Detailed Project Report
And Environmental Assessment
Small Beach Erosion Control Project

Okinawa Beach
West Haven, Connecticut

May 1986

US Army Corps
of Engineers
New England Division

SYLLABUS

This small beach erosion control report was prepared by the Corps of Engineers at the request of the city of West Haven, Connecticut. In a letter dated April 28, 1980, the Mayor requested "Federal assistance under Section 103 of the River and Harbor Act of 1962, as amended, to develop and construct a shore and beach restoration and protection project in the Okinawa area of West Haven." Two reconnaissance reports on West Haven Beaches were completed in June 1981, recommending further detailed study. Coordination meetings were held on a regular basis with city, state and Federal officials. This report only discusses recommended improvements at Okinawa Beach.

Okinawa Beach is located on the south-central coast of Connecticut, along Long Island Sound. This city-owned beach provides backshore protection to a parking lot, walkway and park, and Ocean Avenue, a major road along the West Haven shoreline. It also provides an opportunity for recreational sunbathing and saltwater swimming in Long Island Sound. The report discusses the magnitude, extent and cause of the erosion problems and recommends a solution to restore this valuable public beach and protect the backshore. A combination of wind-driven waves, above normal tides and storms impacting the shoreline have caused serious erosion of the beach and backshore, damage to the road, adjacent wall, and the embankment.

This Detailed Project Report evaluates several alternative plans of erosion control to restore the beach and protect the backshore. The most effective plan of improvement includes:

> Beach widening by the direct placement of suitable sandfill along approximately 600 feet of Okinawa Beach, providing a 75-foot-wide, level-beach berm at elevation 11.0 feet above mean low water (8.2 feet NGVD). Also recommended, but deferred until such time as deemed necessary, is the construction of a timber groin structure at the east limit of the beach and a postconstruction beach monitoring program.

This plan together with the removal of an existing dilapidated timber structure, will provide a protective beach and recreational use area. The selected plan will provide a usable dry beach space width, above the mean high waterline, of approximately 147 feet.

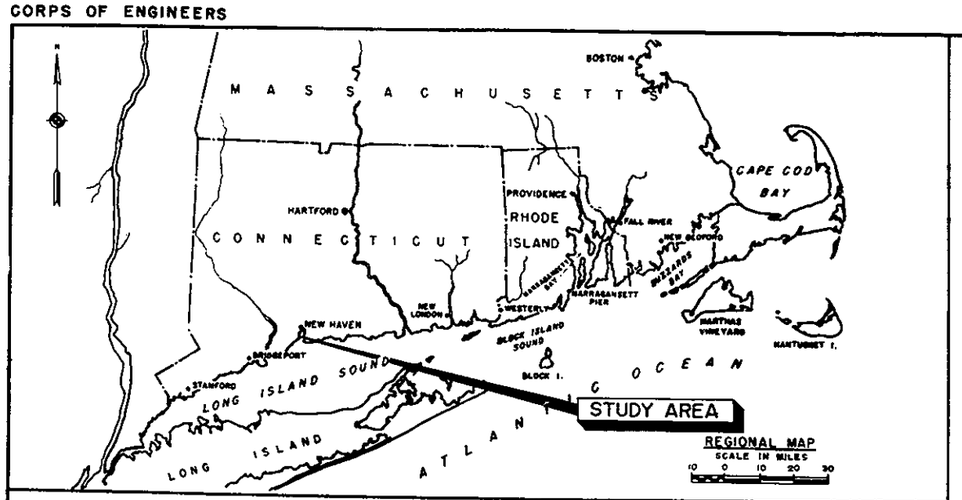
The Division Engineer recommends, subject to certain conditions of non-Federal cooperation, that the selected plan be authorized as a beach erosion control project under Section 103 of the River and Harbor Act of 1962, as amended. The estimated first cost of construction is $350,000. Federal share is estimated at 70 percent or $245,000, and the non-Federal share is estimated at 30 percent or $105,000. The beach will require periodic nourishment, estimated to cost $10,400 annually, with cost-sharing in the same proportion as the first cost of construction. Total

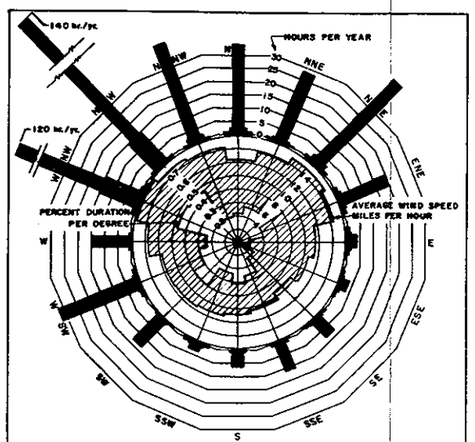
annual charges of $41,400 and the annual project benefits of $63,400, providing a benefit-cost ratio to 1.5 to 1. All aspects of this report are subject to the approval of the Chief of Engineers.

Note: As discussed in the "Economic Criteria" section of the main report, annual benefits and costs were estimated using the FY 1985 interest rate of 8-3/8 percent, in lieu of the FY 1986 interest rate of 8-5/8 percent because FY 1986 unit day values for recreation were not received until March 1986. The resulting FY 1986 changes were too small to warrant changing the economic analysis sections of the report at this time.

PHOTO 1-- Looking northeast note narrow beach above the high tide line.

PHOTO 2-- Marsh grass located along the southern limit of the beach. A section of this grass will be transplanted.





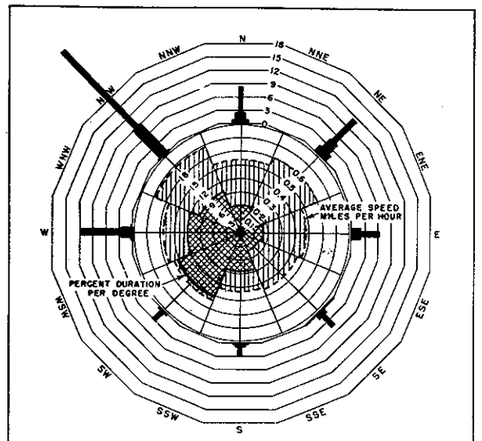
WIND ROSE

LAGUARDIA FIELD NEW YORK, N.Y.

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

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

WINDS GREATER THAN 18 MILES PER HOUR.



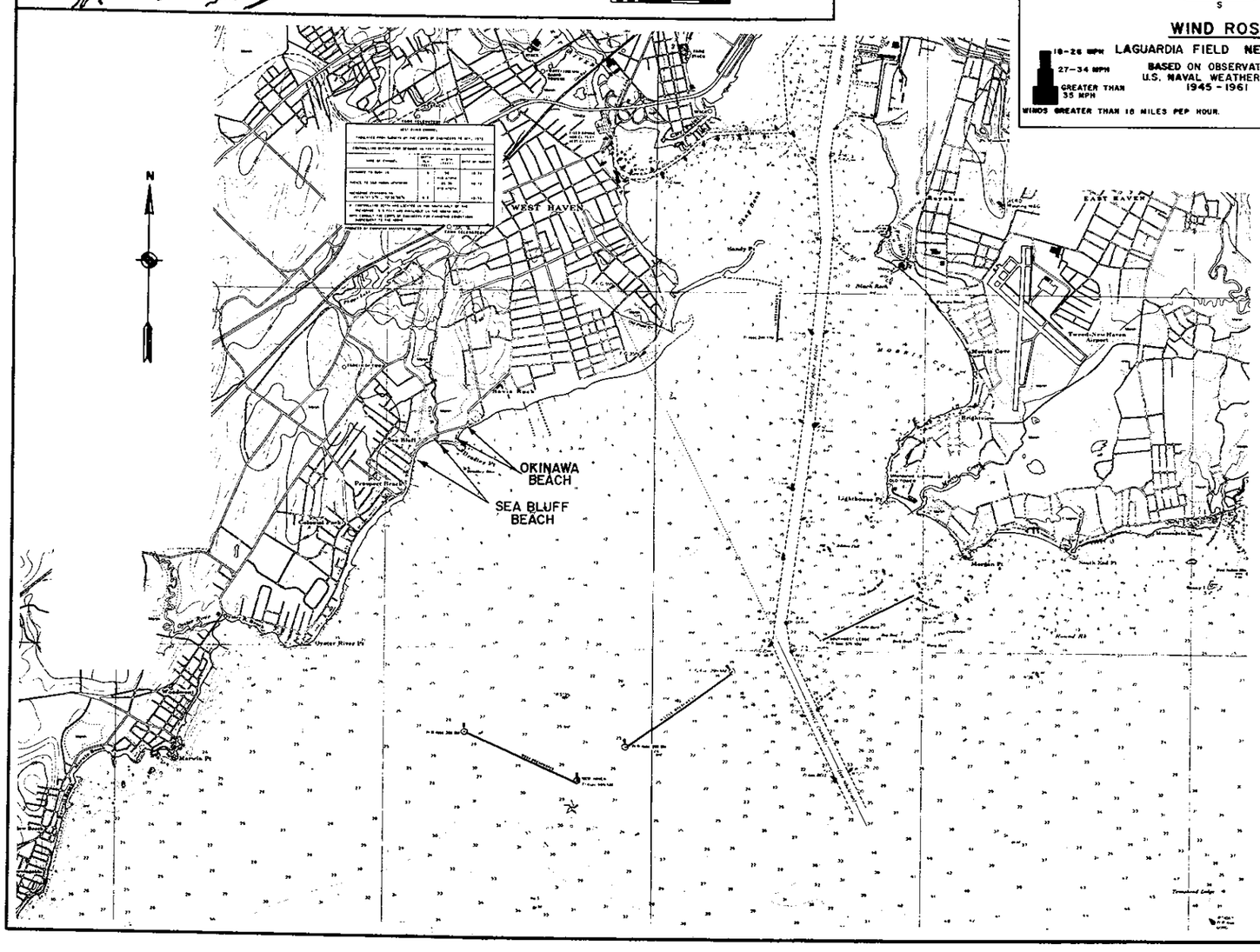
WIND ROSE

BLOCK ISLAND, RHODE ISLAND

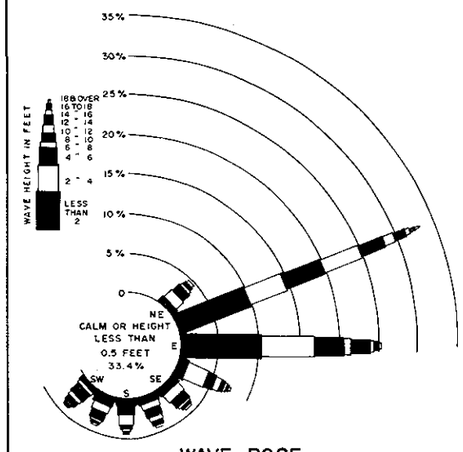
BASED ON OBSERVATIONS OF U.S. WEATHER BUREAU 1921 - 1939

32-40 MPH
41-50 MPH
51-60 MPH
61-70 MPH
71-80 MPH
81-90 MPH

WINDS 32 MILES PER HOUR AND OVER IN OCCURRENCES PER YEAR (1936-1945)



COMPOSED OF DATA OBTAINED BY HINDCAST OF 3 YEARS OF WIND RECORDS (1948-1950) SHOWING PERCENT OF TIME WAVES OF DIFFERENT HEIGHT OCCUR FROM EACH DIRECTION. FROM BEACH EROSION BOARD TECH. MEMO. NO. 55.



WAVE ROSE

OFF NAUSET BEACH, CAPE COD, MASS.

(LAT. 41° 50' N, LONG. 69° 30' W)

BEACH EROSION CONTROL STUDY

WEST HAVEN BEACHES

WEST HAVEN, CONNECTICUT

LOCATION MAP

SCALE 1:20,000

1666' 0' 1666' 3332'

NEW ENGLAND DIVISION, CORPS OF ENGINEERS

OKINAWA BEACH
WEST HAVEN, CONNECTICUT
DETAILED PROJECT REPORT

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OKINAWA BEACH
WEST HAVEN, CONNECTICUT
DETAILED PROJECT REPORT

This detailed project report presents an analysis of beach erosion problems and recreational needs that currently exist at Okinawa Beach. Okinawa Beach is located in West Haven, Connecticut, on the northern shore of Long Island Sound, 5 miles southwest of New Haven Harbor, and about midway along the Connecticut coast. It is a city-owned beach that extends approximately 600 feet northeasterly from Bradley Point. See Plate 1. This report contains detailed engineering, environmental and economic analyses that identify the beach erosion problems at the area.

STUDY AUTHORITY

The report was prepared under the authority granted in Section 103 of the 1962 River and Harbor Act, as amended, which provides authority for the Chief of Engineers to construct small shore and beach restoration and protection projects. A project is adopted for construction under Section 103 only after detailed investigation clearly shows engineering feasibility and economic justification. Each project is limited to a Federal cost of not more than $1,000,000, which includes all project related costs for report preparation, design and construction. A project developed under Section 103 is formulated to provide the same complete-within-itself project that would be recommended under regular Congressional authorization procedures. No additional work should be required to assure effective and successful operation of the project. A dependent increment or portion of a larger overall project is not eligible for construction under this program.

SCOPE OF STUDY AND PURPOSE

A study was conducted to evaluate the economic feasibility of restoring and maintaining approximately 600 feet of public beach and adjacent backshore. The damages that storm winds and waves cause to the shoreline were investigated along with alternative plans for providing shore protection, preventing future damages due to the natural elements and encouraging healthful recreational beach bathing. A detailed analysis was conducted of all the elements necessary for successful water resource planning for the study area, including social, economic and environmental features of the area, associated construction costs for the considered plans, and other related matters.

OTHER STUDIES, REPORTS AND EXISTING WATER PROJECTS

The Corps of Engineers, in cooperation with the State of Connecticut, completed a beach erosion control report in 1951 for the reach of shoreline between New Haven Harbor and the Housatonic River. A report was published in House Document No. 203, 83rd Congress, 1st Session.

The report discussed the six principal beaches in West Haven, now all heavily utilized, in east-to-west order: Sandy Point, Savin Rock, Okinawa, Bradley Rock, Sea Bluff and Prospect. The report recommended Federal participation in beach restoration at Prospect Beach, which was completed in May 1957. No improvements warranting Federal participation were recommended for the other West Haven beaches, at that time.

An interim hurricane report entitled "Connecticut Coastal and Tidal Areas" was completed in 1965 and published in House Document No. 146, 89th Congress, 1st Session. Although a hurricane protection project was recommended for the West Haven area, it found no economic justification for Federal participation.

Several studies have been undertaken at neighboring Prospect Beach, located about 1600 feet southwest of Okinawa Beach. In August 1961, the Coastal Engineering Research Center completed Technical Memorandum No. 127, "Behavior of Beach Fill and Borrow Area at Prospect Beach, West Haven, Connecticut". This technical study reviewed the pre- and post-beachfill behavior problems at Prospect Beach. The Corps of Engineers is in the process of reviewing the May 1957 Corps beach erosion control project at Prospect Beach under the Section 103 Beach Erosion Control Authority, and project will include beach widening and groin modification.

In response to a 28 April 1980 letter from the city of West Haven, reconnaissance reports were completed in June 1981 for Bradley Rock Beach, a 700-foot-long beach located immediately west of Bradley Point, and for Sea Bluff Beach, a 900-foot-long beach located immediately west of Bradley Rock Beach and abutting the eastern end of Prospect Beach. These reports recommended that a full scope Section 103 beach erosion control survey be undertaken for both beaches. Further detailed study at Bradley Rock Beach revealed a substantial quantity of shellfish and other benthic organisms in the intertidal zone, and a very small but productive saltmarsh area. However, conditions do not support the need for erosion control measures. Attention was then given (see letter dated June 23, 1983) to Okinawa Beach, located immediately northeast of Bradley Rock, where back-shore protection and erosion control could be provided by the placement of sandfill.

EXISTING CONDITIONS

Okinawa Beach is a sandy pocket-shaped beach, which extends about 600 feet north and northeast of Bradley Point, a rocky headland separating Bradley Rock and Okinawa Beaches (see Plate 1).

The most serious erosion occurs along the northeastern half of the beach. Over the years the beach has eroded, exposing the base of the existing seawall. The city is required to remove sand and debris from the backshore walkway and redistribute the sand back on the beach. Flooding occurs after major coastal storms. This cleanup operation takes place four to five times a year.

The average dry beach width above the mean high water line is approximately 35 feet. Adjacent to Bradley Point there is a small salt-marsh area of spartina alterniflora. At the other end of the beach is a backshore retaining wall and dilapidated timber groin structure. The wall is in good condition except for some undermining and exposure of the footing. The backshore includes a walkway and bicycle path, picnic area and lighted park with parking.

Okinawa Beach is city-owned and open to the public. The West Haven area near Okinawa is residential, and many beach users walk to the beach. There is easy access to the backshore park and beach for visitors from nearby condominiums and apartments, by car, bicycle or walking. The city is in the process of improving the park with sanitary facilities, picnic tables and other park facilities.

BASE CONDITION

The beach at the time of construction should be relatively unchanged from the conditions as they exist today. There likely would be more erosion depending upon the direction and intensity of the winter storms between now and the time of construction. A preconstruction survey may be required prior to proceeding with the project. However, for this report the "Existing Condition" and the "Base Condition" are to be considered the same.

WITHOUT-PROJECT CONDITION

This condition will not provide any future benefits nor incur any costs to the Federal Government. The beach will continue to erode, causing increased flooding, and undercut the backshore walkway and parking area, thereby requiring continuing cost for the city. The city periodically (after major storms) removes sand from the walkway and backshore picnic area placing it back onto the beach. Also, the adjacent retaining wall is being undermined and is in need of some repair. Periodic repairs will continue to be made as funds are made available. If the fronting beach is eroded away, there would be serious undermining of the embankment and walkway. This would result in wave damage to the embankment, walkway and backshore park, as well as some backshore flooding of the area. The city and/or state would have to determine what action they would take to protect the area and prevent flooding and backshore damage to low lying areas.

CONDITIONS IF NO FEDERAL ACTION IS TAKEN

The present rate of erosion at Okinawa Beach averages 1 to 2 feet per year, but is sometimes as high as 5 feet per year. (See "Historic Shoreline" discussion on page 33 of Appendix 3 which indicates that the shoreline was previously about 300 feet seaward of its present location). If improvements are not made, the existing dry beach width would decrease rapidly. By the end of a 20-year without-project condition, the beach

would be totally deteriorated and erosion of the backshore would worsen. The city would probably abandon the beach and protect the backshore park and walkway with revetment. If Okinawa is to continue to be a usable recreational beach, a program of sandfill, nourishment and possibly a groin structure is necessary to maintain this beach and backshore area.

PROBLEMS, NEEDS AND OPPORTUNITIES

Over the years, Okinawa Beach has experienced the loss of valuable recreational beach space due to storm driven waves and winds. This erosion is particularly severe during storms that last over several tide cycles with elevations above normal stillwater elevations. Okinawa Beach has an open exposure to storms coming from the south and southeast. In New Haven Harbor, there is a series of breakwaters which help provide limited protection to the beach. Several plans of improvements were evaluated to help restore beach area and to help protect the beach and backshore.

NATIONAL OBJECTIVES

The process of evaluating plans was carried out by establishing the contribution of each alternative to the problem and opportunity statements for beach erosion control projects. The National Objective given prime importance in the planning process was the National Economic Development (NED) account. Each plan was evaluated in accordance with this National Objective as it applies to the water resource planning requirements. The plan which resulted in the maximum net economic return was designated the NED plan. Careful consideration was also given to the Environmental Quality (EQ), the Regional Economic Development (RED), and the Other Social Effects (OSE) accounts or plans. Desirability of the plans is governed by the beneficial and adverse impacts to the planning objectives for the study area.

The main objective is discussed below:

National Economic Development increases the nation's output of goods and services and improves its economic efficiency. This is accomplished by:

- Prevention of loss of land and other physical damages
- Reduction in maintenance costs
- Increased recreational usage
- Employment benefits.

Consideration was given to the following objectives:

Environmental Quality is directed toward enhancing the environment through management, conservation, preservation, creation, restoration or improvement of the quality of certain natural, cultural and ecological resources.

Regional Economic Development is concerned with a project's effect on the region. The following criteria were considered:

- o Effects on employment, income and economic base
- o Effects on regional recreational activities
- o Effects on local commercial and industrial activities
- o Effects on public services and facilities.

Other Social Effects considers the direct and indirect implications that would result from the proposed project on the population and their lifestyle. Consideration was given to the following:

- o Community disruption
- o Effects on health, safety and community well-being
- o Effects on desired community growth
- o Effects on educational, cultural and recreational opportunities
- o Effects on emergency preparedness
- o Effects on noise during construction that would tend to raise the overall noise level of the area over the construction period of the project.

PROBLEM AND OPPORTUNITY STATEMENTS

Problem and opportunity statements are derived from known areas of public concern and from anticipated "without-project" conditions that are likely to occur. The statements define water and land related resource management needs that can enhance the National Economic Development (NED) account. Based on these items, the following problem and opportunity statements were established:

- Loss of valuable public land.
- Damage to backshore wall embankment and walkway.
- Overtopping, causing backshore flooding and damage to backshore facilities.
- Contribute to the safety and comfort of the users of the beach.
- Contribute to the economic strength and well-being of the area.
- Preserve the environmental quality of the area.
- Contribute to the restoration of the beach and its continued recreational use.
- Contribute to the stability of the beach.
- Preserve the backshore area.

PLANNING CONSTRAINTS

Planning constraints are limitations that are incorporated into the planning process. These limitations are based on a wide range of

concerns, such as natural conditions, social and environmental factors, economic limits and legal restrictions.

The following constraints were found to be relevant to the study:

o Avoid adverse effects on adjacent shore configurations. Any work performed on this beach must not cause deterioration to any adjacent beaches, waterways and inlets.

o The city's financial capabilities are limited; therefore, formulated plans should stay within the financial capability of the city.

FORMULATION OF PRELIMINARY PLANS

Consideration was given to both structural and nonstructural solutions in formulating alternative plans for Okinawa Beach. All of the alternative plans addressed a broad range of publicly-held concerns, such as economic, environmental and social needs. Meetings were held with Federal, State and local officials to determine their preferences and desires in arriving at the selected plan of improvement. Each plan was screened for feasibility and justification and, depending on the conclusions of this screening, was either recommended for further detailed analysis or eliminated from the study.

ALTERNATIVE PLANS

As a basis for formulating alternative plans, a broad range of structural and nonstructural plans were examined as possible solutions to the problems at Okinawa Beach.

Nonstructural measures included:

- o Do nothing, thereby allowing the beach and backshore to continue to erode and backshore flooding and park clean-up.
- o Improve the backshore and existing recreational facilities.
- o Limit the number of beach bathers on peak days.

Structural measures included:

- o Place suitable sandfill along the entire beach area.
- o Construct groin structures to compartmentalize the beach.
- o Construct an offshore breakwater.
- o Place rock revetment along the backshore.

Nonstructural plans were considered, evaluated and discussed with city officials. City officials were not interested in nonstructural measures as they have plans to develop their entire shoreline, based on a master plan which includes improvements to their beaches and backshore areas. The nonstructural plans were considered in the planning process but were not feasible because the plans do not meet the problem and

opportunity statements and the National Objectives. Therefore, no non-structural solutions were carried forward.

No Action Plan

Although a No Action plan was considered to be a viable alternative and compared to the other plans, there would be no associated benefit or cost to the Federal Government. The city and/or state would continue to protect the backshore walkway, parking area structures and park at some point in the erosion and damage cycle of the beach. Therefore, this plan was not carried forward because it does not meet the problem and opportunity statements or the National Objectives of the project. This is a non-Federal option that was discussed with the city of West Haven before proceeding with this report.

DESCRIPTION OF PLANS

The structural measures mentioned above were studied for their applicability in correcting the problems of the eroding shoreline, damage to the backshore wall, embankment and walkway, and insufficient beach space for the public use.

The following is a brief description of the plans considered:

Plan 1 consists of beach widening to a level beach berm width of 50, 75 or 100 feet, with a backshore elevation of 11.0 feet above mean low water, by the direct placement of suitable sandfill along approximately 600 feet of shoreline, plus the removal of a dilapidated timber groin structure located at the east end of the beach and transplanting a section of saltwater cordgrass (spartina alterniflora) located at the western end of the beach.

Plan 2 (Selected Plan) consists of sandfill as in Plan 1, plus possible deferred construction of a timber groin at the east end of the beach.

Plan 3 consists of sandfill as in Plan 1, plus possible deferred construction of a rock groin at the east end of the beach.

Plan 4 consists of placement of a rock revetment along the 600-foot-long backshore area.

Plan 5 consists of construction of an 800-foot-long offshore breakwater located approximately 1000 feet seaward of the beach.

Consideration was also given to a beach with a higher and longer groin structure at the east end of the beach, but it was eliminated because it would be very expensive. It is cheaper and more environmentally acceptable to build a smaller beach with a groin (deferred) and periodic nourishment. Therefore, a large groin structure option was not considered for further study. (See Periodic Nourishment, Appendix, page 3-35 for details).

COMPARATIVE ASSESSMENT AND EVALUATION OF PLANS

Contributing to the protection of the backshore, continued recreational use of the beach and stability of the restored beach were among the concerns of Federal, State, regional and local interests. Plans 1 through 3 would restore and stabilize the beach, provide continued recreational use of the beach, and protect the backshore area. Plan 4 (rock revetment) and Plan 5 (offshore breakwater) would only provide protection to the backshore from storm driven waves. The revetment would only protect the backshore park and would not contribute to the restoration and recreational use of the beach. The offshore breakwater would not prevent beach overtopping during periods of above normal tides or storms. These plans are not cost effective or environmental acceptable.

Plans 4 and 5 are costly and the minor benefits that they would provide would not justify the high cost of construction. These plans are also more environmentally damaging than the sandfill plans, and by not halting erosion, they would not enhance the environment. These plans did not meet the criteria in the problem and opportunity statements or the National Objectives and were not considered further. Plans 1 through 3 are viable alternatives that were formulated to contribute to the study objectives of the area. These plans were compared and a trade-off analysis performed in the "Assessment and Evaluation of Detailed Plans" section to determine which option best meets the needs and desires of local interests.

ASSESSMENT AND EVALUATION OF DETAILED PLANS

This section contains an analysis of Plans 1 through 3 which were selected for further detailed study. Evaluation of these options was based on their attainment of the project problem and opportunity statements and the National Objectives.

The detailed plans of improvement considered for this final evaluation were developed using the preliminary design data recommended in the reconnaissance stage planning report, and input received from the city and the concerned public. These two factors were foremost in developing the plans which would protect the backshore and restore the recreational use of the shore, based on the needs and desires of the city of West Haven.

The improvement methods considered are groins and sandfill. Each method has a distinct function: groins provide an effective sand retention measure, and sandfill is a wave energy absorber, reducing overtopping of the beach. Protection provided to the eroding backshore by these measures would reduce major flooding and restore the lost beach area. The method or combination of methods that best satisfy the economic, engineering, and environmental criteria set forth in this report form the basis for selection of a final plan.

Plan 1 (sandfill only) would have initially a very positive effect on Okinawa Beach. The restoration of a safe, aesthetically pleasing beach would provide backshore protection and enhance the recreational aspects of the beach. Based on the recent history of erosion in this pocket beach, losses would be reduced by the placement of a better grade of sand. Losses would still occur, but with a beach monitoring program it could be determined at what rate the new material was being lost. The beach is somewhat sheltered, approaching waves would be influenced by offshore shoals and the rocky headland of Bradley Rock. A structure may be necessary at the easterly end of the beach. Therefore, Plan 1 by itself does not meet the needs and objectives of the area.

Plan 2: (Sandfill with deferred timber groin) and Plan 3 (sandfill with rock groin) have all the benefits of Plan 1 with the added dimension of a groin structure. Construction of a groin would be deferred and a monitoring program would be initiated to determine whether or not a groin is really necessary. A groin would act to maintain shore alignment and reduce sand losses, resulting in lower costs.[1] Plans 2 and 3 were carried further for a more detailed analysis.

Plans 2 and 3 also utilize various placements and lengths of groin structure at the notheasterly limits of the beach. The net alongshore movement of material is in a northeasterly direction. Since this littoral movement is to the north, Plan 1 would only provide a temporary solution to the problem and the sandfill would not stay on the beach for very long. Plan 1 would have a higher nourishment rate and could impact the adjacent shorelines and the offshore areas. Plan 2 and Plan 3 with a deferred low profile terminal structure (timber or rock) are the most acceptable, as their nourishment rates are lower than Plan 1 and result in lower costs.[1] Plan 2 and Plan 3 were carried further for a more detailed analysis.

Plans 2 and 3 meet the criteria that were set forth in the problem and opportunities statements. These plans satisfy the requests of the Federal, State, regional, and local interests groups for reducing the loss

[1]The structure is intended to compartmentalize the beach, not prevent material from nourishing downdrift beaches.

of valuable beach area. They restore the quality of the beach, prevent backshore damage and meet the future and present demand for recreational needs of the area.

DESIGN CRITERIA

Plans 2 and 3 were designed to provide needed erosion control protection against wave action experienced during frequent winter storms which generate waves from the southeast through southwest direction and to provide and preserve a much needed recreational beach. Pertinent design features are described below. (See Appendix 3 for details.)

DESIGN TIDE

The design tide selected is 10.0 feet above mean low water (7.2 feet NGVD) and is expected to occur with a frequency of about once in 3 years. The design tide elevation was selected as the maximum practical level that should be considered in constructing protection for the generally low-lying backshore area. (See Appendix 3 for details.)

DESIGN WAVE

The design wave height for the proposed improvement was determined in accordance with methods developed by the Office of the Chief of Engineers (OCE) and the Waterways Experiment Station (WES). The computed shallow water wave heights are the maximum heights that can be attained, based on the fetch, depth and duration. These heights were analytically reduced to allow for the effects of shoaling. The design wave is the maximum wave height that could occur at the beach based on Engineering Technical Letter (ETL) 1110-2-305. The design wave at the beach is a 4.2-foot breaking wave, with a 4.3-second period. (See Appendix 3 for details.)

WAVE RUNUP

Wave runup on the proposed structures and sandfill was computed for a storm estimated to occur with a frequency of once in 10 years, combined with a stillwater elevation of once in three years. An allowance was made for some erosion of the beach in selecting the wave height based upon past coastal engineering experience and conditions observed after storms. A 4.2-foot, 4.3-second wave occuring at the time of the design stillwater elevation (10.0 ft. MLW or 7.2 ft. NGVD) would runup approximately 0.50 feet above the proposed beach berm elevation, (11.0 ft MLW or 8.2 ft. NGVD) based on an average fronting beach slope of 1 vertical on 15 horizontal.

SANDFILL AND PERIODIC NOURISHMENT

To provide protection to the backshore and restore the recreational value of the beach, sandfill and periodic nourishment is recommended. The sandfill required should be clean and free of pollutants. A preliminary

study of potential offshore sandfill sources shows that the material in the area is very fine and does not meet the design criteria specified in the 1984 Shore Protection Manual. Commercial land-based sand meeting the specified criteria is available in the vicinity for beach project use. Detailed information on sandfill criteria is shown in Appendix 3 and also discussed under "Present Coastline" conditions in Appendix 2.

Annual periodic sand nourishment for the project is included as part of the construction cost. This sand nourishment is necessary to maintain project dimensions and is based on available historic data of losses that have occurred in the area. Periodic nourishment with a deferred structure and a beach monitoring program is recommended in lieu of a groin structure, which would be more costly and environmentally unacceptable. If it is found that nourishment costs are high, a timber groin structure with reduced maintenance will be considered.

GROIN DESIGN (Timber)

The timber groin structure was designed based on a stillwater elevation of 10.0 feet above mean low water and a 4.2-foot breaking wave. The top elevation of the landward end of the groin would be 11.0 feet above mean low water (8.2 feet NGVD). The intermediate sloped section would have the same steepness and slope as the proposed sandfill (1 vertical on 15 horizontal). This slope would continue until a 6-foot elevation is reached. This would place the head of the groin at approximately mean high water. This groin structure would replace the existing dilapidated timber structure. The construction of this structure would be deferred until it is determined if it is necessary. A monitoring program would be implemented to determine the need for the structure, based on sand loss of the placed fill after construction (see Appendix 3 for details).

CONSTRUCTION CONSIDERATIONS

Measures for the proposed plans would include measures to control the minor amount of temporary noise, air, and water pollution caused by the placement of sandfill on the beach and the work on the structure. Sandfill placed on the beach would be above MLW and since the material is in the intertidal zone and would eventually be redistributed by the waves and tides conforming to the natural slope of the area. It is felt that the impact in this area and seaward is considered to be insignificant. Other precautions would be taken to assure the quality of the sandfill would be consistent for the entire project. Sandfill placement on the beach would be restricted to spring placement with no construction beyond 30 June. This latter requirement would assure that construction would not interfere with the summer recreation season. Marsh grass transplanting of an area of saltwater cordgrass (spartina alterniflora) is also part of the beach restoration plan and would be implemented prior to placement of the sandfill. See Appendix 1 and 3 for details on transplanting.

ECONOMIC CONSIDERATIONS

Plans 2 and 3 would lead to a projected increase in both beach and shore protection. The economic evaluation was a regional analysis of the West Haven area and is based on beach usage and prevention of damages to and protection of the backshore walkway and the adjacent wall.

A benefit-cost analysis was used to determine the most practical and economically feasible plan. The benefits and costs were estimated using 1985 price levels and an interest rate of 8-3/8 percent, in lieu of 1986 price level interest rate of 8-3/8 percent. Benefits and costs of the plans of improvement are contained in Appendix 4. A summary of benefits and costs for Plans 1, 2 and 3 is contained in Table 1 (see page 19 Comparison of Detailed Plans).

The coastal community of West Haven is primarily residential, with the majority of homes being single family. Over the past several years, high-rise condominiums and housing for the elderly have been developed along the backshore. This provides easy access for residents, with only a minimum of transportation. West Haven owns almost the entire shoreline, approximately 4.4 miles of sandy beach. The city has implemented a master plan designed to improve its saltwater beaches. The plan includes improved access, lighting walkways and parks, additional parking, shuttle service, and sanitary and bathhouse facilities.

Communities along Long Island Sound generally have ample opportunity to enjoy the ocean, but inland metropolitan areas experiences from a shortage of public swimming opportunities. The Connecticut State Comprehensive Outdoor Recreation Plan (SCORP 1978-83) indicates a major deficiency of public swimming facilities within the state. Only 30 percent of the Connecticut shoreline consists of publicly-owned sandy beaches. Three are state-owned and 62 are community-owned.

Because many communities restrict their beaches to residents only, only about 16 percent of the shoreline is open to the general public. A 1977 survey, discussed in the Economics appendix, notes that approximately 30 percent of beach users are nonresidents. It is projected that demand for saltwater beach bathing will increase as the state population increases.

Annual recreation benefits were evaluated for provision of additional beach capacity at Okinawa and Sea Bluff Beaches by the placement of sandfill for three different berm widths (50, 75 and 100 feet) over a 50-year project life period (1987-2036).

Without-project conditions assume early widening of Prospect Beach (Corps action) and Savin Beach (state action) and subsequent Corps widening of Sea Bluff Beach.

Two incremental analyses were made, one assuming implementation of a project at Okinawa Beach, but with no project at Sea Bluff Beach where beach usage would decline to zero by 2007, because no dry beach space would exist because of ongoing erosion. A similar analysis was made for Sea Bluff Beach, assuming no project at Okinawa Beach where usage would decline to zero by 2007 because of ongoing erosion.

Allowing for inclement weather, a 60-day beach season was used for evaluation purposes. Recreation benefits for with-project conditions were taken only for peak day usage (25 days per year), as future beach capacity (measured at 75 square feet of beach area per person) appears adequate to handle average day use. West Haven officials have indicated intent to provide adequate parking facilities, based on a rate of four persons per car, to handle anticipated peak day usage at New Haven beaches.

The unit day value method was used for evaluating general recreation benefits, in accordance with Engineering Regulation 1105-2-40 (Manual of Procedures for Evaluation of National Economic Development Benefits). Connecticut State Comprehensive Outdoor Recreation Plan information (1978-1983) was used for projecting public beach area supply and demand. Approximately 70 percent of beach use would be by West Haven residents, and 30 percent by nonresidents.

Average annual recreation benefits were determined, using an interest rate of 8-3/8 percent, by subtracting recreation values under without-project conditions from recreation values for each of the two proposed projects.

It is assumed that the city will install revetments to protect backshore structues, such as a park and bicycle path behind Okinawa Beach and a road behind Sea Bluff Beach. Annual benefits would also accrue, if sandfill placement were implemented at both beaches, from reduction of periodic costs associated with flooding, such as revetment, road, bikeway and park repairs, and sand cleanup.

A detailed analysis of these benefits is contained in Appendix 4.

ENVIRONMENTAL SUMMARY

The West Haven Beaches project area has been highly altered. At Sea Bluff Beach the natural backshore is essentially gone, replaced by Ocean Avenue, the embankment for Ocean Avenue and parking areas serving the recreational users of Sea Bluff Beach. At Okinawa Beach the alteration has been somewhat less radical. Okinawa Beach is set in an area of open space which is maintained in a parklike setting. This area

consists mainly of regularly mowed lawn grass with scattered tree and shrubbery plantings. At the southwestern end of Okinawa Beach, where it connects into Bradley Point, a small area of saltmarsh vegetation exists.

In addition to the lack of remaining natural environment the biological resources of the project beaches are limited. Terrestrial vegetation, where found, is generally not natural to the beach backshore environment, but has been planted by the city of West Haven. Wildlife usage of the project area appears to be restricted to use as a feeding ground for a small number of sea and shore birds. The intertidal and subtidal areas of the project are also relatively devoid of life. Site investigations by the U.S. Fish and Wildlife Service revealed only sparse populations of soft shell clams (Mya arenaria), hard shell clams (Mercenaria mercenaria) and marine worms existing at either beach. The most productive habitat affected by the project is the small area of salt marsh at the southwestern end of Okinawa Beach. This marsh consists mainly of Spartina alterniflora with some Salicornia virginicum also present. The salt marsh is inhabited by numerous ribbed mussels (Modiolus demissus).

Bradley Point, Bradley Rock Beach and the mouth of the Cove River lie between the two project beaches. These areas will be unaffected by the project but are discussed in the Environmental Assessment due to their position adjacent to the proposed work areas and the significant contribution they make to the ecological diversity and value of the general project area.

The environmental impacts of the project are generally minor and short-term in nature. During the period of actual nourishment several short-term impacts will be evident. The trucking of sandfill to the project area will create a noise impact along the trucking route. At the project site the distribution and placement of sand will create a minor noise and dust impact. Placement of sandfill on the beach will also generate minor amounts of turbidity in nearshore waters as sediment is suspended into the water column by wave action during placement. Beach nourishment will bury and destroy the sessile benthic organisms in the intertidal areas where sandfill is placed. The new intertidal substrate created by beach nourishment should be rapidly recolonized with nearby undisturbed beach areas providing organisms for recruitment. The removal and replacement of existing groin structures with new groin structures will create a similar impact to organisms inhabiting these areas of hard substratum. Recolonization should again take place with Bradley Point and nearby groins providing recruitment organisms. The areas being impacted in this fashion are fairly unproductive and the number of organisms involved is quite small.

The placement of sand at Okinawa Beach will encroach upon the saltmarsh area at the southwestern end of the beach. Most of the saltmash area which will be impacted will be covered by sandfill to shallow 1-2 foot depths. The saltmarsh vegetation should be capable of pushing up

through this fill and recovering to its current vitality. Areas which will be covered to greather depths will be transplanted further out onto Bradley Point and re-established there. There will be no net loss of saltmarsh area.

Long-term impacts to the human environment will be virtually absent. No cultural, historical or archaeological resources are anticipated to exist within the project area, so none will be affected. Also the designated land use of the project area will remain unaffected by the proposed project.

The main social effect of the project will be an enhancement of the currently existing recreational opportunities available in the project area. Environmental quality improves with the project as sandfill will cover the rubble and debris that currently exists on the beach.

Both Sea Bluff and Okinawa Beaches receive heavy recreational use and are an important asset to the city of West Haven in this respect. The city of West Haven has adopted a master plan for the recreational development of these beaches and adjacent open space areas which would be complemented by a beach erosion control project utilizing beach nourishment.

PLAN 2 AND PLAN 3

PLAN DESCRIPTIONS

Both plans consist of beach widening to a level beach berm of 50, 75, or 100 feet to a backshore elevation of 11.0 feet above MLW (8.2 feet NGVD) by the direct placement of suitable sandfill along approximately 600 feet of shoreline plus the removal of a dilapidated timber groin structure and marsh grass transplanting. Plan 2 considers the deferred construction of a timber groin and Plan 3 considers the deferred construction of a rock groin, located at the northeasterly limit of the beach (see page 7 - Description of Plans).

IMPACT ASSESSMENT

Sandfill Impacts - The predominant direction of littoral drift at Okinawa Beach is not clearly understood. Based on past historic data, past surveys and knowledge of the littoral process in the area, it was determined that the losses at this pocket beach could be reduced if a better quality of sandfill (material with fewer fines) were used. The selection of the fill to be placed on the beach would be based on the guidelines set in the 1984 "Shore Protection Manual". Every attempt would be made to obtain fill that would be compatible with the color and texture

of the existing material. In the interest of a more accurate determination of sand movement in and around the beach, a series of post-construction surveys and monitoring programs would be scheduled. This would assist in comparing and evaluating the effects of the use of a better quality of sandfill material and the effect of groin construction on sand movement. It would also determine the need for the construction of the deferred groin structure, based on losses during the monitoring period.

