.

Specific Comments

Page 23, paragraph 1: Clarification is needed to explain why the preservation of Shell Island cannot be linked to the selected alternative. We assume that Corps regulations prohibit the expansion of project's boundaries when non-structural features are involved; however, this is not clear in the draft report.

We appreciate the opportunity to comment on this report.

Sincerely yours,

L. K. (Mike) Gantt
Field Supervisor

DEXTER L. HAYES
PLANNING DIRECTOR

PLANNING DEPARTMENT
NEW HANOVER COUNTY

320 CHESTNUT STREET
WILMINGTON, NORTH CAROLINA 28401

September 3, 1982

Col. Robert Hughes
Corps of Engineers
P. O. Box 1890
Wilmington, NC 28402

RE: SAWPD-EA

Dear Col. Hughes:

Our Planning staff has reviewed the draft Feasibility Report and Environmental Assessment and would offer the following comments.

Impacts to the environment should be minor and of short duration. When combined with the maintenance objective of Masonboro Inlet this dual approach of dredging and beach nourishmentseems quite acceptable.

In regard to the Feasibility Report several questions arise concerning the cost benefit analysis. Potential loss to land and structures includes damages to private property. Direct benefits to these properties are actually private rather than public. Since these individual land owners represent the greatest amount of benefit in any public expenditure, a more equitable comparison might be the potential annual tax value of the property. Certainly, that loss would have a broader impact on the community.

Continued funding of beach nourishment projects should be a burden of those who utilize the beaches. This could be accomplished through special district taxes or certain excise taxes.

Maximum setback requirements should be a condition of further funding. Adequate setbacks can take advantage of the natural shoreline and large primary dunes that act as barriers and offer protection for inland development.

Is the proposed plan consistent with the Department of Interior and FEMA's classification of Shell Island as "Undeveloped?"

We hope these comments are useful and we appreciate the opportunity to review the report.

Sincerely yours,

Dexter Hayes
Planning Director

cc Mr. G. Felix Cooper, County Manager

DH/glt

North Carolina
Department of Administration
116 West Jones Street Raleigh 27611

James B. Hunt, Jr. Governor
Jane Smith Patterson, Secretary

Margaret C. Riddle
Coordinator
Office of Policy and Planning
(919) 733-4131

September 20, 1982

Mr. Robert K. Hughes
Colonel, Corps of Engineers
Department of the Army
Wilmington District Office
P.O. Box 1890
Wilmington, North Carolina 28402

Dear Mr. Hughes:

RE: SCH File #83-E-0000-5039; Feasbility Report and Environmental Assessment for Hurricane Protection and Beach Erosion Control at Wrightsville Beach, N.C.

The State Clearinghouse has received and reviewed the above referenced project. As a result of this review, the State Clearinghouse has received the attached comments from the North Carolina Department of Natural Resources and Community Development.

Thank you for the opportunity to review the above referenced document.

Sincerely,

Chrys Baggett

Chrys Baggett (Mrs.)
Clearinghouse Director

CB/njh

Attachment(s)

cc: Region (O)

North Carolina Department of Natural Resources & Community Development
James B. Hunt, Jr., Governor
Joseph W. Grimsley, Secretary

NATURAL RESOURCES PLANNING AND ASSESSMENT
Telephone 919 733-6376
Anne Taylor
Deputy Assistant Secretary
Telephone 919 733-4984

SEP 1982

MEMORANDUM

To: Chrys Baggett
State Clearinghouse

From: Melba Strickland
Environmental Assessment Section

Re: 83-5039 - Feasibility Report & Environmental Assessment on Hurricane Protection & Beach Erosion Control Project
Wrightsville Beach

Date: September 17, 1982

The Department of Natural Resources & Community Development has reviewed the subject proposal and has the following comments from the Office of Coastal Management to offer at this time. All other reviewing divisions had no comment.

