BEACH EROSION CONTROL REPORT ON COOPERATIVE STUDY OF CONNECTICUT

AREA 3

NEW HAVEN HARBOR TO HOUSATONIC RIVER

CORPS OF ENGINEERS, U. S. ARMY
OFFICE OF THE DIVISION ENGINEER
NEW ENGLAND DIVISION, BOSTON, MASS.

MAY 4, 1951

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CORPS OF ENGINEER, U. S. ARMY
OFFICE OF THE DIVISION ENGINEER
NEW ENGLAND DIVISION
BOSTON 7, MASS.

NEDVN May 4, 1951

SUBJECT: Beach Erosion Control Report on Cooperative Study of Connecticut, Area 3, New Haven Harbor to Housatonic River.

TO: The Chief of Engineers, Department of the Army, Washington 25, D. C.

SYLLABUS

This report, the third of eleven to cover the entire coast of Connecticut includes study of the shore line of the towns of West Haven and Milford between New Haven Harbor and the Housatonic River. The purpose of the study is to determine the most suitable methods of stabilizing and improving the shore line in this area.

The Division Engineer finds that the entire area constitutes a resort development and that major extents of the entire shore have suffered from erosion resulting in the loss of sand beaches and damage to shore property and shore roads. The Division Engineer also finds that the artificial replenishment of the shore by hydraulic pumping of sand from offshore depths, the construction of impermeable groins and the placement of riprap revetment are the most practicable methods of protection and improvement.

The Division Engineer recommends that local interests consider adoption of a project for protection and improvement of the privately-owned shore in Milford known as Burwell Beach.

The Division Engineer recommends adoption of projects authorizing Federal participation to the extent of one-third the first cost of protection and improvement of those portions of the shore which are publicly owned in accordance with the following plans:

a. Prospect Beach, West Haven. - Widening to a 100-foot width by direct placement of sand, 6,000 feet of shore from a point about 350 feet south of South Street, northerly to Ivy Street with an added 50-foot widening at the south end of the fill and construction of eight impermeable groins each 330 feet long.

b. Woodmont Shore, Milford. - Widening to a 100-foot width by direct placement of sand, 500 feet of shore in the first pocket beach west of Marwin Point; widening to a 100 to 150-foot width, 3,500 feet of shore from Chapel Street northerly to a point about 400 feet north of Anderson Avenue; construction of five impermeable groins 300 to 400 feet long.

c. Gulf Beach, Milford. - Widening to a 100-foot width 1,200 feet of Gulf Beach, south of and adjacent to Long Jetty by direct placement of aand.

d. Silver, Myrtle, Walnut, Laurel, and Cedar Beaches, and Meadows End, Milford. - Widening to a 100-foot width by direct placement of aand, 15,600 feet of shore along Silver, Myrtle, Walnut, Laurel, and Cedar Beaches and Meadows End with an added widening of 150 feet around Meadows End, and construction of eleven impermeable groins 350 to 400 feet long.

The total estimated amount of Federal participation in the above projects is $124,800.

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AREA 3

NEW HAVEN HARBOR TO HOUSATONIC RIVER

I. GENERAL

AUTHORITY

1. Basic Agreement. - A formal application dated 22 July 1947, from the State of Connecticut, acting through the Connecticut State Flood Control and Water Policy Commission, for a cooperative study of the problems of beach erosion and shore protection along the entire coast of Connecticut by the United States and the Connecticut State Flood Control and Water Policy Commission was approved by the Chief of Engineers, Department of the Army, 28 August 1947, in accordance with the authority conferred by the provisions of Section 2 of the River and Harbor Act approved 3 July 1930 as amended and supplemented. The approved application provided that the studies of specific areas and problems be defined in appendices; that separate reports be issued for each shore town; and that a composite report be issued for the State of Connecticut summarizing the recommendations contained in the individual reports.

2. Modification of Basic Agreement. - A request of the State of Connecticut dated 3 October 1947, approved by the Chief of Engineers on 20 October 1947, modified the basic agreement to permit separate reports on physiographical bases rather than on political boundaries.

3. In accordance with this modification, the shore line of the State of Connecticut was divided into the following physiographical areas:

1. Ash Creek to Saugatuck River (Fairfield, part of Westport)

2. Hammonasett River to East River (Madison)

3. New Haven Harbor to Housatonic River (West Haven and Milford)

4. Connecticut River to Hammonasset River (Old Saybrook, Westbrook and Clinton)

5. Pawcatuck River to Thames River (Stonington and Groton)

6. Niantic River to Connecticut River (East Lyme and Old Lyme)

7. Housatonic River to Ash Creek (Stratford and Bridgeport)

8. Noroton River to Byram River (Stamford and Greenwich)

9. East River to New Haven Harbor (Guilford, Branford, East Haven, and New Haven)

10. Thames River to Niantic River (New London and Waterford)

11. Saugatuck River to Noroton River (Part of Westport, Norwalk and Darien)

The locations of these areas are shown on Plate 1.

4. Appendices. - Appendix I to the basic agreement was approved by the Chief of Engineers on 20 October 1947, Appendices II and III on 16 December 1947, Appendices IV, V, VI, and VII on 9 September 1948 and Appendices VIII, IX, X, and XI on 1 May 1950. Separate reports dated 7 February 1949 covering Areas 1 and 2 as defined by Appendices I and II respectively have been prepared and submitted to the Chief of Engineers. The subject of this report is Area 3, as defined by Appendix III.

PURPOSE

5. General.- The purpose of this study was to determine the most suitable methods of stabilizing and improving the shore line between New Haven Harbor and the Housatonic River.

6. Scope. - The scope of the study was as follows:

a. Determine the essential characteristics of littoral drift.

b. Determine the source and disposition of littoral material within this area.

c. Determine which sections of the shore line are now subject to undesirable changes, and the most suitable remedial measures for insuring reasonable stability of the shore line in these areas.

d. Analyze the effect of existing structures upon the shore line.

e. Determine which sections of the shore line are desirable locations for beach improvement, and the most effective measures for accomplishing the desired improvement.

f. Analyze the shore line improvements and protective measures considered, determine the advisability of adopting projects for such work, the public interest therein, and the share of the cost, if any, to be borne by the United States.

PRIOR REPORTS

7. The Physical History of the Connecticut Shore Line. - Bulletin No. 46 of the State Geological and Natural History Survey of Connecticut published in 1929 is a paper by Henry Staats Sharp, A.M., titled "The Physical History of the Connecticut Shore Line." This paper describes the geological history of Connecticut and the various topographical features of the shore line. The geological history discussed in Paragraphs 14 to 17 and Appendix B, is based principally upon this report.

8. Effect of Federal Structures on Adjacent Shore Lines. - A report, "Effect of Federal Structures on Adjacent Shore Lines", dated 11 July 1938 and a supplement thereto dated 3 February 1939 were submitted to the Shore Protection Board describing conditions before and

after construction of Federal structures at New Haven Harbor, Milford Harbor, and the Housatonic River. At New Haven Harbor, a dike, known as Sandy Point Dike, authorized by River and Harbor Act of 2 August 1882, was constructed to contract and direct the tidal flow over Fort Hale Bar in order to maintain the dredged channel over the bar. It was concluded that the dike has lessened deposition of material on the bar and has been reasonably successful in accomplishing its purpose. At Milford Harbor, improvements authorized by River and Harbor Act of June 23, 1874 were constructed as follows: 12 groins for shore protection on the east shore of the harbor northwest of Welchs Point; a long jetty below the mouth of Indian River to prevent filling in of the channel and to direct the tidal current into the dredged channel; a jetty at Burns Point to modify the direction of the tidal currents and direct them along the excavated channel and prevent erosion of the west bank immediately below Burns Point. It was concluded that the above structures checked erosion along the east shore of the harbor and lessened deposition of material on the bar. At the Housatonic River, a stone breakwater authorized by the River and Harbor Act of 11 August 1888 was constructed to aid in the maintenance of the bar at the mouth and to protect the channel from littoral drift moving in a westerly direction. It was concluded that since completion of the breakwater, the shoaling of the channel west of the breakwater has been reduced. Slight shoaling occurs in the channel near the outer end of the breakwater.

DESCRIPTION

9. Connecticut. - Connecticut is aptly termed the gateway to New England, and is one of the most popular vacation and tourist areas of the country. Connecticut is approximately 100 miles long in an east-west direction, and 50 miles broad in a north-south direction. The

entire southern boundary of the State is the shore of Long Island Sound, a rather narrow, sheltered arm of the Atlantic Ocean. Only that part of the shore facing open water of Long Island Sound or tributary bays is considered in these reports. This shore is quite irregular and is about 165 miles long. The bulk of the population of Connecticut, which in 1940 was over 1,700,000 people is in close proximity to the shore. About 40,000,000 of the country's population live within 300 miles of Long Island Sound with the result that there is considerable use of the Connecticut shore. The fact that Connecticut is located in a temperate latitude and that the waters of Long Island Sound are generally calmer and warmer than along the exposed ocean shores of the neighboring States further has induced intensive development of water-front activities. A further attribute of the State is that of the flat plain which extends generally a mile or more inland is well suited to resort development. The Connecticut shore is dotted with bays, coves, promontories and near-lying islands, all adding variety to the area, and enhancing its value for resort and other purposes. The existence of United States Route 1 along the site of the Old Kings Highway, following the shore entirely across the State, closely paralleled by the main line of the New York, New Haven and Hartford Railroad, has encouraged more intensive development of the Connecticut shore areas through the past generations than is the usual case.

10. Area 3. - The portion of the Connecticut shore considered in this report is an extent of about sixteen miles from Sandy Point on the west side of New Haven Harbor to Milford Point on the east side of the Housatonic River. The area includes almost the entire shore of the Towns of West Haven and Milford, approximately 6.5 and 9.5 miles in length, respectively. This section of shore is adjacent to and west of the City of New Haven and is approximately 50 to 65 miles east of New

York City. The coast is continuously developed as a summer resort and residential area and contains amusement parks, and town and association owned beaches. Connecticut Route 122 closely follows the entire shore of West Haven. The Milford shore is closely bordered by town roads throughout its extent. The New York, New Haven and Hartford Railroad parallels Long Island Sound about 1-1/2 to 2 miles inland. Easy access to all shore points is available from U. S. Route 1 over a network of state highways and town roads. The 1950 population of West Haven is 31,876 and of Milford is 26,334. The coastal population is largely seasonal in character.

11. Shore Physiography. - The east limit of the area consists of a long sand spit at Sandy Point which has built outward in a northeasterly direction into New Haven Harbor. The shore end of this spit merges into a low marshy area. South of the spit, Old Field Creek, bordered by marsh, empties into the harbor. A wide sand beach extending from Old Field Creek to the foot of Savin Avenue east of Bradley Point has been recently built by the hydraulic placement of material dredged from the navigation channel leading into New Haven Harbor. Bradley Point consists of ledge rock outcrops connected to the mainland by tombolos to form a cuspate bar in front of a marsh area bordering Cove River which empties into Long Island Sound west of Bradley Point. Between Cove River and Oyster River, the shore runs along the foot of Jones Hill and is characterized by a narrow eroded beach consisting largely of gravel and boulders, with numerous outcrops of rock and marsh, fronting an eroded bluff protected in part by sea walls and revetment. Small sandy pocket beaches between rock outcrops exist at the east and west limits of the area. The shore between Oyster River and Merwin Point is similar in nature to that previously described, consisting of a narrow beach of gravel, cobbles, boulders, marsh and rock outcrops with small sandy pocket beaches formed between these outcrops. Here again there is an eroded bluff

protected in part by riprap and sea walls. From Merwin Point west to Merwin Beach, there are large outcrops of rock which project seaward to form small sandy pocket beaches. Merwin Beach is a barrier bar fronting a marsh anchored into rock outcrop at both ends. South of Merwin Beach the backshore area consists of high ground which rises in elevation adjacent to the Sound until at Morningside there exists a high eroded cliff of unconsolidated material which has suffered severely from the attacks of the sea necessitating the construction of an extensive system of protective works consisting of sea walls, riprap revetment and bank paving. South of this protected area, there is a marked drop in the elevation of the cliffs. The unprotected bluff here has eroded 20 to 30 feet further landward than the previously described cliff. The entire beach from Morningside south to and around Pond Point is narrow and consists of very coarse material, generally shingle, cobble and boulders. Pond Point has suffered from erosion which lowered the beach level in front of existing low concrete walls. West of Pond Point, there is a bayhead bar in front of a marsh bordering Calf Pen Meadow Creek. This bar is known as Pond Point Beach. Bay View Beach, situated west of Calf Pen Meadow Creek, consists of a sandy shore which narrows in width at its western end and merges into a rough shingle and boulder shore at Welchs Point. Welchs Point consists of a high cliff of unconsolidated material, which, like Morningside, has suffered from erosion. The material at the foot of the cliff is very coarse, consisting largely of boulders. Dumped riprap affords some protection but in view of the development of the backshore area for residential construction, which is now in progress, more adequate protective structures will no doubt be required. Northwest of Welchs Point along the east shore of Milford Harbor at the entrance to Indian River, there

is a coarse sandy beach fronting marsh. This beach has been partly built up as a result of the construction of a stone jetty at the mouth of Indian River which catches and holds littoral drift. Burns Point at the west side of the entrance to Wepawaug River consists of marsh, shingle and cobbles. West of Burns Point, there is a narrow sandy beach which widens further westward to form the fine sandy beaches known as Fort Trumbull and Silver Beach. This area and that portion of the shore westward to Myrtle Beach is a barrier bar fronting the extensive Meadows End marshes. From this barrier beach, a submarine bar extends seaward to Charles Island forming a long tombolo which is exposed at low water. West of this tombolo, extensive erosion has occurred necessitating the construction of a steel sheet pile bulkhead to protect the shore road built on the barrier bar. West of this barrier bar, there is a narrow sandy shore of varying width in front of cottages and sea walls. This area includes Myrtle, Walnut, and Laurel Beaches. West of Laurel Beach, there is a long sand spit extending in a southwesterly and thence westerly direction out into the Housatonic River to form Milford Point. The eastern half of this spit is known as Cedar Beach and has been partly developed for summer residential use. There is no development on the western half except for a long Federally constructed jetty built in a southeasterly direction to prevent shoaling of the navigation channel leading into the Housatonic River. The spit is covered with sand dunes whose height decrease towards its western extremity. Behind the spit are extensive marshes which are used as a wild life sanctuary.

12. Beach Use. - In Connecticut private title exists only to the mean high water line; seaward the title rests in the State. Technically, this means that the public has access to the entire stretch of shore line below high water. Legally no restrictions are allowed against such public usage of the beaches below high water. Actually, limited accessibility

restricts the public to beaches where the adjacent backshore area is publicly-owned or open to the public on a commercial basis. Even where the beach areas are publicly-owned, use may be limited to area residents or town residents by parking restrictions, preferential admission rates or omission of facilities for travelers.

13. Description and Composition of Beaches. - Detailed descriptive data concerning the entire shore line of Area 3 were obtained by field inspection. The shore line was then divided consecutively from New Haven Harbor to the Housatonic River, generally in accordance with physical character of shore features. A description based on these subdivisions is included in Appendix A. This description includes the name, location, and extent of the area, the width of the beach above high water and from low to high water, the ownership and use (whether public or private), facilities available to the public, and composition of beach below and above the high water line. The shore from Sandy Point to Bradley Point possesses a wide sandy beach which was recently formed by the hydraulic placement of sand fill obtained from dredging the navigation channel into New Haven Harbor. West of this sandy beach to Milford Harbor, the shore is irregular in shape, the beach areas consisting largely of gravel, cobbles, and boulders at the foot of eroded bluffs and cliffs, or in front of sea walls and revetment. There are numerous outcrops of rock in this area. These ledge rock outcrops project into Long Island Sound to form a number of small pockets in which sand is retained. Small sandy beaches so formed are found on the east and west sides of Bradley Point, at the west side of Cove River, on both sides of Oyster River and in the series of pockets around Merwin Point. The finest and largest of these pockets exists at Merwin Beach. Pond Point and Welchs Point project into Long Island Sound to form a large pocket or bay in which exists a stretch of sandy shore comprising Pond Point Beach and Bay View

Beach. There is a coarse sandy shore at the mouth of Indian River, known as Gulf Beach, south of and adjacent to a riprap jetty constructed at the mouth of Indian River. From Burns Point on the west side of Milford Harbor to Milford Point which projects into the Housatonic River, there exists an almost continuous sandy shore. The width of sand beach above high water is generally narrow, in many places the water being at the foot of bulkheads and sea walls which have been built to protect the summer residences which closely crowd upon the shore. The intensive residential development of this shore has necessitated the construction of numerous closely spaced groins to stop the erosion which threatens to remove the narrow strip of sand which lies between this development and Long Island Sound. Samples of beach material were taken at selected locations along the shore. A mechanical analysis of these samples was made to determine median diameter and classification. Tabulation of results of analyses and locations of samples are shown on Plates 11-15. A complete photographic record was made of the shore. Selected photographs are shown on Plates 21-32. The entire shore line of Area 3 is approximately 16 miles long of which about 2.5 miles is publicly-owned. The public beaches are Savin Rock, Sea Bluff, Prospect, Oyster River, Woodmont, Anchor, Gulf, and Silver. The privately-owned shore is principally developed for residential use, much of it seasonal in nature. Use of the private shore is generally limited to residents. There is a large amusement park at Savin Rock and a small amusement area at Myrtle Beach. The development and character of the area is shown on Plates 11-15, and on United States Coast and Geodetic Survey Charts 218 and 219.

GEOLOGY

14. General. - The present Connecticut shore line is the result of submergence following the lowering of the earth's surface in relation

to the water surface of the ocean. The geological processes which effected this condition and a brief history of the geological changes which are significant in explaining the physiography of the area are discussed in Appendix B.

15. Origin of Beaches. - The headlands are composed of unconsolidated glacial drift materials and the lowlands are composed of unconsolidated material of glacial and fluvio glacial origin. These materials erode easily and have contributed to the beaches in the area. The shore line between New Haven Harbor and the Housatonic River is composed largely of these glacial and unconsolidated materials with the result that because of their erosional and depositional characteristics, the coastal outline has changed greatly from its original configuration. Ledge rock outcrops consisting of phyllite and schist exist along the stretch of shore between Savin Rock and Pond Point. This ledge is responsible for the irregularities at Bradley Point, Oyster River Point and Merwin Point. The alternation of drift and phyllite at Merwin Point has resulted in a scalloped shore line with the indentations cut in the drift and the projections formed of the more resistant phyllite. Small sandy pocket beaches have formed in these indentations.

16. Cliffs. - The highest cliffs of unconsolidated material to be found along the Connecticut coast occur between New Haven and Bridgeport. The highest of these is located northeast of Pond Point along the shore at Morningside. This cliff continues southward with diminishing altitude almost to Pond Point. Southeast of Gulf Beach in Milford Harbor, there occurs an abandoned sea cliff caused by the retreat of the uplands during a period of erosion. The southern end of this cliff is abruptly terminated by the embankment running along the southwestern shore of Welchs Point. The entire upland at Welchs Point is composed of till containing many large

boulders.

17. Shore Forms. - Two sand spits of note occur in the study area, the one forming Sandy Point extending in a northeasterly direction from the west side of New Haven Harbor, the other forming Milford Point extending in a southwesterly direction from the east side of the mouth of the Housatonic River. The submarine bar running from the mainland at the western limit of Silver Beach to Charles Island, approximately 3,500 feet offshore, is the one thing of interest along the almost featureless shore from Milford Harbor to Milford Point. This bar is submerged at high tide but at mid tide it is the best example of a tombolo to be seen along the coast of Connecticut. Where the tombolo joins the mainland, there is a well developed cuspate bar which encloses the Meadows End marsh. The base of the tombolo joins the apex of the cuspate bar and together they form a Y tombolo. Material for sustenance of the tombolo is derived from the rapidly eroding Charles Island and from the mainland beaches.

1/5/82

PROSPECT BEACH

FROM May 4 1951 Beach Erosion Control report on Coop. Study of CT. AREA

NEW HAVEN HARBOR ⇒ HOUSATONIC RIVER

Project

In pg 9, 10, 21, 25, 26, (27), 28, 29, 30 – 39A

pg 40, 41, 42, 43, 44, 45, 47, 48, 52, 53, 56, 58

A-1, E-1, F-1, I-1, 2 ea., J-1-3,

(Pg. A-3)

1/6/82

PROSPECT BENEFIT

From May 1957 CT. AREA 3 REPORT.

Pg-9. . From Bradley Pt. to Milford Harbor, shore is irregular, beach area consists mainly of gravel, cobbles and boulders at the foot of eroded bluffs and cliffs, or in front of sea walls and revetments. There are numerous outcrops of rock in this area.

II. FACTORS AFFECTING SHORE PROCESSES

WIND

18. Wind Data. - Wind diagrams compiled from observations of the United States Weather Bureau at Block Island, Rhode Island; New Haven, Connecticut; and New York City, New York; are shown on Plates 3, 4, and 5. The periods covered by these observations are as follows: Block Island 1921-1939, New Haven 1932-1942, New York City 1921-1942. The wind diagrams show the percentage of wind movement and percentage of wind duration from the various directions averaged for the entire period of record and averaged for each of the 12 months of the year for the entire period of record. In addition to the above, wind diagrams showing the yearly cumulative average winds compiled from records of the United States Navy Hydrographic Office for the 5 degree squares nearest the shore line of Connecticut are shown on Plate 2.

19. Prevailing Winds. - At Block Island the prevailing wind is from the southwest from April through September, from the northwest during October to February and from the west during March. On an annual basis there is a slight predominance of southwest winds, while those from the west and northwest which occur next in the order of frequency are approximately the same.

20. At New York the prevailing wind is from the northwest from October to May, from the south from June to August and equally from the southwest and northwest during September. On an annual basis, there is a definite predominance of northwest winds. From the wind diagrams for the 5 degree squares, it is apparent that winds from the westerly quadrants prevail, which is in agreement with the records for Block Island and New York.

21. At New Haven the prevailing wind is from the south from May to August, from the north from September to February, from the northwest in March and from the north in April. On an annual basis, there is a

predominance of north and south winds, the greatest wind movement being from the north. The prevailing winds at New Haven are distinctly different from those found in any of the adjoining areas. New Haven lies in a lowland which runs generally north and south through Connecticut. Winds in this lowland are evidently affected by the topography so that at New Haven the winds are funneled in a north-south direction. It appears that the prevailing winds at New Haven should therefore affect only that portion of the shore line lying at the foot of this lowland east and west of New Haven, which might be defined approximately as extending from Pond Point in Milford to Branford River in Branford.

22. East of Branford River the wind data from Block Island represent the best available information applicable to the shore. West of Pond Point, the wind data from New York represent the best available data applicable to the shore. That portion of Area 3 east of Pond Point is therefore probably under the influence of winds similar to those occurring at New Haven where the prevailing direction is north and south, and west of Pond Point is under the influence of winds similar to those occurring at New York where the prevailing direction is northwest.

TIDES

23. Range of Tide. - Tidal range data for points in Long Island Sound near and within Area 3 are available from "Tide Tables, East Coast, North and South America, 1949" published by the United States Department of Commerce, Coast and Geodetic Survey. At the east end of the study area, at the entrance to New Haven Harbor, the mean range of tide is 6.2 feet and the spring range of tide is 7.3 feet. Within the area at Milford Harbor, the mean range of tide is 6.6 feet and the spring range is 7.8 feet. West of the area, at Bridgeport, the mean range of tide is 6.8 feet and the spring range of tide is 8.0 feet.

24. Storm Tides. - No continuous record of storm tides is available for any location within Area 3. A primary tide station is maintained by the United States Coast and Geodetic Survey at New London, Connecticut. A summary of extreme tides occurring at New London for a ten-year period is given in Appendix C. High water elevations which occurred during the hurricanes of 21 September 1938 and 14-15 September 1944, and during the southeast storm of 25 November 1950 were determined at locations along the shore of Connecticut and they are listed in Appendix C. During the 1938 hurricane, the high water elevation near the eastern end of the area at New Haven, was 13.0 feet above the plane of mean low water. West of the study area, at Bridgeport, the high water was 13.8 feet above the plane of mean low water. The above storm tides of September 1938 are the highest tides of record for this area.

WAVES

25. General. - Wave sizes are markedly smaller in Long Island Sound than along shores completely exposed to the ocean. This is a result of the shelter afforded by Long Island which acts as a natural breakwater shielding practically the entire shore of Connecticut. Wave sizes are dependent on wind velocity and on fetch or expanse of water over which the wave may travel. It is evident from the storm data tabulated in Appendix D that the frequency of storm winds at New Haven is considerably less than at Block Island and New York, which are more directly exposed to the ocean. The close proximity of Long Island to the Connecticut shore limits the fetch over which the winds may act to produce waves. These factors should and do act favorably in reducing wave action. The absence of surf bathing in Connecticut is an indication of the natural protection afforded this area.

STORMS AND THEIR EFFECTS

26. Storms. - Tropical storms of hurricane intensity occasionally pass across or near the Connecticut shore. Ivan Ray Tannehill, in his

book "Hurricanes", lists ten such storms which have been particularly severe in the New England Area. The dates of these storms and the known paths of five of them are shown on Plate 2. The paths of many more hurricanes are known to have passed over New England but their strength was largely dissipated before reaching this area with the result that their effects on the shore were not severe in New England. Two recent hurricanes of exceptional violence have struck across the Connecticut shore. These occurred on 21 September 1938 and 14-15 September 1944. An exceptionally severe southeast storm struck Connecticut on 25 November 1950. Although not classified as a hurricane, recorded winds reached hurricane velocities. Descriptions of hurricanes, in general, and of the above-mentioned storms in particular are included in Appendix D.

27. Storm Data. - Records of storm winds were compiled from United States Weather Bureau data as follows: At New York City, New York, winds equal to or greater than 40 miles per hour for the period 1911 - 1947; at New Haven, Connecticut, and Block Island, Rhode Island, winds equal to or greater than 32 miles per hour for the periods 1905 - 1947 and 1936 - 1945, respectively. These records show that the prevailing direction of storm winds is northwest. At New York and Block Island, storm winds from the west were next in order of frequency. At New Haven, there was no large predominance of storms from any direction. The Connecticut shore is sheltered by Long Island, Fishers Island and other islands extending to the east. Therefore, neither the frequency nor intensity of winds occurring at Block Island and New York City can be expected to occur along the Connecticut shore.

28. A search of newspaper files revealed that storm damages in the area under study reportedly occurs during storms from the northeast, southwest, and southeast directions. The shore faces open water in these directions with the greatest expanse to the southwest (23-30 miles), thence southeast (19-24 miles) and northeast (7 - 8 miles). Records show that winds

equal to or greater than 32 miles per hour from these directions occur on an average about 11 times a year at New York City and about twice a year at New Haven. The area under study is not subject to severe storm attack. Tabulation and analysis of storm records and accounts of storm damage reported by the press are included in Appendix D.

III. EFFECTS OF SHORE PROCESSES

SHORE LINE AND OFFSHORE DEPTH CHANGES

29. General. - Plans showing the location of the shore line and the 6, 12 and 18-foot depth contours have been prepared from United States Coast and Geodetic Survey data by the Beach Erosion Board for the period from 1837 to 1933. For this study a survey during 1949 located the entire shore line and offshore depths on selected profiles. Shore line changes are shown on Plates 7 and 8 and offshore depth changes are shown on Plates 7 to 10, and Plate 16. Detailed descriptions of the principal changes which have occurred since 1837 are included in Appendix E. In general, the entire shore line of Area 3 presents a picture of erosion during the past century, the amount being of the order of 1 to 3 feet per year. The greatest natural changes in the shore line are found at Sandy Point, Bradley Point and west of Silver Beach to and including Milford Point. The location of the sand spit at Sandy Point moved in a northerly direction and accretion added from 20 to 30 feet per year to its length. Erosion caused recession of the shore on both sides of Bradley Point, averaging about 2 feet per year. Meadows End located opposite Charles Island has eroded at the rate of 3 feet per year. The east end of Myrtle Beach has receded at the rate of 2-1/2 feet per year. The shore line from the west end of Myrtle Beach westward, including Walnut and Laurel Beaches, has eroded from 1 to 1-1/2 feet per year. The sand spit, constituting Milford Point, has grown westward at the rate of about 13 feet per year. In recent years, the construction of numerous shore structures has altered the effects of erosion, resulting in the lowering of beach levels or disappearance of beaches rather than in recession of the shore line. Accretion of the shore of about 250 feet was effected in 1948-1949 by the placement of sand between Sandy Point and Bradley Point in connection with hydraulic dredging of a navigation

channel in New Haven Harbor. In general, offshore depths increased between 1837 and 1884, Since 1884, there has been only a small amount of change. It appears that deepening is still continuing, but the amounts are too small to permit of reliable interpretation.

30. Comparative Profiles. - Forty-seven selected profiles were run normal to the shore between Bradley Point and Milford Point spaced about 500 to 3,500 feet apart, extending from above the high water line to the 18-foot depth contour in Long Island Sound. Their locations are shown on Plates 11 - 15. Cross sections spaced about 200 feet apart were run over the newly placed fill between Bradley Point and Sandy Point extending approximately 1,200 feet seaward of the high water line. Profiles were run to determine depth changes which have occurred offshore by comparison with data previously obtained by the United States Coast and Geodetic Survey and also to serve as a basis of comparison with any depth determinations which may be obtained in the future. It was planned that periodic check surveys be made along some of the profiles at intervals a few months apart to determine the character and extent of any seasonal changes which may be occurring along the shore. Experience with such periodic check surveys run for Areas 1 and 2 indicates that they possess little real value. The determination of seasonal changes which are very small would require that check profiles be run over an extended period not possible within the time limits set for this study. They were therefore discontinued. Twelve of the profiles and comparative locations of the 6, 12, and 18-foot depths in 1837-38, 1884, and 1933 are shown on Plate 16. The description of offshore changes which have occurred from 1837 to 1949 are included in Appendix E. In addition to their use in determining offshore depth changes, the profiles have served as a basis for the design of the plans of improvement.

LITTORAL DRIFT

31. Direction of Drift. - The direction and existence of littoral drift were determined by field inspection, study of shore line changes and local testimony. Trailing sand spits, accumulation of material on either side of groins, jetties or other structures and the gradation of beach material were used as indications of direction of drift. The amount of littoral drift in this area is small, particularly between Milford Harbor and New Haven Harbor, where there is a marked absence of natural sandy beaches except in pockets formed by the configuration of the shore. West of Milford Harbor, there is an almost continuous stretch of sandy beach area extending to Milford Point. Here, evidences of littoral drift were more easily discernible. From Pond Point to the east limit of Area 3 at Sandy Point, the direction of littoral currents was found to be generally toward the east limit of the study area, except at Bradley Point where drift was west towards Cove River and along the south side of Oyster River Point where the drift was west towards Oyster River. West of Pond Point, the direction of drift was found to be generally towards the west limit of the study area except along the east side of Welchs Point at Bay View Beach and along Silver Beach where indicated drift was north to northeast. The direction of drift was not everywhere clearly indicated as being in one direction, evidence found at Bay View and Silver Beach, indicating that material moved in both directions. According to testimony by residents, direction of drift varied seasonally. It is believed that in general, the predominant direction of drift is as described above. Indices of drift are listed in tabular form in Appendix F.

IV. EXISTING PROTECTIVE STRUCTURES

32. General. - The shore line has been largely influenced by the construction of protective structures. Between Sandy Point and Bradley Point, the shore formerly consisted of sea walls and riprap revetment protecting the state highway. The placement of sand fill obtained from the dredging of the navigation channel has created a wide sandy beach in front of these protective structures, thereby providing more adequate protection for the highway, in addition to an extensive recreational area. The shore from Bradley Point westward to and including Cedar Beach having a length of about 62,000 feet is protected by approximately 30,000 feet of sea walls, 3,500 feet of bulkheads, 3,500 feet of revetment, and 130 groins having an aggregate length of about 6,000 feet. West of Cedar Beach, the shore area consists of a sand spit known as Milford Point. This sand spit is largely undeveloped and the only shore structure on it is a breakwater constructed by the United States in connection with the Housatonic River navigation channel. Other structures within the study area constructed by the United States in connection with navigation projects, are a dike at Sandy Point, three offshore breakwaters at the entrance to New Haven Harbor, and two jetties and 12 groins at Milford Harbor.

33. A description of each structure in detail would be repetitious and of doubtful value. Typical structures have been selected and descriptions of these structures and an analysis of their effects are included in Appendix G.

34. The structures protecting the shore have destroyed, diminished, or interrupted the natural processes of supply of beach material formerly obtained from erosion of undeveloped areas and transmitted alongshore by littoral currents. This has resulted in diminishing the effectiveness of the numerous groins built along the Connecticut shore

to intercept littoral drift. These groins are now generally effective only in retarding erosion of existing beach material rather than in improving the area. The sea walls and bulkheads have undoubtedly stopped or retarded the recession of the shore line, a process which was generally occurring prior to their construction. Erosion is continuing in front of these structures resulting in disappearance of beaches or the lowering of the level of the shore with the consequent undermining of structures which in time can result in their destruction. The preservation of the shore against the attacks of waves from Long Island Sound will require constant and costly maintenance.

V. PLANS OF IMPROVEMENT

GENERAL

36. Connecticut. - The problem involved along the Connecticut shore line as a whole results in part from storm damage but is more particularly that of gradual erosion and deterioration caused by ordinary wave attack. The problem is not of recent origin but it has become increasingly important with increased use of the shore as a residential or resort and vacation area. Intensive development of the shore has necessitated the construction of protective structures to stop the recession of the shore line resulting from the natural processes of erosion. These structures have cut off the sources of supply of beach building materials which were formerly available through erosion of undeveloped areas. The problem has been intensified by general lack of knowledge of shore processes and changes to be expected and the resultant lack of control, planning, and foresight. The problem is to stabilize and improve the shore line so that existing and future development on the shore front may benefit from restored beach conditions and also to prevent future damages and losses which will otherwise inevitably result from the present deterioration. Local interests throughout the State have become increasingly aware of the growing problem. Evidence of this widespread concern is seen in the application for Federal studies at Compo Beach, Westport in 1935, and at Hawks Nest Beach, Old Lyme in 1939. Studies by private engineering firms at Ocean Beach, New London in 1938, and at Shippan Point, Stamford in 1941, further indicates this interest. In addition, preliminary discussions have been initiated in the past by many towns, beach associations and other interests concerning the conduct of cooperative studies. These various local movements toward separate studies were unified as a result of the State-wide destruction experienced in the 1938 and 1944 hurricanes. At a conference at

Clinton in July 1946 attended by 250 representatives of all shore towns and inland interests, a Beach Erosion Control Committee was appointed to initiate a State-wide study of the problems affecting the entire State shore line. Variation in degree of damage suffered was recognized in the resulting State appropriation for this study by enumeration of seven towns critically affected by shore erosion. The town of Milford, included in this report, is one of the seven so named.

37. Area3. - The problem in the study area is largely one of deterioration and gradual loss of beaches. The condition is fundamentally caused by the loss of natural sources of supply resulting from the nearly continuous development of the entire water front and the protection of areas previously eroding and furnishing material to the littoral drift supplying neighboring areas. This loss of supply has accelerated the processes of erosion and exposed developed areas to destructive wave attack necessitating the construction of expensive protective works. In general, the plans of improvement are based on artificial restoration of beach losses and the creation of sources of supply of beach building materials. Plentiful sources of sand have been determined to exist offshore within practicable distance for hydraulic dredging and pumping to shore. Location and character of material available for replenishment of beaches were determined by probings and borings. The results of the probings are shown in tabular form on Plates 12 to 15. The results of the borings are included in Appendix H. Construction of groins to prevent alongshore erosion of restored beaches is, in general, considered advisable to reduce losses due to erosion. Construction of bulkheads, sea walls and riprap revetment has been considered only where beach restoration has been found to be impracticable, since such restoration would offer equivalent protection in addition to furnishing the shore recreational area so important to the Connecticut shore. Offshore breakwaters are not regarded as offering a

solution for this area in view of the extreme expense involved and the limited benefit to be derived therefrom as the problem is more one of gradual losses from ordinary wave attack than one of damage by violent ocean waves. The plans are considered for each specific area in the following paragraphs.

SPECIFIC PLANS OF IMPROVEMENT

38. Sandy Point to Bradley Point. - This area extends from the sand spit comprising Sandy Point at the west side of New Haven Harbor southwestward to the east side of Bradley Point at the foot of Savin Avenue. The shore south of Sandy Point to a newly constructed timber groin opposite Savin Avenue was used as a disposal area for sand dredged from the navigational channel from July 1948 to January 1949. Over 1,000,000 cubic yards of sand were placed during this operation to create a wide sandy beach about 1-1/2 miles long and about 250 feet wide. This shore area prior to placement of the sand fill consisted of stone riprap and walls protecting Beach Street which very closely parallels the shore. Prior to placement of the sand fill, this shore highway was considered as the most critical in Connecticut in so far as storm damage and erosion were concerned. The new sand fill, in addition to providing extensive recreational area, will furnish the much needed protection for this shore road. The existing beach is considered satisfactory for present needs. Periodic surveys should be run across this new beach to measure the rate and extent of loss of material due to erosion with a view to determining the feasibility of retarding erosion by the construction of groins or replacing losses by offshore dredging.

39. Bradley Point. - This is a point of land between Savin Avenue and Cove River formed by rock outcrops projecting seaward. There are narrow sandy beaches formed in small pockets on both sides of this rocky headland. Shore line change maps indicate that erosion of 250 to 300 feet

has occurred along both sides of the point since 1837. A spit formerly extending westward about 500 feet from the present east shore of Cove River is now gone. High water at the east end of the pocket beach on the east side of Bradley Point is at the foot of a sea wall protecting Connecticut Route 122. A town street runs along the shore behind this pocket. A timber bulkhead has recently been constructed along the seaward side of this street. It was proposed to place fill from the dredging of the navigation channel along this shore but the propery owners, feeling that the material would be of unsatisfactory composition, would not grant the necessary easements for the work. In order to insure that fill pumped along the shore at Savin Rock would not run into the area, it was necessary to construct a timber groin at the foot of Savin Avenue at the west limit of the fill. An excellent opportunity for protecting the shore highway and enlarging and improving this pocket beach was thereby lost. The wooden groin and Bradley Point create an exceptionally well protected area for development of a stable pocket beach needing only the artificial placement of sand fill. The pocket beach on the west side of Bradley Point is very narrow, having a width of about 20 feet above high water in front of an existing town street. A series of short timber groins have been built along the shore in front of timber bulkheads. West of this pocket to Cove River, there is a deteriorating masonry wall. This side of Bradley Point is exposed to southwest storms. The plan of improvement considered for protection and improvement of the area consists of widening the beach to a 100-foot width by the artificial placement of sand and the construction of an impermeable groin at the west limit of the fill. The plan of improvement is shown on Plate 18.

40. Sea Bluff Beach. - This is a town-owned beach located west of and adjacent to Cove River. The easterly 500 feet consists of a sand and gravel shore in front of Connecticut Route 122 ranging in width from zero

at the ends to about 150 feet in the central portion. This area is now used for bathing. West of this sandy shore for about 400 feet, the high water line is at the foot of revetment protecting a state highway which runs parallel to and very close to the shore. There are no public facilities at this bathing beach. The beach is located in an indentation of the shore forming a sheltered pocket. Consideration was given to the placement of sand to widen and enlarge the beach to provide additional recreational area. Due to the proximity of the newly placed sand beach located between Savin Avenue and Sandy Point, the existence of wide offshore flats opposite Sea Bluff Beach which limit its full use to times of high water and the lack of space at this locality for development of facilities for a beach which could receive widespread use, expansion of the present area does not appear advisable.

41. Prospect Beach, Oyster River (Ames) Point and Oyster River Point to Oyster River. - This is a town-owned shore located between Sea Bluff Beach and Oyster River. The area between Sea Bluff Beach and Oyster River Point is known as Prospect Beach. A short stretch of shore adjacent to and east of Oyster River is known as Oyster River Beach. The shore consists of coarse material, generally shingle, cobbles and boulders, with ledge rock outcrops in the vicinity of and west of Oyster River Point. The beach is narrow above high water, varying from 0 to 40 feet in front of walls, revetment and an eroding bluff. One extent of shore located between Sea View Avenue and Lake Street (Prospect Beach) very closely borders the state highway. High water is at the foot of a sea wall built to protect the highway. Oyster River Point is protected throughout most of its extent by sea walls in front of which there has been a lowering of the beach level through erosion which has undermined walls or threatens to do so. The only sandy shore in this entire area exists at Oyster River Beach and it is used by the town for bathing. This town beach consists of small sand pockets between ledge rock outcrops. In colonial times, a

road now referred to as the "Ancient Highway" ran along this entire shore. Erosion forced abandonment of this road and construction of the present highway further inland. A sanitary sewer now closely borders the shore serving the residences in the area. Due to erosion, it has been necessary to construct sea walls and revet the shore for protection of the sewer. The town of West Haven spent $70,000 in ten years for these protective structures. According to residents, erosion resulting in the lowering of the beach level in front of protective structures is still continuing. New sills added at the toe of sea walls offer mute evidence of this erosion. The plan of improvement considered consists of widening Prospect Beach and a stretch of shore west of Oyster River Point by the placement of sand dredged hydraulically from Long Island Sound to create a protecting beach generally 100 feet wide, with added width of about 50 feet along the more exposed ends of this fill adjacent to Oyster River Point. It was originally felt that sand fill alone might be sufficiently stable so as not to require construction of any additional protective works. The possibility of excessive sand losses was recognized, however, and in a preliminary plan, deferred construction of groins, if proven to be needed by experience with the sand fill, was considered. Further study was made with a view to determining the probable direction of travel of waves approaching the shore. This study indicated that the orientation and exposure of Prospect Beach was such that northward drifting would occur, resulting in excessive losses of the proposed beach fill. It was, therefore, considered advisable to include construction of a series of groins to reduce these losses as an item of required rather than deferred construction. Groins designed to give maximum protection to the fill would have to be long, large structures extending out to the 6-foot depth contour. Due to the high cost of such structures, groins of this type are not considered to be a practical method of protection. The groins considered are of a type which will afford protection to the zone of beach lying landward of the low water line. Surveys run on the beach fill at the adjacent beach north of Bradley Point show that the only appreciable losses

of fill are occurring between the high and low water lines. The groins considered will protect this zone. In addition, the smaller groins contemplated will permit the passage of some sand through drifting from the wider south end of the fill to nourish the beach to the north and will, therefore, permit more economical maintenance of the beach by periodically placing sand at its south end. The proposed sand fill west of Oyster River Point should be closely observed and if the rate of erosion is such as to require excessive maintenance, impermeable groins similar to those considered for Prospect Beach should be built. Here, also, the smaller type groins would have the advantage of permitting passage of some sand from the wider east end of the fill to nourish the entire shore to the west. Consideration was given to placement of sand around Oyster River Point. Due to the steep foreshore slope along the east side of the point which would necessitate the placement of very large quantities of sand to create a beach with a stable slope and the natural protection afforded this area by numerous rock outcrops, it was considered advisable to omit this section of shore from the area to be filled. In general, the direct placement of sand is limited to shore areas which have suffered most from erosion. No improvement is regarded as necessary at Oyster River Beach. The existence of wide offshore sand flats limit the full use of this beach to times of high water and space is lacking for development of facilities for a beach which could receive wide-spread use. The proposed sand fill west of Oyster River Point should supply littoral drift material to improve this beach sufficiently to serve present needs. The plan of improvement is shown on Plate 18.