The most serious impact is the temporary disruption of the bottom topography in the intertidal zone which could affect the nearshore environment. This adverse impact would be reduced by specifying that the proposed sandfill material contain a low percentage of fine material, thereby reducing the turbidity caused by the placement of the sandfill. The 15 horizontal on 1 vertical slope would reduce the extent to which the toe of the sandfill extends into the water. This foreshore slope would minimize the impacts on benthic organisms that could be buried by the sandfill.

Shoreline Impacts - Due to the better quality (material with fewer fines) of sandfill proposed to be placed on the beach, the rate of erosion of the shoreline would be reduced. The proposed sandfill placement would extend the MHW line seaward from its existing location, approximately 122 feet for the 50-foot level berm, 147 feet for the 75-foot level berm, and 172 feet for the 100-foot level berm. This would provide much needed beach bathing space and provide protection to the backshore area from storm-driven waves. Periodic nourishment is recommended to maintain the shoreline at or near design dimensions for the 50-year life of the project. The normal alongshore and offshore sand movements were taken into account for this beach nourishment program. No long-term adverse impacts are foreseen at Okinawa Beach or on the adjacent shorelines for Plans 2 and 3, except during construction.

Short-Term Impacts - The proposed sandfill would be placed along the backshore and then distributed within the intertidal zone by normal tidal action and heavy equipment, with natural tidal action distributing the sand further seaward. It is anticipated that most of this material would stay within the beach limits. The beachfill would erode naturally through normal wave and tidal current action. The sand losses offshore and alongshore would be greatly reduced with use of a better quality of material (material with fewer fines). The natural tide and wave action would distribute the placed material and determine the natural slope of placed sandfill.

Nearshore Impacts - Sandfill placed in the nearshore area and the construction of the groin would have little or no impact on marine life in the area.

Long-Term Impacts - Long-term impacts would only occur as a result of the groin structure. The construction of the groin structure would destroy the sessile benthic marine life beneath the structure. This

impact would only be minimal as the area involved is small and new benthic marine species suited to the subsurface provided by the groin would be attracted and colonize there. The new groin structure would also reduce sand losses. The recolonization of the saltwater cordgrass on the southern project limit would have positive long-term impacts. If cordgrass transplanting were not part of the plan, initially placed sandfill on the beach would cover the grass, destroying some of this natural habitat.

Economic Impacts - There are no significant adverse economic impacts as a result of the proposed beachfill. The impacts that result from the placing of sandfill are mostly positive and any adverse impacts are short-term.

Social Impacts - Temporary disruption on local roads and increased noise and dust levels would result from construction of the project. These impacts would be greater for the wider berm width plans with longer and higher groin structures, as related to the total amount of material requiring transfer to the site.

EVALUATION AND TRADE-OFF ANALYSIS

Plans 2 and 3 would provide additional beach bathing space, protect the backshore embankment, walkway, park and parking area, and prevent minor flooding. Storm-driven waves would no longer erode the backshore embankment but would break seaward of the proposed sandfill. A trade-off to these plans is that by constructing the project, additional benefits would be obtained through restoration of the beach and protection to the backshore. Another trade-off is by shortening the beach width and not extending the beach seaward into the intertidal area, the environmental impacts would be minimized. Construction of the project would provide recreational benefits as well as backshore protection.

PUBLIC VIEWS

All of the public views expressed to date have been favorable with respect to the construction of this improvement.

IMPLEMENTATION RESPONSIBILITIES

The purpose of the project is to prevent backshore damage and provide beach related recreation. There are no other components in the Federal project beyond sandfill and groin construction.

The city now provides life guards and bathhouse facilities and the area conforms to the necessary requirements for maximum cost-sharing. This beach qualifies as a "Publicly-Owned Shore, Park and Conservation Area," and is eligible for up to 70 percent Federal cost sharing.

The Federal Government would contribute 70 percent of project construction and periodic nourishment cost up to a $1,000,000 limitation.

Groin maintenance, if necessary, is completely a non-Federal responsibility. In addition, any project costs in excess of the Federal limitation are a non-Federal responsibility.

Non-Federal responsibilities - The recommended Federal beach erosion control project would be subject to the conditions of non-Federal local cooperation as shown in the recommendations at the end of this section. In addition, non-Federal interests would be responsible for permanent diversion of freshwater drainage runoff away from the beach, as necessary, prior to construction.

COMPARISON OF DETAILED PLANS

Plans 2 and 3 were compared to the without-project conditions. The two plans would require the placement of suitable sandfill with a deferred retention structure. Both plans would restore the beach and satisfy the ever-growing demand for much needed dry beach space at Okinawa Beach. The placement of sandfill and periodic nourishment would provide backshore protection for the embankment, walkway, backshore park area and flood prevention. The shoreline to the east is owned by the city and would not be significantly impacted by the project.

Plan 2 would utilize the deferred construction of a timber groin structure at the northeastern limit of the beach, with the top elevation at the beach berm elevation. This plan would require the removal of the existing timber groin structure and the reconstruction of a new timber groin to maintain shore alignment of the placed sandfill. The proposed deferred groin in Plan 2 would not cause any adverse effects to the adjacent shoreline areas beyond the beach. It would replace the existing timber structure.

Plan 3 is similar to Plan 2 except that the annual costs are more expensive for a rock groin as it is much cheaper to replace a timber groin as needed than maintain a rock groin. Therefore, the plan does not optimize the net benefits. Also, plan 3, with its proposed rock structure would require excavation and a much greater disruption of the subsurface area and more costly maintenance. This would environmentally impact the natural habitat in the immediate area of the groin.

Table 1 compares Plans 1 through 3, the considered sandfill plans. The costs and benefits are based on October 1985 price levels. An interest rate of 8-3/8 percent was used over the 50-year period of analysis. Plan 2, with the deferred timber groin structure is the least expensive plan. It optimizes the net benefits and provides a greater B/C ratio. Therefore, Plan 2 was selected. Table 2, the NED plan, appears at the end of this main report.

Environmental Comparison - Consideration was given to the natural processes of the beach, offshore areas and the adjacent shore when

TABLE 1
BENEFITS AND COSTS FOR CONSIDERED PLANS *

PLAN	BERM WIDTH FT	TOTAL FIRST COST $	OKINAWA BEACH 70-30 COST SHARING				ANNUAL BENEFITS $	ANNUAL COST (1) $	B/C RATIO	NET BENEFITS $
			$ COST SHARING		$ ANNUAL COST					
			FEDERAL	NON-FED	FEDERAL	NON-FED				
1	50	224,600	157,200	67,400	23,100	9,900	51,100	33,000	1.6	18,100
	75	297,,200	208,000	89,200	32,500	13,900	63,600	46,400	1.4	17,200
	100	380,400	266,300	114,100	43,200	18,500	75,200	61,700	1.2	13,500
2	50	270,300	189,200	82,000	21,000	10,000	51,100	31,000	1.7	20100
	75	350,000	245,000	105,000	28,300	13,100	63,600	41,400	1.5	22,200
	100	450,600	315,400	135,200	37,200	17,000	75,200	54,200	1.4	21,000
3	50	270,900	189,600	81,300	21,100	13,000	51.100	34,100	1.5	17,000
	75	350,600	245,400	105,200	28,400	16,100	63,600	44,500	1.4	14,100
	100	440,700	308,500	132,200	36,600	19,800	75,200	56,400	1.3	18,800

* assuming 50 - ft. berm selected at Sea Bluff.

(1) annual cost varies because of annual maintenance cost difference between timber and rock groin str..

developing plans for Okinawa Beach. The wider berm-width alternatives of both Plan 2 and Plan 3 would incrementally cause greater impacts on organisms and habitat in the intertidal and nearshore zones. A higher and longer groin structure then designed would not be environmentally acceptable. It would not allow material to move freely downshore and would be considerably more expensive than a smaller structure with periodic nourishment.

Care would be given to all marine life during construction. This would be done by placing a better quality of sandfill, containing less fine materials, on the beach, which would reduce losses from wave action and would result in less marine life being covered up by sediments. This would also maintain the present high water quality of the area.

Table 3, titled "Summary Comparison of Alternative Plans," is a general evaluation of considered plans of improvement and includes the determining factors in selecting the options of improvement for Okinawa Beach. This is accomplished by displaying the significant beneficial and adverse impacts. The table accurately evaluates the analysis that leads to a final decision. (See end of main report).

RATIONALE FOR SELECTED PLAN

Plan 2 with a 75-foot level beach berm was selected for implementation as it provides the maximum net benefit, represents the best engineering solution, and causes the least adverse environmental impacts of the plans considered. The 100-foot berm provides greater protection, but it would be environmentally more damaging than the 50- or 75- foot berms. The wider berm width and the longer structure would have greater impact on the habitat in nearshore and offshore areas. Plan 2, with the deferred construction of a timber groin structure at the northeastern limit of the project, would reduce alongshore losses as well as maintain shore alignment. The low-profile structure would allow windblown sand to move downshore. A detailed engineering analysis determined that Plan 2, with a 75-foot wide level berm, would be the most suitable plan to stabilize and restore the existing beach and provide protection to the backshore area from future erosion and damage. The two other plans were not as cost effective and would not produce any additional benefits to the beach. Although beneficial, the 50- and 100-foot berms did not optimize net benefits and therefore were not selected.

CONCLUSIONS

The proposed project has been reviewed and evaluated with the public interest in mind. The review included an evaluation of all pertinent data concerning the proposed plan of improvement. It has considered the stated views of local interests, public officials and other interested agencies relative to the various alternatives for beach erosion control improvements at Okinawa Beach.

The possible impacts of the proposed improvement have been studied relative to engineering feasibility, environmental effects and economic and social factors. The details of these issues have been stated in the formulation of the plans of improvements and can be found in other sections of this report.

In summary, there are substantial benefits to be derived from providing an erosion control recreational beach erosion improvement at Okinawa Beach.

Table 3, Summary Comparison of Alternative Plans, presents the determinining factors that underlie each final alternative plan by displaying the significant beneficial and adverse impacts. This table was utilized for the purpose of a trade-off analysis and final decisionmaking.

It should be noted that the proposed improvement would temporarily disrupt the environment during construction at the beach. However, these impacts are not considered significant and are so stated in the Environmental Assessment and Finding of No Significant Impact Appendix 1.

The proposed action, as stated in this report, is based on a thorough analysis and evaluation of various practical alternative courses of action for achieving the stated objectives. Each plan was either abandoned or evaluated based on its merit in achieving the specified objective. The recommended action is consistent with national and regional policies, statutes, and administration directives, and should best serve the intended use and interests of the general public and the concerned agencies.

RECOMMENDED PLAN

The recommended plan of improvement for Okinawa Beach, Plan 2, entails beach widening by the direct placement of a suitable sandfill along approximately 600 feet of shorefront and providing for a 75-foot wide level beach berm at elevation 11.0 above feet mean low water (8.2 feet NGVD) and a dry beach above the mean high waterline approximately 147 feet wide. Also included is the removal of the existing timber groin structure and deferred construction of a timber groin structure (if needed) at the northeastern end of the beach, a beach monitoring program, and transplantation of saltwater cordgrass (*Spartina alterniflora*). This plan would provide the needed backshore protection and restore protective beach space. A beach monitoring program should be established for a 5-year period in order to evaluate the newly constructed beach.

TABLE 2

OKINAWA BEACH SELECTED PLAN COST
THE NED PLAN

Item	NED Plan
Length of Project (feet)	600
Length of Beachfill (feet)	600
Volume of Initial Beachfill (c.y.)	16,000
Volume of Periodic Nourishment (c.y.)	800
Groin Structure (Timber l.f.)	190
First Cost	$350,000
Cost Sharing	
Federal	$245,000
Non-Federal	$105,000
Annual Cost	
Interest and Amortization	$ 30,000
Periodic Nourishment	$ 10,400
Groin Maintenance	$ 1,000
Total Annual Cost	$41,400
Annual Benefits	$ 63,600
Net Benefits	$ 22,200
Benefit-to-cost-ratio	1.5
Nourishment and Maintenance for 49 of 50 Year Project Life	
Maintenance (Groin)	
Federal	0.0
Non-Federal	$49,000
Periodic Nourishment (Sandfill)	
Federal	$357,700
Non-Federal	$151,900
Total Nourishment and Maintenance Cost	$558,600

The Federal share in periodic nourishment, construction, and study costs cannot exceed the $1,000,00 Federal limitation. Current estimates indicate that approximately $360,000 is available for the Federal share in periodic nourishment for the NED plan. $25,000 of this money will be used for post-construction monitoring.

RECOMMENDATIONS

The Division Engineer recommends the plan discussed in the previous section "Recommended Plan" as the most practical, economical and environmentally suitable plan of improvement for Okinawa Beach. Approval of the beach erosion control project by the Chief of Engineers is recommended under the provisions of Section 103 of the River and Harbor Act of 1962, as amended. The project, with such modifications that the Chief of Engineers may deem advisable, is estimated to have a total first cost of $350,000 which includes the cost of the first year of periodic nourishment.

I further recommend that Federal participation be authorized in the amount of $245,000 or 70 percent of the first cost of construction of the project, which is estimated to be $350,000, and annual periodic nourishment for the 50-year period of economic analysis. The non-Federal share of the first cost is $105,000. (For detailed cost estimates, See Table 3.)

Federal participation in the recommended project is subject to the following conditions of local cooperation:

1. The local sponsor (city of West Haven) will agree to:

a. Contribute prior to construction, in cash, 30 percent of the first cost of construction and the deferred timber groin construction, if found necessary, including the cost of plans and specifications (total project costs are currently estimated to be $350,000); a final apportionment of first costs will be made after actual costs and values have been determined.

b. Assume full responsibility for all project costs in excess of the Federal cost limitation of $1,000,000, which includes the cost of construction and periodic sand nourishment for the 50-year period of analysis and all other study costs.

c. Maintain continued public ownership of the beach and shore and its administration for public use during the 50-year period of analysis of the project by establishing, prior to construction, a boundary control line which will separate public property from private property used for the realization of the public benefits upon which Federal participation is based.

d. Provide, without cost to the United States, all lands, easements, and rights-of-way necessary for project construction and subsequent maintenance of the project.

e. Hold and save the United States free from all claims for damages that may arise before, during or after prosecution of the work and subsequent maintenance of the project other than damages due to the fault or negligence of the United States or its contractors.

f. Maintain the protective measures during the economic life of the project as may be required to serve their intended purpose by contributing, in cash, 30 percent of the cost of periodic nourishment, and provide 100 percent of the cost of the timber groin maintenance for the 50-year economic life of the project. Such contributions are to be made prior to each nourishment operation. If the Federal limitation of $1,000,000 is reached, the non-Federal interests are responsible for 100 percent of the cost of periodic nourishment. The estimated amount of periodic sand nourishment is 800 cubic yards annually.

g. Control water pollution to the extent necessary to safeguard the health of bathers.

h. Provide, if necessary, at no cost to the Federal Government, a drainage modification to divert freshwater runoff away from the beach.

i. Comply with the requirements of non-Federal cooperation specified in Sections 210 and 305 of Public Law 91-646, approved 2 January 1971, entitled the "Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970."

j. Comply with Title VI of the Civil Rights Act of 1964 (78 Stat 241) and Dept. of Defense Directive 5500.11 issued pursuant thereto and published in Part 300 of Title 32, Code of Federal Regulations.

k. Provide, as may be necessary, additional parking or transportation to the beach during the beach season.

Thomas A. Rhen
Colonel, Corps of Engineers
Division Engineer

The recommendations contained herein reflect the information available at this time and current Departmental policies governing formulation of individual projects. They do not reflect program and budgeting priorities inherent in the formulation of a national Civil Works construction program nor the perspective of higher review levels within the Executive Branch. Consequently, the recommendations may be modified before they are transmitted to the Congress as proposals for authorization and/or implementation funding.

ENVIRONMENTAL ASSESSMENT, FONSI, AND 404 EVALUATION

PREPARED BY:

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Elizabeth A. Parfenuk, Biologist

I. ENVIRONMENTAL ASSESSMENT

A. INTRODUCTION

The city of West Haven, in a letter dated 28 April 1980, requested the Corps of Engineers to undertake a Small Beach Erosion Control Study. This study originally focused on Sea Bluff and Bradley Rock Beaches but Bradley Rock Beach was dropped as part of the study in June of 1983. This was done because of the ecological importance of the habitat present at Bradley Rock Beach. Okinawa Beach, located immediately east of Bradley Point was substituted as a possible alternative site for beach improvement. This Environmental Assessment evaluates separate proposed projects at Sea Bluff and Okinawa Beaches.

B. JUSTIFICATION AND NEED

1) NEED

Over the years Sea Bluff Beach has experienced the loss of valuable recreational beach area due to storm driven waves and winds. The average rate of erosion at Sea Bluff Beach is 1-2 feet per year, and it has experienced up to 5 feet of erosion in some years. Okinawa Beach has experienced similar conditions. Erosion is particularly severe during storms that last over several tidal cycles with elevations above normal stillwater elevations. Local interests have become increasingly concerned about the erosion problems at these beaches. They have experienced an increase in beach use and are projecting this increase in beach use to continue in the future.

2) AUTHORITY

This study is being conducted under the authority of Section 103, Beach Erosion Control, of the River and Harbor Act of 1962, as amended.

C. PROPOSED PLANS

General plan. The proposed plans call for a program of beach restoration which consists of beach widening to a level beach berm width of 50 feet for Sea Bluff Beach and 75 feet for Okinawa Beach, with a backshore elevation of 11.0 feet above mean low water and a foreshore slope of 1 vertical on 15 horizontal. This would be accomplished by direct placement of suitable sandfill along approximately 600 feet of shoreline at Okinawa Beach and 1000 feet at Sea Bluff Beach. Sandfill for the project would be obtained from a commercial land-based source. Five potential sources of suitable sandfill have been identified, in southern Connecticut, within a 35-mile radius of the project area.

Also included at Sea Bluff Beach is the reconstruction of the existing rock groin structure; at Okinawa Beach the existing timber groin

structure would be removed and a new structure authorized for approximately the same location, but its placement would be deferred.

The projects would require an estimated 25,000 cubic yards of sandfill which would be trucked to the beaches and placed at or above the mean high waterline. The fill would then be spread out by bulldozer or front-end loader to the desired berm dimensions. The natural tidal flow of the area would distribute the fill material below the mean high waterline. No fill would be directly placed below the mean low waterline.

Special Provisions. At Okinawa Beach the foreshore slope of the placed sandfill would be varied at each end of the beach. This would reduce the slope of the sand near a small area of salt marsh vegetation at the western end of the beach. Approximately 3000 square feet of this salt marsh area would be covered by sandfill to establish a 75-foot wide berm along Okinawa Beach. To compensate, this thickly covered salt marsh would be transplanted to an adjacent bare surface area within the existing marsh system. This area would be prepared by first placing a sand pad to put the salt marsh at a suitable tidal elevation. The remainder of the salt marsh would only be slightly affected and would be able to reestablish itself. The remains of the timber terminal groin at the eastern end and 8 to 10 old dock pilings located at the western end of Okinawa Beach would be cut off or removed to eliminate the safety hazard they pose for beach users. Also, one storm drain adjacent to the existing beach would have to be modified to continue functioning properly.

Periodic Nourishment. The project would have a 50-year economic life-span and is expected to require periodic nourishment during that time. Anticipated periodic nourishment needs will be approximately 425 cubic yards per year. It is estimated that nourishment and maintenance operations would take place annually. These estimates are based on level berm widths stated in the General Plans Section.

Groin Option. The reconstructed beaches are scheduled to be monitored for approximately 5 years after construction. If, after this time, excessive sand losses are found to be occuring then consideration would be given to constructing the groin structures at Okinawa Beach. At Okinawa Beach this provision would consist of replacement of the existing timber terminal groin located at the eastern end of the beach. This deffered structure would be replaced by a new timber groin of the same size or slightly longer.

D. ALTERNATIVES CONSIDERED

1) NO ACTION

The present rate of erosion in the project areas is on the average of 1.0 to 2.0 feet per year and sometimes as high as 5.0 feet per year. If improvements are not made, the existing dry beach width at Sea Bluff and Okinawa Beaches will decrease rapidly. By the end of the 50-year project life the beaches will probably be badly deteriorated and erosion of the

backshore could be a problem. As these are heavily utilized recreational beaches allowing their continued deterioration is not considered to be a desirable course of action. Also the city of West Haven has extensive plans to develop the adjacent 17-acre Bradley Point area for public access and recreational use which will be implemented regardless of whether or not beach nourishment takes place. Nourishment of Sea Bluff and Okinawa Beaches would complement these plans by protecting the area from coastal erosion, enhancing the recreational opportunities available and increasing the area's aesthetic appeal.

2) NONSTRUCTURAL ALTERNATIVES

a) SHORELINE MANAGEMENT

A shoreline management plan consisting of planning guidelines for managing the use of the backshore facilities and providing for future public participation in water related activities could be implemented. This plan would include such items as restricting the number of beach users on peak days, erecting sand fencing and controlling access onto the beach. This alternative is inadequate by itself since it does not provide any increased benefits (increased recreational space, etc.) for the beaches and fails to meet all the needs of the present problem. Such a plan could be implemented by the town of West Haven and should certainly be incorporated into West Haven's master plan for the Bradley Point area.

b) ALTERNATIVE SAND SOURCES

Sea Bluff Beach is fronted by a large tidal flat which could possibly be used as a source area for some of the sandfill for Sea Bluff Beach (Michael Ludwig, NMFS, per com. 5 September 1984). The tidal flat is a dynamic environment with a large volume of sediment constantly in motion. Consequently, the benthic population on the tidal flat is quite small and use of this material would not have a significant biological impact. The main problem with using material from the tidal flat is that it is probably predominantly finer grained sediment which is too fine for use as beach nourishment material. It may still be possible to use this material to provide a base which could be overlain with a thick blanket or layer of more suitable, larger grain size, material to provide protection against erosion. This possibility will be investigated during final plans and specifications.

c) ALTERNATIVE BEACH AREAS

Bradley Point Beach which was originally considered for beach nourishment has been found to be an ecologically significant area. It will be left undisturbed and used only for passive recreational activities, such as fishing, and by local schools for ecology classes. The town plans to improve the 17-acre Bradley Point area which will encourage these uses.

d) ALTERNATIVE BERM WIDTHS

Several level beach berm widths of 50,75 and 100 feet were considered for both Okinawa and Sea Bluff Beaches. These alternatives would create impacts identical to those created by the recommended beach plan except that the magnitude of impacts would vary. Similarly, they would provide varying amounts of dry beach space and different levels of protection against beach erosion and backshore protection.

3) STRUCTURAL ALTERNATIVE

a) ROCK REVETMENT

Protection against erosion of the backshore could be provided by construction of rock revetments. This alternative would require a revetment 600 feet long at Okinawa Beach and one 600 feet long at Sea Bluff Beach. This alternative would not guarantee preservation of the existing recreational beach space nor would it provide any additional beach space. This comparative lack of benefits renders this option economically unjustifiable.

b) OFFSHORE BREAKWATER

Some limited protection could be provided to the shoreline by construction of offshore breakwaters. A breakwater 1000 feet long and 2000 feet offshore at Sea Bluff and another 800 feet long and approximately 1000 feet offshore at Okinawa Beach would be necessary to provide adequate protection to the project beaches. This alternative would only protect the existing beaches from further erosion. It would not prevent beach overtopping at above normal tides and storms. This fact together with the high cost of constructing a breakwater renders this alternative unjustifiable.

E. AFFECTED ENVIRONMENT

1) PHYSICAL ENVIRONMENT

a) MORPHOLOGY

Sea Bluff, Bradley Rock and Okinawa Beaches are located on the northern shore of Long Island Sound in West Haven, Connecticut, toward the mouth of the New Haven Harbor.

Sea Bluff Beach extends 1000 feet southwesterly from the mouth of the Cove River to the eastern end of Prospect Beach and faces to the southeast. At mean high water the average dry beach width varies between 25 feet at the west limit and 45 feet at the east limit. At low tide a tidal flat is exposed and extends out approximately 900 feet from the beach. The present foreshore slope is 1 vertical on 9 horizontal near mean high water changing to 1 vertical on 250 horizontal near mean low water. Longshore transport appears to result in net transport of sand toward the

northeastern end of the beach. At the northeastern end of the beach there is typically a sand bar present, oriented approximately perpendicular to the shoreline. At the extreme northeastern end of the foreshore slope is much steeper than average. This form probably represents an equilibrium distribution of sediments between longshore littoral currents and discharge from the Cove River.

Bradley Rock Beach, which will remain undisturbed, extends 600 feet east from the Cove River to Bradley Point and faces south. At mean high water the average dry beach width is approximately 15 feet. At low tide a tidal flat is exposed and extends out 300 feet. An existing alongshore revetment protects the inland area behind Bradley Rock Beach from wave attack and erosion.

Okinawa Beach extends 600 feet northeasterly from Bradley Point and, like Sea Bluff, faces to the southeast. At mean high water the average dry beach width is 35 feet. The present foreshore slope is 1 vertical on 10 horizontal near mean low water. The pattern of littoral transport at Okinawa Beach is not clearly understood. It is believed that Okinawa is a pocket beach with sediment transport proved or demonstrated. Although it seems probable (based upon site visits) that there is some net longshore transport to the southwest and a local drift reversal caused by Bradley Point, on and offshore losses prevail at this beach.

All three beaches are composed of well sorted medium to fine grained sand. The backshore area along Okinawa, Bradley Rock and about half of Sea Bluff is composed of artificial fill (see Figure 1) which is at least 5 feet thick and appears to probably cover former tidal marsh and tidal flat deposits. The original configuration of the shoreline before placement of this fill is not known. Behind the area of artificial fill, tidal wetlands still persist on the flood plain of the Cove River.

The Cove River, which flows out between Sea Bluff and Bradley Rock Beaches, is a small coastal stream less than 10 miles long which is blocked at its mouth by an old tidal gate. No anadromous fish appear to use the Cove River (Peter Menta, Connecticut Fisheries Unit per. comm. 23 August 1984). Therefore, project operations would not interfere with any spawning runs. The Cove River and its associated marshes would remain entirely unaffected by the proposed plan of action.

Bradley Point which lies between Bradley Rock and Okinawa Beaches has bedrock (phyllite) exposed at its outer end but is largely composed of artificial fill. The fill is held in place by several small retaining walls. There have been subjected to wave attack and are in a state of advanced disrepair. These walls should be repaired or replaced to prevent erosion of the fill behind them. Such work would have to be performed by the city of West Haven. Before the fill was placed, Bradley Point may have existed as a rock islet or may have been joined to the mainland by a sand spit and tidal wetlands.

b) HYDRODYNAMICS SETTING

The dominant waves in the study area are storm generated wind waves approaching from the southeast through the southwest. The design wave generated for this study is a breaking wave with a height of 4.2 feet and a period of 4.3 seconds.

Tides in the area are semi-diurnal. Mean and Spring tide ranges in the study area are 6.2 and 7.3 feet above mean low water respectively. A design tide of 10.0 feet above mean low water was selected for design purposes. The highest tide that has occurred in the study area was 13.8 feet during the 1938 hurricane.

Water Quality. The waters of New Haven Harbor in the project area are designated class SB-SC by the Connecticut Dept. of Environmental Protection. Class SB waters are suitable for bathing and other recreational purposes, industrial cooling, and shellfish harvesting for human consumption after depuration; they are excellent fish and wildlife habitat and have good aesthetic value. Class SC waters are suitable for fish, shellfish and wildlife habitat; suitable for recreational boating and industrial cooling and have good aesthetic value.

2) BIOLOGICAL RESOURCES

a) VEGETATION

Salt Marsh Areas. Bradley Point creates a practical wave shadow on its flanks in which small areas of salt marsh vegetation have become established on both its eastern and western sides. On the eastern flank and out onto the western end of Okinawa Beach a small area of salt marsh exists which consists of *Spartina alterniflora* and some *Salicornia virginicum*. On the western flank of Bradley Point and out onto the eastern end of Bradley Rock Beach a slightly larger area of saltmarsh exists consisting solely of *Spartina alterniflora*.

Hard Substrate Areas. The outcropping of phyllitic bedrock on Bradley Point supports the growth of rockweed (*Fucus spp.*), green sea lettuce (*Ulva lactuca*) and additional algal species in the intertidal and subtidal zones.

Backshore Upland Areas. The backshore area at all three beaches is highly developed. Directly behind Sea Bluff Beach and running parallel to the shoreline is a roadway. Behind Bradley Rock and Okinawa Beaches is a park area consisting mainly of lawn grass with a few scattered tree and shrub plantings.

b) BENTHIC RESOURCES

Beach Areas. The U.S. Fish and Wildlife Service conducted site visits to the two project beaches and Bradley Rock Beach in 1938 and 1984. At Okinawa Beach they dug numerous test pits resulting in a total take of 1 soft clam (Mya arenaria) and 1 hard clam (Mercenaria mercenaria). Marine worms were noted throughout the area but were not abundant. While it is evident that shellfish can be found within the immediate area of Okinawa Beach, it appears that a significant population does not exist. The comment/response section contains additional information on shellfish resources on this beach received during the public comment period (Mr. Gordon Beckett, U.S. Fish and Wildlife Service letter dated 10 January 1986).

At Sea Bluff test pits dug by the U.S. Fish and Wildlife Service indicate that some soft-shell clams are present but that a large population does not exist (thirteen random test pits yielding only one clam). The comment/response section contains additional information on shellfish resources on this beach received during the public comment period (Mr. Gordon Beckett, U.S. Fish and Wildlife Service letter dated 10 January 1986).

Bradley Rock Beach, a small cove-like area, supports a significant population of soft-shell clams (Mya arenaria). A survey conducted by the U.S. Fish and Wildlife Service and Conn. Aquaculture in February 1983, yielded an average of 3.6 clams per test pit. The area also provides good habitat for other invertebrate species such as snails, worms, and crabs. When visited the beach was covered with algae and remains of horseshoe crabs (Limulus polyphemus) that had washed up to shore along the mean high water line.

Hard Substrate Areas. In addition to marine vegetation the bedrock outcrops on Bradley Point support a diverse community of barnacles (Balanus spp.), blue mussels (Mytulis edulis), periwinkles (Littorina spp.), and oyster spat (Crassostrea virginica). The small groin at the end of Sea Bluff Beach also supports a small population of barnacles, blue mussels, periwinkles and oyster spat.

Salt Marsh Areas. The U.S. Fish and Wildlife Service noted that numerous ribbed mussels (Modiolus demissus) inhabited the small salt marsh areas on the flanks of Bradley Point.

Offshore Areas. There are significant commercial oyster (Crassostrea virginica) and hard clam (Mercenaria mercenaria) grounds in the offshore area. The inshore boundary (Connecticut Department of Agriculture, Aquaculture Division, Map of New Haven and West Haven Oyster Ground, February 1981.) of these grounds is approximately 1,000 feet or more offshore from the projecet area.

c) FINFISH RESOURCES

Finfish species found in the area include winter flounder, Pseudopleuronectes americanus), sand dabs (Citharichthys spp.), blackfish (Taytog spp.), summer flounder (Paralichthys dentatus), scup (Stenotomus chrysops), Searobins (Prionotus spp.), cunner (Tautogolabrus adspersus), bluefish (Pomatomus saltatrix), mackerel (Scomber spp.), weakfish

(Cynoscion regalis), and striped bass (Morone saxatilis). The general area, especially Bradley Point, is quite heavily utilized by fishermen with the most frequently caught species being winter flounder and bluefish.

d) OTHER WILDLIFE

Three swallows (Tachycineta bicolor) were observed in the saltmarsh area located adjacent to Bradley Point. Herring gulls (Larus argentatus), laughing gulls (Larus atricilla), and a snowy egret (Egretta thula) were found occupying the shores of Sea Bluff Beach. A great blue heron (Ardea herodias) was sighted just outside of the project area. These species appear to be utilizing the project area as a feeding area only and nest somewhere outside of the project area.

e) ENDANGERED SPECIES

No threatened or endangered species of fauna or flora, or their critical habitat have been identified as existing in the project area (U.S. Fish and Wildlife Service, letter, 21 November 1984) (National Marine Fisheries Service, letter, 21 November 1984).

3) SOCIAL AND ECONOMIC RESOURCES

The West Haven area around Sea Bluff and Okinawa Beaches is very residential. For this reason many of the beachgoers walk to the beach. Sea Bluff Beach has a parking lot which provides parking for approximately 50 cars. Okinawa Beach has a parking lot which provides parking for approximately 45 cars. Access to these beaches is also provided by public transportation.

4) HISTORIC AND ARCHAEOLOGICAL RESOURCES

Soils and surficial geology maps indicate that the entire study area, with the exception of Bradley Rock, consists of fill deposited some time between 1870 and 1949.

Given the above data, and the eroding condition of the beaches, no significant archaeological resources are expected to be present within the study area.

F. ENVIRONMENTAL EFFECTS

1. PHYSICAL EFFECTS

Beach nourishment operations would potentially cause occurences of localized and minor turbidity. Due to the coarse nature of the material involved in restoring the project, any material which is placed in suspension would rapidly settle out. Also, because of the method of construction, any turbidity which is caused during construction should be

no more than the level of naturally occuring, storm-induced, turbidity and should be of shore duration. Water quality should not otherwise be altered by project activities as the sandfill being placed would be clean and free of contaminants.

Trucking of sandfill to the project area would cause a noise impact to the adjacent areas. Any route taken to the project area would require 2 to 3 miles of travel through residential and commercial areas. The estimated 24,500 cubic yards of sandfill, necessary to complete both projects, would require some 1500 truckloads to be brought into the project site.

A minor noise and duct impact would also be created in the project area by the trucks unloading sand and by the construction equipment distributing the material onto the beach face. The impact on air quality caused by beach nourishment operations and possible groin construction would be negligible.

2) BIOLOGICAL EFFECTS

a) SALT MARSH.

The main impact resulting from project construction would be the burial of a small area of saltmarsh vegetation mostly comprised of *Spartina alterniflora* at the eastern end of Okinawa Beach. Approximately 3000 square feet of marsh growth would be covered by nourishment operations. This loss of salt marsh can be compensated for by transplanting (Knutson 1983). The transplant site must be prepared by placement of a sand pad so that the transplanted marsh would be at a suitable tidal elevation (within the top two thirds of the tidal range). The remainder of the impacted marsh, approximately 2000 square feet, would be impacted by tidal action on the placed sandfill during construction. That portion of the impacted marsh should be capable of growing through the sandfill and reestablishing itself (Michael Ludwig, National Marine Fisheries Service, per. comm. 5 September 1984). The loss of salt marsh would therefore be compensated.

b) BENTHIC ORGANISMS.

Approximately 150,000 square feet of intertidal habitat at Sea Bluff and Okinawa Beaches would be covered by sandfill. The sessile and infaunal benthic organisms which inhabit these areas would be destroyed by burial. Other more mobile organisms would be able to avoid the project area during the time of construction.

Recovery of the disturbed areas would occur reasonably fast by organisms relocating from the surrounding areas. Reilly and Bellis (1979) predicted that recovery of a nourished beach should occur within one or two seasons following implementation of a project. Parr, Dieher, and Lacy (1978) reported only short-term effects, 5 weeks or less, and noted

increases in the abundance of motile crustaceans and evidence of planktonic recruitment of polychaetes.

The physical characteristics of the substrate would remain very similar both before and after nourishment which should also facilitate recolonization by similar organisms Whitlatch (1982).

Replacement of the groin at Sea Bluff Beach would cause the temporary removal of a small area of hard substratum and any benthic fauna or flora associated with it. Recolonization of the new groin from adjacent areas (other nearby groins, Bradley Point) would take place relatively rapidly. The surface area and number of organisms involved is small and any impact associated with groin replacement would not be significant.

c) FISH AND WILDLIFE.

Fish occupying the vicinity of the project area should not be affected by project activities and could avoid work areas if necessary. Food from the surf zone for shore birds and other wildlife will decline temporarily (about one growing season - see reference in benthic organisms section). Neighboring areas such as Prospect Beach should provide an adequate substitution until the project area has recovered.

3) SOCIAL AND ECONOMIC EFFECTS

The proposed beach nourishment project would not affect the current land use plans held by the city of West Haven. The project beaches and the entire Bradley Point area would be maintained as open space and for park use. The project also would not encourage development of the surrounding area.

The project would enhance the recreational opportunities available in the area and help meet the demand for additional beach space.

4) HISTORIC AND ARCHAEOLOGICAL EFFECTS

Soils and surficial geology maps indicate that the entire study area, with the exception of Bradley Rock, consists of fill deposited some time between 1870 and 1949.

Given the above data, and the eroding condition of the beaches, no effect upon significant archaeological resources is anticipated due to the proposed beach restoration project. A letter from the State Historic Preservation Officer confirming this determination may be found in Section V.

G. MITIGATION MEASURES

1) SAND PLACEMENT.

On Okinawa Beach, placement of sandfill would be tailored to minimize adverse impact on the area of salt marsh vegetation at the western end of the beach. The slope at which the sandfill is placed would be reduced as the salt marsh is approached to limit encroachment onto the salt marsh some of the impacted marsh, as noted below, will be transplanted.

2) MARSH TRANSPLANTING.

Even with the above measure, approximately 33 percent of the salt marsh vegetation present at the western of the beach is expected to be covered by sandfill. Approximately 3000 square feet of the most thickly covered marsh is to be transplanted, rehabilitating and extending the existing adjacent marsh. This area would be prepared by placement of a sand pad so that the marsh vegetation would be transplanted at a suitable elevation with respect to the area tides. The sand pad would be placed by the Contractor and marsh vegetation transplanted prior to beach nourishment operations. This would leave approximately 2000 square feet which could be impacted by the sandfill. This covered vegetation should be capable of growing up through the sand and re-establishing itself. Eventually the salt marsh may even propogate further along the beach because of the somewhat greater upper beach foreslope created by the nourishment project. Success of the marsh transplanting program will be monitored by the Corps of Engineers recovery of the affected area is expected to occur in about two growing seasons.

3) LAND USE.

Sand placement would be restricted to the Spring. This would minimize interference of beach nourishment with recreational use of the beach, as all work would be completed during the beaches' off-season.

H. COORDINATION

Coordination of the planning of this project has been conducted with the following agencies:

Federal: U.S. Fish and Wildlife Service; Concord, NH Office

National Marine Fisheries Service; Milford, CT Office

Environmental Protection Agency Region I
Office of Environmental Project Review, Boston, MA

State: Connecticut Dept. of Environmental Protection; Hartford, CT
Office of Coastal Area Management - CZM consistency

Bureau of Fisheries

Water Compliance Unit

Water Resources Unit - Section 401; Water Quality Certification

Connecticut Dept. of Agriculture; Hartford, CT
Division of Aquaculture

Public: City of West Haven

Office of Community Development

COMPLIANCE WITH ENVIRONMENTAL PROTECTION STATUTES AND EXECUTIVE ORDERS

Statutes	Compliance
1. Archaeological and Historic Preservation Act, as amended, 16 U.S.C. 469 *et seq.*	No cultural resources were identified as being impacted by the proposed action.
2. Clean Air Act, as amended, 42 U.S.C. 7401 *et seq.*	Submission of this report to the Regional Administrator of the Environmental Protection Agency (EPA) for review constitutes compliance with the Act.
3. Clean Water Act (Federal Water Pollution Control Act), as amended, 33 U.S.C. 1251 *et seq.*	A Section 404 (b)(1) Evaluation has been prepared as part of this document. A water quality certificate under Section 401 has been granted by the State.
4. Coastal Zone Management Act of 1972, as amended, 16 U.S.C. 1451 *et seq.*	Coordination with the State is ongoing.
5. Endangered Species Act of 1973, as amended, 16 U.S.C. 1531 *et seq.*	Coordination with the U.S. Fish Wildlife Service and the National Marine Fisheries Service of the proposed action has yielded no formal consultation requirements.
6. Estuary Protection Act, 16 U.S.C. 1221 *et seq.*	Coordination with the Department of Interior constitutes compliance with this Act.
7. Federal Water Project Recreation Act, as amended, 16 U.S.C. 4601-12 *et seq.*	Same as above.
8. Fish and Wildlife Coordination Act, as amended, 16 U.S.C. 661 *et seq.*	Coordination with the U.S. Fish and Wildlife Service and the National Marine Fisheries Service constitutes compliance with this Act.
9. Land and Water Conservation Fund Act of 1965, as amended, 16 U.S.C. 4601-4 *et seq.*	Coordination with the Department of the Interior constitutes compliance with this Act.
10. Marine Protection, Research, and Sanctuaries Act of 1972, as amended, 33 U.S.C. 1401 *et seq.*	Not Applicable.
11. National Historic Preservation Act of 1966, as amended, 16 U.S.C. 470 *et seq.*	No cultural resources would be impacted by the proposed action.
12. National Environmental Policy Act of 1969, as amended, 42 U.S.C. 432 *et seq.*	The preparation of this document constitutes compliance with this Act.
13. Rivers and Harbors Appropriation Act of 1899, as amended, 33 U.S.C. 401 *et seq.*	Not Applicable.
14. Watershed Protection and Flood Prevention Act, as amended, 16 U.S.C. 1001 *et seq.*	Not Applicable.
15. Wild and Scenic Rivers Act, as amended, 16 U.S.C. 1271 *et seq.*	Not Applicable.
Executive Orders	
1. Executive Order 11988, Floodplain Management, 24 May 1977.	In compliance; project will have no affect upon floodplain.
2. Executive Order 11990, Protection of Wetlands, 24 May 1977.	In compliance; the proposed action includes all practicable measures to minimize harm to wetlands which may result from the project.
3. Executive Order 12114, Environmental Effects Abroad of Major Federal Actions, 4 January 1979.	Not Applicable.

REFERENCES

1. Beckett, G., 1984, 1983. U.S. Fish and Wildlife Service, Concord, New Hampshire, Planning Aid letters.

2. Bigford, T., 1984. National Marine Fisheries Service, Gloucester, Massachusetts, letter.

3. Knutson, P.L. and W.W. Woodhouse Jr., 1983. Shore Stabilization with Salt Marsh Vegetation. Special Rept. No. 9. U.S. Army Corps of Engineers, Coastal Engineering Research Center.