Plan Number Five (5) has been the chosen alternative for continued maintenance of the beach renourishment project. The same borrow areas are proposed including that area south of Marker #14 in banks channel and the inlet wier collection reservoir. The Office of Coastal Management's major agency concerns aren't centered on the continued use of these borrow areas which are highly disturbed deep water, sandy bottom sites, but the timing of the dredging activities. As stated before, it is very important in order to protect juvenile shrimp and fin fish populations that no excavation or filling occur between April 1 and September 30 of any given year. The Office of Coastal Management would recommend that the winter months become considered for such operations to lessen impacts to ocean surf feeding fish as well.

The Wrightsville Beach Land Use Plan heavily concentrates its biggest problem as finding funds to continue the maintenance of the renourishment project. It states ... "That the preferred alternative for erosion control be renourishment, supplemented by land use controls, access planning and vegetation maintenance". It is hoped that the Corps' recommendation would also include a note that explains the specific land use and flood proofing recommendations described in Plans #2 and #4 to be implemented as much as feasible. Even though the benefit-to-cost ratios were found to be not favorable for these two plans, it should be recognized that emergency phases of future maintenance north of the defined project limits (Shell Island) are inevitable and that the town should acquire public beach access easements along these private streets. The final Corps' recommendation should be emphatically clear about Federal participation contingent upon provision of beach access through the existing Shell Island private development.

The rest of the Plan #5 appears to be consistent with the Land Use Plan and CAMA guidelines.

Thank you for the opportunity to review. If questions arise, please notify me at 733-6376.

MS:lp

TOWN OF WRIGHTSVILLE BEACH
TOWN HALL 400 WAYNICK BOULEVARD • P. O. BOX 626
WRIGHTSVILLE BEACH, N. C. 28480

September 27, 1982

Col. Robert Hughes
Department of Army
Corps of Engineers
P. O. Box 1890
Wilmington, North Carolina 28402

Dear Col. Hughes:

We are in receipt of and have reviewed the draft Feasibility Report and Environmental Assessment Document. While we are perhaps disappointed in the benefit-to-cost ratios developed in preliminary plans 1A, 1B, 2, 3, 3A and 4, the findings were not totally unexpected.

It is the position of the Town that the conclusions drawn and the recommendations made are in order and should be supported by the Town. We further totally agree that there is no necessity for an EIS and the Finding of No Significant Impact statement should be signed.

Please advise if we may be of further assistance.

Sincerely yours,

Eugene N. Floyd

Eugene N. Floyd, Mayor
TOWN OF WRIGHTSVILLE BEACH

mcd

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

REGION IV

345 COURTLAND STREET
ATLANTA, GEORGIA 30365

[illegible]

SEP 28 [illegible]

Colonel Robert K. Hughes
U.S. Army Corps of Engineers, Wilmington
P.O. Box 1890
Wilmington, North Carolina 28402

Dear Colonel Hughes:

We have reviewed the Draft Feasibility Report and Environmental Assessment on the Hurricane Protection and Beach Erosion Control Project at Wrightsville Beach, New Hanover County, North Carolina. Our evaluation of the document revealed it to be well prepared and that the proposed action should cause little in the way of long-term and/or significant adverse environmental consequences over which this Agency has mandated authority.

However, we do observe that while the selected alternative may provide some temporary increases in the areal extent of the beach, it actually may foster the potential for future increased property losses there. For example, using excess project funds from a previous authorization, Moore's Cut was filled in and Shell Island connected to Wrightsville Beach. The subsequent development to the north including a Holiday Inn were seriously threatened until another emergency nourishment was undertaken (see enclosed photographs). Hence, it has been our experience that beach nourishment often engenders improvident development. This development in turn creates the demand for even more protection at ever increasing Federal cost.

"Saving the American Beach: A Position Paper by Concerned Coastal Geologists" contains some provocative information on this subject. Mr. Richard Jackson of your staff has a copy should you care to read it. Its premise could figure largely in your public interest determination on this facility.