42. South of and Adjacent to Oyster River. - At the West Haven-Milford town line south of Oyster River, Connecticut, Route 122 closely parallels the shore for about 400 feet. The highway is protected by a disintegrating concrete sea wall and riprap revetment. The shore is from 0 to 20 feet

wide in front of the wall and consists of medium to coarse sand with marsh and sand flats below high water.. The westerly portion of this shore turns away from the highway to a point formed by a ledge rock outcrop and consists of medium and coarse sand with shingle and marsh below high water. The beach width here is 50 to 100 feet. The Connecticut State Highway Department lists the highway in this area as being affected by shore erosion. The shore property is owned by the town of Milford and could possibly be developed into a town beach. Consideration has been given to the artificial placement of sand to create a beach about 100 feet wide to provide protection for the highway, improve the composition of the beach, and furnish additional recreational area. Since the configuration of the shore forms a natural pocket, such a beach would be fairly stable. A training wall at the mouth of Oyster River at the east limit of the fill would be required to prevent closure of the river. In view of the proximity of a town-owned beach in West Haven on the opposite side of Oyster River and the existence of sand flats offshore which would discourage use of the beach except during high water, it is not considered advisable to develop a recreational area in this location. If need for such a beach should arise, consideration should be given to the improvement described above. In the meantime, maintenance of the present highway protection is all that is considered necessary.

43. Woodmont Shore. - This extent of shore is characterized by a number of pocket beaches between ledge rock outcrops. The only sandy shore areas are found in these pockets. The first pocket at the north end of the area has a medium sand and gravel beach above high water, about 50 feet wide and 250 feet long with coarse sand and a large admixture of gravel below high water. There are no protective structures along this shore. Further south, the w idth of shore above high water diminshes to 20 feet and the shore material consists of rock outcrops, shingle, cobbles, boulders, and marsh grass. Thebackshore is protected by sea walls. The footings of these walls are exposed for about two feet, indicating a lowering of the beach level.

South of this walled area, the shore consists of an eroded bluff 15 to 20 feet behind the line of the existing sea wall. The next southerly 1,000 feet of shore is closely bordered by a town street. Along this section, the shore is protected by riprap revetment and high water is at the foot of this revetment. The unprotected shore north of this revetted area has been eroded behind the line of the revetment very close to the above mentioned town street. South of this revetted area to outcrops of ledge rock at Merwin Point, there is a shallow pocket beach about 20 feet wide above high water fronting a low concrete wall. The beach composition is coarse sand and gravel above high water and shingle below high water. West of Merwin Point, between ledge rock outcrops, there is a narrow sand and gravel pocket beach 0 to 20 feet wide in front of a concrete wall. This beach is separated in the middle by a projecting concrete bastion. Loss of material through erosion has resulted in lowering of the beach level and undermining of the bastion and concrete steps which provide access to the beach. This appears to be an excellent location for development of a small bathing beach. The plan of improvement considered consists of artificial placement of sand along the entire shore north of Merwin Point and in the pocket west of Merwin Point to create a protective sand beach approximately 100 feet wide, with added widening of the fill at the south end of the revetted shore and construction of a terminal groin at the northerly limit of the fill to catch northward drifting material which could create shoals at the mouth of Oyster River. It was originally felt that the proposed sand fill north of Merwin Point might be sufficiently stable so as not to require construction of any additional groins. The possibility of excessive sand losses was recognized, however, and in a preliminary plan, deferred construction of additional groins, if proven to be needed by experience with the sand fill, was considered. Further study was made with a view to determining the probable direction of travel of waves approaching the shore. This study indicated that the orientation and exposure of the Woodmont shore

north of Merwin Point was such that northward drifting would occur, resulting in excessive losses of the proposed beach fill. It was, therefore, considered advisable to include construction of a series of groins to reduce these losses as an item of required rather than deferred construction. The need for and the selection of the type of groins considered are based on considerations identical with those contained in Paragraph 41 pertinent to groins at Prospect Beach. The plan of improvement is shown on Plate 18.

44. Anchor Beach and Merwin Beach. - Anchor Beach is a small town-owned pocket beach between projecting ledge rock outcrops located west of Merwin Point near the west limit of the Borough of Woodmont. The beach varies in width above high water from 10 to 100 feet. The beach material consists of fine sand above high water and medium sand below high water. Anchor Beach is used intensively by local residents for bathing. The ledge rock outcrops continue westward from Anchor Beach to Merwin Beach, which is a barrier bar fronting marsh located in an indentation of the shore. There are ledge rock outcrops at both ends of this bar. The beach is composed of fine sand above high water, and varies below high water from medium sand and fine gravel at its easterly end to fine and medium sand at its westerly end. The easterly end of the beach is narrow above high water, generally 10 to 20 feet wide in front of a concrete sea wall. It increases to a width of 100 feet further west where there are no protective structures. The present condition of the beaches is considered satisfactory and due to the natural protection afforded by the configuration of the coast, it is believed they will remain reasonably stable. No improvement is considered necessary.

45. Morningside, Farview, and Burwell Beaches. - Extending southward from Merwin Beach, the backshore area rises in elevation so that at Morningside there exists a high cliff of unconsolidated material which, due to its proximity to the Sound, has suffered severely from erosion. This area, including Burwell and Farview Beaches and Morningside, is almost continuously protected by sea walls. These walls are low at the north end of the area

at Burwell Beach where they are fronted by a narrow sand and gravel beach 15 to 30 feet wide. The sea walls increase in size toward the south end of Burwell Beach and at Farview Beach where they consist of high, massive concrete and masonry structures. The beach composition becomes coarser towards the south, consisting of shingle, cobbles and boulders, except along two short stretches of shore where groins have succeeded in holding some coarse sand. The shore along a large part of Farview Beach consists of exposed bedrock. Around Morningside, there is a lower concrete wall, about 3 to 4 feet high. Supplemental protection above this wall is provided by revetment, bank paving and bulkheads. Where such additional protection is absent, erosion or weathering of the bank above the wall is evident. The northerly end of Burwell Beach appears to be fairly stable. Progressing further south, the increasing coarseness of the material fronting the sea walls and the exposure and undermining of walls attest to the erosion which is taking place, resulting in the lowering of the beach level. This is particularly notable along sections of Morningside where one to two toe walls have been added in front of portions of the original structure, indicating a lowering of beach level of 3 to 4 feet. The existence and stability of the sandy shore along Burwell Beach indicates that it is practicable to provide additional protection for this area by direct placement of sand fill. The existing walls along Farview Beach and Morningside generally provide adequate protection to the bluff behind them. Extension of the system of bank revetment along unprotected slopes above the low wall at Morningside is needed to protect these steep slopes from weathering and wave attack during storms. Protection is also needed to prevent undermining of the sea walls by gradual lowering of the beach level. A large measure of protection is already afforded to the walls by the outcrops of bedrock along Farview Beach, and the coarse blanket of boulders and cobbles along Morningside. In a preliminary plan, consideration was given to the construction of a series of short groins along the Morningside shore to reduce losses of beach material

and also to the placement of sand fill along Farview and Burwell Beaches to create a protective beach. Additional study indicated that it would be advisable to revise the above plan for the following reasons. (a) There is no apparent source of supply of beach building material which can be impounded by the proposed groins at Morningside to replace losses of existing beach material which occurs through offshore movement. There is, therefore, some doubt concerning the effectiveness of the proposed groins in stabilizing the shore. (b) Studies made to determine the probable direction of movement of waves approaching the shore of Farview Beach indicate that northward drifting occurs. Northward drifting of the proposed sand fill and movement of sand offshore down the steep foreshore slopes would result in excessive losses and high maintenance costs. (c) Northward drifting also occurs along Burwell Beach, making it advisable to reduce losses of the proposed sand fill which would occur through northward movement. In view of the above, the plan considered most practicable consists of placement of riprap revetment along the toes of sea walls at Morningside and Farview Beach as the need therefor arises, direct placement of sand fill to widen Burwell Beach to a 100-foot width and construction of an impermeable groin at the north limit of the fill. The plan of improvement is shown on Plate 19.

46. Point and Pond Point Beaches. - This area extends southward from Morningside to and around Pond Point and thence north and west along the shore of an embayment to Calf Pen Meadow Creek. Point Beach is the southern shore of Pond Point and Pond Point Beach lies between Pond Point and Calf Pen Meadow Creek. The northerly 1,400 feet of shore consists of an eroding unprotected bluff with height decreasing towards Pond Point. This bluff is eroded 20 to 30 feet back of the line of the protected adjacent area at Morningside. The beach is composed of coarse sand and fine gravel above high water, 30 to 50 feet wide, and of cobbles and boulders below high water. The backshore area is undeveloped. The south shore of Pond Point, continuously protected by concrete walls about 3 feet high, is located south and west of

the above section. The beach here consists of fine gravel and coarse sand above and shingle below high water. The gradation is finer at the west end. A series of short timber groins, catching westerly drift, exists along the westerly end of this area. A lowering of the beach of from 1 to 3 feet is evident from the relationship between the present beach level and the bottoms of undermined concrete walls and steps. The west side of Pond Point is protected by low concrete walls, wooden bulkheads, and groins. The beach is composed of fine gravel and coarse sand above and shingle and cobbles below high water. West of Pond Point along the inner shore of the embayment, the shore width decreases from about 75 feet at the east end to 0 at the westerly end near Calf Pen Meadow Creek. The beach composition becomes finer towards the west, consisting generally of fine gravel and fine sand above and shingle and fine gravel below high water, except adjacent to Calf Pen Meadow Creek where the beach widens out to a width of about 200 feet composed of fine sand above and coarse to medium sand and gravel below high water. The narrow westerly end of this latter area is protected by low concrete walls and bulkheads. The unprotected bluff adjacent to and south of Morningside is subject to wave attack and erosion during storms. This area is now undeveloped and is, therefore, in no immediate need of protection. Continued erosion of the south end of this bluff adjacent to the area now developed for residential use at Pond Point could result in flanking of existing protective structures and endangering of residences. The existing sea walls around Pond Point generally provide adequate protection to the backshore. This type of protection, if maintained, should continue to protect the residential development. Some of the walls have been damaged or destroyed by exceptional storms of infrequent occurrence. In general, it is not considered economically feasible to construct protective works that will completely eliminate such damage. Maintenance of the sea walls requires protection against undermining due to lowering of the beach level. Due to the coarseness of the beach, losses of material and lowering of the beach

level occur at a slow rate. In a preliminary plan, consideration was given to construction of a series of short impermeable groins along the unprotected bluff and placement of a stockpile of sand around Pond Point. The groins were intended to reduce losses of material as it was eroded from the bluff, thereby building a fronting beach which would eventually protect the bluff. The sand stockpile was intended to act as a protective beach for the walled section of Pond Point and to supply material to adjacent beaches. Further consideration given to this plan indicates that the rate of loss of material from the stockpile would be high, and the high cost of maintenance would make the plan impracticable for local interests. It is considered more practicable to protect the toes of sea walls by placement of riprap revetment along those sections which are in immediate need of protection and to extend the revetment to other sections as the need arises. It also appears that more positive protection of the unprotected bluff north of the sea walls would be more desirable. The plan considered for this purpose consists of placement of riprap revetment along the toe of the bluff up to a height sufficient to protect against wave wash during ordinary storms. The revetment would also provide a large measure of protection during exceptional storms which infrequently attack the bluff and cause the greatest losses. Protection can also be provided by construction of sea walls. If this method is preferred, riprap revetment will be required along the toes of the walls to guard against undermining of the walls through erosion. The proposed methods of protection are shown on Plate 19.

47. Welchs Point - Bay View and Gulf Beaches. - Bay View Beach is located in an embayment between Welchs Point and Calf Pen Meadow Creek. Gulf Beach is situated northwest of Welchs Point and south of Long Jetty at the mouth of Indian River. Welchs Point is an eroding cliff of unconsolidated material projecting into Long Island Sound between the above named beaches. High water is at the foot of this cliff. The shore at the foot of Welchs Point is irregularly eroded, consisting of cobbles and boulders. There is no sand

along the shore. The cliff is protected by dumped boulder revetment held on the bank slopes by a line of wooden poles. A series of roughly built dumped boulder groins have been built along the west side of the point, but there is no evidence that they are catching any littoral drift. Part of the cliff embankment is protected by timber bulkheads. In general, the protective works are of a makeshift nature. In view of the initiation of development of the land on top of the cliff for residential construction, more effective protection of the cliff will undoubtedly be required. The composition of the shore material becomes finer east of Welchs Point along Bay View Beach, changing to fine sand above high water with width of 10 to 30 feet in front of cottages at the west end and 75 to 100 feet adjacent to Calf Pen Meadow Creek. West of Welchs Point, the shore material is very coarse, the size of boulders and cobbles diminishing towards Gulf Beach where a coarse sand and fine gravel beach exists, held by Long Jetty. This latter area is used as a town bathing beach. A series of timber groins along Gulf Beach catch material on their south sides, indicating a strong littoral drift northwest towards the mouth of Indian River. Consideration was given to a plan of improvement consisting of artificial placement of sand along the shore around Welchs Point and northwesterly thereof to an including Gulf Beach with increased width of fill at Welchs Point. This fill would serve as a stockpile to nourish Bay View Beach to the east, provide needed protection for the eroding cliff and nourish the entire shore between Welchs Point and Indian River. Due to the steep foreshore slopes around Welchs Point, the plan described above would require the placement of large quantities of sand. Since Welchs Point and the shore northwest to Gulf Beach are largely undeveloped at present, the benefits to be derived from the improvement would not be sufficient to warrant the large expenditure which would be necessary. For the present, only that portion of the above plan involving the direct placement of sand along the town-owned Gulf Beach is

considered advisable. This would improve the composition of the present coarse shore and provide additional recreational area. Gulf Beach receives considerable use at present, resulting in serious overcrowding. It is estimated that at times of peak use, there is only 20 square feet of space available per person on the usable beach area. A desirable optimum space requirement would be about 75 square feet per person. Maintenance of the protective sturctures along the Welchs Point area is all that appears warranted until such time as development of the area justifies a more complete plan of improvement and protection. Bay View Beach is regarded as being fairly stable. Although some widening of the sand beach is desirable, there does not appear to be any urgent need for improvement at this time. If protection or improvement is desired, it can be accomplished by direct placement of sand to widen the existing beach. The placement of sand fill may make it necessary to construct a training wall at the west side of the mouth of Calf Pen Meadow Creek to prevent excessive shoaling of the channel by eastward drifting. The plan of improvement for Gulf Beach is shown on Plate 19.

48. Milford Harbor to Milford Point. - The shore from Burns Point in Milford Harbor westward to Milford Point at the Housatonic River, the westerly limit of the study area, is almost continuously sandy in composition. The principal shore features consist of a barrier bar fronting the large Meadows End marshes, a submarine bar or tombolo from this bar extending seaward and connecting with Charles Island and a long sand spit which has grown westward to form Milford Point. The entire area, except the west half of Milford Point, has been intensively developed for summer and year round residences. Due to this intensive development, erosion of the shore has become a serious problem necessitating the construction of an almost continuous system of protective structures consisting of bulkheads, sea walls, revetment and closely spaced groins. Silver and Fort Trumbull Beaches located east of the

aforementioned submarine bar are generally 50 to 75 feet wide above high water. West of this bar, along a large part of the shore, high water is at the foot of protective walls and bulkheads. The greatest width of beaches is generally less than 50 feet. The beaches east of the submarine bar benefit from the natural protection afforded by the bar on the west and Welchs Point on the east. The beaches west of the bar are more exposed and erosion has, therefore, been greater. Shore line changes indicate that erosion around Meadows End has been rapid during the past century, resulting in a shore line recession averaging 3 feet per year. This recession diminishes westward to a rate of one foot per year along Cedar Beach. This erosion has created a serious problem. Some form of protection is urgently needed. It is pertinent to note that during the southeast storm of 25 November 1950, which caused wide-spread destruction along the entire Connecticut shore, the greatest damage occurred along the Milford beaches west of Meadows End. In a preliminary plan, consideration was given to protection and improvement of the shore by direct placement of sand fill along Cedar, Laurel, Walnut and Myrtle Beaches to create a protective beach 100 feet wide, and placement of sand on the submarine bar connecting Meadows End and Charles Island to nourish the above beaches to the west and Silver Beach to the east. A terminal groin was included at the west end of the proposed fill at Cedar Beach. The sand on the bar was also intended to provide needed protection to the highway which closely parallels the shore at Meadows End. It would also indirectly benefit the small town-owned public beach located north of the submarine bar by enlarging the area available for recreational use. The above plan is shown on Plate 20A. Additional study was made to determine the probable direction of approach of waves along the shore and the consequent direction of movement of the proposed fill. This study indicated that loss of material from Meadows End and the east end of Myrtle Beach occurs by offshore movement. It, therefore, appears doubtful that the proposed fill on the submarine bar would be

effective in supplying material to the beaches located to the west. Further west, along Myrtle, Walnut and Laurel Beaches, littoral drift occurs, resulting in reversing movement of material to the east and west. The prevailing direction of drifting at the west end of the shore at Laurel Beach is west. Along Cedar Beach, littoral drift is predominantly westward. The growth of Milford Point westward is evidence of the large amounts of material formerly moved towards the Housatonic River. In view of the manner of movement of material along the shore, it appears advisable to use some other means of stabilizing the proposed fill along the beaches west of the submarine bar. A plan has been considered involving construction of a series of impermeable groins along those portions of the shore of Cedar, Laurel, Walnut and Myrtle Beaches where littoral drifting occurs in lieu of the proposed sand fill on the submarine bar. This plan includes protection of the Meadows End shore by placement of a sand fill 250 feet wide. No groins were considered along the east end of Myrtle Beach and around Meadows End because the apparent manner of movement of material in an offshore direction indicates that groins would be of doubtful value. The increased width of sand fill around Meadows End is required because the past rate of shore recession has been rapid, indicating that future losses will also be rapid. The proposed sand fill should be extended east of the submarine bar along Silver Beach to create a protective beach 100 feet wide in front of existing cottages. Losses from Meadows End should supply some material and tend to maintain the Silver Beach fill. Periodic replacement of sand will be required to maintain the fill areas. The above plan of protection and improvement is shown on Plate 20.

VI. ECONOMIC ANALYSIS

GENERAL

49. Statutory Authorization. - Public Law 727, 79th Congress, approved 13 August 1946, established a policy of Federal participation in the cost of improving and protecting the shores of publicly-owned property. It provides in part that:

> "With the purpose of preventing damage to public property and promoting and encouraging the healthful recreation of the people, it is hereby declared to be the policy of the United States to assist in construction, but not the maintenance, of works for the improvement and protection against erosion by waves and currents of the shores of the United States that are owned by States, municipalities, or other political subdivisions: Provided, That the Federal contribution toward the construction of protective works shall not in any case exceed one-third of the total cost."

50. Economic analyses have been made for all contemplated projects. Detailed estimates are included in Appendices I and J. Where public and private shore areas are included in one integrated improvement, the analyses have been made for the combined area. Where an improvement involving only publicly-owned shore area is contemplated, the analysis has been restricted to such area. A cost estimate of a preliminary plan for protection and improvement of Silver, Myrtle, Walnut, Laurel and Cedar Beaches and Meadows End, involving the placement of sand fill on the submarine bar connecting Meadows End and Charles Island, is included in Appendix I because of widespread local interest in a plan of this type. This plan was subsequently revised in favor of one which provides more positive protection to the shore. Reasons for the revision are given in Paragraph 48. The estimated cost of the preliminary plan is not included in the following pages. Improvements which have been considered are as follows:

Improvements Considered

Area	Ownership	Paragraph Reference	Plate
Bradley Point, West Haven	Private	39	18
Prospect Beach, West Haven	Combined Public and Private	41	18
Oyster River Point to Oyster River, West Haven	Combined Public and Private	41	18
Woodmont Shore, Milford	Combined Public and Private	43	18
Burwell Beach, Milford	Private	45	19
Gulf Beach, Milford	Public	47	19
Silver, Myrtle, Walnut, Laurel, and Cedar Beaches, and Meadows End, Milford	Combined Public and Private	48	20

COSTS

51. First Costs. - The first costs of the projects considered, computed in detail in Appendix I, area as follows:

Project	Quantity	Cost
Bradley Point	2,000 cubic yards sand fill, 750 tons riprap groin	$ 22,000
Prospect Beach	380,000 cubic yards sand fill, 4,200 tons riprap groins	213,600
Oyster River Point to Oyster River	145,000 cubic yards sand fill, 1,000 tons riprap groins	95,000
Woodmont Shore	240,000 cubic yards sand fill and 3,000 tons riprap groins	151,800
Burwell Beach	32,000 cubic yards sand fill, 1,350 tons riprap groin	41,500
Gulf Beach	45,000 cubic yards sand fill	31,000
Silver, Myrtle, Walnut, Laurel and Cedar Beaches and Meadows End	740,000 cubic yards sand fill and 12,500 tons riprap groins	455,000

BENEFITS

52. General. - The benefits anticipated from the plans of improvement are estimated on the recreational value of increased public beach area, direct damages prevented, and increased earning power or value of shore lands. Benefits accruing from increased value of areas behind and adjacent to improved shore property and increased business, although known to exist, have not been estimated. Recreational benefit has been evaluated for anticipated increased patronage at public beaches by assigning a per capita value for beach use estimated as the minimum charge which would be made if the beach were a private enterprise. Direct damages prevented have been evaluated by placing a value per cubic yard on reduction of losses of beach material and by estimating the savings in maintenance costs of existing protective structures. Benefits from increased earning power or value of shore lands have been evaluated by estimating the increased tax on im-

proved land due to increase in value of the property and also by taking a gain represented by interest on increase in land value which could be realized by sale of such land and investment of the additional money so obtained.

53. Benefits. - Detailed estimates of benefits are included in Appendix J and summarized below:

ESTIMATED BENEFITS

Project	Recreational	Direct Damages Prevented	Increased Earning Power	Total
Bradley Point	$ 0	$ 500	$ 976	$ 1,476
Prospect Beach	20,000	3,225	690	23,915
Oyster River Point to Oyster River	0	2,700	3,140	5,840
Woodmont Shore	4,000	4,850	2,070	10,920
Burwell Beach	0	1,125	1,250	2,375
Gulf Beach	3,600	730	0	4,330
Silver, Myrtle, Walnut, Laurel and Cedar Beaches and Meadows End	10,000	19,150	14,430	43,580

INTERESTS

54. Federal, Non-Federal, Public and Private Interests. - The Federal interest in a shore protection project is considered to be essentially the benefit secured by the United States as a land-owner. Non-Federal public interest is defined as (a) the benefits accruing to a State or a political subdivision thereof as a land-owner and (b) the benefits accruing to the general public. Private interest is defined as the benefit derived by individuals or non-public groups of individuals on account of ownership of lands and business enterprises affected. The United States is not a land-owner in any of the areas for which projects have been considered. Therefore, no Federal interest is involved.

55. Non-Federal publicly-owned land values in the areas considered for projects are estimated as follows:

Project	Area	Estimated Value
Prospect Beach	Town-owned shore and public beach	$146,000
Oyster River Point to Oyster River	Town-owned public beach and street ends	70,000
Woodmont Shore	Town and Association-owned shore and street ends	235,000
Gulf Beach	Entire	110,000
Silver, Myrtle, Walnut, Laurel and Cedar Beaches and Meadows End	Town-owned public beach, small lots and street ends	90,000

56. The assessed value and annual tax income on privately-owned property directly affected by the proposed improvements are as follows:

Project	Assessed Value	Annual Tax Income
Bradley Point	$ 90,000	$ 2,250
Prospect Beach	58,000	1,450
Oyster River Point to Oyster River	205,000	5,125
Woodmont Shore	182,000	5,460
Burwell Beach	87,000	2,610
Gulf Beach	All publicly-owned	0
Silver, Myrtle, Walnut, Laurel and Cedar Beaches and Meadows End	1,155,000	34,650

57. The total Grand List for the town of Milford is $55,444,681, the tax rate is $30 per thousand, and sales of property run 200 to 250% over the assessed valuation. The total Grand List for the town of West Haven is $65,000,000, the tax rate is $25 per thousand and assessed value is the same as real value.

58. The classification of benefits to be derived from the proposed projects in accordance with the interest involved is as follows:

ESTIMATED BENEFITS

Project	Federal	Non-Federal Public	Private	Total
Bradley Point	0	$ 406	$ 1,070	$ 1,476
Prospect Beach	0	22,015	1,900	23,915
Oyster River Point to Oyster River	0	1,300	4,540	5,840
Woodmont Shore	0	9,470	1,450	10,920
Burwell Beach	0	375	2,000	2,375
Gulf Beach	0	4,330	0	4,330
Silver, Myrtle, Walnut, Laurel and Cedar Beaches and Meadows End	0	15,380	28,200	43,580

ALLOCATION OF COSTS

59. General. - The Federal policy for the expenditure of Federal funds for the improvement and protection of shores owned by States, Municipalities, and other political subdivisions is set forth in Public Law 727, 79th Congress, 2nd Session. In accordance with this policy, the Federal share of the cost has been determined so as not to exceed one-third of the first cost of construction, but not the maintenance of works for the improvement and protection of publicly-owned shores. Where the area to be improved and protected is 100% publicly-owned, the Federal participation has been computed as one-third of the entire first cost of the project. Where the area to be improved is divided between public and private ownership, the Federal participation has been computed as one-third of the first cost of that part of the project which improves and protects only the publicly-owned portion of the shore.

60. Allocation. - The Federal and non-Federal share of the costs of projects considered are estimated in detail in Appendix I and summarized below:

ALLOCATION OF COSTS

Project	Federal Share	Non-Federal Share	Total
Bradley Point	$ 0	$ 22,000	$ 22,000
Prospect Beach	64,000	149,600	213,600
Oyster River Point to Oyster River	7,200	87,800	95,000
Woodmont Shore	35,300	116,500	151,800
Burwell Beach	0	41,500	41,500
Gulf Beach	10,300	20,700	31,000
Silver, Myrtle, Walnut, Laurel and Cedar Beaches and Meadows End	15,200	439,800	455,000

ANNUAL CHARGES

61. Federal and Non-Federal Annual Charges. - Annual charges are based on the Federal and non-Federal share of the estimated costs of proposed projects. The detailed estimates are included in Appendix I. Interest has been computed at the rate of 3 percent on Federal funds and 3.5 percent on non-Federal funds. A useful life of 50 years has been assumed in determining amortization charges. Annual maintenance costs are included as a non-Federal charge. A summary of annual charges is given below:

ANNUAL CHARGES

Project	Federal	Non-Federal	Total
Bradley Point	$ 0	$ 1,620	$ 1,620
Prospect Beach	2,490	13,100	15,590
Oyster River Point to Oyster River	280	6,770	7,050
Woodmont Shore	1,370	9,290	10,660
Burwell Beach	0	2,410	2,410
Gulf Beach	400	1,985	2,385
Silver, Myrtle Walnut, Laurel and Cedar Beaches and Meadows End	590	27,160	27,750

JUSTIFICATION

62. Benefit and Cost Ratio. - The estimated annual benefits and costs and the resulting ratio of benefits to costs are summarized in the following table:

BENEFITS AND COSTS

Project	Estimated Annual Benefits	Estimated Annual Costs	Ratio of Benefits to Costs
Bradley Point	$ 1,476	$ 1,620	0.9
Prospect Beach	23,915	15,590	1.5
Oyster River Point to Oyster River	5,840	7,050	0.8
Woodmont Shore	10,920	10,660	1.0
Burwell Beach	2,375	2,410	1.0
Gulf Beach	4,330	2,385	1.8
Silver, Myrtle, Walnut, Laurel and Cedar Beaches and Meadows End	43,580	27,750	1.6

COORDINATION WITH OTHER AGENCIES

63. General Coordination. - Close coordination has been maintained with the Connecticut State Flood Control and Water Policy Commission, the official agency representing the State of Connecticut in this cooperative study. The Connecticut Beach Erosion Advisory Committee appointed by the Governor to report to the State Legislature has in like manner been advised and consulted. The Selectmen of the towns concerned have been contacted and their views sought. The Connecticut Development Commission, State Park Department, State Highway Department and State Board of Fisheries and Game have been contacted as to aspects of the study pertaining to their interests. In addition, widespread personal contact has been made with the shore residents to ascertain data concerning the problem.

64. Comments by Local Interests. - The proposed plans have been discussed with the cooperating agency, the Connecticut State Flood Control and Water Policy Commission. Meetings were arranged by the cooperating agency at the towns of West Haven and Milford, at which the proposed improvements were explained to town officials and interested parties. There was a general concurrence in the proposed plans.

65. Responsibilities of Local Interests. - The State of Connecticut, acting through the Connecticut State Flood Control and Water Policy Commission, feels that the requirements of local cooperation can and will be met although the furnishing of definite commitments is necessarily dependent upon future municipal subdivisions. Local interests are required to:

a. Adopt the projects recommended in the reports;

b. Assure maintenance of the improvements during their useful life as may be required to serve their intended purpose;

c. Provide, at their own expense, all necessary lands, easements, and rights-of-way;

d. Hold and save the United States free from all claims for damages that may arise either before, during or after prosecution of the work;

e. Assure continued public ownership of those portions of the shore included in the improvements which are now publicly-owned and their administration for public use only;

f. Assure that water pollution that would endanger the health of bathers will not be permitted;

g. Agree to approval by the Chief of Engineers, prior to commencement of work, of detailed plans, specifications, arrangements for prosecuting the work, adequacy of the proposed work, and the assurances as listed above.

VII. DISCUSSION

67. General. - Discussions of the proposed plans of protection and improvement for areas for which adoption of a Federal project has been considered are included below. Discussions of other plans are included in Paragraphs 38 to 48 inclusive.

68. Prospect Beach. - The plan considered most suitable consists of widening the shore by the hydraulic dredging of sand from offshore areas and construction of a series of groins. The area to be improved consists of a long stretch of undeveloped town-owned eroded shore and a short extent of shore which, though town-owned, is developed for private residential use. The placement of sand to widen and improve the shore is limited to a short portion of the area now developed privately and protected by sea walls and an adjacent long stretch of public shore. The shore in front of the sea walls protecting private residences is suffering from erosion resulting in lowering of the beach level. The public shore is also suffering from erosion. It closely parallels a shore highway which is partly protected by a sea wall and riprap revetment. Public ownership of an extensive length of shore land in close proximity to a densely populated urban area makes this an excellent location for development of a public bathing beach. The present composition of the shore is very coarse and entirely unsuitable for recreational purposes. Widening of the beach by placement of sand will provide needed protection for the residential area and shore highway, will improve the composition of the shore and provide a large recreational area. Added widening of the south end of the fill will create a source of supply of material to nourish the entire area to and including Sea Bluff Beach located north of Prospect Beach. Construction of groins is intended to reduce losses of sand fill which otherwise would probably be excessive. A larger reduction of losses could probably be effected by construction of larger groins. The cost of larger

groins would be so much greater than the cost of the groins considered that they would not be economically justifiable. Comparison of estimated benefits and costs indicates a favorable ratio of 1.5 to 1.

69. Oyster River Point to Oyster River. - The plan considered most suitable consists of widening the shore by hydraulic dredging of sand from offshore areas. The area to be improved consists of an eroded shore continuously developed for residential use and a small town-owned bathing beach. The residential development is protected by sea walls. Erosion has lowered the beach level in front of these structures and threatens to undermine them. The public beach consists of small pockets of sand between ledge rock outcrops. This beach is suitable for limited use. Due to extensive offshore flats and lack of space for construction of facilities needed for a beach receiving widespread use, it is not advisable to enlarge the present bathing beach by direct placement of sand. The placement of sand to widen the shore is limited to that portion of the area developed for residential use. This sand fill will provide needed protection for the sea walls. Added widening at the eastern end of the fill will provide a source of supply to feed the entire area through littoral drift. The limited improvement of the public beach which will benefit from the source of supply should be sufficient for present needs. The proposed sand fill should be observed closely to determine the extent of losses through erosion. If losses are such as to necessitate excessive maintenance, impermeable groins to retard erosion can be constructed at locations to be determined by study of the losses. These groins, if proven necessary, should if possible, be built so as not to interfere unduly with free distribution of beach material from the east end of the proposed fill, thereby making it possible to effect some economies in maintenance costs by permitting replenishment of the entire beach by periodic placement of sand at Oyster River Point for movement westward by littoral currents. Consideration has

been given to protection of sea walls by placement of riprap, in lieu of sand fill. Such protection is not considered to be as desirable as sand fill, since the latter, in addition to providing protection, will also improve the present unsatisfactory composition of the shore, thereby, furnishing recreational area which is an important part of the value of shore front residential areas. Comparison of estimated benefits and costs indicates an unfavorable ratio of 0.8 to 1.

70. Woodmont Shore. - The plan considered most suitable consists of widening the shore by placement of sand obtained hydraulically from offshore areas and the construction of a series of impermeable groins. The area to be improved consists of an eroded shore developed for residential use or contiguous to town streets which closely parallel the shore. Erosion has resulted in the lowering of the beach level and exposure of the footings of protecting sea walls. One section of unprotected shore is an eroding bluff very close to an existing town street. This street is in danger of being undermined if protection is not provided. Only that portion of the improvement which borders town streets is considered to be for the protection of publicly-owned property. The portion of the improvement fronting areas developed for private residential use is considered to be for protection of privately-owned property. The sand fill will provide needed protection to all eroded areas and in addition will provide a large recreation area available to the general public. The northerly groin is intended to hold the sand fill within the area that it is desired to protect and reduce drifting which would result in shoaling at the mouth of Oyster River. The other groins are intended to reduce losses of the sand fill which otherwise would probably be excessive. A larger reduction of losses could probably be effected by construction of larger groins. The cost of larger groins would be so much greater than the cost of the groins considered that they would not be economically justifiable. Comparison

of estimated benefits and costs indicates a favorable ratio of 1.0 to 1.

71. Gulf Beach. - The plan considered most suitable consists of widening the town-owned public beach by the placement of sand. This beach receives intensive use by townspeople, resulting in overcrowding. Due to the coarseness of the shore material, only a small portion of the beach adjacent to Long Jetty is usable. The placement of sand will cover the eroded cobble and gravel shore which constitutes the greater part of the present publicly-owned beach, thereby increasing the area available for recreational purposes. The improvement of the composition of the existing beach area and the additional area provided by widening, will eliminate the present congestion and result in more widespread use of the recreational facilities by the general public. The sand fill will also provide additional protection to a public beach area now protected by a sea wall and a series of closely spaced groins. Comparison of estimated benefits and costs indicates a favorable ratio of 1.8 to 1.

72. Silver, Myrtle, Walnut, Laurel and Cedar Beaches, and Meadows End. - The plan considered most suitable consists of widening the beaches by direct placement of sand obtained by hydraulic dredging of material from offshore areas and construction of a series of impermeable groins. The shore to be improved is largely developed for residential use. It contains a small town-owned bathing beach which is inadequate for present needs. The shore is subject to erosion which has averaged from 1 to 3 feet per year. Shore areas formerly occupied by cottages have been eroded away. This erosion has moved the shore line at Myrtle Beach landward to the edge of a town road now protected by a steel sheet pile bulkhead and riprap revetment. Residential areas are almost continuously protected by sea walls and numerous closely spaced groins have been built in front of these structures to hold the thin strand of sand beach which remains. In many places, high water is at the foot of these walls. The widening of the beaches by artificial place-

ment of sand will partly restore past losses, provide needed protection for areas now exposed to wave and storm attack, improve the character of shore property, and provide needed recreational areas. A system of groins has been included along those portions of the shore from which losses of sand fill are likely to occur through littoral drifting. No groins are included around Meadows End since losses of sand fill in this area will be largely through offshore movement. Groins are not considered necessary along Silver Beach, since past losses along this beach have not been excessive and drifting of small amounts of sand from Meadows End should tend to replace any losses which occur through drifting. Maintenance of the sand fill will be required by periodic replacement of sand losses. Comparison of estimated benefits and costs indicates a favorable ratio of 1.6 to 1.

VIII. CONCLUSIONS

73. General. - The plans of protection and improvement are based on the artificial restoration of beaches by hydraulic dredging of sand from offshore areas. There are no adequate sources of littoral material within the area. Creation of such sources is included in the plans of improvement wherever practical through the placement of sand at strategic locations. Feasibility of artificial restoration of shore areas by pumping sand has been proven by projects of that nature at Westport, Bridgeport, West Haven, and New London. No cases of pollution exist to prohibit any of the improvements considered for Federal projects. Federal participation in the cost of protection and improvement should be made contingent on the requirements of local cooperation listed in Paragraph 65.

74. Bradley Point. - The proposed plan consists of widening the shore by direct placement of sand and the construction of an impermeable groin. The estimated first cost of the improvement is $22,000 and the estimated annual maintenance is $680. The estimated annual cost is $1,620 and the annual benefits $1,476. The ratio of benefits to costs is 0.9 to 1. The public interest amounts to an annual non-Federal public benefit of $406 or 27% of all evaluated benefits. The improvement involves a shore area which is all privately-owned. No policy has been established by Public Law for Federal contribution of funds for improvement and protection of privately-owned shores. The proposed plan is not economically justified by evaluated benefits. Benefits which have not been evaluated or cannot be evaluated in monetary terms may make it advisable for local interests to adopt a project for the improvement, in which case consideration should be given to the plan which has been developed.

75. Prospect Beach. - The proposed plan includes placement of sand to widen the beach and construction of a series of impermeable groins. The estimated first cost of the improvement is $213,600 and the estimated annual

maintenance is $6,720. The estimated annual cost is $15,590 and the annual benefits $23,915. The ratio of benefits to costs is approximately 1.5 to 1. The public interest is substantial amounting to an annual non-Federal public benefit of $22,015 or 92% of all evaluated benefits. The project involves protection and improvement of a shore area in which ownership is 90% public and 10% private. Annual public benefits exceed annual costs applicable to the publicly-owned portion of the shore. The Federal share of the first cost has, therefore, been estimated as one-third the cost of protection and improvement of that portion of the area which is publicly owned. This Federal share of the first cost is estimated as $64,000. It is advisable for the United States to adopt a project authorizing Federal participation in the first cost of improvement.

76. Oyster River Point to Oyster River. - The proposed plan includes placement of sand to widen the beach and construction of a series of impermeable groins if experience proves that they are necessary to reduce excessive maintenance of the fill. The estimated first cost of the improvement is $95,000 and the estimated annual maintenance is $3,025. The estimated annual cost is $7,050 and the annual benefits $5,840. The ratio of benefits to costs is approximately 0.8 to 1. The public interest amounts to an annual non-Federal public benefit of $1,300 or 22% of all evaluated benefits. The improvement involves a shore area in which ownership is 40% public and 60% private. Due to lack of sufficient economic justification, it is not advisable for the United States to adopt a project authorizing Federal participation in the cost of the improvement. Benefits which have not been evaluated or cannot be evaluated in monetary terms may make it advisable for local interests to adopt a project for the improvement. The proposed plan is considered to be the most desirable method of improvement and protection. If local interests desire to adopt a project for this area, consideration should be given to the plan which has been developed.

77. Woodmont Shore. - The proposed plan includes placement of sand to widen the beach and construction of a series of impermeable groins. The estimated first cost of the improvement is $151,800 and the estimated annual maintenance is $4,320. The estimated annual cost is $10,660 and the annual benefits $10,920. The ratio of benefits to cost is approximately 1.0 to 1. The public interest is substantial amounting to an annual non-Federal public benefit of $9,470 or 86% of all evaluated benefits. The improvement involves a shore area in which ownership is 56% public and 44% private. Annual benefits exceed annual costs applicable to the publicly-owned portion of the shore. The Federal share of the first cost has, therefore, been estimated as one-third the cost of protection and improvement of that portion of the area which is publicly-owned. The Federal share of the first cost is estimated as $35,300. It is advisable for the United States to adopt a project authorizing Federal participation in the first cost of the improvement.

78. Burwell Beach. - The proposed plan includes placement of sand fill to widen the beach and the construction of an impermeable groin. The estimated first cost of the improvement is $41,500 and the estimated annual maintenance is $640. The estimated annual cost is $2,410 and the annual benefits $2,375. The ratio of benefits to costs is approximately 1 to 1. The public interest amounts to an annual non-Federal public benefit of $375 or 16% of all evaluated benefits. The improvement involves a shore area which is all privately-owned. No policy has been established by Public Law for Federal contribution of funds for improvement and protection of privately-owned shores. Annual costs slightly exceed evaluated annual benefits. Recreational and other benefits which have not been evaluated or cannot be evaluated in monetary terms would undoubtedly justify the project. It is considered advisable for local interests to adopt a project for the improvement.

79. Gulf Beach. - The proposed plan includes placement of sand to widen the beach. The estimated first cost of the improvement is $31,000 and the estimated annual maintenance is $1,100. The estimated annual cost is $2,385, and the annual benefits $4,330. The ratio of benefits to costs is approximately 1.8 to 1. The beach is publicly-owned. The public interest is substantial. All evaluated benefits are non-Federal public benefits, and they exceed the annual costs. The Federal share of the first cost is, therefore, estimated as one-third the total first cost of the improvement. This Federal share is $10,300. It is advisable for the United States to adopt a project authorizing Federal participation in the first cost of the improvement.