4. Ludwig, M., 1984. National Marine Fisheries Service, Milford, Connecticut, letter.

5. Maddox, D., 1984. State Historic Preservation Office, Hartford, Connecticut, letter.

6. Reilly, F.J. and V.J. Bellis, 1979. A study of the ecological impact of beach nourishment with dredged material on the intertidal zone. 93 pp.

7. Parr, T. Diener, D. and S. Lacy, 1978. Effects of Beach Replenishment on the Nearshore Sand Fauna at Imperial Beach, California. Miscel. Rept. 78-4. U.S. Army Corps of Engineers, Coastal Engineering Research Center.

8. Volk, R.B., 1982. Connecticut Department of Agriculture, Aquaculture Division, Milford, Connecticut, letter.

9. Whitlatch, R.B., 1982. The Ecology of New England Tidal Flats - A Community Profile. Univ. Of Conn., for the Office of Biological Services, U.S. Fish and Wildlife Service.

FINDING OF NO SIGNIFICANT IMPACT

Factors considered include the effects of beach restoration and groin replacement along 1000 feet of shoreline at Sea Bluff Beach and along 600 feet of shoreline at Okinawa Beach in West Haven, CT. The proposed plans call for constructing a level beach berm width of 50 feet for Sea Bluff Beach and 75 feet for Okinawa Beach with a backshore elevation of 11.0 feet above MLW and a foreshore slope of 1 vertical on 15 horizontal where these dimensions do not currently exist. Evaluation of the project sites and planned construction activities indicate that there should be no unacceptable environmental impacts.

This finding has been prepared in accordance with the National Environmental Policy Act of 1969, and appropriate environmental laws and regulations. My determination that an Environmental Impact Statement is not required is based on the information contained in the Environmental Assessment for this project and the following considerations.

1. The proposed plan would not effect any cultural resources.

2. The proposed plan would not cause any significant secondary or growth inducing impacts.

3. The turbidity associated with the project would be minimal due to the coarse nature of the sandfill being used.

4. The proposed plan would not affect any threatened or endangered species.

5. Sand placement would be tailored and some salt marsh growth transplanted to eliminate adverse impacts to the small area of salt marsh at the western end of Okinawa Beach.

6. Groin construction would be limited and would include replacing or restoring an existing structure.

7. Significant soft-shell clam (*Mya arenaria*) beds at Bradley Rock Beach and signficant commercial oyster (*Crassostrea virginica*) and hard-shell clam (*Mercenaria mercenaria*) grounds offshore of the project area will remain unaffected.

8. The benthic organisms that would be destroyed by burial at Sea Bluff and Okinawa Beaches would be replaced by recolonization of organisms from adjacent areas which would be left undisturbed.

In view of the foregoing I have determined that the proposed Beach Erosion Control Projects will not have any significant impacts which would necessitate the preparation of Environmental Impact Statements.

8 April 86
DATE

Thomas A. Rhen
THOMAS A. RHEN
Colonel, Corps of Engineers
Division Engineer

NEW ENGLAND DIVISION
U.S. ARMY CORPS OF ENGINEERS WALTHAM, MA

PROJECT Section 103 Beach Erosion Control Project
West Haven Beaches, West Haven, Connecticut
PROJECT MANAGER Thomas Bruha EXT. 554
FORM COMPLETED BY Ernest Waterman EXT. 231

PROJECT DESCRIPTIONS:

The proposed plans consist of the restoration of a protective beaches to provide erosion control along approximately 600 feet of shoreline at Okinawa Beach and 900 feet of shoreline at Sea Bluff Beach. Specifically, the projects call for construction of a level beach berm with an average width of 50 feet at Sea Bluff Beach and 75 feet for Okinawa Beach at an elevation of 11.0 feet above MLW where these dimensions do not currently exist. This would require an estimated 25,000 cubic yards of material for initial placement. Suitable sandfill would be obtained from a land-based source and trucked to the sites. The sandfill would be placed above MHW and then be distributed by bulldozer or front end loader to the desired berm dimensions above MHW. The natural tidal action would distribute the fill material below MHW and no fill would be placed directly below MLW. Replacement of an existing rubble mound groin at the western end of Sea Bluff Beach and a timber terminal groin at the eastern end of Okinawa Beach would also be authorized.

Replacement of the structure at Okinawa Beach would be deferred unless monitoring of the beaches after nouishment indicated that its replacement is necessary.

NEW ENGLAND DIVISION
U.S. ARMY CORPS OF ENGINEERS WALTHAM, MA

PROJECT Section 103 Beach Erosion Control Project
West Haven Baches, West Haven, Connecticut

SHORT-FORM
Evaluation of Section 404(b)(1) Guidelines

1. Review of Compliance (Sect. 230.10(a)-(d)	Preliminary (circle one)	Final
a. The discharge represents the least environmentally damaging practical alternative and if in a special aquatic site, the activity associated with the discharge must have direct access or proximity to, or be located in the aquatic ecosystem to fulfill its basic purpose (if no, see section 2 and information gathered for EA alternative);	YES X	NO ___
b. The activity does not appear to: 1) violate applicable state water qualtiy standards or effluent standards prohibited under Section 307 of the CWA; 2) jeopardize the existence of Federally listed endangered species or their habitat; and 3) violate requirements of any Federally designated marine sanctuary (if no, see section 2b and check responses from resource and water quality certifying agencies);	YES X	NO ___
c. The activity will not cause or contribute to significant degradation of waters of the U.S. including adverse effects on human health, life stages of organisms dependent on the aquatic ecosystem, ecosystem diversity, productivity and stability, and recreational, aesthetic, and economic values (if no, see section 2);	YES X	NO ___
d. Appropriate and practicable steps have been taken to minimize potential adverse impacts of the discharge on the aquatic ecosystem (if no, see section 5).	YES X	NO ___

Proceed to Section 2
*1/, 2/ See page 6

Technical Evaluation Factors (Subparts C-F).

	N/A	Significant	Significant
a. Physical and Chemical Characteristics of the Aquatic Ecosystem (Subpart C).			
1) Substrate impacts		x	
2) Suspended particulates/turbidity impacts.		x	
3) Water column impacts.		x	
4) Alteration of current patterns and water circulation	x		
5) Alteration of normal water fluctuations/hydroperiod	x		
6) Alteration of salinity gradients.	x		
b. Biological Characteristics of the Aquatic Ecosystem (Subpart D).			
1) Effect on threatened/endanered species and their habitat.	x		
2) Effect in the aquatic food web.		x	
3) Effect on other wildlife (mammels, birds, reptiles and amphibians).	x		
c. Special Aquatic Sites (Subpart E).			
1) Sanctuaries and refuges.	x		
2) Wetlands		x	
3) Mud flats		x	
4) Vegetated shallows	x		
5) Coral reefs	x		
6) Riffle and pool complexes	x		
d. Human Use Characteristics (Subpart F).			
1) Effects on municipal and private water supplies.	x		
2) Recreational and Commercial fisheries impacts.		x	
3) Effects on water-related recreation.		x	
4) Aesthetic impacts.		x	
5) Effects on parks, national and historic monuments, national seashores, wilderness areas, research sites, and similar preserves.		x	

Remarks: Where a check is placed under the significant category, preparer add explanation below.

Proceed to Section 3

*See page 6

3. Evaluation of Dredged or Fill Material (Subpart C).

a. The following information has been considered in evaluating the biological availability of possible contaminants in dredged or fill material (Check only those appropriate).

1) Physical characteristics.....x
2) Hydrography on relation to known or anticipated sources of contaminants.....
3) Results from previous testing of the material in the vicinity of the project.....
4) Known, significant sources of persistent pesticides from land runoff or percolation.....
5) Spill records for petroleum products or designated (Section 311 or CWA) hazardous substances.....
6) Other public records of significant introduction of municipalities or other sources.....
7) Known existence of substantial material deposits of substances which could be released in harmful quantities to the aquatic environment by man-induced discharge activities.....
8) Other sources (specify).....x

List appropriate references.

Clean sandfill for beach nourishment will be provided from a land-based source. Material selected for use will be free of contaimin ants.

b. An evaluation of the appropriate information in 3a above indicates that there is reason to believe the proposed dredged of fill material is not a carrier of contaminants, or that levels of contaminants are substantively similar at extraction and disposal sites and not likely to constraints. The material meets the testing exclusion criteria.....

Proceed to Section 4
*See page 6.

4. Disposal Site Delineation (Sect. 230.11(f))

a. The following factors as appropriate, have been considered in evaluating the disposal site.

1) Depth of water at disposal site.....x
2) Current velocity, direction, and variability at disposal site.....x
3) Degree of turbulence.....x
4) Water column stratification.....
5) Discharge vessel speed and direction.....
6) Rate of discharge.....
7) Dredged material characteristics (constituents, amount, and type of material, settling velocities).....
8) Number of discharges per unit of time.....
9) Other factors affecting rates and patterns of mixing (specify).....

List appropriate references.

b. An evaluation of the appropriate factors in 4a above indicates that the disposal site and/or size of mixing zone are acceptable..... YES x NO

5. Actions to Minimize Adverse Effects (Subpart 11).

All appropriate and practicable steps have been taken, through through application of recommendation of Sect. 230.70-230.77 to ensure minimal adverse effects of the proposed discharge. YES x NO

List actions taken.....

a) Nourishment operations will be confined to the spring to minimize the recreational use of Sea Bluff and Okinawa Beaches.
b) Sandfill will be placed above mean high water and then be redistributed by bulldozer down to mean low water to insure minimal turbidity impacts in the project area.
c) The new berm level may provide access for the existing wetland at Okinawa to propagate further on shore, thus extending the area of critical habitat.

N.B. Return to section 1 for final stage of compliance review.
*See page 6

6. Factual Determination (Sect. 230.11)

A review of appropriate information as identified in items 2-5 above indicates that there is minimal potential for short or long term environmental effects of the proposed discharge as related to:

a.	Physical substrate at the disposal site (review sections 2a, 3, 4, and 5 above).	YES x	NO _
b.	Water circulation, fluctuation and salinity (review sections 2a, 3, 4, and 5).	YES x	NO _
c.	Suspended particulates/turbidity (review sections 2a, 3, 4, and 5)	YES x	NO _
d.	Contaminant availability (review sections 2a, 3, and 4)	YES x	NO _
e.	Aquatic ecosystem structure and function (review sections 2b and c, 3, and 5)	YES x	NO _
f.	Disposal site (review sections 2, 4, and 5)	YES x	NO _
g.	Cumulative impact on the aquatic ecosystem	YES x	NO _
h.	Secondary impacts on the aquatic ecosystem	YES x	NO _

7. Findings

a. The proposed disposal site for discharge of dredged or fill material complies with the Section 404(b)(1) guidelines.....x

b. The proposed disposal site for discharge of dredged or fill material complies with the Section 404(b)(1) guidelines with the inclusion of the following conditions.....

c. The proposed disposal site for discharge of dredged or fill material does not comply with the Section 404(b)(1) guidelines for the following reasons:

1. There is a less damaging practicable alternative.....

2. The proposed discharge will result in significant degradation of the aquatic ecosystem.....

3. The proposed discharge does not include all practicable and appropriate measures to minimize potential harm to the aquatic ecosystem.....

8 April 86
DATE

THOMAS A. RHEN
Colonel, Corps of Engineers
Division Engineer

FOOTNOTES

*A negative, significant or unknown response indicates that the proposed project may not be in compliance with the Section 404(b)(1) Guidelines.

1) Negative responses to three or more of the compliance criteria at this stage indicate that the proposed projects may not be evaluated using this "short form procedure". Care should be used in assessing pertinent portions of the technical information of items 2 a-e, below before completing the final review of compliance.

2) Negative response to one of the compliance criteria at this stage indicates that the proposed project does not comply with the guidelines. If the economics of navigation and anchorage or Section 404(b)(1) are to be evaluated in the decision-making process, the "short form evaluation process is inappropriate".

CONNECTICUT DEPARTMENT OF ENVIRONMENTAL PROTECTION

Coastal Management Consistency
Review Worksheet

- Supplemental Evaluation for Projects Located Within the Coastal Boundary

Refer to coastal management consistency review instructions (attached) for sources of information and instructions for filling out this review worksheet.

I. Description of the Proposed Project

A. Briefly describe the entire project including its location, setting, purpose and component activities (i.e., site alterations and improvements, proposed buildings, type of use, etc.).

Beach Erosion Control is proposed for approx. 1,000 feet of shoreline at Sea Bluff and 600 feet at Okinawa Beach. The proposed plans consists of beach nourishment to produce a level beach berm width of 50 feet at Sea Bluff Beach and 75 feet for Okinawa Beaches with a backshore elevation of 11.0 feet above MLW and a foreshore slope of 1 vertical on 15 horizontal. Sandfill for the project would be obtained from a land based source. Removal of an existing timber terminal groin at the eastern end of Okinawa Beach and replacement of an existing rubble mound groin at ivy Street on Sea Bluff Beach will also take place. The replacement of the timber terminal groin an Okinawa Beach will be authorized but its construction will be deferred unless monitoring of the reconstructed beach indicates that the structure is necessary to prevent excessive sand loss from the beach.

II. Project Location

A. Location Description: as applicable

coastal boundary map quad (U.S.G.S. map quad) New Haven, Conn.

location of activity site (including street address, names of roads in vicinity of site, etc.) Sea Bluff Beach and Okinawa Beach off of Ocean Avenue between Ivy Street and Kelsey Avenue West Haven, Conn.

name(s) of waterway(s) on or adjacent to the site Project site is located on the western side of outer New Haven Harbor

III. Determination of Coastal Management Policies' Applicability and Consistency.

A. Identify any and all coastal use policy categories (as reprinted in CAM Planning Report No. 30, Sections II-A to II-P) corresponding to all activities and uses associated with the proposed project.

COASTAL USE POLICY CATEGORIES			COASTAL USE POLICY CATEGORIES		
X	II-A.	General Development	___	II-I.	Sewer and Water Lines
X	II-B.	Water Dependent Uses	___	II-J.	Energy Facilities
___	II-C.	Ports and Harbors	___	II-K.	Fuel, Chemicals & Hazardous Mat'l
X	II-D.	Coastal Structures & Filling	___	II-L.	Transportation
___	II-E.	Dredging and Navigation	___	II-M.	Solid Waste
___	II-F.	Boating	___	II-N.	Dams, Dikes, & Reservoirs
X	II-G.	Fisheries	___	II-O.	Cultural Resources
X	II-H.	Coastal Recreation & Access	___	II-P.	Open Space & Agricultural Lands

B. Identify any and all coastal resource policy categories (as reprinted in CAM Planning Report No. 30, Section I-A to I-N) for all resources on and adjacent to the proposed site and affected by the proposed activity.

RESOURCE POLICY CATEGORIES		On Site	Adjacent To Site	Affected by Activity	Not Applicable
I-A.	General Resources	x	x	x	
I-B.	Bluffs or Escarpments		x		
I-C.	Rocky Shorefronts		x		
I-D.	Beaches or Dunes	x	x	x	
I-E.	Intertidal Flats	x	x	x	
I-F.	Tidal Westlands		x		
I-G.	Freshwater Wetlands/Watercourse				x
I-H.	Coastal Hazard Areas	x	x	x	
	Flood Hazard	x	x		
	Erosion Hazard	x	x	x	
I-I.	Developed Shorefront				x
I-J.	Islands				x
I-K.	Shorelands		x		
I-L.	Shellfish Concentration Areas		x		
I-M.	Coastal Waters	x	x		
	Nearshore Waters	x	x		
	Offshore Waters				x
	Estuarine Embayments		x		
I-N.	Air Resources and Air Quality	x	x		

C. Identify any and all government process policies as reprinted in CAM Planning Report No. 30, Section III-A to III-F for all government processes associated with the proposed project.

GOVERNMENT PROCESS CATEGORIES

___ III-A. Intergovernmental Coordination of Planning & Regulatory Activities.
___ III-B. Coordination & Consistency of State Programs, Projects, Expenditures and Acquisitions
X III-C. Flooding and Erosion Planning
X III-D. Dredging and Dredged Material Disposal Planning
___ III-E. Coastal Related Research
___ III-F. National Interest Facilities and Resources

C. Determine if the proposed project is consistent with all of the coastal policies within the categories identified in III(A), (B) and (C) above. (List each policy under the appropriate column heading.) Note: If a project conflicts with any policy, the project should be modified to reduce or eliminate the conflict. Refer to specific policies as lettered in Planning Report No. 30 within each applicable category (e.g., III-A.A, B, C, etc.).

	Consistent		Inconsistent	Not Applicable to This Project	
Use Policies	II-A			II-C	II-K
	II-B			II-E	II-L
	II-D			II-FI	I-M
	II-G;A			II-G;B	II-N
	II-H;C,E			II-H;A,B,D	II-O
				II-I	II-P
					II-J
Resources Policies	I-A	I-M;A,C		I-E;B	I-N;A
	I-B	I-N;B		I-F;B,C,E	
	I-C			I-G	
	I-D			I-H;F,H	
	I-E;A,C,D,E				I-I
	I-F;A,D*			I-J	
	I-H;A,B,C,D,E,G,I			I-L;B,C,D	
	I-K			I-M;B,D*	
Government Process Policies	III-C			III-A	
				III-B	
				III-D	
				III-E	
				III-F	

IV. Evaluation of the Potential Adverse Impacts of the Project and Description of Proposed Methods to Mitigate Adverse Effects.

A. Identification of Potential Adverse Impacts.

	NONE/MINOR	MODERATE	SIGNIFICANT
Tidal Wetlands	x		
Beaches	x		
Dunes	x		
Rocky Shorefront	x		
Bluffs and Escarpments	x		
Wildlife	x		
Finfish	x		
Shellfish		x	
(include impacts on habitat, breeding, feeding, nursery areas and migratory routes)			
Coastal Flooding	x		
Surface Water Quality	x		
Coastal Water Circulation	x		
Groundwater Quality	x		
Surface Water Quality	x		
Coastal Water Quality	x		
Visual Quality	x		
Other	x		

B. Briefly describe and evaluate the potential adverse impacts identified above as moderate or significant and the proposed measures to mitigate any adverse impacts. Explain why any remaining adverse impacts were not mitigated.

Shellfish and other sessile benthic organisms within the project area would be destroyed by burial during beach construction surveys by the State Aquaculture Division and the U.S. Fish & Wildlife Service, however, indicate that there is little if any shellfish resources present at the project beaches. Bradley Rock Beach, which was originally included in the beach restoration plans will be left undisturbed because of its ecological importance. This beach does support a significant population of soft shell clams (Mya arenaria) and other benthic organisms. Bradley Rock Beach is located adjacent to both Okinawa and Sea Bluff Beaches and would provide organisms for rapid recolonization of the proposed beaches. This would mitigate the initial loss of benthic organisms at the project beaches.

Beach nourishment operations would also cause a localized and short-term, increase in turbidity levels and suspended sediment loads. The sand being placed is relatively coarse and would rapidly settle out of the water column; only a minor turbidity impact would occur. This minor and short-term increase in turbidity would be the only water quality impact associated with the project.

At the western end of Okinawa Beach a small area of salt marsh vegetation exsists. About 600 square yards of this vegetation will be directly impacted by sand placement of this, about 200 square yards can be transplanted to a small area on the adjacent Bradley Point. The remaining 400 square yards of impacted salt marsh will be covered to depths no greater than 1 to 2 feet and the buried vegetation should be capable of growing up through the sandfill and reestablishing itself.

V. Determination

Policies:	x Consistent	____ Inconsistent
Adverse Impacts:	x Acceptable	____ Unacceptable

TABLE 3
OKINAWA BEACH
SUMMARY COMPARISON OF ALTERNATIVE PLANS

ACCOUNTS	BASE CONDITION	WITHOUT PROJECT	PLAN 2	PLAN 3
A. Plan Description				
1. Major Features	Eroding Beach	Loss of backshore, undermining of the adjacent seawall.	Protection to the backshore, and provide a much needed beach.	Protection to the backshore, and provide a much needed beach.
2. Recreational Land Area	0.5 acres	Continuing loss of land at 1.0 -2.0 ft./yr.	Maintain base condition and provide a protective beach.	Maintain base condition and provide a protective beach.
3. Level Beach Berm	35 Feet	continuing erosion	50'/75'/100'	50'/75'/100'
4. Beach Width Above MHW	35 Feet	continuing erosion	122'/147'/172'	122' / 147'/172'
5. Ownership	City	City	City	City
6. Structures				
(a) Federal				
(1) Seawalls	None	None	None	None
(2) Groins	None	None	None	None
(3) Jettys	None	None	None	None

TABLE 3 (Cont.)

SUMMARY COMPARISON OF ALTERNATIVE PLANS

ACCOUNT	BASE CONDITION	WITHOUT PROJECT	PLAN 2	PLAN 3
(b) Non-Federal				
(1) Seawalls	yes	yes	None	None
(2) Groins	timber(1)	timber(1)	timber(1)	timber(1)
(3) Jettys	None	None	None	None
7. Dry Beach Width Above MHW				
(a) Existing	35 feet	Loss of fronting beach and backshore.	35 ft.	35 ft.
(b) Future				
(1) 50 ft. level berm	Restoration and protection.	Restoration and protection.	122 ft.	122 ft.
(2) 75 ft. level berm	Restoration and protection.	Restoration and protection.	147 ft.	147 ft.
(3) 100 ft. level berm	Restoration and protection.	Restoration and protection.	172 ft.	172 ft.
(c) Non-Structural	Continued erosion.	Continued erosion.		
(d) Structures	Continued erosion.	Continued erosion.		
(e) Revetments	Continued erosion.	Continued erosion.		

TABLE 3 (Cont.)

SUMMARY COMPARISON OF ALTERNATIVE PLANS

ACCOUNT	BASE CONDITION	WITHOUT PROJECT	PLAN 2	PLAN 3
B. Impact Assessment				
1. National Economic Development				
(a) 50 ft. Level Berm				
(1) Total Annual Benefits	None	None	$51,100	$51,100
(2) Total Annual Charges	None	None	$31,000	$34,100
(3) B/C Ratio	None	None	1.7	1.5
(4) Net Benefits	None	None	$20,100	$17,000
(b) 75 ft. Level Berm				
(1) Total Annual Benefits	None	None	$63,600	$63,600
(2) Total Annual Charges	None	None	$41,400	$44,500
(3) B/C Ratio	None	None	1.5	1.4
(4) Net Benefits	None	None	$22,200	$14,100

TABLE 3 (Cont.)

SUMMARY COMPARISON OF ALTERNATIVE PLANS

ACCOUNT	BASE CONDITION	WITHOUT PROJECT	PLAN 2	PLAN 3
(c) 100 ft. Level Berm				
(1) Total Annual Benefits	None	None	$75,200	$75,200
(2) Total Annual Charges	None	None	$54,200	$56,400
(3) B/C Ratio	None	None	1.4	1.3
(4) Net Benefits	None	None	$21,000	$18,800
(d) Nonstructural				
(1) Total Annual Benefits	None	None	Nonstructural plans were considered, but written off as not feasible because they did not meet the problem and opportunity statements and the national objectives.	
(2) Total Annual Charges	None	None		
(3) B/C Ratio	None	None		
(4) Net Benefits	None	None		

TABLE 3 (Cont.)

SUMMARY COMPARISON OF ALTERNATIVE PLANS

ACCOUNT	BASE CONDITION	WITHOUT PROJECT	PLAN 2	PLAN 3
2. Environmental Quality				
a. Air Quality	No Impact	No Impact	Moderal increase in dust levels during construction. Prolonged for wider berm widths.	
d. Archaeological Properties	No Impact	No Impact	No Impact	No Impact
c. Biological Resources	No Impact	No Impact	Temporary disruption of aquatic ecosystem benthic organisms, and soft clam habitat during construction.	
d. Water Quality	No Impact	No Impact	Temporary increase in turbidity during fill and construction phases. Increased for wider berms.	
e. Noise	No Impact	No Impact	Temporary increase in noise levels during construction.	
f. Aesthetic Values	No Impact	No Impact	Will be improved through project construction.	
3. Other Social Effects	Cont'd erosion & loss of land	Continued erosion and loss of land.	Temporary disruption of usual activity by construction. Increased beach recreational opportunities.	
4. Regional Development	Cont'd erosion & loss of land	Continued erosion and loss of land.	Increased salt water recreational opportun in this metropolitan area. Increased commercial activities for local businesses and revitilizing old business.	

TABLE 3 (Cont.)

SUMMARY COMPARISON OF ALTERNATIVE PLANS

ACCOUNT	BASE CONDITION	WITHOUT PROJECT	PLAN 2	PLAN 3
C. Plan Evaluation				
1. Conforms to Planning Constraints and Concerns				
a. ~~XXXXXX~~ Adverse Effects on Adjacent Shoreline	No	No	Yes, impacts increase somewhat with berm widths.	
b. ~~NX~~ Unreasonable Finanical Burden on City	No	No	No, but increases with longer berm widths.	
2. Achieves Problem and Opportunity Statements				
a. Provides a Safe Recreational Beach	No	No	Yes	Yes
b. Contributes to Economic Strength and Well-Being of the Area	No	No	Yes	Yes
c. Preserves the Environmental Quality of the Area	Yes	Yes	Yes	less than Plan 2
d. Contributes to the Stability of the Beach	No	No	Yes	Yes

TABLE 3 (Cont.)

SUMMARY COMPARISON OF ALTERNATIVE PLANS

ACCOUNT	BASE CONDITION	WITHOUT PROJECT	PLAN 2	PLAN 3
D. Public Response - Favorable	No response	No response	Yes	Yes
E. Implementation Responsibility	0	0	70% Federal Share and Share.	30% Non-Federal

ACKNOWLEDGEMENT AND IDENTIFICATION OF PERSONNEL

This report was prepared under the supervision and management of the following New England Division personnel:

Colonel Thomas A. Rhen, Division Engineer
Joseph L. Ignazio, Chief, Planning Division
John T. Smith, Chief, Coastal Development Branch

The study and report was developed by Thomas C. Bruha, Project Manager; William Coleman prepared the engineering design material; Charles Weiner prepared the hydrologic material; Ernest Waterman prepared the environmental material; Edmund O'Leary, Jr. prepared the economic and social resources material; John Wilson prepared the cultural resources material; Frank Fessenden prepared the coastal processes material; and personnel of the Word Processing Center typed the report.

The New England Division is appreciative of the cooperation and assistance provided to this study by Fred Benson of the U.S. Fish and Wildlife Service; Michael Ludwig of the National Marine Fisheries Service; David Porier of the Connecticut State Historic Preservation Office; Tina Suarez-Murias of Connecticut Coastal Area Management Program; John Volk of the Connecticut Department of Agriculture, Aquaculture Division; and Peter Menta of the Connecticut Bureau of Fishers. Very special thanks are extended to the Mayor of the city of West Haven, Mr. Lawrence C. Minichino; Mr. Ralph Paollilo, Community Development Manager; and Ms Mary Tracy, Community Development Administrative Coordinator.

APPENDIX 1

PERTINENT CORRESPONDENCE

PERTINENT CORRESPONDENCE

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State of Connecticut
Department of Environmental Protection
Stanley J. Pac
Commissioner
165 Capitol Avenue Hartford, Connecticut 06106

January 28, 1986

Mr. Joseph Ignazio
Chief, Planning Division
Impact Analysis Branch
Army Corps of Engineers
New England Division
424 Trapelo Road
Waltham, Mass. 02154

Dear Mr. Ignazio:

This is written in response to your letter of November 1, 1985 requesting a Water Quality Certificate and Coastal Management Consistency Concurrence with your consistency determination for the Okinawa Beach and Sea Bluff Beach Erosion Control Projects in West Haven. The proposed project consists of beach nourishment to produce a level beach berm width of 50 feet at Sea Bluff Beach and 75 feet for Okinawa Beach. The project also proposes the removal of an existing timber terminal groin at the eastern end of Okinawa Beach and replacement of an existing rubble mound groin at Ivy Street and Sea Bluff Beach. The replacement of the timber terminal groin at Okinawa Beach would be authorized, but construction would be deferred unless deemed necessary to prevent excessive sand loss from the reconstructed beach.

This agency's considerations in reviewing this proposal are:

1) the impacts of placing sandfill on intertidal flats;

2) the impacts of sandfill on marine organisms, shellfish, finfish, and wildlife;

3) the impacts of placing sandfill over a small, undesignated tidal wetland area at the western end of Okinawa Beach and the proposed transplanting of Spartina alterniflora to an adjacent area; and

4) the impacts of rehabilitating and raising an existing rubble mound groin at Ivy Street and Sea Bluff Beach on coastal resources, circulation and sedimentation patterns, erosion, and public access.

We note that the Draft Detailed Project Report reflects changes which resulted from comments generated preliminary to the Environmental Assessment in 1984 by this agency and others. Our letter of September 12, 1984 focused on avoiding Bradley Rock Beach, the necessity of replacing the terminal groin at the eastern end of Okinawa Beach, and mitigation/compensation for loss of a Spartina alterniflora marsh. As we indicated at that time, it is our opinion that this is an ephemeral "marsh" or habitat. Specifically, we find S. alterniflora growing on silty intertidal slope deposits. Such vegetated intertidal flats are not true tidal wetland ecosystems and are not generally equivalent, in terms of biological and habitat value, to tidal wetland ecosystems that develop in sheltered tidal water bodies.

Remaining potential adverse impacts to coastal resources in this area are, we believe, outweighed by the public recreational benefits which are likely to result from a wider and more stable beach. Both areas are open to the general public, close to urban population centers, and served by public transportation.

This letter is to certify that the proposed activity will not permanently violate Connecticut's Water Quality Standards and is our concurrence with your Coastal Management Consistency Certification, provided that the following condition is met:

1) As indicated, no dredging shall take place between June 1st and September 30th so as to avoid the shellfish spawning season.

If there are any further questions, please contact Ms. Janet Wilscam of the Water Resources Unit at (203)566-7160, or Mr. Dan Rothenberg of my Planning and Coordination/Coastal Management staff at (203)566-7404. Thank you for your cooperation.

Sincerely,

Stanley J. Pac

Stanley J. Pac
Commissioner

SJP/DBR/11

cc Horace H. Brown

STATE OF CONNECTICUT

OFFICE OF POLICY AND MANAGEMENT
COMPREHENSIVE PLANNING DIVISION

February 4, 1986

Mr. Joseph L. Ignazio
Chief of the Planning Division
Coastal Development Branch
U.S. Army Corps of Engineers
424 Trapelo Road
Waltham, MA 02254-9149

SUBJ: Detailed Project Reports and Environmental Assessments - Small Beach Erosion Control Projects, Sea Bluff Beach and Okinawa Beach, West Haven

Dear Mr. Ignazio:

The Office of Policy and Management is the designated State Single Point of Contact in regard to intergovernmental review of federal financial assistance and direct federal development.

The above referenced documents were distributed in accordance with Connecticut Intergovernmental Review procedures with the opportunity for review and comment. Enclosed are the comments of Commissioner Stanley J. Pac of the Connecticut Department of Environmental Protection which were sent directly to you. Also enclosed is correspondence from the State Historic Preservation Officer.

We appreciate the opportunity to provide comments concerning the proposed project.

Sincerely,

Horace H Brown Jr.

Gary E. King
Under Secretary

GEK/edb
enclosures
cc: Hon. Stanley J. Pac, DEP
Dawn Maddox, Historical Commission
David Fox, DEP

80 WASHINGTON STREET, HARTFORD, CONNECTICUT 06106-4459
An Equal Opportunity Employer

Response to the State of Connecticut
Office of Policy and Management
Letter dated 4 February 1986

No response is necessary to the comments received in the Office of Policy and Management letter.

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Habitat Conservation Branch
Sandy Hook Marine Laboratory
Highlands, New Jersey 07732

JAN 27 1985

Mr. Thomas Bruha
U.S. Army Corps of Engineers
New England Division
424 Trapelo Road
NEDPL-C, Bldg. 114-S
Waltham, Massachusetts 02254

Dear Mr. Bruha:

The National Marine Fisheries Service (NMFS) has reviewed the draft Detailed Project Reports and Environmental Assessments for Sea Bluff and Okinawa Beaches at West Haven, Connecticut. These two draft reports accompanied your request of November 1, 1985, for our review and comment.

1 Our review reveals that the two documents thoroughly cover the topic and propose activities we found environmentally acceptable during the field inspection stage of the analysis process. However, there is one major error in the documents we believe needs to be corrected. Both reports describe the Okinawa Beach wetland area to be impacted as being 600 square yards in size. We believe that figure is wrong. Our records reveal that the actual value is approximately 300 square feet. Permanent loss due to burial would be about half this lesser value. However, since transplantation will be attempted, there should, theoretically, be no net loss of saltmarsh. If your review of the matter reveals the 600 square yard value is correct then the NMFS requests a meeting with the involved parties to determine the impact of this forty fold increase in proposed saltmarsh disturbance. Should our value be correct, we concur that a "Finding of No Significant Impact" (FONSI) is appropriate for these two projects.

2 On a minor note, the blackfish genus is Tautog not Dallia and the horseshoe crab species name is polyphemus not polyphorn.

Should you wish to discuss these projects further, please contact Michael Ludwig at (FTS) 642-5200.

Sincerely,

Stanley W. Gorski

Stanley W. Gorski
Assistant Branch Chief

Response to National Marine Fisheries Service
Letter dated 27 January 1986

CMT1 The wetland area which would be impacted by project construction measures approximately 50' X 100' or approximately 555 square yards of salt marsh. The regional office of NMFS in Milford, Connecticut was contacted on 10 March 1986 and informed that 600 square yard area of salt marsh area impact reported in the Draft Environmental Assessment was correct and the 300 square feet recorded by NMFS was in error. The representative of NMFS contacted was assured that this impact area was <u>not</u> an increase in area over that viewed during a joint site visit on 5 September 1984. A new joint site visit to the area was arranged for 24 March 1986 to review the project area.

CMT2 The blackfish genus and horseshoe crab species name have been changed to the appropriate scientific names.

OFFICE OF THE MAYOR
CITY OF WEST HAVEN
CONNECTICUT

AZELIO M. GUERRA
MAYOR

January 22, 1986

Mr. Thomas Bruha
U.S. Army Corps of Engineers
New England Division
424 Trapelo Road
NEDPL-C, Bldg. 114-S
Waltham, Ma. 02254-9149

RE: Sea Bluff Beach & Okinawa Beach, West Haven, Connecticut

Dear Mr. Bruha:

I and members of my staff have reviewed the draft of the detailed Project reports for beach erosion control for the above referenced beaches in West Haven, Connecticut. We are in general concurrence with the conslusions and recommendations and approve these reports for implementation of the recommended facilities.

The City is ready and willing to assume full responsibility for its share towards the first cost of construction and periodic sand nourishment required to maintain the beaches. The City will fully cooperate with and provide any assistance required of it in implementing these vital projects to successful completion.

As you are aware, the City has already provided a parking lot at Bradley Point Park. Additionally, the City is studying the feasability of utilizing the West Haven High School parking lot and a shuttle bus service to provide adequate parking and access to the City beaches.

Finally, I must note that the City of West Haven is generally a residential community and beaches are its major resource. The general health and welfare of its residents depend to a large degree to its fine beaches. These projects are vital to the residents of West Haven and I strongly urge their implementation as soon as possible.

OFFICE OF THE MAYOR

CITY OF WEST HAVEN
CONNECTICUT

AZELIO M. GUERRA
MAYOR

I sincerely appreciate the assistance of the Corps of Engineers and other agencies in achieving a meaningful and productive working relationship with the City of West Haven without which these projects could not have acheived success.

Sincerely,

Azelio M. Guerra
Mayor, City of West Haven

AMG/lb

cc: Engineer, C.D.A.

United States Department of the Interior

OFFICE OF THE SECRETARY
Office of Environmental Project Review
1500 Custom House
165 State Street
Boston Massachusetts 02109

IN REPLY REFER TO:

ER 85/1625

January 22, 1986

Colonel Thomas Rhen
Division Engineer
New England Division
U.S. Army Corps of Engineers
424 Trapelo Road
Waltham, Massachusetts 02254

Dear Colonel Rhen:

This letter constitutes the Department of Interior's (DOI) response to the Draft Detailed Project Report (DDPR) and Environmental Assessment for the Sea Bluff Beach Erosion Control Project in West Haven, Connecticut (ER 85/1625).

1 In considering proposals of this kind, Interior is primarily concerned with all of the possible impacts of dumping sand on intertidal mudlfats supporting shellfish resources. Due to the productive shellfish habitat on Bradley Rock Beach and within the eastern portion of Sea Bluff Beach, we are concerned that the cumulative impacts of dumping sand on Sea Bluff Beach might adversely impact these resources. For this reason, we recommend that sandfill be limited to the western and central portions of Sea Bluff Beach above the mean water line. Construction activities should be conducted between October and May to avoid impacting shellfish reproduction and shorebird migration seasons.

2 Interior believes that the Corps of Engineers needs to develop a strategic plan concerning the proper Federal responsibilities with respect to beach erosion projects since it appears that no long-term solution exists for this natural phenomena.

Sincerely yours,

William Patterson

William Patterson
Regional Environmental Officer

Response to U.S. Fish and Wildlife Service
Letter dated 22 January 1986

CMT1 Sampling performed by the U.S. Fish and Wildlife Service on 4 December 1985 indicates that a low density population of Mya arenaria exists in the intertidal sand flats of Sea Bluff Beach. This population would be impacted by the direct placement of sandfill and will suffer a decline where direct placement of sandfill occurs. The Corps of Engineers does not consider the low density clam population (0.0376 clam/ft^2) present at Sea Bluff Beach to be a significant resource. This low population should be replenished by recolonization from adjacent areas (Bradley Rock Beach) within several seasons.

The adjacent Bradley Rock Beach shellfish habitat would not be threatened by the proposed project. Sand transport from Sea Bluff Beach, possibly onto Bradley Rock Beach, will occur, but only at natural erosion rates to which local benthic populations are accustomed.

From the project engineering viewpoint it would not be of any substantial benefit to attempt to restrict sand placement to the western and central portions of the beach. Sandfill placement is not planned to occur below mean low water and construction activities would be undertaken in the spring.

CMT2 The proposed beach nourishment project represents a long term control measure of beach restoration and shore protection. It will not prevent erosion, but will reduce the detrimental effect of erosion to backshore areas. Control of beach erosion by these means is of economic benefit to the city and the Federal government, and in this project has met with the approval of the local sponsor and the State of Connecticut.

United States Department of the Interior

FISH AND WILDLIFE SERVICE
ECOLOGICAL SERVICES
P.O. BOX 1518
CONCORD, NEW HAMPSHIRE 03301

Colonel Thomas A. Rhen
Division Engineer
New England Division
U.S. Army Corps of Engineers
424 Trapelo Road
Waltham, Massachusetts 02254

JAN 10 1986

Dear Colonel Rhen:

This letter constitutes our response to the Draft Detailed Project Report (DDPR) for the Sea Bluff Beach Erosion Control Project in West Haven, Connecticut. It has been prepared under the authority of the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661 et seq.) and constitutes our Fish and Wildlife Coordination Act Report on the project.

The proposed project is designed to restore the city-owned Sea Bluff Beach by widening the level beach berm to a width of 50 feet with a backshore elevation of 11.0 feet above the mean low water line. This would be accomplished by direct placement of approximately 17,350 cubic yards of sandfill on nearly 900 feet of beach shoreline. The proposed project would also include reconstruction of the existing rock groin structure at the western end of the beach near Ivy Street. Approximately 800 cubic yards of sand would be added to the beach annually as beach nourishment.

Shellfish and wildlife resource usage of the Sea Bluff beach ecosystem is minimal due primarily to human alteration of the environment. The natural backshore of Sea Bluff beach has been replaced by Ocean Avenue and a parking lot. The high visitation rate by sunbathers precludes usage of the beach by nesting shorebirds during the spring-summer months. The Fish and Wildlife Service investigated the area in February 1983, May 1984 and on December 4, 1985, and determined that most of the sandy intertidal area at Sea Bluff beach does not support populations of shellfish. Sand placed on the beach in the past has significantly reduced shellfish populations. Eight to ten pits were dug in each of the dozen transects established by the Service during the December survey. Substantial numbers of soft-shelled clams were found in several test pits in the transect nearest Cove River (Profile 5). Most were age class I clams but some 2-3 inch clams were found. These pockets of clams are evidence that despite environmental degradation, the habitat is of sufficient quality to support a clam population. Therefore, since the area is being reestablished by clams, the beach area within 200 feet of the Cove River should not receive sand directly or indirectly from this proposed project. 1

Moreover, we do not understand the need for beach restoration along its entire length. The DDPR states that the proposed project is designed to widen the level beach berm to a width of 50 feet with a backshore elevation of 11.0 feet above the mean low water line. We examined the beach berm and determined that it ranged from about 50 feet wide near the Ivy Street groin to approximately 165 feet wide near the Cove River. The mouth of Cove River east 2

to Bradley Point is productive shellfish habitat and could be indirectly impacted by sand drift from the Sea Bluff Beach Restoration Project. Therefore, considering the potential impacts to the shellfish populations in combination with the wide beach berm near the Cove River, we believe that
3 beach restoration should only proceed from the Ivy Street groin to the Profile 4 area of beach identified on your project maps. We recommend that sand fill be limited to the western and central portions of the beach above the mean water line. Construction activities should be conducted between October and May to avoid impacting shellfish reproduction and shorebird migration seasons.

