CHAPTER 74

TIDAL INLET PROBLEMS ALONG THE NEW ENGLAND COAST

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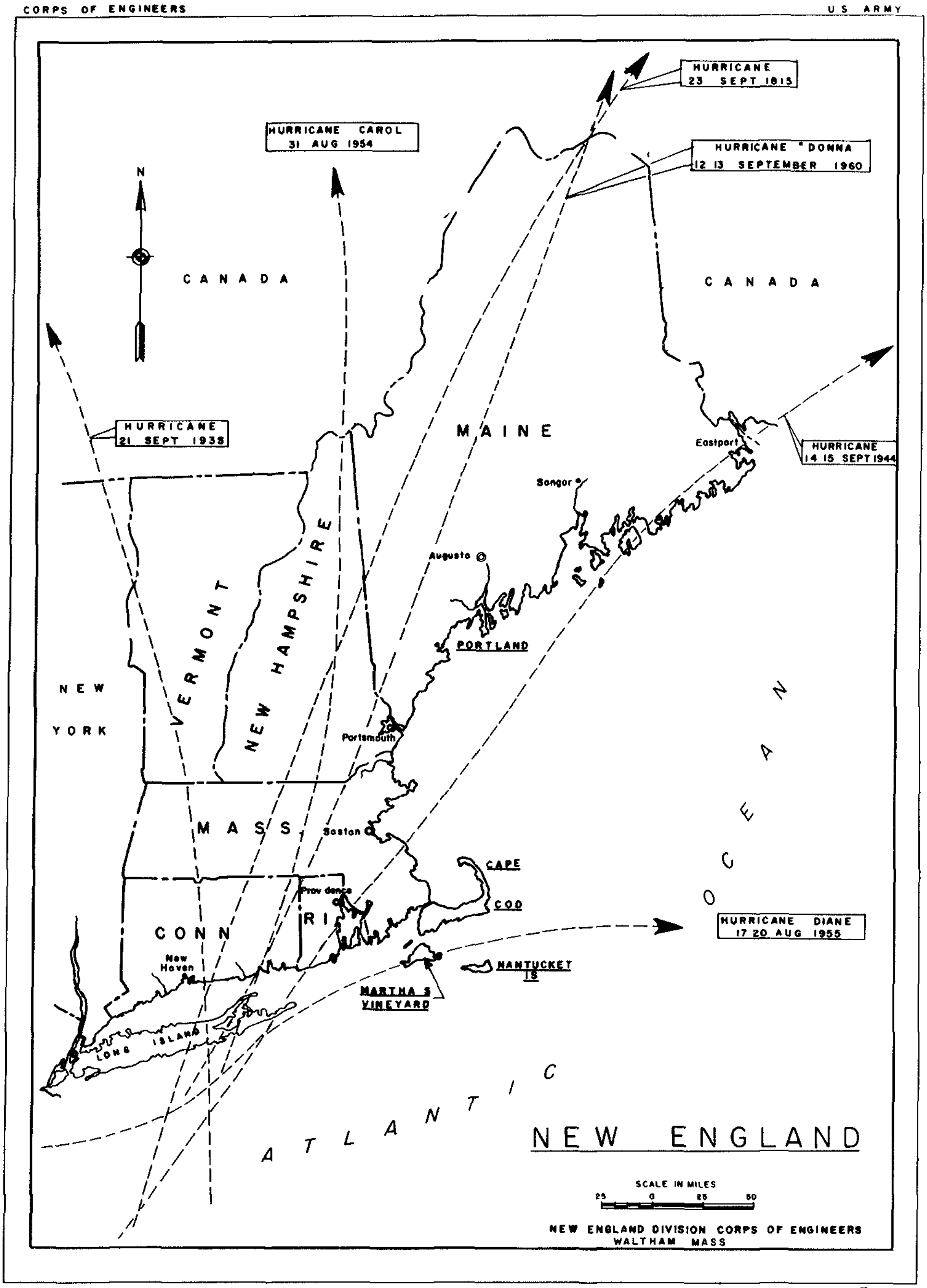
ABSTRACT

The New England Division of the United States Army Corps of Engineers has created and improved many harbors along the New England coast for the benefit of commercial fishing and recreational boating fleets A harbor, to be effective, must provide a protected area for boats and it must have a safe access, that is, a protected and stabilized tidal inlet A coastal inlet has been defined as a waterway connecting a bay, lagoon or similar body of water with a larger body of water The major engineering problems encountered in the development of harbors have involved stabilization of these inlets The problems have been caused by excessive littoral drift resulting from erosion of the shorefront adjacent to the inlets by wave attack Planning, designing, constructing, and modifying these inlets under very dynamic conditions is complex and difficult Each inlet is unique This paper discusses very briefly some of the problems encountered

INTRODUCTION

Two principal factors are involved in producing littoral drift One factor involves storm waves and tides New England is often subjected to severe storms, including hurricanes (See Figure No 1) New England has been battered by a severe hurricane on the average of once every five years during the last 60 years The second factor involves geologic structure Storm wave attack on unconsolidated materials results in severe shoreline recession and an excessive rate of littoral drift The section of the New England coast where tidal inlet problems have been encountered is that extending southerly from Portland, Maine to and including Cape Cod and the offshore islands of Martha's Vineyard and Nantucket

Littoral drift does not pose a problem along the coast of Maine extending between Portland and the Canadian border, as this shorefront is composed largely of massive ledge outcrops which are very resistant to erosion forces, in spite of severe storm wave attack and normal tide ranges up to 20 feet The shore of Connecticut is composed largely of hard rock Further, it is afforded some protection from severe storm