80. Silver, Myrtle, Walnut, Laurel, and Cedar Beaches, and Meadows End. The proposed plan includes placement of sand to widen the beaches and construction of a series of impermeable groins. The estimated first cost of the improvement is $455,000 and the estimated annual maintenance is $8,450. The estimated annual cost of the improvement is $27,750 and the annual benefits, $43,580. The ratio of benefits to costs is approximately 1.6 to 1. The public interest is substantial, amounting to an annual non-Federal public benefit of $15,380 or 35% of all evaluated benefits. The improvement involves a shore area in which ownership is 10% public and 90% private. Annual benefits exceed annual costs applicable to the publicly-owned portion of the shore. The Federal share of the first cost has, therefore, been estimated as one-third the cost of protection and improvement of that portion of the area which is publicly-owned. This Federal share of the first cost is estimated as $15,200. It is advisable for the United States to adopt a project authorizing Federal participation in the first cost of the improvement.

IX. RECOMMENDATIONS

81. General. - It is recommended that the most suitable method of stabilizing and improving the shore line between New Haven Harbor and the Housatonic River consists of general restoration of the shore and creation of sources of supply of littoral drift material by direct placement of sand obtained by hydraulic dredging from offshore areas and that retention of the sand so placed be effected wherever necessary by the construction of impermeable groins all in accordance with the specific plans of improvements discussed in Paragraphs 38-48 inclusive, and as shown on Plates 18-20 inclusive. It is further recommended that future development and use of the shore be planned and controlled on the basis of the fullest knowledge of shore processes and probable changes, and probable costs and benefits to be incurred thereby.

82. Improvements Recommended for Local Interests. - It is recommended that local interests consider adoption of a project for improvement and protection of the Burwell Beach, Milford.

83. Improvements Recommended for Federal Projects. - The following beaches are recommended for adoption of separate projects by the United States authorizing Federal participation by the contribution of Federal funds in an amount equal to one-third of the first cost of construction of protective works for that portion of the shore which is publicly-owned, generally as shown on Plates 18-20, the projects to be accomplished in their entirety or such integral part thereof as may be approved by the Chief of Engineers upon application therefor by local interests.

a. Prospect Beach, West Haven, Connecticut. - Widening to a 100-foot width by direct placement of sand 6,000 feet of shore from a point about 350 feet south of South Street northerly to Ivy Street with an added 50-foot widening at the south end of the fill and construction of eight impermeable groins each 330 feet long. El. Top of Sand 9.5 mlw

b. Woodmont Shore, Milford, Connecticut. - Widening to a 100-foot width by direct placement of sand, 500 feet of shore in the first pocket beach west of Merwin Point; widening to a 100 to 150-foot width 3,500 feet of shore from Chapel Street northerly to a point about 400 feet north of Anderson Avenue; construction of five impermeable groins 300 to 400 feet long.

c. Gulf Beach, Milford, Connecticut. - Widening to a 100-foot width 1,200 feet of Gulf Beach by direct placement of sand.

d. Silver, Myrtle, Walnut, Laurel, and Cedar Beaches and Meadows End, Milford, Connecticut. - Widening to a 100-foot width by direct placement of sand 15,600 feet of shore along Silver, Myrtle, Walnut, Laurel and Cedar Beaches and Meadows End, with an added widening of 150 feet around Meadows End, and the construction of eleven impermeable groins 350 to 400 feet long.

The recommendations are subject to the conditions that local interests will:

1. Adopt the projects named herein;

2. Assure maintenance of the improvements for their useful life as may be required to serve their intended purpose;

3. Provide, at their own expense, all necessary lands, easements, and rights-of-way;

4. Hold and save the United States free from all claims for damages that may arise either before, during, or after prosecution of the work;

5. Assure that water pollution that would endanger the health of bathers will not be permitted;

6. Assure continued public ownership of those portions of the shore included in the improvements which are now publicly-owned and their administration for public use only.

The recommendations are further subject to the conditions that the adequacy of the work proposed by local authorities, detailed plans, specifications, assurances that the requirements of local cooperation will be met and arrangements for prosecuting the work be approved by the Chief of Engineers prior to commencement of work.

The estimated amounts of Federal participation, in accordance with the foregoing recommendations, are as follows:

Prospect Beach	$64,000
Woodmont Shore	35,300
Gulf Beach	10,300
Silver, Myrtle, Walnut, Laurel, and Cedar Beaches and Meadows End	15,200
TOTAL	$124,800

H. J. WOODBURY
Colonel, Corps of Engineers
Division Engineer

43 Inclosures:
11 Appendices
32 Plates

BEACH EROSION CONTROL REPORT ON COOPERATIVE STUDY OF CONNECTICUT

AREA 3

New Haven Harbor to Housatonic River

May 4, 1951

Revisions to Report Dated 22 March 1950

Original Pages and Plates Revised

Cover and title page.

Pages. - ii to vii inclusive, 2, 6, 15, 20, 24, 28 to 60 inclusive, Table of Contents for Appendices, A-3, A-6, C-1, C-3, D-3, D-4, E-11, H-1 to H-12 inclusive, I-1 to I-12 inclusive, J-1, J-2, K-1 to K-4 inclusive, L-1 to L-4 inclusive.

Plates. - 1, 7 to 20 inclusive.

New Pages and Plates Substituted

Cover and title page

Pages. - ii to vii inclusive, 2, 6, 15, 16, 20, 24, 28 to 58 inclusive, Table of Contents for Appendices, A-3, A-6, C-1, C-3, D-3, D-4, D-4a, D-4b, E-11, H-1 to H-5 inclusive, I-1 to I-12 inclusive, J-1 to J-14 inclusive, K-1 to K-4 inclusive.

Plates. - 1, 7 to 16 inclusive, 18, 19, 20A, 20.

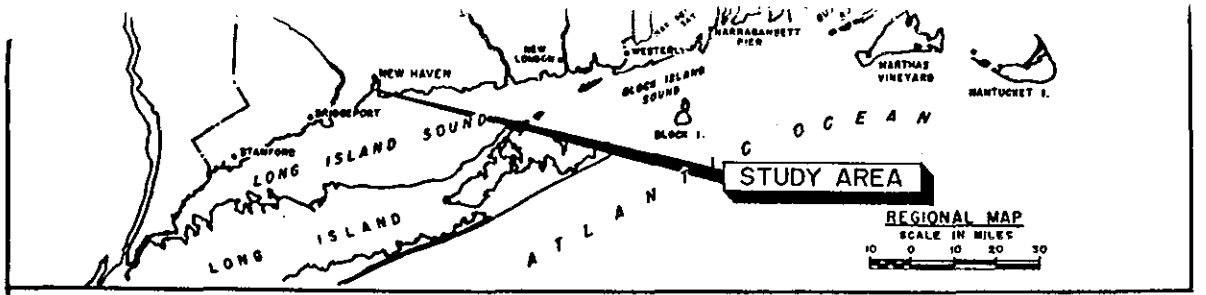
BEACH EROSION CONTROL REPORT ON COOPERATIVE STUDY OF CONNECTICUT

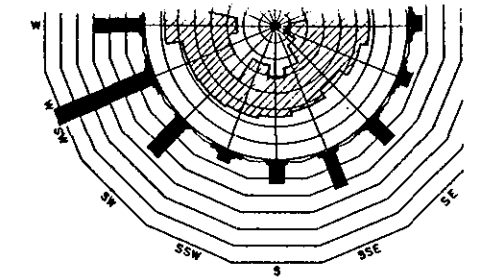
AREA 3

NEW HAVEN HARBOR TO HOUSATONIC RIVER

Appendices A - K

TABLE OF CONTENTS





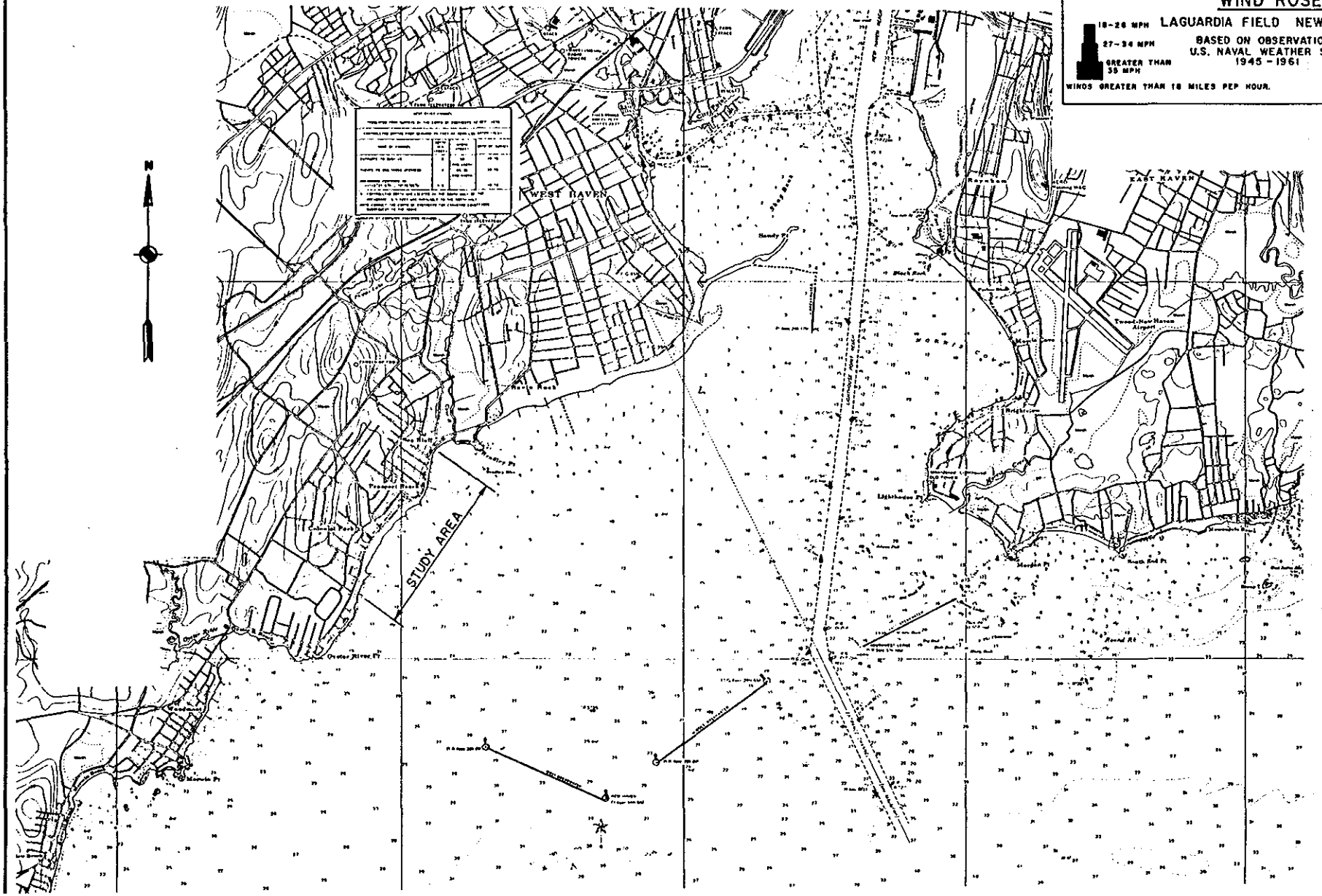
WIND ROSE

18-26 MPH
27-34 MPH
GREATER THAN 35 MPH

LAGUARDIA FIELD NEW YORK, N.Y.

BASED ON OBSERVATIONS BY U.S. NAVAL WEATHER SERVICE 1945 - 1961

WINDS GREATER THAN 18 MILES PER HOUR.



APPENDIX A

DESCRIPTION AND COMPOSITION OF BEACHES

Detailed descriptive data for the entire shore line of Area 3 was obtained by field inspections. The shore line was then divided consecutively from New Haven Harbor to the Housatonic River generally in accordance with the physical character of shore features. Descriptions of these subdivisions are presented below. In addition to visual inspection, samples of beach material were obtained at selected locations throughout the area and a mechanical analysis of these samples was made to determine median diameter and classification. Beach sample analysis results and locations are shown on Plates 11-15. A complete photographic record was made of the shore. Selected photographs are shown on Plates 21 - 32.

WEST HAVEN

A.

1. Location: Sandy Point
2. Extent: 3200 feet +
3. Width - above H.W.: 75-125 feet
   - H.W. to L.W.: 0-1200 feet
4. Ownership: Town of West Haven.
5. Use: None.
6. Public Facilities: None.
7. Composition: Medium to coarse sand, small amount gravel.

B.

1. Location: Sandy Point to Old Field Creek.
2. Extent: 1200 feet+
3. Width - Above H.W.: 200 feet +
   - H.W. to L.W.:1000 feet +

4. Ownership: Town of West Haven except southerly 180 feet ±, private.

5. Use: None.

6. Public Facilities: None

7. Composition: Medium sand, traces of silt (Newly placed hydraulic fill).

C.

1. Location: Old Field Creek to foot of Savin Avenue.

2. Extent: 7800 feet ±

3. Width - Above H.W.: 200-350 feet.

- H.W. to L.W.: 300-950 feet.

4. Ownership: West Haven (1270'), State of Connecticut (365'), remainder privately owned.

5. Use: Bathing beach and amusement park (Savin Rock).

6. Public Facilities: Amusements, restaurants, refreshment stands, resort hotels, (all privately operated).

7. Composition: Medium to fine sand, traces of silt and clay (newly placed hydraulic fill beach).

D.

1. Location: Bradley Point (Foot Savin Avenue to Cove River).

2. Extent: 2000 feet ±

3. Width:- Above H.W.: 0-30 feet

- H.W. to L.W.: 800-1000 feet.

4. Ownership: Private.

5. Use: Private, residential and summer cottages.

6. Public Facilities: None.

7. Composition: Projecting ledge rock at the point, medium sand and gravel beach east side, coarse sand and gravel beach west side.

E.

1. Location: West of Cove River (Sea Bluff Beach).

2. Extent: 900 feet.

3. Width - Above H.W.: 0-150 feet easterly 500 feet, 0 at westerly 400 feet.

   - H.W. to L.W.: 1300 feet +/

4. Ownership: Town of West Haven.

5. Use: Town beach at east end.

6. Public Facilities: None.

7. Composition: Town beach - medium sand above H.W., sand and gravel below H.W. West end - highway revetment above H.W., shingle and marsh below H.W.

F.

1. Location: Prospect Beach and Oyster River Point.

2. Extent: 900 feet west of Cove River to 1200 feet + east of Oyster River (10,000' +).

3. Width - Above H.W.: 0-40 feet.

   - H.W. to L.W.: 100-200 feet.

4. Ownership: Town of West Haven (See Appendix I, pars. 3b and 4b).

5. Use: Private, residential and shore highway.

6. Public Facilities: None.

7. Composition: Shingle, cobbles, boulders, marsh and ledge rock outcrops. Small amount of sand above H.W.

G.

1. Location: Oyster River Beach. (East of Oyster River).

2. Extent: 1200 feet.

3. Width - Above H.W.: Easterly 400 feet +, 30-40 feet; central pocket beach 75 feet +; west pocket beach 75-100 feet.

   - H.W. to L.W.: 300-600 feet.

4. Ownership: Town of West Haven

5. Use: Town beach.

6. Public Facilities: None

7. Composition: Easterly 400 feet ±, sand and gravel above H.W., shingle below H.W. Central pocket, medium sand above and below H.W. West Pocket, medium sand above H.W., sand and gravel, few boulders below H.W.

MILFORD

H.

1. Location: West of Oyster River.

2. Extent: 1000 feet ±

3. Width - Above H.W.: Easterly 400 feet, 0-20 feet; westerly 600 feet, 0-100 feet.

- H.W. to L.W.: 150-600 feet.

4. Ownership: Town of Milford.

5. Use: None

6. Public Facilities: None

7. Composition: Easterly 400 feet, medium to coarse sand above H.W., marsh and sand flats below H.W. Westerly 600 feet, medium and coarse sand above H.W., shingle and marsh below H.W.

I.

1. Location: Woodmont Shore (north of Merwin Point).

2. Extent: 2800 feet ±

3. Width - Above H.W.: 0-50 feet.

- H.W. to L.W.: 70-170 feet.

4. Ownership: Town of Milford and Borough of Woodmont.

5. Use: Private residences and shore road.

6. Public Facilities: None

7. Composition: Northerly pocket beach, medium sand mixed with gravel above H.W., coarse sand with larger mixture of gravel below H.W. Remainder of shore, shingle, cobbles, boulders, marsh grass, ledge rock outcrops with small amount sand above H.W.

J.

1. Location: Woodmont Shore(Merwin Point to Merwin Beach).

2. Extent: 4000 +

3. Width: - Above H.W.: First Pocket Beach, 20 feet.
Second Pocket Beach, 0-20 feet.
Third Pocket Beach, 10-100 feet.
Fourth Pocket Beach, 30-40 feet.

- H.W. to L.W.: 0-150 feet.

4. Ownership: Town of Milford and Borough of Woodmont.

5. Use: Bathing beach, shore road and residential.

6. Public Facilities: None

7. Composition: A series of pocket beaches between projecting ledge rock outcrops; first (easterly) pocket, coarse sand and gravel above H.W., shingle below H.W.; second pocket, fine sand and gravel above H.W., shingle below H.W.; third pocket, fine sand above H.W., medium sand below H.W.; fourth pocket, fine sand above H.W., gravel and shells east end below H.W. grading to fine sand at west end.

K.

1. Location: Merwin Beach.

2. Extent: 2000 feet +

3. Width: - Above H.W.: Northerly walled section 10-20 feet; southerly section 50-100 feet.

- H.W. to L.W.: 400-500 feet.

4. Ownership: Private.

5. Use: Bathing beach.

6. Public facilities: None.

7. Composition: Fine sand above H.W., medium sand to fine gravel below H.W. at north end, fine to medium sand below H.W. at south end. This is a pocket beach between projecting ledge rock outcrops.

L.

1. Location: Burwell and Farview Beaches.
2. Extent: 2400 feet ±
3. Width - Above H.W.: 0-30 feet.
   - H.W. to L.W.: 125-200 feet.
4. Ownership: Private.
5. Use: Summer residences.
6. Public Facilities: None.
7. Composition: Medium sand and gravel above H.W. at north end changing to shingle and cobble beach with some boulders and ledge rock outcrops at south end. Coarse sand and fine gravel below H.W. at north end changing to shingle, cobbles, and boulders at south end. Foreshore of Farview Beach largely composed of exposed bedrock.

M.

1. Location: Morningside.
2. Extent: 2500 feet ±
3. Width - Above H.W.: 0-30 feet.
   - H.W. to L.W.: 100-200 feet.
4. Ownership: Morningside Association.
5. Use: Shore road, residential and limited bathing by Association members.
6. Public Facilities: None.
7. Composition: Rough shingle and boulder shore except short stretches at groins where there is coarse sand and fine gravel.

N.

1. Location: Point Beach.
2. Extent: 4200 feet ±
3. Width - Above H.W.: 20-50 feet.
   - H.W. to L.W.: 80-200 feet.
4. Ownership: Private.
5. Use: Summer residences.
6. Public Facilities: None.

7. Composition: Coarse sand and fine gravel above H.W., shingle, cobbles and boulders below H.W.

O.

1. Location: Pond Point Beach (Pond Point to 300 feet ± east of Calf Pen Meadow Creek).

2. Extent: 2200 feet ±

3. Width - Above H.W.: Easterly 800-1000 feet, 50-75 feet decreasing to 0 at west limit.

- H.W. to L.W.: 100-500 feet.

4. Ownership: Private.

5. Use: Cottage type residences.

6. Public Facilities: None.

7. Composition: Fine gravel and small amount of fine sand above H.W., quantity of sand increasing towards west limit. Below H.W., shingle at east end, fine gravel at west end.

P.

1. Location: Pond Point and Bay View Beaches.

2. Extent: 300-400 feet east and west of Calf Pen Meadow Creek.

3. Width - Above H.W.: 75-100 feet.

- H.W. to L.W.: 700 feet.

4. Ownership: Private.

5. Use: Summer cottages and permanent homes.

6. Public Facilities: None.

7. Composition: Fine sand above H. W. Coarse and medium sand and gravel below H.W.

Q.

1) Location: Bay View Beach.

2) Extent: 400 to 2100 feet west of Calf Pen Meadow Creek.

3. Width - Above H. W.: Easterly 600 feet, 200 feet +, thence 10-30 feet.

- H.W. to L.W.: 150 feet.

4. Ownership: Bay View Improvement Association and private.

5. Use: Bathing beach (east 600 feet), cottages and larger residences.

6. Public Facilities: None.

7. Composition: Fine sand above H.W. Below H.W., coarse and medium sand and gravel at east end changing to shingle at westerly end.

R.

1. Location: Welchs Point.

2. Extent: Bay View Beach to Gulf Beach, 3700 feet +.

3. Width - Above H.W.: High water at foot of bluff.

- H.W. to L. W.: 60-120 feet.

4. Ownership: Private.

5. Use: Residential development on bluff.

6. Public Facilities: None.

7. Composition: Boulders, cobbles, very rough irregular eroded shore, no sand.

S.

1. Location: Gulf Beach.

2. Extent: 1200 feet +, south of and adjacent to Long Jetty, Milford Harbor.

3. Width- Above H.W.: 30-40 feet south end, 150-200 feet adjacent to jetty.

- H.W. to L.W.: 100-150 feet.

4. Ownership: Town of Milford.

5. Use: Public beach.

6. Public Facilities: Refreshment stand.

7. Composition: Cobble and fine gravel at south end varying to coarse sand and fine gravel at north end. Some fine sand above H.W. at north end.

T.

1. Location: Burns Point.
2. Extent: 600 feet ±
3. Width - Above H.W.: 0-20 feet.
   - H.W. to L.W.: 600 feet.
4. Ownership: Private.
5. Use: Residential.
6. Public Facilities: None.
7. Composition: Cobbles east end, medium sand west end above H.W. Marsh grass and medium sand below H.W. east end, marsh and shingle below H.W. west end.

U.

1. Location: Fort Trumbull Beach (eastern part).
2. Extent: 2000 feet ±
3. Width - Above H.W.: 0-40 feet.
   - H.W. to L.W.: 600 feet.
4. Ownership: Private.
5. Use: Residential.
6. Public Facilities: None.
7. Composition: Medium to fine sand above H.W. edium sand, fine gravel, marsh, silt and sand flats below H.W.

V.

1. Location: Fort Trumbull Beach (western part)
2. Extent: 1500 feet ±
3. Width - Above H.W.: 50-75 feet at east end widening to over 200 feet at west end.
   - H.W. to L.W.: 600 feet.
4. Ownership: Private.
5. Use: Residential.
6. Public Facilities: None.

7. Composition: Fine to medium sand above H.W. Coarse sand, marsh, sand and silt flats below H. W,

W.

1. Location: Silver Beach(West of Silver Creek).

2. Extent: 1800 feet ±

3. Width - Above H. W.: 50-75 feet.

- H.W. to L.W.: 600 feet.

4. Ownership: Private, except a 40-foot lot, town-owned.

5. Use: Summer residences.

6. Public Facilities: None

7. Composition: Medium and fine sand above H.W. Coarse sand below H. W.

X.

1. Location: Silver Beach (western part).

2. Extent: 400 feet ±

3. Width - Above H. W.: 75 feet east end, 150 feet west end.

- H.W. to L. W.: 800 feet.

4. Ownership: Town of Milford and private.

5. Use: Public beach.

6. Public Facilities: Bathhouse, refreshments, sanitaries, float, life guards.

7. Composition: Fine and medium sand above H.W. Coarse sand below H.W.

Y.

1. Location: Myrtle Beach(Charles Island Tombolo to Nettleton Avenue).

2. Extent: 2900 feet ±

3. Width - Above H. W.: 0-50 feet except at tombolo, east end, 200 feet ±

- H.W. to L.W.: 250-750 feet.

4. Ownership: Private, except 40 feet lot town-owned.

5. Use: Cottages

6. Public Facilities: None.

7. Composition: Medium to fine sand above H.W. Coarse sand, fine gravel, shingle, marsh grass below H. W.

Z.

1. Location: Myrtle Beach (Nettleton Avenue to Naugatuck Avenue).

2. Extent: 2700 feet ±

3. Width - Above H.W.: 20-50 feet in front cottages.

- H. W. to L.W.: 350 feet.

4. Ownership: Private

5. Use: Private - cottages.

6. Public Facilities: Bathing pavilion east end and numerous concession stands. (Privately operated amusement area).

7. Composition: Medium and fine sand above H.W. Coarse sand and gravel below H.W.

AA.

1. Location: Walnut Beach(Naugatuck Avenue to Wildwood Avenue).

2. Extent: 2800 feet ±

3. Width - Above H.W.: Practically none except where buildings and bulkheads are set back.

- H.W. to L.W.: 200-350 feet.

4. Ownership: Private - except street ends and one 40-foot lot, town-owned.

5. Use: Summer cottages and small residences.

6. Public Facilities: None.

7. Composition: Medium to coarse sand above H.W. Coarse sand and fine gravel below H. W.

BB.

1. Location: Walnut Beach(Wildwood Avenue to 8th Avenue).

2. Extent: 1100 feet ±.

3. Width- Above H.W.: 0-20 feet.

- H.W. to L.W.: 250 feet.

4. Ownership: Private.

5. Use: Large summer residences.

6. Public Facilities: None.

7. Composition: Fine and medium sand above H.W. Coarse sand and gravel below H.W.

CC.

1. Location: Laurel Beach (8th Avenue to Laurel Beach Road).

2. Extent: 2200 feet ±

3. Width - Above H.W.: 0-60 feet, wider west half.

- H.W. to L.W.: 200-700 feet.

4. Ownership: Private.

5. Use: Large summer homes.

6. Public Facilities: None.

7. Composition: Fine and medium sand above H.W. Coarse sand and gravel below H.W.

DD.

1. Location: Cedar Beach (eastern part).

2. Extent: 1700 feet ±

3. Width - Above H.W.: 0-40 feet.

- H.W. to L.W.: 700-900 feet.

4. Ownership: Private.

5. Use: Summer cottages.

6. Public Facilities: None.

7. Composition: Medium sand above H.W. Coarse sand and large amount gravel below H. W.

EE.

1. Location: Cedar Beach (western part).

2. Extent: 1300 feet ±

3. Width - Above H.W.: East 400 feet ±, 20-30 feet wide to foot of sand dune, remainder, width of spit.

- H.W. to L.W.: 700 feet ±

4. Ownership: East 800 feet, State of Connecticut; remainder, private.

5. Use: East 800 feet, State Military reservation; remainder, summer cottages.

6. Public Facilities: None.

7. Composition: Medium and fine sand above H.W. Shingle and coarse sand below H.W.

FF.

1. Location: Milford Point Sand Spit.

2. Extent: 3000 feet ±

3. Width - Above H.W.: Width of spit.

- H.W. to L.W.: 100-1000 feet.

4. Ownership: Private, except 50 feet at breakwater, U. S. Government.

5. Use: Undeveloped.

6. Public Facilities: None.

7. Composition: Medium to fine sand above H.W. Medium to coarse sand and gravel below H. W.

APPENDIX B

GEOLOGY

1. General. - The coastal formation in Connecticut is the result of a complicated series of geological changes. That portion of the geological history which is significant in explaining the physiography of the area is discussed briefly in chronological sequence.

2. Pre-Cambrian and Paleozoic Period. - During this period, through endless ages, series after series of sediments were deposited, injected by liquid magmas and under the influence of heat and mountain making pressures, were folded, broken and profoundly altered so that their original character can no longer be recognized. The only semblance of unity in the rocks underlying the New England Province seems to be the general presence of a north, northeast trend in the direction of the rock structure.

3. Triassic Period. - At the end of the Paleozoic Period, this complex structure was worn down at least in part to a peneplane and deposits of Triassic clastic sediments were laid down. Simultaneously with this deposition of great thicknesses of Upper Triassic shales and limestones, the intrusion and extrusion of massive layers of trap occurred. Faulting took place throughout this period and was pretty well distributed over the area. By means of great north-south boundary faults, which to this day separate the sediments from the crystallines on the east, the net result in Connecticut was to lower all strata differentially and give them a regional dip of 5 to 20 degrees east.

4. Fall Zone Cycle. - After this period of disturbance an era of great quiet prevailed during which for countless centuries erosion worked on the highlands, reducing them to a low and rolling country just a few feet above sea level. Regardless of geologic structure and differences in rock hardness, a peneplane was formed across the great faults which separate the

sediments from the harder crystallines. Great thicknesses of Triassic rock were removed. That which is still preserved in the Connecticut Valley lowland owes its existence to the faulting which dropped it below the base level of erosion. The extensive surface formed at this time is called the Fall Zone peneplane.

5. Burial of the Fall Zone Peneplane. - The long period of quiet drew to a close and the great peneplane was slowly covered by a thick series of deposits derived from the waste of the land. In Connecticut these deposits were apparently of Upper Cretaceous age, probably largely marine in origin. Earth movements resulted in uplift in the north and northwest, while seaward the surface was depressed to near or below sea level. In Connecticut the depression carried the peneplane below sea level. Thus toward the north a new cycle of erosion was started by the streams rejuvenated by uplift and the Fall Zone surface began to be destroyed, while the wastes from this destruction with the aid of marine sediments buried the lower surface in the south. When the submergence in the Connecticut area had reached its greatest extent, the streams once emptying into the ocean considerably to the south found that their mouths had moved to the north with the advancing shore line. This shore line was probably even more irregular than that of today.

6. The New England Upland Cycle. - At or near the end of the tilting which started the destruction of the Fall Zone peneplane, a new movement of the earth's surface occurred, resulting in uplift. Coincident with the movement raising the land above sea level, the shore line retreated toward the southeast and the streams extended their lower courses across the young coastal plain thus exposed. At this early date the Connecticut River left its course across the soft Triassic rocks in the vicinity of Middletown and made a sharp bend to the southeast over the newly uncovered sediments of the coastal plain, assuming the course which, with few exceptions, it follows to this day. The

uplift initiated a new cycle of erosion which wore down the land mass and a peneplane, the most extensive of any in New England, was formed. Today the remnants of this surface are known as the New England Upland peneplane.

7. The Connecticut Valley Lowland Cycle. - Another uplift accompanied by tilting terminated the Upland cycle of erosion. This tilting appears to have been to the southeast about 15 feet per mile. The uplift started another cycle of erosion, during which the Coastal Plain deposits were removed most rapidly, while the Triassic shales and limestones, being more resistant, remained somewhat longer. The Upland, underlain by the more resistant crystalline rocks, were still far from total destruction when the Coastal Plain and Triassic areas were reduced almost to sea level. It was during this period that the Connecticut Valley lowland was formed by the erosion of the Triassic rocks. This lowland, which now follows the Connecticut River to about Middletown and enters Long Island Sound at New Haven, is essentially the same as when originally formed.

8. The Sound Valley Cycle. - The Lowland cycle was terminated by another uplift, by which the land was raised in reference to the sea. This uplift raised the surface of the Connecticut Lowland peneplane, which continued as a Coastal Plain along the entire southern edge of the State in a belt about as wide as the present Long Island Sound. The forces of erosion renewed their work and cut a valley in the inner lowland, called the Sound Valley, which was eventually to become the present Long Island Sound.

9. Formation of Long Island Sound. - The cutting of the inner lowland was interrupted by a climatic change which resulted in the formation of a great ice sheet covering the northeastern United States and Canada. This glacier, moving under the impulse of gravity, carried a tremendous amount of debris gathered from the country over which it passed. In passing over Connecticut, the glacier scraped away practically every bit of the thick

mantle of soil and decomposed rock in its path. All the material was not carried to its terminal moraine, which followed a line from the northern fluke of Long Island, through Fishers Island to Watch Hill and the southern coast of Rhode Island. Much of the material was strewn over the surface of Connecticut as the glacier advanced and retreated, and forms the present unevenly distributed soil of Connecticut which varies in depth from 0 to 20 or more feet. In addition to eroding and depositing of materials, a sinking of this region occurred which might have been due to the enormous weight of the ice sheet. The exact amount of submergence occurring is not known but when the ice disappeared, the inner lowland or Sound Valley was below sea level. These waters are what now constitute Long Island Sound, while Long Island is that part of the cuesta and glacial drift which remained above sea level.

10. Postglacial Changes of Level. - Since the withdrawal of the glacier from Connecticut, one small diastrophic movement has occurred. This resulted in the submergence of land masses for a depth generally determined and accepted to be 20 feet. After this movement, authorities generally agree that movements of the land and sea ceased and the relation of the elevation of the waters in Long Island Sound and Connecticut have remained constant. Minor local changes in water elevation may have occurred in restricted areas due to localized conditions. This last lowering of the land masses resulted in the present day shore line of Connecticut being a shore line of submergence, having all the irregularities of such a shore line due to the drowning of coastal valleys.

11. Present Day Trends. - Connecticut at present is in the period of sub-aerial erosion which follows a diastrophic change. During this period erosional forces will work to the reduction of land masses to another penelane with the streams transporting materials from the uplands to the lowlands.

Along the coast, waves attacking the shore line will tend to cut back all headlands, building and rebuilding bars and spits of materials from eroded headlands until a regular, even shore line is produced. This regular shore line will be landward of the present day shore line since the beaches, bars and spits will recede landward as the headlands are lost.

APPENDIX C

TIDES

1. General Characteristics. - The tides along the shore of the State of Connecticut are of two types. The eastern sector from Watch Hill Point, Rhode Island, to Cornfield Point, Connecticut, is subject to the normal ocean or progressive wave type of tide which causes high water to occur at increasingly later times as it progresses from east to west. The western sector from Cornfield Point, Connecticut, to the entrance to East River, New York is subject to the stationary wave type of tide which causes high and low waters to occur almost simultaneously at all points within this sector, while the range of tide increases in a fairly uniform manner from east to west.

2. Tidal Range. - Tidal range data for points along the shore of Connecticut are given in tide tables published by the United States Department of Commerce, Coast and Geodetic Survey. These are tabulated below:

Location	Mean Range	Spring Range	Reference Station	Time Interval
Stonington, F. Is. Sd.	2.7	3.2	New London	-0 35
Noank, Mystic R. Entrance	2.6	3.1	" "	-0 30
New London, State Pier	2.6	3.1	" "	0 00
Millstone Point	2.7	3.2	" "	+0 05
Saybrook Jetty	3.5	4.2	" "	+1 00
Duck Island	4.5	5.3	Bridgeport	-0 35
Madison	4.9	5.8	"	-0 30
Falkner Island	5.4	6.4	"	-0 25
Money Island, The Thimbles	5.6	6.6	"	-0 20
Branford Harbor	5.9	7.0	"	-0 15
New Haven Harbor, Entrance	6.2	7.3	"	-0 15
Milford Harbor	6.6	7.8	"	-0 10
Stratford, Housantonic River	5.5	6.5	"	+0 40
Bridgeport	6.8	8.0	"	0 00
Black Rock Harbor, Entrance	6.9	8.1	"	-0 05
Saugatuck River, Entrance	7.0	8.3	"	-0 05
South Norwalk	7.1	8.4	"	+0 10
Greens Ledge	7.2	8.5	"	-0 05
Stamford	7.2	8.5	"	0 00
Coscob Harbor	7.2	8.5	"	+0 05
Greenwich	7.4	8.7	"	0 00

3. Tidal Observations - New London. - A primary tide station is maintained by the United States Coast and Geodetic Survey at New London, Connecticut. A summary of the highest tide observed at this station during each month for the period from June 1938 to April 1948 is tabulated below. When the highest monthly tide occurred on more than one day in any month, it has been included in the tabulation for each day of its occurrence.

Height and Frequency of Highest Monthly Tides
New London, Connecticut. June 1938 - April 1948

Month	Height of Tide (feet)							
	3.6-3.9	4.0-4.4	4.5-4.9	5.0-5.4	5.5-5.9	6.0-6.4	Over 6.5	Total
January		3	6					
February		9	2					
March	1	6	1	1	1	1		
April	2	6	4					
May	2	4	3					
June	6	8						
July	11	5						
August	11	4						
September	3	9					2	
October	1	5	3	1	1			
November	1	3	3	1	1	2		
December		5	4	3	2			
TOTAL	38	67	26	6	5	3	2	147

The two tides listed in the tabulation as being in excess of 6.5 feet occurred during the hurricanes of 21 September 1938 and 14-15 September 1944. In September 1938, the recorded height of tide at New London was 11.1 feet and in September 1944 the height was 7.6 feet.

4. Extreme Hurricane Tides - September 1938. - Elevations of high water marks referred to the plane of mean low water occurring during the hurricane of 21 September 1938 at selected locations along the shore of Connecticut are tablulated below:

Location	Actual High Water	Predicted High Water
Stonington	11.0	3.2
Mystic	10.8	
Noank	10.3	3.1
New London	11.1	3.0
Saybrook	13.4	4.1
Branford	11.8	6.9
New Haven	13.0	7.2
Bridgeport	13.8	7.8
Southport	13.4	
South Norwalk	11.6	8.1
Rowayton	14.3	
Stamford	15.6	8.2
Greenwich	15.0	8.4

5. Extreme Hurricane Tides - September 1944. - Elevations of high water marks referred to the plane of mean low water occuring during the hurricane of 14-15 September 1944 were reported as follows:

Location	Actual High Water
Stonington	7.7
New London	7.6
Saybrook	8.0

6. Storm Tides - November 1950. - Reported elevations of high water marks referred to the plane of mean low water occured during the southeast storm of 25 November 1950 as follows:

Location	Actual High Water	Predicted High Water
Stonington Harbor	7.6	3.0
New London Harbor	8.1	2.0
Saybrook Point	8.75	3.8
Clinton Harbor	9.0	
Branford River	10.9	6.0
New Haven Harbor	10.6	6.4
Milford Harbor	11.3	6.7
Bridgeport Harbor	12.0	6.9
Black Rock Harbor	12.2	7.0
Saugatuck River	12.0	7.1
South Norwalk Harbor	12.1	7.2
Five Mile River	12.1	
Stamford Harbor	12.9	7.3
Greenwich Harbor	13.5	7.5

APPENDIX D

STORMS

1. Tropical Storms. - Hurricanes can be defined as tropical cyclones with a central barometric pressure of 29.0 inches or less and winds near the center of more than 60 miles per hour in some points in the path. In the northern hemisphere they are known to consist of winds revolving in a counter-clockwise direction about a calm center or "eye". This calm center has an average diameter of approximately 14 miles. The diameter of hurricanes varies considerably, some being 50 to 75 miles; the majority greater, in many instances exceeding 500 miles. Winds at the outer limits are usually light, increasing to moderate and gusty toward the center, and they blow with great fury adjacent to the "eye". Hurricanes move bodily along a path in a motion of translation at an average speed of approximately 12 miles per hour. The greatest damage caused by these tropical cyclones to shore areas is due to the inundation which usually accompanies them. This is especially true where there is a bay to the right of the point where the hurricane center moves inland. The rise of water in Narragansett Bay, Rhode Island, during the hurricane of September 1938, which moved inland west of this bay is an example of the devastating effect which such a condition can engender. The strong currents created by hurricanes is an important factor in the destruction caused by such storms.

2. Severe Hurricanes in New England. - Only a few hurricanes which have passed through the New England area are known to have caused considerable destruction. Ivan Ray Tannehill, in his book "Hurricanes", mentions ten such tropical cyclones as occurring between 1635 and 1944. The paths of several of these are shown on Plate 2. The 1944 hurricane has been described as the most violent in history but it did not cause as much destruction in New England as the one which struck in 1938. A comparison of these storms indicates certain attendant characteristics which

can be expected to result in great damage. The 1938 hurricane struck about normal to the shore line at a time when tides were high. The 1944 hurricane struck obliquely to the shore at low tide. The latter hurricane did not produce the inundation and consequent destruction which occurred during the former. Very little information is available concerning the damage caused by most of the hurricanes which have passed through or near New England. This lack of detailed information makes it difficult, if not impossible, to draw conclusions concerning probable shore damage which can be expected from such storms.

3. Hurricane of 21 September 1938. - On 21 September 1938, the New England area was struck by a devastating hurricane which originated around the Cape Verde Islands. It traveled in a curved path in a northwesterly and then northerly direction, arriving in the New England area during mid-afternoon of the 21st of September. The hurricane entered the State of Connecticut with its center just west of New Haven at 3:30 P.M., E.S.T., and continued its progress northward at the rate of 50 to 60 miles per hour. The eye of the storm was clearly observed at New Haven. Winds that were easterly since noon died down between 3:00 and 4:00 P.M., and were then followed by increasing southwesterly winds. The region of strongest wind lay in the dangerous semi-circle at a distance of about 75 miles to the right of the storm center. Barometric pressures reported indicate the severity of the storm along the Connecticut shore. Minimum pressures were reported as follows: at Bridgeport 28.30 inches, at New Haven 28.11 inches at 3:50 P.M., at Hartford 28.04 inches at 4:17 P.M. Barometric pressures dropped gradually until 12:00 noon, and then dropped rapidly until about 4:00 P.M., when the lowest pressures were reached. Pressures then rose rapidly until 8:00 P.M., when the 12:00 noon pressure was attained; thence rose gradually. Wind velocities were observed as follows: maximum for a five minute period, 38 miles per hour at New Haven, 46 miles per hour at Hartford, 70 to 90 miles per hour over an area

80 miles wide from Saybrook, Connecticut, to Marthas Vineyard, Massachusetts, maximum gust velocities, 46 miles per hour at New Haven, 59 miles per hour at Hartford, Probably in excess of 100 miles per hour in the area from Saybrook to Marthas Vineyard. The amount of precipitation directly attributable to the hurricane is difficult to determine due to the fact that it rained for 2 days prior to the storm. The total precipitation ranged from 2 to 5 inches along the Connecticut shore, the major portion of which was probably directly due to the storm. The hurricane increased tidal heights above their predicted ranges. Its approach was manifested in the higher water levels of the preceding low and high water. During these preceding tides, tidal heights were increased more to the east of the hurricane center than to the west because of the counter-clockwise wind rotation. Reported high tide during the hurricane occurred 2 to 2-3/4 hours before the time of predicted tide. The effect of the hurricane was an addition of about 9 to 10 feet to the predicted high tide at the entrance to Long Island Sound, this addition decreasing to 7 feet at Bridgeport and increasing to 9 feet at the west end of the Sound. Wave action accompanying the storm produced a devastating effect upon the shore line, pounding it mercilessly and resulting in widespread damage. Wave heights ranged from 10 feet at New London to 15 feet at New Haven and Bridgeport.