The DDPR does not address the long-term solution to beach erosion at Sea Bluff, a naturally occurring phenomenon. The cumulative impacts of dumping 800 cubic yards of sand annually on the beach threatens clam recolonization of the flats adjacent to Cove River, as well as the productive shellfish habitat
4 at Bradley Rock Beach. The NED should explore the possibility of constructing groins or other structures to prevent the movement of eroded sand onto the shellfish beds. We realize it is outside the scope of this project, but the NED needs to address how to best alleviate erosion of the beaches within the Division's jurisdiction since it appears that no long-term solution exists.

Please contact Ron Joseph of my staff if you should have any questions concerning this report.

Sincerely yours,

Gordon E. Beckett

Gordon E. Beckett
Supervisor
New England Area

CC: NMFS, Milford (M. Ludwig)
CT Aquaculture Div., Milford (J. Volk)
CT DEP, Marine Reg. Hdqtrs., Waterford (B. Sampson)
CT CZM (T. Suarez-Marias)
WO/ES/FP
RO/HR Reading File
EPA, 404
ES: RJoseph:jd:1-10-86:834-4797

Response to U.S. Fish and Wildlife Service
Letter dated 10 January 1986

CMT1 On 4 December 1985, the U.S. Fish and Wildlife Service conducted benthic sampling of Sea Bluff Beach by establishing a grid of 12 transects on a 50 to 70' spacing with test pits spaced every 10 feet on the transects. Individual test pits measured 2' X 2' and were raked to a depth of 1-1.5'. A total of 120 test pits were dug resulting in a total take of 18 clams. This sampling data indicated a clam population density of 0.0376 clams per square foot. The New England Division does not consider this low density population to be a significant resource.

The Fish and Wildlife Service also notes that "sand placed on the beach in the past has significantly reduced shellfish populations and that the beach is in a state of 'environmental degradation'." Sand "placement" on the beach presently consists of an annual regrading of the beach conducted by the town of West Haven wherein bulldozers are used to push sand from the intertidal zone up onto the beach face. This practice would continue with or without the proposed project being constructed. No beach nourishment plan of the type proposed by the Corps of Engineers, however, has ever been conducted at Sea Bluff Beach. Depletion of the clam population at Sea Bluff Beach, if occurring, would be attributable to the practices of the town of West Haven. It does not appear that the Fish and Wildlife Service has the historical records on Sea Bluff to verify the supposition that clam populations have been depleted by past practices.

CMT2 Beach restoration will occur over the entire length of the beach in the sense that a beach nourishment project must be designed for a whole beach system to be effective. In actuality those areas which are at or exceed the proposed project dimensions will not receive placement of sandfill.

CMT3 Implementation of the Sea Bluff Beach project as designed should not endanger the productive Bradley Rock Beach area. Sand drift from Sea Bluff Beach will occur in response to natural littoral processess but only at natural erosion rates or less, to which local benthic populations are accustomed. As stated above a beach nourishment project should not be designed for a part or segment of a beach but for the whole of a beach system.

It would not be beneficial to attempt to restrict sand placement to the western and central portions of the beach. Sandfill placement is not planned to occur below mean low water and construction activities would be undertaken in the spring months.

CMT 4 The proposed plan represents a long term control measure for beach erosion and backshore protection at Sea Bluff Beach. It will not prevent erosion but will prevent the detrimental effects of erosion to backshore areas by supplying an artificial sand source for the replenishment of the beach. Periodic nourishment will not greatly threaten shellfish habitat or shellfish population because it is such a small incremental input of sand relative to the volume of the beach. Beach nourishment is in many ways the best solution possible for Sea Bluff Beach because it will work in concert with natural beach processess while maintaining the benefits of having a beach.

United States Department of the Interior

OFFICE OF THE SECRETARY
Office of Environmental Project Review
1500 Custom House
165 State Street
Boston Massachusetts 02109

IN REPLY REFER TO:

ER 85/1626

January 3, 1986

Colonel Thomas Rhen
Division Engineer
New England Division
U.S. Army Corps of Engineers
424 Trapelo Road
Waltham, Massachusetts 02254

Dear Colonel Rhen:

This letter constitutes the Department of Interior's (DOI) response to the Draft Detailed Project Report (DDPR) and Environmental Assessment for the Okinawa Beach Erosion Control Project in West Haven, Connecticut (ER 85/1626).

1 — In considering proposals of this kind, Interior is primarily concerned with all of the possible impacts of dumping sand on a saltmarsh, intertidal mudflats and the resultant impacts upon the shellfish resources associated with both kinds of habitat. There appears to be a basis for contradiction in certain aspects of this proposal and the mandates of Executive Order 11990 (Wetland Protection). The proposed project is not seen as complying with that directive to avoid or at least to minimize the destruction, loss or degradation of wetlands. Similarly, it is not believed the project proposal will contribute to the preservation or enhancement of wetlands in the carrying out of federal programs in this case as is urged. In addition to the apparent contradictions with the Executive Order, the proposal is not believed to comply with the Section 404 (b) (1) Guidelines and feasible measures do exist to avoid impacting the saltmarsh and intertidal mudflats.

2 — To avoid impacting the saltmarsh, shellfish beds and intertidal mudflats, we recommend that sandfill be limited to the central and eastern portions of the beach above the mean water line. Construction activities should be constructed in the fall-winter period between October and May to avoid impacting shellfish reproduction and shorebird migration seasons.

Sincerely yours,

William Patterson

William Patterson
Regional Environmental Officer

Response to the Department of the Interior
Letter dated 3 January 1986

CMT1 The purpose of the proposed Corps of Engineer's project at Okinawa Beach is to maintain a protective recreational beach and backshore protection through a program of beach nourishment. Beach nourishment has been identified by the Corps as the only viable means of achieving the goal of maintaining this beach. The beach is fronted by extensive sand flats and at the southern end of the beach exists an ephemeral S. alterniflora marsh 1,667 square yards or 0.34 acres in size which supports a dense population of ribbed mussels. Approximately 1/3 or 0.11 acres of this marsh would be impacted by the proposed project. The project has been designed to incorporate the transplanting of S. alterniflora and tailored sand placement to minimize this impact even further.

The implementation of this project will result in a minimal impact to an ephemeral salt marsh. The proposed project is the only feasible and practicable alternative and has incorporated measures to minimize its impact on the project area. This project is therefore seen to be in compliance with Executive Order 11990 and Section 404 of the Clean Water Act as it avoids or minimizes impact and is the only practicable project alternative.

CMT2 It would not be practicable to restrict sand placement to the central and eastern portions of Okinawa Beach. To be an effective and complete project, beach nourishment should be placed along the entire beach. Sand placement to only a portion of the beach would not be good engineering pratice and would be of considerable expense.

Such control measures would be of little benefit as the size of the area to be protected by these elaborate measures is quite small and not of great utility to the surrounding area.

Office of the
STATE HISTORIC PRESERVATION OFFICER
for Connecticut

59 SOUTH PROSPECT STREET - HARTFORD, CONNECTICUT 06106 - TEL: (203) 566-3005

December 31, 1985

Mr. Horace H. Brown, Director
State of Connecticut
Comprehensive Planning Division, OPM
80 Washington Street
Hartford, CT 06106-4459

SUBJECT: Local Flood Protection
Okinawa Beach and Sea Bluff Beach
West Haven, Connecticut

Dear Mr. Brown:

The State Historic Preservation Office has reviewed the above-named project. In the opinion of the State Historic Preservation Office, this project will have no effect on historical, architectural, or archaeological resources listed on or eligible for the National Register of Historic Places.

This office appreciates the opportunity to have reviewed and commented upon this project.

For further information, please contact David A. Poirier, Archaeologist.

Sincerely,

Dawn Maddox

Dawn Maddox
Deputy State Historic
Preservation Officer

DAP/PW

Rev. 4/85

JAN 3 1986

STATE HISTORIC PRESERVATION OFFICER: The person responsible for implementation in Connecticut of the National Historic Preservation Act of 1966 administered by the Department of the Interior, Heritage Conservation and Recreation Service, Washington, D.C.

Response to the State of Connecticut
State Historic Preservation Office
Letter dated 31 December 1985

No response is necessary to the comments received in the State Historic Preservation Office letter.

United States Department of the Interior

FISH AND WILDLIFE SERVICE
ECOLOGICAL SERVICES
P.O. BOX 1518
CONCORD, NEW HAMPSHIRE 03301

Colonel Thomas A. Rhen
Division Engineer
New England Division
U.S. Army Corps of Engineers
424 Trapelo Road
Waltham, Massachusetts 02254

DEC 20 1985

Dear Colonel Rhen:

This letter constitutes our response to the Draft Detailed Project Report (DDPR) for the Okinawa Beach Erosion Control Project in West Haven, Connecticut. It has been prepared under authority of the Fish and Wildlife Coordination Act (48 stat. 401, as amended; 16 U.S.C. 661 et seq.) and constitutes our Fish and Wildlife Coordination Act Report on the project.

The proposed project is designed to restore the city-owned Okinawa Beach by widening the level beach berm to a width of 75 feet with a backshore elevation of 11.0 feet above the mean low water line. This would involve placing approximately 8,550 cubic yards of sand along 600 feet of shoreline at Okinawa Beach. The proposed project would also involve the replacement of an existing timber groin structure with a new groin. However, it is our understanding that the new groin structure would not be built concurrent with the beach restoration project. Beach nourishment would require approximately 400 cubic yards of sand annually.

The primary concerns of the Fish and Wildlife Service (FWS) are the direct impacts of dumping sand on a small salt marsh, the shellfish populations associated with it and adjacent intertidal habitat suitable for shellfish and other invertebrates. Our December 4 field trip to the Okinawa Beach marsh reconfirmed the findings of our previous field investigations in February 1983
1 and May 1984 that dense beds of blue mussels and ribbed mussels remain in this habitat. Numerous oysters also exist within the marsh and adjacent area. These resources would be destroyed if 600 square yards of marsh are buried beneath the sand placed on Okinawa Beach. Indirect impacts of sand drift further threatens the salt marsh, the shellfish beds within it and the adjacent intertidal mudflat. The habitat to be impacted is designated as Resource Category 2 because of its high ecological value and its relative scarcity on a national scale (FR Vol. 46, No. 15). In our opinion, the proposed project does not comply with Executive Order 11990 (Wetland
2 Protection) or with the Section 404(b)(1) Guidelines because practicable measures exist to avoid impacting the saltmarsh and intertidal mudflats. Even though the saltmarsh is relatively small, it is a significant issue because it is federal policy to protect and enhance these wetlands. Historically, countless acres of similar size saltmarshes have been destroyed along the Atlantic coast from illegal fills and permitted activities. We are opposed to
3 the direct placement of sand on the marsh because of its local importance to

shellfish and detrital production and other marine ecological values. Contrary to the DDPR, transplanting 200 square yards of Spartina alterniflora would not compensate the loss of saltmarsh habitat nor do we believe it is
4 easily achievable. Furthermore, we do not concur with the report that the remaining 400 square yards of marsh would fully recover after being buried beneath one to two feet of sand. We do not believe that filling wetlands can be properly identified as a legitimate beach nourishment activity as stated in
5 the report. The health of organisms inhabiting the marsh and intertidal flats would not be sustained or promoted by the proposed beach nourishment activities.

The DDPR states that erosion at Okinawa Beach averages about two feet per year and occasionally exceeds five feet per year. It is not clearly stated in the report how the initial placement of 8,550 cubic yards of sand followed by
6 periodic "nourishment" of 400 cubic yards of sand would alleviate the erosion rate of Okinawa Beach. Is this an effective long-term erosion control project or is it a short-term solution that will require annual maintenance indefinitely?

We recommend that sandfill be limited to the central and eastern portions of the beach above the mean water line. Construction activities should be conducted in the fall-winter period between October and May to avoid impacting
7 shellfish reproduction and shorebird migration seasons. Sandfill should not be placed either directly or indirectly on the saltmarsh or on the intertidal mudflats. A groin structure should be built if necessary to protect the marsh and intertidal mudflats from drifting sand.

Please contact Vern Lang or Ron Joseph of my staff if you should have any questions concerning this report or any of our comments.

Sincerely yours,

Vernon B. Lang

Gordon E. Beckett
Supervisor
New England Area

Response to U.S. Fish and Wildlife Service
Letter dated 20 December 1985

CMT1 On 7 March 1986 personnel of the Corps of Engineers revisited the Okinawa project site to inspect the ephemeral Spartina alterniflora marsh at the southern end of the beach. We found, as stated in the EA, that numerous ribbed mussels existed in the salt marsh area. In addition, some occasional blue mussels were noted as being present. It was also apparent that first year oyster set has been present in the area but that a viable reproducing population does not exist. The oyster set observed by Fish and Wildlife Service was probably introduced by wash in from nearby oyster beds in New Haven Harbor.

Implementation of the Corps proposed project will directly impact 0.11 acres of this 0.34 acre ephemeral salt marsh at the southern end of Okinawa Beach. This impact will be minimized by transporting marsh areas and tailoring sand placement onto the beach. A strip of the landward most portion of the intertidal sand flat adjacent fronting the beach will also be directly impacted by sand placement. Indirect impacts of sand drift are not anticipated to occur because movement of sand onto or off the beach will be at the same rate or less than presently exist at the project site.

CMT2 The Corps has identified the proposed beach nourishment plan as the only feasible, practicable alternative to achieve the goal of maintaining a stable, protective, recreational beach at Okinawa Beach. This plan has been designed to minimize impact to the ephemeral salt marsh at the project's southerly limit. As such, this plan is seen as being in compliance with both Executive Order 11990 and Section 404 of the Clean Water Act.

CMT3 The Corps maintains that the 0.11 acres of ephemeral salt marsh which will be impacted by the proposed project is not important to detrital production and other marine ecological values in the area of New Haven Harbor where it is located and is of only limited importance to shellfish.

CMT4 The transplanting of 200 square yards of salt marsh will compensate for part of the loss of 555 square yards of salt marsh habitat and can be achieved using proven techniques. Most of the remainder of the impacted salt marsh should be capable of reestablishing itself as studies done for the Corps have shown that Spartina alterniflora can recover through upwards of 12 to 15 inches of placed sand material (Reimold, R., M. Hardisky, P. Adams: 1978). On 24 March 1986 personnel from NED visited Okinawa Beach with representatives of the USFWS and the CT Division of Aquaculture. The purpose of the visit was to resolve the USFWS concerns about the impacts to the salt marsh, located at the west limit of the study, as a result of project implementation. Coordination meetings were held by NED, in the field, prior to selecting a final plan of improvement. The State suggested that a mitigation plan be implemented, which consisted of transplanting that part of the saltmarsh to be directly affected by the initial construction of the project. The project, as designed, is acceptable to the State of Connecticut and in compliance with state regulations. During this site visit the Corps sought to achieve an additional mitigation package that would be satisfactory to the USFWS as well. After negotiation at the site, the USFWS's final position was that, the only measure acceptable to them would be total avoidance of sandfill placement on the marsh. This is not a viable alternative and would not be considered sound engineering design for the project. To compromise as fully as possible the Corps has designed and will implement transplanting for 100% of the initially impacted marsh area in addition to the 50% of the marsh anticipated to reestablish itself through the placed sandfill. Detailed design of this mitigation plan will occur during the plans and specification stage of project implementation.

CMT5 The Okinawa Beach project involves the nourishment of 600 feet of shoreline, the southern 100 feet of which encounters portions of an ephemeral salt marsh which has encroached onto the eroded beach. The intent of this project is to restore that beach not to create new beach by the filling of wetlands. That nourishment of this beach encroaches onto the ephemeral wetland at its present southern limit does not alter the legitimacy of this project as beach nourishment.

CMT6 The proposed beach nourishment project at Okinawa Beach, like that at Sea Bluff, will not end beach erosion. It will control erosion by maintaining an acceptable beach width which will prevent the deleterious effects of erosion which would occur in an uncontrolled situation.

CMT7 It would not be practicable to restrict sand placement to the central and eastern portions of Okinawa Beach. To be an effective and complete project, beach nourishment should be placed along the entire beach. Sand placement to only a portion of the beach would not be good engineering practice and would be of considerable expense.

Such control measures would be of little benefit as the size of the area to be protected by these elaborate measures is quite small and not of great utility to the surrounding area.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION I
J. F. KENNEDY FEDERAL BUILDING, BOSTON, MASSACHUSETTS 02203

November 20, 1985

Joseph L. Ignazio, Chief
Planning Division
New England Division
U.S. Army Corps of Engineers
424 Trapelo Road
Waltham, MA 02254

Dear Mr. Ignazio:

In accordance with Section 176(c) and 309 of the Clean Air Act, and the National Environmental Policy Act, we have reviewed the Detailed Project Report, the Environmental Assessment/Environmental Finding of No Significant Impact, and Section 404(b)(1) Evaluation for the Okinawa Beach Small Beach Erosion Control Project, West Haven, Connecticut.

The project has been found to be satisfactory from the standpoint of environmental quality, health and welfare, within EPA's areas of jurisdiction and expertise.

Thank you for the opportunity to review the Finding of No Significant Impact.

Sincerely yours,

Elizabeth A. Higgins

Elizabeth A. Higgins, Assistant Director
for Environmental Review
Office of Government Relations & Environmental Review

cc: Ernest Waterman, COE, Impact Analysis Branch
Doug Thompson, EPA, WQP-2103
Ed Reiner, EPA, WQP-2103

Response to the U.S. Environmental Protection Agency
Letter dated 20 November 1985

No response is necessary to the comments received in the U.S. Environmental Protection Agency letter.

United States Department of the Interior

FISH AND WILDLIFE SERVICE
ECOLOGICAL SERVICES
P.O. BOX 1518
CONCORD, NEW HAMPSHIRE 03301

Mr. Joseph Ignazio, Chief
Planning Division
U.S. Army Corps of Engineers
New England Division
424 Trapelo Road
Waltham, Massachusetts 02254

NOV 21 1984

Dear Mr. Ignazio:

This responds to your October 18, 1984 request for information on the presence of Federally listed and proposed endangered or threatened species in conjunction with proposed beach erosion control projects at Sea Bluff and Okinawa Beaches in West Haven, Connecticut.

Our review shows that except for occasional transient individuals, no Federally listed or proposed species under our jurisdiction are known to exist in the project impact area. Therefore, no Biological Assessment or further consultation is required with us under Section 7 of the Endangered Species Act. Should project plans change, or if additional information on listed or proposed species becomes available, this determination may be reconsidered.

This response relates only to endangered species under our jurisdiction. It does not address other legislation or our concerns under the Fish and Wildlife Coordination Act.

A list of Federally designated endangered and threatened species in Connecticut is enclosed for your information. Thank you for your cooperation and please contact us if we can be of further assistance.

Sincerely yours,

Gordon E. Beckett

Gordon E. Beckett
Supervisor
New England Field Office

Enclosure

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE

Services Division
Habitat Protection Branch
14 Elm Street
Gloucester, MA 01930

November 21, 1984

Mr. Joseph L. Ignazio
Chief, Planning Division
Department of the Army
Corps of Engineers
424 Trapelo Road
Waltham, Massachusetts 02254

Dear Mr. Ignazio:

This is in response to your September 27, 1984, request for a list of endangered or threatened species present in the areas of Sea Bluff and Okinawa Beaches, New Haven, Connecticut pursuant to Section 7(c) of the Endangered Species Act of 1973, as amended. We have identified the presence of no endangered or threatened species in the project area that come under the jurisdiction of the National Marine Fisheries Service. Should project plans change, or additional information on listed or proposed species become available, this determination may be reconsidered.

If you have any comments or questions regarding this project you may contact Tracey McKenzie of my staff at FTS 837-9239.

Sincerely,

Thomas E. Bigford

Thomas E. Bigford
Branch Chief

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Services Division
Habitat Protection Branch
Federal Building, 14 Elm Street
Gloucester, Massachusetts 01930

SEP 24 1984

Mr. Tom Bruha
New England Division
Corps of Engineers
424 Trapelo Road
Waltham, Massachusetts 02254

Dear Mr. Bruha:

In summary of our joint field trip of September 4, 1984, to Okinawa and Prospect Beaches in West Haven, Connecticut, we offer the following points made during that visit.

1. Nourishing Okinawa Beach would require burial of a portion of the salt marsh located on the southern end.

2. The existing littoral drift movement along Okinawa Beach appears to be moving sand into the existing marsh.

3. Along the southern flank of the Okinawa Beach Cove is an area where salt marsh vegetation does not grow.

4. Two actions could be undertaken to lessen the biological impacts of the beach nourishment.

a. Grade the proposed beach face down on the southern end to be a thin veneer. The grading would allow the marsh to grow through the newly placed fill. This is mitigation.

b. Filling and subsequent planting of the "no growth" area in the southern flank of Okinawa Beach would make it a continuous bed of productive salt marsh. This would be compensation.

5. The southern portion of the West Haven Beach system is being scoured by littoral action in a northward direction toward Bradley Point. Material carried northward along the beaches is in an active transport mode and is less than ideal for most nearshore organisms. Why not utilize the deposition site at Bradley Point for at least some beach nourishment material? This means that reclaiming that material has few biological impacts if carried out during the spring or late fall. This option should be considered.

Should you wish to further explore these points please contact Michael Ludwig at the Milford Biological Laboratory. (FTS 642-5213)

Sincerely,

Bruce E. Higgins
Acting Branch Chief

DISPOSITION FORM

For use of this form, see AR 340-15; the proponent agency is TAGO.

OFFICE SYMBOL	SUBJECT
NEDPL-I	West Haven Beaches

TO MFR FROM Mr. Waterman, Impact Analysis Branch DATE 20 Sept. 1984 CMT 1

1. DATE OF TRIP: 5 September 1984

2. PLACE: West Haven Beach Erosion, West Haven, CT.

3. LIST OF PARTICIPANTS:

Michael Ludwig, National Marine Fisheries Service
Tina Suarez-Murias, Connecticut Department of Environmental Protection
Paul Beuner, City of West Haven
Mary Tracy, City of West Haven
Thomas Bruha, Planning, NED, CDB
Betty Parfenuk, Planning, NED, IAB
Ernest Waterman, Planning, NED, IAB

4. REPORT:

The purpose of this trip was to fully evaluate the affected environment at Okinawa and Sea Bluff Beaches; to discuss possible mitigation measures and alternatives to the proposed plans; and to coordinate and update our activities with local, State and Federal officials.

Discussions-The party met at Okinawa Beach at 10:30 a.m. and inspected this portion of the project site. The major environmental concern associated with Okinawa Beach is a small (566 sq. yds.) area of salt marsh (mainly *Spartina alterniflora* and *Salicornia virginica*) located at the western end of the beach which would be covered by beach nourishment operations. Mike Ludwig suggested that a portion of the impacted salt marsh could be transplanted to an area on Bradley Point which is adjacent to the unimpacted existing wetland and the nourished beach and could be made suitable for marsh growth with construction of a sand pad to place the marsh at a suitable tidal elevation. The remainder of the impacted marsh should be covered by only 1 to 2 feet of sandfill. That part of the marsh should be capable of growing through the sandfill and reestablishing itself.

Tina Suarez- Murias pointed out that the remains of the timber groin at the eastern end of the beach and the old dock pilings toward the western end would constitute a safety hazard. Tom Bruha said that these structures would be cut off or extracted before nourishment took place.

Paul Buener stated that the city was planning to put in a low wall on the backshore to control access and protect the backshore area and asked if this was necessary. Tom Bruha stated that this was unneccessary for erosion control. Tina Suarez-Murias said that if the city wished to control for traffic onto the beach, that plantings of Rugosa rose (*Rosa rugosa*) would probably be more effective and more aesthetically pleasing.

PREVIOUS EDITIONS WILL BE USED

Tina Suarez-Murias asked if the timber groin at the eastern end of the beach would be replaced. We responded that NED was considering a deferred replacement of the groin. Beach nourishment only would take place unless subsequent monitoring of the beach showed that the groin was needed to prevent excessive sandloss and maintain the beach. All present agreed that this would be the best course of action.

After viewing Okinawa Beach we discussed plans for and looked at Sea Bluff Beach. Mike Ludwig pointed out that the tidal flat in front of Sea Bluff supported very few Bentheic organisms because the substrate is extremely dynamic and constantly shifting. He suggested that the beach might be nourished or partially nourished by bulldozing material from the tidal flat back onto the beach face. Tom Bruha stated that we would examine the feasibility of this alternative.

E. WATERMAN

STATE OF CONNECTICUT

DEPARTMENT OF ENVIRONMENTAL PROTECTION

COASTAL AREA MANAGEMENT PROGRAM

September 12, 1984

Tom Bruha
Army Corps of Engineers - NED
Planning Branch
424 Trapelo Road
Waltham, Massachusetts 02254

RE: West Haven Beach Projects

Dear Mr. Bruha:

This letter is written as a follow-up to the site visit of September 5, 1984 with you and your staff and representatives of the Town of West Haven and the National Marine Fisheries Service. I have discussed the projects with DEP's Water Resources Unit and offer the following comments preliminary to the preparation of your Environmental Assessment.

Okinawa Beach

The proposal which we discussed consisted of beach nourishment using sand fill, a terminal groin at the eastern end of the beach and transplanting a small patch of *Spartina alterniflora* to new substrate at the western end of the beach.

The *Spartina* presently grows on silty deposits in the rocks forming Bradley Point and on the sandy, low-energy intertidal area edging the Point. Old aerial photographs indicate that these grasses may be ephemeral, responding to fluctuations in water elevations, impacting land use and in-water structures over the years. To minimize impact to the existing grasses, beach fill should be designed so that the grasses can grow in the intertidal area. New beach sand placed over the currently unvegetated rocky intertidal area at the base of Bradley Point should also be at a proper elevation to support any transplanted grasses. The above discussion refers to a very small area but the proposal should be clearly and explicitly described and mapped in your plans.

As regards the proposed groin, it is state policy (section 22a-92(b)(2)(J) C.G.S to discourage structural solutions to erosion problems unless the structure is necessary and unavoidable for the protection of infrastructural facilities and unless there is no other feasible, less environmentally damaging alternative and all reasonable mitigation measures have been utilized. It appears that the rocky headland at the eastern end of the beach may be sufficient to protect the sand fill from excessive erosion and that a groin may be redundant and unnecessary at that location. Therefore we feel strongly that the groin be deferred. After the sand fill has been placed and the sand movement and circulation has been sufficiently evaluated, then the need for a groin could be discussed.

165 Capitol Avenue • Hartford, Connecticut 06106
An Equal Opportunity Employer

The placement of sand fill should be scheduled so as to avoid the shellfish spawning season of June 1 to September 30 in order to minimize the adverse impacts of turbidity on the shellfish.

Bradley Rock Beach

As we agreed in a previous site visit, Bradley Rock Beach between Bradley Point and the Cove River is a valuable and diverse habitat area and should be left undisturbed. The large natural shellfish bed on the intertidal flat should not be covered with sand fill. Although closed to commercial and recreational harvesting, it is extremely productive biologically in comparison to the intertidal areas of the other beaches under discussion. The flat, in combination with the rocky headland of Bradley Point, the fringing tidal marsh and the adjacent Cove River with its natural oyster population make the Bradley Rock Beach a very valuable natural area. It can be well utilized for educational purposes and passive recreation.

Sea Bluff Beach

As an alternative to placing exogenous sand fill at Sea Bluff Beach, it may be possible to move the sand from the intertidal flats up onto the beach above high water, thus creating a steeper beach profile. The new beach could be blanketed with coarser exogenous sand, lessening the erosion of the finer material. Should you choose this alternative, analysis of the impacts to littoral sand transport would be necessary. Adverse impacts to avoid would be degradation of natural erosion patterns through significant alteration of littoral transport of sediments in terms of deposition or source reduction. This analysis would be important since you are also studying erosion problems at adjacent Prospect Beach.

If redistributing sand from the intertidal flat is designed as an alternative for the Sea Bluff Beach project, it could be carried out by the town. The town must obtain a permit from DEP for the non-Federal work under section 22a-361 of the Connecticut General Statutes to conduct the beach regrading. The Water Resource Unit, 203-566-7160 is the correct contact for permitting. Issuance of the state license serves as the coastal consistency concurrence and the water quality certification for the town-operated part of the project.

As you know, all of these projects, as Federal actions, will require Coastal Management consistency review under Section 307(c) of the Federal Coastal Zone Management Act and Water Quality Certification under Section 401 of the Clean Water Act from the state. You may request these reviews jointly from the Commissioner of DEP. You may submit the Environmental Assessment as background information. The Water Resources Unit handles Water Quality Certification and the Planning and Coordination/Coastal Management staff handles the coastal consistency review but we can offer a joint response.

Should you have any other questions, please feel free to contact me at (203)566-7404. Thank you for consulting with us early in project planning.

Sincerely,

Tina Suarez-Murias

Tina Suarez-Murias
Senior Environmental Analyst

TSM/mic

Office of the
STATE HISTORIC PRESERVATION OFFICER
for Connecticut

59 SOUTH PROSPECT STREET - HARTFORD, CONNECTICUT 06106 - TEL: (203) 566-3005

September 6, 1984

Department of the Army
New England Division
Corps of Engineers
424 Trapelo Road
Waltham, MA 02154

Attn: Mr. Joseph L. Ignazio
Chief, Planning Division
Impact Analysis Branch

Subject: Sea Bluff Beach and Okinawa Beach
West Haven, CT

Dear Sir:

The State Historic Preservation Officer has reviewed the above-named project. In the opinion of the State Historic Preservation Officer, this project will have no effect on historical, architectural or archaeological resources listed on or eligible for the National Register of Historic Places.

This office appreciates the opportunity to have reviewed and commented upon this project.

For further information, please contact David A. Poirier, Archaeologist.

Sincerely

Dawn Maddox

Dawn Maddox
Deputy State Historic
Preservation Officer

DAP/IL

Rev. 4/83

STATE HISTORIC PRESERVATION OFFICER: The person responsible for implementation in Connecticut of the National Historic Preservation Act of 1966 administered by the Department of the Interior, Heritage Conservation and Recreation Service, Washington, D.C.
AN EQUAL OPPORTUNITY EMPLOYER/AFFIRMATIVE ACTION AGENCY

August 29, 1984

Planning Division
Impact Analysis Branch

Mr. John W. Shannahan
State Historic Preservation Officer
59 South Prospect Street
Hartford, Connecticut 06106

Dear Mr. Shannahan:

As discussed in a telephone conversation of August 22, 1984 between Mr. Porier, of your staff, and our Division Archaeologist, John S. Wilson, we enclose a plan illustrating proposed beach restoration in West Haven.

Plan 1 of restoration involves widening of Sea Bluff and Okinawa beaches to a maximum of 100 feet, with possible construction of groins at the west end of Sea Bluff Beach and east end of Okinawa Beach. Plan 2 involves addition of a rock revetment along the backshore of both beaches.

Soils and surficial geology maps indicate that the entire study area, with the exception of Bradley Rock, consists of fill deposited some time between 1870 and 1949.

Given the above data, and the eroding condition of the beaches, no effect upon significant archaeological resources is anticipated due to the proposed beach restoration project. We would appreciate your timely concurrence, for inclusion in our project Environmental Assessment, which is now being written.

Sincerely,

Joseph L. Ignazio
Chief, Planning Division

United States Department of the Interior

FISH AND WILDLIFE SERVICE
ECOLOGICAL SERVICES
P.O. BOX 1518
CONCORD, NEW HAMPSHIRE 03301

JUL 3 1984

Colonel Carl B. Sciple
Division Engineer
U.S. Army Corps of Engineers
New England Division
424 Trapelo Road
Waltham, MA 02254

Dear Colonel Sciple:

This Planning Aid letter is intended to aid your study planning efforts for the development of beach erosion control measures at Okinawa Beach, West Haven, Connecticut. It has been prepared under authority of the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661 et seq.).

Okinawa Beach is a small city-owned beach located between Bradley Point and Savin Rock. We understand that your preliminary beach improvement plan for this area includes beach widening, by the direct placement of sandfill, and possible removal and/or replacement of a timbered groin at the eastern terminus of the project.

A field investigation of the project area was conducted on May 22, 1984, by personnel of this Service. A small area of saltmarsh, Spartina alterniflora, is located at the western end of the beach near Bradley Point. Numerous ribbed mussels were noted in this saltmarsh habitat. The rock outcroppings at Bradley Point support a diverse biological community and numerous barnacles, blue mussels, periwinkles, and oyster spat were noted in the intertidal area on this stable hard surfaced habitat.

The intertidal area of the beach is predominantly sand with a moderate amount of organic deposition. Many test pits were dug in this area resulting in a total take of 1 soft clam and 1 hard clam. Marine worms were noted throughout the area but were not abundant. While it is evident that shellfish can be found within the immediate area of Okinawa Beach, it appears that a large population does not exist.

There are significant commercial oyster and hard clam grounds in the offshore area. The inshore boundary of these grounds is approximately 1,000 feet from Bradley Point.[1]

[1] Connecticut Department of Agriculture, Aquaculture Division, Map of New Haven and West Haven Oyster Ground, February 1981.

Finfish species found in the area include winter flounder, sand dabs, blackfish, summer flounder, scup, sea robins, cunner, bluefish, mackerel, weakfish and striped bass. The general area, especially Bradley Point, is quite heavily utilized by fishermen with the most frequently caught species being winter flounder and snapper bluefish.

Removal and/or replacement of the eastern groin would have no signficant adverse impacts upon fish and wildlife resources. If the groin is replaced we suggest that a rock groin be utilized and that it be made suitable for safe use by fishermen, since this would provide some additional fishing opportunity.

Placing sandfill throughout the intertidal area of the beach would destroy a small S. alterniflora marsh. This adverse impact could be avoided by limiting sandfill to the central and eastern portions of the beach. Additional sand in this area, above the mean low water line, is not expected to significantly impact existing resources within the sandfill area. The most potential for adverse impact is the migration of a large amount of sand from the central and eastern portions of the beach to the saltmarsh or to offshore shellfish beds.

Your studies should include an analysis of sand movement so that (1) sand placed on the central and eastern portion of the beach can be contained as much as possible, and (2) the impact on benthic habitat of sand lost from the beach during placement and subsequent storms can be determined.

We would be pleased to assist you in the various stages of project planning, and we will report on the potential impacts of your alternative project plans.

Sincerely yours,

for Gordon E. Beckett
Supervisor
New England Field Office

.NCE C. MINICHINO
MAYOR

OFFICE OF THE MAYOR

CITY OF WEST HAVEN
CONNECTICUT

June 23, 1983

Colonel Carl Sciple, Division Engineer
Department of the Army
Corps of Engineers
New England Division
424 Trapelo Road
Waltham, Mass. 02154

Dear Colonal Sciple,

I call to your attention the attached copy of a letter to Joseph Ignazio, Chief of your Planning Division.

Members of my staff accompanied John Volk and Tom Bruha and others during the June 1, 1983 inspection of Bradley Rock Beach referred to. I concur with Mr. Volk's opinion regarding the Bradley Rock Beach Area.

During the inspection it was observed that the area from Bradley Rock east to Savin Rock, locally known as Okinawa Beach, is eroded to the extent that the retaining wall just west of Savin Rock is subject to wave erosion at high water. The beach at this point was formerly 150 feet deep where, now, there is no beach at all.

I am very familiar with this area and it is my opinion that there is a legitimate need for erosion control to stop the continuing encroachment into Bradley Point Park and to prevent possible future undermining of the Sea Wall which was rebuilt by the City at considerable expense less that a year ago.

For the reasons stated, I ask that the Okinawa beach area from Bradley Point to Savin Rock be included in your beach nourishment program in lieu of the Bradley Rock Beach.

Sincerely,

Lawrence C. Minichino

Lawrence C. Minichino
Mayor

LCM/jdc

STATE OF CONNECTICUT
DEPARTMENT OF AGRICULTURE — AQUACULTURE DIVISION
~~ROGERS AVENUE~~ • MILFORD, CONNECTICUT 06460
P.O. Box 97 TELEPHONE 874-0696

June 14, 1983

Mr. Joseph Ignazio
Chief, Planning Division
Army Corps of Engineers
424 Trapelo Road
Waltham, Massachusetts 02254

Subject: Bradley Rock Beach
West Haven, Conn.

Dear Mr. Ignazio:

On June 1, 1983, I participated in an on-site inspection of Bradley Rock Beach in West Haven, Connecticut.

This beach is one of several West Haven beaches under consideration for development and improvement by the Corps of Engineers.

Based on field observations made during the above mentioned inspection, this division recommends that Bradley Beach be left undisturbed and that no further consideration be given to the development of this ecologically important site.

Bradley Rock Beach is characterized as an area of moderate organic deposition, consisting of intertidal flats which support a dense population of soft clams (Mya arenaria) and abundant marine worms. Along the eastern portion of this covelike beach is a developing saltmarsh (Spartina alterniflora) and a rock outcropping of diverse biological productivity along the intertidal zone.

This division feels that in its present state, Bradley Rock Beach offers the following socio-economic benefits to the City of West Haven:

1. The cove provides a biologically productive habitat significant to the ecological welfare of West Haven's shoreline.

2. This area is an excellent site for recreational fishermen to pursue their activities away from bathers and other swimming activities.

3. Furthermore, this natural area provides an outstanding opportunity for educators to introduce West Haven's young citizens to marine biology and ecology, through school field trips to this site.

(cont'd. on Page 2)

(Mr. Joseph Ignazio, cont'd.)

I believe that the Bradley Rock Beach area, if allowed to remain in its present natural condition, makes an outstanding contribution to the City of West Haven's overall plan for shoreline usage.

Additionally, during the June 1, 1983 field investigation, we inspected the beach located between Bradley Point Rocks and Savin Rock. This area is known locally as Okinawa Beach.

This division feels that Okinawa Beach, in particular the center and eastern portions, can be suitably developed for structured aquatic activities to be offered in the future by West Haven's Recreation Department.

I sincerely hope that you will find the above comments useful in your planning efforts for the City of West Haven's shoreline.

If I can be of further assistance, please let me know.

Yours truly,

John H. Volk
Division Chief

JHV:p

c.c. Coastal Area Management

Mayor Lawrence Minichino
City of West Haven

Michael Ludwig
Habitat Protection Branch
National Marine Fisheries Service

Gordon Beckett, Supervisor
U.S. Fish & Wildlife Service
Department of the Interior

United States Department of the Interior

FISH AND WILDLIFE SERVICE
ECOLOGICAL SERVICES
P.O. BOX 1518
CONCORD, NEW HAMPSHIRE 03301

Colonel Carl B. Sciple
Division Engineer
New England Division
U.S. Army Corps of Engineers
424 Trapelo Road
Waltham, Massachusetts 02254

MAR 11 1983

Dear Colonel Sciple:

This Planning Aid letter is intended to aid your study planning efforts for the development of beach erosion control measures at Sea Bluff and Bradley Rock Beaches, West Haven, Connecticut. It has been prepared under authority of the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661 et seq.).

We understand that both Sea Bluff and Bradley Rock Beaches are city-owned and are open to the public. Sea Bluff Beach extends 1,000 feet west from the mouth of Cove River to the eastern edge of Prospect Beach at Ivy Street. Bradley Rock Beach extends 600 feet east from the Cove River inlet to Bradley Point. Your preliminary beach improvement plans for these areas include beach widening, to a level berm width of 50 feet, by the direct placement of sandfill along approximately 1,600 feet of shoreline, plus groin structures at various locations.

A field investigation of the project areas was conducted on February 24, 1983, by personnel of the Connecticut Department of Agriculture, Aquaculture Division, and this Service. The existing groin structures at the western terminus of both beaches and the rock outcroppings at Bradley Point were fairly well covered by barnacles and numerous blue mussels, periwinkles, and oyster spat were noted on this stable, hard-surfaced habitat.

The intertidal area of both beaches is predominantly sand. Shells of oyster, blue mussel, and soft-shell and hard-shell clams were noted throughout this area. However, thirteen (13) randomly dug test pits at Sea Bluff Beach resulted in a total take of one (1) soft-shell clam. While it is evident that shellfish can be found within the immediate area of Sea Bluff Beach, it appears that a large population does not exist.

Bradley Rock Beach is a cove-like area located between the groin at Cove River and Bradley Point. There is essentially no dry beach at mean high water. A small area of saltmarsh, Spartina alterniflora, is located in the eastern bend of the cove near Bradley Point. Eighteen (18) randomly dug test pits, paralleling the mean high water line at distances of 25 to 50 feet and 100 to 125 feet from shore, resulted in a total take of 50 soft-shell clams. Numerous

bloodworms were found, but not counted. Most pits, approximately 1-foot square, yielded 3-4 clams. Only 4 out of 18 pits contained no clams. Based on these data, the intertidal area of Bradley Rock Beach supports a significant soft-shell clam population of about 2.8 clams per square foot.

There are significant commercial oyster and hard-shell clam grounds in the offshore area of both Bradley Rock and Sea Bluff Beaches. The inshore boundary of these grounds is approximately 1,000 feet from Bradley Point. 1

The Cove River separates Sea Bluff and Bradley Rock Beaches. Inspection of the river above the old tide gate revealed that it was literally paved with oysters. This area probably serves as an important seed source for offshore oyster grounds.

Finfish species found in the area include winter flounder, sand dabs, blackfish, summer flounder, scup, sea robins, cunner, bluefish, mackrel, weakfish and striped bass. The general area, especially Bradley Rock Beach, is quite heavily utilized by fishermen with the most frequently caught species being winter flounder and snapper bluefish.

Placing sandfill in the intertidal area of Bradley Rock Beach would destroy a small S. alterinflora saltmarsh and bury a portion of a productive clam flat. Placement of groins in this area would destroy an additional area of clam flat. Based on our field investigation, we recommend that no additional sandfill and/or groins be placed in the intertidal area of Bradley Rock Beach.

Placing additional sand on Sea Bluff Beach and the addition of groins is not expected to significantly impact existing resources of the immediate project area. The most potential for adverse impact is the migration of a large amount of sand from this beach to the clam flats in the Bradley Rock Beach area or to offshore shellfish beds.