CORPS OF ENGINEERS
U S ARMY
HURRICANE 23 SEPT 1815
HURRICANE CAROL 31 AUG 1954
HURRICANE "DONNA 12 13 SEPTEMBER 1960
N
CANADA
CANADA
HURRICANE 21 SEPT 1938
MAINE
Eastport
HURRICANE 14 15 SEPT 1944
Bangor
Augusta
PORTLAND
VERMONT
NEW HAMPSHIRE
NEW YORK
Portsmouth
MASS
Boston
CAPE COD
Providence
RI
CONN
New Haven
HURRICANE DIANE 17 20 AUG 1955
NANTUCKET IS
MARTHA S VINEYARD
LONG ISLAND
ATLANTIC OCEAN
NEW ENGLAND
SCALE IN MILES
25 0 25 50
NEW ENGLAND DIVISION CORPS OF ENGINEERS
WALTHAM MASS
Figure 1

waves by Long Island to the south and it experiences tide ranges of relatively few feet Thus, its coast remains irregular in configuration, whereas the shore of Rhode Island just to the east, also composed of unconsolidated glacial debris like that of Connecticut, is now almost straight with long sand barrier beaches The primary differences are that the Rhode Island shore consists of boulders mixed with clay, uncemented and thus easily eroded, and the shore is directly exposed to severe storm waves from southerly quadrants This coast, much of which is still privately owned, is relatively undeveloped The littoral drift encountered in Narragansett Bay, Rhode Island and in Buzzards Bay, Massachusetts is not of major significance The chief difficulty requiring attention within these bays is tidal flooding due to hurricanes

Continuous battering of the unconsolidated materials of Cape Cod and the offshore islands of Martha's Vineyard and Nantucket by large waves generated over vast expanses of water, result in rapid and extensive erosion For example, much of the south shore of Martha's Vineyard is estimated to be receding at a rate of 8 feet each year, involving sand losses of 400,000 cubic yards. Some portions of the south side of Nantucket Island and of the southeasterly side of the outer arm of Cape Cod are estimated to be receding at rates up to 15 feet each year

Newburyport Harbor, Massachusetts

Man has studied storms and their generated waves and the geologic structure of the coasts for many years He uses all the advanced and sophisticated knowledge available concerning coastal development He conducts wave refraction, diffraction and reflection studies and makes mathematical and hydraulic model studies He does all this and more, only to find that nature interjects a new unforeseen factor An example of this occurred in February 1969 at Newburyport Harbor, Massachusetts, located 55 miles north of Boston, Massachusetts (See Figure No 2) First, a little background The Federal navigation project for this harbor was constructed in the early 1900's to stabilize the badly migrating inlet at the mouth of the Merrimack River which rises in central New Hampshire and has a drainage basin of about 5,000 square miles The south jetty is nearly 2,500 feet long The north jetty is over 4,100 feet long Both jetties were built to an elevation of 12 feet above mean low water In February, 1969 three northeast storms struck within a relatively short time of each other The first prevailed during 9 and 10 February, the second from 19 through 21 February, and the third lasted for about 4 days, 24 through 27 February

Storm waves from the northeast overtopped and diffracted around the end of the deteriorated north jetty Waves from the east entered the inlet directly These waves ran generally along the smooth face of the south jetty, then being rehabilitated, and attacked the shore fronting the United States Coast Guard Station located at the inshore end of the south jetty The mean high water line receded 150 feet as a result of these