Sincerely yours,

[signature]

Sheppard N. Moore, Chief
Environmental Review Section
Environmental Assessment Branch

Enclosure

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Southeast Region
9450 Koger Boulevard
St. Petersburg, FL 33702

May 11, 1982 F/SER64:AM

Colonel Robert K. Hughes
District Engineer, Wilmington District
U.S. Army Corps of Engineers
P. O. Box 1890
Wilmington, NC 28402

Dear Colonel Hughes:

This responds to your April 30, 1982, letter regarding the multi-objective planning study of Wrightsville Beach, North Carolina, and Section 7 of the Endangered Species Act of 1973 (ESA).

We agree that the Corps' January 1980 biological assessment would also apply to the subject planning effort. Accordingly, our March 3, 1980, letter on this project continues to apply (i.e., we concur with your determination that endangered/threatened species under our purview would not be affected).

This concludes consultation responsibilities under Section 7 of the ESA. However, consultation should be reinitiated if new information reveals impacts of the identified activity that may affect listed species or their critical habitat, a new species is listed, the identified activity is subsequently modified or critical habitat determined that may be affected by the proposed activity.

Sincerely yours,

Chuck Oravetz

Charles A. Oravetz
Chief, Marine Mammals and Endangered Species Branch

cc:
FWS, Asheville, NC

United States Department of the Interior
FISH AND WILDLIFE SERVICE
PLATEAU BUILDING, ROOM A-5
50 SOUTH FRENCH BROAD AVENUE
ASHEVILLE, NORTH CAROLINA 28801

May 7, 1982

Lieutenant Colonel A. A. Kopcsak
Acting District Engineer
U.S. Army Corps of Engineers
P.O. Box 1890
Wilmington, North Carolina 28402

Re: 4-2-82-287

Dear Colonel Kopcsak:

We agree to accept your earlier biological assessment (4-2-79-A-285) regarding pelican, manatee, and loggerhead turtle for the proposed 40-year erosion control and hurricane protection work at Wrightsville Beach in New Hanover County, North Carolina, submitted April 22, 1982.

The biological assessment is adequate and supports the conclusion of no effect with which we concur. In view of this, we believe that the requirements of Section 7 of the Endangered Species Act have been satisfied. However, obligations under Section 7 of the Act must be reconsidered if (1) new information reveals impacts of this identified action that may affect listed species or Critical Habitat in a manner not previously considered, (2) this action is subsequently modified in a manner which was not considered in this biological assessment (i.e. summer work), or (3) a new species is listed or Critical Habitat determined that may be affected by the identified action.

Your interest and initiative in enhancing Endangered and Threatened species is appreciated.

Sincerely yours,

William C. Hickling
Area Manager

cc:
Mr. Stuart Critcher, NC Wildlife Res. Commission, Raleigh, NC
Director, NC Natural Heritage Program, Raleigh, NC
Director, FWS, Washington, DC (AFA/OES)
Regional Director, FWS, Atlanta, GA (ARD-FA/SE)
Field Supervisor, ES, FWS, Raleigh, NC

TOWN OF WRIGHTSVILLE BEACH
TOWN HALL 400 WAYNICK BOULEVARD • P. O. BOX 626
WRIGHTSVILLE BEACH, N. C. 28480

October 29, 1970

The Honorable Alton A. Lennon, M. C.
Rayburn House Office Building
Washington, D. C. 20001

Dear Congressman Lennon:

I am authorized by the Board of Aldermen to request that you initiate the inclusion into the necessary authorization and appropriation acts of the Congress the following studies. It is our feeling that an early accomplishment of these studies is necessary and vital to us here.

1. A study to supplement and continue investigation of the shore erosion and beach process on the ocean shore at Wrightsville Beach between Mason's Inlet and Masonboro Inlet. This would expand current programs and projects to include all of the continuous shores between these inlets and should result in renewal of the present erosion and hurricane protection project at its presently scheduled termination.