4. Hurricane of 14-15 September 1944. - On 14 September 1944, the New England area was struck by a tropical hurricane which originated in the West Indies. This hurricane traveled in a northwesterly then northerly direction to Cape Hatteras, thence swerved north, northeast across Long Island, reaching the mainland in the vicinity of Westerly, Rhode Island. From there it proceeded northeastward across Providence, Rhode Island, and thence followed closely along the New England coast and passed over Newfoundland and out to sea. The hurricane reached Westerly, Rhode Island, about 11:00 P.M., E.W.T. The greatest wind intensities occurred to the east of the storm center. The calm during the passage of the "eye" of the storm,

with the shift in the wind direction after its passage, was clearly noted at Westerly and Providence, Rhode Island. The following minimum barometric pressures were reported in the Connecticut area on 14 September: at New Haven, Connecticut, 28.86 inches at 9:50 P.M.; at Hartford, Connecticut, 28.94 inches at 10:50 P.M.; at Fishers Island, New York, 28.41 inches at 10:45 P.M.; at Groton, Connecticut, 28.40 inches at 11:00 P.M.; at Westerly, Rhode Island, 28.30 inches at 11:00 P.M.; at Block Island, Rhode Island, 28.34 inches at 11:09 P.M. Wind velocities reported for the Connecticut area are as follows: New Haven, maximum five minute wind, N 33 m.p.h.; and extreme wind NE 38 m.p.h.; Hartford, maximum five minute wind, N 50 m.p.h. and extreme wind, N. 62 m.p.h.; New London, extreme wind 70 m.p.h. Westerly, Rhode Island, extreme wind, 75 m.p.h.; Block Island, maximum five minute wind, SE 82 m.p.h. and extreme wind, SE 88 m.p.h. Extreme winds were mostly estimated. Heavy rainfall was reported practically throughout the coastal portion of the Providence District, which extended from New York State to Cape Cod. In Providence, a total of 4.49 inches fell from 5:55 P.M. to midnight on 14 September. The following elevations of high water in feet above mean high water were reported: Saybrook, Connecticut, 4.5; New London, Connecticut, 5.0; Stonington, Connecticut, 5.0; Watch Hill, Rhode Island, 6.9; Providence, Rhode Island, 8.0. The hurricane effect occurred on the ebb tide from about 3 to 5 hours after predicted gravitational high water in the area from Watch Hill, Rhode Island, to Woods Hole, Massachusetts.

4A. Storm of 25 November 1950. - On 25 November 1950, the New England area was struck by an east to southeast storm which moved north northwest ward from Virginia, reaching Connecticut during the early hours of the morning and continuing through Massachusetts until the early hours of the 26th. Winds continued in northern Maine until the 27th. Hurricane

velocities in the gusts were attained at many points both coastal and inland. Interior Connecticut, nearer to the storm center, recorded gusts up to 100 miles per hour. Sustained five minute winds of 34 miles per hour and greater were recorded at New Haven, Connecticut during each hour of the 25th of November from 4:00 A.M. to 5:00 P.M. The prevailing wind direction was southeast. Maximum velocities recorded at New Haven were as follows: fastest mile, 57 m.p.h. at 1:56 P.M.; maximum gusts, 66 m.p.h. at 1:35 P.M.; 4:20 P.M. and 7:40 P.M., and 77 m.p.h. (5-second gust) at 4:45 P.M. The above maximums were probably exceeded between 8:00 P.M. and 9:00 P.M., a period for which no velocities were recorded. The wind died down suddenly after the above period. Heavy rainfall generally exceeding two inches occurred during the night of the 25th-26th in southern New England and as much as four inches in parts of Maine, New Hampshire and Massachusetts on the following day. The storm increased tidal heights in Long Island Sound above their predicted heights. Flood tides which occurred about midday of the 25th exceeded predicted tides by about 5 feet from Bridgeport eastward along the Connecticut shore and up to 6 feet west of Bridgeport to Greenwich. At 9:18 P.M. on the 25th at New London, the flood tide reached 6.1 feet above its predicted height. The storm subsided before the time of high tide along the western part of Connecticut, and the night tides did not reach the maximum heights which occurred during midday. Shore damage along the Connecticut shore was widespread. The greatest amount of shore damage occurred west of New Haven. Wave action was exceptionally violent causing considerable destruction to coastal highways, sea walls, cottages and small craft. The Town of Milford was hit harder than any other location in Connecticut, with damages estimated at $2,000,000. The greatest damage occurred at Cedar, Walnut and Myrtle Beaches. In the entire town, 46 houses were reported as completely destroyed, 100 as heavily damaged and several hundred received minor damages. All low-lying beach areas were flooded and thousands of tons of sand were washed landward

covering shore roads. Many sea walls were destroyed or damaged. Bluffs at Welchs Point, Pond Point and Morningside were badly eroded. The shore road at Woodmont, north of Merwin Point was washed out. A long steel pier west of Merwin Point was demolished. West Haven suffered damages estimated at $50,000. The severest damage occurred at Prospect Beach and consisted of destruction of a portion of the sea wall opposite Lake Street and damage to the shore highway.

5. Storm Data. - Summaries of records of winds equal to or greater than 40 miles per hour at New York City, New York, and of winds equal to or greater than 32 miles per hour at New Haven, Connecticut, and Block Island, Rhode Island, compiled from United States Weather Bureau data covering the

periods indicated, are tabulated below.

Winds Equal To or Greater Than 40 Miles Per Hour
New York City, N.Y., 1911 - 1947

Direction	Number	Percent of Total	Probable Number in 100 Years
N	73	5	197
NE	29	2	80
E	15	1	40
SE	44	3	118
S	117	8	316
SW	88	6	236
W	161	11	434
NW	934	64	2527
TOTAL	1461	100	3948

Winds Equal To or Greater Than 32 Miles Per Hour
New Haven, Connecticut, 1905 - 1947

Direction	Number	Percent of Total	Probable Number in 100 Years
N	38	15	88
NE	41	15	90
E	12	5	28
SE	24	9	56
S	40	15	93
SW	25	10	58
W	34	13	79
NW	46	18	107
TOTAL	260	100	599

Winds Equal To or Greater Than 32 Miles Per Hour
Block Island, Rhode Island, 1936 - 1945

Direction	Number	Percent of Total	Probable Number in 100 Years
N	78	10	780
NE	102	13	1020
E	63	8	630
SE	45	6	450
S	24	3	240
SW	35	4	350
W	117	14	1170
NW	341	42	3410
TOTAL	805	100	8050

6. Analysis of Storm Data. - From the observed data, the probable frequency of occurrence of storm winds from various directions has been computed on the basis of a 100-year period and the results are shown in the last column of the above tabulations. It should be noted that the storm winds occurring at New York and Block Island are similar in that

they show a high preponderance in a northwest direction. The frequency of occurrence at these stations is not comparable since 40 miles per hour winds are listed for New York and 32 miles per hour winds are listed for Block Island. At New York City during 1947 there were 110 winds of 32 miles per hour or greater, as against only 42 winds equal to or greater than 40 miles per hour. Applying the ratio (110/42 = 2.6) determined between 32 and 40 m.p.h. winds in 1947 to the total number of winds listed in the table above for New York City (2.6 x 3948), it appears that approximately 10,300 winds of intensity equal to or greater than 32 miles per hour can be expected during a 100-year period as against 8050 at Block Island.

Due to the location of New Haven about midway between New York City and Block Island, it would be natural to expect the wind frequency and direction at New Haven to be somewhere between those for New York City and Block Island. This is definitely not so. Storm winds occur here without any marked differences in frequency from the west clockwise around to northeast and from the south. It is the stated opinion of weather bureau officials that winds at New Haven are peculiar to that area alone and do not indicate winds which can be expected along Long Island Sound. This is because New Haven is located in a lowland which runs generally north and south through Connecticut, the winds in this lowland being directed in a north-south direction creating a condition which is not typical of wind expectancy along Long Island Sound. Records for Block Island and New York City give a more accurate picture of the direction of wind expectancy in Long Island Sound. It should be born in mind that the Connecticut shore is well sheltered by Long Island, Fishers Island and other islands extending to the east. Therefore, neither the frequency nor intensity of winds occurring at Block Island and New York City can be expected to occur along the Connecticut shore.

7. Storm Damage. - The area between New Haven Harbor and the Housatonic River is reportedly subject to storm damage from the northeast, southwest, and southeast directions. There are open fetches of water opposite the shore in these directions as follows:

Shore Area	Direction	Length of Fetch (Miles)
New Haven Harbor to Pond Point	NE	7.5 ±
New Haven Harbor to Housatonic River	SE	19 - 24
Pond Point Area	SW	23.5
Sandy Point Area	SW	30 ±

Offshore breakwaters afford protection to the west side of New Haven Harbor from south and southeast storms. From the wind data tabulated above, the number of winds equal to or in excess of 32 miles per hour from the northeast, southwest and southeast directions that can be expected to occur annually at New York City is about 11, at New Haven about 2 and at Block Island about 18. Since New York and Block Island lie outside the sheltered area of Long Island Sound, winds at these two stations are more intense than in the Sound. The frequency of occurrence of storm winds along Long Island Sound is considered to be closer to that at New Haven than at either New York or Block Island. The shore line between New Haven Harbor and Pond Point in Milford is regarded as being affected by winds similar to those recorded at New Haven. The shore line between Pond Point and the Housatonic River is considered to be under the influence of winds of directions similar to those recorded at New York City. Storms which result in severe shore damage in this area are comparatively infrequent. Condensed accounts which follow of storm damage as reported by the press in recent years indicate the type of storm damage likely to occur.

Location	Account
Savin Point	8 October 1907. Southwest storm, heavy seas. Several piers destroyed.
New Haven	1 October 1920. Southwest storm, 40 M.P.H. - winds heavy sea. Mamaugin Hotel damaged by sea. Thousands of dollars of damage to piers, bulkheads and boats.
Savin Rock	1 October 1920. Concrete sidewalks torn up by sea.
Milford	23-24 May 1925. Southwest storm, hail, heavy seas. $20,000 damage along water-front.
Milford	20 February 1927. Northeast storm, heavy seas "highest tide in 20 years". Several cottages undermined. Dunes at Trumbull beach washed through.
Milford	23 August 1930. Northerly storm, high seas. Several cottages damaged by seas at Myrtle, Laurel, and Walnut Beaches.
Milford	1-2 November 1932. Southeast storm, heavy seas, high tides. Several cottages damaged.
Milford	26 January 1933. Northerly storm, 40 M.P.H. - gusts, cottages flooded and under-mined.
Milford	17-18 November 1935. Northeast storm, high seas, tides above normal. Yacht Club boardwalk destroyed. Five cottages damaged.
New Haven	12 November 1940. Northeast storm, heavy seas. West shore of harbor battered. Minor damage reported.

Location	Account
New Haven	15 September 1944. Southeast hurricane winds. Many cottages destroyed. Lower highways undermined or blocked by tons of sand and rock.
Milford	15 September 1944. Southeast hurricane winds. Shore property badly damaged. Three cottages destroyed by undermining. East Broadway blocked, tons of rock and sand washed through in several sections.
New Haven	30 November 1944. Northeast to west storm. High seas and tide. Considerable damage to shore structures. Lower streets flooded.
New Haven	29 November 1945. Northeast storm near hurricane force. Tides greatly above normal. Great seas damage coastal installations and roads.
Milford	29 November 1945. Same storm as above. Beach dwellers evacuated. Beach street blocked with wave washed sand and rocks. Cottage destroyed on Silver Beach.
New Haven	12 November 1947. Southwest to northwest storm. Much damage to shore area from high tides and heavy seas.

APPENDIX E.

SHORE LINE AND OFFSHORE DEPTH CHANGES

1. Basic Data. - Plans showing the location of the shore line and the 6, 12, and 18-foot depth contours have been prepared from United States Coast and Geodetic Survey data by the Beach Erosion Board for the period from 1837 to 1933. For this study, a survey run during 1949 located the entire shore line and offshore depths on selected profiles. Shore line changes are shown on Plates 7 and 8 and offshore depth changes are shown on Plates 7 to 10 and Plate 16. The principal shore line and offshore depth changes are described below. Due to the scale (1:10000) used on these plans, it is obviously difficult to measure small changes with accuracy. Change descriptions are therefore limited to those which appear large enough to permit reliable reading. Amounts of change when given in feet are necessarily scaled distances, and therefore approximate. The changes described can generally be considered accurate in so far as they indicate the trend in the area described and approximate only in indicating the actual quantitative change.

2. Sandy Point. - This is a sand spit extending about 3000 feet in a northeasterly direction from the west shore of New Haven Harbor. The spit started to form between 1837 and 1884. In 1910, the spit occupied the same position as in 1884. In 1933, the shore end was approximately 1,300 feet north of its original location, the bar had shifted to a more easterly direction, and a breach had occurred near the inshore end. Between 1933 and 1949, about 300 feet were added to its length and the breach was closed. The present trend appears to be growth in a northeasterly direction.

3. Sandy Point to Bradley Point. - This stretch of shore extends about 8,000 feet between Old Field Creek and the foot of Savin Avenue. From 1837 to 1884, small changes occurred in the position of the shore

line, the principal change being accretion of approximately 50 feet. Between 1884 and 1933, the shore receded about 50 to 100 feet. During 1948-1949, more than one million cubic yards of sand was placed along the shore in connection with hydraulic dredging of the navigation channel leading into the harbor. This resulted in a movement of the high water line 200 to 350 feet seaward of its 1933 position.

Offshore depth changes between 1837 and 1884 moved the 6-foot contour from a few hundred to more than 2,000 feet landward. The 12-foot contour was also moved shoreward, the maximum movement being about 500 feet. Present trends are obscured by the artificial deepening of the navigation channel and the placement of large quantities of fill along the shore.

4. Bradley Point. - This is a point of land formed by rock outcrops projecting into Long Island Sound between Savin Avenue and Cove River in front of marshes bordering Cove River. There are small sandy pocket beaches on both sides of Bradley Point and together with the projecting ledge rock, they form a cuspate tombolo. Between 1837 and 1884, erosion of about 250 feet occurred on the east side. Since 1884, there has been little change on this side. In 1837, there existed what appears to have been a spit extending westward about 500 feet from the east side of Cove River. This spit still existed in substantially the same form in 1884. From 1884 to 1933, extensive changes occurred on this west side of Bradley Point. The spit disappeared and erosion of 100 to 200 feet moved the shore line shoreward. No apparent change occurred between 1933 and 1949. The present narrow shore is held by sea-walls, bulkheads, and groins, and no changes are now evident.

5. Cove River to Oyster River.- Between 1837 and 1884, accretion moved the shore line seaward, the amount varying from 50 to 100 feet. Between 1884 and 1933, this process reversed itself. A general recession of the shore line occurred. This erosion does not appear to have been

as great as the previous accretion, the movement which occurred varying from about 25 to 50 feet. Between 1933 and 1949, erosion continued, the amount being generally small. The greatest movement occurred in the vicinity of Oyster River Point while other portions of the shore remained relatively unchanged. Changes today are not evident in the position of the high water line. The area is largely protected by revetment and sea walls. Erosion is occurring in front of these structures, resulting in a lowering of the beach level rather than in the movement of the position of the shore.

Offshore depths have increased along the entire extent of shore. Movements of the 6, 12, and 18-foot contours varied from a few hundred to over a thousand feet from 1837 to 1872 and 1874. This deepening continued up to 1949 except opposite the mouth of Oyster River where some shoaling occurred in the vicinity of the 6 and 12-foot contours.

6. Oyster River to Merwin Point. - The greatest changes in this area have occurred in the vicinity of Oyster River. Between 1837 and 1933, the mouth of the river moved 50 to 100 feet southward and accretion ranging up to 100 feet occurred along the shore south of the river. Since 1933, the shore line has moved slightly landward. The area today is largely protected by sea walls and revetment. Where no protective structures exist, erosion is attacking the shore. The results of erosion are evident in the coarse composition of the beach materials which are largely shingle, cobbles, and boulders.

Offshore, there has been a continuous deepening resulting in a movement shoreward since 1837 of about 400 feet in the 18-foot contour, 100 to 500 feet in the 12-foot contour, and 200 to 400 feet in the 6-foot contour.

7. Merwin Point to Merwin Beach. - This extent of shore is characterized by a series of projecting ledge rock outcrops with small

sandy pocket beaches held between them. Since 1837, there has been little apparent change in the shore line. The changes, if any, which have occurred, are too small to determine reliably from the shore line change maps.

Offshore depth changes between 1837 and 1884 have resulted in deepening in the vicinity of the 12 and 18-foot contours resulting in a shoreward movement of 200 to 400 feet for the 18-foot contour and 100 to 300 feet for the 12-foot contour. The 6-foot contour has moved irregularly 100 to 200 feet landward along the eastern half of the area and 0 to 500 feet seaward along the western half. A profile run during 1949 indicates that offshore deepening is continuing in the area where deepening was occurring previously.

8. Merwin Beach. - This is a large pocket beach between ledge rock outcrops located west of Merwin Point. Between 1837 and 1884, there was accretion of about 50 feet along the entire extent of the pocket. During this period, a creek which emptied into the central part of the beach shifted its mouth about 200 feet to the north. From 1884 to 1933, there was practically no change in the shore line. The 1933 shore line map does not show any creek emptying at the beach and there was no creek in existence in 1949. Between 1933 and 1945, accretion generally less than 25 feet occurred along all but the easterly end of the pocket where there was no change.

Depths offshore generally increased from 1837 to 1884 resulting in a landward movement of 50 to 450 feet for the 18-foot contour, 400 to 600 feet for the 12-foot contour, 150 to 200 feet for the 6-foot contour. The 1884 contours indicate the existence of a long tongue or bar extending seaward opposite the central portion of the beach. This bar moved the 6-foot contour about 700 feet seaward and the 12-foot contour about 200 feet seaward of the 1837 locations. This bar may have been caused by the stream which formerly emptied onto the beach.

9. Morningside, Farview, and Burwell Beaches. - This is an extent of shore about 5,000 feet long located between Merwin Beach and Pond Point. Burwell Beach along the northerly 1,000 feet of the area, consists of a shallow pocket beach. Between 1837 and 1933, accretion moved the shore line in this pocket seaward about 150 feet along the northerly end and about 50 feet along the southerly portion. Between 1933 and 1949, there was no appreciable change in the location of the high water line. South of this area, along Farview Beach, the next southerly 1,500 feet of shore exhibits only small changes through the years. From 1837 to 1884, changes consisted of a small amount of accretion. Between 1884 and 1949, small amounts of erosion occurred moving the shore line back approximately to its 1837 position. The greatest movement in either direction did not exceed 50 feet. The shore is now continuously protected by sea-walls with the high water line generally at the foot of the walls. Erosion has removed all the finer sandy material and lowered the beach level so that the protecting walls are being undermined. South of Farview Beach, the most southerly 2,500 feet of shore, known as Morningside, was built seaward by accretion ranging up to 50 feet between 1837 and 1884. Thence to 1933, very little change occurred in the position of high water line except at a projecting point about 1,000 feet north of the south limit of the area where erosion of about 40 feet occurred. Between 1933 and 1949, the above mentioned projecting point continued to suffer from erosion, the maximum movement during this period being about 50 feet. Elsewhere along Morningside, changes if any, are too small for reliable interpretation from shore line change maps.

Offshore depths generally increased throughout the area between 1837 and 1884. Landward movement of depth contours during this period were as follows: 6-foot, 50 to 300 feet; 12-foot, 200 to 700 feet; 18-foot, 100 to 700 feet. Profiles run during 1949 indicate that

little change has occurred in offshore depths since 1884.

10. Pond Point. - This is an extent of shore about 4,000 feet long between the walled section of Morningside and Pond Point Beach. Accretion occurred along the northerly 1,700 feet of this area adjacent to Morningside between 1837 and 1933, the movement of the shore line being small, generally less than 50 feet. From 1933 to 1949, there was very little change. Some erosion appears to have occurred along the central and southerly end of this section resulting in a recession of the shore of about 25 feet. The shore of Point Beach along the southerly side of Pond Point, approximately 1,500 feet long, moved seaward in places from 50 to 75 feet between 1837 and 1884. Thence to 1933, considerable erosion occurred causing a recession of the shore of about 100 feet, the greatest movement taking place at the westerly end of the beach. Between 1933 and 1949, erosion continued causing irregular shore line changes, the maximum movement probably not exceeding 25 feet. The effects of present day erosion are apparent. The bottoms of walls and steps are undermined several feet by the lowering of the beach level and the beach composition is very coarse due to the removal of the finer beach materials. The shore along the west side of Pond Point adjacent to Pond Point Beach moved seaward from 50 to 200 feet between 1837 and 1933. Since 1933, a recession of the shore has occurred, resulting in a shore line movement of about 25 feet. Here also the effects of erosion are evident today in the very coarse nature of existing beach materials and the lowering of beach level in front of protecting sea-walls.

Offshore depths generally increased between 1837 and 1884, except opposite the east end of Point Beach where no change occurred in the vicinity of the 6 and 18-foot contours and the 12-foot contour moved seaward about 100 feet and at the west end of Point Beach where the 6-foot contour moved about 150 feet seaward. Elsewhere, the depth

contours moved landward, the amounts of movement varying as follows: 6-foot, 100 to 200 feet; 12-foot, 0 to 200 feet; 18-foot, 0 to 700 feet. Profiles run during 1949 indicate shoaling occurred offshore at the east end of Point Beach in the vicinity of the 6 and 12-foot contours and deepening in the vicinity of the 6-foot depths at the west end of Point Beach.

11. Pond Point Beach. - This shore area located between Pond Point and Calf Pen Meadow Creek is about 2,500 feet long. Between 1837 and 1884, accretion occurred along the easterly half of the area and erosion along the westerly half, the shore line movement being small, generally less than 50 feet. From 1884 to 1933, erosion caused recession of the entire beach of 25 to 50 feet. Thence to 1949, the shore was fairly stable except for a short stretch 400 to 900 feet east of Calf Pen Meadow Creek where erosion continued, resulting in a shore line movement less than 25 feet. Between Calf Pen Meadow Creek and a point about 400 feet to the east, accretion of about 50 feet occurred.

Offshore depths opposite the beach increased between 1837 and 1884, the landward movement of depth contours being as follows: 6-foot, 150 to 300 feet; 12-foot, 200 to 450 feet; 18-foot, 100 to 1,000 feet. Profiles run in 1949 indicate that deepening of offshore areas is continuing.

12. Bay View Beach. - This is a sandy beach about 2,500 feet long located between Calf Pen Meadow Creek and Welchs Point. The easterly 900 feet of the shore has changed very little since 1837. Changes were too small to permit of reliable determination from shore line change maps. West of this stable area, recession of the shore of about 25 to 75 feet occurred between 1837 and 1884. Thence to 1933, the only appreciable change occurred along the westerly portion of the beach where accretion of about 25 feet took place along 900 feet of shore.

Between 1933 and 1949, erosion moved the shore line back generally less than 25 feet along the westerly half of the area while little change occurred elsewhere.

Offshore depths increased between 1837 and 1884 resulting in a landward movement of depth contours as follows: 6-foot, 0 to 350 feet; 12-foot, 0 to 650 feet; 18-foot, 100 to 350 feet. Profiles run in 1949 indicate that offshore deepening is continuing.

13. Welchs Point. - This area extends from the west end of Bay View Beach to the south limit of Gulf Beach. Accretion and erosion have alternately occurred along the east side of Welchs Point, the net result being that the shore line in 1949 is in approximately the same position as in 1837. The southerly tip of Welchs Point has experienced continuous erosion since 1837 with only a small amount of this occurring between 1933 and 1949. The total recession since 1837 has resulted in loss of about 100 feet of shore. The west shore of Welchs Point extending about 1,600 feet north from the southerly tip has undergone small irregular changes, the net result of which is that there is practically no change in the shore line since 1837. This stretch of shore has been continuously protected by shore structures since 1874 when the Federal Government constructed 12 groins to prevent erosion and movement of material to prevent shoaling of the Milford Harbor navigation channel. In 1949, protective works consisted of a series of riprap groins, riprap revetment of bank slopes, and wooden bulkheads. The remainder of the shore between points 1600 to 2800 feet north of Welchs Point eroded about 50 feet from 1837 to 1884. The 1933 shore line was in the same position as that of 1884. Between 1933 and 1949, erosion appears to have moved the high water line landward about 25 feet.

The principal change offshore has been deepening. This has resulted in landward movement of depth contours between 1837 and 1884

as follows: south of Welchs Point, 18-foot, 300 to 500 feet; 12-foot, 500 feet; 6-foot, 250 feet; north and west of Welchs Point, 12-foot, 300 to 400 feet; 6-foot, 150 to 250 feet. Profiles run during 1949 indicate that the only appreciable change since 1884 is offshore deepening south of the tip of Welchs Point.

14. Gulf Beach. - This beach, about 1200 feet long, is adjacent to and south of Long Jetty at the mouth of Indian River. Since 1837, it has experienced both erosion and accretion. From 1837 to 1884, erosion of about 50 feet occurred along all but the southerly 300 feet where accretion up to 100 feet took place. Between 1884 and 1933, probably as a result of the construction of Long Jetty during 1875-1876, accretion up to 50 feet occurred along the northerly 800 feet of the beach while a small amount of erosion occurred along the southerly 400 feet. Since 1933, there has been little change in the position of the high water line. The shore is now held by a series of closely spaced groins and except immediately adjacent to Long Jetty, the beach consists of very coarse material, most of the finer material apparently having been removed by erosion.

Offshore, the 6-foot depth contour moved landward about 50 to 100 feet between 1837 and 1884. Profiles run during 1949 indicate that there has been no change in the location of the 6-foot contour since 1884.

15. Fort Trumbull Beach. - This shore, located between Burns Point at the mouth of Wepawaug River and Silver Creek, is about 4,000 feet long. Since 1837, the eastern or Burns Point end of the beach grew or was built eastward about 150 feet. The 2500 feet of shore west of Burns Point was eroded between 1837 and 1933 resulting in a shore line movement of about 100 feet. Little change occurred along this section of the beach between 1933 and 1949. The westerly 1500 feet of shore adjacent to Silver Creek changed very little between

1837 and 1884. At this latter date, Silver Creek was an open stream emptying into Long Island Sound across the beach. In 1933, apparently as a result of enclosure of Silver Creek, the shore east of the former mouth of the creek filled out and aligned itself with adjoining shore areas. Maximum accretion which occurred during this period was about 100 feet. Between 1933 and 1949, the accretion continued so that today this section of shore forms a smooth line with adjoining beach areas with accretion since 1884 varying between 100 and 150 feet.

Offshore depth changes were as follows between 1837 and 1884: 6-foot contour, landward movement of 50 feet opposite the west end of the beach and 400 feet at the east end; 12-foot contour, landward movement of 400 feet at the west end, little change in the central portion and landward movement of 200 feet at the east end; 18-foot contour, seaward movement of about 100 feet at the east end and landward movement of approximately 250 feet at the west end. Profiles run during 1949 indicate that deepening is continuing in the vicinity of all contours.

16. Silver Beach. - This stretch of shore extends westward about 2200 feet from the mouth of Silver Creek to the inshore end of the submarine bar connecting the mainland to Charles Island. Between 1837 and 1884, erosion occurred along the entire beach. Adjacent to Silver Creek about 200 feet of shore receded over 100 feet. Recession of the shore along the remainder of the beach varied between 25 to 50 feet. Between 1884 and 1933, little change occurred except at the mouth of Silver Creek where enclosure of the stream apparently resulted in accretion of about 100 feet, the shore line aligning itself with that of adjacent areas. The high water line at the inshore end of the aforementioned submarine bar moved about 50 feet seaward during this latter period. Between 1933 and 1949, there was a recession of the shore line averaging about 25 feet in width except at the inshore end of the

submarine bar at the west end of Silver Beach where accretion of about 50 feet occurred.

Offshore, depths of water generally increased between 1837 and 1884. Landward movements of depth contours during this period were as follows: 6-foot, 0 to 400 feet; 12-foot, 0 to 600 feet; 18-foot, 0 to 300 feet. Between 1884 and 1949, the 6-foot contour opposite the west end of Silver Beach moved seaward while deepening continued further east. The process of offshore deepening continued in the vicinity of the 12- and 18-foot contours.

17. Meadows End and Myrtle Beach. - This stretch of shore extends westward about 2300 feet from the inshore end of the submarine bar connecting the mainland and Charles Island. Erosion has been exceptionally severe along this area. Between 1837 and 1884, the shore line receded up to 200 feet. Between 1884 and 1933, the erosion continued removing an additional 100 to 200 feet of the shore except at the extreme westerly end of the area where only slight change occurred. In 1884, an open stream emptied into Long Island Sound across the beach at the west limit of this area. This stream was apparently enclosed between 1884 and 1933. Between 1884 and 1933, erosion continued removing another 50 to 150 feet of shore. Cottages formerly existing on the beach are now gone and the high water line is generally at the foot of riprap revetment and a steel sheet pile bulkhead protecting a shore road.

Offshore depths increased between 1837 and 1884. Landward movement of depth contours during this period were as follows: 6-foot, 100 to 200 feet; 12-foot, 0 to 500 feet; 18-foot, 800 to 900 feet. Profiles run during 1949 indicate that deepening is continuing opposite the west end of the area while shoaling is occurring to the east.

18. Myrtle Beach (west end). - This is a stretch of shore about 3500 feet long extending eastward from Naugatuck Avenue. There has been continuous erosion throughout the area since 1837. Between 1837

and 1884, erosion caused a shore line recession of 150 to 250 feet along the easterly half of this section and an average recession of about 50 feet along the westerly half. Between 1884 and 1933, an additional recession varying from 50 to 100 feet occurred throughout the shore area. Between 1933 and 1949, erosion continued removing another 25 to 50 feet of shore.

Offshore depth changes varied between deepening and shoaling from 1837 to 1884. The 18-foot contour moved about 900 feet landward opposite the east end of the area and about 250 feet seaward at the west end. Very little change occurred in the position of the 12-foot contour during this period. The 6-foot contour moved about 100 to 150 feet landward opposite the entire area. Profiles run during 1949 indicate that offshore deepening is generally occuring throughout the area.

19. Walnut Beach. - This is an extent of shore about 3600 feet long located between Naugatuck Avenue and Wildemere Avenue. The shore has been subject to erosion continuously since 1837. Between 1837 and 1884, there was a shore line recession varying between 50 and 100 feet. Between 1884 and 1933, erosion continued, loss of shore being generally less than 25 feet except between Andrews Street and Hauser Street where a recession of about 75 feet occurred. Between 1933 and 1949, only a small amount of shore recession, generally less than 25 feet, is apparent.

Offshore depth changes between 1837 and 1884 were as follows: movement of the 6-foot contour landward, 100 to 300 feet; movement of the 12-foot contour landward of 500 feet opposite the west end of the beach with little change elsewhere; movement of the 18-foot contour about 200 feet seaward opposite the east end of the beach and about 450 feet landward at the west end. Profiles run during 1949 indicate that deepening is continuing offshore, depths opposite the entire beach being greater than in 1884.

20. Laurel Beach. - This beach is about 2200 feet long and is located between Wildemere Avenue and Laurel Beach Road. Between 1837 and 1884, erosion removed 50 to 75 feet of shore area except at the extreme westerly end where a small amount of accretion occurred. From 1884 to 1933, the shore line receded 25 to 50 feet along the easterly 1000 feet of the beach, little change occurred along the next westerly 400 feet and recession varying from 0 to 75 feet occurred along the westerly portion. Between 1933 and 1949, probably as a result of construction of protecting sea-walls and groins, little change occurred in the location of the shore. Some small amounts of accretion may have been effected during this latter period but they are too small to be reliably measured on the shore line change maps.

Offshore, depths increased in the vicinity of the 6 and 18-foot contours between 1837 and 1884, the resulting landward movement of depth curves being as follows: 6-foot, 150 to 300 feet; 18-foot, 0 to 450 feet. During this same period, the 12-foot contour moved landward about 500 feet opposite the east end of the beach and about 150 feet at the west end while in the central area it moved seaward about 450 feet. Profiles run during 1949 indicate that the offshore depths are generally greater than in 1884.

21. Cedar Beach and Milford Point. - This is a sand spit, about 5000 feet long which has grown westward into the Housatonic River. The easterly end of the spit, known as Cedar Beach, is developed for residential use for about 1700 feet adjacent to and west of Laurel Beach. In 1837, the spit was about 3800 feet long. It increased in length to 4300 feet in 1884, 4600 feet in 1910 and 5100 feet in 1933. The length of the spit in 1949 was about the same as in 1933. During this period of growth, changes occurred in the width of the spit. These changes were particularly notable west of a point about 1000 feet west of Laurel Beach. They consisted generally of increases in width resulting from

accretion, mostly on the seaward shore. The greatest size was attained around 1910 and 1933. Since 1933, erosion has caused the seaward shore at the easterly third of the spit to recede 50 to 100 feet, thence to the Housatonic River breakwater there has been alternately erosion and accretion while west of the breakwater, the outer end of the spit has curved to a more northerly direction and erosion has removed up to 100 feet of the seaward shore.

Offshore changes were irregular between 1837 and 1884, the principal changes consisting of shoaling which resulted in seaward movements of depth contours as follows: 6-foot, 0 to 1000 feet; 12-foot, 150 to 500 feet; 18-foot, 150 to 900 feet. A profile run about 3000 feet east of the breakwater during 1949 indicates that some deepening has occurred since 1884.

APPENDIX F.

LITTORAL DRIFT

Listed below are indices of littoral drift obtained from field inspection and study of shore line change maps. Direction of littoral drift was interpreted as being in the direction of growth of sand spits, towards the side of groins, jetties or other structures at which accretion was found or towards the ends of beaches where material was finer as shown by variation of beach composition where there was a change in gradation from coarse to finer material.

Indices of Drift

Area	Indicated Direction of Drift	Evidence	Date	Authority
West shore New Haven Harbor	Northeast	Growth of Sandy Point sand spit	—	Shore line changes
West side Bradley Point	West	Small amount sand east side timber groins	Mar.1949	Visual inspection
Prospect Beach	North	Accumulation of sand along south side groins	Mar.1949	Visual inspection
Oyster River Point	West	Gradation of material, finer at west end.	Mar.1949	Visual inspection
Oyster River Beach	West	Existence of small sandy pocket beach at west end of area and gradation of material finer at west end.	Mar.1949	Visual inspection
Woodmont shore	North	Small amount sand along south side crib groins.	Mar.1949	Visual inspection
First Pocket Beach east of Anchor Beach	West	Accumulation of sand east side of concrete bastion and rock outcrop.	Mar.1949	Visual inspection.

Area	Indicated Direction of Drift	Evidence	Date	Authority
Anchor Beach	West	Sand caught by rock outcrop at west end beach. Gradation material finer at west end.	Mar.1949	Visual inspection
Pocket between Merwin and Anchor Beach	West	Gradation material finer at west end. Sand beach wider at west end.	Mar.1949	Visual inspection
Merwin Beach	Southwest	Gradation of material finer west end. Accumulation of sand at wall at west end beach.	Mar.1949	Visual inspection
Morningside (south end)	South	Accumulation of sand and fine gravel north side of groin.	Mar.1949	Visual inspection
South side Pond Point	West	Accumulation small amounts sand and fine gravel east side groins.	Mar.1949	Visual inspection
West side Pond Point	North	Accumulation of drift at south side groins and concrete walks.	Mar.1949	Visual inspection
Pond Point Beach	West	Gradation of material finer at west end beach.	Mar.1949	Visual inspection
Bay View Beach	West	Sand level above H.W. higher at west end beach.	Mar.1949	Visual inspection
Bay View Beach	East	Accumulation of sand west side drain at waters edge.	Mar.1949	Visual inspection

Area	Indicated Direction of Drift	Evidence	Date	Authority
Bay View Beach (West end)	East	Gradation of material below H.W., finer east end.	Mar.1949	Visual inspection
Gulf Beach	Northwest	Large accumulation drift material south side of groins.	Mar.1949	Visual inspection
Fort Trumbull Beach	Southwest	Accumulation sand east side short timber groins.	Mar.1949	Visual inspection
Silver Beach	Northeast	Accumulation sand west side groins at ends beach.	Mar.1949	Visual inspection
Silver Beach	Southwest	Accumulation sand east side groins, central portion of beach.	Mar.1949	Visual inspection
Shore end Charles Island tombolo	Northeast	Material accumulated south side crib groin south limit public beach.	Mar.1949	Visual inspection
Myrtle Beach	Southwest	Accumulation sand east side drain pipe and wood groins.	Mar.1949	Visual inspection
Walnut Beach	Southwest	Accumulation sand east side groins.	Mar.1949	Visual inspection
Laurel Beach	Southwest	Accumulation sand east side groins.	Mar.1949	Visual inspection
Cedar Beach	Southwest	Accumulation sand east side groins.	Mar.1949	Visual inspection
Milford Point	Southwest	Growth of Milford Point sand spit.		Shore line changes

APPENDIX G.

EXISTING PROTECTIVE STRUCTURES

1. Sandy Point Dike. - The dike is located on the west side of New Haven Harbor opposite Fort Hale and consists of a shore arm extending easterly from a long sand spit known as Sandy Point and a channel arm running north and south approximately parallel to the main harbor channel. It was constructed as a Federal project authorized by River and Harbor Act of August 2, 1882. Construction was started in 1882. The shore arm and one-half of the channel arm were built in 1888 and the structure was completed in 1890. The shore arm is 2,140 feet long, the inner 1,294 feet consisting of riprap and the remainder of 2 rows of creosoted piling, 8 feet apart, filled with riprap. The channel arm was built to a length of 2,089 feet, the northern 20 feet consisting of an ice breaker of heavy riprap on a log foundation, the next southerly 254 feet of two rows of creosoted piling, 8 feet apart filled with riprap, and the remaining 1,815 feet of riprap construction of which the north 273 feet are on a log foundation. The top elevation of the dike was approximately 5.25 feet above mean low water, the riprap portions being of triangular cross section having side slopes of 1 on 1 and the pile and riprap portions were constructed with vertical sides. Between 1886 and 1933, the spit at Sandy Point built out in a northeasterly direction from the dike for over 1000 feet, and the shore end of the spit shifted to a more northerly position and was breached. The changes which occurred during this period were probably largely due to the loss of natural sources of supply of sand which originally formed Sandy Point by littoral drift. The present form of the spit is undoubtedly influenced by the dike which retarded the processes of erosion which set in following this loss of sources of supply. The

dike and training wall decreased the width of the waterway between Sandy Point and Fort Hale sufficiently to lessen deposition of material on Fort Hale Bar. No scouring occurred in the channel where all depths were attained by dredging.

2. New Haven Harbor Breakwaters. - There are three riprap breakwaters at the entrance to New Haven Harbor. These structures were constructed as Federal projects authorized by the River and Harbor Acts of 3 March 1879 and 19 September 1890. Construction of the East Breakwater was started in 1880 and was completed to a length of 3,450 feet in 1890. The Middle or Luddington Rock Breakwater was started in 1891 and completed to a length of 4,500 feet in 1896. The West Breakwater was begun in 1896 and completed to a length of 4,200 feet in 1915. The breakwaters were built with a top width of 12 feet, top elevation 6 feet above mean high water, side slopes of 1 on 1.5 on the seaward side and 1 on 1 on the harbor side. These structures provide a harbor of refuge at the mouth of the harbor and afford protection to the harbor from all but southwest storms. Their effect on that portion of the shore of West Haven at the east end of Area 3 has been to afford protection from south and southeast storms thereby reducing storm damage to this area.

3. Oyster River Point Sea Walls. - Oyster River Point is largely protected by concrete and masonry sea walls. These walls are generally high along the east side of the point and protect a high bluff. West of the point, the walls are lower, about 2 to 3 feet above beach level. The entire area appears to have suffered from erosion which has removed the finer beach materials leaving a coarse shingle and cobble beach. There is an evident lowering of the beach level in front of the walls resulting in exposure and undermining of the base of the structures. Toe walls have been added in places to stop this undermining. The need for carrying sea wall construction to greater depths is clearly indicated.

4. Bank Revetment at Woodmont. - A section of shore closely bordering Beach Avenue between Clark and Clinton Streets in the Woodmont section of Milford is protected by revetment. This revetment is laid on the face of an eroding bluff and consists of small stones generally not exceeding one cubic foot in size. A short section at the north end of this revetment has been bound together by a Portland cement mortar. The stone is too small to provide adequate protection in its loose state. Heavy stone facing or continuation of the binding of the light revetment with mortar to form a bank paving would give more satisfactory protection.

5. Walls and Bank Protection at Morningside. - Morningside consists of a high bluff of unconsolidated material which, due to its proximity to the shore has suffered severely from erosion. The base of the bluff is now protected by a continuous concrete sea wall 3 to 4 feet high above beach level. The steeply sloping banks above this low wall are largely protected by boulder or cobble revetment, laid loose or set in mortar and by bituminous bank paving. Portions of the bank are further protected by wooden bulkheads. The structures appear satisfactory in protecting the slopes of the bluff. Some erosion occurs above the low wall where no slope protection has been provided indicating a need for extending the revetment to these areas. The shore in front of the concrete wall exhibits signs of serious erosion which has removed the finer materials, leaving a very coarse cobble and boulder beach. Construction of added toe walls indicates that there has been considerable lowering of the beach level. Stabilization of the shore is needed to make the present protective system satisfactory.

6. Wall System at Pond Point. - The southern end of Pond Point is continuously protected by low concrete walls, approximately 3 feet high above beach level. In front of one section of the walls, a series of closely spaced short timber groins holds fine gravel and small amounts of sand serving to maintain the beach level. Along the easterly half of

the point, lowering of the beach level of 1 to 3 feet has undermined the walls and concrete steps leading to the beach.

7. Milford Harbor Jetties and Groins. - Federal improvements authorized by River and Harbor Act of June 23, 1874 were constructed as follows: 12 groins along the east shore of the harbor northwest of Welchs Point; a long jetty below the mouth of Indian River; a jetty at Burns Point.