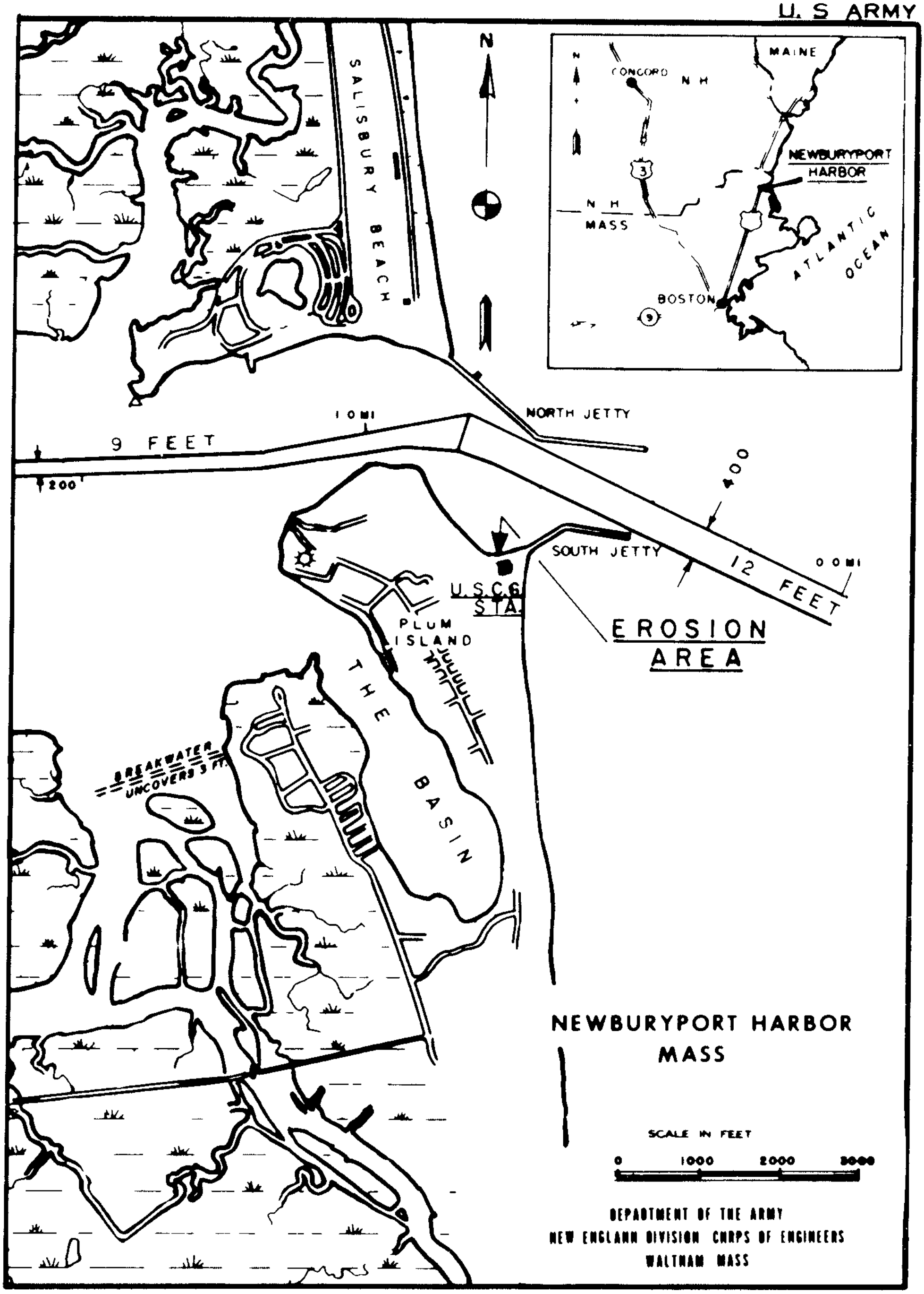

U. S ARMY
SALISBURY BEACH
N
MAINE
CONCORD
N H
NEWBURYPORT HARBOR
N H
MASS
ATLANTIC OCEAN
BOSTON
NORTH JETTY
1.0 MI
9 FEET
200'
400
SOUTH JETTY
0.0 MI
12 FEET
U.S.C.G. STA.
PLUM ISLAND
EROSION AREA
THE BASIN
BREAKWATER UNCOVERS 3 FT.
NEWBURYPORT HARBOR
MASS
SCALE IN FEET
0
1000
2000
3000
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION CORPS OF ENGINEERS
WALTHAM MASS

Figure 2

storms The erosion, once triggered, continued at a more gradual rate toward the station A special study was quickly made to determine what corrective measures were necessary to save the station, which was built in 1930 to provide emergency assistance to ships and small boats in distress offshore A stone mound with sandfill, and revetment was recently completed to stabilize that shorefront. Erosion had reached one corner of the station at the time of initiation of the emergency work

Green Harbor, Massachusetts

Another inlet problem recently developed at Green Harbor, Massachusetts, located 35 miles south of Boston (See Figure No 3) The Commonwealth of Massachusetts and the Town of Marshfield have provided and maintained navigation improvements at this harbor for over 70 years The jetties were constructed by the Commonwealth in 1898 and 1899 In 1969, the United States government, in financial cooperation with the State, County and Town governments, completed a modification of the existing project The modification provided for sealing and extending the west jetty 200 feet to prevent littoral drift from passing through and around the end of the jetty and into the channel It is interesting to note that the south to north drift at the inlet constitutes a local reversal of the overall predominant net north to south drift along these shores Project modification also included raising the top of the east jetty from 12 to 14 feet above mean low water and dredging a harbor channel and anchorage

Shortly after completion of these improvements, erosion began along the shore at the inshore end of the east jetty Field observations and wave studies indicate that the erosion is probably the result of reflection of easterly waves off the smooth face of the west jetty extension with little reduction in wave height A stone revetment and sandfill are being prescribed for stopping the erosion

Andrews River, Massachusetts

In 1968, a new harbor was created in an area of negligible value marshlands within Andrews River in Harwich, Massachusetts, a small tidal creek on the south side of Cape Cod (See Figure No 4) The project provides for a Federal entrance channel protected by stone jetties and a maneuvering area to serve a marina complex provided jointly by the Commonwealth and the town The harbor was developed to accommodate the fast growing recreational boating fleet in the area Nearby harbors had long been saturated After much study and consultation between the New England Division and the Office of the Chief of Engineers in Washington, D C , it was decided to defer construction of the west jetty until experience and observation showed the need for it It was generally considered that the long jetty protecting and stabilizing the Wychmere Harbor inlet immediately to the west would also provide