2. A separate study to investigate the present erosion of the shores of Banks Channel, Motts Channel and other connected waterways within and adjacent to the Town of Wrightsville Beach. Erosion from currents and wave wash is causing a rapid loss of materials which threaten to ultimately destroy improvements such as roadways, structures, dwellings, piers, bulkheads, water supply well houses, pipelines and other facilities. This condition has appeared to accelerate as a result of recent improvements and increased traffic.

We will be pleased to provide together with New Hanover County and the State of North Carolina sponsorship of projects which may be recommended as a result of these studies and will provide all available records, data and right of way for use in making the study.

We respectfully request that you keep us advised as to the status of this request and your action concerning it.

Very sincerely yours,

Luther T. Rogers, Jr.

Luther T. Rogers, Jr., Mayor
Town of Wrightsville Beach,
North Carolina

LTR.Jr:jb

Copies to:

Col. Paul Denison, District Engineer
U. S. Army Corps of Engineers
P. O. Box 1890
Wilmington, North Carolina 28401

Mr. George E. Pickett, Director
State of North Carolina
Department of Water and Air Resources
P. O. Box 27048
Raleigh, North Carolina 27611

Mr. John Van B. Metts, Chairman
New Hanover County Commissioners
New Hanover County Court House
Wilmington, North Carolina 28401

RESOLUTION

Resolution providing the Town's intent to comply with the federally required items of local cooperation for the shore and hurricane wave protection project for Wrightsville Beach, North Carolina.

WHEREAS, in order for the U.S. Army Corps of Engineers to pursue the required congressional authorization for continued Federal participation in the cost sharing of beach nourishment for the life of the existing Shore and Hurricane Wave Protection at Wrightsville Beach, the Town of Wrightsville Beach has been requested to comply with the federally required items of local cooperation, and;

WHEREAS, the federally required items of local cooperation are as outlined below;

a. Provide all lands, easements, and rights-of-way, including borrow areas, necessary for construction of the project.

b. Accomplish all relocations and alterations of sewerage and drainage facilities, buildings, streets, utilities, and other structures made necessary by the construction.

c. Hold and save the Government free from damages that may result due to the maintenance of the project other than damages due to the fault or negligence of the Government or the Contractors.

d. Contribute its proportionate share of the cost of the periodic nourishment to be performed by the Government.

e. Maintain during the economic life of the project, continued public ownership of the publicly-owned shore upon which the Federal participation is based.

f. Adopt and enforce appropriate ordinances to provide for the preservation of the improvement and its protective vegetation.

g. Control water pollution to the extent necessary to safeguard the health of bathers.

h. Continue to enforce flood plain regulations that comply with Federal Emergency Management Agency (FEMA) guidelines.

Now, Therefore, be it resolved by the Board of Aldermen of Wrightsville Beach, North Carolina.

Section 1. That this Board hereby intends to comply with the above federally required items of local cooperation.

Section 2. That this Board recognizes that this resolution does not bind the Town to any or all of the required items of local cooperation, and prior to nourishment of the project an agreement must be entered into between the Federal Government and Wrightsville Beach.

Done at Wrightsville Beach, North Carolina this 10th day of February, 1983.

Eugene N. Floyd
Eugene N. Floyd, Mayor

ATTEST:

H. H. Perry, Jr.
H. H. Perry, Jr., Town Clerk

JUN 15 1983

DAEN-CWP-A

Honorable Malcolm Baldrige
Secretary of Commerce
Washington, DC 20230

Dear Mr. Secretary:

Four copies of the proposed report of the Chief of Engineers on Wrightsville Beach, North Carolina, and other pertinent reports are being forwarded to the Director, Office of Regulatory Policy.