The 12 groins were built to prevent the continuous erosion of the shore and the movement of material up the harbor. They were constructed in 1874 mostly with stone picked up along the beach, to a triangular cross section with a top height of 9 feet above mean low water and side slopes of about 1 on 1. Of the twelve, all but two extended from high to low water mark. These groins varied in length from 100 to 130 feet and were spaced from 100 to 200 feet apart, all within a distance of about 2000 feet from Welchs Point. In 1875, it was reported that "a considerable accumulation of sand and gravel is found on both sides of nearly all jetties". In 1876, it was reported that the groins were so effective in retaining drifting sand and gravel "that the accumulated material threatened to raise the level of the beach above that of the jetties and it was found necessary to build the shore ends higher; this was done in August, 1875, adding a height of 3 feet at high water mark".

The long jetty at the mouth of Indian River was built during 1875-1876 with stone obtained from the vicinity. It was constructed to prevent the filling in of the channel by sand drifting along the shore and to direct the tidal current into the dredged channel. The jetty was built to a length of 550 feet with a 6-foot top width and height 10-1/2 feet above mean low water. Side slopes were 2 on 3 on the outer side and 1 on 1 on the inner side. In 1889, the jetty was shortened 60 feet. Periodic repairs have been made. The latest repairs were made

in 1948 at which time the shore end was raised 3.2 feet to a height of 13.7 feet above mean low water sloping down to the original height of 10.5 feet, 180 feet out. The jetty was raised to stop overtopping of the shore end by accumulated drift material.

From November 1879 to January 1880, a riprap jetty was constructed at Burns Point opposite and nearly at right angle to the long jetty at the mouth of Indian River. This jetty was built to modify the direction of tidal currents and conduct them along the excavated channel and to prevent the erosion of the west bank immediately below Burns Point. This jetty is 350 feet long of triangular cross section with height of 7 to 8 feet above mean low water and side slopes of 1 on 1. It is not stated whether the contraction afforded by this jetty caused any tidal scouring of the channel. The jetty appears to have been effective in stopping erosion of the shore west of Burns Point, very little change having occurred along this shore since 1884.

8. Meadows End Bulkheads. - There is a shore road on the barrier bar fronting the Meadows End marshes opposite Charles Island. This bar has been subject to erosion averaging 3 feet per year. A steel sheet pile bulkhead has been constructed along the seaward side of the road. High water reaches the bulkhead along several hundred feet of shore. Riprap revetment consisting of large dumped rock and wood pile cribs have been placed in front of the more exposed sections of the bulkhead. Erosion has lowered the fronting shore several feet. The shore erosion problem here is serious and will require continuous and costly maintenance to stop encroachment of the Sound.

9. Walnut, Laurel and Cedar Beach Walls and Groins. - The beaches in this area have been subject to erosion averaging about 1 foot per year. Due to the intensive residential development of the area in close proximity to the shore, it has become necessary to provide an almost continuous system of sea wall protection. These walls are generally

low averaging about 3 feet in height above beach level. They appear to provide adequate protection for backshore areas. Erosion has continued in front of the walls. A large number of short, closely spaced timber groins have succeeded in retaining a narrow strip of sand beach. These groins are in general too short and too closely spaced to result in the accumulation of any large quantities of littoral drift materials. Longer groins spaced further apart would probably be more effective.

10. Housatonic River Breakwater. - The riprap breakwater located at Milford Point at the east side of the mouth of the Housatonic River was authorized as a Federal project by River and Harbor Act of August 11, 1888. It was built to aid in the maintenance of the bar at the mouth and to protect the channel from littoral drift moving in a westerly direction. Construction started in 1889 and was completed to a length of 5,821 feet in 1895. The inner 3,250 feet was built to project dimensions with height of 3 feet above mean low water, top width of 6 feet and side slopes of 1 on 1. The outer arm was built to a height of 4 feet above mean low water with a top width of 5 feet. In 1906, the inshore end was extended 35 feet up onto the beach to check the shifting of the sand. From 1912 to 1914, the outer arm was enlarged in cross section by raising its height to 6 feet above mean low water with top width of 8 feet and outer side slope of 1 on 1-1/2 and inner slope of 1 on 1. The project dimensions of the outer arm of 12-foot top width and outer slope of 1 on 2 have not been required to secure a stable structure. Since construction of the breakwater, the sand spit which constitutes Milford Point has grown in a westerly direction and is now approximately parallel to the channel at its outer end. The breakwater has induced sufficient scouring to maintain a fairly constant depth over the outer bar. Slight shoaling occurs in the channel near the outer end of the breakwater. Extension and raising the elevation of the inner end would more effectively prevent littoral drift material from passing to the westward.

APPENDIX H

SHORE AND OFFSHORE MATERIAL INVESTIGATION

1. General. - Subsurface explorations were made at selected locations along the shore and offshore. Explorations were limited to those portions of the study area in which considered plans of protection and improvement include direct placement of material along the shore by hydraulic dredging from offshore sources. The locations of samples are shown on Plates 11 to 15. Explorations were generally made to a minimum depth of five feet below the ground or bottom surface and to a maximum depth of ten feet. Samples were obtained using a 2-inch inside diameter solid sample spoon for the first five feet of penetration and a 1-1/2-inch inside diameter spoon for penetration in excess of five feet. Penetration was achieved by driving the 2-inch spoon with a 140-pound hammer falling 18 inches for the first five feet and jetting the 1-1/2-inch spoon to the previously sampled depth and then driving for greater penetration. Samples of representative materials from each exploration were preserved for laboratory classification.

2. Sample Analysis. - A visual laboratory classification was made of all samples obtained. In addition, a mechanical analysis to determine grain size was made of each soil type encountered. Fourteen different soil types typical of all material sampled were analyzed, and all materials sampled are classified by reference to these fourteen types. Soil size fractions finer than .074 millimeters (passing a No. 200 U.S. Standard sieve) were not analyzed, but the percentage by weight of these fractions was determined. The results of the analysis of the soil types are included in Table 1, and the list of all borings referred to these soil types, is included as Table 2.

TABLE I

SOIL TYPE ANALYSIS

Soil Type	Grain Size in Millimeters Median Diameter	Character of Material in percent				Description
		Silt or Clay	Fine Sand	Coarse Sand	Gravel	
1	0.33	4	57	35	4	Coarse to fine SAND
2	0.54	2	32	62	4	Coarse to fine SAND
3	0.48	2	41	41	16	Gravelly, coarse to fine SAND
4	0.21	26	56	18	0	Silty, fine SAND
5	0.42	8	44	46	2	Coarse to fine SAND
6	0.34	0	86	14	0	Uniform fine SAND
7	0.24	23	39	24	14	Silty, gravelly SAND
8	Finer than 0.074	63	33	4	0	Sandy SILT
9	5.8	12	10	15	63	Silty, sandy GRAVEL
10	0.67	10	30	32	28	Silty, gravelly SAND
11	9.2	0	2	26	72	Sandy GRAVEL
12	0.24	26	43	29	2	Silty SAND
13	0.40	0	60	25	15	Gravelly SAND
14	0.30	4	72	22	2	Coarse to fine SAND

TABLE II

LIST OF BORINGS

Boring	Depth of Water or Top Elevation	Penetration Range	Length of Penetration (feet)	Soil Type
1	0.8	0.8 to 4.3	3.5	1
		4.3 to 5.8	1.5	2
2	0.5	0.5 to 2.5	2.0	8
		2.5 to 9.5	7.0	12
		9.5 to 10.5	1.0	5
3	2.3	2.3 to 6.8	4.5	1
		6.8 to 11.7	4.9	10
4	5.6	5.6 to 7.1	1.5	1
		7.1 to 9.6	2.5	13
		9.6 to 10.8	1.2	5
		10.8 to 12.6	1.8	2
5	6.2	6.2 to 6.7	0.5	1
		6.7 to 9.7	3.0	3
		9.7 to 14.2	4.5	2
6	4.4	4.4 to 6.4	2.0	1
		6.4 to 9.4	3.0	13
		9.4 to 12.2	2.8	3
		12.2 to 12.4	0.2	10
7	12.7	12.7 to 14.7	2.0	13
		14.7 to 17.7	3.0	10
8	16.2	16.2 to 16.7	0.5	4
		16.7 to 18.2	1.5	12
		18.2 to 19.7	1.5	2
9	+5.1	+5.1 to +3.1	2.0	11
		+3.1 to +0.1	3.0	10
10	+5.0	+5.0 to +4.4	0.6	11
		+4.4 to 0.0	4.4	10
11	+7.1	+7.1 to +4.1	3.0	13
12	3.6	3.6 to 4.6	1.0	6
		4.6 to 6.1	1.5	3
		6.1 to 8.6	2.5	13
13	1.8	1.8 to 2.3	0.5	10
		2.3 to 8.6	6.3	13
		8.6 to 9.8	1.2	5
14	16.5	16.5 to 19.0	2.5	7
		19.0 to 20.7	1.7	10
		20.7 to 21.5	0.8	6

Boring	Depth of Water or Top Elevation	Penetration Range	Length of Penetration (feet)	Soil Type
15	+6.2	+6.2 to +5.2	1.0	11
16	+5.7	+5.7 to +3.7	2.0	11
		+3.7 to +2.5	1.2	7
17	20.4	20.4 to 22.8	2.4	7
		22.8 to 23.9	1.1	10
18	16.2	16.2 to 17.7	1.5	1
		17.7 to 19.0	1.3	6
		19.0 to 21.2	2.2	8
19	5.9	5.9 to 6.5	0.6	Rock
20	+6.5	+6.5 to +2.8	3.7	11
21	17.4	17.4 to 18.0	0.6	8
22	17.9	17.9 to 19.9	2.0	9
23	+2.4	0	0	Rock
24	11.8	11.8 to 12.8	1.0	12
		12.8 to 16.8	4.0	10
25	6.8	6.8 to 8.0	1.2	8
		8.0 to 10.1	2.1	10
		10.1 to 11.8	1.7	13
26	6.7	6.7 to 11.7	5.0	8
27	4.4	4.4 to 9.4	5.0	8
28	5.2	5.2 to 8.7	3.5	1
		8.7 to 10.2	1.5	5
29	3.5	3.5 to 5.0	1.5	8
		5.0 to 8.0	3.0	13
		8.0 to 8.5	0.5	8
30	+3.8	+3.8 to 1.2	5.0	13
31	3.5	3.5 to 8.5	5.0	13
32	2.5	2.5 to 6.0	3.5	1
		6.0 to 7.5	1.5	13
33	3.4	3.4 to 5.4	2.0	13
		5.4 to 8.4	3.0	14
34	+2.0	+2.0 to +0.8	1.2	1
		+0.8 to 1.0	1.8	13
		1.0 to 1.5	0.5	2
		1.5 to 3.0	1.5	14

Boring	Depth of Water or Top Elevation	Penetration Range	Length of Penetration (feet)	Soil Type
35	4.1	4.1 to 9.1	5.0	13
36	3.8	3.8 to 7.3	3.5	13
		7.3 to 8.8	1.5	14
37	+5.2	+5.2 to +2.2	3.0	13
		+2.2 to +0.2	2.0	14
38	3.5	3.5 to 6.9	3.4	13
		6.9 to 8.5	1.6	14
39	5.2	5.2 to 8.2	3.0	13
		8.2 to 10.2	2.0	8
40	10.7	10.7 to 11.2	0.5	1
		11.2 to 15.7	4.5	14
41	7.7	7.7 to 9.7	2.0	8
		9.7 to 11.7	2.0	14
		11.7 to 12.7	1.0	2
42	7.2	7.2 to 8.2	1.0	13
		8.2 to 11.0	2.8	14
43	+8.0	+8.0 to +6.2	1.8	5
		+6.2 to +3.0	3.2	11
44	2.5	2.5 to 4.0	1.5	13
		4.0 to 7.5	3.5	3
45	+6.4	+6.4 to +5.7	0.7	14
		+5.7 to +1.4	4.3	11
46	2.0	2.0 to 7.0	5.0	3

Note:

Borings are in feet and tenths and are referred to the plane of Mean Low Water.

Borings were taken November 1950 and their locations shown on Plates 11 to 15.

Depths below the plane of Mean Low Water are shown thus: 16.2. Elevations above the plane of Mean Low Water are shown thus: +5.1.

APPENDIX I

ESTIMATES OF COSTS OF IMPROVEMENTS

1. General. - The estimated life of the considered projects is 50 years. The rate of interest on Federal investments is computed at 3 percent, and on non-Federal investments at 3.5 percent. Maintenance requirements of sand fills are based on maximum rates of loss determined from past shore recession. Where sand fill is proposed for a shore composed of coarse material, which is now more resistant to erosion than sand, an estimated rate of loss twice as great as previously experienced has been used. Where sand fill is proposed for a shore now sandy in composition, a rate of loss equal to the maximum recorded past rate has been used. A minimum rate of shore recession of one foot per year has been used as a basis for estimates of losses for all sand fills.

2. Bradley Point (west side). - The plan of protection and improvement consists of widening 650 feet of shore to a 100-foot width by the direct placement of sand and the construction of an impermeable groin 300 feet long.

a. First Costs

Sand fill 12,000 cubic yards at $1.00	$12,000
Groin - 750 tons riprap at $10	7,500
Engineering and contingencies	2,500
TOTAL COST	$22,000

b. Non-Federal Annual Charges (Entire shore privately-owned).

Interest	$ 770
Amortization	170
Annual Maintenance	
Replenishment of sand losses, 600 cubic yards at $1.00	600
Repairs to groin, 8 tons at $10	80
Total Non-Federal Annual Charges	$ 1,620

3. Prospect Beach. - The plan of protection and improvement considered consists of widening to a 100-foot width, 6000 feet of shore from a point about 350 feet south of South Street northerly to Ivy Street with an added 50-foot widening at the south end of the beach and construction of eight impermeable groins.

a. First Costs.

Sand fill 380,000 cubic yards at $0.40	$152,000
Eight groins 4,200 tons of riprap at $8	33,600
Engineering and contingencies	28,000
Total Cost	$213,600

b. Annual Charges. - The riparian ownership of the entire shore rests in the Town of West Haven through ownership of a shore road, known as the "Ancient Highway" which formerly existed. The land between the present shore highway, Ocean Avenue, and Long Island Sound belongs to the Town of West Haven except for an undeveloped privately-owned piece of land 250 feet long located north of South Street and a privately-owned piece of land 350 feet long located south of South Street. The private land south of South Street is occupied by private residences. These residences represent the only development in the Prospect Beach area considered for protection and improvement. The total length of beach to be protected and improved is 6,800 feet. The southerly 6000 feet of the shore will be improved by direct placement of sand. The remainder will benefit by movement of sand from the area of direct placement, i.e., through littoral drift. The publicly-owned shore is 6,200 feet long and is considered to be eligible to receive Federal aid up to one-third of the first cost of construction of protective works. Although the entire shore legally belongs to the town through its riparian ownership, there is actually only a narrow strip of publicly-owned land fronting 600 feet of the area, the boundaries of which are not clearly established. Along this 600 feet, the plan is considered to

be for protection of privately-owned property. The publicly-owned shore represents 90% of the entire shore. The Federal share of the first cost of construction is computed as one-third the cost applicable to the publicly-owned shore. The Federal share, therefore, becomes one-third of 90% or 30%.

First costs are allocated as follows:

Federal Cost	$ 64,000
Non-Federal Cost	149,600
Total Cost	$213,600

Federal Annual Charges

Interest	$ 1,920
Amortization	570
Total Federal Annual Charges	$ 2,490

Non-Federal Annual Charges

Interest	$ 5,240
Amortization	1,140
Annual Maintenance Replenishment of sand losses, 8,400 cubic yards at $0.75	6,300
Repairs to groins, 42 tons at $10	420
Total Non-Federal Annual Charges	$ 13,100
Total Annual Charges	$ 15,590

4. Oyster River Point to Oyster River. - The plan of protection and improvement consists of widening to a 100-foot width, 2,400 feet of shore from Oyster River Point approximately 150 feet east of Morris Street to Hubert Street with an added 50-foot widening at the east end of the area. Impermeable groins are included as deferred construction if experience proves that they are necessary to reduce excessive losses of sand fill.

a. First Costs.

Sand fill, 100-foot widening, 90,000 cubic yards at $0.50	$45,000
Added 50-foot widening, 55,000 cubic yards at $0.50	27,500
Groins (deferred construction) Number of groins, if any, to be based on experience with the sand fill. Assume 4 short groins at 250 tons - 1000 tons riprap at $10	10,000
Engineering and contingencies	12,500
TOTAL COST	$95,000

b. Annual Charges. - The riparian ownership of the entire shore rests in the Town of West Haven. The backshore area east of Hubert Street, in front of which direct placement of sand is proposed, is continuously developed for private residential use. Sea walls in front of this residential area are constructed so that there is little or no land between the walls and Long Island Sound. Although the shore legally belongs to the town through its riparian ownership, there is actually only a narrow strip of publicly-owned land in existence and the boundaries of this land are not clearly established. The sand fill is considered to be for protection and improvement of privately-owned property. Only that portion of this privately-developed shore consisting of town-owned street ends is considered to be eligible to receive Federal aid in the first cost of construction of protective works. West of Hubert Street to Oyster River, there is a town-owned bathing beach known as Oyster River Beach in front of privately-owned property developed for residential use. Due to the present use of this area as a public bathing beach and because there is a substantial width of town-owned land in front of the private residences, the area is regarded as being eligible to receive Federal aid in the first cost of construction of protective works. The plan considered will benefit this public beach through provision of a source of supply to nourish it. The Federal share of the cost is computed as a percentage of the cost of the added 50-foot widening

determined from the relationship between length of publicly- and privately-owned shore area which will benefit through littoral drift. The length of shore to be improved is 3,500 feet. The easterly 2,400 feet of this area will be improved by the direct placement of sand. The westerly 1,100 feet will benefit by movement of sand from the area of direct placement; i.e., by littoral drift. Publicly-owned property along the easterly 2,400 feet of shore consists of street ends which constitute 300 feet or 12.5% of this area. The improvement of this easterly area involves the placement of 90,000 cubic yards of sand, 12.5% of which, or 11,250 cubic yards being for protection and improvement of publicly-owned property. Publicly-owned property along the entire area consists of 300 feet of street ends and 1,100 feet of public bathing beach. This represents 40% of the entire shore, all of which will benefit from the added widening to be placed at Oyster River Point. The added widening involves placement of 55,000 cubic yards of sand, 40% of which, or 22,000 cubic yards, being for protection and improvement of publicly-owned property. The total improvement involves placement of 145,000 cubic yards of sand, 33,250 of which, or 22.9% being for protection and improvement of publicly-owned property. The Federal share of the first cost is computed as one-third the cost of protective works for the publicly-owned property, or one-third of 22.9% equal to 7.6%. First costs are allocated as follows:

Federal Cost	$ 7,200
Non-Federal Cost	87,800
Total Cost	$95,000

Federal Annual Charges

Interest	$ 220
Amortization	60
Total Federal Annual Charges	$ 280

Non-Federal Annual Charges

Interest	$ 3,075
Amortization	670
Maintenance	
Replacement of sand losses, 3,900 cubic yards at $0.75	2,925
Repairs to groins, 10 tons at $10	100
Total Non-Federal Annual Charges	$ 6,770
Total Annual Charges	$ 7,050

5. Woodmont Shore. - The plan of improvement consists of protection of portions of the Woodmont shore by the placement of sand fill as follows: widening to a 100-foot width about 500 feet of shore in the first pocket beach west of Merwin Point; widening to a 100- to 150-foot width about 3,500 feet of shore from Chapel Street northerly to a point approximately 400 feet north of Anderson Avenue; the construction of five impermeable groins.

a. First Costs

Sand Fill:		
Widening first pocket beach west of Merwin Point 20,000 cubic yards at $0.45	$ 9,000	
Widening beach from Chapel Street to Clinton Avenue, 25,000 cubic yards at $0.45	11,250	
Widening beach from Clinton Avenue to Bonsilene Avenue, 150,000 cubic yards at $0.45	67,500	
Widening beach from Bonsilene Avenue to 400 feet north of Anderson Avenue 45,000 cubic yards at $0.45	20,250	
Engineering and contingencies	16,200	
	$124,200	
Groin construction, 3000 tons riprap at $8	$ 24,000	
Engineering and contingencies	3,600	
	$ 27,600	
Total Cost	$151,800	

b. Annual Charges.- The ownership of the shore rests in the Town of Milford and the Woodmont Association. The Woodmont Association is listed as a borough in the Connecticut State Manual and by the Tax Department of the State of Connecticut. Its charter gives it the right to tax, to issue bonds and set the interest rate thereon, to construct piers and docks, build and maintain highways and public square, to condemn property for certain public improvements and make payments on such lands, to make special appropriations and lay special taxes to meet the same. The Association has all rights necessary to negotiate beach improvements that are ordinarily allowable to any other political subdivision. The charter of the Association or the ordinances and by-laws adopted by the Association give it no rights to restrict the use of the public beach fronts unless for violations of decency, safety or sanitation. The beach that will be created by the placement of fill will accrue to public ownership and it will be available for use by the general public. Portions of the shore are developed for private residential use with only a narrow strip of beach between these residential developments and Long Island Sound. The purpose of the proposed improvement along shore areas so developed is considered to be for the protection of privately-owned property and, therefore, not eligible to receive Federal assistance, except for the percentage of such shore area represented by publicly-owned street ends. The remainder of the area lies in front of publicly-owned streets which run parallel to the shore. Such areas are regarded as being eligible to receive Federal aid up to one-third the first cost of construction. The lengths of shore areas and percentages of these lengths considered eligible to receive Federal assistance in the first cost of improvement and protection are listed below:

Area	Length (Feet) Public	Length (Feet) Private	Percentage of Shore Eligible for Federal Assistance
First Pocket Beach west of Merwin Point	500	0	100
Chapel Street to Clinton Avenue	100	500	16-2/3
Clinton to Bonsilene Avenue	1550	0	100
Bonsilene Avenue to 400 feet north of Anderson Avenue	115 (Street Ends)	1235	8-1/2

Construction of groins is proposed between Merwin Point and the north limit of the fill. Approximately 50% of the shore to be protected by groins is considered eligible to receive Federal assistance in the first cost of construction. The Federal share of the cost of groin construction has been determined as 1/3 x 50% or 16-2/3%.

First costs are allocated as follows:

Federal Cost

Sand Fill:	
Pocket beach west of Merwin Point	$ 3,000
Chapel St. to Clinton Avenue	625
Clinton Ave. to Bonsilene Ave.	22,500
Bonsilene Ave. to 400 feet north of Anderson Avenue	575
Groin Construction	4,000
Engineering and contingencies	4,600
Total Federal Cost	$ 35,300

Non-Federal Cost

Sand Fill:	
Pocket Beach west of Merwin Point	$ 6,000
Chapel St. to Clinton Avenue	10,625
Clinton Ave. to Bonsilene Ave.	45,000
Bonsilene Ave. to 400 feet north of Anderson Avenue	19,675
Groin Construction	20,000
Engineering and contingencies	15,200
Total Non-Federal Cost	$116,500
Total Cost	$151,800

Federal Annual Charges

Interest	$1,060
Amortization	310
Total Federal Annual Charges	$1,370

Non-Federal Annual Charges

Interest	$ 4,080
Amortization	890
Maintenance	
Replenishment of sand losses 6,700 cubic yards at $0.60	4,020
Repairs to groins 30 tons at $10	300
Total Non-Federal Annual Charges	$ 9,290
Total Annual Charges	$10,660

6. Burwell Beach. - The plan of protection and improvement considered consists of widening 900 feet of Burwell Beach to a 100-foot width and construction of an impermeable groin at the north end of the fill.

a. First Costs

Sand Fill 32,000 cubic yards at $0.75	$24,000
Groin 1,350 tons riprap at $9	12,150
Engineering and contingencies	5,350
Total Cost	$41,500

b. Non-Federal Annual Charges (Entire shore privately-owned)

Interest	$ 1,450
Amortization	320
Annual Maintenance	
Replenishment of sand losses 500 cubic yards at $1.00	500
Repairs to groin 14 tons at $10	140
Total Non-Federal Annual Charges	$ 2,410

7. Gulf Beach. - The plan of protection and improvement considered consists of widening approximately 1200 feet of Gulf Beach to a 100-foot width by the direct placement of sand.

a. First Costs

Sand fill 45,000 cubic yards at $0.60	$27,000
Engineering and contingencies	4,000
Total Cost	$31,000

b. Annual Charges. - The shore to be improved is publicly-owned and, therefore, eligible for Federal participation up to one-third of the first cost of construction. First costs are allocated as follows:

Federal Cost	$10,300
Non-Federal Cost	20,700
Total Cost	$31,000

Federal Annual Charges

Interest	$ 310
Amortization	90
Total Federal Annual Charges	$ 400

Non-Federal Annual Charges

Interest	$ 725
Amortization	160
Maintenance Replenishment of sand losses 1,100 cubic yards at $1.00	1,100
Total Non-Federal Annual Charges	$ 1,985
Total Annual Charges	$ 2,385

8. Silver, Myrtle, Walnut, Laurel and Cedar Beaches and Meadows End. - The plan of protection and improvement consists of widening to a 100-foot width by direct placement of sand, 15,600 feet of shore between and including Silver and Cedar Beaches with an added 150-foot widening around Meadows End, and construction of 11 impermeable groins along Myrtle, Walnut, Laurel and Cedar Beaches.

a. First Costs

Sand fill 740,000 cubic yards at $0.40	$296,000
Groins 12,500 tons riprap at $8	100,000
Engineering and contingencies	59,000
Total Cost	$455,000

b. Annual Charges. - The ownership of the shore to be protected and improved is part public and part private. Publicly-owned shore property consisting of street ends, small lots and a public bathing beach belongs to the Town of Milford. The aggregate length of this publicly-owned shore frontage is 1,560 feet or 10% of the entire shore. The publicly-owned shore is considered to be eligible to receive Federal aid up to one-third of the first cost of construction of protective works. The Federal share of the first cost of construction is computed as a percentage of the total first cost of construction equal to one-third of the percentage of the shore which is publicly-owned. The Federal share of the first cost of construction is thereby determined to be 1/3 of 10% or 3-1/3%. First costs are allocated as follows:

Federal Cost	$ 15,200
Non-Federal Cost	439,800
Total Cost	$455,000
Federal Annual Charges	
Interest	$ 460
Amortization	130
Total Federal Annual Charges	$ 590
Non-Federal Annual Charges	
Interest	$ 15,360
Amortization	3,350
Annual Maintenance Replenishment of sand losses 12,000 cubic yards at $0.60	7,200
Repairs to groins 125 tons riprap at $10	1,250
Total Non-Federal Annual Charges	$ 27,160
Total Annual Charges	$ 27,750

9. Silver, Myrtle, Walnut, Laurel, and Cedar Beaches and Meadows End. - A preliminary plan of improvement was considered consisting of widening to a 100-foot width, 13,000 feet of shore along Silver, Myrtle, Walnut, Laurel and Cedar Beaches, placing sand fill on the bar connecting Charles Island to the mainland and construction of an impermeable groin 400 feet long at the west limit of the fill at Cedar Beach. This plan, and the reasons for its revision in favor of a plan that would provide more positive shore protection, is discussed in paragraph 48. Though not as desirable as the revised plan from the standpoint of shore protection, the plan does possess features involving more recreational development. The estimate of costs is included here because of widespread local interest in a development of this type.

a. First Costs

Sand Fill:	
980,000 cubic yards at $0.40	$392,000
Groin Construction	
1,250 tons riprap at $10.00	12,500
Engineering and contingencies	60,900
Total Cost	$ 465,400

b. Annual Charges. - Since this plan is not considered to be as desirable for shore protection as the one recommended, all costs are computed as non-Federal costs and all annual charges as non-Federal annual charges.

Non-Federal Annual Charges

Interest	$ 16,300
Amortization	3,550
Maintenance	
Replacement of sand losses 22,000 cubic yards at $0.60	13,200
Repairs to groin 15 tons riprap at $10	150
Total Non-Federal Annual Charges	$ 33,200

APPENDIX J

ESTIMATES OF BENEFITS FROM IMPROVEMENTS

1. General. - Public Law 727, 79th Congress, authorizing Federal participation, states that "with the purpose of preventing damage to public property and promoting and encouraging the healthful recreation of the people, it is hereby declared to be the policy of the United States to assist in the construction, but not the maintenance, of works for the improvement and protection against erosion by waves and currents of the shores of the United States that are owned by States, municipalities, or other political subdivisions**". The problem in Connecticut is primarily the loss and deterioration of its beaches, and secondarily the protection of shore structures from direct damage. The benefits computed herein are based on the promotion and encouragement of the healthful recreation of the people by improvement and restoration of public beaches, protection of shore property, and increased earning power or value of shore lands. Benefits accruing from increased value of areas behind and adjacent to shore property, increased business and recreational use of privately-owned shores have not been estimated.

2. Bradley Point (west side). - a. Federal Benefits. - The United States does not own land in this area. Therefore, no Federal benefit will result from the improvement.

b. Non-Federal Public Benefit. -

(1) Earning Power or Value of Shore Land. - The improvement will result in increased land values. Public benefit therefrom will be derived from increased taxes on privately-owned land.

Assessed value of shore land	$ 32,500
Estimated increase in land value due to improvement - 50%	$ 16,250
Tax rate $25.00 per thousand	
Estimated increase in tax income 25 x 16.25	$ 406

c. Private Benefit.

(1) Average Annual Direct Damages Prevented. - The shore area to be improved is protected by groins, bulkhead, and a sea wall. A benefit will result computed as a savings in cost of maintenance of protective structures.

Estimated value wooden groins and bulkhead	$ 1,000
Estimated value of 200-foot sea wall	$ 5,000
	$ 6,000
Estimated savings in maintenance cost, 10% value of bulkhead and groins and 5% of value of sea wall	$ 350

The existing beach is subject to sand losses due to erosion. A benefit is computed based on prevention of these losses.

Estimated annual sand losses 100 cubic yards.	
Replacement value $1.50 per cubic yard Benefit 100 x $1.50	$ 150

(2) Benefit from Increased Earning Power or Value of Shore Land. - The improvement will result in increased land values. The annual benefit is computed as a 3-1/2% interest gain on the increase in value.

Estimated increase in land value	$ 16,250
Annual gain, .035 x 16,250	$ 570

d. Summary of Benefits, Bradley Point. - Evaluated benefits are tabulated below:

Benefit	Federal	Non-Federal Public	Private	Total
Increased earning power	0	$ 406	$ 570	$ 976
Direct damages prevented	0	0	500	500
Total	0	$ 406	$1070	$1,476

3. Prospect Beach. - a. Federal Benefit. - The United States does not own land in the area. Therefore, no Federal benefit will result from the improvement.

b. Non-Federal Public Benefit.

(1) Average Annual Direct Damages Prevented. - The shore highway and public shore are protected by sea walls and revetment. The placement of fill will provide additional protection. Benefit therefrom is computed as a savings in maintenance cost of protective structures.

Length of sea walls, 570 feet. Estimated value	$ 28,500
Length of revetment, 600 feet. Estimated value	$ 6,000
Total estimated value of structures	$ 34,500
Estimated annual savings in maintenance costs, 5% or	$ 1,725

(2) Increased Earning Power or Value of Shore Lands. - The improvement will result in increased value of shore land. Benefit therefrom will be derived from increased taxes on privately-owned land.

Benefit from Increased Taxes

Assessed value of privately-owned land	$ 23,000
Estimated increase in value due to improvement, 50% or	$ 11,500
Tax rate $25.00 per thousand.	
Estimated tax increase	$ 290

(3) Recreational Benefit. - The existing shore area is unsuitable for recreational use. It consists of sea walls and revetment protecting a highway and bluff and a coarse shingle, cobble, and boulder shore. Placement of sand will improve the composition of the shore and provide a large area suitable for recreational purposes. The improvement will provide more than 500,000 square feet of usable beach area. Allowing a desirable optimum space standard of 75 square

feet per person, the proposed beach would accommodate 6,600 persons during peak use. Patronage of the beach is estimated by comparison with attendance figures compiled during 1948 at Anchor, Gulf, and Silver Beaches in the adjoining town of Milford. These three small public beaches, having a combined area not exceeding one-fourth the area which would be provided at Prospect Beach, had a combined annual attendance of 121,000 people. The population of West Haven (31,500) exceeds that of Milford (25,300). In addition, Prospect Beach is located only a short distance from the densely populated area comprising New Haven (population 160,000). There is a town-owned beach in West Haven between Sandy Point and Old Field Creek. This beach is adjacent to a polluted harbor area. Pollution that could endanger the health of bathers exists along the south side of Sandy Point (the northern end of the town-owned beach). For purely recreational use, Prospect Beach would be the most desirable area in West Haven for development of a bathing beach. Due to the large population to be served it is felt that attendance at West Haven beaches would greatly exceed attendance at beaches in Milford. It is conservatively estimated that annual attendance at Prospect Beach will be at least 100,00 persons. The value per person for beach use is evaluated as the minimum fee that patrons would be required to pay if the beach were a private enterprise. This is estimated as $0.20 per person. The annual estimated recreational value of the improvement, therefore, is determined as follows:

100,000 x $0.20 = $20,000

a. Private Benefits.

(1) Average Annual Direct Damages Prevented. - Privately-owned property is protected by sea walls. The improvement will provide additional protection. Benefit therefrom is estimated as a savings in cost of maintenance of protective structures.

Length of sea walls, 600 feet, estimated value.....$ 30,000

Estimated annual savings in maintenance cost, 5% or.....$ 1,500

(2) Benefit from Increased Earning Power or Value of Shore Land. - The improvement will result in increased value of privately-owned shore land. Benefit therefrom is computed as a 3-1/2% interest gain on the increase in value.

Real value of privately-owned land.....$ 23,000

Estimated increase in value.....$ 11,500

Estimated benefit, 3-1/2% of above.....$ 400

d. Summary of Benefits, Prospect Beach. - Evaluated benefits are tabulated below:

Benefit	Federal	Non-Federal Public	Private	Total
Direct damages prevented	0	$ 1,725	$ 1,500	$ 3,225
Increased earning power	0	290	400	690
Recreational	0	20,000	0	20,000
Total	0	$ 22,015	$ 1,900	$23,915

4. Oyster River Point to Oyster River. - a. Federal Benefit. - The United States does not own land in the area. Therefore, no Federal benefit will result from the improvement.

b. Non-Federal Public Benefit.

(1) Benefit from Increased Earning Power or Value of Shore Land. - The improvement will result in increased value of shore land. Benefit therefrom will be derived from increased taxes on privately-owned land.

Benefit from Increased Taxes

Assessed value of privately-owned shore land.....$105,000

Estimated increase in assessed value, 50%.....$ 52,500

Tax rate, $25.00 per thousand.

Estimated increase in taxes.....$ 1,300

c. Private Benefit.

(1) Average Annual Direct Damages Prevented. - Privately-owned property is protected by sea walls. The improvement will provide additional protection needed to prevent undermining of existing structures through erosion. Benefit therefrom is estimated as a savings in cost of maintenance of protective structures.

Length of sea walls, 2160 feet.
Estimated value.....$ 54,000

Estimated annual savings in maintenance costs, 5%.....$ 2,700

(2) Benefit from Increased Earning Power or Value of Shore Land. - The improvement will result in increased value of privately-owned shore land. Benefit therefrom is computed as a 3-1/2% interest gain on the increase in value.

Real value of privately-owned shore land...$105,000

Estimated increase in value, 50%.....$ 52,500

Estimated annual benefit, 3-1/2% of above..$ 1,840

d. Summary of Benefits, Oyster River Point to Oyster River. - Evaluated benefits are tabulted below:

Benefit	Federal	Non-Federal Public	Private	Total
Direct damages prevented	0	0	$2,700	$2,700
Increased earning power	0	$1,300	1,840	3,140
Total	0	$1,300	$4,540	$5,840

5. Woodmont Shore. - a. Federal Benefit. - The United States does not own land in this area. Therefore, no Federal benefit will result from the improvement.

b. Non-Federal Public Benefit.

(1) Average Annual Direct Damage Prevented. - The shore area to be improved is partly protected by sea walls and riprap revetment. An unprotected stretch of shore is eroded to the edge of an existing street. Land and road along this unprotected shore are in danger of being lost if protection is not provided. Existing shore protective structures have been constructed by the Woodmont Association, largely through funds obtained through WPA grants. Benefit is computed as a savings in maintenance costs of existing structures and prevention of damage to the unprotective shore area.

ESTIMATED SAVINGS IN MAINTENANCE COSTS OF PROTECTIVE STRUCTURES

Structure	Length (Feet)	Estimated Value	Estimated Annual Maintenance Cost
Sea Walls	2350	$67,000	$2,100
Riprap revetment	1000	10,000	500
		Total Estimated Savings	$2,600

PREVENTION OF DAMAGE TO UNPROTECTED SHORE AREA.

Estimated value of 400 feet of shore land and street	$ 45,000
Estimated annual loss based on total destruction in 20 years	5%
Estimated annual loss or damage prevented	$ 2,250

(2) Benefit From Increased Earning Power or Value of Shore Land. - The improvement will result in increased land values. Benefit therefrom is computed as estimated increased taxes on privately-owned land.

BENEFIT FROM INCREASED TAXES

Assessed value of shore land	$ 83,000
Estimated increase in value due to improvement	25%
Estimated increase in assessed value	$ 20,750
Tax rate $30.00 per thousand.	
Estimated increase in tax income 30 x 20.75	$ 620

(3) Recreational Benefit. - The shore area to be improved is eroded very close to existing protective structures. The existing beach is narrow and coarse in composition and generally unsuitable in its present condition for recreational use. The improvement will provide a long extent of sandy beach which can be used for recreational purposes. There is at present only one small pocket beach about 300 feet long known as Anchor Beach at Woodmont, which is used for bathing. According to counts made by life guards during 1948, 20,225 persons used Anchor Beach during June, July, and August. The improvement will provide another 2265 feet of public beach suitable for recreational use. It is conservatively estimated that this additional beach will result in an increased beach use of this shore area at least equal to present use of Anchor Beach. The recreational value per person for beach use is evaluated as the minimum fee that patrons would be required to pay if the beach were a private enterprise. This is estimated as $0.20 per person. Using an estimated increase in use of the beach of 20,000 persons per year, the recreational value is computed as follows:

20,000 x $0.20 = $4,000

c. Private Benefit.

(1) Benefit from Increased Earning Power or Value of Shore Land. - The improvement will result in increased value of shore land. The annual benefit is computed as a 3-1/2% interest gain on the estimated increase in value of privately-owned shore land.

Assessed value of privately-owned shore land	$ 83,000
Real value of privately-owned shore land	$166,000
Estimated increase in value, 25%	$ 41,500
Annual gain at 3-1/2%	$ 1,450

d. Summary of Benefits, Woodmont Shore

Benefit	Federal	Non-Federal Public	Private	Total
Direct damages prevented	0	$4,850	0	$ 4,850
Increased earning power	0	620	$1,450	2,070
Recreational	0	4,000	0	4,000
Total	0	$9,470	$1,450	$10,920

6. Burwell Beach. - a. Federal Benefit. - The United States does not own land in the area. Therefore, no Federal benefit will result from the improvement.

b. Non-Federal Public Benefit.

(1) Increased Earning Power or Value of Shore Land. - The improvement will result in increased land values. Public benefit therefrom will be derived from increased taxes on privately-owned land.

BENEFIT FROM INCREASED TAXES

Assessed value of shore land	$ 25,000
Estimated increase in value due to improvement	50%
Estimated increase in assessed value	$ 12,500
Tax Rate is $30 per thousand	
Estimated increase in tax income	$ 375

c. Private Benefit.

(1) Average Annual Direct Damages Prevented. - A wide sand beach will provide protection to sea walls fronting the shore property. Benefits are computed as a savings in maintenance cost of these structures.

ESTIMATED SAVINGS IN MAINTENANCE COSTS OF PROTECTIVE STRUCTURES

Length of existing sea walls.	900 feet
Estimated value of sea walls per linear foot	$ 25
Total estimated value of sea walls	$ 22,500
Estimated savings in maintenance costs 5% or	$ 1,125

(2) Benefit from Increased Earning Power or Value of Shore Land. - The improvement will result in increased land values. The annual benefit therefrom is computed as interest of 3-1/2% on the estimated increase in value.

Estimated increase in assessed value.....$ 12,500

Estimated increase in real value,
2 x $12,500.....$ 25,000

Annual gain - .035 x 25,000.....$ 875

d. Summary of Benefits, Burwell Beach. - Evaluated Benefits are tabulated below:

Benefit	Federal	Non-Federal Public	Private	Total
Direct damages prevented	0	0	$1,125	$1,125
Increased earning power	0	$375	875	1,250
Total	0	$375	$2,000	$2,375

7. Gulf Beach. - a. Federal Benefit. - The United States does not own land in this area. Therefore, no Federal benefit will result from the improvement.

b. Non-Federal Public Benefit.

(1) Average Annual Direct Damages Prevented. - The beach area is protected by a concrete sea wall and a series of groins. Widening the beach by the placement of sand will cover the groins and protect the sea wall resulting in a benefit evaluated as a reduction of maintenance costs of protective structures. This benefit is computed as follows:

Structure	Length (feet)	Estimated Value	Estimated Annual Maintenance Cost
Sea Wall	810	$ 24,000	$480
Groins	415	2,500	250
		Total Estimated Savings	$730

(2) Recreational Benefit. - The present beach is largely unusable for recreational purposes due to the coarse nature of the shore materials. The present available area is inadequate for present attendance. During June, July, and August 1948, life guards checked in 36,000 people. During peak use, it is estimated that 1,300 people used the beach, allowing about 15 square feet of beach area per person. A desirable optimum area is 75 square feet per person. Placement of sand will increase the usable area from about 20,000 to 110,000 square feet, allowing peak use by 1,470 persons $\left(\frac{110,000}{75}\right)$ at optimum space standards. This peak use is considered to be low. Actual patronage of Gulf Beach is expected to increase at least 50% due to the proposed improvement. The increased patronage is estimated as follows:

$$36,000 \times 1/2 = 18,000$$

The recreational value per person for beach use is evaluated for the increased attendance as the minimum fee which patrons would be required to pay if beach were a private enterprise. This is conservatively estimated as $0.20 per person. Therefore, the annual recreational value of the improvement is as follows:

18,000 x $0.20 = $3,600

c. Summary of Benefits, Gulf Beach. - Evaluated benefits are tabulated below:

Benefit	Federal	Non-Federal Public	Private	Total
Direct damages prevented	0	$ 730	0	$ 730
Recreational	0	3,600	0	3,600
Total	0	$4,330	0	$4,330

8. Silver, Myrtle, Walnut, Laurel and Cedar Beaches and Meadows End -

a. Federal Benefit. - The United States does not own land in the area. Therefore, no Federal benefit will result from the improvement.

b. Non-Federal Public Benefit.