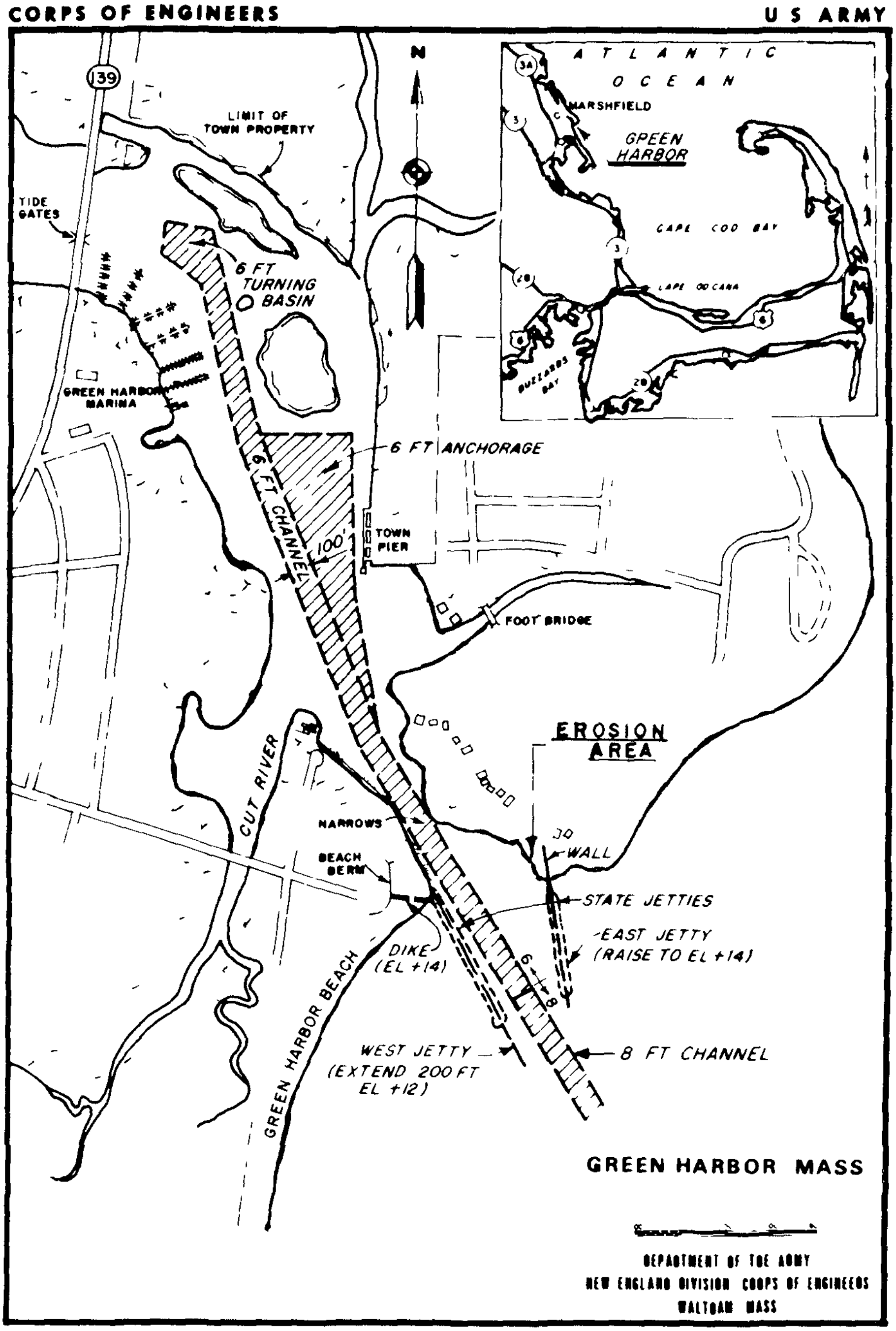

CORPS OF ENGINEERS
U S ARMY
139
LIMIT OF TOWN PROPERTY
TIDE GATES
N
6 FT TURNING BASIN
GREEN HARBOR MARINA
ATLANTIC OCEAN
MARSHFIELD
GREEN HARBOR
CAPE COD BAY
6 FT ANCHORAGE
6 FT CHANNEL
100'
TOWN PIER
FOOT BRIDGE
EROSION AREA
CUT RIVER
NARROWS
BEACH BERM
WALL
STATE JETTIES
EAST JETTY (RAISE TO EL +14)
DIKE (EL +14)
GREEN HARBOR BEACH
WEST JETTY (EXTEND 200 FT EL +12)
8 FT CHANNEL
GREEN HARBOR MASS
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION CORPS OF ENGINEERS
WALTHAM MASS

Figure 3

CORPS OF ENGINEERS U S ARMY

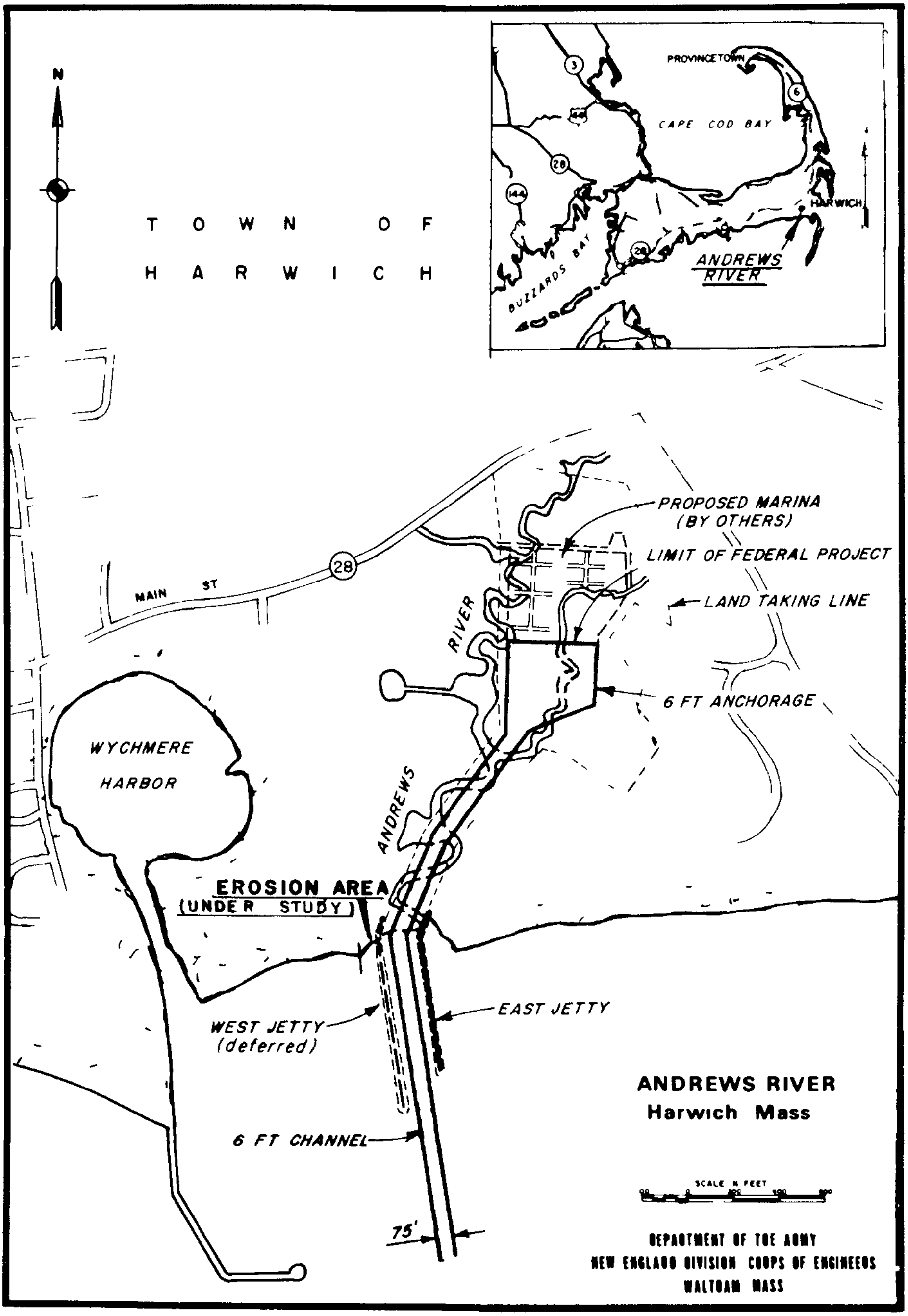


Figure 4

protection to and prevent the west to east littoral drift from fouling up the Andrews River inlet Since completion of the project, erosion of the shore just west of the new inlet and shoaling of the entrance channel have occurred Field observations and wave studies made to date indicate that south and southeasterly storm waves may be diffracting around the end of the Wychmere Harbor jetty and then moving easterly More detailed studies are being made to determine if the west jetty should now be recommended for construction, or if some other corrective measure is required