In accordance with established coordination procedures on water resources reports, we would appreciate receiving your comments and recommendations on the report within 90 days, or preferably at such earlier date as may be convenient. Please direct your response to:

Lieutenant General J. K. Bratton
Chief of Engineers
ATTN: DAEN-CWP
Department of the Army
Washington, DC 20314

Sincerely yours,

James W. Ray
Colonel, Corps of Engineers
Executive Director, Engineer Staff

CF:
Director, Office of Regulatory Policy, w/3 enclosures (4 cys)
1. Proposed Chief's Rpt
2. BERH Rpt
3. Dist Engr Rpt, dtd Sep 82

Proposed Report*

DEPARTMENT OF THE ARMY
OFFICE OF THE CHIEF OF ENGINEERS
WASHINGTON, D.C. 20314

REPLY TO ATTENTION OF:

DAEN-CWP-A

SUBJECT: Wrightsville Beach, North Carolina

THE SECRETARY OF THE ARMY

1. I submit for transmission to Congress my report on Wrightsville Beach, North Carolina. It is accompanied by the reports of the Board of Engineers for Rivers and Harbors and the Division and District Engineers. These reports are in response to a resolution adopted 2 December 1970 by the Committee on Public Works of the United States House of Representatives. The Committee requested the Secretary of the Army to direct the Chief of Engineers to make a survey of Wrightsville Beach and adjacent beaches in the interest of erosion control, hurricane protection, and related purposes.

2. The District and Division Engineers considered various structural and nonstructural plans to solve beach erosion problems and to meet the recreational needs of the area. The reporting officers recommend modification of the existing Federal project for beach erosion control and hurricane protection at Wrightsville Beach to extend Federal participation in periodic nourishment from 10 years to project life. Average annual charges, based on 7-7/8 percent interest rate and a 50-year period for economic analysis, are estimated at $688,000. Average annual benefits are estimated at $910,000, and the benefit-cost ratio is 1.4.

3. The Board of Engineers for Rivers and Harbors concurs in the views and recommendations of the reporting officers. The Board recommends the plan subject to cost-sharing and financing arrangements satisfactory to the President and the Congress.

4. I concur in the findings, conclusions, and recommendations of the Board.

J. K. BRATTON
Lieutenant General, USA
Chief of Engineers

*This report contains the proposed recommendations of the Chief of Engineers. The recommendations are subject to change to reflect substantive comments.

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL OCEAN SERVICE
Rockville, MD 20852

JUL 7 1983

N/MB2x5:VLS

ACTION: CHANDLER/ALLIN
CC: PT

TO: N/CG - H. R. Lippold, Jr.
N/OMS - Wesley V. Hull
N/ORM - Peter Tweedt

FROM: N/MB - Robert B. Rollins

SUBJECT: U.S. Army Corps of Engineers' Feasibility Report and Environmental Assessment on Shore and Hurricane Wave Protection for Wrightsville Beach, North Carolina

Please submit any comments you may have regarding the subject report (copy attached) to this office by Wednesday, September 8, 1983.

Attachment

DEPARTMENT OF THE ARMY
BOARD OF ENGINEERS FOR RIVERS AND HARBORS
KINGMAN BUILDING
FORT BELVOIR, VIRGINIA 22060

REPLY TO
ATTENTION OF:

BERH-PLN

23 March 1983

SUBJECT: Wrightsville Beach, North Carolina

Chief of Engineers
Department of the Army
Washington, DC 20314

Summary of Board Action

The Board finds that modification of the existing project at Wrightsville Beach, North Carolina, for beach erosion control and hurricane protection is needed and is economically justified and environmentally acceptable. The Board concurs in the reporting officers' plan to extend Federal participation in the cost of periodic nourishment of the existing project from 10 years to project life. The annual cost is estimated at $668,000, and the benefit-cost ratio is 1.4. The Board recommends implementation of the proposed plan subject to cost-sharing and financing arrangements satisfactory to the President and the Congress.

Summary of Report Under Review

1. Authority. This report is in response to a resolution adopted 2 December 1970 by the Committee on Public Works of the United States House of Representatives. The Committee requested the Secretary of the Army to direct the Chief of Engineers to make a survey of Wrightsville Beach and adjacent beaches in the interest of erosion control, hurricane protection, and related purposes. The resolution is quoted in the District Engineer's Report.