(1) Average Annual Direct Damages Prevented. - Erosion has necessitated the protection of the shore road, East Broadway, by the construction of a steel sheet pile bulkhead and the placement of rip-rap revetment in from of portions of this bulkhead. The placement of sand fill should result in savings by eliminating the need for protective structures. The value of this benefit is estimated as a savings in cost of maintenence of existing structures.

Length of steel sheet pile bulkhead..... 700 feet

Estimated value of bulkhead at $30. per linear foot - $30 x 700.....$ 21,000

Estimated annual savings in maintenance, 5% of $21,000 = ...$ 1,050

(2) Benefit from Increased Earning Power or Value of Shore Land. - Artificial placement of fill will permit result in increased land values of shore property. Benefits therefrom will be derived from increased taxes on privately-owned land.

BENEFIT FROM INCREASED TAXES

Area	Length (feet)	Assessed Value	Estimated Increase in Value (%)	Estimated Increase in Assessed Value
Silver Beach	1,850	$ 55,500	25	$ 13,900
Meadows End	3,800	64,600	100	64,600
Myrtle Beach	1,360	40,800	50	20,400
Walnut Beach	3,360	144,450	10	14,400
Laurel Beach	2,050	98,400	10	9,800
Cedar Beach	1,700	42,500	50	21,200
				$ 144,300

The 1948 tax rate is $30. per thousand.
Estimated increased tax income $30 x 144.3 = $4,330

(3) Recreational Benefit. - The existing public beach is too small to provide adequate recreational area. During June, July, and August 1948, 65,000 persons were checked in by life guards at Silver Beach. During peak use, it is estimated that 2,400 persons used the beach, allowing less than 20 square feet of beach area per person. A desirable optimum area is 75 square feet per person. In addition to the attendance at the public beach, intensive recreational use is made of the numerous street ends which compose the greatest extent of publicly-owned shore. It is estimated that 100,000 persons per year use the publicly-owned areas now available. Placement of sand fill will more than double the area of these town-owned sections of beach. Public benefit will result from this enlargement of beaches through increased beach patronage estimated as 50% of present patronage or 50,000 persons. The recreational value per person for beach use is evaluated for the increased attendance as the minimum fee which patrons would be required to pay if the beach were a private enterprise. This is conservatively estimated at $0.20 per person. Therefore, the annual recreational value of the improvement is as follows:

50,000 x $0.20 = $10,000

c. Private Benefit.

(1) Average Annual Direct Damages Prevented. - The shore area along which it is proposed to place sand fill is protected by numerous sea walls, bulkheads, and groins. The sand fill will cover the groins and give protection to the walls and bulkheads resulting in a benefit through reduction of maintenance costs. Erosion of the shore and storm damage have resulted in the destruction of buildings formerly located on the beaches. Continued erosion will result in further losses to buildings now located at the water's edge. The plan of improvement will provide protection for these buildings resulting in a benefit computed as prevention of anticipated losses. Past erosion of 1 to 3 feet per year has resulted in loss of existing beaches. A benefit will result from reduction of these annual losses. This latter benefit has not been evaluated. Evaluated benefits are as follows:

ESTIMATED SAVINGS IN MAINTENANCE COSTS OF PROTECTIVE STRUCTURES

Structure	Length in Feet	Estimated Value	Estimated Annual Maintenance Cost
Sea walls	4,700	$ 195,000	$ 9,700
Bulkheads	960	25,000	2,500
Groins	3,900	24,000	2,400
		Total Estimated Savings	$ 14,600

ESTIMATED SAVINGS IN BUILDING LOSSES

Assessed value of buildings subject to loss through erosion or storm damage	$ 70,000
Real value of buildings = 2 x $70,000	$140,000
Assuming a possible 50% salvage of buildings, anticipated loss $\frac{140,000}{2}$ =	$ 70,000
From past rate of erosion of 1 to 3 feet per year, building losses would occur within 20 years. Annual loss estimated as 1/20 x 70,000 =	$ 3,500
Therefore, estimated annual savings =	$ 3,500

(2) Increased Earning Power or Value of Shore Land. - Placement of fill will result in increase of land values. The estimated increase in assessed values of shore land is $144,300. The real value of this increase is 2 x $144,300 = $288,600. Benefit from this increase is computed as a gain of 3-1/2% per annum, which could be realized by direct sale of improved shore land.

Annual Benefits = .035 x $288,600 = $10,100

d. Summary of Benefits, Silver, Myrtle, Walnut, Laurel, and Cedar Beaches and Meadows End. - Evaluated benefits are tabulated below:

Benefit	Federal	Non-Federal Public	Private	Total
Direct damages prevented	0	$ 1,050	$18,100	$19,150
Increased earning power	0	4,330	10,100	14,430
Recreational	0	10,000	0	10,000
Total	0	$15,380	$28,380	$43,580

APPENDIX K

POLLUTION ALONG THE CONNECTICUT SHORE

1. Pollution Study. - A sanitary study of shore bathing waters was carried out by the State of Connecticut, Department of Health, during the summers of 1945, 1946 and 1948. The purpose of the study was to obtain specific information concerning the sanitary condition of bathing areas and to notify local authorities and interested persons about "danger spots" along the shore which are seriously affected by sewage pollution. The entire shore line of the State of Connecticut, including a number of small coves and the lower part of some tidal streams, was examined during this period.

2. Bacterial Survey. - A bacterial survey was made consisting of water samples taken at approximately 1000-foot intervals along the shore at over 1000 stations in water depths of from 2 to 6 feet, such depths covering most of the areas used for bathing. These samples were taken at four stages of the tide; namely, high, low, mean ebb and mean flood. Wind direction at the time of sampling was recorded. No attempt was made to take samples under different wind conditions as it was believed that the run of the tide was the principal factor influencing the travel of pollution along the shore. A laboratory analysis in each of three dilutions of 10 ml., 1.0 ml. and 0.1 ml. was made for each sample obtained. From this analysis the most probable number of coliform organisms per 100 ml. was computed. The final result for each sampling station was obtained by averaging the computed most probable numbers for the four samples at each station.

3. Sanitary Survey. - In addition to the bacterial survey described above, a sanitary survey of shore areas was conducted. This included the location of sewer outlets, with data as to flows and character of untreated

and treated sewage. Much of this data was already available from previous detailed studies. The nearness of polluting influences and possibilities of shifting direction of travel of pollution under different wind conditions were taken into account in this part of the study. In connection with studies of shellfish areas in many harbors, floats had been set out to measure the rapidity of water travel and these data were available in considering bathing waters in these localities.

4. Comparison of Bacterial and Sanitary Surveys. - The entire shore area was divided into sections varying in length from 1000 feet to one or more miles for the purpose of classification. The shore was classified as A, B, C or D, representing good, fair, doubtful to poor, and poor conditions, respectively. From the bacterial survey, Class A was considered to include samples containing from 0 to 50 coliform organisms per 100 ml.; Class B, 51 to 500; Class C, 501 to 1000; and Class D, over 1000. From the sanitary survey data the shore sections were also classified into the four groups described above. A tabulation of the results of these two classifications is given below.

	Bacterial Analysis Classification		Sanitary Survey Classification	
	Mileage	Percentage	Mileage	Percentage
Class A	90.7	35.9	65.1	25.8
Class B	103.6	41.1	75.9	30.1
Class C	15.1	6.0	65.7	26.0
Class D	42.9	17.0	45.6	18.1
	252.3	100.0	252.3	100.0

A comparison of the bacterial analysis and sanitary survey classifications shows that 61.1 percent of the shore was graded the same in both classifications; 34.3 percent of the shore falls into one grade lower according to the sanitary survey classification than according to the bacterial analysis classification; 3.6 percent of the shore falls into one

grade higher and 1.0 percent of the shore falls into two grades lower according to the sanitary survey classification. In general, then, it can be said that with minor exceptions the bacterial analysis classification grades the shore the same as or one class higher than the sanitary survey classification.

5. Spread of Disease at Bathing Places. - The Joint Committee on Bathing Places of the American Public Health Association and the Conference of State Sanitary Engineers published a comprehensive report in which is reviewed the possibilities of the spread of disease through the use of bathing places. This review was prepared after a comprehensive survey of reported cases of illness attributed to such waters. Although recognizing the possibilites of transmission of disease at bathing places, the Joint Committee concludes that there is little known evidence that this has occurred. They point out that careful surveillance and proper sanitary control should be exercised and recommend against bathing in grossly polluted waters.

6. Polluted Shore Areas in Connecticut. - In general, from the Connecticut study it was found that pollution existed principally in harbor waters and in waters in close proximity to harbors. This pollution is rapidly dissipated by dilution in Long Island Sound so that many miles of Connecticut shore line are in excellent condition. Considerable progress has been made in the improvement of conditions in harbors through sewage treatment plant installations. Due to a tendency toward extensive use of bathing beaches near urban centers, a few bathing places are located in areas close to the border line of safety. Although this condition is undesirable and indicates a need for improvement, no alarm is felt at present in view of the absence of reported cases of illness acquired at these localities. Many individual cases of local pollution have been disclosed by the

survey. These sources though small in magnitude are considered more dangerous due to their proximity to bathing areas than larger sources of pollution at a greater distance. The two principal rivers entering Long Island Sound, the Connecticut and the Housatonic, receive a large amount of pollution. Due to self-purification and later dilution in Long Island Sound, these rivers cause very little pollution load on the Sound. Within a distance of 1000 feet on either side of the Housatonic River no pollution effect was noted. The bacteria counts of samples along the mouth of the Connecticut River were all relatively low. The following areas in Connecticut were classified as being in poor condition:

a. Vicinity of sewer outlets at New London and Groton

b. Localized areas at Bridgeport, Norwalk and New Haven

c. Byram River between Portchester, N. Y., and Greenwich

d. The upper part of Cos Cob Harbor in Greenwich

e. The Saugatuck River section of Westport

f. The Mill River section of Fairfield

g. The mouth of the Branford River

h. The vicinity of Grove Beach in Westbrook

i. Stonington Harbor

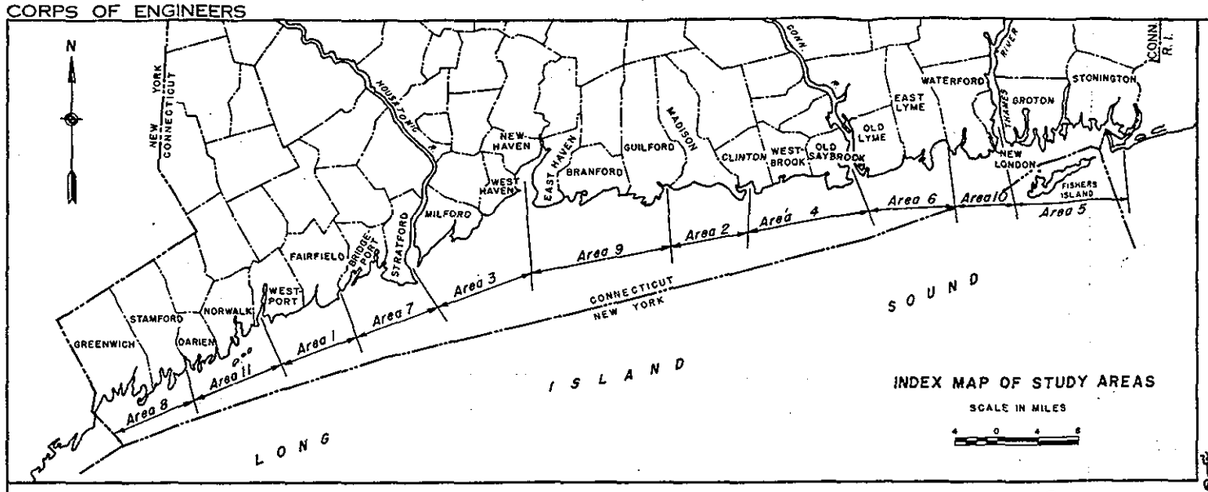
j. The easterly section of Stonington, particularly the vicinity of the mouth of the Pawcatuck River

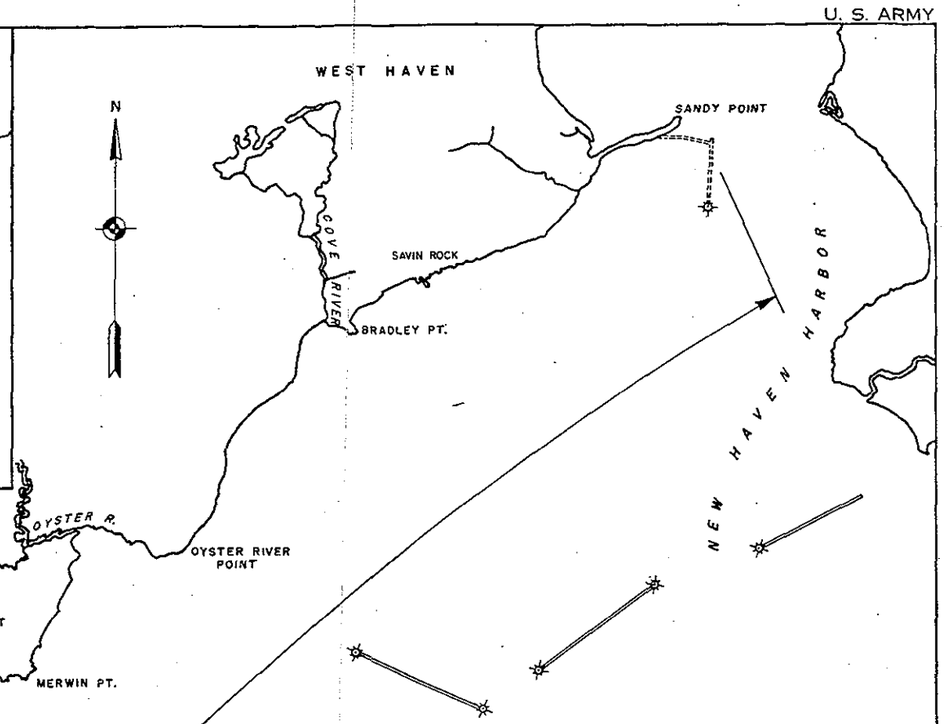
k. Many sewer outlets in Mystic

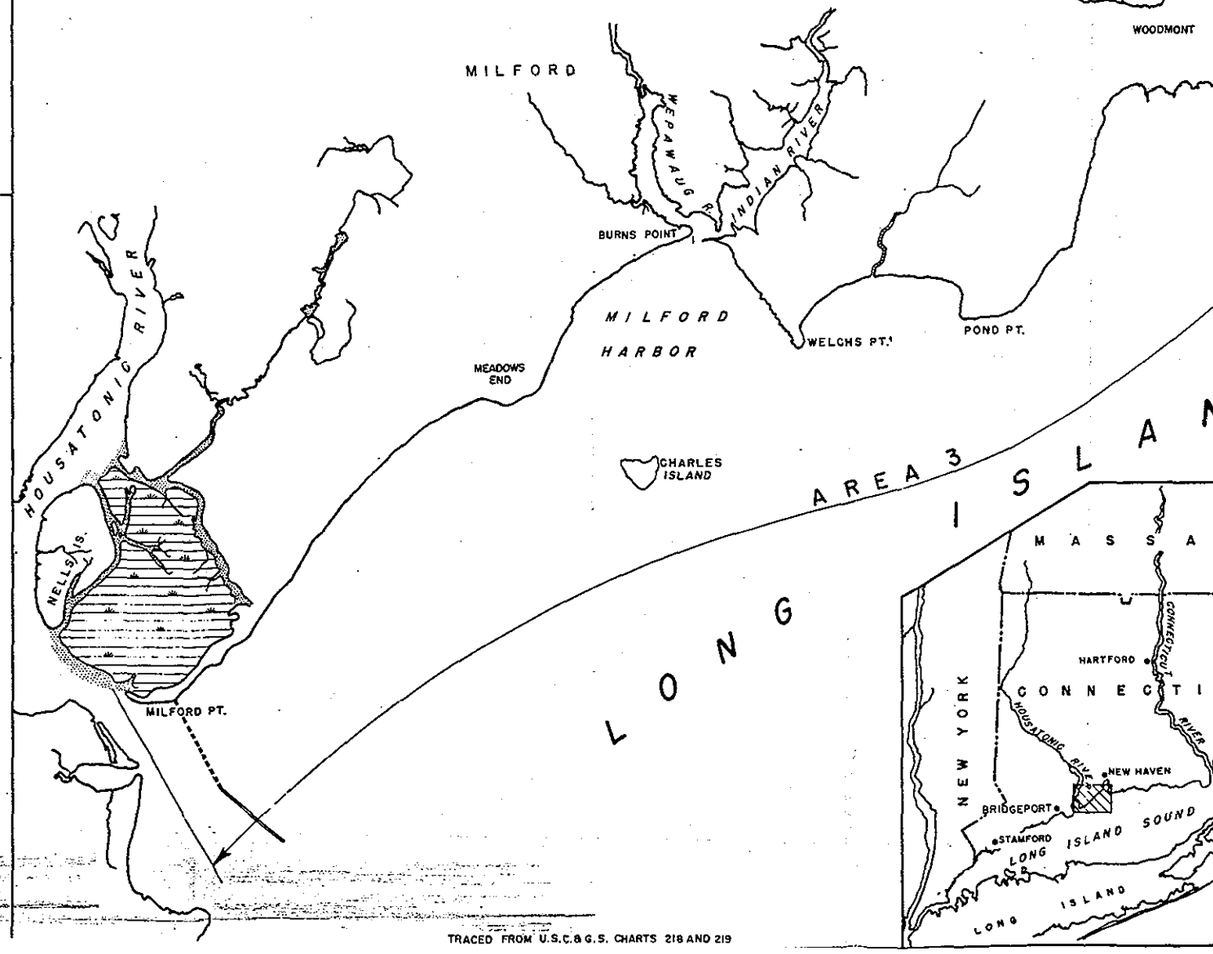
The pollution in the above areas is very local with little pollution effect noticeable at relatively short distances away, with the exception of the Pawcatuck River area where the pollution carries for a considerable distance.

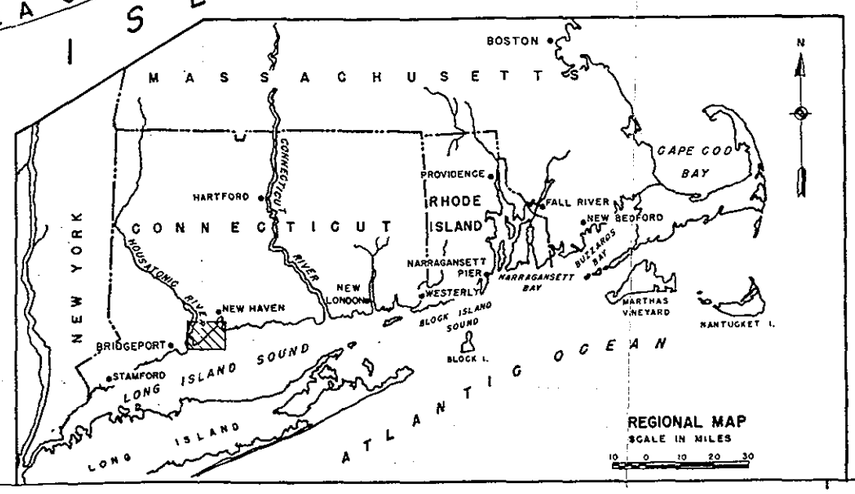
CORPS OF ENGINEERS

U. S. ARMY









TRACED FROM U.S.C.&G.S. CHARTS 218 AND 219

CONNECTICUT BEACH EROSION CONTROL STUDY

LOCATION MAP AREA 3

NEW HAVEN HARBOR TO HOUSATONIC RIVER

IN 1 SHEET

SCALE IN FEET 2000 0 2000 4000

NEW ENGLAND DIVISION, BOSTON, MASS. MARCH 15, 1951

APPROVED: CHIEF, ENGINEERING DIVISION

APPROVED: COL., C.E. DIVISION ENGINEER

SUBMITTED: CHIEF, PLANNING AND REPORTS BRANCH

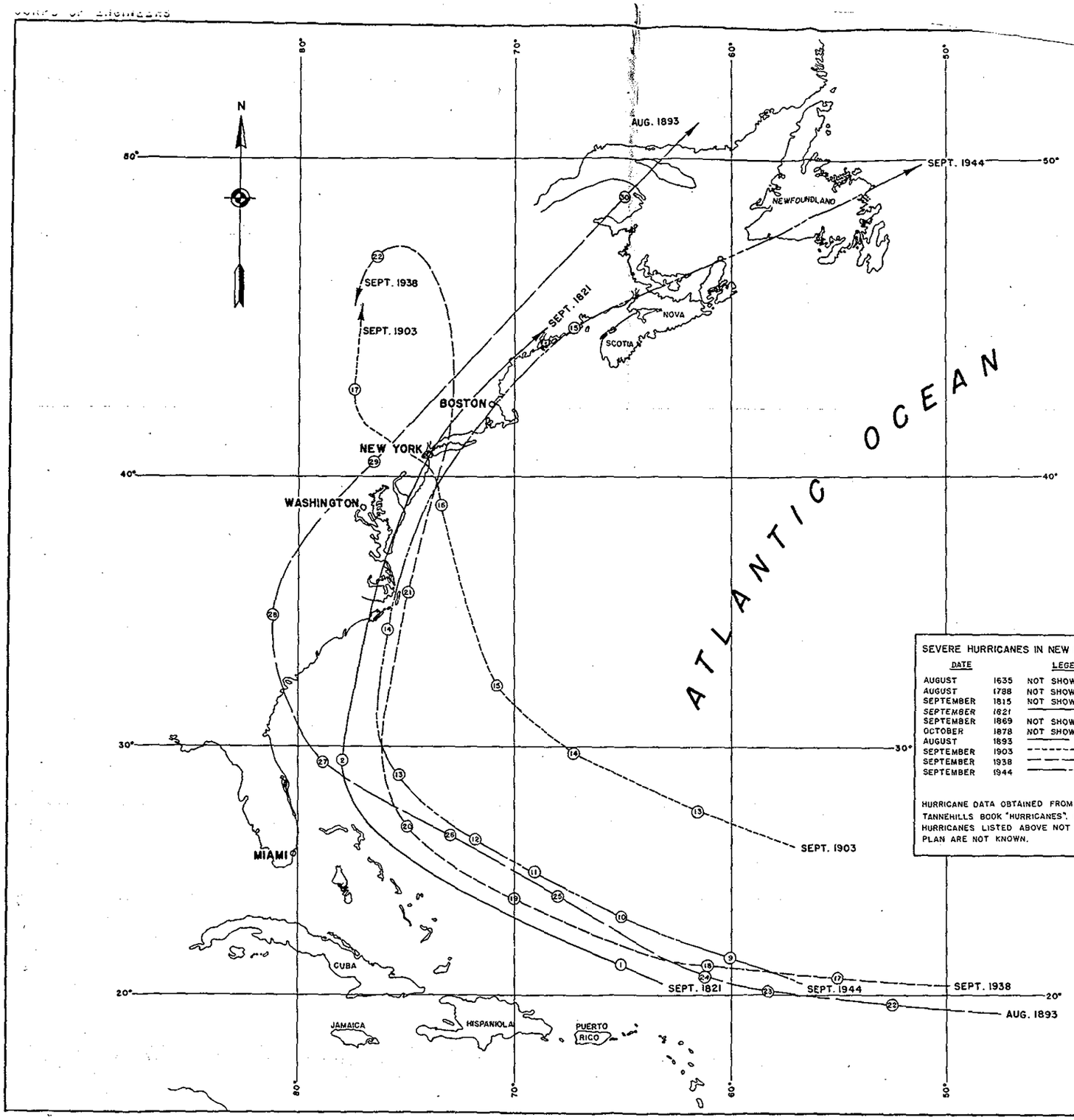
DR. BY C.F.R. TR. BY L.W.B. CH. BY

CHIEF, R.B.E. SECTION

TRANSMITTED WITH REPORT DATED MAY 4, 1951

FILE NO. B.E. Cl. 24

PLATE 1



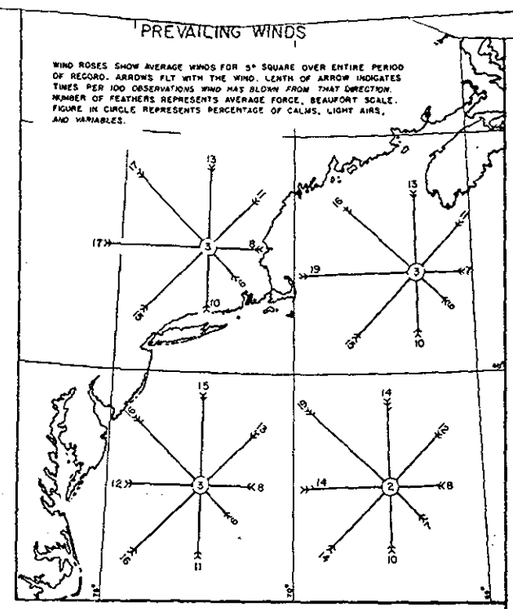
SEVERE HURRICANES IN NEW ENGLAND

DATE		LEGEND
AUGUST	1635	NOT SHOWN
AUGUST	1788	NOT SHOWN
SEPTEMBER	1815	NOT SHOWN
SEPTEMBER	1821	
SEPTEMBER	1869	NOT SHOWN
OCTOBER	1878	NOT SHOWN
AUGUST	1893	
SEPTEMBER	1903	
SEPTEMBER	1938	
SEPTEMBER	1944	

HURRICANE DATA OBTAINED FROM IVAN RAY TANNEHILLS BOOK "HURRICANES". PATHS OF HURRICANES LISTED ABOVE NOT SHOWN ON PLAN ARE NOT KNOWN.

PREVAILING WINDS

WIND ROSES SHOW AVERAGE WINDS FOR 5° SQUARE OVER ENTIRE PERIOD OF RECORD. ARROWS FLY WITH THE WIND. LENGTH OF ARROW INDICATES TIMES PER 100 OBSERVATIONS WIND HAS BLOWN FROM THAT DIRECTION. NUMBER OF FEATHERS REPRESENTS AVERAGE FORCE, BEAUFORT SCALE. FIGURE IN CIRCLE REPRESENTS PERCENTAGE OF CALMS, LIGHT AIRS, AND VARIABLES.



NOTE

Figures in circles shown thus (13) represent location of the center of hurricane on the day of month of its occurrance.

CONNECTICUT BEACH EROSION CONTROL STUDY

HURRICANES AND PREVAILING WINDS

NEW ENGLAND DIVISION, BOSTON, MASS. JAN. 20, 1949.

APPROVAL RECOMMENDED — Chief, Operations Division

APPROVED — Lt Col, C.E., Asst Division Engineer

SUBMITTED — Chief, Projects and Reports Branch

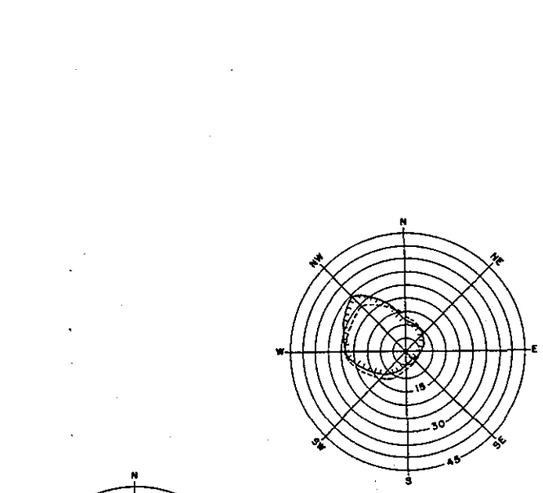
DR BY H.S.P.
TR BY P.D.
CH BY WJC

FILE NO. 8.E.CI.2

PLATE 2

CORPS OF ENGINEERS

U.S. ARMY



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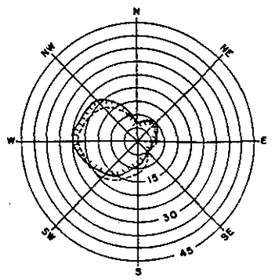

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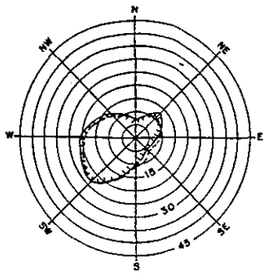

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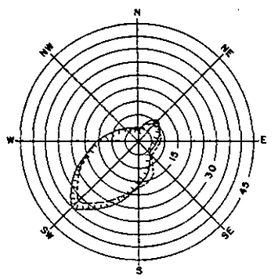

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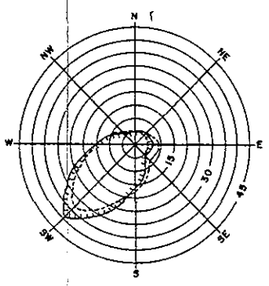

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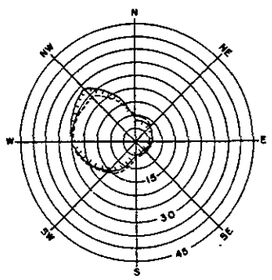

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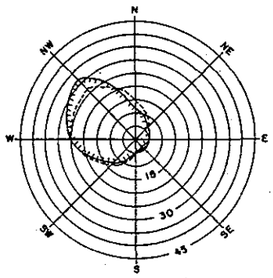

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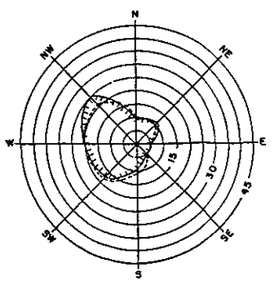

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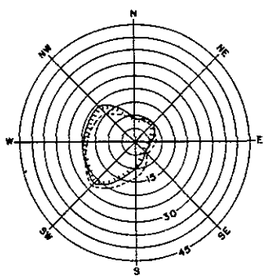
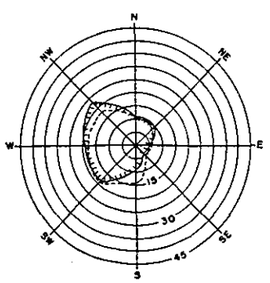
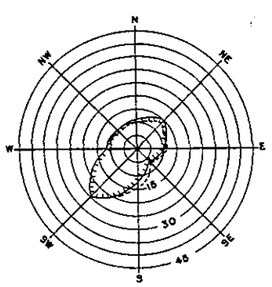


ANNUAL



OCTOBER



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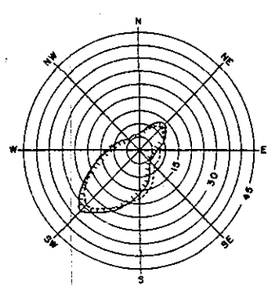
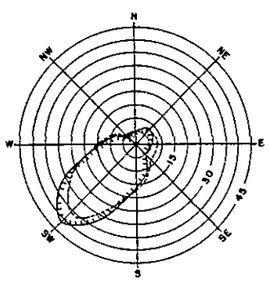


AUGUST



JULY

LEGEND

PERCENTAGE OF TOTAL WIND MOVEMENT

PERCENTAGE OF TOTAL WIND DURATION

NOTES

EACH CONCENTRIC CIRCLE STARTING AT THE CENTER REPRESENTS FIVE PERCENT OF THE TOTAL WIND MOVEMENT OR TOTAL WIND DURATION.

THE WIND DIAGRAMS REPRESENT PERCENTAGE OF TOTAL WIND MOVEMENT OR WIND DURATION AVERAGED FOR A PERIOD FROM 1921 TO 1939.

THE ANNUAL DIAGRAM REPRESENTS AVERAGES COMPUTED FOR THE ENTIRE PERIOD. THE MONTHLY DIAGRAMS REPRESENT AVERAGES COMPUTED FOR EACH MONTH OF THE YEAR FOR THE ENTIRE PERIOD.

BASIC DATA COMPILED FROM OBSERVATIONS OF THE U.S. WEATHER BUREAU AT BLOCK ISLAND, RHODE ISLAND.

CONNECTICUT BEACH EROSION CONTROL STUDY

WIND DATA

BLOCK ISLAND, RHODE ISLAND

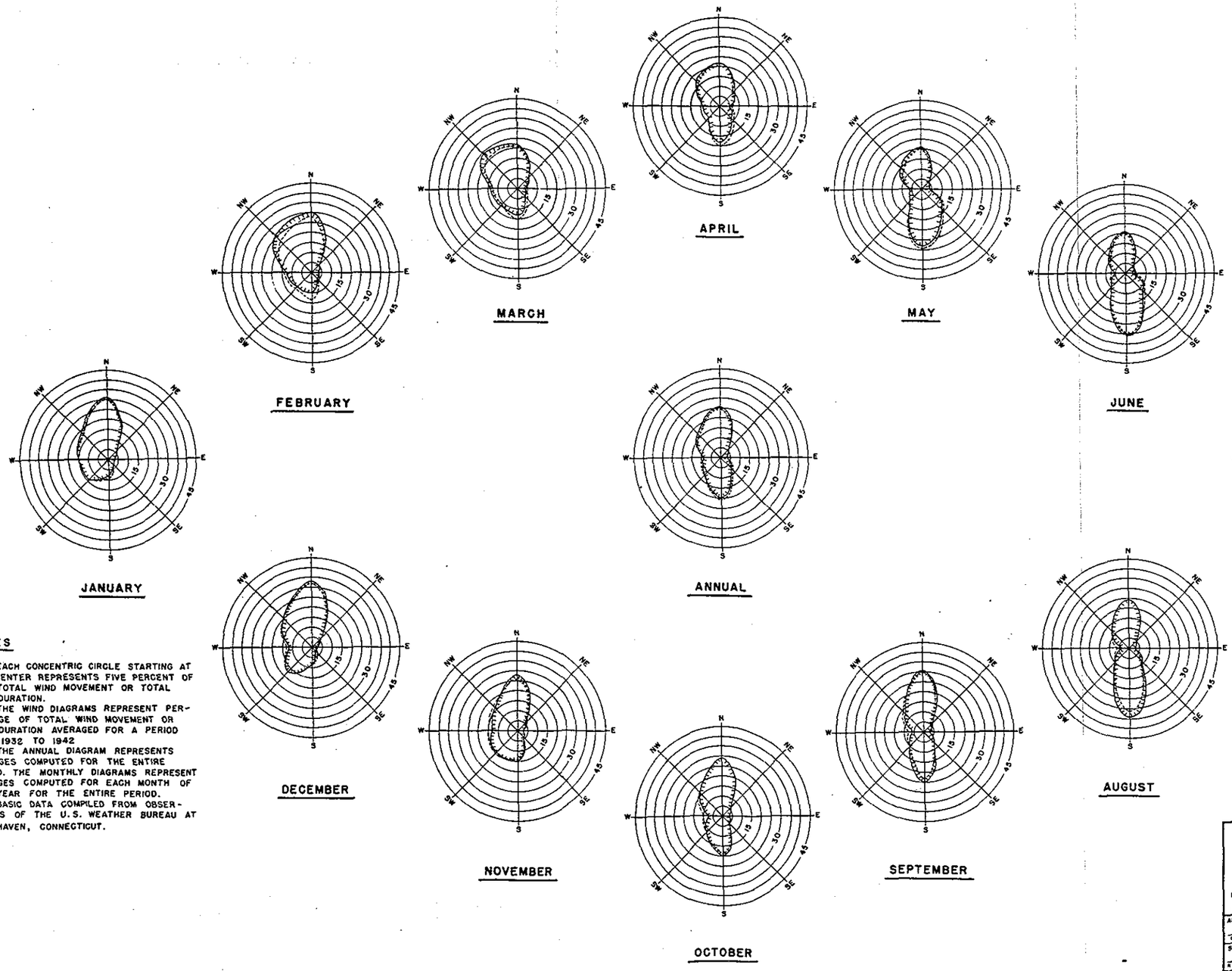
1921 - 1939

IN 1 SHEET

NEW ENGLAND DIVISION BOSTON, MASS. JAN 20, 1949

APPROVAL RECOMMENDED	APPROVED
CHIEF, R & H OPERATIONS DIVISION	LT COL, CE, ASST DIVISION ENGINEER
SUBMITTED R & H PROJECTS AND REPORTS BRANCH	
DR BY H.S.F TR BY A.S CH. BY JWG	FILE NO. B.E.CI.3

PLATE 3



NOTES

EACH CONCENTRIC CIRCLE STARTING AT THE CENTER REPRESENTS FIVE PERCENT OF THE TOTAL WIND MOVEMENT OR TOTAL WIND DURATION.

THE WIND DIAGRAMS REPRESENT PERCENTAGE OF TOTAL WIND MOVEMENT OR WIND DURATION AVERAGED FOR A PERIOD FROM 1932 TO 1942

THE ANNUAL DIAGRAM REPRESENTS AVERAGES COMPUTED FOR THE ENTIRE PERIOD. THE MONTHLY DIAGRAMS REPRESENT AVERAGES COMPUTED FOR EACH MONTH OF THE YEAR FOR THE ENTIRE PERIOD.

BASIC DATA COMPILED FROM OBSERVATIONS OF THE U.S. WEATHER BUREAU AT NEW HAVEN, CONNECTICUT.

LEGEND

PERCENTAGE OF TOTAL WIND MOVEMENT

PERCENTAGE OF TOTAL WIND DURATION

CONNECTICUT BEACH EROSION CONTROL STUDY

WIND DATA

NEW HAVEN, CONNECTICUT

1932 - 1942

IN 1 SHEET

NEW ENGLAND DIVISION BOSTON, MASS. JAN. 20, 1949

APPROVAL RECOMMENDED
CHIEF, R & H OPERATIONS DIVISION

APPROVED
LT COL, C.E., ASST DIVISION ENGINEER

SUBMITTED
R & H PROJECTS AND REPORTS BRANCH

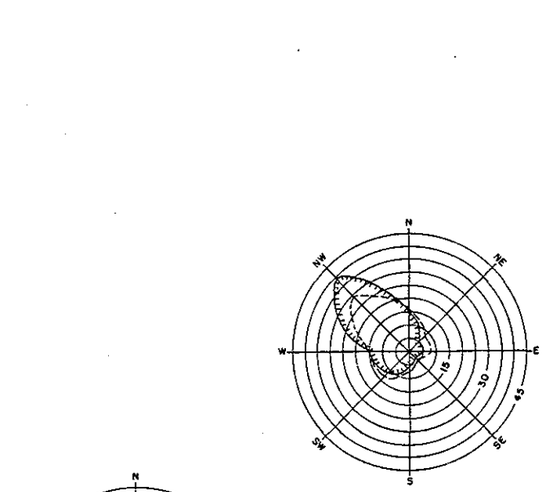
OR 97 N.S.P.
CR 97 N.S.
CH. 97 N.D.

FILE NO. B.E.CT.4

PLATE 4

CORPS OF ENGINEERS

U.S. ARMY



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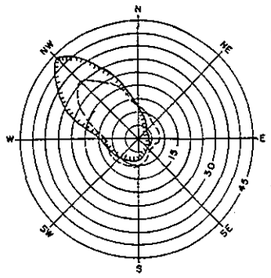
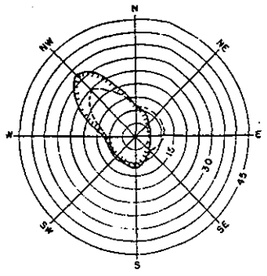


MARCH



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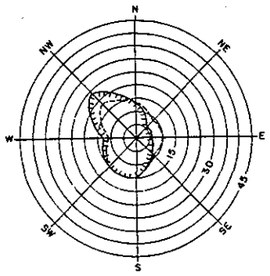

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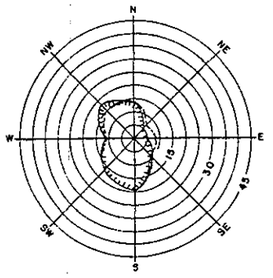

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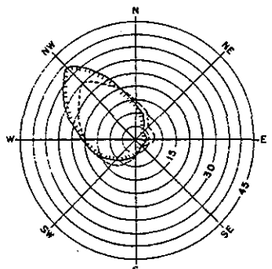

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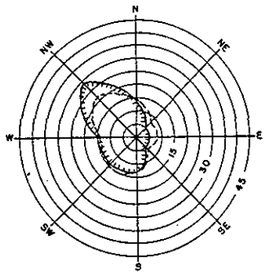
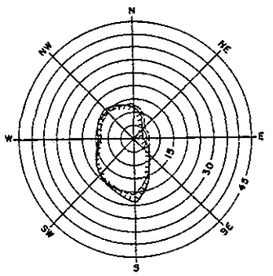


ANNUAL



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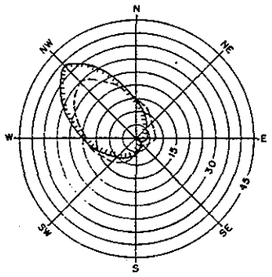
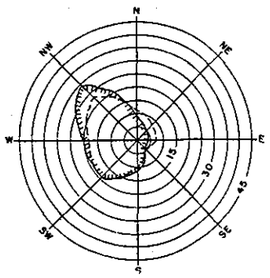


DECEMBER



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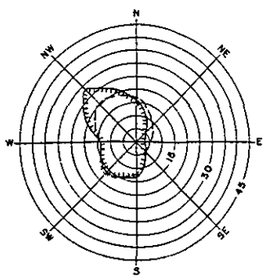
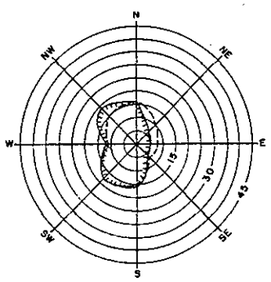
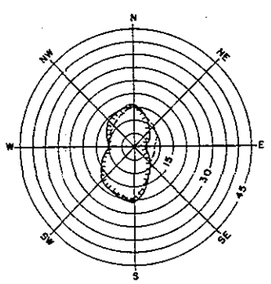


OCTOBER



SEPTEMBER



AUGUST

NOTES

EACH CONCENTRIC CIRCLE STARTING AT THE CENTER REPRESENTS FIVE PERCENT OF THE TOTAL WIND MOVEMENT OR TOTAL WIND DURATION.