Scarboro River, Maine

In 1960, a problem was encountered during construction of a jetty at Scarboro River, a small shallow stream rising in the marshlands of the town of Scarboro, Maine about 17 miles southeast of Portland, Maine (See Figure No 5) The jetty was being built to impound excessive west to east littoral drift, which was rapidly shoaling the Federal entrance channel constructed several years earlier When the jetty had been constructed 350 feet from the shoreline, severe scour occurred at the seaward end The area of scour extended 100 feet beyond the end of the jetty, beyond which accretion occurred The sea bottom in the area of scour went from 2 feet below mean low water to nearly 19 feet below mean low water. Consultation with known experts in the field of tidal hydraulics revealed that tidal currents were flowing nearly perpendicular to the jetty during both the ebb and flood tides resulting from a shift in tidal flow not anticipated Also, the bottom materials were found to consist of very fine sand A greater thickness of bedding, 3 to 4 feet instead of 18 inches, consisting of 10-150 pound stone placed at least 50 feet in advance of the core and armor stone, was found to be the answer to the problem

Wells Harbor, Maine

As a result of the establishment of the Wells Harbor Committee in 1953 to determine what measures were necessary to develop a harbor at Wells, Maine (See Figure No 6), the Federal government constructed two converging stone jetties at the mouth of the Webhannet River to stabilize the migrating inlet The project included dredging a channel and anchorage in the marshlands During construction of the south jetty to its angle point, that is, where it then extends parallel to the channel, accretion of the northerly tip of Wells Beach took place However, as construction of the jetty progressed to its full length of 940 feet parallel to the channel, erosion of the tip of Wells Beach occurred rapidly Over 400 feet were lost in eight months Concurrently, the north jetty, 640 feet long, was already nearly completely impounded, with littoral materials about to enter the inlet These occurrences meant that the proposed anchorage would be directly exposed to easterly storm waves and to severe shoaling

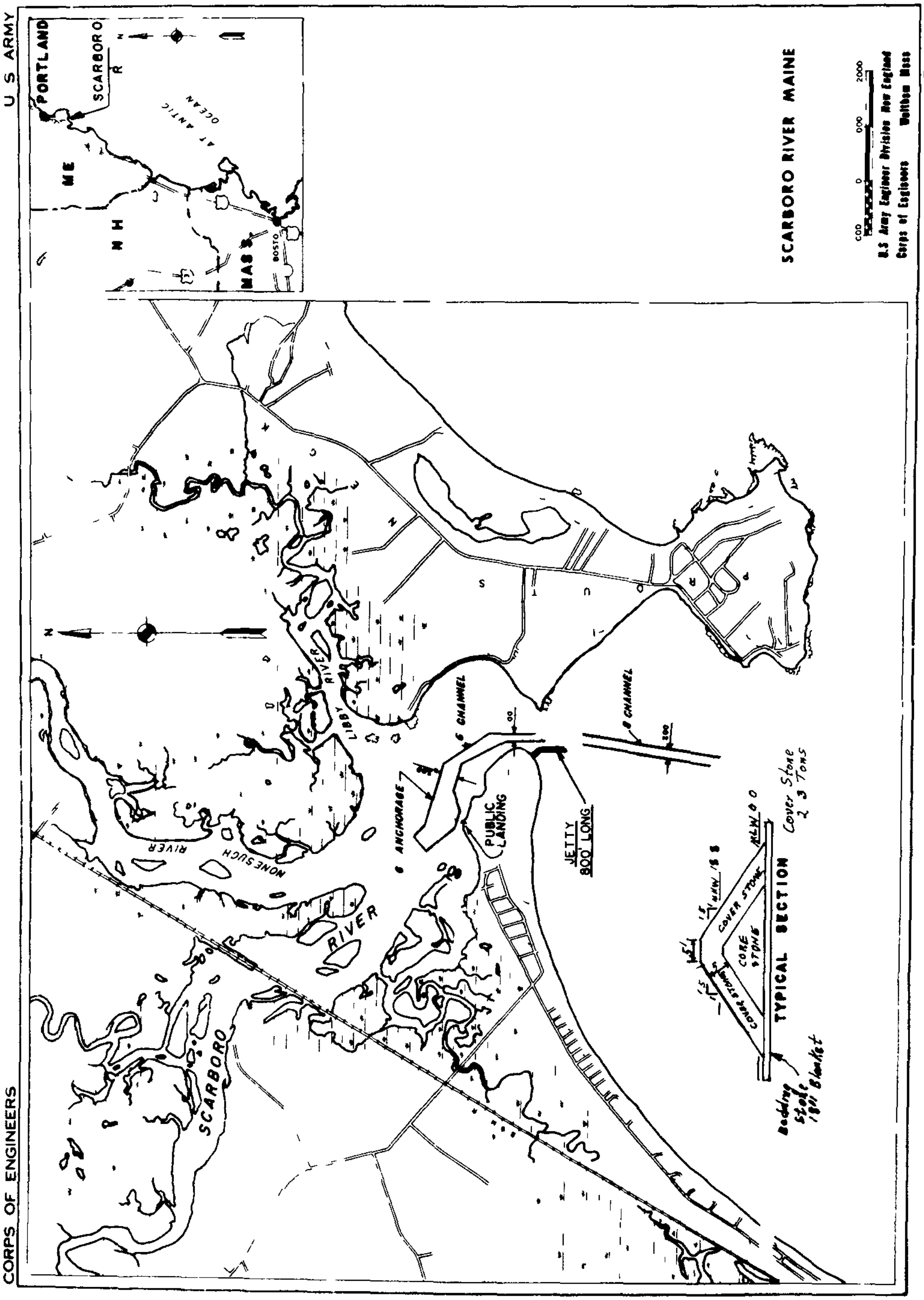

U S ARMY
CORPS OF ENGINEERS
SCARBORO RIVER MAINE
U.S. Army Engineer Division New England
Corps of Engineers Waltham Mass
PORTLAND
SCARBORO R
ATLANTIC OCEAN
ME
NH
MASS
NONESUCH RIVER
LIBBY RIVER
SCARBORO
RIVER
ANCHORAGE
CHANNEL
PUBLIC LANDING
JETTY 800' LONG
TYPICAL SECTION
COVER STONE
CORE STONE
Cover Stone 2 3 Tons
Bedding Stone 18" Blanket