Your studies should include an analysis of sand movement so that (1) sand placed on the beach can be contained as much as possible, and (2) the impact on benthic habitat of sand lost from the beach during placement and subsequent storms can be determined.

1 Connecticut Department of Agriculture, Aquaculture Division. Map of New Haven and West Haven Oyster Ground, February, 1981.

We would be pleased to assist you in the various stages of project planning, and we will report on the potential impacts of your alternative project plans.

Sincerely yours,

for Vernon B. Lang

Gordon E. Beckett
Supervisor

OFFICE OF THE MAYOR
CITY OF WEST HAVEN
CONNECTICUT

ROBERT A. JOHNSON
MAYOR

June 26, 1981

Colonel C. E. Edgar, III
Corps of Engineers
Commander and Division Engineer
New England Division
DEPARTMENT OF THE ARMY
424 Trapelo Road
Waltham, Massachusetts 02254

Dear Colonel Edgar:

The purpose of this letter is to indicate the City of West Haven's general concurrence with, and approval of the Reconnaissance Reports for Small Beach Erosion Control Improvements at Bradley Rock and Sea Bluff Beaches.

The City is anxious to enter the final step in this study process and, therefore, renders its approval with the understanding that local concerns relative to the scope and boundaries of the projects may be addressed in greater detail on the staff level during the course of the phase II project schedule.

As Mayor of the City of West Haven, I would like to extend my appreciation to you for your support and assistance in achieving a meaningful and productive working relationship between the U.S. Army Corps of Engineers and the City of West Haven without which these projects could not have achieved success.

I have asked City Engineer, Robert Kulacz, to contact Thomas Bruha, Chief of the Corps' Beach Erosion Section, to relate any modification which may be appropriate. In the interim, I urge that phase II of this extremely important study be initiated.

Sincerely,

Robert A. Johnson
Mayor

RAJ/dmm

OFFICE OF THE MAYOR

CITY OF WEST HAVEN
CONNECTICUT

ROBERT A. JOHNSON
MAYOR

April 28, 1980

Colonel Max B. Scheider
Division Engineer
Corps of Engineers
New England Division
424 Trapelo Road
Waltham, Massachusetts 02154

Dear Colonel Scheider:

Recently, personnel from the Army Corps of Engineers, and the State Department of Environmental Protection, together with our city personnel, assessed the beach erosion along the shorefront of West Haven. The city has approximately five miles of beach which is heavily utilized by the citizens of West Haven and area municipalities, including New Haven, Orange, Milford, Woodbridge and others.

It was the unanimous opinion of all who made the tour of inspection that extensive work must be done on the entire five miles of beach! We were informed however, that a project of this scope and magnitude would not be possible at this time because of routine application and scheduling requirements coupled with federal financial constraints. In addition, we were informed that, at best, we should not expect approval for corrective work along the entire five miles of beaches for five to six years.

In view of the abovementioned timetable, the City of West Haven would like to request federal assistance under Section 103 of the River and Harbor Act of 1962, as amended, to develop and construct a shore and beach restoration and protection project in the Sea Bluff area of West Haven. This area has been identified as an eligible pocket area by a member of the Corps of Engineers, Mr. Thomas Bruha. The City Engineer, Mr. Robert Kulacz and our engineering department, will provide Mr. Bruha with back-up information as requested during his visit to our city.

Although we realize that a heavy workload faces all agencies, we would appreciate it if we could receive a response in the very near future. This is necessary in order for us to proceed to inform the State Department of Environmental Protection, which is initiating a study of the entire shoreline in conformance with Corps standards.

If your department needs any additional back-up information, please feel free to call on us.

Sincerely,

Robert A. Johnson
Mayor

RAJ/srp

APPENDIX 2

COASTAL PROCESSES

COASTAL PROCESSES

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COASTAL PROCESSES

GEOLOGY

OVERVIEW

Sea Bluff and Okinawa are sandy pocket beaches located in the city of West Haven on the western shore of New Haven Harbor. The beaches are separated from each other by Bradley Point, Bradley Rock Beach and Cove River immediately southwest of the point. Sea Bluff Beach extends 1000 feet southwest of the mouth of Cove River to the eastern end of Prospect Beach. Okinawa Beach abuts Bradley Point on its northeast side and extends northeast for 600 feet. Low hills of till and bedrock rise in back of Sea Bluff Beach and adjacent beaches to the southwest and provide the shingles, pebbles, and coarse sediments which constitute the natural materials of these beaches. Okinawa Beach fronts a low lying area of glacially derived unconsolidated sand deposits. This section of the report will discuss the geologic history of the study area.

BEDROCK GEOLOGY

The bedrock of the embayed and irregular coastline of Connecticut consists primarily of crystalline metamorphic and igneous rock formed during a long and complex history of repeated intrusions, uplift, erosion and periods of folding and faulting. Of special interest in the general area of Prospect Beach is the presence of the Connecticut Low Land. In early Mesozoic time a major series of north-south trending faults occurred in a narrow belt through central Connecticut and Massachusetts. These faults resulted in a low trough which became filled with sediments from the eroding highlands on either side. Subsequent periods of erosion wore away these softer sedimentary rocks leaving a low lying area extending from New Haven northwards to Middletown and then northerly along the present course of the Connecticut River. This low area, termed the Connecticut Low Land, is bordered on both sides by highlands of older crystalline bedrock.

The embayed New Haven Harbor is a reflection of this more easily eroded low land area and serves as a topographic expression of the southern end of the trough. The older crystalline highlands to the east are seen at Lighthouse Point, on the eastern edge of New Haven Harbor, and the western border highlands outcrop at Jones Hill which rises immediately adjacent to Prospect Beach.

Following the formation of the lowland and associated bordering highlands, the entire region was subjected to further erosion including that which carved out the depression now occupied by Long Island Sound. Further erosion of the coastal area was halted approximately 2 million years ago by the advent of Pleistocene glaciation. It is the results of this episode of glaciation which has had the most profound and immediate effect on the coastal geology of Connecticut including the area of New Haven Harbor and Prospect Beach.

SURFICIAL GEOLOGY

With the cooling of the earth's climate at the beginning of the Pleistocene, ice began to spread over New England from the north. This glacial ice eventually reached thicknesses of several thousands of feet and, as it moved over the land, eroded, transported and redeposited vast quantities of earth material which markedly altered the shape and topography of the effected area. There were four major advances of the ice and it is the effect of the last advance, the Wisconsin stage, that remains most in evidence today. Wisconsin ice began about 80 thousand years ago and reached its maximum southern extent approximately 18,000 years ago. It occupied this position for a sufficient length of time to allow the melting wasting ice to deposit an east-west trending linear moraine of till which forms the backbone of Long Island. Subsequent shaping by the forces of winds and waves resulted in the familiar shape of the Island seen today. Following deposition of the moraine, the rate of ice melting increased and the margin of the ice sheet retreated northerly. Large quantities of material previously carried by the glacier were deposited during this melting. These glacial deposits are of two types: till, an unsorted unstratified deposit of material ranging in size from clay to boulders; and stratified drift. One of the most common deposits of stratified drift is called outwash and consists of flat lying beds of well sorted sands and gravel.

The present day configuration of the coastline in the vicinity of New Haven Harbor is largely a result of the combined influence of the nature and topography of the bedrock in the area and the effect of glacial erosion and deposition on that bedrock surface. The shoreline from Sea Bluff Beach and Bradley Point and extending about 1.5 miles southwest to Oyster River Point is characterized by mixed deposits of glacial outwash and till with local outcrops of bedrock. The till is commonly seen as a thin veneer over crystalline bedrock hills. Till and bedrock are much more resistant to erosion than are deposits of outwash. Oyster River Point, a prominent headland at the southwest side of New Haven Harbor, owes its topographic expression to the presence of till. The bulge at Prospect Beach, 2,000 feet south of Cove River, is due to the shape of Jones Hill, which has been mapped as till covered bedrock. Bradley Point is a bedrock outcrop tied to the mainland as a tombolo. Sea Bluff Beach borders the northern end of Prospect Beach, a thin beach bordering this till-bedrock area. In its natural state the beach is composed of pebbles and shingles eroded from the till and bedrock. For several years, however, the beach has been nourished with sand from offshore borrow areas, and the present beach sediment bears little resemblance to that which would naturally occur there if no improvements had been made.

From Bradley Point including Okinawa Beach, North to West River, deposits of sandy outwash are found. These deposits are part of the New Haven outwash delta laid down by the retreating ice sheet margin in the Connecticut Low Land. The surficial geology of this area produces a

flatter more gently sloping shoreline and nearshore area in contrast to the steeper, narrower and deeper coastline topography south of Cove Beach. Tidal flats are common offshore of the study area beaches but are lacking further south along most of Prospect Beach. The east side of New Haven Harbor near Lighthouse Point is more similar to Prospect Beach with a very narrow beach skirting till and bedrock deposits.

In summary, there are two distinct physiographic provinces in the area. The highlands, veneered with till, are bordered by narrow beaches whose coarse sediments are derived from till and bedrock. Sea Bluff Beach is located at the northern boundary of the highland province. The lowland area to the north of Cove River is fronted by wider more sandy beaches with gentler slopes such as Okinawa Beach.

PRESENT COASTLINE

Sea Bluff and Okinawa Beaches front on the northwest side of the outer section of New Haven Harbor which opens to Long Island Sound. The two beaches are separated by Bradley Point. Sea Bluff Beach extends from Ivy Street 1000 feet north to Cove River which is 600 feet west of Bradley Point. At mean high water Sea Bluff exhibits 55 feet of dry beach space and at low tide approximately 900 feet of tidal flat area is exposed. A groin situated at the southerly margin of the beach is in need of repair. Sea Bluff Beach is composed of well sorted fine to medium sized sand. Much of the sediment is made up of sand applied during nourishment programs begun in 1957 and periodically continued by the city of West Haven. Much of the natural sediment of the area, not covered by nourished sand, consists of sandy silt, sand, cobbles and shingles. The northern portion of the backshore is artificial sand fill at least 5 feet thick covering earlier formed tidal flats and marshes. Sea Bluff Beach slopes about 1:9 to high water and then changes to a very gentle 1:250 slope near mean low water.

Since its initial widening by nourishment, Sea Bluff Beach has been undergoing erosion at the rate of 1-2 feet per year and occasionally up to 5 feet per year. Cove River may have contributed sediment to the tidal flats in front of Sea Bluff Beach in the past. Examination of aerial photos suggest a well formed ebb tide delta. However, visual observation suggests that little sediment is now carried out from the river's mouth. The beach is in need of replenishment, especially in the southern two-thirds of its length.

Okinawa Beach extends 600 feet northeast of Bradley Point and fronts a low flat area of unconsolidated glacial outwash. This gently curving pocket beach consists of well sorted fine to medium sand with several gravelly areas. At mean high water the dry beach width is 35-40 feet. At low tide a 500-foot wide tidal flat is exposed. The foreshore slopes approximately 1:10 to MHW and 1:300 to low tide. The limits of the pocket are defined by Bradley Point on the south and a dilapidated groin structure attached to a seawall to the north.

An examination of historical records reveals no significant nourishment programs for Okinawa Beach. Substantial fill, dredged from the New Haven Harbor navigational channel, was placed on the shore just north of Okinawa Beach. The effect of a timber groin constructed at the north end of Okinawa Beach together with the prevailing northeasterly longshore transport in the immediate vicinity prohibited any significant amount of the filled sand material from being deposited on Okinawa Beach. The beach at Okinawa is therefore presumed to be natural, formed at the same time or immediately after the formation of the tombolo at Bradley Point.

An environmental assessment of Okinawa Beach reports that the beach is undergoing erosion of the same magnitude as is occuring at Sea Bluff Beach. The shoreline is retreating on the order of 1-2 feet per year. The timber groin erected at the north end of the beach in 1950 is now in disrepair and this may be a factor in the erosion of the beach. Slumping and erosion of portions of the backshore have been observed.

The backshore of Okinawa Beach is composed of artificial fill approximately 5 feet thick covering earlier formed tidal marsh flat areas. An area of environmental interest along the backshore is a small growth of marsh-sea grass in and near the intertidal zone at the south limit of Okinawa Beach, next to Bradley Point. Some concern has been expressed about potential damage to the marsh grass due to sandfill. This problem and its solution are adequately addressed in the main report.

Cove River, located between the two beaches is a significant part of the coastal processes operating in the area. The river is a small coastal stream less than 10 miles long flowing in a southerly direction to its mouth at the northern margin of Sea Bluff Beach. The stream drains marshland for several thousand feet inland to Phipps Lake. Cove River is an underfit stream flowing in a valley previously carved by a large river draining glacial meltwater. Wetland and marsh have recently developed along the course of this glacially formed valley. A study of aerial photographs show that the mouth of Cove River was much wider in the past than is seen now. In 1932 Sea Bluff Beach was a narrow rocky beach abutting the wider mouth of the Cove River. By 1951 the mouth of the river had narrowed and a pocket beach at Sea Bluff was created. By 1970-1980 Cove River had narrowed further and Sea Bluff has become the significantly wider beach now present just to the south of the river's mouth. Wide tidal flats has developed in the vicinity of the beach.

COASTAL PROCESSES IMPACTING THE STUDY AREA

OVERVIEW

The forces of winds, waves, tides and currents are the basic natural elements working to modify and reshape the configuration of coastlines. The dominant force at Sea Bluff and Okinawa Beaches is the action of wind generated waves. This section discusses the effects of wind and waves on the erosion, deposition and general sediment transport in the study area. Available information regarding the more minor effects of tides will also be included.

WIND

Waves affecting beach erosion and sand movement at the study area are caused by wind. Wind generated waves are influenced by the following three factors: wind velocity, fetch (length of open water over which the wind blows) and wind duration. Generally speaking, a longer fetch increases the probability of having stronger winds to create higher waves for a longer duration.

Because of their locations along New Haven Harbor (facing easterly to Long Island Sound), Sea Bluff and Okinawa Beaches are affected only by onshore winds from the ENE through SSW. The eastern side of New Haven Harbor blocks winds from the east and east-northeast. Long Island (off the southeastern end of New York State) is located 19 miles to the south and south-southwest of Prospect Beach. The longest fetch distance is towards Block Island in an east-southeast direction.

Wind velocity has been monitored at Stratford, Connecticut. Wind measurements (one minute average wind speed data recorded in one-hour intervals) were recorded at Stratford from 1949 to 1974. Analysis of these data indicate that the onshore wind directions with the highest frequencies of occurence are from the ENE, E, S and SSW. The maximum average wind speed (9.7 mph) is from the SSW and the greatest maximum speed (47.5 mph) was recorded from the east.

Table 2-1 shows the percentage of occurence and fetch distances of the winds influencing Sea Bluff and Okinawa Beaches.

TABLE 2-1
Percentage of Occurance and Fetch Distances

Direction	Percentage of Occurrence	Fetch (Miles)
ENE	18	3.0
E	19	2.9
ESE	11	30.0
SE	9	25.0
SSE	9	20.0
S	16	19.0
SSW	18	19.0

Table 2-2 shows the percentage of occurrence of various ranges of wind speeds including that of winds equal to or greater that 15 mph and winds equal to or greater than 25 mph.

TABLE 2-2
Percentage of Winds of given speed range from given directions

Direction	All	0-15	≥ 15	0-25	≥ 25
ENE	18	17	22	18	28
E	19	17	21	18	41
ESE	11	11	9.5	11	7
SE	9	10	4	9	2
SSE	9	10	3	9	2
S	16	18	11	17	12
SSW	18	18	17	18	8

Winds of slower speeds (less than 25 mph) are principally from the ENE, E, S and SSW, similar to the pattern of wind of all speeds as seen in Table 2-1. The principal directions of storm winds (greater than 25 mph) are more clearly defined as E and ENE. These probably arise during periods of northeast winter storms.

A study of wind speed, duration and direction for the period 1949-1974 was performed on data from Stratford. Thirteen years of records are included in that period. The results of this study were expressed in tabular form and related duration in hours to class intervals of wind speed for given directions. The analysis further showed the actual number of occurrences of a given speed class interval during each duration period and also listed the average wind speed in each class-duration data cell. An example of the data tabulation is shown below.

NUMBER OF OCCURENCES AND (AVERAGE WIND SPEED, MPH)

Consecutive Hourly Values	Wind Speed Class MPH >5	>10	>15	Direction ENE >40	>50
1	1265 (19)	625 (12)	177 (17)	1 (42)	0 (0)
2	457 (10)	251 (13)	64 (18)	0 (0)	0 (0)
3	194 (11)	107 (14)	25 (19)	0 (0)	0 (0)
.	.	.	.	.	.
.	.	.	.	.	.
.	.	.	.	.	.

This analysis was used to evaluate onshore wind speed and duration at Prospect Beach. Winds of average speed of >25 mph with duration of at least two hours were considered as having the greatest potential for beach erosion and sand transport. Average speed/duration data and number of occurrences for wind directions from ENE to SSW were used to compute the annual frequency of occurrence for winds >25 mph by dividing the number of occurrences by years of record. These data are seen in Table 2-3. Additionally, the minimum and maximum average wind speed for each duration class is also included.

Table 2-4 lists data for winds of >15 mph and ≥2 hours duration. This table is similar to table 2-3 but is simplified, showing only the number of occurrences and annual frequencies.

TABLE 2-3
ANNUAL FREQUENCY AND OTHER DATA:
Winds >15 MPH and ≥2 hours duration

1949-1974

WIND DIRECTION	MAXIMUM CONSECUTIVE HOURLY VALUES	# OF OCCURRENCES	AVERAGE CLASS WIND SPEED >25 MPH MINIMUM	MAXIMUM	ANNUAL FREQUENCY OF WINDS >25 MPH
ENE	2	4	29	35	0.46
	3	2	29		
E	2	4	27	32	1.07
	3	4	31	38	
	4	3	33	36	
	7	1	29		
	8	1	27		
	10	1	37		
ESE	3	3	28		0.31
	4	1	26		
SE	2	1	28		0.077
SSE	-		-	-	-
S	2	3	28	31	0.54
	3	3	28		
	5	1	32		
SSW	2	2	31	35	0.31
	3	2	27		

TABLE 2-4

ANNUAL FREQUENCY AND OTHER DATA:
Winds >15 MPH and ≥2 hours duration

Wind Direction	# Occurrences	Annual Frequency
ENE	133	10.2
E	140	10.8
ESE	98	7.6
SE	29	2.2
SSE	26	2
S	95	7.3
SSW	156	12

Figure 2-1 illustrates in vector form the direction and magnitude of the annual frequency of occcurrence of these winds. This vector diagram clearly shows that the dominant high wind direction is from the east, and the resultant high wind direction is from the ESE. It should be noted, however, that some high winds have been recorded from the south. The frequency distribution of winds >15 MPH is similar to that of the stronger winds except that a significant component is present from the SSW.

In summary, the principal strong wind direction is from the east, and the principal direction of winds for all speeds is from the SE. Some strong winds, although relatively infrequent, do occur from the south direction. The less strong winds (>15 MPH) are significant from the south as well as the east. Winds exert relatively little direct impact on Okinawa Beach. Strong easterly onshore winds most probably move some sand inland, but no data is available for a quantitative evaluation and the amount is most probably small. It is in the generation of waves that winds most severely impact Okinawa Beach.

WAVES

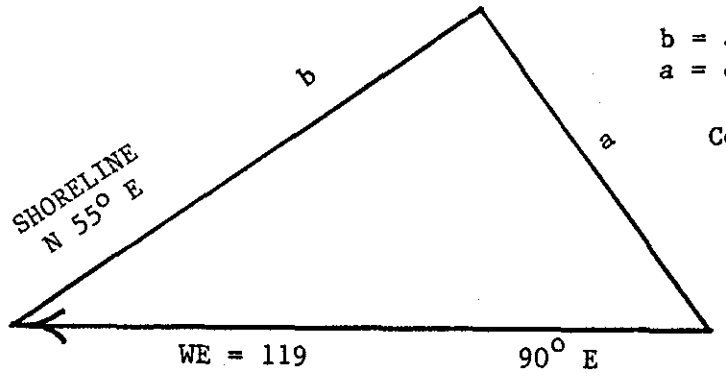
The only significant waves affecting Sea Bluff and Okinawa Beaches are wind-generated. The size of these waves is a function of fetch distance, water depth, and the magnitude and direction of sustained wind speed. Because of the location of the study area, waves impact upon it only in an arc ranging from ENE to SSW. Wind-generated waves erode the shoreline by moving sediment on and offshore and by moving sediment along the shoreline. This last type of sand movement is termed longshore transport. The nature of beach erosion due to wave action is discussed in this section. Conclusions were drawn regarding the natural trends of beach erosion on the study area, and the results were be applied toward consideration of the potential effects of beach nourishment and other shoreline modifications.

A vector analysis of winds impacting the shoreline at Sea Bluff Beach and their frequency of occurence was performed to arrive at a generalized quantitative estimate of potential sand movement by waves from different directions. Because winds from the various onshore directions strike the beach from different angles with different impacts, the effect of each onshore wind direction must be evaluated separately. By manipulation of data, a theoretical "ideal" orientation of the beach can be determined at which the least amount of erosion would occur.

The winds considered in this analysis were in the sets ≥15 mph and ≥25 mph. The percent occurrence of winds of various speeds were previously determined for each of the seven wind directions affecting the study area (see Table 2-2). This percentage occurrence was multiplied by the corresponding fetch to obtain an <u>index of wind effectiveness</u>. For example, of all winds ≥25 mph impacting on the beach, 41 percent are from the East. The fetch distance from that direction is 2.9 miles. The product of fetch distance (2.9 miles) and percent occurrence (41) gives a wind effectiveness index of 119. The purpose of the wind effectiveness index is to incorporate the two factors of frequency and potential strength (velocity and fetch) into the analysis.

For each wind direction, a component with a value equal to the wind effectiveness index was resolved into an alongshore component and an onshore component. Figure 2-2 illustrates the vector resolution for a wind ≥25 mph from the East.

Figure 2-2



b = alongshore component
a = on/offshore component

$\cos 35^0 = b/119$
$b = 97$

The alongshore component for winds $\geq$25 mph from the east has a value of 97 to the South. In a similar fashion, alongshore component values for winds $\geq$25 mph and $\geq$15 mph for each onshore wind direction were calculated. The absolute value of the components has little meaning. The relative values are significant. The larger the alongshore value, the greater the wave erosion expected from that particular wind direction. The various components were calculated for each wind direction, and the results were compiled.

Table 2-5 lists fetch distances, wind effectiveness values, and alongshore components for winds $\geq$25 mph from the several wind directions at Sea Bluff Beach. Also shown is the resultant total which serves as a comparative value for expected alongshore transport at this level of wind. Table 2-5 also illustrates the same parameters and resultant total for winds $\geq$15 mph.

Table 2-5 shows that under conditions of stronger winds ($\geq$25 MPH) there is a weak resultant component of longshore transport to the south. With the more numerous gentler winds ($\geq$15 MPH), the resultant component of longshore transport is to the north. It is significant that this resultant northward component is of a higher value than the resultant component to the south. This can be interpreted to mean that with the stronger storm winds which tend to erode and move sand offshore, the primary movement of sand will be shore normal or slightly to the south. With the gentler winds which tend to promote accretion and buildup, the movement is to the north.

This vector analysis can be used to determine the beach orientation which would result in the least potential longshore transport. For stronger winds ($\geq$25 mph) a beach orientation of N 52 E would result in very minor potential longshore transport as determined by vector analysis. For lighter winds ($\geq$15 mph) the null littoral drift condition would be achieved with a beach oriented at N 64° E. These results suggest that natural wind and wave processes are attempting to shape the beach

into a stable orientation of approximately N 58° E. The existing orientation of the beach is N 55° E. The small difference between actual and theoretical beach configuration strongly suggests that unless there is a significant change in environment, little change in beach orientation will occur in the near future.

A similar vector analysis was performed on Okinawa Beach. Since the beach is a pocket beach bordered by bedrock with a seawall to the north and the headland of Bradley Point to the south, the results of this vector analysis must be interpreted differently than that of Sea Bluff Beach. Table 2-6 lists the relative values of the alongshore components from the given wind directions for winds $\geq$15 MPH and $\geq$25 MPH. The fetch distances and wind effectiveness values are the same as shown in Table 2-5.

This analysis indicates a significant northerly longshore component along Okinawa Beach for both sets of winds. The effects of refraction of north moving waves around Bradley Point, however, is not included in the simple vector analysis discussed above. As waves generated by winds from southerly directions approach Okinawa Beach, they are refracted around Bradley Point and strike the shoreline in a much more shore normal fashion. Consequently the potential for northerly drift is significantly less than implied by the vector analysis.

A more realistic assessment of potential longshore transport at Okinawa Beach based upon both the vector analyses and the effect of refraction would be that of either no significant potential movement or only relatively weak longshore movement to the north. In short, Okinawa Beach, contained at both ends by natural and artificial barriers, appears to be stable with respect to longshore transport. Fine material being eroded offshore would soon be transported along the shoreline and would not be available to be transported back onto the beach. The beach itself, it appears, experiences little or no along shore movement. The monitoring program after construction will assist us in verifying changing beachface movement due to seasonal conditions. Based upon these analyses, it is unlikely that any application of suitable sandfill would exhibit rapid significant longshore movement.

TABLE 2-5

WIND DIRECTION AND ALONGSHORE COMPONENT VALUES

SEA BLUFF BEACH

WINDS ≥ 25

Fetch (Miles)	Wind Direction	Wind Effectiveness	Value Alongshore Component
3.0	ENE	84	81 to South
2.9	E	119	97 to South
30	ESE	210	111 to South
25	SE	50	9 to South
20	SSE	40	9 to North
19	S	228	131 to North
19	SSW	152	129 to North
		Resultant:	29 to South

WINDS ≥ 15

Fetch (Miles)	Wind Direction	Wind Effectiveness Value	Alongshore Component
3.0	ENE	66	64 to South
2.9	E	61	50 to South
30	ESE	285	151 to South
25	SE	100	17 to South
20	SSE	60	13 to North
19	S	209	120 to North
19	SSW	323	273 to North
		Resultant	124 to North

TABLE 2-6

WIND DIRECTION AND ALONGSHORE COMPONENT VALUES

OKINAWA BEACH

WINDS ≥25

Wind Direction	Alongshore Component
ENE	70 to South
E	68 to South
ESE	43 to South
SE	8 to North
SSE	22 to North
S	186 to North
SSW	148 to North
Resultant	183 to North

WINDS ≥ 15

Wind Direction	Alongshore Component
ENE	55 to South
E	35 to South
ESE	59 to South
SE	17 to North
SSE	32 to North
S	171 to North
SSW	148 to North
Resultant	386 to North

Wave Height and Frequency

Several analyses and techniques were employed to arrive at reliable planning estimates of the values of height and frequency of waves likely to impact the shoreline of the study area. Possible significant wave heights were determined for each onshore wind direction. The number of occurrences per year and the percent occurrence of waves of given heights from each onshore direction was also determined. Using this data, a table summarizing the annual frequency and percent occurrence of design wave by direction and wind return period was prepared.

Possible Significant Wave Heights

Using data supplied in the Hydrology Report (see Appendix 3), wind velocities with a duration of 2 hours and an expected return period of 5 years were compiled for each onshore direction. Because of short fetch distances, a 1-hour duration was used for winds from E and ENE. The

shallow water wave forecast curves (as modified from the Shore Protection Manual) furnished values for wave heights and period for the selected velocities. These figures are displayed in Table 2-7.

The information displayed in Table 2-7 is limited in that it gives no indication of the frequency of occurrence of the given waves. To acquire that information, values of wind velocity and duration required to support waves of various heights were gathered, and the annual frequency of their occurrence was calculated using data in the Hydrology Appendix. Using the 30 foot shallow wave forecasting curve (the 20-foot shallow wave forecasting curve was used for the E and ENE directions because of the short fetches and shallower depths found there), and a general lower limit of 10-15 mph velocity and 30-minute duration, various combinations of wind velocity and duration required to support waves of 1-foot and greater in height were determined. Data on number of occurrences and percentage of onshore winds was then used to determine the occurrences per year of the velocity and duration values gathered from the shallow water forecast curves. The values for annual number of occurrences were summed and converted to percent occurrence. These values are seen in Table 2-8.

TABLE 2-7

POSSIBLE SIGNIFICANT WAVE HEIGHTS

Direction	Fetch (miles)	Velocity Winds of 2 hours duration and 5-year return period* (MPH)	Possible significant wave heights and periods Heights(ft)	Periods(sec)	Limiting Factor
ENE	3.0	33	2.1	2.6	Fetch
E	2.9	29	1.9	2.5	Fetch
ESE	30	26	3.2	3.7	duration
SE	25	24	3.0	3.6	duration
SSE	20	24	3.0	3.6	duration
S	19	29	4.0	4.1	Fetch
SSW	19	27	3.5	4.0	duration

Possible significant wave heights from winds with a duration of two hours and an expected return period of five years; wave heights gained from 30 foot depth shallow water wave forecasting curve.

* For waves from ENE and E, waves of one hour duration were selected. Wave heights gained from 20 foot depth shallow water wave forecasting curves.

TABLE 2-8

Annual Frequency and Percent Occurrence of Wave Heights by Direction

Direction	ENE			E			ESE			SE			SSE			S			SSW			TOTAL	
Fetch (miles)	3.0			2.9			30.0			25.0			20.0			19.0			19.0				
Wave Height (feet)	A	%	dur. (hrs)	A	%	dur. (hrs)	A	%	dur. (hrs)	A	%	dur. (hrs)	A	%	dur. (hrs)	A	%	dur. (hrs)	A	%	dur. (hrs)	A	%
1	3.8	3.4	1	4.0	3.6	1	14.7	13.3	1-3	7.7	7.0	1	7.7	7.0	1-3	22.1	20.1	1-3	31.1	28.2	1-3	91.1	82.6
2	1.6	1.5	1	0.2	0.2	1	3.9*	3.5	2-4	1.2	1.1	2-3	1.1	1.0	2-3	3.9	3.5	1-3	6.2	5.6	2-3	18.1	16.4
3	-	-	-	-	-	-	0.2	0.2	2	-	-	-	-	-	-	0.3	0.3	2	0.4	0.4	2-3	0.9	0.9
4	-	-	-	-	-	-	0.1	0.1	2-3	-	-	-	-	-	-	-	-	-	-	-	-	0.1	0.1
Total A	5.4			4.2			18.9			8.9			8.8			26.3			37.7			110.2	
Total %		4.9			3.8			17.1			8.1			8.0			23.9			34.2			100

A = Annual Frequency % = percent occurence (A/ΣA)

* Example: a wave train of 2 feet in height from the ESE direction with a duration of 2-4 hours will occur 3.9 times/year or 3.5 percent of the time.

Table 2-8 shows that at Sea Bluff Beach winds from the ENE, E, SE and SSE exert a moderate effect on the beach while winds from the ESE, S and SSW have a pronounced effect. Seventy-five percent of the winds that generate waves of 1 foot or more are from the ESE, S and SSW.

This table also shows that 91 percent of waves generated by onshore winds at Sea Bluff Beach which are equal to or greater than 10-15 mph and 30 minutes in duration are 1 foot or less in height. These numbers, while only statistical estimates, do strongly suggest a low wave regimen operations at the study area. The high percentages of low energy waves affecting the area from the south quandrant also supports the results of the wave vector analysis discussed earlier.

Design Wave

Design waves were selected for each of the several onshore wind directions and for different wind return periods. The selection was performed according to procedures outlined in ETL 1110-2-305 dated February 1984. Adjusted annual and maximum wind speeds, for various durations and expected return periods were obtained from the Hydrology Appendix. Design waves are chosen with the use of wind speed-duration curves in conjunction with wave forecasting curves. For each onshore wind direction wind velocity-duration ordered pair curves were developed. Additionally, a velocity-duration curve for each wind direction fetch was developed. Those curves were then plotted and the design wind velocity was taken from the point of intersection of the fetch curve and the given return period curve. Figure 2-3 illustrates these plots.

Once the design wind velocities for each wind direction was determined, the 30-foot shallow wave forecasting curve was used to determine the corresponding design wave height. The 20-foot shallow wave forecasting curve was used for the E and ENE directions. Reference to Table 2-8 supplied the number of occurrences per year and the percentage occurrence for each design wave. Maximum wave heights range from 3.5 feet to 4.2 feet.

The results of this design wave analysis are seen in Table 2-9. The data in Table 2-9 complements and reinforces that seen in Table 2-8. Similar analyses were not performed on Okinawa Beach because of its pocket shape and the probability, discussed earlier in this report, that longshore transport there would be minimal.

TABLE 2-9

ANNUAL FREQUENCY AND PERCENT OCCURANCE OF DESIGN WAVE BY DIRECTION AND WIND RETURN PERIOD

WIND RETURN PERIODS

DIRECTION	FETCH (MILES)	10 YEAR A[1]	10 YEAR H[2]	10 YEAR 1%[3]	5 YEAR A	5 YEAR H	5 YEAR %	2 YEAR A	2 YEAR H	2 YEAR %	1 YEAR A	1 YEAR H	1 YEAR %
ENE	3.0	<1.6	2.7	<1.5	<1.6	2.4	<1.5	2.3	1.7	2.1	3.4	1.2	3.0
E	2.9	<0.2	2.8	<0.2	<0.2	2.5	<0.2	0.6	1.9	0.5	3.2	1.2	2.9
ESE	30	0.1*	4.0	0.1	0.14	3.6	0.14	0.2	3.0	0.2	6.1	1.8	5.5
SE	25	<1.2	3.5	<1.2	<1.2	3.2	<1.2	<1.2	2.5	<1.2	4.5	1.5	4.0
SSE	20	<1.1	3.5	<1.1	<1.1	3.2	<1.1	<1.1	2.6	<1.1	4.4	1.5	4.0
S	19	<0.3	4.2	<0.3	<0.3	4.0	<0.3	<0.3	3.5	<0.3	13	1.5	11.8
SSW	19	<0.4	4.0	<0.4	<0.4	3.7	<0.4	<0.4	3.5	<0.4	5.0	2.2	4.6

NOTES: [1] A = ANNUAL FREQUENCY [2] H = DESIGN WAVE HEIGHT IN FEET [3] % = PERCENT OCCURENCE

* EXAMPLE: For 0.1 Percent of time that onshore winds blow a 4 foot wave from the ESE will be produced; or the 10 year return design wave from the ESE will occur 0.1% of the time that onshore winds blow.

ALSO NOTE: Fetch is not the predominate factor in determining maximum wave height. Frequency of higher velocity winds, is also significant.

TIDES AND CURRENTS

No quantitative information on the effect of tides on the present shorelines of Sea Bluff and Okinawa Beaches is available. Field observation of the beach suggests, however, that tides are only minor factors affecting the erosion of the beach.

Mean tide level for the study area as measured at New Haven Harbor is 0.34 feet above the National Geodetic Vertical Datum (NGVD). The mean tidal range is 6.2 feet, and the mean spring range of tide is 7.1 feet MLW. (See Appendix 3, Figure 1).

Recorded annual maximum still water tide heights (tidal flooding) have been analyzed, and their frequency of occurrence has been established. Tidal flooding 3.25 feet above MHW (6.7 NGVD) occurs every 2 years on the average. A tidal flood of approximately 1.5 feet above MHW (5.0 NGVD) occurs once a year on the average.

Data from observation of tidal gage data and high water mark indicate that tropical storms (hurricanes) pose the greatest threat of extremely severe tidal flooding. With the exception of infrequent severe tidal flooding events, tidal action has a minimal effect on the configuration of Sea Bluff and Okinawa Beaches.

RATES OF EROSION

Studies of Prospect Beach, immediately adjacent to the south, indicate that erosion at Okinawa Beach has proceeded at rates estimated up to 2 feet per year. Okinawa Beach is in need of replenishment and repair, especially on its southerly reach.

A report on the environmental assessment of Okinawa Beach indicates that the shoreline there is retreating at the rate of 1-2 feet per year. Visual observation of this beach reveals evidence of backshore erosion.

EFFECTS OF STRUCTURAL MODIFICATIONS

In addition to the natural coastal processes of wind, wave and tidal action described in the preceding sections, on site project modifications can also influence the shape of the shoreline in the study area.

Sea Bluff Beach has been influenced by periodic sand nourishment on beaches to the south and by construction of a groin at its south margin. The dominate northerly longshore transport direction in this area has carried substantial sand into the area immediately offshore from Sea Bluff Beach. In addition the beach itself has been nourished. The groin built at the south margin of Sea Bluff Beach is in need of repair and is no longer exerting any significant influence on the beach.

No significant sand nourishment has been applied at Okinawa Beach. The fill placed north of Okinawa Beach following dredging of the New Haven Harbor Navigational Channel was prevented from moving to Okinawa Beach by a timber groin built at the north end of the beach and by the overall northerly direction of longshore transport prevailing in the area. Part of Bradley Point has been armored and reinforced. This modification serves to protect the point from erosion and maintain the diffraction of northerly waves around the point, emphasizing the protected pocket beach nature of Okinawa Beach.

COASTAL PROCESSES SUMMARY

Several geologic and coastal processes are of special significance to the study area. A summary follows of the coastal processes affecting Okinawa and Sea Bluff Beaches.

Geology and Coastline Description

Sea Bluff and Okinawa Beaches are situated in different physiographic provinces. Sea Bluff Beach fronts an area of low hills veneered with till. Okinawa Beach fronts an area of low relief composed of sand deposited from glacial outwash. Generally speaking the till covered bedrock highland province is characterized by a narrow and steep coastline. In contrast the shore in front of the outwash deposits is generally wider and more gently sloping. These two provinces are approximately divided by Cove River.

Sea Bluff Beach has been periodically nourished with sand for several years. The northern part of the backshore is composed of several feet of artificial fill covering earlier formed marsh deposits. Little of the natural pebble-shingle beach (supplied through erosion of the till) now remains. A large ebb tide delta of the Cove River and sediments brought in by the dominant northerly longshore transport occurring immediately to the south have contributed to the formation of a broad tidal flat in front of Sea Bluff Beach. This beach is then an exception to the generally narrow relatively steep coastline fronting the highland province and in fact can be regarded as a transition zone between the two provinces.

Okinawa Beach is a sandy pocket beach protected on both its north and south limits by bedrock and artificial structures. The sediments on Okinawa Beach are believed to be natural even though substantial placing of dredged fill has occurred in the area. The backshore is composed of artificial fill covering previously formed tidal marsh flats.

Both Okinawa and Sea Bluff Beaches are eroding. Estimates of the rates of shoreline retreat range from 1 to 2 feet per year for both beaches.

Wind and Wave Conditions

Onshore winds affect the study area in an arc ranging from ENE to SSE. Fetch distances from the ENE and E are approximately 3 miles in length and thus very minimal. Several analyses of wind data supplied from the Tidal Hydrology Report (see Appendix 3) were performed to better evaluate the impact of wind driven waves on Sea Bluff and Okinawa Beaches. The frequency of occurrence of winds from the SE and SSE was small, especially so for winds > or = to 15 MPH.

The short fetch distances from the ENE and E and the low frequency of occurrence of winds from the SE and SSE markedly reduce the potential impact of waves from these several directions. It is from the ESE, S, and SSW that waves with significant potential for erosion and substantial sediment transport will occur.

A semiquantitative vector analysis of longshore transport components due to wave action showed that there is a moderate northward resultant component on Sea Bluff Beach from gentle (> or = to 15 MPH) winds which tend to promote accretion. Stronger winds (> or = to 25 MPH) result in a weak southerly resultant component of longshore transport. This analysis also suggests that the orientation of Sea Bluff Beach is stable.

A similar analysis of Okinawa Beach, in conjunction with consideration of the refraction of southerly waves around Bradley Point, leads to the conclusion that no significant potential movement of sand due to longshore transport exists. In short, Okinawa Beach appears to be stable with respect to potential longshore sand movement.

Wave Height and Occurrence

Several analyses and techniques were employed to arrive at reliable planning estimates of the values of height and frequency of waves likely to impact the shoreline of the study area. Using shallow wave forecasting curves and a general lower limit of 15 MPH, various combinations of wind velocity and duration required to support waves of given heights were determined. Data on wind frequency was used to determine the percent occurrence of these various winds. This series of analyses showed that waves of greater than 1 foot in height occurred with measurable frequency only from the ESE, S, and SSW directions. The heights of significant waves from these directions ranged from 3.2 feet with a 3.7 second period to 4.0 feet with a 4.1 second period.

Design waves were selected for each of the several onshore wind directions and for different wind return periods. The selection was done in accordance with procedures outlined in TEL 1110-2-305. Maximum design wave heights ranged from 3.5 feet to 4.2 feet. A combination of 19 mile fetch and a 10-year return period design wave velocity of 32 MPH from the south produced the maximum design wave height of 4.2 feet with a period of

4.3 seconds. The analyses of frequency of occurrence of significant wave heights and selection of design wave heights (see Tables 2-7 and 2-8) agree with conclusions derived from analyses of probable longshore transport and displayed in Tables 2-4 and 25.