THE WIND DIAGRAMS REPRESENT PERCENTAGE OF TOTAL WIND MOVEMENT OR WIND DURATION AVERAGED FOR A PERIOD FROM 1921 TO 1942

THE ANNUAL DIAGRAM REPRESENTS AVERAGES COMPUTED FOR THE ENTIRE PERIOD. THE MONTHLY DIAGRAMS REPRESENT AVERAGES COMPUTED FOR EACH MONTH OF THE YEAR FOR THE ENTIRE PERIOD.

BASIC DATA COMPILED FROM OBSERVATIONS OF THE U.S. WEATHER BUREAU AT NEW YORK CITY, NEW YORK.

LEGEND

PERCENTAGE OF TOTAL WIND MOVEMENT

PERCENTAGE OF TOTAL WIND DURATION

CONNECTICUT BEACH EROSION CONTROL STUDY

WIND DATA

NEW YORK CITY, NEW YORK

1921 - 1942

IN 1 SHEET

NEW ENGLAND DIVISION BOSTON, MASS. JAN. 20, 1949

APPROVAL RECOMMENDED
CHIEF, R & H OPERATIONS DIVISION

APPROVED
LT. COL., C.E., ASST. DIVISION ENGINEER

SUBMITTED
R & H PROJECTS AND REPORTS BRANCH

DR. BY
CH. BY

FILE NO. B.E.C.t.5

PLATE 5

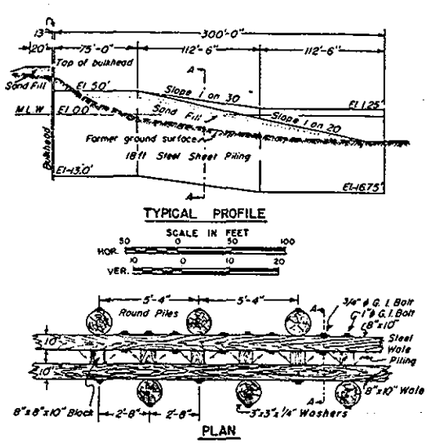


FIGURE 1

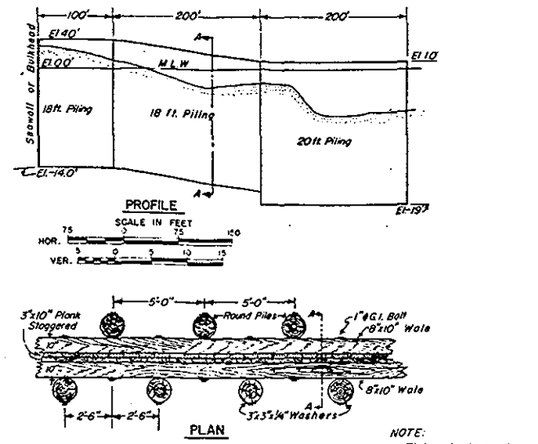


FIGURE 2

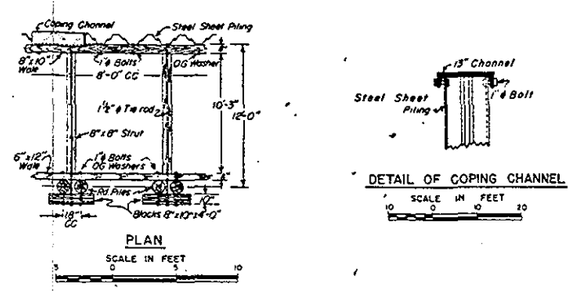


FIGURE 3

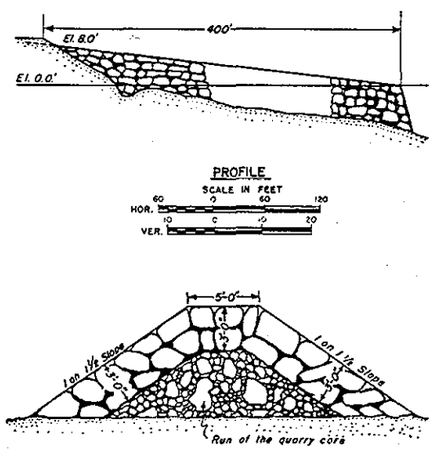


FIGURE 4

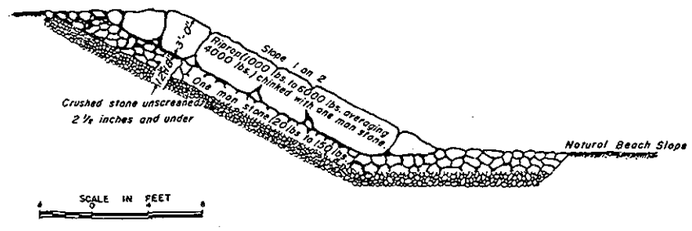


FIGURE 5

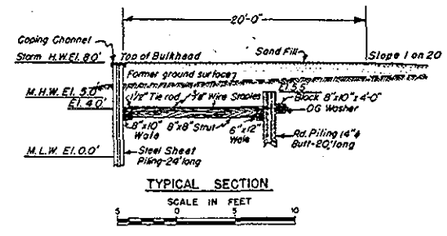


FIGURE 3

NOTE

Typical construction details reproduced from "Engineering Manual for Civil Works, Beach Erosion Studies," Part CXXXIII dated April 1947.

CONNECTICUT BEACH EROSION CONTROL STUDY

SHORE STRUCTURES

TYPICAL CONSTRUCTION DETAILS

IN 1 SHEET SCALE AS SHOWN

NEW ENGLAND DIVISION BOSTON, MASS. JAN. 20, 1949

APPROVAL RECOMMENDED: Chief, A.&M. Operations Division

APPROVED: Lt. Col., C.E., Asst. Division Engineer

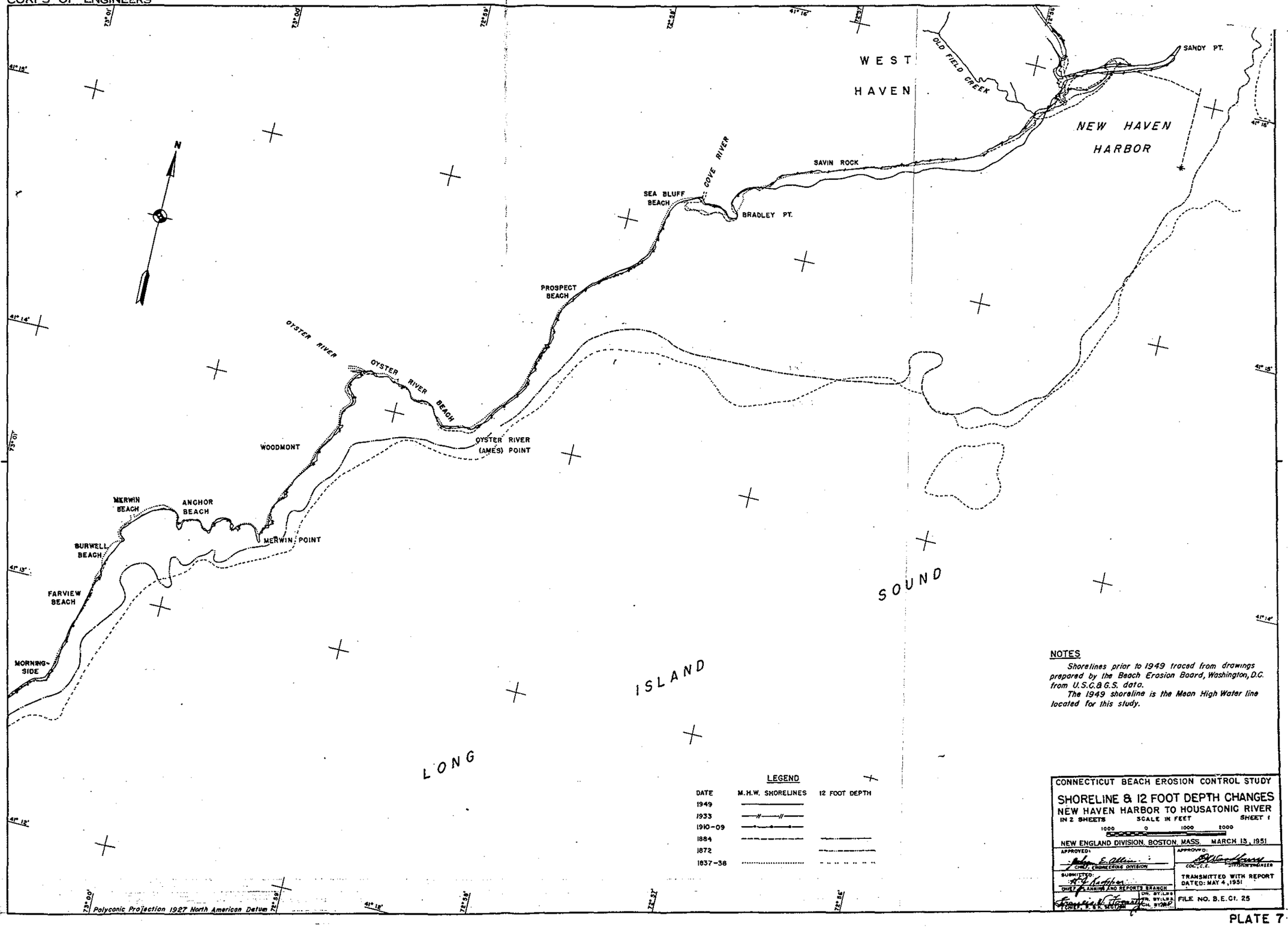
SUBMITTED: B.B.H. Projects and Reports Branch

DR. BY M.S.F. TR. BY M.B. CH. BY W.H.

FILE NO B.E.Cl. 6

PLATE 6

CORPS OF ENGINEERS



LEGEND

DATE	M.H.W. SHORELINES	12 FOOT DEPTH
1949	———	
1933	—//—//—	
1910-09	—•—•—•—	
1884	— — — — —	———
1872		- - - - -
1837-38	.....	- - - - -

NOTES

Shorelines prior to 1949 traced from drawings prepared by the Beach Erosion Board, Washington, D.C. from U.S.C.&G.S. data.

The 1949 shoreline is the Mean High Water line located for this study.

CONNECTICUT BEACH EROSION CONTROL STUDY

SHORELINE & 12 FOOT DEPTH CHANGES NEW HAVEN HARBOR TO HOUSATONIC RIVER

IN 2 SHEETS — SCALE IN FEET — SHEET 1

1000 0 1000 2000

NEW ENGLAND DIVISION, BOSTON, MASS. MARCH 15, 1951

APPROVED: John E. Allen, CHIEF, ENGINEERING DIVISION

APPROVED: [signature], COL., C.E., DIVISION ENGINEER

SUBMITTED: A.F. Matthes, CHIEF, PLANNING AND REPORTS BRANCH

TRANSMITTED WITH REPORT DATED: MAY 4, 1951

DR. BY: L.M.S. CH. BY: L.P.S. CHIEF, P. & R.N. SECTION [signature] CHIEF, ENGR. DIV.

FILE NO. B.E.Ct. 25

PLATE 7

CORPS OF ENGINEERS

U. S. ARMY

MILFORD

WEPAWAUG RIVER

INDIAN RIVER

GULF BEACH

FORT TRUMBULL BEACH

SILVER GREEK

SILVER BEACH

MILFORD HARBOR

GALF PEN MEADOW GREEK

BAY VIEW BEACH

POND PT. BEACH

WELCHS POINT

POND POINT

POINT BEACH

MYRTLE BEACH

WALNUT BEACH

LAUREL BEACH

CEDAR BEACH

MILFORD PT.

HOUSATONIC RIVER

CHARLES ID.

LONG ISLAND SOUND

N

73° 01'

73° 00'

41° 13'

41° 12'

41° 11'

41° 10'

41° 09'

73° 09'

73° 08'

73° 07'

73° 06'

73° 05'

73° 04'

73° 03'

73° 02'

Polyconic Projection 1927 North American Datum

LEGEND

DATE	M.H.W. SHORELINES	12 FOOT DEPTH
1949	———	
1933	—//—//—	
1910-09	—•—•—•—	
1884	– – – – –	———
1837-38	.....	. . . . .

NOTES

Shorelines prior to 1949 traced from drawings prepared by the Beach Erosion Board, Washington, D.C. from U.S.C.&G.S. data.

The 1949 shoreline is the Mean High Water line located for this study.

CONNECTICUT BEACH EROSION CONTROL STUDY

SHORELINE & 12 FOOT DEPTH CHANGES NEW HAVEN HARBOR TO HOUSATONIC RIVER

IN 2 SHEETS SCALE IN FEET SHEET 2

1000 0 1000 2000

NEW ENGLAND DIVISION, BOSTON, MASS. MARCH 15, 1951

APPROVED: John E. Allen, CHIEF, ENGINEERING DIVISION

APPROVED: [signature], COL., C.E. DIVISION ENGINEER

SUBMITTED: [signature], CHIEF, PLANNING AND REPORTS BRANCH

TRANSMITTED WITH REPORT DATED: MAY 4, 1951

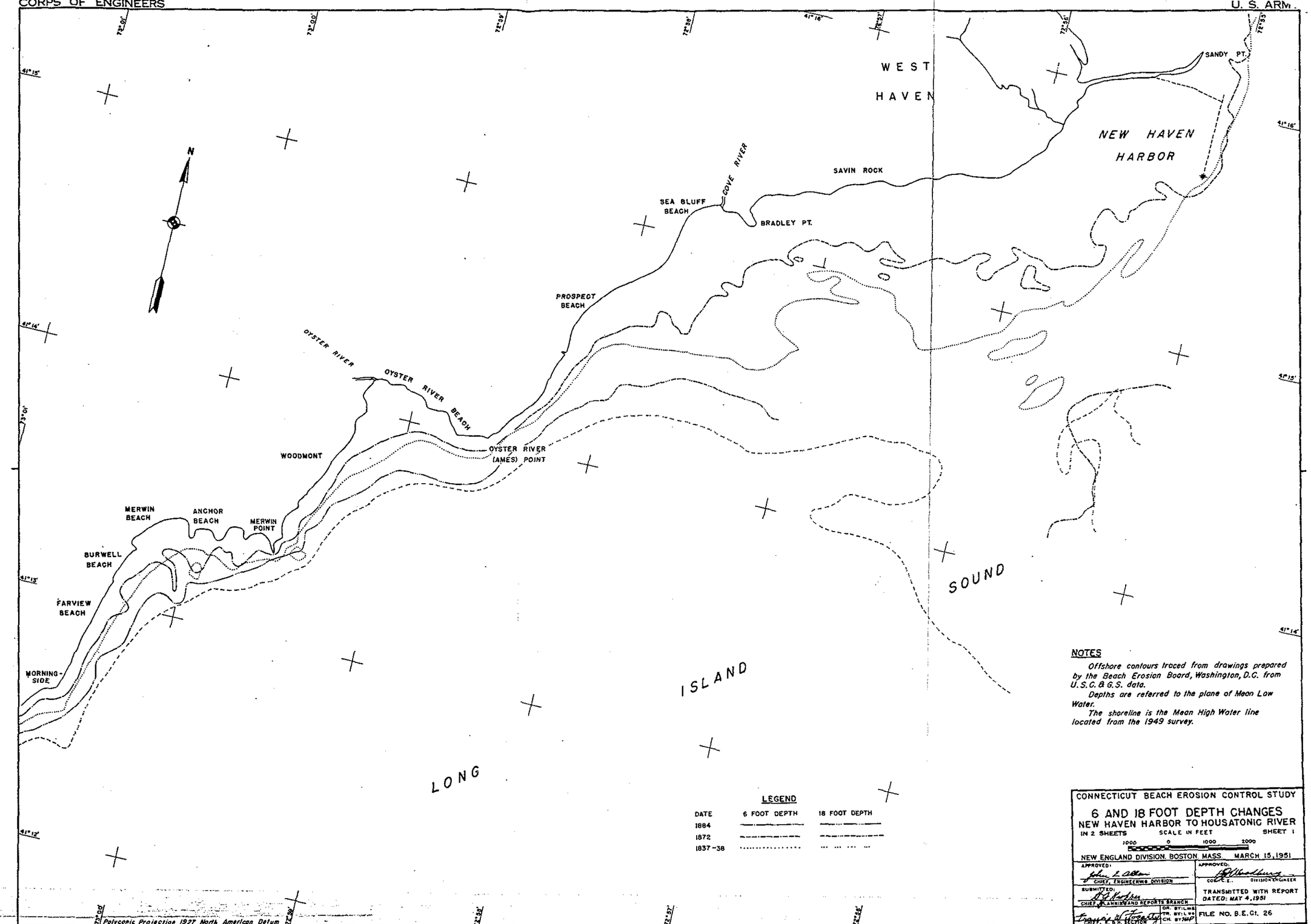
DR. BY: L.W.S. TR. BY: L.S.S. CH. BY: [illegible]

[signature], CHIEF, R. & H. SECTION

FILE NO. B.E. Ct. 25

PLATE 8

CORPS OF ENGINEERS U. S. ARMY



Polyconic Projection 1927 North American Datum

LEGEND

DATE	6 FOOT DEPTH	18 FOOT DEPTH
1884	———	———
1872	— · — · —	— · — · —
1837-38	·····	··· ··· ···

NOTES

Offshore contours traced from drawings prepared by the Beach Erosion Board, Washington, D.C. from U.S.C.&G.S. data.

Depths are referred to the plane of Mean Low Water.

The shoreline is the Mean High Water line located from the 1949 survey.

CONNECTICUT BEACH EROSION CONTROL STUDY

6 AND 18 FOOT DEPTH CHANGES
NEW HAVEN HARBOR TO HOUSATONIC RIVER

IN 2 SHEETS SCALE IN FEET SHEET 1

1000 0 1000 2000

NEW ENGLAND DIVISION, BOSTON, MASS. MARCH 15, 1951

APPROVED: John S. Allen, CHIEF, ENGINEERING DIVISION

APPROVED: [illegible], COL., C.E., DIVISION ENGINEER

SUBMITTED: [illegible], CHIEF, PLANNING AND REPORTS BRANCH

TRANSMITTED WITH REPORT DATED: MAY 4, 1951

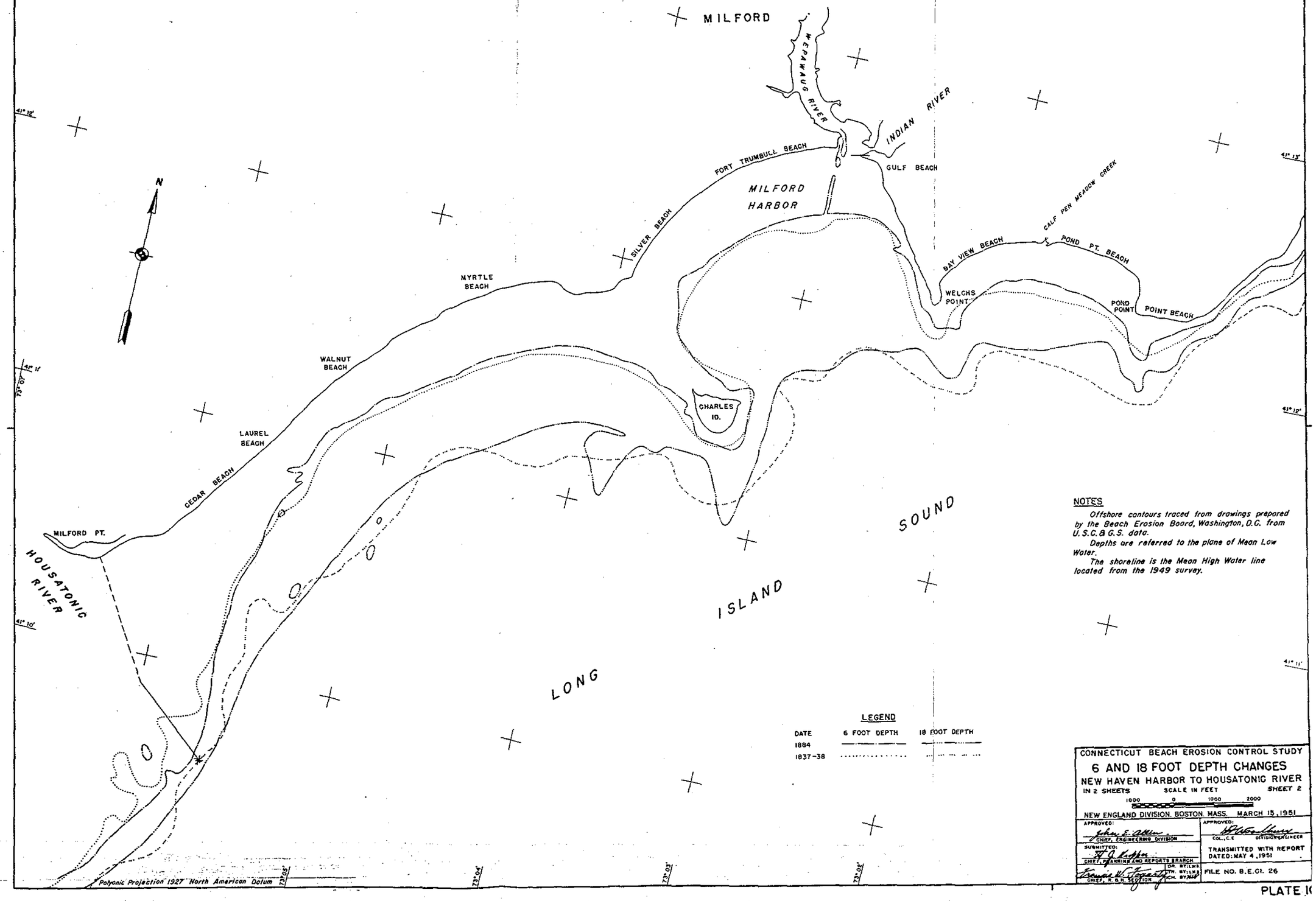
DR. BY: LMS CH. BY: JHP

[illegible], CHIEF, C.E.D. SECTION

FILE NO. B.E.Ct. 26

PLATE 9

CORPS OF ENGINEERS U. S. ARMY



NOTES

Offshore contours traced from drawings prepared by the Beach Erosion Board, Washington, D.C. from U.S.C.&G.S. data.

Depths are referred to the plane of Mean Low Water.

The shoreline is the Mean High Water line located from the 1949 survey.

LEGEND

DATE	6 FOOT DEPTH	18 FOOT DEPTH
1884	———	———
1837-38	.....	.....

CONNECTICUT BEACH EROSION CONTROL STUDY

6 AND 18 FOOT DEPTH CHANGES

NEW HAVEN HARBOR TO HOUSATONIC RIVER

IN 2 SHEETS SCALE IN FEET SHEET 2

1000 0 1000 2000

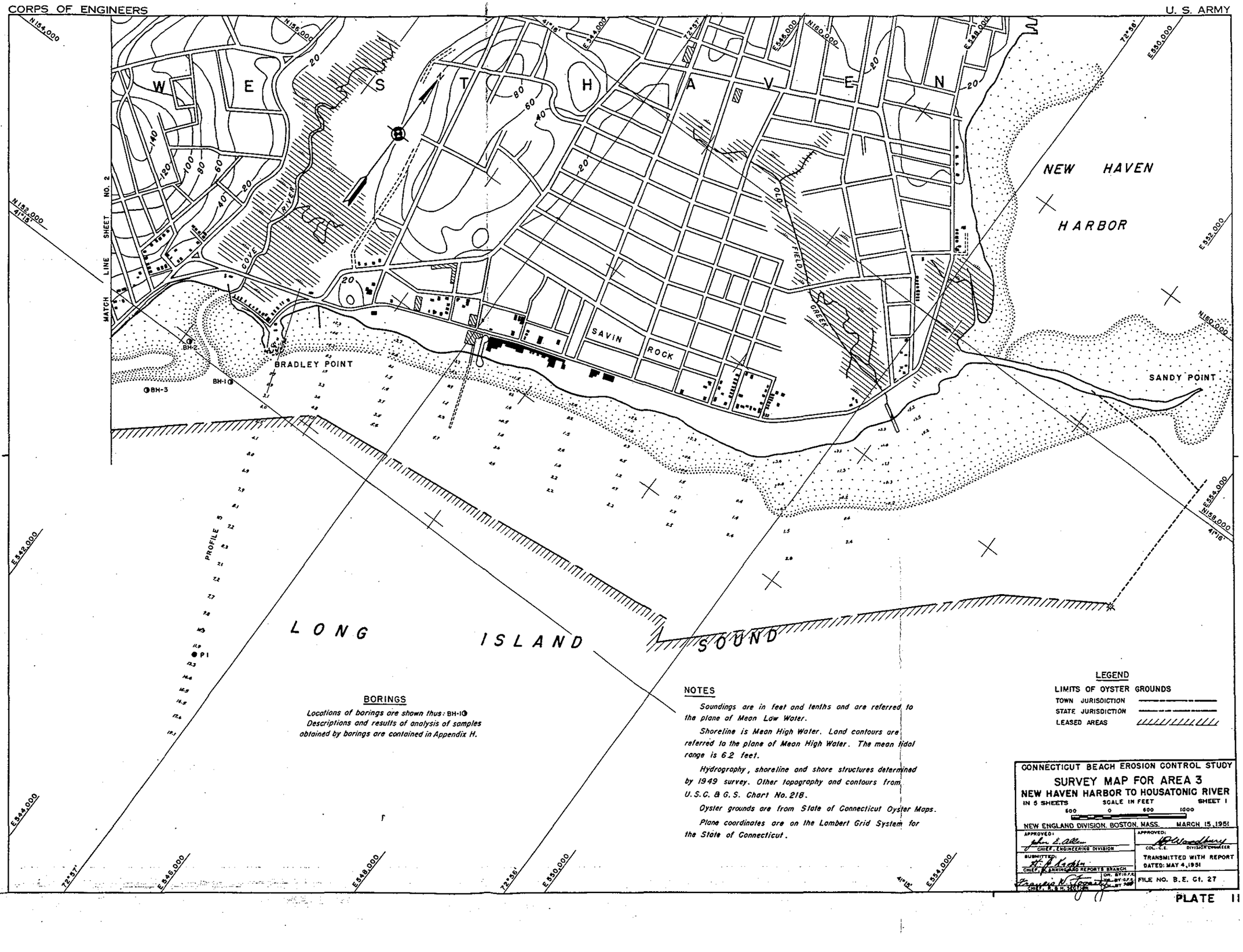
NEW ENGLAND DIVISION, BOSTON, MASS. MARCH 15, 1951

APPROVED: John E. Allen, CHIEF, ENGINEERING DIVISION	APPROVED: [illegible], COL., C.E. DIVISION ENGINEER
SUBMITTED: [illegible], CHIEF, PLANNING AND REPORTS BRANCH	TRANSMITTED WITH REPORT DATED: MAY 4, 1951
DR. BY: L.H.S. TH. BY: L.H.S. CH. BY: [illegible] [illegible], CHIEF, R.B.H. SECTION	FILE NO. B.E.C. 26

PLATE 1

CORPS OF ENGINEERS

U. S. ARMY



BORINGS

Locations of borings are shown thus: BH-1

Descriptions and results of analysis of samples obtained by borings are contained in Appendix H.

NOTES

Soundings are in feet and tenths and are referred to the plane of Mean Low Water.

Shoreline is Mean High Water. Land contours are referred to the plane of Mean High Water. The mean tidal range is 6.2 feet.

Hydrography, shoreline and shore structures determined by 1949 survey. Other topography and contours from U.S.C. & G.S. Chart No. 218.

Oyster grounds are from State of Connecticut Oyster Maps.

Plane coordinates are on the Lambert Grid System for the State of Connecticut.

LEGEND

LIMITS OF OYSTER GROUNDS

TOWN JURISDICTION

STATE JURISDICTION

LEASED AREAS

CONNECTICUT BEACH EROSION CONTROL STUDY

SURVEY MAP FOR AREA 3

NEW HAVEN HARBOR TO HOUSATONIC RIVER

IN 5 SHEETS SCALE IN FEET SHEET 1

600 0 600 1000

NEW ENGLAND DIVISION, BOSTON, MASS. MARCH 15, 1951

APPROVED: CHIEF, ENGINEERING DIVISION

APPROVED: COL., C.E. DIVISION ENGINEER

SUBMITTED: CHIEF, PLANNING AND REPORTS BRANCH

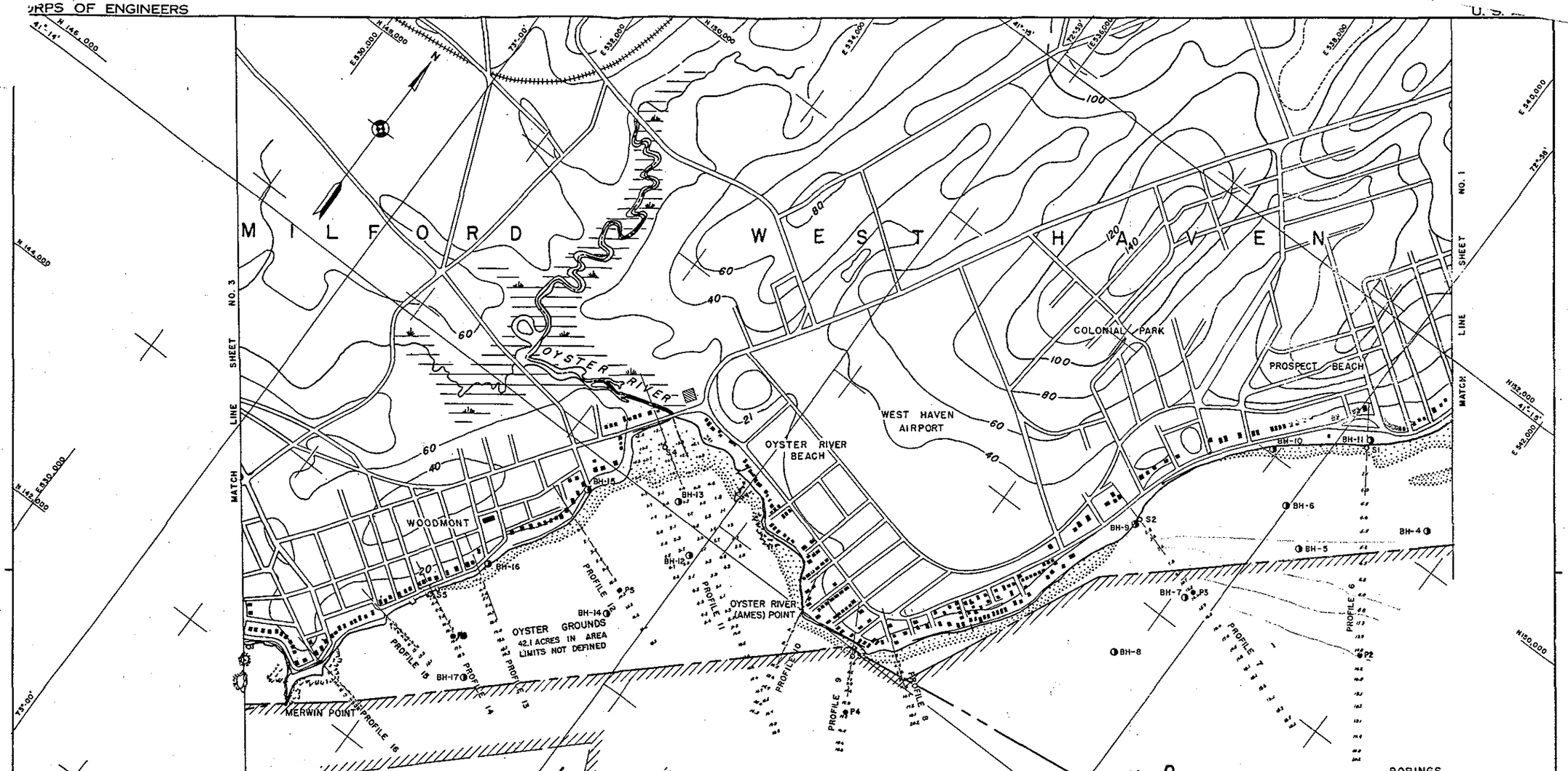
TRANSMITTED WITH REPORT DATED: MAY 4, 1951

DR. BY I.P.K. TR. BY G.F.S. CH. BY [illegible]

CHIEF, R. & H. SECTION

FILE NO. B.E. Ct. 27

PLATE 11



LIST OF PROBINGS

NUMBER	DEPTH OR ELEVATION	TOTAL DEPTH	MATERIAL AS INDICATED BY PROBING
P 1	13.6	20.0	6.4 Sand. (For location see Sheet No. 1)
P 2	14.3	20.6	6.3 Sand.
P 3	13.9	20.4	6.5 Sand.
P 4	13.9	19.6	5.7 Sand.
P 5	13.5	19.4	5.9 Sand to Gravel.
P 6	13.2	19.6	6.4 Sand.

NOTE:
Probings are in feet and tenths, and are referred to the plane of Mean Low Water. Probings are shown thus: ● P5

Probings were made by hand during February and March 1949.

Depths below the plane of Mean Low Water are shown thus: 13.5. Elevations above the plane of Mean Low Water are shown thus: +3.6

BEACH SAMPLE ANALYSIS

SAMPLE NUMBER	GRAIN SIZE IN MILLIMETER		CHARACTER OF MATERIAL IN PERCENT			
	RANGE	MEDIAN DIAMETER	FINE SAND	MED. SAND	COARSE SAND	GRAVEL
S 1	0.10-38.0	6.70	1	9	26	64
S 2	0.15-100.0	54.00	1	6	10	83
S 3	0.074-39.0	9.70	3	16	15	66
S 4	0.20-26.6	4.30	0	4	22	74
S 5	0.30-26.5	6.70	0	7	26	67

Note: All samples taken at Mid Tide Elevation and are shown thus ○S5

BORINGS

Locations of borings are shown thus: BH-4 ◑
Descriptions and results of analysis of samples obtained by borings are contained in Appendix H.

LEGEND

LIMITS OF OYSTER GROUNDS
TOWN JURISDICTION
STATE JURISDICTION
LEASED AREAS

NOTES

Soundings are in feet and tenths and are referred to the plane of Mean Low Water.

Shoreline is Mean High Water. Land contours are referred to the plane of Mean High Water. The mean tidal range is 6.4 feet.

Hydrography, shoreline and shore structures determined by 1949 survey. Other topography and contours from U.S.C. & G.S. Chart No. 218.

Oyster grounds are from State of Connecticut Oyster Maps.

Plane coordinates are on the Lambert Grid System for the State of Connecticut.

CONNECTICUT BEACH EROSION CONTROL STUDY

SURVEY MAP FOR AREA 3
NEW HAVEN HARBOR TO HOUSATONIC RIVER

IN 5 SHEETS SCALE IN FEET SHEET 2

500 0 500 1000

NEW ENGLAND DIVISION, BOSTON, MASS. MARCH 15, 1951

APPROVED: John E. Allen, CHIEF, ENGINEERING DIVISION

APPROVED: [signature], COL., C.E., DIVISION ENGINEER

SUBMITTED: [signature], CHIEF, PLANNING AND REPORTS BRANCH

TRANSMITTED WITH REPORT DATED: MAY 4, 1951

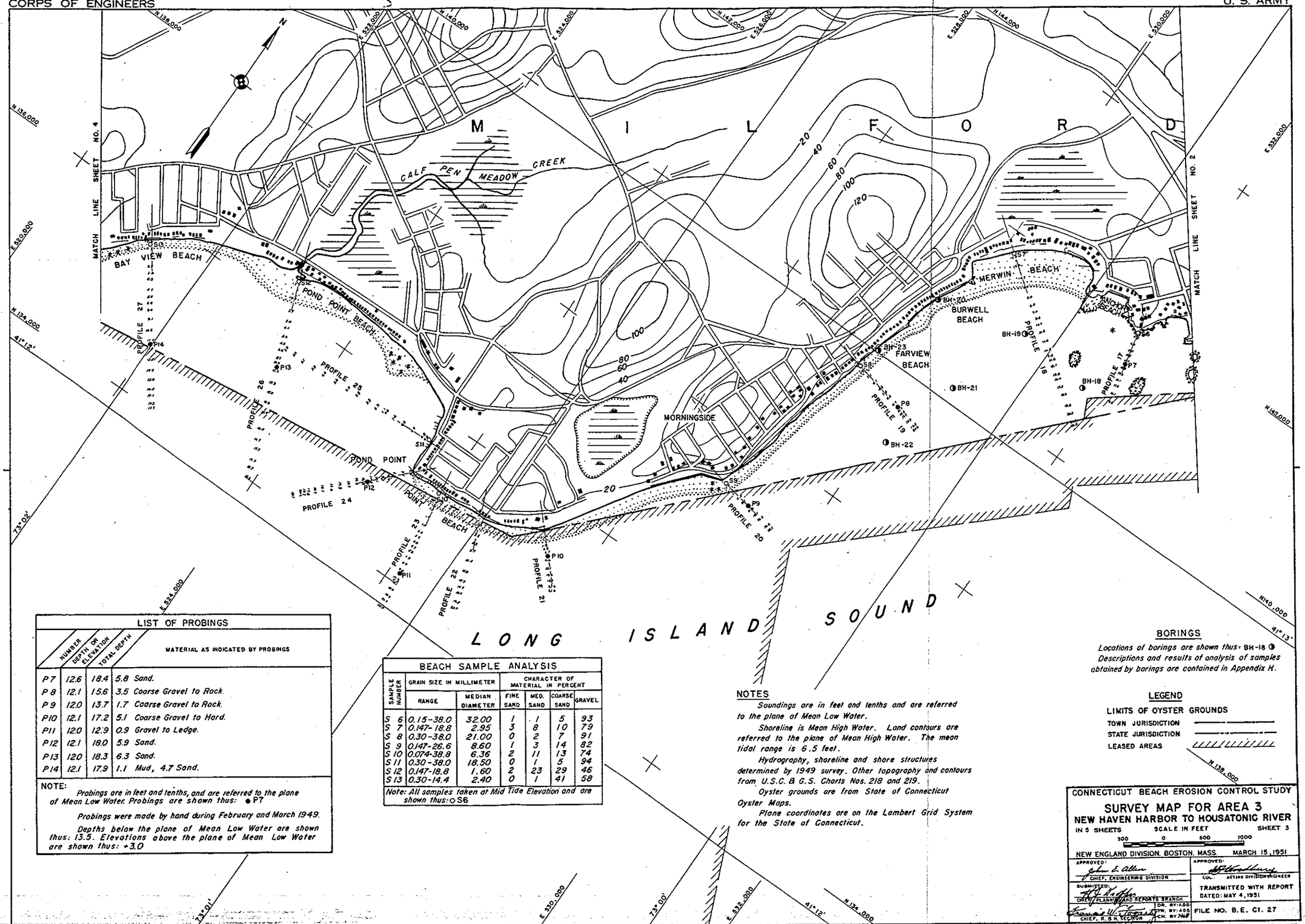
[signature], CHIEF, R. & H. SECTION

DR. BY: ABB
TR. BY: ABB
CH. BY: JWP

FILE NO. B.E. 01.27

PLATE 12

CORPS OF ENGINEERS — U. S. ARMY



LIST OF PROBINGS

NUMBER	DEPTH OR ELEVATION	TOTAL DEPTH	MATERIAL AS INDICATED BY PROBINGS
P 7	12.6	18.4	5.8 Sand.
P 8	12.1	15.6	3.5 Coarse Gravel to Rock.
P 9	12.0	13.7	1.7 Coarse Gravel to Rock.
P10	12.1	17.2	5.1 Coarse Gravel to Hard.
P11	12.0	12.9	0.9 Gravel to Ledge.
P12	12.1	18.0	5.9 Sand.
P13	12.0	18.3	6.3 Sand.
P14	12.1	17.9	1.1 Mud, 4.7 Sand.

NOTE:
Probings are in feet and tenths, and are referred to the plane of Mean Low Water. Probings are shown thus: ● P7

Probings were made by hand during February and March 1949.

Depths below the plane of Mean Low Water are shown thus: 13.5. Elevations above the plane of Mean Low Water are shown thus: +3.0

BEACH SAMPLE ANALYSIS

SAMPLE NUMBER	GRAIN SIZE IN MILLIMETER		CHARACTER OF MATERIAL IN PERCENT			
	RANGE	MEDIAN DIAMETER	FINE SAND	MED. SAND	COARSE SAND	GRAVEL
S 6	0.15-38.0	32.00	1	1	5	93
S 7	0.147-18.8	2.95	3	8	10	79
S 8	0.30-38.0	21.00	0	2	7	91
S 9	0.147-26.6	8.60	1	3	14	82
S 10	0.074-38.8	6.36	2	11	13	74
S 11	0.30-38.0	18.50	0	1	5	94
S 12	0.147-18.8	1.60	2	23	29	46
S 13	0.30-14.4	2.40	0	1	41	58

Note: All samples taken at Mid Tide Elevation and are shown thus: ○ S6

NOTES

Soundings are in feet and tenths and are referred to the plane of Mean Low Water.

Shoreline is Mean High Water. Land contours are referred to the plane of Mean High Water. The mean tidal range is 6.5 feet.

Hydrography, shoreline and shore structures determined by 1949 survey. Other topography and contours from U.S.C. & G.S. Charts Nos. 218 and 219.

Oyster grounds are from State of Connecticut Oyster Maps.

Plane coordinates are on the Lambert Grid System for the State of Connecticut.

BORINGS

Locations of borings are shown thus: BH-18 ◑
Descriptions and results of analysis of samples obtained by borings are contained in Appendix H.