2. Description of the study area. The study area is a barrier island on the southern coast of North Carolina, about 10 miles east of Wilmington in New Hanover County. The island is bounded by the Atlantic Ocean on the east, the Atlantic Intracoastal Waterway (AIWW) on the west, Mason Inlet on the north, and Masonboro Inlet on the south. The entire study area, except for the northernmost 1,600 feet of the island, is either within the corporate limits of the Town of Wrightsville Beach or is serviced by the Town. The area north of the Town's jurisdiction is known as Shell Island and is undeveloped. Wrightsville Beach is a long established seaside resort providing tourist homes, hotels, restaurants, an inlet from the sea, a protected back-bay waterfront, access to the AIWW, fishing, and ocean bathing.

Beach use in 1979 was estimated at 440,000 user days and is projected to increase at a rate of 4 percent annually.

3. Existing improvements.

a. A combined beach erosion control and hurricane protection project for Wrightsville Beach was constructed by the U.S. Army Corps of Engineers in 1965. The project extends north from Masonboro Inlet for a distance of 14,000 feet. The project provides for a 50-foot-wide berm in front of a 25-foot-wide dune. Federal participation in periodic nourishment was limited to 10 years. Following completion of the project, the Town of Wrightsville Beach corporate limits were extended northward an additional 2,800 feet.

b. A Federal navigation project was completed at Masonboro Inlet in 1980. It consists of a channel 14 feet deep and 400 feet wide through the ocean bar; a depth of 12 feet and width of 90 feet in Motts and Banks Channels connecting to the AIWW; jetties on each side of the ocean channel; and a deposition basin inside the north jetty.

c. A project at Wrightsville Beach was approved by the Chief of Engineers in October 1980 under authority of Section 111 of the River and Harbor Act of 1958. The Section 111 implementation would mitigate for damages to the existing beach protection project caused by the Federal navigation project at Masonboro Inlet.

4. Problems and needs. Federal participation in periodic nourishment of the existing beach erosion control and hurricane protection project was authorized for only 10 years. After that time, the project was to be reexamined to determine the technical viability of periodic nourishment and to determine if continued Federal participation in periodic nourishment is the most effective and economic solution to erosion problems in the area. There is a need to continue shore and hurricane protection at the current level. Prior to the existing project, Wrightsville Beach had a history of erosion problems and damages during hurricane events.

5. Improvements desired. Local interests desire continued shore protection at Wrightsville Beach consisting of Federal participation in periodic beach nourishment for the life of the existing project. They also desire extension of the existing project 2,800 feet northward to the present town limit.

6. Alternatives considered. The District Engineer reexamined the technical and economic viability of continued periodic nourishment. He also considered several plans to extend shore

protection about 2,800 feet to protect the developed area immediately north of the existing project limit. These plans have benefit-cost ratios significantly less than unity. Another plan, which would acquire the entire presently undeveloped section of Shell Island for preservation in its natural state, was determined to be a separable environmental quality feature and not eligible for Corps of Engineers implementation. Consideration was given to acquisition of Shell Island with management for recreational use. The benefit-cost ratio of this alternative was also well below unity. Nonstructural flood damage reduction measures such as raising structures in place, relocating buildings out of the flood hazard zone, and constructing small floodwalls were also considered and were economically infeasible.

7. Plan of improvement. The recommended plan provides for modifying the existing beach erosion control and hurricane protection project for Wrightsville Beach to extend Federal participation in periodic nourishment from 10 years to the life of the project. It is estimated that shore protection will require 70,000 cubic yards of beachfill annually in addition to the 60,000 cubic yards required annually under the Section 111 project. Material would be obtained from the deposition basin in Masonboro Inlet and the adjacent Banks Channel.

8. Economic evaluation. Based on October 1982 price levels, the District Engineer estimates the average annual costs of nourishment at $668,000. The Federal and non-Federal annual costs are $311,000 and $357,000, respectively, based on traditional cost-sharing policies. Average annual benefits are estimated at $910,300, consisting of $435,000 for beach erosion control, $204,800 for flood damage reduction, and $270,500 for recreation. The economic analysis is based on an interest rate of 7-7/8 percent and a 50-year period. The benefit-cost ratio is 1.4.