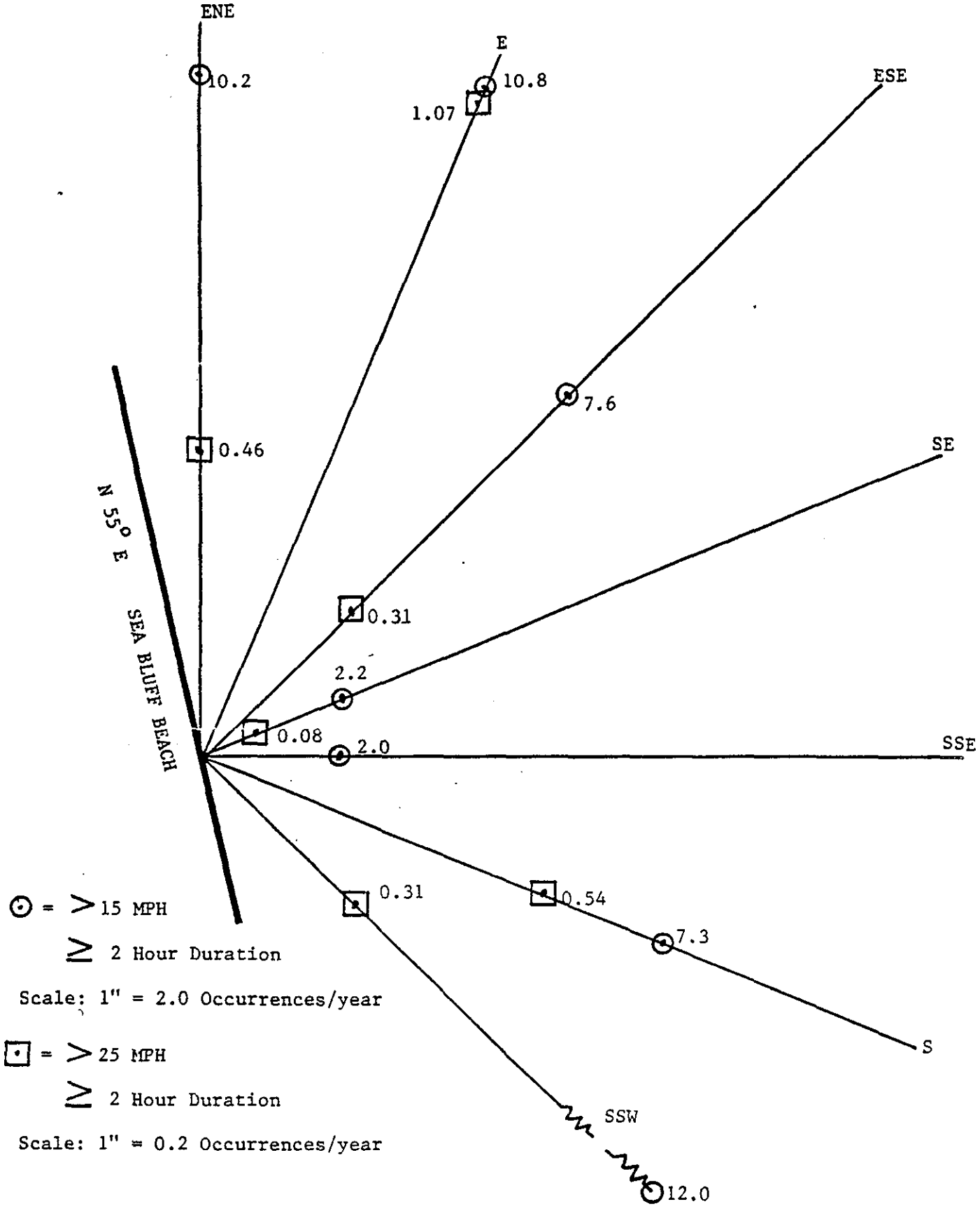
Impact of Coastal Processes on Possible Plans of Improvement

Sand nourishment applied at Sea Bluff Beach will most probably be subject to some movement due to longshore transport. The orientation of the beach will not change significantly, but some sand will move northerly to the tidal flats off of Cove River due to longshore transport. Some structural solution may be needed to compartmentalize the added sandfill.

Study and analyses of the various coastal processes affecting Okinawa Beach suggest that this beach is stable with respect to longshore transport of sand. The pocket beach is bounded on its north and south limits by bedrock and/or structures. The refraction of waves from the southerly quadrant around Bradley Point results in most waves striking the beach in a nearshore normal fashion. The principal sediment movement to be expected is on-offshore in direction. There appears to be every likelihood that sandfill applied as nourishment to Okinawa Beach will not rift north or south in any substantial amount.

FIGURE 2-1

ANNUAL FREQUENCY OF WINDS >15 MPH AND >25 MPH OF ≥2 HOUR DURATION



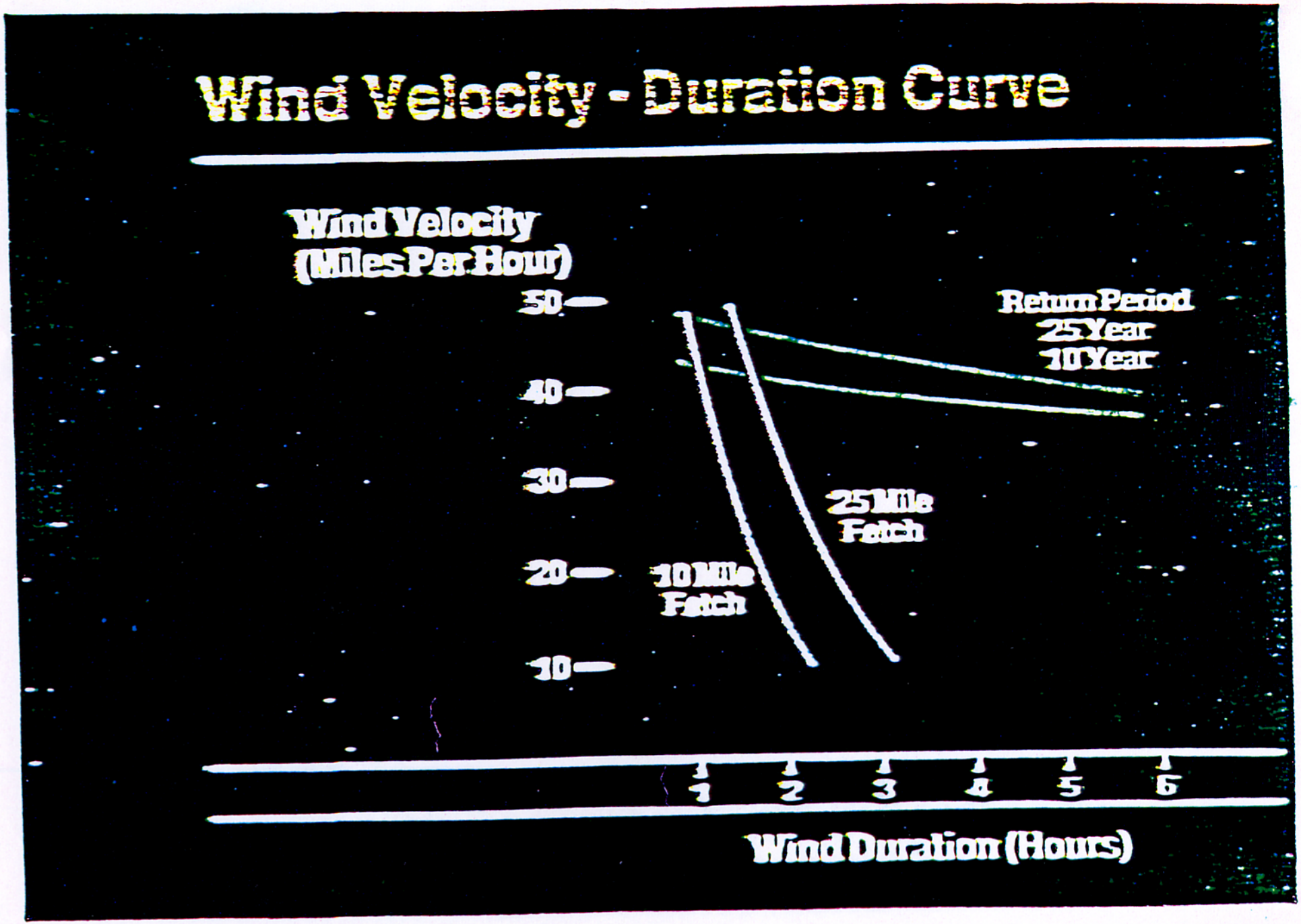

Wind Velocity - Duration Curve
Wind Velocity
(Miles Per Hour)
50
40
30
20
10
Return Period
25 Year
10 Year
25 Mile
Fetch
10 Mile
Fetch
1
2
3
4
5
6
Wind Duration (Hours)

FIGURE 2-3

APPENDIX 3

TIDAL HYDROLOGY, ENGINEERING DESIGN, COST ESTIMATES AND SYSTEM OF ACCOUNTS

TIDAL HYDROLOGY, ENGINEERING DESIGN, AND COST ESTIMATES

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TIDAL HYDROLOGY
EROSION CONTROL STUDY
WEST HAVEN BEACHES
WEST HAVEN, CONNECTICUT

1. GENERAL

The purpose of this appendix is to provide the coastal engineer with climatic and tidal hydrology information necessary for evaluation of erosion processes at West Haven Beaches and for the design of proper corrective measures.

Wind generated waves are the principal agent of coastal erosion. Near shore currents generated by waves, winds, astronomical tides or riverine flow also play an essential role. The precise location of most active erosion is determined to a significant extent by the water level as averaged over many tide cycles and wave periods. Substantial variations in water level can be produced by astronomical tides and by storm surges caused by the combination of high onshore winds and low atmospheric pressure. Factors related to water level variations and the production of waves in the study area will be discussed in this appendix.

2. ASTRONOMICAL TIDES

a. Tide Range. At West Haven, tides are semidiurnal, with two high and two low waters occurring during each lunar day (approximately 24 hours 50 minutes). The resulting tide range is constantly varying in response to the relative positions of the earth, moon, and sun; the moon having the primary tide producing effect. Maximum tide ranges occur when the orbital cycles of these bodies are in phase. A complete sequence of tide ranges is approximately repeated over an interval of 19 years, which is known as a tidal epoch. At New Haven Harbor (the nearest location for which tide data is available), the mean range of tide and the mean spring range of tide are 6.2 feet and 7.1 feet, respectively (see figure 3-1). However, the maximum and minimum probable astronomic tide ranges at New Haven Harbor have been estimated at about 0.3 and 2.4 feet, respectively, in studies by the Corps Coastal Engineering Research Center (CERC). The variability of astronomical tide ranges is a significant factor in tidal flooding potential at West Haven. This is explained further in section 5.

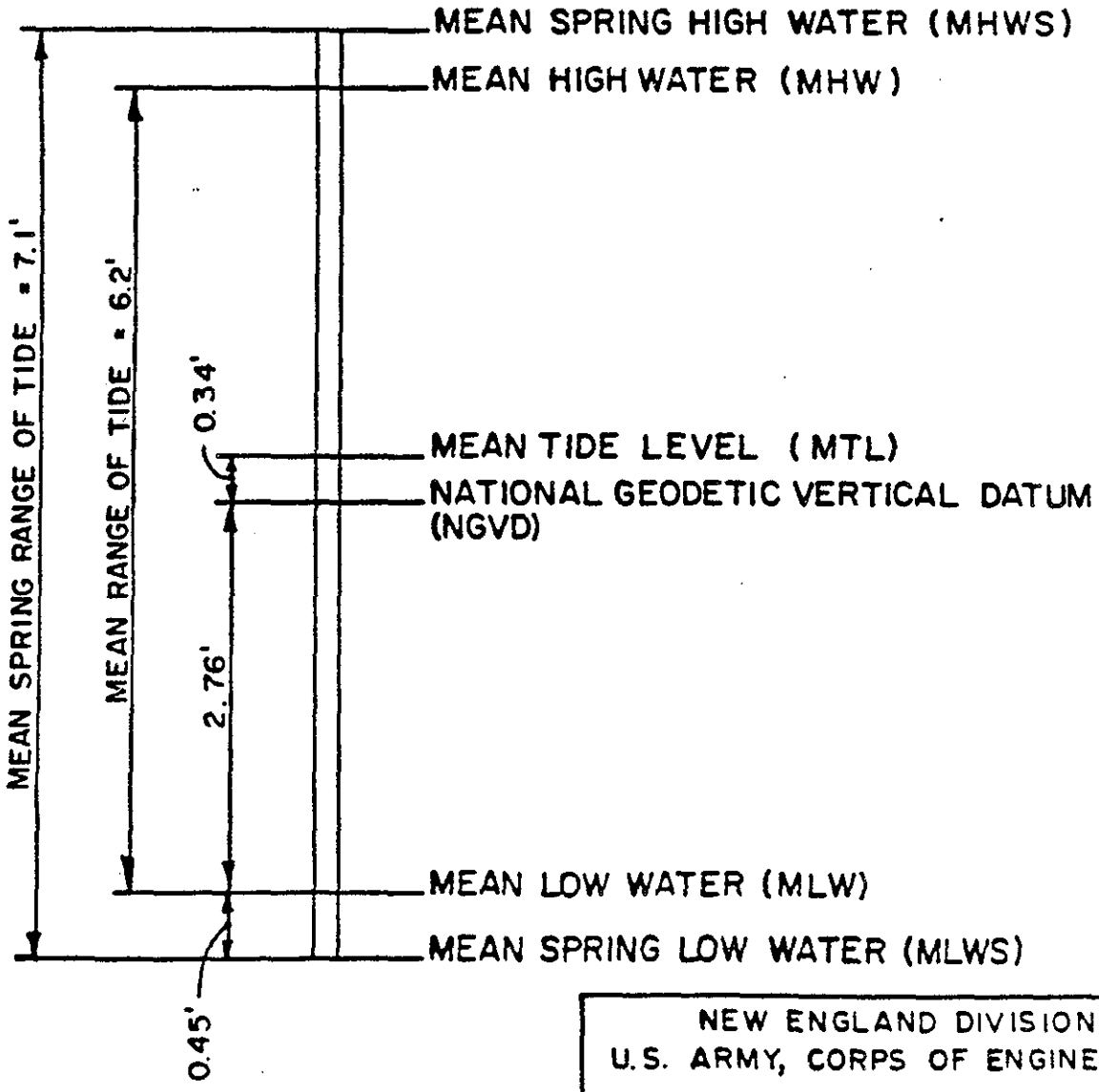
b. Tidal Datums. Because of the continual variation in water level due to the tides, several reference planes, called tidal datums, have been defined to serve as a reference zero for measuring elevations of both land and water. Tidal datum information for New Haven Harbor is presented on figure 3-1 and table 3-1. These data were compiled using currently available short term NOS tidal benchmark data for New Haven Harbor along with the CERC report entitled "Tides and Tidal Datums in the United States", SR No. 7, 1981.

FIGURE 3-1

TIDAL DATUM PLANES

NEW HAVEN HARBOR, CONNECTICUT

(BASED UPON CURRENTLY AVAILABLE, SHORT TERM, NATIONAL OCEAN SURVEY TIDAL BENCHMARK DATA.)



NEW ENGLAND DIVISION
U.S. ARMY, CORPS OF ENGINEERS
WALTHAM, MASS. MAY 1982

TABLE 3-1

NEW HAVEN HARBOR
TIDAL DATUM PLANES

	Tide Level (ft. NGVD)
Maximum Probable Astronomic High Water	5.6
Mean Spring High Water (MHWS)	3.9
Mean High Water (MHW)	3.4
Minimum Probable Astronomic High Water	1.4
Mean Tide Level (MTL)	0.3
National Geodetic Vertical Datum (NGVD)	0.0
Maximum Probable Astronomic Low Water	-1.0
Mean Low Water (MLW)	-2.8
Mean Spring Low Water (MLWS)	-3.2
Minimum Probable Astronomic Low Water	-4.7

c. Rising Sea Level. A phenomenon that has been observed through tide gaging and tidal benchmark measurements is that sea level is apparently rising with respect to the land along most of the US coast. At New Haven Harbor, the rise has been estimated to be slightly less than 0.1 foot per decade. Sea level determination is generally revised at intervals of about 25 years to account for the changing sea level phenomenon. The National Ocean Survey is presently engaged in the process of reducing tide data from the 1960-1978 tidal datum epoch to make such a revision.

3. STORM TYPES

Two distinct types of storms, distinguished primarily by their place of origin as being extratropical and tropical cyclones, influence coastal processes in New England. These storms can produce above normal water levels and must be recognized in studying New England coastal problems.

a. Extratropical Cyclones. These are the most frequently occurring variety of cyclones in New England. Low pressure centers frequently form or intensify along the boundary between a cold dry continental air mass and a warm moist marine air mass just off the coast of Georgia or the Carolinas and move northeastward more or less parallel to the coast. These storms derive their energy from the temperature contrast between cold and warm air masses. The organized circulation pattern associated with this type of storm may extend for 1000 to 1500 miles from storm center. The wind field in an extratropical cyclone is generally asymmetric with the highest winds in the northeastern quadrant. Since the storm center generally passes parallel and to the southeast of the New England coastline, highest onshore wind speeds are generally from the northeast. For this reason these storms are called "northeasters" or "nor'easters" by New Englanders. As the storm passes, local wind

directions may vary from southeast to slightly west of north. Coastline exposed to these winds can experience high waves and extreme storm surge. Such storms cause frequent minor tidal flooding along the Connecticut coastline. The prime season for northeasters in New England is November through April.

b. Tropical Cyclones. These storms form in a warm moist air mass over the Caribbean and the waters adjacent to the West Coast of Africa. The energy for the storm is provided by the latent heat of condensation. When the maximum windspeed in a tropical cyclone exceeds 75 mph, it is labeled a hurricane. Wind velocity at any position can be estimated based upon the distance from the storm center and the forward speed of the storm. The organized wind field may not extend more than 300 to 500 miles from the storm center. Recent hurricanes affecting New England generally have crossed Long Island Sound and proceeded landward in a generally northerly direction. However, hurricane tracks can be erratic. The storms lose much of their strength after landfall. For this reason the southern coast of New England experiences the greatest surge and wave action from the strong southerly to easterly flowing hurricane winds. However, on very rare occasions, reaches of coastline in northern New England may experience some storm surge and wave action from the weakened storm. Hurricanes are the principle cause of major tidal flooding at West Haven. The hurricane season in New England generally extends from August through October.

4. WINDS

An estimate of wind speed is one of the essential ingredients in any wave hindcasting effort. The most accurate estimate of winds at sea, which can generate waves and propel them landward, is obtained by utilizing isobars of barometric pressure recorded during a given storm. However, actual recorded wind speed and direction data observed at land-based coastal meteorological stations can serve as a useful guide when more locally generated waves and currents are of interest. The disadvantage with using land-based wind records is that they may not be totally indicative of wind velocities at the sea-air interface where the waves are generated. However, often they are the only available source of information and adjustments must be made to develop overwater estimates from the land based records.

The National Weather Service (NWS) recorded 13 years of hourly observations of one-minute average wind speed and direction at Bridgeport Municipal Airport in Stratford, Connecticut during the period 1949 through 1974, this being the closest location to the project for which relatively complete, systematically recorded, wind data are available. This wind speed data was then adjusted to a standard 33-foot observation height and one-minute average wind speeds were converted to one-hour average wind speeds. Since Bridgeport Municipal Airport is directly adjacent to the ocean, no land-to-sea conversion was applied. However, for all fetches of interest at West Haven beaches greater than 10 miles an air-sea

temperature difference adjustment of 1.1 for unstable conditions was applied. All adjustments were made in accordance with ETL 1110-2-305 on the subject of determining wave characteristics on sheltered waters. Utilizing these one-hour average wind speed data, their percent occurrence of wind direction for various wind speed ranges has been computed. Since only onshore winds at West Haven Beaches are of interest, the wind directions applicable in this analysis have been limited to those between east-northeast (ENE) and south-southwest (SSW). The results, which are shown in table 3-2, indicate that the principal onshore wind direction for wind speeds from 0 to 15 mph is from the S to SSW and, for wind speeds 15 mph or greater, it is from the E to ENE. The maximum average wind speed (9.7 mph) is from the SSW and the greatest maximum speed was 47.5 mph from the E. Overall average speed is 9.1 mph. Table 3-2 also shows the resultant wind direction and percentage of observations for various wind speed ranges. The resultant wind direction is a vector quantity computed using the product of wind speed and direction. It is an indicator of net air movement past a given location. Overall, the resultant wind direction (in the zone from ENE to SSW) is from the SE at the average resultant speed of 5.9 mph. The greatest percentage of wind speeds is shown to be in the 10 to 15 mph range.

Using the height adjusted data base described above, average wind speeds and resultant directions were computed over various durations. Adjustments for air-sea temperature differences were then applied to these data. Annual maximum values were then determined for each onshore direction. The frequency of these annual values was determined using a Pearson Type III distribution function with expected probability adjustment. The systematic record alone was used for all analyses. In some cases severe northeast storm winds were identified as high outliers in a statistical test and sometimes high skews were observed. Results are summarized in tables 3-3(a) through 3-3(g).

Additionally, wind speed persistence was determined on a directional basis. The resulting wind speed persistence data, shown on tables 3-4(a) through 3-4(g), for directions ENE through SSW, indicate the number of consecutive hourly wind speed persistence data, shown on tables 3-4(a) through 3-4(g), for directions ENE through SSW, indicate the number of consecutive hourly wind speed observations that occurred at or above a given speed from a particular direction. Data on table 3-4(b) disclose one occurrence when winds blew in excess of 35 mph for seven consecutive hours from the east. Four consecutive hourly values greater than 25 mph from the east-southeast are shown on table 3-4(c), while one such value greater than 30 mph from the south is shown on table 3-4(f). Data on table 3-4(g) indicate that winds averaging 45 mph from the south-southwest have occurred for three consecutive hours. All these data indicate that high onshore winds can occur for extended periods of time in the study area. Table 3-4(h) is simply a cumulative summation of tables 3-4(a) through 3-4(g) for the selected onshore directions (ENE through SSW). Similar to tables 3-4(a) through (g), tables 3-4(i) through (o) indicated percentages of occurrences on a directional basis for each speed class and

TABLE 3-2

STRATFORD, CONNECTICUT
ADJUSTED HOURLY WIND OBSERVATIONS BETWEEN ENE AND SSW
(One-Hour Average Values)

PERCENT OF ONSHORE WIND SPEED AND DIRECTION OBSERVATIONS (X 10)

Direction	Wind Speed Range (MPH) 0-5	5-10	10-15	15-20	20-25	25-30	Over 30	All Inclusive	Avg. Speed	Max. Speed
ENE	26	46	70	24	12	5	1	185	9.5	41.9
E	25	49	70	22	13	5	3	186	9.6	47.5
ESE	17	38	41	11	5	1	0	113	9.3	36.9
SE	21	35	28	5	1	0	0	91	7.9	38.9
SSE	20	35	24	4	1	1	0	85	7.7	26.6
S	30	59	56	13	4	2	1	164	8.8	38.9
SSW	22	53	71	20	8	1	0	176	9.7	37.9
ENE-SSW	161	315	360	100	44	15	5	1,000	9.1	47.5
Resultant Direction:	SE	SE	SE	SE	ESE	ESE	ESE	SE		

NOTES: 1) Wind speed ranges indicated include values greater than or equal to the lower limit and less than the higher limit.

2) Onshore winds occur 27 percent of the time. Therefore, average annual number of occurrences (A) = percent occurrence times 24.05. For instance, for a wind speed of 0-5 mph from the east A = 2.5 (24.05) = 60.

TABLE 3-3

FREQUENCY OF ADJUSTED ANNUAL MAXIMUM WIND SPEEDS (MPH)
STRATFORD, CONNECTICUT
(Based on 13 Years of Hourly Observations, 1949-1974)

(a)

Direction: ENE

Duration (hours)	Expected Return Period (Years) 1	2	5	10	25	50	100	Station Skew	Outliers
1	19	27	33	37	42	47	52	1.2	(1H)
3	18	24	27	29	32	35	37	0.9	(1H)
8	16	22	24	25	26	27	28	0.0	(0)

(b)

Direction: E

Duration (hours)	Expected Return Period (Years) 1	2	5	10	25	50	100	Station Skew	Outliers
1	20	29	37	42	48	54	60	1.2	(1H)
3	17	26	33	38	45	50	55	1.1	(1H)
8	15	22	29	33	40	46	52	1.5	(1H)

(c)

Direction: ESE

Duration (hours)	Expected Return Period (Years) 1	2	5	10	25	50	100	Station Skew	Outliers
1	18	25	29	33	37	41	45	1.2	(1H)
3	13	21	24	26	27	28	29	-0.1	(0)
8	13	19	22	24	27	29	31	0.7	(0)

(d)

Direction: SE

Duration (hours)	Expected Return Period (Years) 1	2	5	10	25	50	100	Station Skew	Outliers
1	15	22	29	33	39	44	50	1.3	(1H)
3	12	18	21	22	23	24	25	0.1	(0)
8	7	15	18	19	20	20	21	-0.5	(0)

Legend: (#H) = Number of high outliers identified by high outlier test
(#L) = Number of low outliers identified by low outlier test

(e)

Direction: SSE

Duration (hours)	Expected Return Period (Years) 1	2	5	10	25	50	100	Station Skew	Outliers
1	15	24	26	27	28	28	28	-0.9	(1L)
3	14	20	23	26	29	31	34	0.9	(0)
8	7	16	18	20	22	23	24	-0.0	(0)

(f)

Direction: S

Duration (hours)	Expected Return Period (Years) 1	2	5	10	25	50	100	Station Skew	Outliers
1	19	28	33	35	39	41	44	0.5	(1H)
3	18	25	28	30	32	34	36	0.5	(1L)
8	5	20	24	26	28	29	30	-0.5	(0)

(g)

Direction: SSW

Duration (hours)	Expected Return Period (Years) 1	2	5	10	25	50	100	Station Skew	Outliers
1	19	28	32	35	39	42	45	0.7	(0)
3	18	23	25	27	29	30	32	0.6	(0)
8	15	19	23	27	32	36	40	1.7	(1H)

duration. Wind speed persistence between ENE and SSW, without regard to individual changes in onshore wind direction, is shown in table 3-4(p). Developed similarly to table 3-4(p), table 3-4(q) shows resultant direction and average resultant speed for each wind speed class and duration.

5. STORM TIDES AND TIDE STAGE FREQUENCY

a. General. The total effect of astronomical tide combined with storm surge produced by wind, wave, and atmospheric pressure contributions is reflected in actual tide gage measurements. Since the astronomical tide is so variable at the study area, the time of occurrence of the storm surge greatly affects the magnitude of the resulting tidal flood level. Obviously, a storm surge of three feet occurring at a low astronomic tide would not produce as high a water level as would be produced if it occurred at a higher tide. It is important to note that the storm surge itself varies with time thus introducing another variable into the makeup of the total flood tide.

b. Summary of Extreme High Tides at New Haven. A listing of annual maximum, observed, stillwater tide heights (measurements taken in protected areas in which waves are dampened out) has been developed for New Haven; see table 3-5. Also shown are the tide heights with an adjustment applied to account for the effect of rising sea level (see section 2.c). This listing was developed utilizing, (a) high watermark and recording tide gage data gathered at New Haven by the Corps of Engineers (COE); (b) high watermark (COE), staff gage (Bridgeport Harbormaster) and recording tide gage (COE and National Ocean Survey, NOS) data gathered at Bridgeport and stage related to New Haven, and (c) NOS recording tide gage data from New London stage related to New Haven. Data in table 3-5 shows that several hurricanes or tropical storms have caused major tidal flood levels at New Haven. Therefore, it appears that although the extratropical storm is the prevalent type of storm affecting the study area, the tropical storm poses the greatest threat of extremely severe tidal flooding.

c. Tidal Flood Frequency. A tide stage-frequency relationship for Bridgeport has been developed utilizing a Pearson Type III distribution function, using expected probability adjustment, for analysis of adjusted annual maximum stillwater tide levels. A knowledge of historical tidal flooding at Providence in conjunction with a stage correlation between Bridgeport and Providence were utilized to adjust the statistics and extend the historic period at Bridgeport. A similar frequency curve was developed for New Haven using a tide stage correlation between New Haven and Bridgeport. The tide stage frequency relationship for New Haven, which is believed to be valid for the West Haven Beaches area, is shown in figure 3-2.

d. Tidal Flood Profiles. Profiles of major past tidal floods have been developed along the New England coast. NOS tide gage records and

high watermark data gathered between gage locations after major storms have been utilized in the development of these profiles. Additionally, profiles of storm tides of selected frequencies have been developed utilizing frequency distributions at tide gages and high watermark information. Location map and profiles for the West Haven Beaches area are shown on plates 1, 3-1 and 3-2.

6. SUMMARY

In the preceding sections, astronomical tides were discussed with emphasis on typical tide levels and datum conversions for the study area. Sea level rise relative to the land was mentioned. Meteorological factors including storm types and winds were evaluated. Recorded extreme high tides at New Haven were utilized to indicate the combined effect of astronomical tide and storm surge due to wind, wave, and barometric effects on water level. Tidal flood frequency was estimated and tidal flood profiles were presented. This climatic and tidal hydrology information will provide the coastal engineer with essential background information for evaluating erosion processes at the study area and for designing proper corrective measures.

WIND SPEED PERSISTENCE SITE LOCATION : BRDGPRT AP ADJUSTED DATE : 490101 TO 741231 DIRECTION : ENE

NUMBER OF OCCURENCES AND (AVERAGE WIND SPEEDS, MPH)

CONSECUTIVE HOURLY VALUES	WIND SPEED CLASS, MPH >5	>10	>15	>20	>25	>30	>35	>40	>45	>50
1	1265 (9)	625 (12)	177 (17)	41 (23)	18 (27)	3 (34)	2 (39)	1 (42)	0 (0)	0 (0)
2	457 (10)	251 (13)	64 (18)	15 (23)	4 (29)	1 (35)	0 (0)	0 (0)	0 (0)	0 (0)
3	194 (11)	107 (14)	25 (19)	7 (23)	2 (29)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
4	105 (11)	66 (13)	16 (18)	2 (24)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
5	65 (11)	35 (14)	5 (18)	2 (24)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
6	44 (12)	24 (15)	4 (20)	4 (24)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
7	30 (12)	19 (15)	5 (20)	1 (24)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
8	15 (15)	11 (17)	7 (21)	1 (23)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
9	9 (13)	5 (16)	1 (19)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
10	7 (12)	4 (16)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
11	10 (13)	3 (16)	0 (0)	1 (22)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
12	4 (17)	3 (19)	1 (21)	1 (24)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
13	0 (0)	0 (0)	1 (22)	1 (22)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
14	1 (12)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
15	0 (0)	0 (0)	2 (22)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
16	2 (11)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
17	1 (15)	1 (15)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
18	2 (19)	2 (19)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
19	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
20	2 (16)	1 (20)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
21	0 (0)	1 (19)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
22	1 (18)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
23	0 (0)	0 (0)	1 (23)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
24	2 (18)	2 (18)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
MAX AVG SPEED:	19	20	23	24	29	35	39	42	0	0
MAX DURATION:	24	24	23	13	3	2	1	1	0	0

TABLE 3-4(a)

WIND SPEED PERSISTENCE SITE LOCATION : BRDGPRT AP ADJUSTED DATE : 490101 TO 741231 DIRECTION : E

NUMBER OF OCCURENCES AND (AVERAGE WIND SPEEDS, MPH)

CONSECUTIVE HOURLY VALUES	WIND SPEED CLASS, MPH >5	>10	>15	>20	>25	>30	>35	>40	>45	>50
1	1157 (9)	567 (12)	184 (17)	53 (22)	18 (27)	5 (31)	1 (35)	0 (0)	2 (47)	0 (0)
2	460 (10)	221 (13)	62 (18)	17 (23)	4 (27)	2 (32)	1 (41)	3 (43)	0 (0)	0 (0)
3	210 (11)	125 (13)	25 (19)	8 (24)	4 (31)	1 (38)	1 (43)	0 (0)	0 (0)	0 (0)
4	112 (11)	52 (14)	13 (20)	5 (28)	3 (33)	2 (36)	0 (0)	0 (0)	0 (0)	0 (0)
5	75 (12)	41 (15)	11 (22)	5 (25)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
6	49 (12)	24 (16)	14 (20)	3 (23)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
7	32 (14)	23 (16)	4 (20)	0 (0)	1 (29)	0 (0)	1 (40)	0 (0)	0 (0)	0 (0)
8	24 (12)	8 (15)	3 (19)	2 (26)	1 (27)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
9	8 (12)	3 (15)	2 (18)	0 (0)	0 (0)	1 (39)	0 (0)	0 (0)	0 (0)	0 (0)
10	6 (12)	6 (14)	0 (0)	0 (0)	1 (37)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
11	6 (15)	7 (15)	3 (22)	1 (26)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
12	2 (12)	1 (13)	1 (25)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
13	5 (17)	3 (21)	0 (0)	1 (34)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
14	2 (11)	0 (0)	0 (0)	1 (26)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
15	2 (11)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
16	1 (21)	1 (21)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
17	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
18	2 (27)	2 (27)	2 (27)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
19	1 (16)	1 (16)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
20	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
21	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
22	1 (15)	1 (15)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
23	1 (12)	1 (12)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
24	1 (9)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
MAX AVG SPEED:	27	27	27	34	37	39	43	43	47	6
MAX DURATION:	24	23	18	14	10	9	7	2	1	0

TABLE 3-4(b)

NO SPEED PERSISTENCE SITE LOCATION : BRIDGPRT AP ADJUSTED DATE : 490101 TO 741231 DIRECTION : ESE

NUMBER OF OCCURENCES AND (AVERAGE WIND SPEEDS, MPH)

SECUTIVE RLY VALUES	WIND SPEED CLASS, MPH >5	>10	>15	>20	>25	>30	>35	>40	>45	>50
1	1079 (9)	471 (13)	135 (17)	34 (22)	4 (29)	2 (34)	1 (37)	0 (0)	0 (0)	0 (0)
2	356 (10)	141 (13)	47 (17)	9 (22)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
3	146 (11)	56 (14)	23 (18)	3 (25)	3 (28)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
4	70 (11)	32 (14)	11 (19)	1 (26)	1 (26)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
5	28 (13)	17 (15)	8 (19)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
6	24 (12)	9 (17)	5 (19)	1 (23)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
7	6 (15)	5 (16)	1 (23)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
8	10 (12)	6 (15)	1 (17)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
9	5 (13)	3 (14)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
10	3 (15)	2 (17)	1 (19)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
11	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
12	3 (19)	3 (19)	1 (25)	1 (25)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
13	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
14	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
15	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
16	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
17	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
18	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
19	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
20	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
21	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
22	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
23	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
24	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
* AVG SPEED:	19	19	25	26	29	34	37	0	0	0
* DURATION:	12	12	12	12	4	1	1	0	0	0

TABLE 3-4(c)

WIND SPEED PERSISTENCE SITE LOCATION : BRDGPRT AP ADJUSTED DATE : 490101 TO 741231 DIRECTION : SE

NUMBER OF OCCURENCES AND (AVERAGE WIND SPEEDS, MPH)

CONSECUTIVE HOURLY VALUES	WIND SPEED CLASS, MPH >5	>10	>15	>20	>25	>30	>35	>40	>45	>50
1	896 (8)	315 (12)	93 (17)	12 (24)	2 (34)	1 (39)	1 (39)	0 (0)	0 (0)	0 (0)
2	280 (9)	93 (13)	19 (17)	3 (24)	1 (28)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
3	96 (10)	33 (13)	4 (17)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
4	35 (10)	10 (13)	2 (18)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
5	19 (11)	10 (15)	3 (19)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
6	9 (10)	3 (16)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
7	6 (12)	4 (14)	1 (17)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
8	4 (12)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
9	1 (11)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
10	2 (7)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
11	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
12	1 (9)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
13	1 (12)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
14	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
15	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
16	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
17	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
18	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
19	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
20	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
21	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
22	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
23	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
24	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
MAX AVG SPEED:	12	16	19	24	34	39	39	0	0	0
MAX DURATION:	13	7	7	2	2	1	1	0	0	0

TABLE 3-4(d)

WIND SPEED PERSISTENCE SITE LOCATION : BRDGPRT AP ADJUSTED DATE : 490101 TO 741231 DIRECTION : SSE

NUMBER OF OCCURENCES AND (AVERAGE WIND SPEEDS, MPH)

CONSECUTIVE HOURLY VALUES	WIND SPEED CLASS, MPH >5	>10	>15	>20	>25	>30	>35	>40	>45	>50
1	958 (8)	271 (12)	66 (18)	15 (23)	6 (26)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
2	209 (9)	76 (13)	19 (18)	4 (23)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
3	105 (9)	30 (13)	3 (19)	1 (23)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
4	27 (11)	11 (13)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
5	21 (11)	4 (16)	1 (21)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
6	9 (9)	2 (12)	3 (18)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
7	1 (12)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
8	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
9	2 (9)	2 (17)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
10	2 (17)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
11	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
12	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
13	1 (11)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
14	1 (16)	1 (16)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
15	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
16	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
17	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
18	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
19	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
20	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
21	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
22	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
23	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
24	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
MAX AVG SPEED:	17	17	21	23	26	0	0	0	0	0
MAX DURATION:	14	14	6	3	1	0	0	0	0	0

TABLE 3-4(e)

WIND SPEED PERSISTENCE SITE LOCATION : BRDGPRT AP ADJUSTED DATE : 490101-TO-741231 DIRECTION :-S

NUMBER OF OCCURENCES AND (AVERAGE WIND SPEEDS, MPH)

CONSECUTIVE HOURLY VALUES	WIND SPEED CLASS, MPH >5	>10	>15	>20	>25	>30	>35	>40	>45	>50
1	1316 (9)	639 (12)	211 (17)	39 (22)	16 (27)	4 (35)	2 (38)	0 (0)	0 (0)	0 (0)
2	498 (9)	181 (13)	48 (18)	10 (23)	3 (29)	1 (31)	0 (0)	0 (0)	0 (0)	0 (0)
3	206 (10)	80 (14)	27 (18)	5 (26)	3 (28)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
4	107 (11)	41 (14)	6 (21)	3 (25)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
5	53 (12)	26 (15)	6 (23)	3 (27)	1 (32)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
6	37 (11)	13 (15)	5 (21)	1 (24)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
7	23 (15)	10 (17)	3 (19)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
8	8 (13)	3 (14)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
9	4 (11)	2 (13)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
10	3 (11)	1 (13)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
11	2 (10)	1 (12)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
12	1 (13)	1 (13)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
13	1 (11)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
14	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
15	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
16	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
17	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
18	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
19	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
20	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
21	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
22	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
23	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
24	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
MAX AVG SPEED:	11	17	23	27	32	35	38	0	0	0
MAX DURATION:	13	12	7	6	5	2	1	0	0	0

TABLE 3-4(F)

WIND SPEED PERSISTENCE SITE LOCATION : BRDGPRT AP ADJUSTED DATE : 490101 TO 741231 DIRECTION : SSW

NUMBER OF OCCURENCES AND (AVERAGE WIND SPEEDS, MPH)

CONSECUTIVE HOURLY VALUES	WIND SPEED CLASS, MPH >5	>10	>15	>20	>25	>30	>35	>40	>45	>50
1	1728 (9)	861 (13)	296 (17)	63 (22)	8 (29)	4 (33)	1 (38)	0 (0)	0 (0)	0 (0)
2	642 (10)	309 (13)	85 (18)	15 (23)	2 (31)	1 (35)	0 (0)	0 (0)	0 (0)	0 (0)
3	243 (11)	121 (14)	40 (19)	7 (24)	2 (27)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
4	108 (12)	60 (15)	16 (18)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
5	48 (12)	22 (15)	5 (18)	1 (26)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
6	27 (13)	17 (15)	4 (18)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
7	11 (12)	4 (15)	3 (18)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
8	4 (16)	7 (16)	1 (20)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
9	8 (14)	3 (15)	1 (19)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
10	0 (0)	1 (21)	1 (21)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
11	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
12	1 (15)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
13	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
14	1 (19)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
15	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
16	0 (0)	1 (17)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
17	1 (16)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
18	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
19	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
20	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
21	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
22	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
23	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
24	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
MAX AVG SPEED:	19	21	21	26	31	35	38	0	0	0
MAX DURATION:	17	16	10	5	3	2	1	0	0	0

TABLE 3-4(g)

WIND SPEED PERSISTENCE SITE LOCATION : BRDGPRT AP ADJUSTED DATE : 490101-TO-741231 DIRECTION : ENE-SSW

CUMMULATIVE NUMBER OF OCCURENCES AND (AVERAGE WIND SPEEDS, MPH)

CONSECUTIVE HOURLY VALUES	WIND SPEED CLASS, MPH >5	>10	>15	>20	>25	>30	>35	>40	>45	>50
1	8399 (9)	3749 (12)	1162 (17)	257 (23)	72 (29)	19 (34)	8 (38)	1 (42)	2 (47)	0 (0)
2	2902 (10)	1272 (13)	344 (18)	73 (23)	14 (29)	5 (33)	1 (41)	3 (43)	0 (0)	0 (0)
3	1200 (10)	552 (14)	147 (18)	31 (24)	14 (29)	1 (38)	1 (43)	0 (0)	0 (0)	0 (0)
4	564 (11)	272 (14)	64 (19)	11 (26)	4 (30)	2 (36)	0 (0)	0 (0)	0 (0)	0 (0)
5	309 (12)	155 (15)	39 (20)	11 (25)	1 (32)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
6	199 (11)	92 (15)	35 (20)	9 (23)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
7	109 (13)	65 (15)	17 (20)	1 (24)	1 (29)	0 (0)	1 (40)	0 (0)	0 (0)	0 (0)
8	65 (13)	35 (16)	12 (19)	3 (25)	1 (27)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
9	37 (12)	18 (15)	4 (19)	0 (0)	0 (0)	1 (39)	0 (0)	0 (0)	0 (0)	0 (0)
10	23 (12)	14 (16)	2 (20)	0 (0)	1 (37)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
11	18 (13)	11 (14)	3 (22)	2 (24)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
12	12 (14)	8 (16)	3 (24)	2 (24)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
13	8 (13)	3 (21)	1 (22)	2 (28)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
14	5 (14)	1 (16)	0 (0)	1 (26)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
15	2 (11)	0 (0)	2 (22)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
16	3 (16)	2 (19)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
17	2 (15)	1 (15)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
18	4 (23)	4 (23)	2 (27)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
19	1 (16)	1 (16)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
20	2 (16)	1 (20)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
21	0 (0)	1 (19)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
22	2 (17)	1 (15)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
23	1 (12)	1 (12)	1 (23)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
24	3 (13)	2 (18)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
MAX AVG SPEED:	23	23	27	28	37	39	43	43	47	0
MAX DURATION:	24	24	23	14	10	4	1	2	1	0