LEGEND

LIMITS OF OYSTER GROUNDS
TOWN JURISDICTION
STATE JURISDICTION
LEASED AREAS

CONNECTICUT BEACH EROSION CONTROL STUDY

SURVEY MAP FOR AREA 3
NEW HAVEN HARBOR TO HOUSATONIC RIVER

IN 5 SHEETS — SCALE IN FEET — SHEET 3

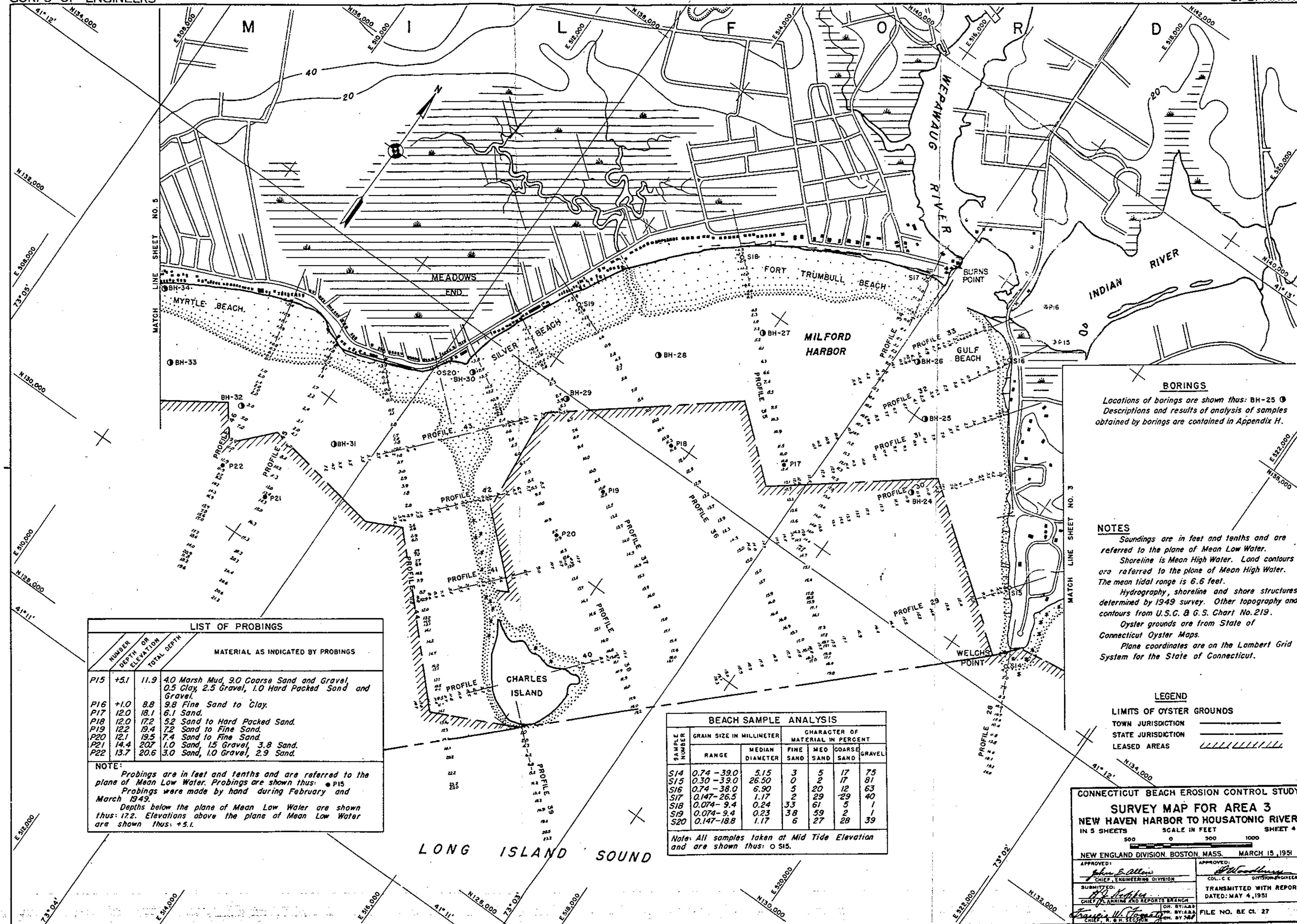
500 0 500 1000

NEW ENGLAND DIVISION, BOSTON, MASS. MARCH 15, 1951

APPROVED: John L. Allen, CHIEF, ENGINEERING DIVISION
APPROVED: A. P. Woodbury, COL. ACTING DIVISION ENGINEER
SUBMITTED: CHIEF, PLANNING AND REPORTS BRANCH
TRANSMITTED WITH REPORT DATED: MAY 4, 1951
DR. BY: ADC
TR. BY: ADC
CH. BY: JHP
CHIEF, R & H SECTION
FILE NO. B.E. Ct. 27

PLATE 13

CORPS OF ENGINEERS U. S. ARMY



LIST OF PROBINGS

NUMBER	DEPTH OR ELEVATION	TOTAL DEPTH	MATERIAL AS INDICATED BY PROBINGS
P15	+5.1	11.9	4.0 Marsh Mud, 9.0 Coarse Sand and Gravel, 0.5 Clay, 2.5 Gravel, 1.0 Hard Packed Sand and Gravel.
P16	+1.0	8.8	9.8 Fine Sand to Clay.
P17	12.0	18.1	6.1 Sand.
P18	12.0	17.2	5.2 Sand to Hard Packed Sand.
P19	12.2	19.4	7.2 Sand to Fine Sand.
P20	12.1	19.5	7.4 Sand to Fine Sand.
P21	14.4	20.7	1.0 Sand, 1.5 Gravel, 3.8 Sand.
P22	13.7	20.6	3.0 Sand, 1.0 Gravel, 2.9 Sand.

NOTE:
Probings are in feet and tenths and are referred to the plane of Mean Low Water. Probings are shown thus: ● P15
Probings were made by hand during February and March 1949.
Depths below the plane of Mean Low Water are shown thus: 17.2. Elevations above the plane of Mean Low Water are shown thus: +5.1.

BEACH SAMPLE ANALYSIS

SAMPLE NUMBER	GRAIN SIZE IN MILLIMETER		CHARACTER OF MATERIAL IN PERCENT			
	RANGE	MEDIAN DIAMETER	FINE SAND	MED SAND	COARSE SAND	GRAVEL
S14	0.74 – 39.0	5.15	3	5	17	75
S15	0.30 – 39.0	26.50	0	2	17	81
S16	0.74 – 38.0	6.90	5	20	12	63
S17	0.147 – 26.5	1.17	2	29	29	40
S18	0.074 – 9.4	0.24	33	61	5	1
S19	0.074 – 9.4	0.23	38	59	2	1
S20	0.147 – 18.8	1.17	6	27	28	39

Note: All samples taken at Mid Tide Elevation and are shown thus: ○ S15.

BORINGS

Locations of borings are shown thus: BH-25 ◑
Descriptions and results of analysis of samples obtained by borings are contained in Appendix H.

NOTES

Soundings are in feet and tenths and are referred to the plane of Mean Low Water.
Shoreline is Mean High Water. Land contours are referred to the plane of Mean High Water. The mean tidal range is 6.6 feet.
Hydrography, shoreline and shore structures determined by 1949 survey. Other topography and contours from U.S.C. & G.S. Chart No. 219.
Oyster grounds are from State of Connecticut Oyster Maps.
Plane coordinates are on the Lambert Grid System for the State of Connecticut.

LEGEND

LIMITS OF OYSTER GROUNDS
TOWN JURISDICTION
STATE JURISDICTION
LEASED AREAS

CONNECTICUT BEACH EROSION CONTROL STUDY

SURVEY MAP FOR AREA 3

NEW HAVEN HARBOR TO HOUSATONIC RIVER

IN 5 SHEETS SCALE IN FEET SHEET 4
500 0 500 1000

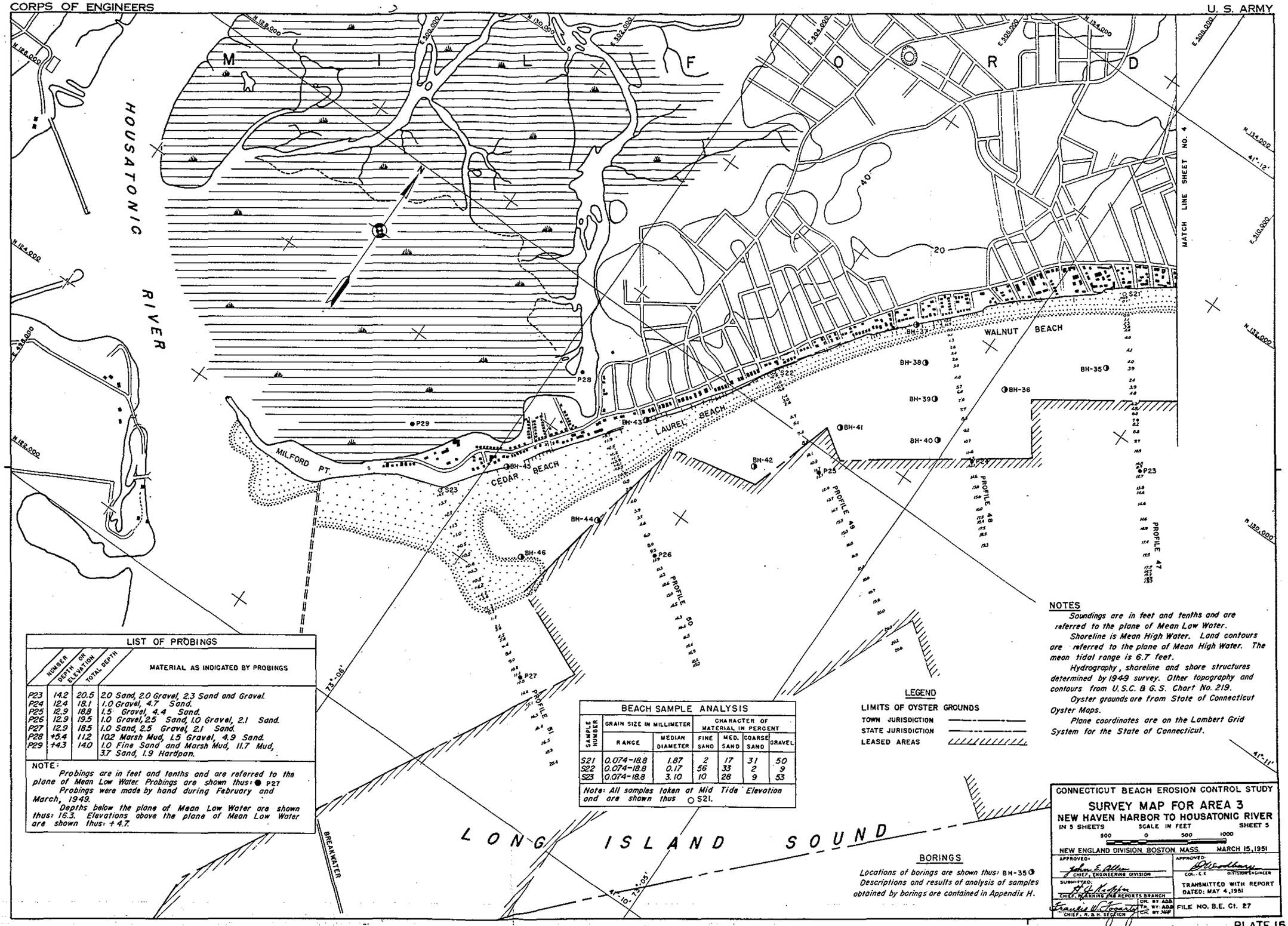
NEW ENGLAND DIVISION, BOSTON, MASS. MARCH 15, 1951

APPROVED: John E. Allen, CHIEF, ENGINEERING DIVISION
APPROVED: Woodbury, COL., C.E. DIVISION ENGINEER
SUBMITTED: CHIEF, PLANNING AND REPORTS BRANCH
TRANSMITTED WITH REPORT DATED: MAY 4, 1951
Francis W. Fogarty, CHIEF, R. & H. SECTION
DR. BY: A.A.B. TR. BY: A.A.B. CH. BY
FILE NO. BE Ct. 27

PLATE 14

CORPS OF ENGINEERS

U. S. ARMY



LIST OF PROBINGS

NUMBER	DEPTH OR ELEVATION	TOTAL DEPTH	MATERIAL AS INDICATED BY PROBINGS
P23	14.2	20.5	2.0 Sand, 2.0 Gravel, 2.3 Sand and Gravel.
P24	12.4	18.1	1.0 Gravel, 4.7 Sand.
P25	12.9	18.8	1.5 Gravel, 4.4 Sand.
P26	12.9	19.5	1.0 Gravel, 2.5 Sand, 1.0 Gravel, 2.1 Sand.
P27	12.9	18.5	1.0 Sand, 2.5 Gravel, 2.1 Sand.
P28	+5.4	11.2	10.2 Marsh Mud, 1.5 Gravel, 4.9 Sand.
P29	+4.3	14.0	1.0 Fine Sand and Marsh Mud, 11.7 Mud, 3.7 Sand, 1.9 Hardpan.

NOTE:

Probings are in feet and tenths and are referred to the plane of Mean Low Water. Probings are shown thus: ● P27

Probings were made by hand during February and March, 1949.

Depths below the plane of Mean Low Water are shown thus: 16.3. Elevations above the plane of Mean Low Water are shown thus: +4.7.

BEACH SAMPLE ANALYSIS

SAMPLE NUMBER	GRAIN SIZE IN MILLIMETER		CHARACTER OF MATERIAL IN PERCENT			
	RANGE	MEDIAN DIAMETER	FINE SAND	MED. SAND	COARSE SAND	GRAVEL
S21	0.074-18.8	1.87	2	17	31	50
S22	0.074-18.8	0.17	56	33	2	9
S23	0.074-18.8	3.10	10	28	9	53

Note: All samples taken at Mid Tide Elevation and are shown thus ○ S21.

LEGEND

LIMITS OF OYSTER GROUNDS

TOWN JURISDICTION

STATE JURISDICTION

LEASED AREAS

NOTES

Soundings are in feet and tenths and are referred to the plane of Mean Low Water.

Shoreline is Mean High Water. Land contours are referred to the plane of Mean High Water. The mean tidal range is 6.7 feet.

Hydrography, shoreline and shore structures determined by 1949 survey. Other topography and contours from U.S.C. & G.S. Chart No. 219.

Oyster grounds are from State of Connecticut Oyster Maps.

Plane coordinates are on the Lambert Grid System for the State of Connecticut.

BORINGS

Locations of borings are shown thus: BH-35 ◑
Descriptions and results of analysis of samples obtained by borings are contained in Appendix H.

CONNECTICUT BEACH EROSION CONTROL STUDY

SURVEY MAP FOR AREA 3
NEW HAVEN HARBOR TO HOUSATONIC RIVER

IN 5 SHEETS — SCALE IN FEET — SHEET 5

500 0 500 1000

NEW ENGLAND DIVISION, BOSTON, MASS. MARCH 15, 1951

APPROVED: John E. Allen, CHIEF, ENGINEERING DIVISION

APPROVED: [illegible], COL., C.E., DIVISION ENGINEER

SUBMITTED: [illegible], CHIEF, PLANNING AND REPORTS BRANCH

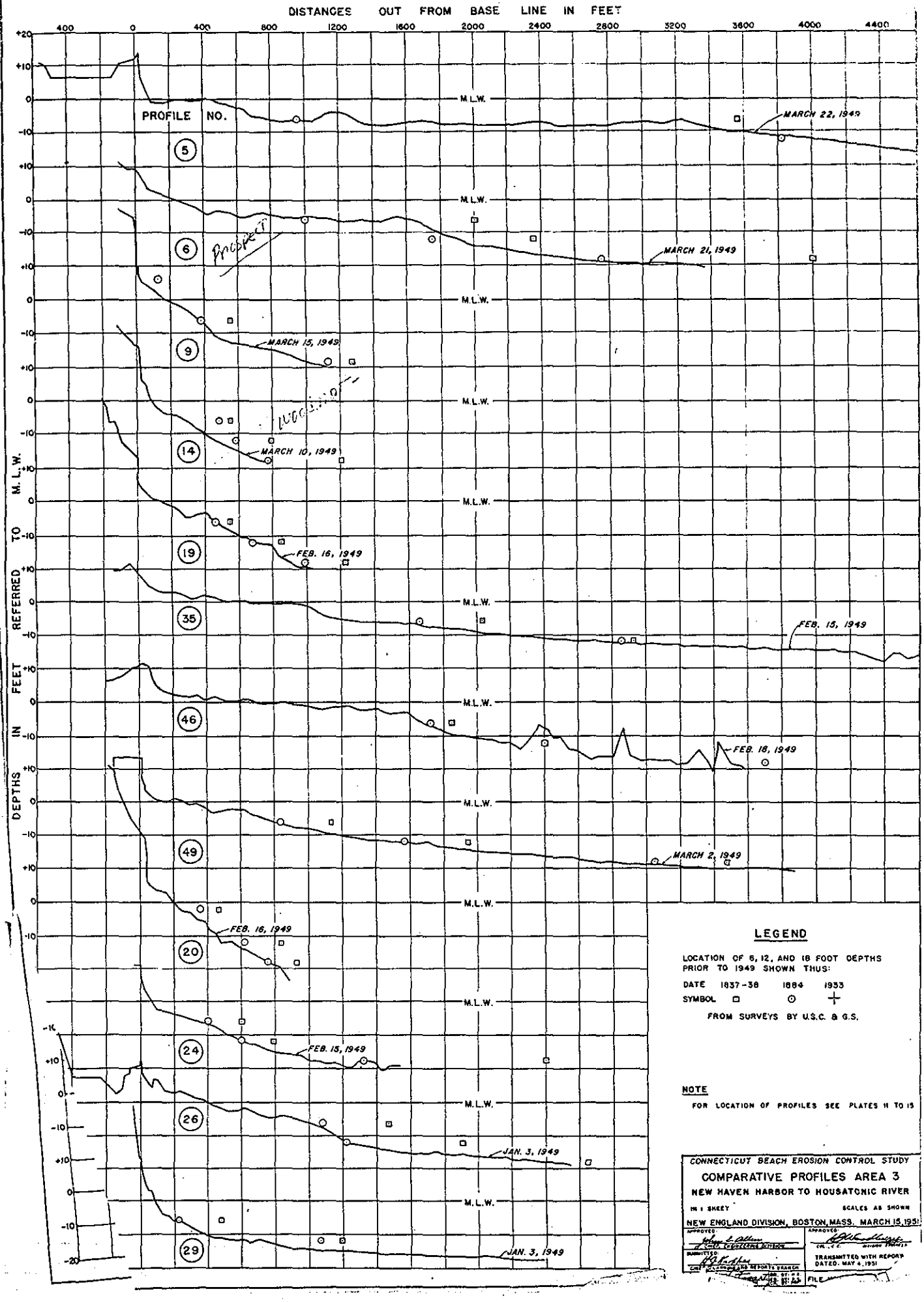
Frances W. Fogarty, CHIEF, R. & H. SECTION

DR. BY: ADB TR. BY: ADB CHK. BY: MP

TRANSMITTED WITH REPORT DATED: MAY 4, 1951

FILE NO. B.E. Ct. 27

PLATE 15



LEGEND

LOCATION OF 6, 12, AND 18 FOOT DEPTHS PRIOR TO 1949 SHOWN THUS:

DATE	1837-38	1884	1933
SYMBOL	□	⊙	+

FROM SURVEYS BY U.S.C. & G.S.

NOTE

FOR LOCATION OF PROFILES SEE PLATES 11 TO 15

CONNECTICUT BEACH EROSION CONTROL STUDY

COMPARATIVE PROFILES AREA 3

NEW HAVEN HARBOR TO HOUSATONIC RIVER

IN 1 SHEET SCALES AS SHOWN

NEW ENGLAND DIVISION, BOSTON, MASS. MARCH 15, 1951

APPROVED: John L. Allen, Chief, Engineering Division

APPROVED: [illegible], Col., C.E., Division Engineer

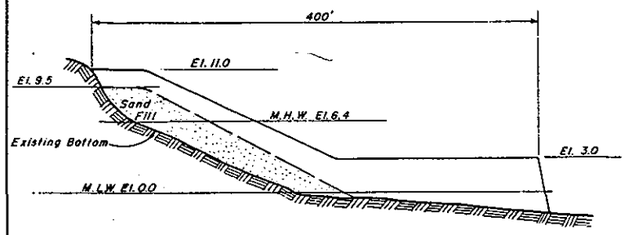
SUBMITTED: [illegible], Chief, Planning and Reports Branch

TRANSMITTED WITH REPORT DATED: MAY 4, 1951

FILE

CORPS OF ENGINEERS

U. S. ARMY

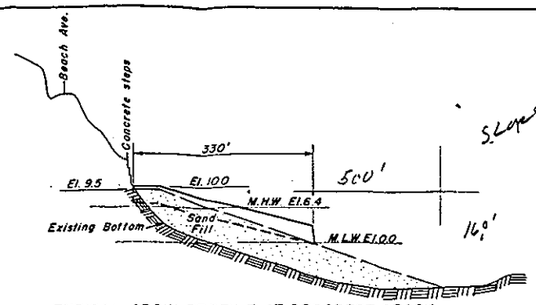


TERMINAL GROIN PROFILE AT WOODMONT

SCALE IN FEET

HOR. 50 0 50 100

VERT. 5 0 5 10

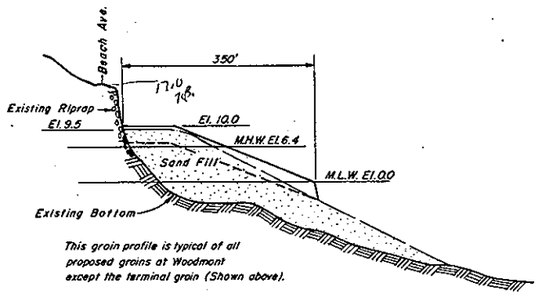


TYPICAL GROIN PROFILE AT PROSPECT BEACH

SCALE IN FEET

HOR. 100 0 100 200

VERT. 10 0 10 20



This groin profile is typical of all proposed groins at Woodmont except the terminal groin (Shown above).

GROIN PROFILE AT WOODMONT

SCALE IN FEET

HOR. 100 0 100 200

VERT. 10 0 10 20

IMPROVEMENTS RECOMMENDED
MAINTAIN EXISTING WALL AND REVETMENT

IMPROVEMENTS CONSIDERED FOR FEDERAL PROJECT
NOT RECOMMENDED
WIDEN BEACH TO 100 - 150 FOOT WIDTH
DEFERRED CONSTRUCTION OF GROINS

IMPROVEMENTS RECOMMENDED
MAINTAIN EXISTING WALLS
NO NEW CONSTRUCTION

IMPROVEMENTS CONSIDERED
NOT RECOMMENDED
WIDEN BEACH TO 100 FOOT WIDTH
GROIN 300 FEET LONG

IMPROVEMENTS RECOMMENDED
FOR FEDERAL PROJECT
WIDEN BEACH TO 100-150 FOOT WIDTH
& GROINS 330 FEET LONG

NO IMPROVEMENTS RECOMMENDED

IMPROVEMENTS RECOMMENDED
FOR FEDERAL PROJECT
WIDEN BEACH TO 100 - 150 FOOT WIDTH
5 GROINS 300-400 FEET LONG

NO IMPROVEMENTS RECOMMENDED

PROPOSED GROINS

PROPOSED GROIN

PROPOSED GROINS

PROPOSED M.H.W.

PROPOSED M.H.W.

PROPOSED M.H.W.

PROPOSED M.H.W.

Bradley Point

Oyster River (Ames) Point

Merwin Point

Anchor Beach

Merwin Beach

Oyster River Beach

SOUTH OF OYSTER RIVER (TOWN OF MILFORD)

OYSTER RIVER POINT TO OYSTER RIVER (TOWN OF WEST HAVEN)

OYSTER RIVER (AMES POINT) (TOWN OF WEST HAVEN)

TOWN OF MILFORD AND BOROUGH OF WOODMONT

MERWIN AND ANCHOR BEACHES (TOWN OF MILFORD)

SEA BLUFF BEACH (WEST HAVEN)

BRADLEY POINT

BRADLEY POINT TO SANDY POINT

GOLF RIVER

PROSPECT TOWN OF WEST HAVEN

BEACH HAVEN

SEA VIEW AVE.

ARLINGTON ST.

PROSPECT LANE

OCEAN AVE.

SOUTH ST.

HUBERT ST.

ANDERSON AVE.

BOWER AVE.

CLINTON AVE.

CHAPEL ST.

Profile 7

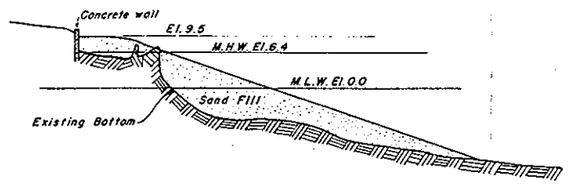
Profile 10

Profile 14

LONG ISLAND SOUND

E330,000 E332,000 E334,000 E336,000 E338,000 E340,000

N142,000 N144,000 N146,000 N148,000 N150,000 N152,000

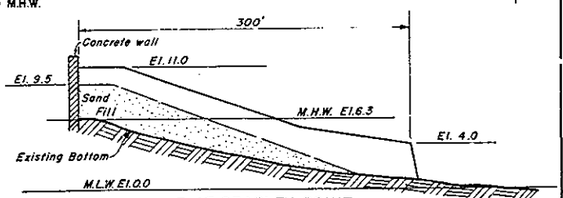


PROFILE 10 AT OYSTER POINT

SCALE IN FEET

HOR. 100 0 100 200

VERT. 10 0 10 20



GROIN PROFILE AT BRADLEY POINT

SCALE IN FEET

HOR. 50 0 50 100

VERT. 5 0 5 10

NOTES:

Shoreline is Mean High Water. The mean tidal range is 6.3 feet.

Shoreline and shore structures determined by 1949 survey.

Coordinates are on the Lambert Grid System for the State of Connecticut.

For additional construction details for shore structures see Plate 6.

Publicly owned shore property shown thus: ▨

CONNECTICUT BEACH EROSION CONTROL STUDY

PLANS OF IMPROVEMENT AREA 3

NEW HAVEN HARBOR TO HOUSATONIC RIVER

IN 4 SHEETS SCALE IN FEET 500 0 500 1000 SHEET 1

NEW ENGLAND DIVISION, BOSTON, MASS. MARCH 15, 1951

APPROVED: John B. Allen, CHIEF, ENGINEERING DIVISION

APPROVED: [illegible], COL. C. E., DIVISION ENGINEER

SUBMITTED: [illegible], CHIEF, PLANNING AND REPORTS BRANCH

TRANSMITTED WITH REPORT DATED: MAY 4, 1951

DR BY: KW TR BY: KW CR BY: JMP

Francis W. Fitzgerald, CHIEF, E. & H. SECTION

FILE NO. B.E. Ct. 30

PLATE 18

CORPS OF ENGINEERS

U. S. ARMY

FORT TRUMBULL BEACH

NO IMPROVEMENTS RECOMMENDED

WE PAWAUG RIVER

Burns Point

INDIAN RIVER

LONG ISLAND SOUND

PROPOSED M.H.W.

Profile 32

TOWN OF MILFORD GULF BEACH

IMPROVEMENT RECOMMENDED FOR FEDERAL PROJECT
WIDEN BEACH TO 100 FOOT WIDTH

Concrete Wall

Road

Marsh

El. 10.0

M.H.W. El. 6.6

Sand Fill

Existing bottom

M.L.W. El. 0.0

PROFILE 32 AT GULF BEACH

SCALE IN FEET

HOR. 50 0 50 100

VERT. 5 0 5 10

IMPROVEMENTS RECOMMENDED
MAINTAIN EXISTING PROTECTIVE STRUCTURES
NO NEW CONSTRUCTION

WELCHS POINT, BAY VIEW

MEADOW CREEK

CALF PEN AND POND POINT BEACHES

Bay View Beach

Welchs Point

Pond Point Beach

Pond Point

Steep bluff

El. 17.0

Riprap (1000 lbs. to 4000 lbs., averaging 2000 lbs.) chinked with one man stone

One man stone (20 lbs. to 150 lbs.)

Crushed stone, unscreened, 2½ inches and under

M.H.W. El. 6.5

Existing bottom

M.L.W. El. 0.0

BLUFF REVETMENT AT POINT BEACH

SCALE IN FEET

450'

El. 11.5

El. 9.5

M.H.W. El. 6.5

Sand Fill

M.L.W. El. 0.0

Existing bottom

GROIN PROFILE AT BURWELL BEACH

SCALE IN FEET

HOR. 100 0 100 200

VERT. 10 0 10 20

Riprap (1000 lbs. to 4000 lbs., averaging 2000 lbs.) chinked with one man stone

M.H.W. El. 6.5

Existing bottom

One man stone (20 lbs. to 150 lbs.)

Crushed stone, unscreened, 2½ inches and under

M.L.W. El. 0.0

TYPICAL REVETMENT AT WALLS FOR POINT, MORNINGSIDE AND FARVIEW BEACHES

SCALE IN FEET

IMPROVEMENTS RECOMMENDED
MAINTAIN EXISTING PROTECTIVE STRUCTURES
REVETMENT AT TOE OF WALLS

IMPROVEMENTS RECOMMENDED
MAINTAIN EXISTING PROTECTIVE STRUCTURES
REVETMENT AT TOE OF WALLS
REVETMENT OR WALLS AT TOE OF UNPROTECTED BLUFF

IMPROVEMENTS RECOMMENDED
WIDEN BEACH TO 100 FOOT WIDTH
GROIN 450 FEET LONG

BURWELL BEACH

Burwell Beach

450'

PROPOSED GROIN

PROPOSED M.H.W.

MORNINGSIDE AND FARVIEW BEACHES

Farview Beach

Morningside

POINT BEACH

Point Beach

(Unprotected Bluff)

NOTES

Shoreline is Mean High Water. The mean tidal range is 6.5 feet.

Shoreline and shore structures determined by 1949 survey.

Coordinates are on the Lambert Grid System for the State of Connecticut.

For additional construction details for shore structures see Plate 6.

CONNECTICUT BEACH EROSION CONTROL STUDY

PLANS OF IMPROVEMENT AREA 3

NEW HAVEN HARBOR TO HOUSATONIC RIVER

IN 4 SHEETS SCALE IN FEET SHEET 2

500 0 500 1000

NEW ENGLAND DIVISION, BOSTON, MASS. MARCH 15, 1951

APPROVED: John S. Allen, CHIEF, ENGINEERING DIVISION

APPROVED: [illegible], COL. C.E., DIVISION ENGINEER

SUBMITTED: [illegible], CHIEF, PLANNING AND REPORTS BRANCH

TRANSMITTED WITH REPORT DATED MAY 4, 1951

DR. BY: K.M. TR. BY: K.W. CH. BY: M&F

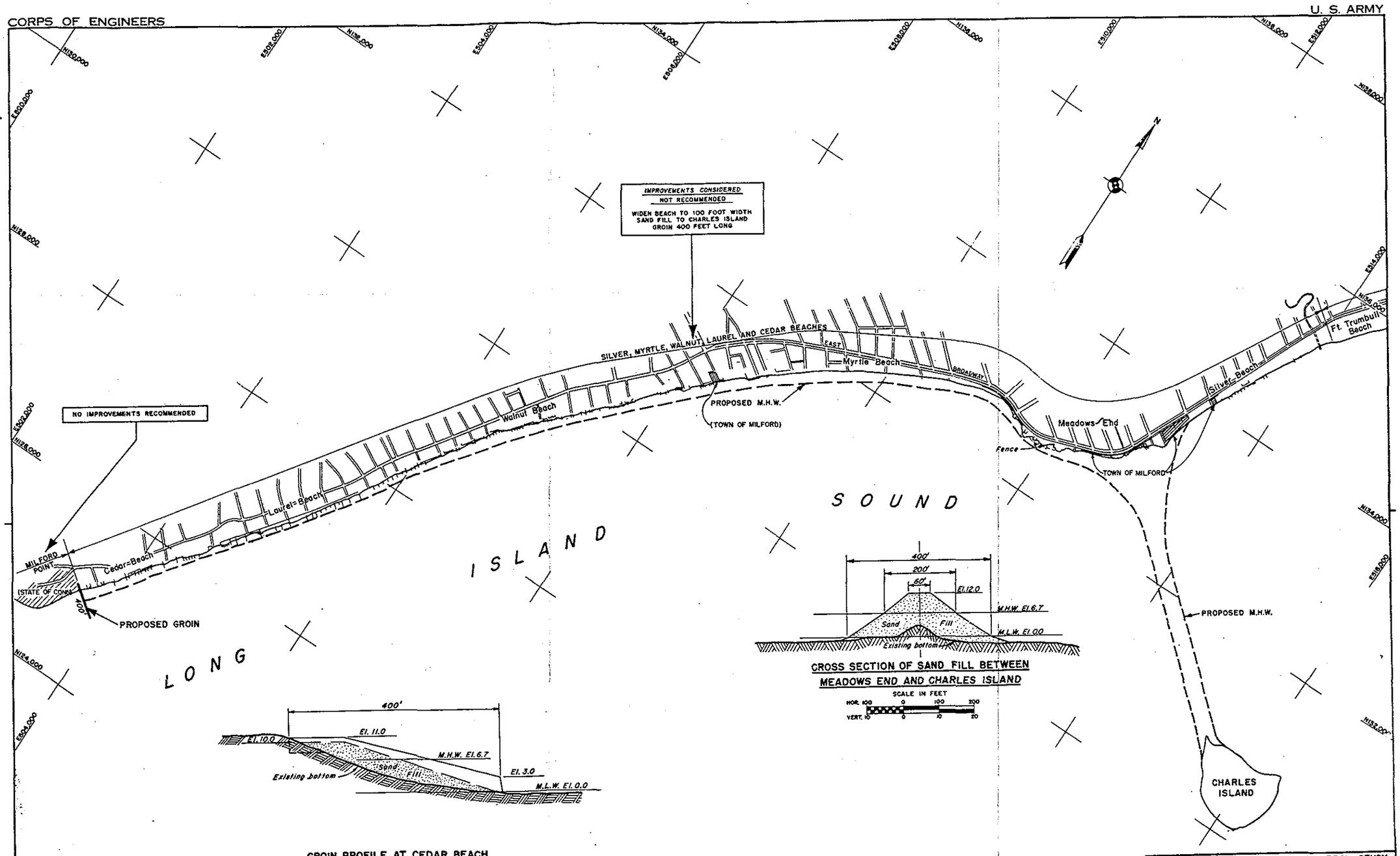
Francis V. Fogarty, CHIEF, R. & H. SECTION

FILE NO. B.E. Ct. 30

PLATE 19

CORPS OF ENGINEERS

U. S. ARMY



GROIN PROFILE AT CEDAR BEACH

SCALE IN FEET

HOR. 100 0 100 200

VERT. 10 0 10 20

CROSS SECTION OF SAND FILL BETWEEN MEADOWS END AND CHARLES ISLAND

SCALE IN FEET

HOR. 100 0 100 200

VERT. 10 0 10 20

NOTES:

Shoreline is Mean High Water. The mean tidal range is 6.7 feet.

Shoreline and shore structures determined by 1949 survey.

Coordinates are on the Lambert Grid System for the State of Connecticut.

For additional construction details for shore structures see Plate 6.

Publicly owned shore property shown thus: ▨

CONNECTICUT BEACH EROSION CONTROL STUDY

PLANS OF IMPROVEMENT AREA 3

NEW HAVEN HARBOR TO HOUSATONIC RIVER

IN 4 SHEETS SCALE IN FEET SHEET 3

500 0 500 1000

NEW ENGLAND DIVISION, BOSTON, MASS., MARCH 15, 1951

APPROVED: John L. Allen, CHIEF, ENGINEERING DIVISION

APPROVED: H. Woodbury, COL., C.E., DIVISION ENGINEER

SUBMITTED: H. G. Kohler, CHIEF, PLANNING AND REPORTS BRANCH

TRANSMITTED WITH REPORT DATED: MAY 4, 1951

Frances V. Fogarty, CHIEF, P. & H. SECTION

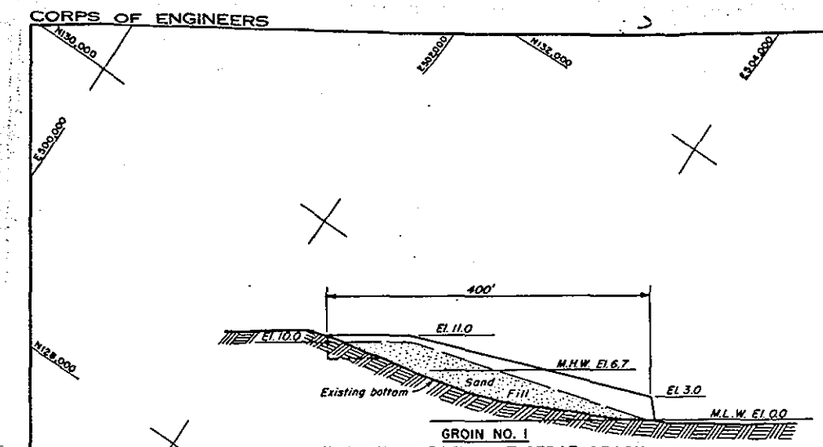
DR. BY: K.W.
TR. BY: K.W.
CH. BY: WHF

FILE NO. B.E. 61.30

PLATE 20A

CORPS OF ENGINEERS

U. S. ARMY



GROIN NO. 1

TERMINAL PROFILE AT CEDAR BEACH

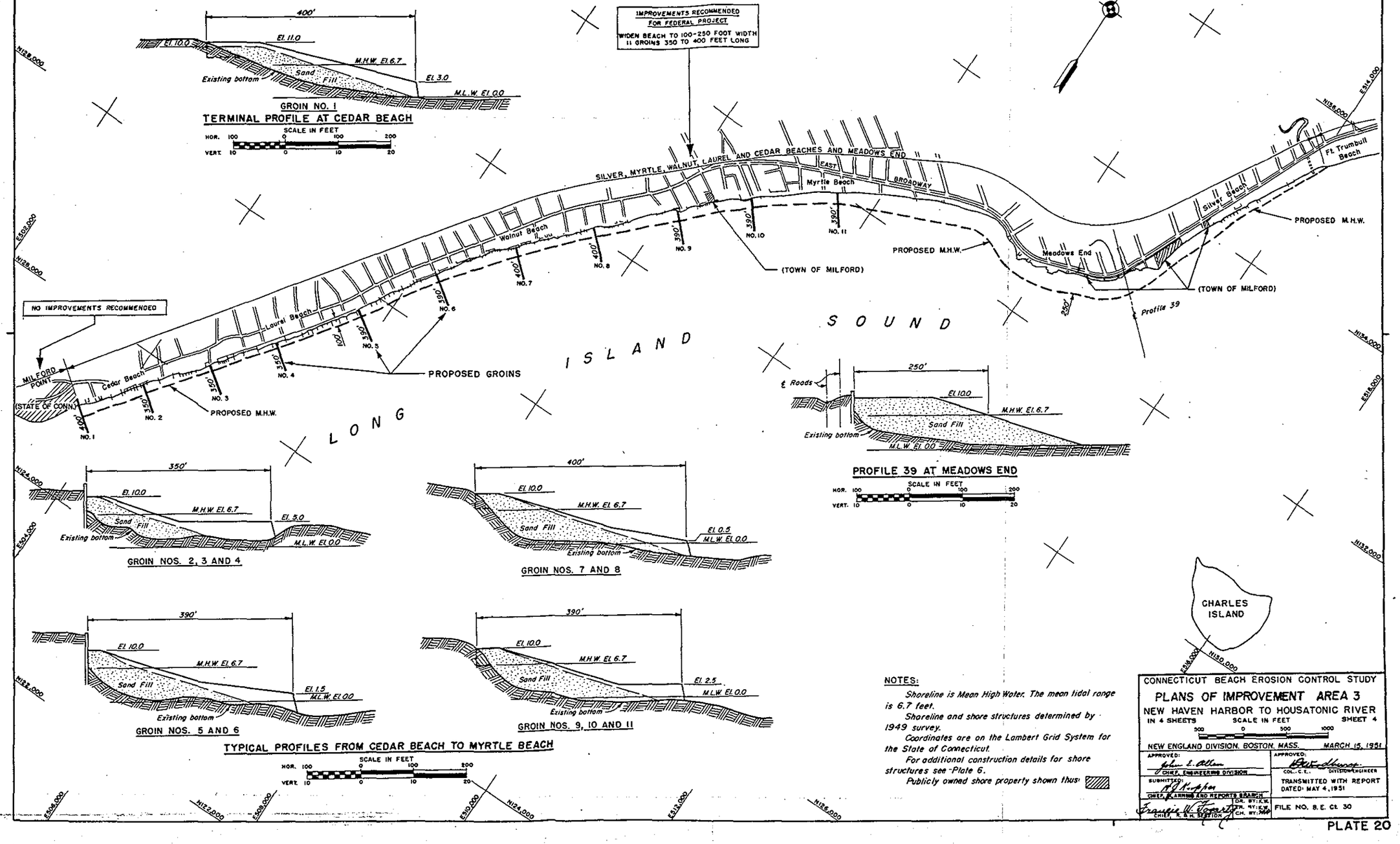
SCALE IN FEET

HOR. 100 0 100 200

VERT. 10 0 10 20

IMPROVEMENTS RECOMMENDED FOR FEDERAL PROJECT

WIDEN BEACH TO 100-250 FOOT WIDTH
11 GROINS 350 TO 400 FEET LONG



GROIN NOS. 2, 3 AND 4

GROIN NOS. 7 AND 8

GROIN NOS. 5 AND 6

GROIN NOS. 9, 10 AND 11

TYPICAL PROFILES FROM CEDAR BEACH TO MYRTLE BEACH

SCALE IN FEET

HOR. 100 0 100 200

VERT. 10 0 10 20

PROFILE 39 AT MEADOWS END

SCALE IN FEET

HOR. 100 0 100 200

VERT. 10 0 10 20

NOTES:

Shoreline is Mean High Water. The mean tidal range is 6.7 feet.

Shoreline and shore structures determined by 1949 survey.

Coordinates are on the Lambert Grid System for the State of Connecticut.

For additional construction details for shore structures see Plate 6.

Publicly owned shore property shown thus: ▨

CONNECTICUT BEACH EROSION CONTROL STUDY

PLANS OF IMPROVEMENT AREA 3

NEW HAVEN HARBOR TO HOUSATONIC RIVER

IN 4 SHEETS SCALE IN FEET SHEET 4

500 0 500 1000

NEW ENGLAND DIVISION, BOSTON, MASS. MARCH 15, 1951

APPROVED: CHIEF, ENGINEERING DIVISION

APPROVED: COL., C. E., DIVISION ENGINEER

SUBMITTED: CHIEF, PLANNING AND REPORTS BRANCH

DR. BY: K.W. CH. BY:

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CHIEF, E. & H. SECTION

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PLATE 20