Figure 5

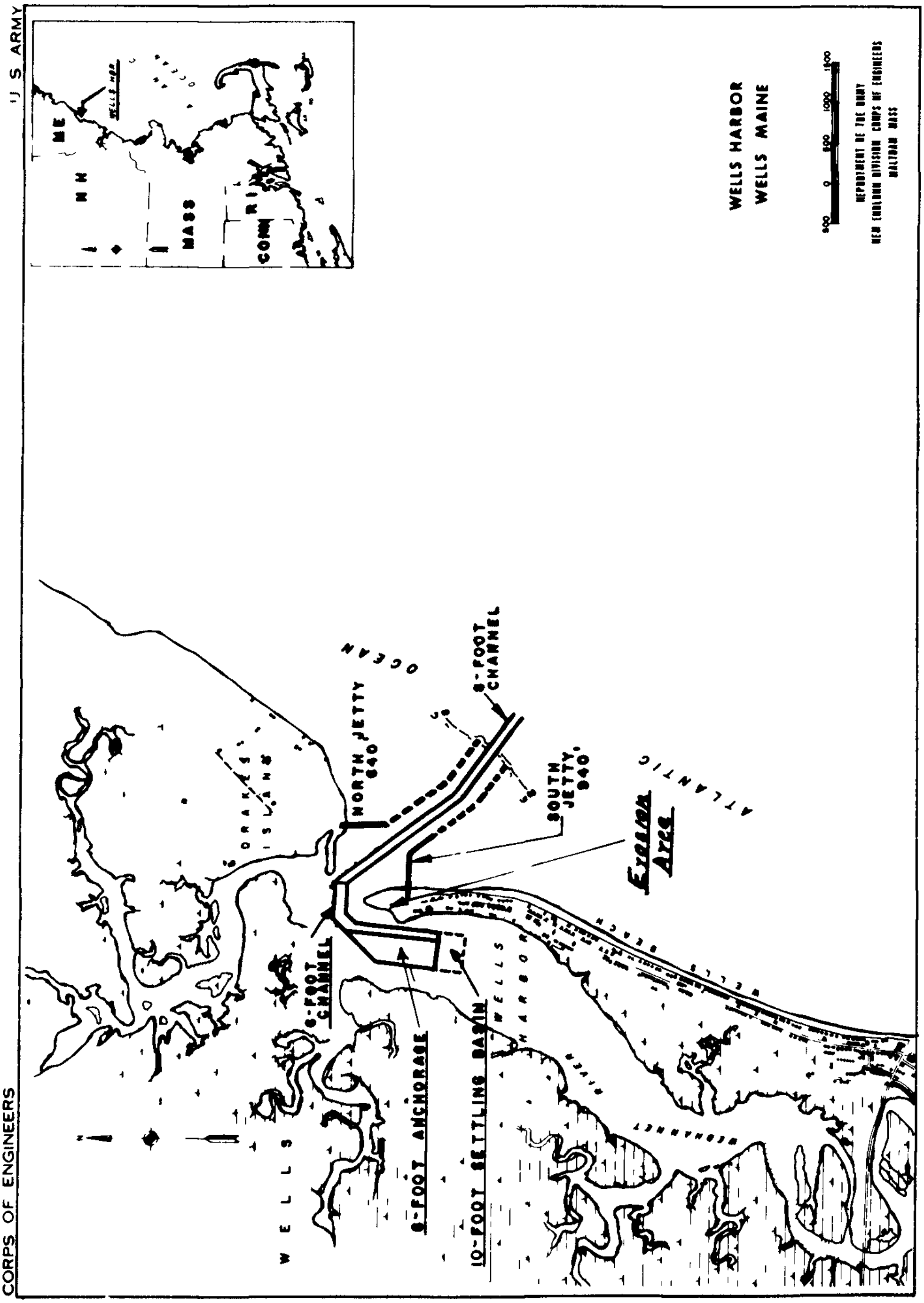

CORPS OF ENGINEERS
U S ARMY
WELLS HARBOR
WELLS MAINE
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION CORPS OF ENGINEERS
WALTHAM MASS
ME
NH
MASS
CONN
RI
WELLS HBR
OCEAN
ATLANTIC
NORTH JETTY 840
SOUTH JETTY 840
8-FOOT CHANNEL
6-FOOT CHANNEL
8-FOOT ANCHORAGE
10-FOOT SETTLING BASIN
Erosion Area
DRAKES ISLAND
WELLS BEACH
WELLS HARBOR
WEBHANNET RIVER
WELLS