TABLE 3-4(h)

WIND SPEED PERSISTENCE SITE LOCATION : BRDGPRT AP ADJUSTED DATE : 490101 TO 741231 DIRECTION : ENE

PERCENTAGES OF OCCURENCES AND (AVERAGE WIND SPEEDS, MPH)

CONSECUTIVE HOURLY VALUES	WIND SPEED CLASS, MPH >5	>10	>15	>20	>25	>30	>35	>40	>45	>50
1	15 (9)	17 (12)	15 (17)	16 (23)	25 (27)	16 (34)	25 (39)	100 (42)	0 (0)	0 (0)
2	16 (10)	20 (13)	19 (18)	21 (23)	29 (29)	20 (35)	0 (0)	0 (0)	0 (0)	0 (0)
3	16 (11)	19 (14)	17 (19)	23 (23)	14 (29)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
4	19 (11)	24 (13)	25 (18)	18 (24)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
5	21 (11)	23 (14)	13 (18)	16 (24)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
6	22 (12)	26 (15)	11 (20)	44 (24)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
7	28 (12)	29 (15)	29 (20)	100 (24)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
8	23 (15)	31 (17)	58 (21)	33 (23)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
9	24 (13)	28 (16)	25 (19)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
10	30 (12)	29 (16)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
11	56 (13)	27 (16)	0 (0)	50 (22)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
12	33 (17)	38 (19)	33 (21)	50 (24)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
13	0 (0)	0 (0)	100 (22)	50 (22)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
14	20 (12)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
15	0 (0)	0 (0)	100 (22)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
16	67 (11)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
17	50 (15)	100 (15)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
18	50 (19)	50 (19)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
19	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
20	100 (16)	100 (20)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
21	0 (0)	100 (19)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
22	50 (18)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
23	0 (0)	0 (0)	100 (23)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
24	67 (18)	100 (18)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
MAX AVG SPEED:	19	20	23	24	29	35	39	42	[illegible]	[illegible]

TABLE 3-4(1)

WIND SPEED PERSISTENCE SITE LOCATION : BROGPRT AP ADJUSTED DATE : 490101 TO 741231 DIRECTION : E

PERCENTAGES OF OCCURENCES AND (AVERAGE WIND SPEEDS, MPH)

CONSECUTIVE HOURLY VALUES	WIND SPEED CLASS, MPH >5	>10	>15	>20	>25	>30	>35	>40	>45	>50
1	14 (9)	15 (12)	16 (17)	21 (22)	25 (27)	26 (31)	13 (35)	0 (0)	100 (47)	0 (0)
2	16 (10)	17 (13)	18 (18)	23 (23)	29 (27)	40 (32)	100 (41)	100 (43)	0 (0)	0 (0)
3	17 (11)	23 (13)	17 (19)	26 (24)	29 (31)	100 (38)	100 (43)	0 (0)	0 (0)	0 (0)
4	20 (11)	19 (14)	20 (20)	45 (28)	75 (33)	100 (36)	0 (0)	0 (0)	0 (0)	0 (0)
5	24 (12)	26 (15)	28 (22)	45 (25)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
6	25 (12)	26 (16)	40 (20)	33 (23)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
7	29 (14)	35 (16)	24 (20)	0 (0)	100 (29)	0 (0)	100 (40)	0 (0)	0 (0)	0 (0)
8	37 (12)	23 (15)	25 (19)	67 (26)	100 (27)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
9	22 (12)	17 (15)	50 (18)	0 (0)	0 (0)	100 (39)	0 (0)	0 (0)	0 (0)	0 (0)
10	26 (12)	43 (14)	0 (0)	0 (0)	100 (37)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
11	33 (15)	64 (15)	100 (22)	50 (26)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
12	17 (12)	13 (13)	33 (25)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
13	63 (17)	100 (21)	0 (0)	50 (34)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
14	40 (11)	0 (0)	0 (0)	100 (26)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
15	100 (11)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
16	33 (21)	50 (21)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
17	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
18	50 (27)	50 (27)	100 (27)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
19	100 (16)	100 (16)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
20	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
21	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
22	50 (15)	100 (15)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
23	100 (12)	100 (12)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
24	33 (9)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
MAX AVG SPEED:	27	27	27	34	37	39	43	43	47	0
MAX DURATION:	24	23	18	14	10	9	7	2	1	0

TABLE 3-4(J)

WIND SPEED PERSISTENCE SITE LOCATION : BRDGPRT AP ADJUSTED DATE : 490101 TO 741231 DIRECTION : ESE

PERCENTAGES OF OCCURENCES AND (AVERAGE WIND SPEEDS, MPH)

CONSECUTIVE HOURLY VALUES	WIND SPEED CLASS, MPH >5	>10	>15	>20	>25	>30	>35	>40	>45	>50
1	13 (9)	13 (13)	12 (17)	13 (22)	6 (29)	11 (34)	13 (37)	0 (0)	0 (0)	0 (0)
2	12 (10)	11 (13)	14 (17)	12 (22)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
3	12 (11)	10 (14)	16 (18)	10 (25)	21 (28)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
4	12 (11)	12 (14)	17 (19)	9 (26)	25 (26)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
5	9 (13)	11 (15)	21 (19)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
6	12 (12)	10 (17)	14 (19)	11 (23)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
7	6 (15)	8 (16)	6 (23)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
8	15 (12)	17 (15)	8 (17)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
9	14 (13)	17 (14)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
10	13 (15)	14 (17)	50 (19)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
11	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
12	25 (19)	38 (19)	33 (25)	50 (25)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
13	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
14	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
15	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
16	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
17	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
18	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
19	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
20	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
21	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
22	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
23	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
24	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
MAX AVG SPEED:	19	19	25	26	29	14	17	0	0	0
MAX DURATION:	12	13	12	12	4	1	1			

TABLE 3-4(k)

WIND SPEED PERSISTENCE SITE LOCATION : BRDGPRT AP ADJUSTED DATE : 490101 TO 741231 DIRECTION : SE

PERCENTAGES OF OCCURENCES AND (AVERAGE WIND SPEEDS, MPH)

CONSECUTIVE HOURLY VALUES	WIND SPEED CLASS, MPH >5	>10	>15	>20	>25	>30	>35	>40	>45	>50
1	11 (8)	8 (12)	8 (17)	5 (24)	3 (34)	5 (39)	13 (39)	0 (0)	0 (0)	0 (0)
2	10 (9)	7 (13)	6 (17)	4 (24)	7 (28)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
3	8 (10)	6 (13)	3 (17)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
4	6 (10)	4 (13)	3 (18)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
5	6 (11)	6 (15)	8 (19)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
6	5 (10)	3 (16)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
7	6 (12)	6 (14)	6 (17)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
8	6 (12)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
9	3 (11)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
10	9 (7)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
11	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
12	8 (9)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
13	13 (12)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
14	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
15	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
16	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
17	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
18	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
19	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
20	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
21	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
22	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
23	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
24	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
MAX AVG SPEED:	12	16	19	24	34	39	39	0	0	0
MAX DURATION:	13	7	7	2	2	1	1	0	0	0

TABLE 3-4(1)

WIND SPEED PERSISTENCE SITE LOCATION : BRDGPRT AP ADJUSTED DATE : 490101 TO 741231 DIRECTION : SSE

PERCENTAGES OF OCCURENCES AND (AVERAGE WIND SPEEDS, MPH)

CONSECUTIVE HOURLY VALUES	WIND SPEED CLASS, MPH >5	>10	>15	>20	>25	>30	>35	>40	>45	>50
1	11 (8)	7 (12)	6 (18)	6 (23)	8 (26)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
2	7 (9)	6 (13)	6 (18)	5 (23)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
3	9 (9)	5 (13)	2 (19)	3 (23)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
4	5 (11)	4 (13)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
5	7 (11)	3 (16)	3 (21)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
6	5 (9)	2 (12)	9 (18)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
7	1 (12)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
8	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
9	5 (9)	11 (17)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
10	9 (17)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
11	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
12	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
13	13 (11)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
14	20 (16)	100 (16)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
15	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
16	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
17	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
18	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
19	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
20	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
21	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
22	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
23	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
24	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
MAX AVG SPEED:	17	17	21	23	26	0	0	0	0	0
MAX DURATION:	14	14	6	3	1	0	0	0	0	0

TABLE 3-4(m)

WIND SPEED PERSISTENCE SITE LOCATION : BRDGPRT AP ADJUSTED DATE :-490101 TO-741231 DIRECTION :-S

PERCENTAGES OF OCCURENCES AND (AVERAGE WIND SPEEDS, MPH)

CONSECUTIVE HOURLY VALUES	WIND SPEED CLASS, MPH >5	>10	>15	>20	>25	>30	>35	>40	>45	>50
1	16 (9)	17 (12)	18 (17)	15 (22)	22 (27)	21 (35)	25 (38)	0 (0)	0 (0)	0 (0)
2	17 (9)	14 (13)	14 (18)	14 (23)	21 (28)	20 (31)	0 (0)	0 (0)	0 (0)	0 (0)
3	17 (10)	14 (14)	18 (18)	16 (26)	21 (28)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
4	19 (11)	15 (14)	9 (21)	27 (25)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
5	17 (12)	17 (15)	15 (23)	27 (27)	100 (32)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
6	19 (11)	14 (15)	14 (21)	11 (24)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
7	21 (13)	15 (17)	18 (19)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
8	12 (13)	9 (14)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
9	11 (11)	11 (13)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
10	13 (11)	7 (13)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
11	11 (10)	9 (12)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
12	9 (13)	13 (13)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
13	13 (11)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
14	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
15	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
16	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
17	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
18	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
19	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
20	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
21	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
22	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
23	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
24	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
MAX AVG SPEED:	13	17	23	27	32	35	38	0	0	0
MAX DURATION:	13	12	7	6	5	2	1	0	0	0

TABLE 3-4(m)

WIND SPEED PERSISTENCE SITE LOCATION : BRDGPRT AP ADJUSTED DATE : 490101 TO 741231 DIRECTION : SSW

PERCENTAGES OF OCCURENCES AND (AVERAGE WIND SPEEDS, MPH)

CONSECUTIVE HOURLY VALUES	WIND SPEED CLASS, MPH >5	>10	>15	>20	>25	>30	>35	>40	>45	>50
1	21 (9)	23 (13)	25 (17)	25 (22)	11 (29)	21 (33)	13 (38)	0 (0)	0 (0)	0 (0)
2	22 (10)	24 (13)	25 (18)	21 (23)	14 (31)	20 (35)	0 (0)	0 (0)	0 (0)	0 (0)
3	20 (11)	22 (14)	27 (19)	23 (24)	14 (27)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
4	19 (12)	22 (15)	25 (18)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
5	16 (12)	14 (15)	13 (18)	9 (26)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
6	14 (13)	18 (15)	11 (18)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
7	10 (12)	6 (15)	18 (18)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
8	6 (16)	20 (16)	8 (20)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
9	22 (14)	17 (15)	25 (19)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
10	0 (0)	7 (21)	50 (21)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
11	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
12	8 (15)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
13	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
14	20 (19)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
15	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
16	0 (0)	50 (17)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
17	50 (16)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
18	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
19	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
20	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
21	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
22	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
23	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
24	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
MAX AVG SPEED:	19	21	21	26	31	35	38	0	0	0
MAX DURATION:	17	16	10	5	4	2	1	0	0	0

TABLE 3-4(o)

WIND SPEED PERSISTENCE SITE LOCATION : BRDGPRT AP ADJUSTED DATE : 490101 TO 741231 DIRECTION : ENE-SSW

SUMMARY OF OCCURENCES AND (AVERAGE WIND SPEEDS, MPH)

CONSECUTIVE HOURLY VALUES	WIND SPEED CLASS, MPH >5	>10	>15	>20	>25	>30	>35	>40	>45	>50
1	2090 (8)	1671 (12)	678 (17)	161 (22)	47 (27)	14 (32)	7 (37)	0 (0)	2 (47)	0 (0)
2	980 (9)	645 (12)	227 (17)	53 (22)	18 (28)	7 (34)	1 (41)	1 (41)	0 (0)	0 (0)
3	522 (9)	355 (13)	118 (18)	34 (23)	7 (28)	1 (38)	0 (0)	0 (0)	0 (0)	0 (0)
4	368 (10)	255 (13)	62 (18)	17 (24)	8 (29)	1 (32)	0 (0)	0 (0)	0 (0)	0 (0)
5	242 (10)	149 (13)	44 (18)	9 (24)	2 (28)	0 (0)	0 (0)	1 (44)	0 (0)	0 (0)
6	208 (10)	99 (14)	37 (18)	7 (25)	2 (32)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
7	145 (10)	78 (14)	25 (19)	6 (24)	1 (29)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
8	127 (11)	83 (14)	17 (20)	4 (26)	1 (27)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
9	112 (10)	49 (14)	21 (20)	4 (26)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
10	88 (11)	31 (14)	12 (20)	1 (23)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
11	99 (10)	37 (14)	9 (20)	2 (24)	0 (0)	0 (0)	1 (41)	0 (0)	0 (0)	0 (0)
12	85 (10)	20 (16)	3 (21)	2 (24)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
13	65 (11)	26 (15)	12 (20)	1 (22)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
14	59 (11)	26 (16)	1 (21)	0 (0)	0 (0)	1 (39)	0 (0)	0 (0)	0 (0)	0 (0)
15	62 (10)	17 (16)	3 (21)	3 (24)	1 (39)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
16	40 (11)	15 (17)	3 (21)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
17	31 (12)	14 (16)	1 (23)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
18	30 (11)	7 (16)	1 (20)	1 (36)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
19	21 (11)	8 (16)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
20	20 (12)	7 (17)	2 (20)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
21	17 (13)	8 (16)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
22	17 (13)	6 (15)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
23	16 (10)	3 (16)	3 (25)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
24	117 (12)	24 (17)	2 (23)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
MAX AVG SPEED:	13	17	25	36	39	39	41	44	47	0
MAX DURATION:	24	24	24	18	15	14	11	5	1	0

TABLE 3-4(p)

WIND SPEED PERSISTENCE SITE LOCATION : BRDGPRT AP ADJUSTED DATE : 490101 TO 741231 DIRECTION : ENE-SSW

RESULTANT WIND DIRECTIONS AND (AVERAGE RESULTANT SPEEDS ,MPH)

CONSECUTIVE HOURLY VALUES	WIND SPEED CLASS, MPH >5	>10	>15	>20	>25	>30	>35	>40	>45	>50
1	SSE(4)	SSE(7)	SSE(10)	SE (13)	ESE(18)	SE (20)	SE (26)	CAL(0)	E (47)	CAL(0)
2	SSE(5)	SSE(7)	SE (11)	SE (14)	SE (18)	SE (20)	E (41)	E (41)	CAL(0)	CAL(0)
3	SSE(6)	SSE(8)	SSE(11)	SE (15)	SE (19)	E (38)	CAL(0)	CAL(0)	CAL(0)	CAL(0)
4	SSE(7)	SSE(8)	SE (11)	SE (16)	E (29)	E (32)	CAL(0)	CAL(0)	CAL(0)	CAL(0)
5	SSE(7)	SE (9)	SE (12)	ESE(18)	S (27)	CAL(0)	CAL(0)	E (44)	CAL(0)	CAL(0)
6	SSE(6)	SE (8)	ESE(12)	E (19)	SE (20)	CAL(0)	CAL(0)	CAL(0)	CAL(0)	CAL(0)
7	SE (6)	SE (8)	SE (13)	ESE(16)	E (29)	CAL(0)	CAL(0)	CAL(0)	CAL(0)	CAL(0)
8	SSE(7)	SE (9)	SE (13)	SE (16)	E (27)	CAL(0)	CAL(0)	CAL(0)	CAL(0)	CAL(0)
9	SSE(7)	ESE(9)	SE (13)	ESE(20)	CAL(0)	CAL(0)	CAL(0)	CAL(0)	CAL(0)	CAL(0)
10	SE (7)	ESE(10)	ESE(14)	E (23)	CAL(0)	CAL(0)	CAL(0)	CAL(0)	CAL(0)	CAL(0)
11	SE (7)	ESE(10)	ESE(14)	E (24)	CAL(0)	CAL(0)	E (40)	CAL(0)	CAL(0)	CAL(0)
12	ESE(7)	ESE(12)	E (18)	E (22)	CAL(0)	CAL(0)	CAL(0)	CAL(0)	CAL(0)	CAL(0)
13	ESE(8)	ESE(11)	E (18)	ENE(22)	CAL(0)	CAL(0)	CAL(0)	CAL(0)	CAL(0)	CAL(0)
14	ESE(8)	ESE(11)	ENE(21)	CAL(0)	CAL(0)	E (39)	CAL(0)	CAL(0)	CAL(0)	CAL(0)
15	ESE(8)	E (13)	E (20)	E (23)	E (38)	CAL(0)	CAL(0)	CAL(0)	CAL(0)	CAL(0)
16	ESE(8)	ESE(12)	ENE(21)	CAL(0)	CAL(0)	CAL(0)	CAL(0)	CAL(0)	CAL(0)	CAL(0)
17	ESE(9)	ESE(13)	E (23)	CAL(0)	CAL(0)	CAL(0)	CAL(0)	CAL(0)	CAL(0)	CAL(0)
18	ESE(9)	E (14)	ENE(19)	E (36)	CAL(0)	CAL(0)	CAL(0)	CAL(0)	CAL(0)	CAL(0)
19	ESE(8)	ESE(14)	CAL(0)	CAL(0)	CAL(0)	CAL(0)	CAL(0)	CAL(0)	CAL(0)	CAL(0)
20	ESE(9)	ESE(12)	E (19)	CAL(0)	CAL(0)	CAL(0)	CAL(0)	CAL(0)	CAL(0)	CAL(0)
21	E (11)	E (13)	CAL(0)	CAL(0)	CAL(0)	CAL(0)	CAL(0)	CAL(0)	CAL(0)	CAL(0)
22	ESE(10)	E (13)	CAL(0)	CAL(0)	CAL(0)	CAL(0)	CAL(0)	CAL(0)	CAL(0)	CAL(0)
23	ESE(8)	E (16)	E (25)	CAL(0)	CAL(0)	CAL(0)	CAL(0)	CAL(0)	CAL(0)	CAL(0)
24	ESE(10)	E (15)	E (21)	CAL(0)	CAL(0)	CAL(0)	CAL(0)	CAL(0)	CAL(0)	CAL(0)

TABLE 3-4(q)

TABLE 3-5

ANNUAL MAXIMUM STILLWATER TIDE HEIGHTS
NEW HAVEN, CONNECTICUT
(1938-1975)

Date	Observed Elevation (ft.NGVD)	Adjusted* Elevation (ft. NGVD)	Recurrence** Interval (Years)
21 Sep 1938 (Hurricane)	9.5	9.8	50
31 Aug 1954 (Hurricane - Carol)	9.5	9.7	40
14 Sep 1944 (Hurricane)	8.9	9.2	25
25 Nov 1950	8.9	9.	25
7 Nov 1953	8.7	8.9	18
12 Sep 1960 (Hurricane - Donna)	8.1	8.3	9
14 Oct 1955	7.8	8.0	7
12 Nov 1968	7.7	7.8	6
13 Apr 1961	7.6	7.7	5
28 Jan 1966	7.6	7.7	5
6 Mar 1962	7.5	7.6	4
4 Apr 1973	7.2	7.2	3
16 Feb 1958	7.1	7.3	3
26 Dec 1969	7.1	7.2	3
19 Feb 1972	7.1	7.1	3
2 Dec 1974	7.1	7.1	3
31 Oct 1947	7.0	7.3	3
12 Mar 1959	7.0	7.2	3
16 Feb 1964	7.0	7.1	3
2 Apr 1939	6.9	7.2	3
5 Dec 1957	6.9	7.1	3
17 Jan 1965	6.9	7.0	3
16 Sep 1971	6.9	6.9	2
27 Nov 1940	6.5	6.8	2
29 Nov 1945	6.5	6.8	2
7 May 1967	6.2	6.3	1
5 Nov 1970	6.2	6.3	1
26 Oct 1943	6.0	6.3	1
17 Mar 1956	6.0	6.2	1
2 Dec 1942	5.9	6.2	1
22 May 1951	5.9	6.1	1
14 Mar 1975	5.8	5.8	1
20 Feb 1946	5.7	6.0	1
6 Aug 1948	5.6	5.9	1

11 May 1949	5.6	5.9	1
12 May 1952	5.6	5.8	1
7 Nov 1963	5.6	5.7	1
12 May 1941	5.1	5.4	1

*Observed values after adjustment for rising sea level; adjustment made to 1975 sea level based on the publication Trends and Variability of Yearly Mean Sea Level, 1893-1972, National Ocean Survey, N.O.A.A., Hicks & Crosby.

**Recurrence interval of adjuted tide elevations, Obtained from tide stage-frequency relationship, figure 3-2.

CONSIDERED PLANS
for
OKINAWA BEACH

A range of plans were considered before arriving at the most practical and economical solution to the erosion problems at Okinawa Beach. The following is a brief description of the plans considered:

PLAN 1: Consists of beach widening by the direct placement of suitable sandfill to a level beach berm width of 50, 75, or 100 feet, to a backshore elevation of 11.0 feet above MLW (8.2 NGVD), along approximately 600 feet of shoreline. Also included is the transplanting of a section of marsh area located along the eastern side of Bradley Rock and the removal of the existing timber groin structure.

PLAN 2: Consists of beach widening as stated in Plan 1, plus the deferred construction of a timber groin structure at the East end of the beach. The structure will be used to maintain shore alignment of the placed sandfill.

PLAN 3: Consists of beach widening as stated in Plan 1, plus the deferred construction of a rock groin structure at the East end of the beach. The structure will be used to maintain shore alignment of the placed sandfill.

Other structural and nonstructural plans were considered, but not carried forward because they did not meet the problem and opportunity statement criteria.

In formulating the plans for Okinawa Beach, consideration was given to the impact on the environment due to the placement of sandfill on a grassy area located along the east side of Bradley Rock. The plans described call for the direct placement of sandfill on the beach. A portion of this fill will impact the grassy area; therefore, to mitigate this impact a section of this grass will be transplanted and placed in a new location seaward of the proposed fill (see plate No 3-6). The proposed groin structure will be deferred until it can be determined, through a monitoring program that it is necessary and essential to insure that the project will function as designed. The existing timber structure will be removed prior to construction.. Plan 2, with a 75-foot level berm was selected because it provides maximum benefits and is the best engineered project for Okinawa Beach.

A System of Accounts for Plans 2 and 3 is contained in Table 3-3 at the end of this report section.

DESIGN TIDE

The design tide elevation selected for the West Haven Beaches was based on data obtained from the National Weather Service and National Ocean Survey. Frequency of tidal flood records of stillwater elevations recorded at Bridgeport, Connecticut were used and corrected to be representative of the study area. Based on these data, a design tide elevation of 10.0 feet MLW (7.2 feet NGVD) was selected. This tide level is approximately 4.0 feet above MHW and is estimated to occur in the project area with a frequency of once in three years.

DESIGN CONDITIONS

Sea Bluff and Okinawa Beaches are located along the north shore of Long Island Sound. The beaches are sheltered from deepwater storm-driven waves by Long Island (in New York State) to the south, the East Haven (Connecticut) shore to the east and a series of three breakwaters located approximately 2 miles offshore. The openings between these breakwaters are wide enough to allow a wave developed in Long Island Sound to continue uninterrupted between the structures (no diffraction) to the beach. The maximum fetch distance available to develop wind-driven waves at the beach is 30 miles from the east-southeast. The duration of the wind and its speed (including fastest mile) are critical factors in the development of waves and wave heights. These parameters were determined from actual readings taken at nearby Bridgeport airport and discussed earlier in Appendix 2. These data were also used to analyze and determine the impact on longshore and offshore movement of material along the beach. The data was also used in evaluating groin design, rock and timber, for new construction or rehabilitation of the existing structures.

DESIGN WAVE

The design wave is the largest wave that is expected to occur in the project area at the time of the design stillwater level during storm conditions. Wave heights in the area are limited by available fetch distances and depths of water. In order to develop the maximum wave that could occur for the given design conditions, it is necessary to have a substantial fetch distance and have the winds in and around the study area blow for an extended period of time. Because the fetch distance is limited to a maximum of 30 miles and as a result of the shoaling that has occurred in the area of the offshore breakwaters and the flat near shore configuration, the beach is not subjected to attack by large deep water waves. Three directions, east-southeast, south, and south-southwest were selected as being critical in determining the design wave. The east southeast has a fetch distance of 30 miles and the southeast has a fetch distance of 25 miles.

The fetch distance and duration that the wind blows has a major influence on the size of the wave. The depth of water at the beach for the design stillwater elevation is $\pm$ 10.0 feet. Therefore, the fetch

distance and/or wind duration and not the depth of water will govern in determining the design wave. See Table 2-8, Appendix 2.

The criteria used in selecting the design wave was based on figures and charts in this Appendix and Appendix 2, taken from the Shore Protection Manual (SPM) & the Coastal Engineering Technical Notebook, are as follows:

- Stillwater elevation 10.0 feet above MLW (7.2 NGVD), once in three years.
- Storm conditions, once in ten years.
- Wind speed, 32 miles per hour.
- Wind duration, two hours.
- Direction, south.
- Fetch distance 19 miles.

From this design criteria, it was calculated that a 4.2-foot-high wave with a 4.3-second-period could develop and approach the study area from the east-southeast direction. This is the maximum wave that can be expected to occur in the area under the design conditions (See the beginning of this Appendix and Appendix 2).

GROIN DESIGN

GENERAL

A groin which is higher el +11.0 feet above MLW (8.2 feet NGVD), and longer than the old structure, would allow for some overflow of sandfill to other down drift beaches. Therefore, a low profile groin el +11 feet above MLW (8.2' NGVD) was chosen. Sandfill would be allowed to move over the groin if an excess were to build up along the side of the groin. Sloping the groin 15 on 1 (to coincide with slope of sandfill) would encourage material to move easterly to nournish down drift beaches.

TIMBER DESIGN PARAMETERS

The design of the timber groin at Okinawa Beach was based on the following:

1. Stillwater elevation of 10.0 feet (7.2 feet NGVD) above MLW.
2. 4.2-foot breaking wave.
3. Minimum of 2/3 substructure to 1/3 superstructure for timber planks - Anchor pole design.

TIMBER GROIN DESIGN AND CONSTRUCTABILITY

The proposed timber groin would be approximately 190 feet in length and vary in elevation from 11.0 feet at the landward end to 6.0 feet at the seaward end.

Details of the design are shown on Plate 3-6. This design is both practical and safe, as based on performance of a similar groin at Sherwood Island State Park, Westport, Connecticut. Two timber groins, located at the east end of that beach, have been in place since 1957 and are still functioning well and are in excellent condition.

WAVE RUNUP

Computations for wave runup were made for storms that would occur at the design stillwater elevation of 10.0 feet above mean low water (7.2 feet NGVD). Runup values were calculated using the "Shore Protection Manual" (SPM) dated 1984 and the Coastal Engineering Technical Notebook. A design slope of 1 vertical on 15 horizontal was used for the beach face based on recent experience using this as the average slope that occurs naturally with this proposed sandfill. Wave runup is expected to exceed the beach berm elevation of 11.0 feet above MLW (8.2 feet NGVD) by approximately 0.5 feet. This overtopping is not expected to cause any serious erosion of beach material. There could be some minor redistribution of sandfill, but the material is expected to remain within the nearshore area.

HISTORIC SHORELINE

The shoreline in West Haven over the years has changed dramatically. Historically, the Long Island Sound shoreline has been composed primarily of unconsolidated material, primarily sand. As a result, it has been susceptible to continued erosion from the physical forces such as winds and storm driven waves. Erosion of this unconsolidated material has resulted in the rapid recession of the mean high water line averaging in excess of between 1.0 and 2.0 feet per year. The result is the gradual loss of valuable public property, walkways and a shore road, not to mention natural dry beach space. Information obtained from historic reports, city records and plot plans indicated that the mean high waterline in the vicinity of the West Haven Shore was once approximately 300 feet seaward of its present location. In Colonial times, it was recorded that a road, now referred to as the Ancient Highway, once ran along the entire shore. Erosion forced its abandonment and the subsequent construction of a new road, and a revetment to prevent the further inland retreat of the shore.

SANDFILL

Sandfill to be used on this beach is critical. Consideration was given to the existing sand on the beach, the requirements set forth in the 1984 "Shore Protection Manual" and the availability of sand in the Connecticut and New York (Long Island) areas. It appears at this time that the most economical source of suitable beachfill would be obtained from a nearby land source. A detailed sand source analysis has been completed for this study. An update of this analysis would be performed during the plans and specifications phase of the project to assure that the sources are still available.

For this evaluation it was found that in order to maintain a fairly stable beach, a better grade of sandfill should be used than the native material. The criteria for this sandfill was established based on information in the 1984 "Shore Protection Manual". The following criteria is considered adequate to provide a stable beach based on the design criteria and conditions: sand color should be as close to that of the natural sand as possible; median diameter particle size of between 0.4 to 1.00 millimeters; a sorting coefficient of between 1.5 and 1.8; and a specific gravity of not less than 2.60. The following gradation requirements pertain to percent passing by weight through a U.S. Standard Sieve: 100%, 3/8 sieve; 95-100%, #4 sieve; 50-95%, #20 sieve; 10-50%, #50 sieve; 0-20%, #100 sieve; 0-5%, #200 sieve. These gradation requirements and other sandfill requirements should be reevaluated during the plans and specifications stage, and consideration should be given to the availability of sandfill and the cost of processing the material if necessary. Preliminary analysis of the nearby land borrow pits indicated that material with the desired characteristics is available or can be provided.

The slope of the seaward face of the proposed sandfill was selected to be 1 vertical on 15 horizontal. This was based in part from experience with other beaches along the Connecticut shore and the existing conditions in the intertidal zone fronting the beach.

The proposed sandfill slope is considered consistent with the natural slope in the intertidal zone. However, with the use of a better quality material, the beachfill could be placed on a slightly steeper slope within the limits of the tide range. The wave action during construction will then redistribute the material naturally in the intertidal zone. An additional 5 percent of material is included in the estimated number of cubic yards of material to be placed along with the periodic nourishment required for the first year to allow for losses during construction. Also included in the estimated cost is a contingency factor to allow for unexpected overruns. Experience indicates that the losses due to normal wave action during construction are not significant when a good quality beachfill is used.

A horizontal level beach berm elevation of 11.0 feet above mean low water (8.2 feet NGVD) is the maximum practical berm elevation to use com-

mensurate with the design stillwater elevation, wave run-up and the natural backshore area.

Samples of the existing beach sand were taken on selected profiles and at various elevations along the beach. The average median diameter is approximately 0.3 millimeters.

CONSTRUCTION

During construction, every precaution will be taken to assure that the contractor places the specified quality of sand on the beach. This will be accomplished by frequent sampling and testing of the material during construction. This in turn will reduce the potential for loss in the offshore area. During the construction sandfill placement methodology will be at the discretion of the contracting officer's representative. Because of the state and local restrictions and requirements that will be placed on the construction, it may be necessary to construct the project over a three-month period. The contractor will not be permitted to place sandfill on the beach from July 1st through September 30, due to the impact on fish and wildlife, and sunbathers during this period. See Appendix 5 for letters from the State and Federal agencies explaining the need for this restriction.

BEACH MONITORING

Upon completion of the project, a monitoring program should be implemented. With the cooperation of the local interest, a series of surveys and photographs should be taken to evaluate changes in the design. Surveys should be taken in the spring, late summer and periodically during the fall and winter. Fall and winter profiles should extend to approximately the Mean Low Water Line. Spring and summer profiles should extend to a depth necessary to determining major changes. Monitoring should continue for a period of not more than 5-years. Beach profile changes, accretion and erosion, should be evaluated and the time of year and weather conditions stated. This information should then be evaluated and analyzed to determine nourishment requirements and if a structure or structures are necessary.

PERIODIC NOURISHMENT

Federal participation in the cost of annual periodic beach nourishment is recommended for the 50-year economic project life. Periodic nourishment is considered to be part of the cost of construction when it is found to be the most economical erosion protection method of maintaining project alignment and dimensions. Artificial nourishment will actually be applied only when necessary.

Periodic nourishment is considered part of the initial construction of the project. Consideration was given to alternative plans with longer and higher groins. These plans were more costly and environmentally

unacceptable; therefore the recommended plan, with the deferred groin structure, monitoring and cost sharing in periodic nourishment, was proposed as the best engineered, most practical and economical plan for this beach.

Nourishment quantities for the proposed sandfill are calculated on both past and present surveys. The nourishment estimates are calculated over the project life and are displayed as annual values. The estimated amount of annual nourishment is approximately 800 cubic yards per year, using a better grade of sandfill than the native material.

The proposed project would provide beach widening by the direct placement of sandfill, the removal of the timber groin and the deferred construction of the groin structure. The use of a well graded sandfill with very few fines and the construction of the groin would reduce losses substantially below their current level. With the use of a better grade of sandfill, the material would remain in the nearshore area to act as a source during the beach-building season.

The cost of periodic nourishment to replace normal losses will be cost-shared on the same basis as the initial project cost sharing. Our analysis of the sand budget indicates that, with a better grade of sandfill, losses at the beach would be substantially less than those experienced at the adjacent beach, after the construction in 1957. Estimates of future periodic nourishment costs include allowances for engineering, design and supervision.

COST APPORTIONMENT

Federal participation in the costs of beach erosion control projects is based on shore ownership and use. The following is the Corps' criteria for determining 70 percent Federal cost sharing:

1. Must be publicly owned.

2. It includes a zone extending landward from the mean low water line which excludes all permanent human habitation but not including the residences of park administrative and maintenance personnel.

3. It includes a beach suitable for recreational use.

4. It provides for preservation, conservation and development of the natural resources of the environment in accordance with the overall mission or purpose of the park.

5. Extends landward a sufficient distance to include protective dunes, bluffs or other natural features to absorb and dissipate wave energy and flooding effects of the design storm tide.

6. It provides essentially full park facilities for appropriate public use.

Okinawa Beach satisfies all of the above criteria; therefore, the city qualifies for 70 percent Federal cost sharing, with the remaining 30 percent to be paid by local interests.

The apportionment of cost sharing in the construction and first cost of the improvement between Federal and non-Federal interests for the proposed improvement and periodic nourishment is 70 percent Federal and 30 percent non-Federal for Okinawa Beach. The apportionment of costs for the considered plans is summarized in Table 3-6. The Selected Plan, the plan that provides the maximum return on the investment consists of the plan that provides the optimum net benefits. The Selected Plan is the one that optimizes net benefits and is described as follows:

Okinawa Beach Plan 2, 75-foot wide level beach berm.

> The recommended plan for this beach consists of the direct placement of suitable sandfill along approximately 600 feet of beach, providing a 75-foot wide level beach berm at elevation 11.0 feet above mean low water (8.2 feet NGVD). It is further recommended but deferred, until such time as deemed necessary, is the replacement of the existing timber groin structure located at the east limit of the beach. This evaluation would be made after the beach has been constructed and monitored for a number of years. Also included is marsh grass transplanting and the removal of the existing timber groin structure. This plan provides a dry beach width above the mean high waterline of approximately 147 feet.

The costs for the Selected Plan (Plan 2 with a 75-foot-wide berm) are summarized in Table 3-7.

TABLE 3-6
COST APPORTIONMENT FOR CONSIDERED PLANS

PLAN	BERM WIDTH	(1) OKINAWA BEACH 70 - 30 COST SHARING					
		$ COST SHARING		$ ANNUAL COST		$ PERIODIC NOURISHMENT	
	FT	FEDERAL	NON-FED	FEDERAL	NON-FED	FEDERAL	NON-FED
1	50	157,200	67,400	23,100	9,900	9,600	4,100
	75	208,00	89,200	32,500	13,900	14,600	6,200
	100	266,300	114,100	43,200	18,500	20,300	8,700
2	50	189,200	82,000	21,000	10,000	4,800	2,000
	75	245,000	105,000	28,300	13,100	7,300	3,100
	100	315,400	135,200	37,200	17,000	10,100	4,400
3	50	189,600	81,300	21,100	13,000	4,800	2,000
	75	245,400	105,200	28,400	16,100	7,300	3,100
	100	308,500	132,200	36,600	19,800	10,100	4,400

(1) Periodic sand nourishment cost are the same for Plan 2 and Plan 3. Groin structure total cost and maintenance cost differ between rock and timber groins.

TABLE 3-7

COSTS FOR SELECTED PLAN

A. FIRST COST

Sandfill	16,000 cy x $11/cy	$176,000
Timber	190 ft x $231/ft	44,000
Removal of Existing Groins and Grass Transplanting		5,000
	Subtotal	$225,000
Contingencies		45,000
	Subtotal	$270,000
Engineering & Design		40,000
	Subtotal	$310,000
Supervision & Administration		40,000
	TOTAL FIRST COST	$350,000

B. COST SHARING

Federal	(70%)	= $245,000
Non-Federal	(30%)	= $105,000

C. INVESTMENT COST
(Note: The investment cost is the total first cost plus interest during construction as calculated by using the formula below. The interest during construction is based on the present interest rate of 8-3/8 percent for civil work projects in FY 85 and the construction period is estimated to be three months.)

USCAF= $\frac{(1 + i)^n - 1}{}$ = 3.0210 $350,000 x 3.0210/3 = $352,350

D. ANNUAL CHARGES

Federal

Interest & Amortization	0.08527 x $246,645	$21,000
Nourishment:	560 cy x $13/cy	7,300
	TOTAL FEDERAL/YR	$28,300

Non-Federal

Interest & Amortization	0.08527 x $105,700	$9,000
Nourishment:	240 cy x 13/cy	3,100
Groin Maintenance		1,000
	TOTAL NON-FEDERAL/YR	$13,100
	TOTAL ANNUAL CHARGES/YR	$41,400

TABLE 3-8
OKINAWA BEACH
SYSTEM OF ACCOUNTS

ACCOUNT	**FOOTNOTES	PLAN 2		PLAN 3	
1. National Economic Development (NED)					
a. Beneficial Impacts (Annual)					
Increased Recreation					
50' Berm	2,5,7,9	$44,600		$44,600	
75' Berm	2,5,7,9	$57,100		$57,100	
100' Berm	2,5,7,9	$68,700		$68,700	
Nonstructural Plan	2,5,7,9	NONE		NONE	
Recreational Fishing	2,5,7,9	NONE		NONE	
Prevention Backshore damages & others	2,5,7,9	6,500		6,500	
b. Project Costs (Annual)		Federal	Local	Federal	Local
50' Berm		$21,000	$10,000	$21,100	$13,000
75' Berm		$28,300	$13,100	$28,400	$16,100
100' Berm		$37,200	$17,000	$36,600	$19,800
Nonstructural Plan		NONE	NONE	NONE	NONE
(1) Total NED Costs (Annual)					
50' Berm		$31,000		$34,100	
75' Berm		$41,400		$44,500	
100' Berm		$54,200		$56,400	
Nonstructural Plan		NONE		NONE	

TABLE 3-8

OKINAWA BEACH

SYSTEM OF ACCOUNTS

ACCOUNT	**FOOTNOTES	PLAN 2	PLAN 3
c. Total NED Benefits (Annual)		$51,100	$51,100
50' Berm		$63,600	$63,600
75' Berm		$75,200	$75,200
100' Berm		NONE	NONE
Nonstructural plan			
d. Benefit-Cost Ratio			
50' Berm		1.7	1.5
75' Berm		1.5	1.4
100' Berm		1.4	1.3
Nonstructural plan		NONE	NONE
2. Environmental Quality (EQ)			
a. Beneficial Impacts			
(1) Restoration of Valuable Beach using Sandfill from land source	2,6,9	yes	yes
(2) Protection of Recreational Facilities (new groins and sandfill will protect beach from erosion)	2,6,9	yes	yes
(3) Provision of Recreational Beach Area (Sandfill will provide increased beach area)	2,6,9	yes	yes
(4) Provision of Fishing Facilities (New groin structures)	2,6,9	no	no

TABLE 3-8
OKINAWA BEACH
SYSTEM OF ACCOUNTS

ACCOUNT	**FOOTNOTES	PLAN 2	PLAN 3
(5) Prevention of Littoral Sand Drift (New groin structures)	2,5,9	No	yes
b. Adverse Impacts			
(1) Archaelogical/Historical Resources		No impact	No impact
(2) Air Quality (Degraded temporarily due to construction activities; i.e., dust emissions, etc.)	1,5	Minor-temporary	Minor-temporary
(3) Noise (Increased due to construction; fill transport by trucks)	1,6	Minor-temporary	Minor-temporary
(4) Water Quality (Increases in turbidity during fill and construction activities may cause short-term decrease in the oxygen level in the water)	1,5	yes	yes
3. Other Social Effects			
a. Beneficial Impacts			
Effects on Desired Community Growth	2,5,8,9	Compatible with local land use to improve the backshore park.	
Effects on Educational, Cultural, and Recreational Opportunities		Increase recreational opportunities by providing additional dry beach space with increased capacity.	