9. Project effects. The proposed modification to the existing project would continue to reduce storm damages and stabilize the recreational beach. Adverse impacts to environmental resources in the project area would be minor and temporary in nature.

10. Recommendation of the reporting officers. The District Engineer recommends that the existing Federal project for Wrightsville Beach, North Carolina, be modified in accordance with the plan described in his report and subject to certain items of local cooperation. The Division Engineer concurs.

Review by the Board of Engineers for Rivers and Harbors

11. General. The Board's review encompassed the overall technical, economic, social, environmental, and policy aspects

involved in the modifications proposed by the District Engineer, including conformance with the essential elements of the Water Resources Council's Principles and Standards for Planning Water and Related Land Resources. The Board also considered the views of local interests, as well as Federal and State agencies.

12. Response to the Division Engineer's public notice. The Division Engineer issued a public notice on 28 December 1982 stating the reporting officers' findings and recommendations and inviting interested parties to present additional information to the Board. No letters were received in response to the notice.

13. Findings and conclusions. The Board of Engineers for Rivers and Harbors concurs in the findings and recommendations of the reporting officers. The Board recognizes the need for continued storm protection at Wrightsville Beach where development is vulnerable to significant losses, and the continued need to stabilize the beach for extensive recreational use.

14. General legislation authorizing implementation of water resources projects, the most recent being the Water Resources Development Act of 1976, generally contained local cooperation requirements established by enactment of various laws. The Administration is reviewing project cost sharing and financing across the entire spectrum of water resource development functions. The basic principle governing the development of specific cost-sharing policies is that, whenever possible, the cost of services produced by water projects should be paid for by their direct beneficiaries. It also is recognized that the Federal Government can no longer bear the major portion of the financing of water projects. New sources of project financing, both public and private, will have to be found. While specific policies applicable to the Wrightsville Beach, North Carolina, project have not yet been established, non-Federal interests can expect that, under the Administration's financing and cost-sharing principles, the level of their financial participation will need to be substantial.

15. Recommendations. The Board recommends that modification of the Federal project for beach erosion control and hurricane protection at Wrightsville, Beach, North Carolina, to extend Federal participation in periodic nourishment from 10 years to project life, be authorized for implementation generally in accordance with the reporting officers' plan, with such modifications thereto as in the discretion of the Chief of Engineers may be advisable, and in accordance with cost-sharing and financing arrangements satisfactory to the President and the Congress. The estimated annual cost to the United States is $311,000. This recommendation is made with the provision that, prior to implementation, non-Federal interests will agree to comply with the following requirements:

BERH-PLN 23 March 1983
SUBJECT: Wrightsville Beach, North Carolina

a. Provide without cost to the United States all lands, easements, and rights-of-way, including suitable borrow and disposal areas as determined by the Chief of Engineers to be necessary for implementation and nourishment of the project;

b. Accomplish all relocations and alterations of sewerage and drainage facilities, buildings, streets, utilities, and other structures made necessary by the construction;

c. Hold and save the United States free from damages that may result due to the maintenance of the project other than damages due to the fault or negligence of the United States or its contractors;

d. Provide a cash contribution for its proportionate share of the cost of periodic nourishment equal to the appropriate percentage of the construction costs, the percentage to be in accordance with existing law and based on shore ownership and use at the time of implementation or nourishment;

e. Maintain during the economic life of the project continued public ownership of the publicly owned shore upon which the Federal participation is based;

f. Adopt and enforce appropriate ordinances to provide for the preservation of the improvement and its protective vegetation; and

g. Provide and maintain clearly marked beach access, nearby parking areas, and other public use facilities, open and available to all on equal terms.

FOR THE BOARD:

E. R. HEIBERG III
Major General, USA
Chairman