Figure 6

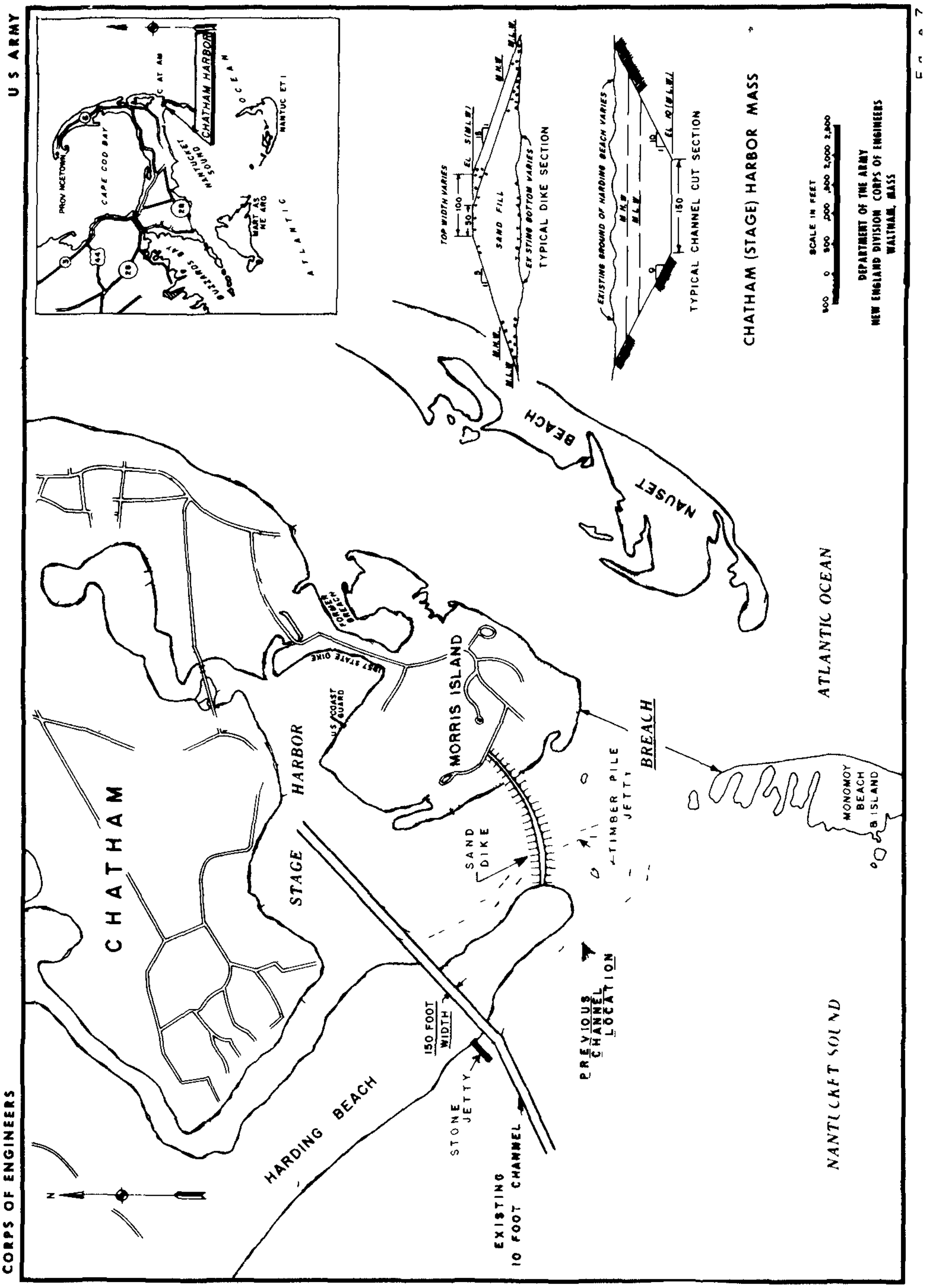
After discussions with the Committee on Tidal Hydraulics and representatives of the Waterways Experiment Station at Vicksburg, Mississippi, it was decided to construct a 100-foot long wave absorber along the inner end of the south jetty, place stone revetment along 680 feet of the tip of Wells Beach, and extend the north jetty The channel and anchorage were then dredged However, because of a continued high rate of shoaling, both from littoral drift and from sediments carried down the Webhannet River, both jetties were later extended to about the 8-foot depth contour and a 10-foot deep settling basin dredged at the upstream end of the anchorage to intercept river sediment In spite of numerous problems encountered in the creation of Wells Harbor, it now is overcoming the growing pains and is beginning to function as planned It is a safe harbor for the commercial fishing boats which transferred from nearby inadequate coves and for a new fleet of recreational boats which could not be accommodated at the saturated harbors to the north and south of Wells Harbor

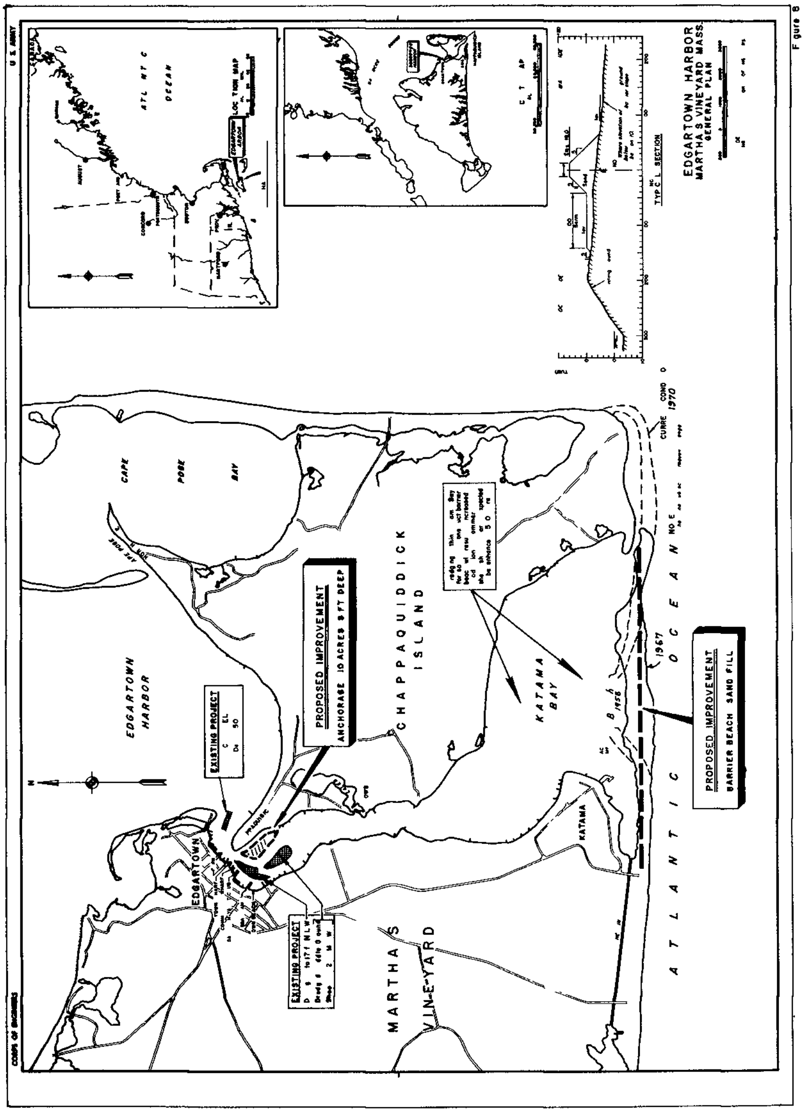
Chatham Harbor, Massachusetts

Chatham Harbor, Massachusetts is located on the southeasterly corner of Cape Cod in an area of very rapid and continuously changing shoreline conditions (See Figure No 7) The directions, rates, and amounts of littoral drift are extremely complex and variable Planning and designing a modification of the existing Federal navigation project at Chatham Harbor proved to be difficult under these unique conditions In 1956, Monomoy Beach, a long narrow barrier beach, was connected to Morris Island At that time, it was breached by storm waves The breach widened, deepened and became a continuous waterway By 1961, sediment moved by the tidal currents through the breach, extended over a wide area and filled the existing Federal channel around the tip of Harding Beach The shoaling continued to advance westward along the south side of Harding Beach toward the Chatham Roads approach channel Concurrently, tidal flows in the vicinity of Harding Beach caused its tip to erode rapidly and the deep scour hole at the breach to extend toward Harding Beach and Chatham Harbor Detailed studies found that the most feasible solution was to construct a sand dike between Morris Island and Harding Beach with a timber pile structure seaward of the dike to protect it against severe tidal currents, and relocate the channel through Harding Beach stabilized by a stone jetty The improvement has proved to be successful

Edgartown Harbor, Massachusetts

Edgartown Harbor, Massachusetts is located on the easterly end of Martha's Vineyard (See Figure No 8) The natural sand barrier beach extending for 3 miles along the south side of Katama Bay has had a history of breaches caused by storm waves recorded back to 1776 These breaches occur at the west to mid-portion of the barrier beach as the offshore hydraulic grade line lengthens and flattens in this area, the tidal currents diminish, and the beach narrows in width The breaches result in excessive tidal currents at Edgartown Harbor and in shifting sands


U S ARMY
CORPS OF ENGINEERS
CHATHAM HARBOR
CAPE COD BAY
NANTUCKET SOUND
ATLANTIC
OCEAN
TYPICAL DIKE SECTION
TOP WIDTH VARIES
SAND FILL
EXISTING BOTTOM VARIES
TYPICAL CHANNEL CUT SECTION
EXISTING GROUND OF HARDING BEACH VARIES
CHATHAM (STAGE) HARBOR MASS
SCALE IN FEET
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION CORPS OF ENGINEERS
WALTHAM, MASS
NAUSET BEACH
FORMER BREACH
MORRIS ISLAND
U.S. COAST GUARD
BREACH
ATLANTIC OCEAN
CHATHAM
STAGE HARBOR
SAND DIKE
TIMBER PILE JETTY
MONOMOY BEACH & ISLAND
PREVIOUS CHANNEL LOCATION
150 FOOT WIDTH
STONE JETTY
HARDING BEACH
EXISTING 10 FOOT CHANNEL
NANTUCKET SOUND


EDGARTOWN HARBOR
MARTHA'S VINEYARD MASS.
GENERAL PLAN
U.S. ARMY
CORPS OF ENGINEERS
LOCATION MAP
ATLANTIC OCEAN
TYPICAL SECTION
EDGARTOWN HARBOR
CAPE POGE BAY
EXISTING PROJECT
PROPOSED IMPROVEMENT
ANCHORAGE 10 ACRES 8 FT DEEP
CHAPPAQUIDDICK ISLAND
KATAMA BAY
EDGARTOWN
KATAMA
MARTHA'S VINEYARD
EXISTING PROJECT
PROPOSED IMPROVEMENT
BARRIER BEACH SAND FILL
1967
1956
1970
ATLANTIC OCEAN

within Katama Bay, which destroys the valuable shellfish crops in the bay The breaches migrate to the east until they reach Chappaquidick Island at which time the westerly portion of the barrier beach is once again susceptible of a new breach At present, the barrier beach connects Martha's Vineyard to Chappaquidick Island A survey report now being forwarded to Congress for consideration for authorization, recommends that the barrier beach be raised and widened to prevent future breaches The Fish and Wildlife Service of the United States Department of Interior, in cooperation with State and town fish and wildlife agencies, expects the improvement to result in a complete re-establishment of the shellfish industry within Katama Bay involving benefits of nearly two million dollars each year In addition, the recreational boating fleet will be benefited

CONCLUSIONS

As a result of the inlet problems discussed above, the following observations are offered First, inlet jetties should be studied closely to avoid their construction with smooth faces resulting from placed stone, if it appears that this condition could contribute to excessive wave run-up, run-along, or reflection All available advanced knowledge concerning inlet development should be utilized and exhaustive wave studies made for each inlet Field observations of inlet sites should be made more often and more intensively Every effort should be made by the coastal engineer to respond to the greatest desire and need of local interests while cooperating and coordinating fully with all affected interests to provide the optimum plan of improvement within the dictates of available funds and environmental controls

It should be recognized that inlet problems can occur at any stage of development It should also be recognized that changes in shorelines adjacent to inlet developments are a rather frequent occurrence Congress responded to this recognition by including Section 110 into the River and Harbor Act of 1968, which authorizes the Corps of Engineers to provide corrective measures at shorefront areas shown to be adversely affected by Federal inlet improvements

In summary, the coastal engineer should plan for all predictable factors, but he should be prepared to modify his plans at any time to correct for the unpredictable

ACKNOWLEDGEMENTS

The information presented herein represents largely a summary of the very extensive and detailed studies made by coastal engineering experts of the New England Division office of the U S Army Corps of Engineers for each of the project areas discussed

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