TABLE 3-8

SYSTEM OF ACCOUNTS

ACCOUNT	**FOOTNOTES	PLAN 2	PLAN 3
b. Adverse Impacts			
Community Distruption	1,6,9	Temporary disruption during construction; site specific disruptions.	
Effects on Health, Safety, and Community Well-Being	1,6,9	Temporary threat during construction on local roads and areas at or near project site.	
4. Regional Economic Development			
a. Beneficial Impacts			
Effects on Regional Recreational Activity	2,5,9	Increase salt water based recreational opportunities.	
Effects on Employment	1,6,7,9	Use of local labor pool for construction of project.	
Effects on Local Commercial and Industrial Activities	2,4,9	Probable increase in business for local establishments resulting from increased numbers of beach users.	
b. Adverse Impacts			
Effects on Public Services	2,5,9	Possible need for increased police and life guarding services.	
Effects on Public Facilities	2,5,9	No effect	No effect

TABLE 3-8

SYSTEM OF ACCOUNTS

*PLANS	**FOOTNOTES
Considered Plans of Improvement Plan 1 consists of beach widening, to a level beach berm width of 50, 75, or 100 feet by the direct placement of suitable sandfill along approximately 600 feet of shoreline and deferred groin construction. There will also be marsh grass planting and beach monitoring. The considered plans are: Plan 2 - Sandfill and the deferred construction of a timber groin structure at the northern limit of the beach. Plan 3 - Sandfill and the deferred construction of a terminal rock groin structure at the northern limit of the beach.	Timing 1. Impact is expected to occur to or during implementation of the plan. 2. Impact is expected within 15 years following plan implementation. 3. Impact is expected in a longer time frame (15 or more years following implementation.) Uncertainty 1/ 4. The uncertainty associated with the impact is 50% or more. 5. The uncertainty is between 10% and 50%. 6. The uncertainty is less than 10%. Exclusivity 7. Overlapping entry; fully monetized in NED account. 8. Overlapping entry; not fully monetized in NED account. 1/ Easily reversible measures are desirable cases where uncertainty of impact is high.

TABLE 3-8

SYSTEM OF ACCOUNTS

*PLAN	**FOOTNOTES
	Actuality 9. Impact will occur with implementation. 10. Impact will occur only when specific additional actions are carried out during implementation. 11. Impact will not occur because necessary additional actions are lacking.

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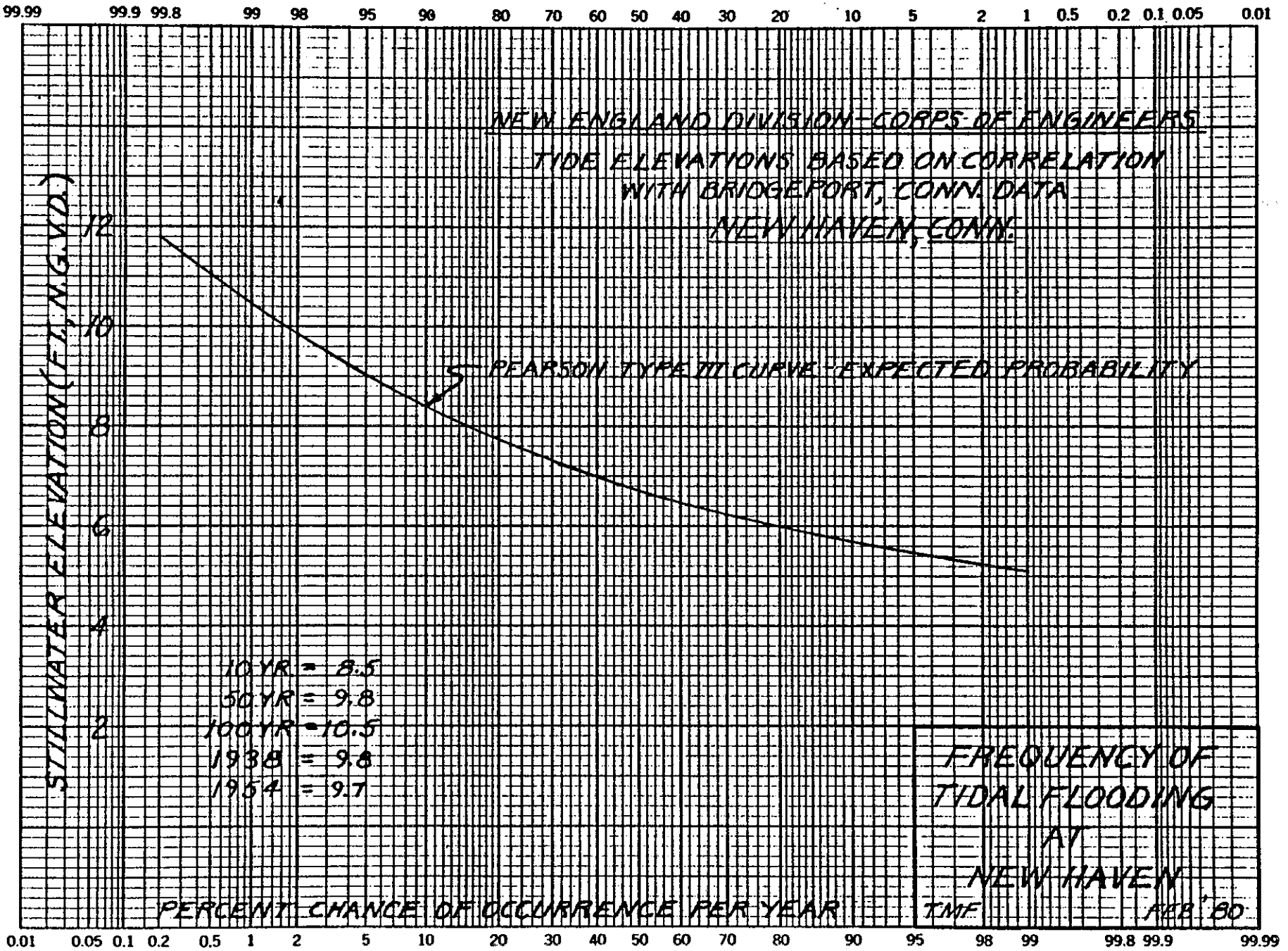
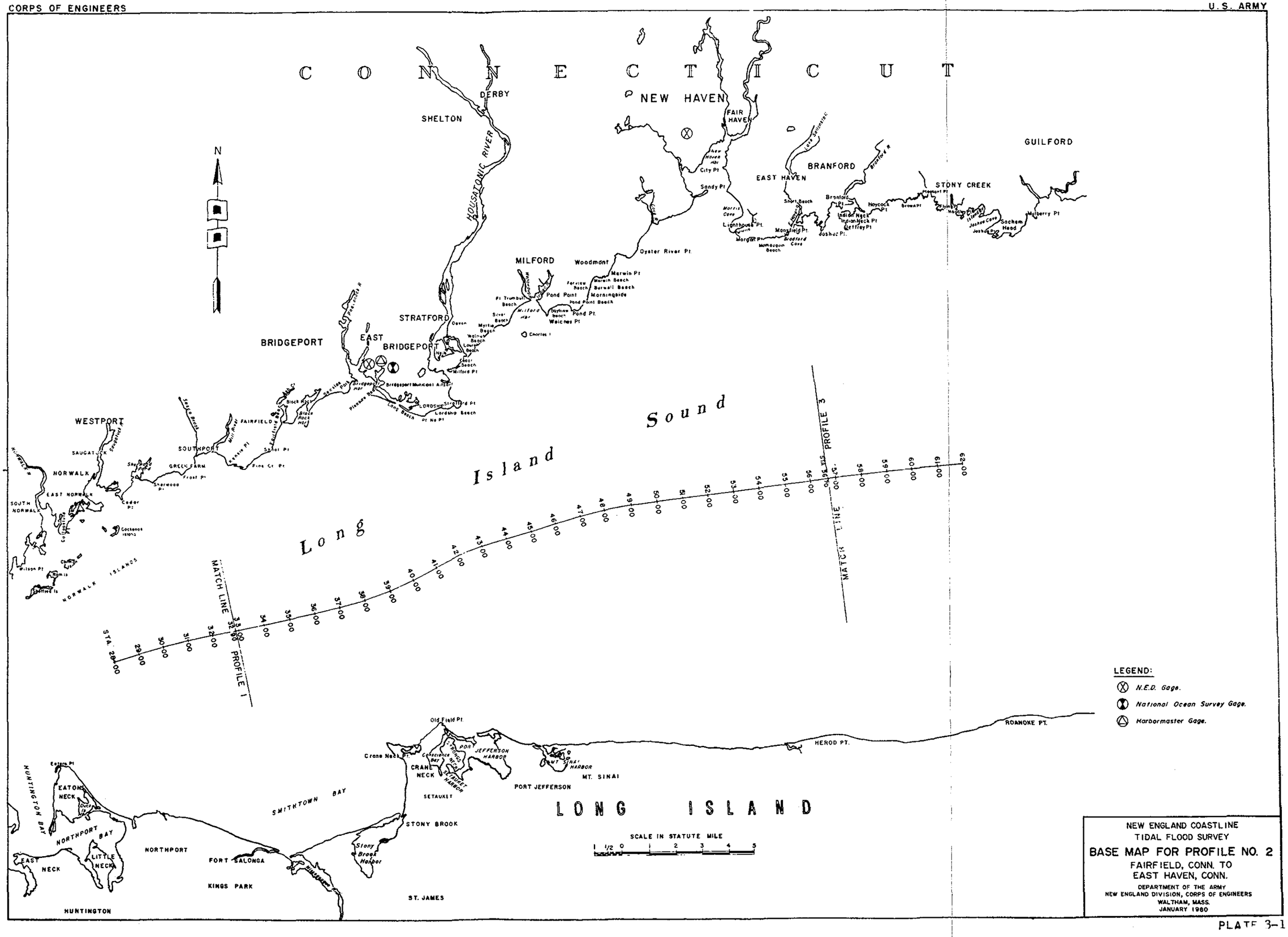


FIGURE 3-2



NEW ENGLAND COASTLINE
TIDAL FLOOD SURVEY
BASE MAP FOR PROFILE NO. 2
FAIRFIELD, CONN. TO
EAST HAVEN, CONN.
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS.
JANUARY 1960

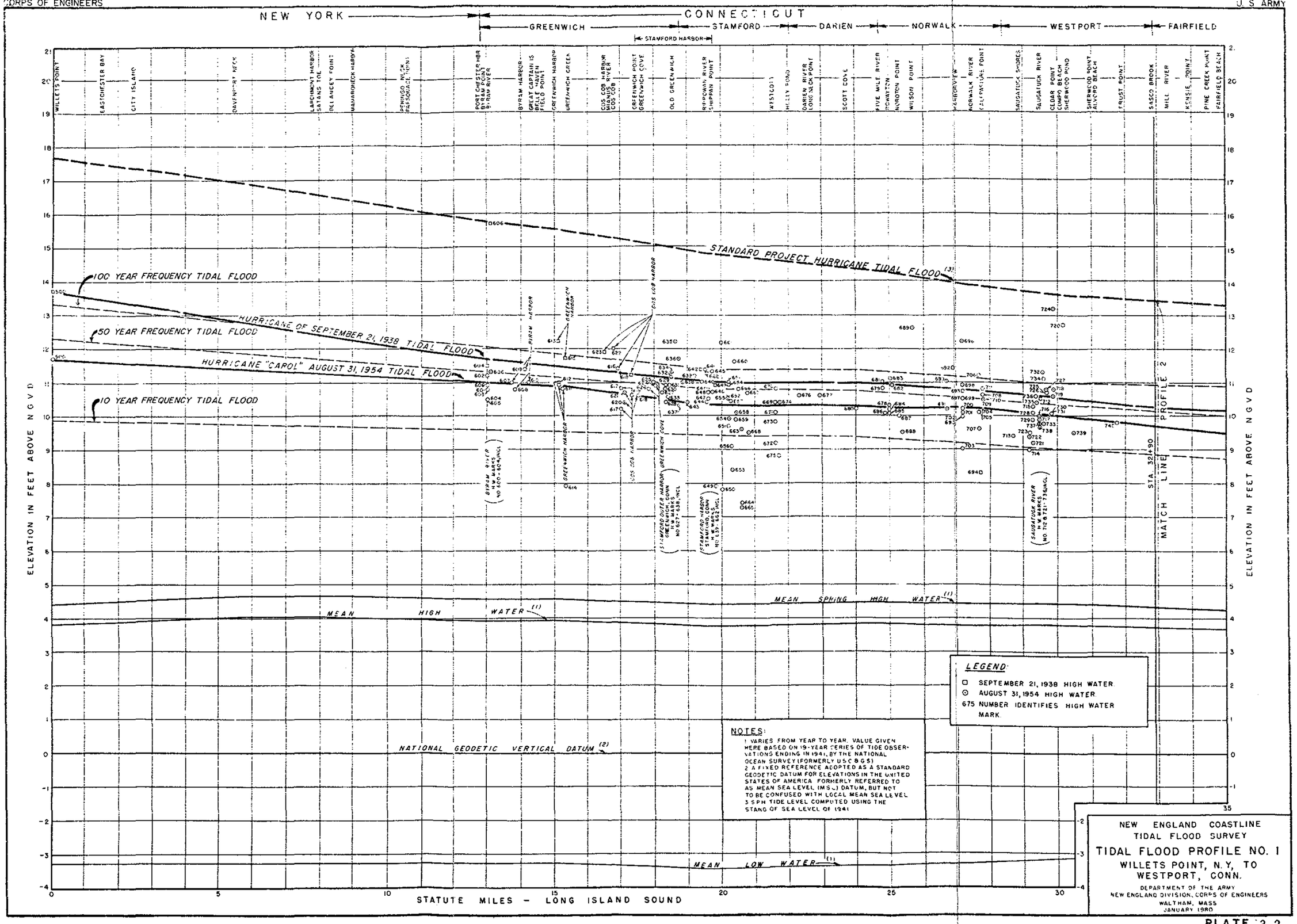
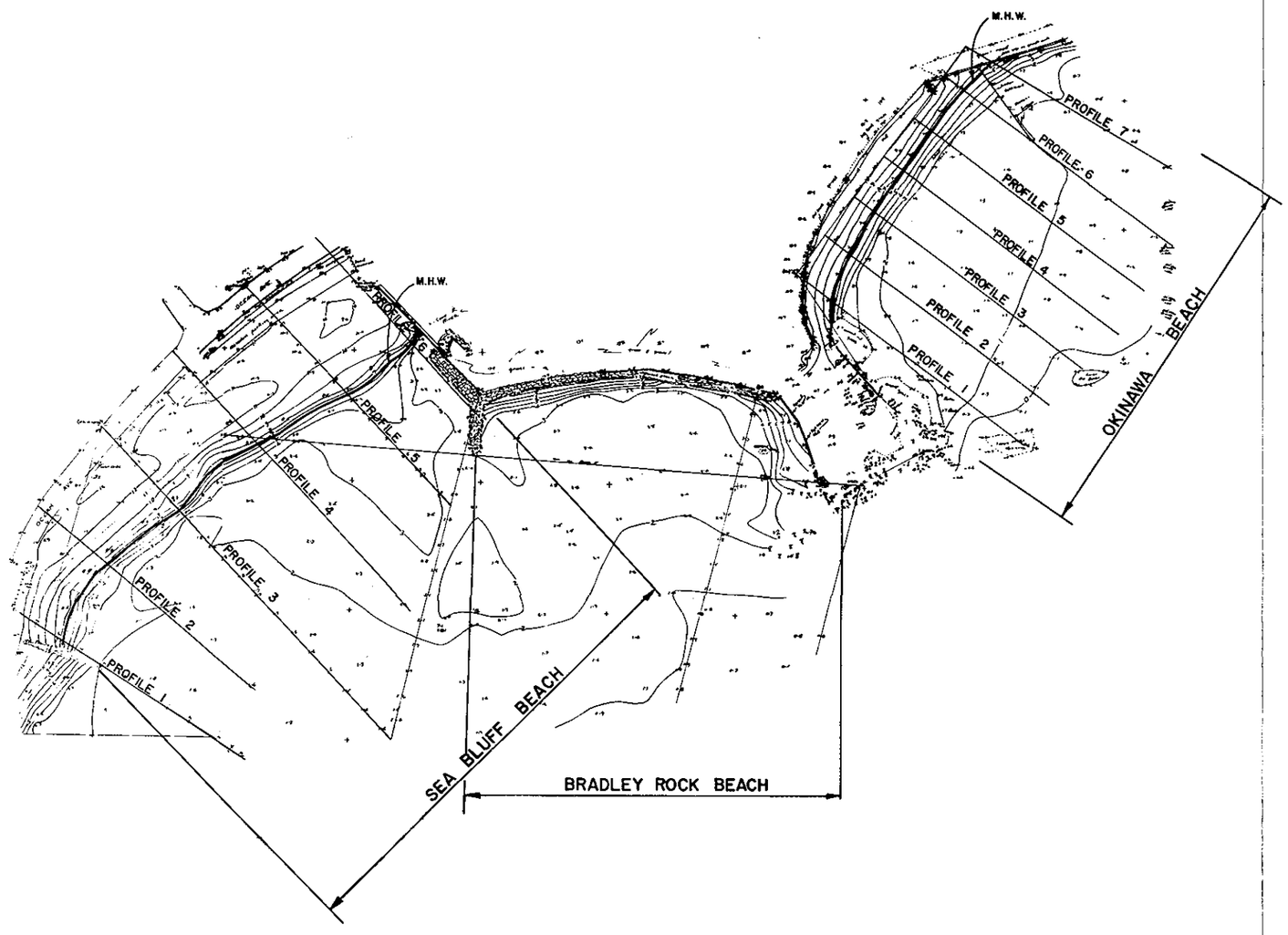

NEW YORK
CONNECTICUT
GREENWICH
STAMFORD
DARIEN
NORWALK
WESTPORT
FAIRFIELD
STAMFORD HARBOR
WILLETS POINT
EASTCHESTER BAY
CITY ISLAND
DAVENPORT NECK
LARCHMONT HARBOR
SATANS TOE
DELANCEY POINT
MAMARONECK HARBOR
PENINGO NECK
PASSONAGE POINT
PORT CHESTER HBR
BYRAM POINT
BYRAM RIVER
BYRAM HARBOR
GREAT CAPTAIN IS
BELLE HAVEN
FIELD POINT
GREENWICH HARBOR
GREENWICH CREEK
COS COB HARBOR
MIANUS RIVER
COS COB
GREENWICH POINT
GREENWICH COVE
OLD GREENWICH
RIPPOWAN RIVER
SHIPPAN POINT
WESTCOTT
HOLLY POND
DARIEN RIVER
LONG NECK POINT
SCOTT COVE
FIVE MILE RIVER
ROWAYTON
NOROTON POINT
WILSON POINT
HARBORVIEW
NORWALK RIVER
CALEPASTURE POINT
SAUGATUCK SHORES
SAUGATUCK RIVER
CEDAR POINT
COMPO BEACH
SHERWOOD POND
SHERWOOD POINT
ALVORD BEACH
FRUST POINT
SASCO BROOK
MILL RIVER
KENSIE POINT
PINE CREEK POINT
FAIRFIELD BEACH
STANDARD PROJECT HURRICANE TIDAL FLOOD (3)
100 YEAR FREQUENCY TIDAL FLOOD
HURRICANE OF SEPTEMBER 21, 1938 TIDAL FLOOD
50 YEAR FREQUENCY TIDAL FLOOD
HURRICANE "CAROL" AUGUST 31, 1954 TIDAL FLOOD
10 YEAR FREQUENCY TIDAL FLOOD
BYRAM HARBOR
GREENWICH HARBOR
COS COB HARBOR
BYRAM RIVER H.W. MARKS NO 600-604 INCL
STAMFORD OUTER HARBOR GREENWICH, CONN H.W. MARKS NO 627-638 INCL
STAMFORD HARBOR STAMFORD, CONN H.W. MARKS NO 639-662 INCL
SAUGATUCK RIVER H.W. MARKS NO 712 & 721-736 INCL
STA. 32+90
MATCH LINE PROFILE 2
MEAN SPRING HIGH WATER (1)
MEAN HIGH WATER (1)
NATIONAL GEODETIC VERTICAL DATUM (2)
MEAN LOW WATER (1)
ELEVATION IN FEET ABOVE N G V D
STATUTE MILES - LONG ISLAND SOUND
LEGEND:
SEPTEMBER 21, 1938 HIGH WATER
AUGUST 31, 1954 HIGH WATER
675 NUMBER IDENTIFIES HIGH WATER MARK
NOTES:
1 VARIES FROM YEAR TO YEAR. VALUE GIVEN HERE BASED ON 19-YEAR SERIES OF TIDE OBSERVATIONS ENDING IN 1941, BY THE NATIONAL OCEAN SURVEY (FORMERLY U.S.C.&G.S.)
2 A FIXED REFERENCE ADOPTED AS A STANDARD GEODETIC DATUM FOR ELEVATIONS IN THE UNITED STATES OF AMERICA. FORMERLY REFERRED TO AS MEAN SEA LEVEL (M.S.L.) DATUM, BUT NOT TO BE CONFUSED WITH LOCAL MEAN SEA LEVEL
3 S.P.H. TIDE LEVEL COMPUTED USING THE STAND OF SEA LEVEL OF 1941
NEW ENGLAND COASTLINE
TIDAL FLOOD SURVEY
TIDAL FLOOD PROFILE NO. 1
WILLETS POINT, N.Y. TO WESTPORT, CONN.
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS
JANUARY 1980

PLATE 3-2



N

NOTES:

SOUNDINGS AND ELEVATIONS ARE IN FEET AND TENTHS AND ARE REFERRED TO THE PLANE OF MEAN LOW WATER.
SHORELINE IS MEAN HIGH WATER. MEAN TIDAL RANGE IS 6.2 FEET
BEACH PROFILES ARE FROM SURVEY BY CORPS OF ENGRS. SEE PLATE NO. 3-4.
R. & H. BOOKS: 4074, 4075
FATHOMETER ROLL: 81-72
PLANE COORDINATES ARE BASED ON THE LAMBERT GRID SYSTEM FOR THE STATE OF CONNECTICUT.

BEACH EROSION CONTROL STUDY

WEST HAVEN BEACHES

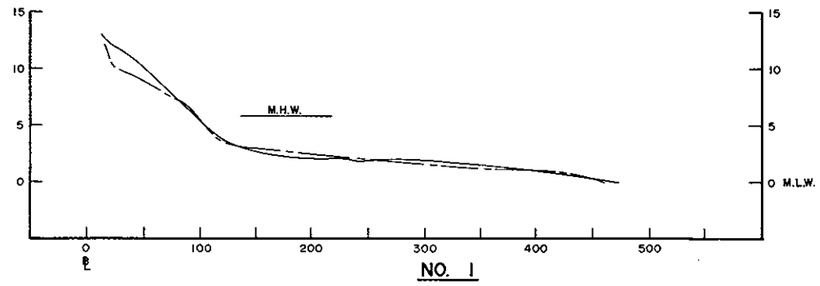
WEST HAVEN CONNECTICUT

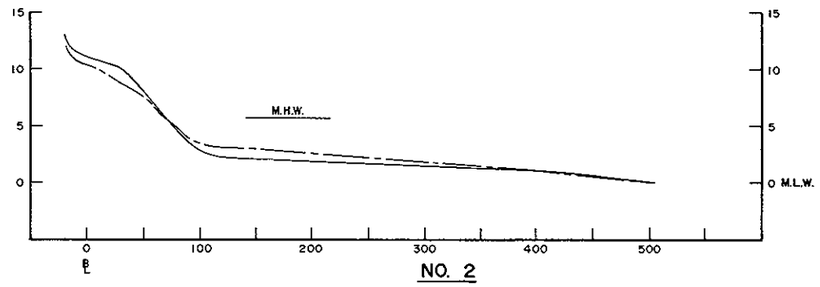
SURVEY MAP
1983
OKINAWA BEACH

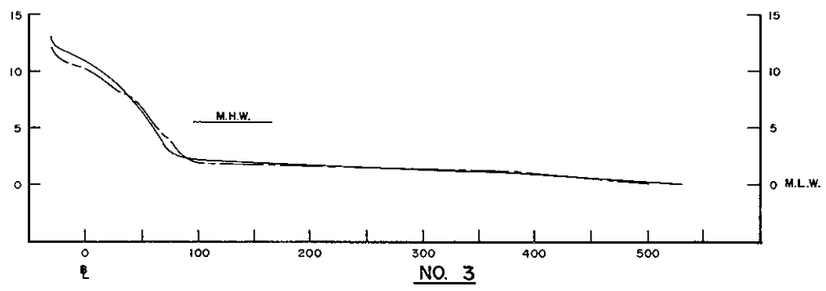
SCALE IN FEET
100' 0' 100' 200'

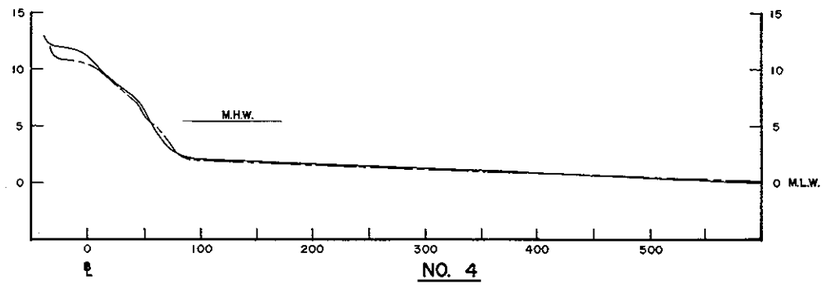
NEW ENGLAND DIVISION, CORPS OF ENGINEERS

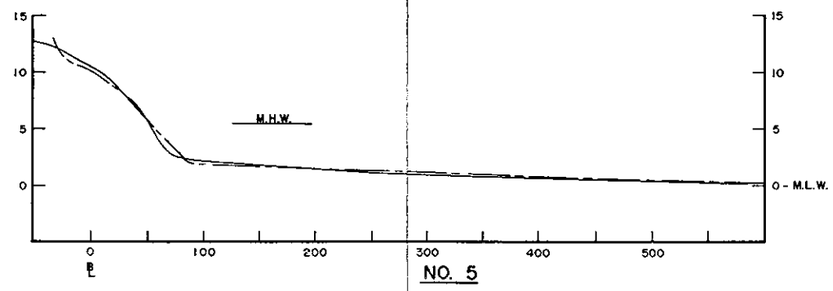
PLATE 3-3

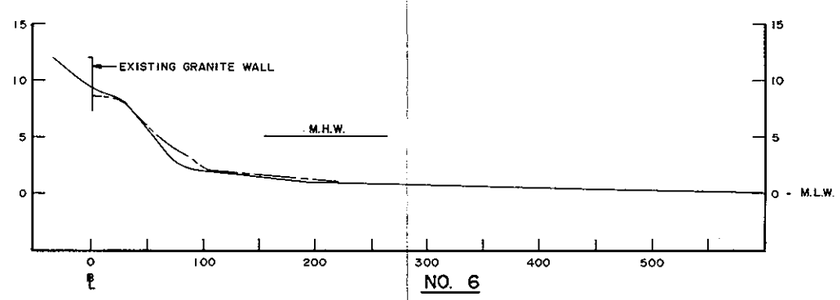


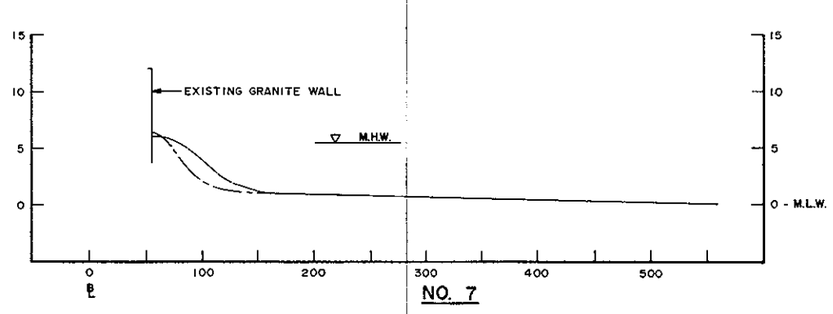












LEGEND	
SYMBOL	DESCRIPTION
— — — —	SURVEY OF JUNE 1983
————	SURVEY OF SEPT. 1984

NOTE:

ELEVATIONS ARE IN FEET AND REFER TO THE PLANE OF MEAN LOW WATER (M.L.W.).
SEE PLATE 3-3 FOR LOCATION OF PROFILES.

PROFILES

SCALE: VERT. 1" = 5'
HOR. 1" = 50'

GRAPHIC SCALES

1" = 5' 5' 0 5' 10'

1" = 50' 50' 0 50' 100'

BEACH EROSION CONTROL STUDY

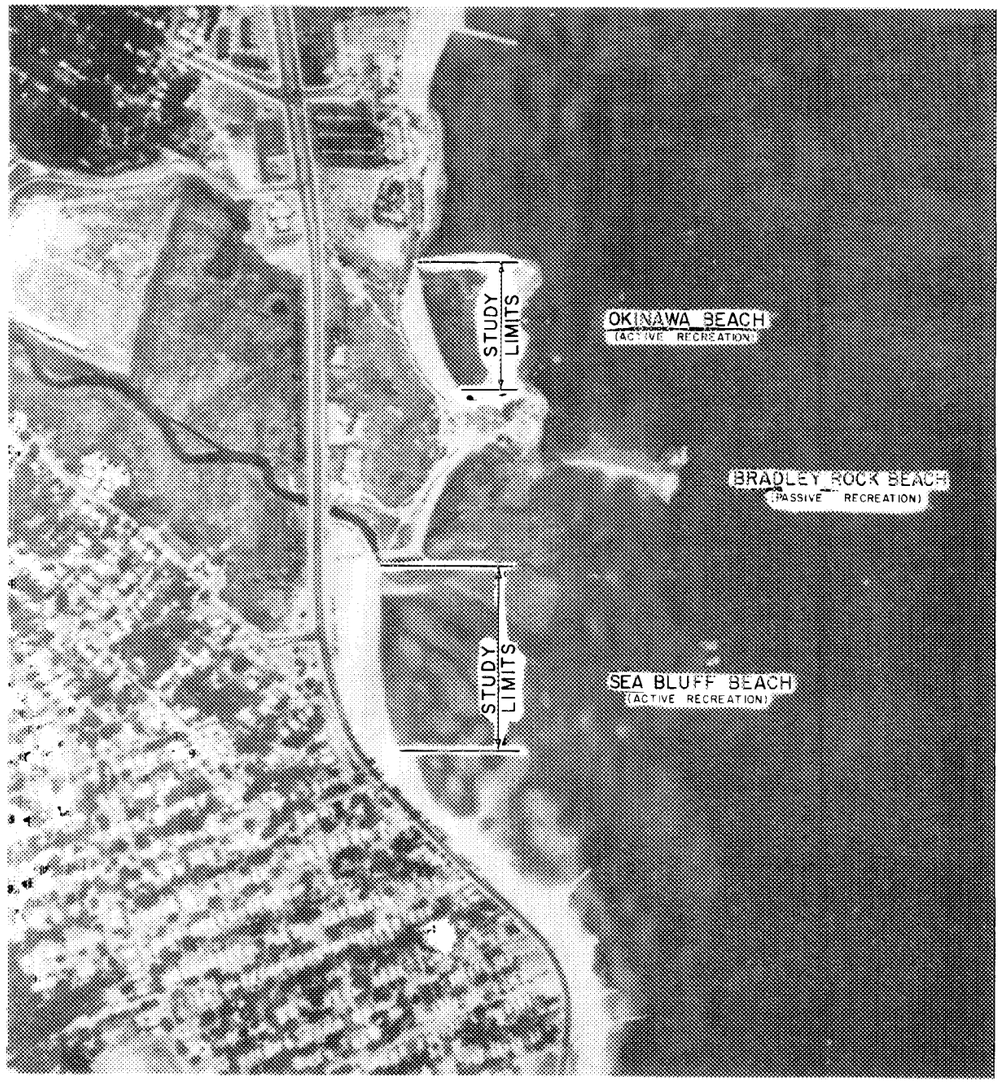
WEST HAVEN BEACHES

WEST HAVEN, CONN.

OKINAWA BEACH

PROFILES

NEW ENGLAND DIVISION, CORPS OF ENGINEERS



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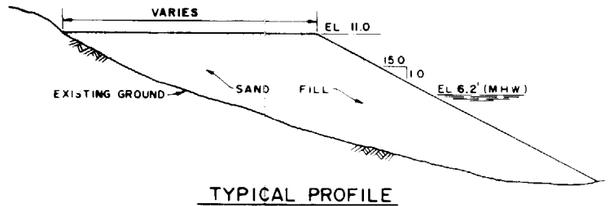
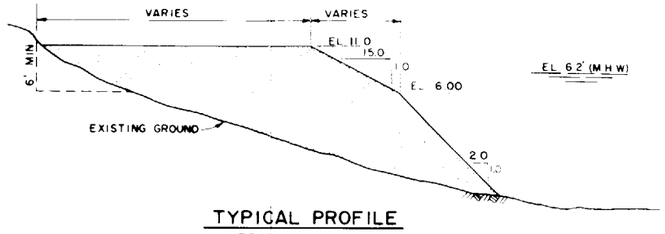
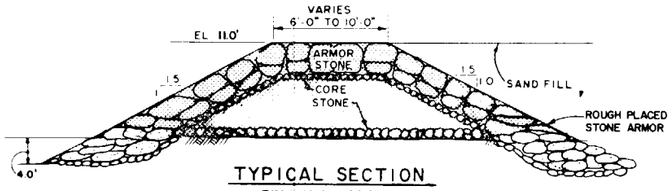


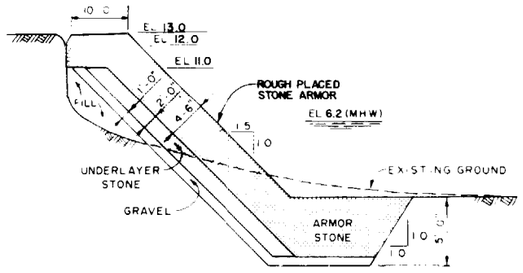
TYPICAL PROFILE
SAND FILL
NOT TO SCALE



TYPICAL PROFILE
TERMINAL GROIN
NOT TO SCALE



TYPICAL SECTION
TERMINAL GROIN
NOT TO SCALE



TYPICAL SECTION
ROCK REVETMENT
NOT TO SCALE

NOTES:

1. *Elevations are in feet and tenths and are referred to the plane of M.L.W.*
2. *Sandfill in Plan I includes considered level berm widths of 50, 75, and 100 feet at elevation 11.0 feet above M.L.W.*

   PLAN I: *This plan consists of beach widening at the west end of Sea Bluff Beach and along the entire length of Okinawa Beach by placement of suitable sandfill. The east end of Sea Bluff Beach would be raised to el. 11.0' though not widened.*

   OPTION 1: *Sandfill only*

   OPTION 2: *Sandfill and construction of a terminal groin at the west end of Sea Bluff Beach (across from Ivy Street).*

   OPTION 3: *Sandfill and construction of a groin to replace existing groin at Okinawa Beach. (Timber or rock), Located at the northern end of the beach.*

   OPTION 4: *Sandfill and construction of both groins as described in options 2 and 3 defferred.*
3. PLAN 2: *Addition of Rock revetment along the backshore areas of Sea Bluff and Okinawa Beaches. No sandfill or groin will be placed.*

BEACH EROSION CONTROL STUDY

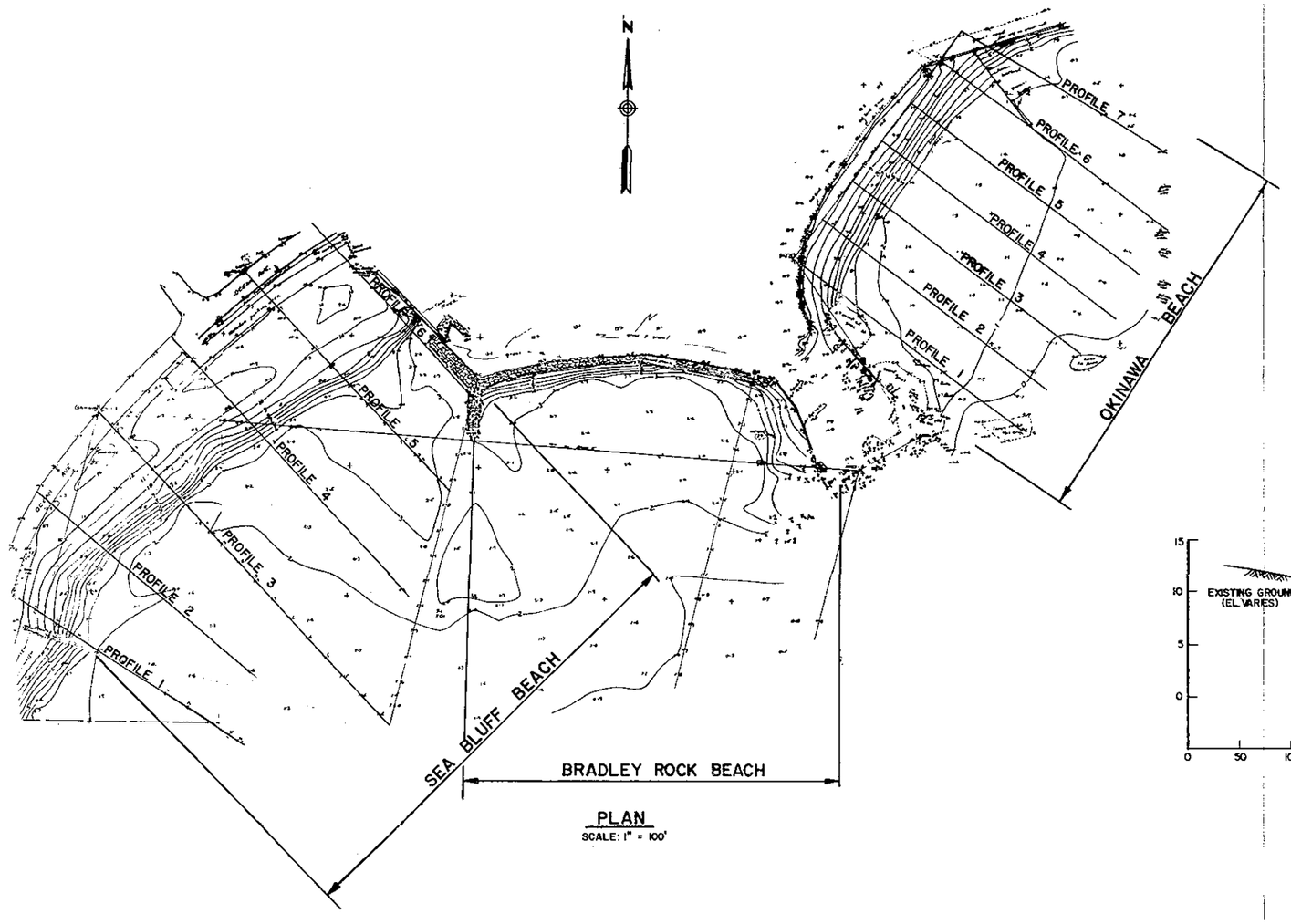
WEST HAVEN BEACHES

WEST HAVEN, CONNECTICUT

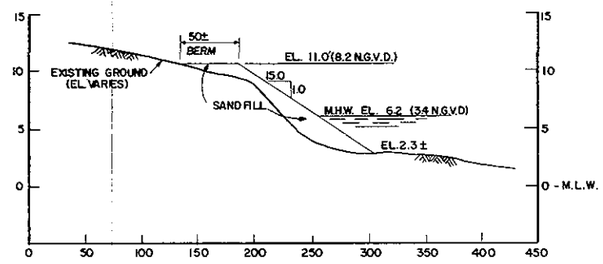
OKINAWA BEACH

PLANS OF CONSIDERED IMPROVEMENT

NEW ENGLAND DIVISION, CORPS OF ENGINEERS



PLAN
SCALE: 1" = 100'

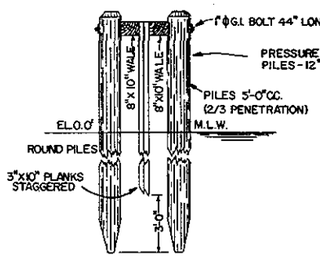


TYPICAL PROFILE - OKINAWA

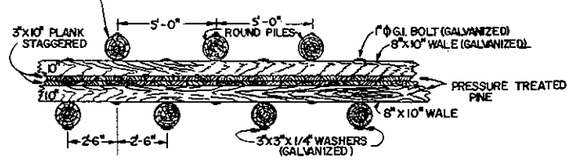
SAND FILL
SCALE: VERT 1" = 5'
HORIZ 1" = 50'

NOTES:

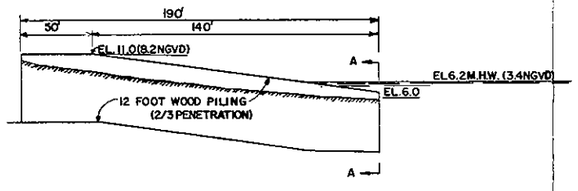
1. Elevation are in feet and tenths and refer to the plane of Mean Low Water. (M.L.W.)
2. Topography is based on June 1983 survey by The Corps of Engineers.
3. Detailed design will be done during preparation of plans and specifications.



SECTION A-A



PLAN



PROFILE OF TIMBER GROIN (DEFFERED)

TIMBER GROIN STRUCTURE
NOT TO SCALE

1" = 5'
1" = 50'
1" = 100'

BEACH EROSION CONTROL STUDY
WEST HAVEN BEACHES
WEST HAVEN CONNECTICUT
SELECTED PLAN OF IMPROVEMENT
OKINAWA BEACH

NEW ENGLAND DIVISION, CORPS OF ENGINEERS

PLATE 3-6

APPENDIX 4

ECONOMIC AND SOCIAL ANALYSES

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	Plans for Improvement - State Beaches	4-4
	West Haven Beaches	4-5
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OKINAWA AND SEA BLUFF BEACHES

ECONOMICS APPENDIX

Beach Space: Supply and Demand

The level of recreation benefits derived from beach erosion control projects at Okinawa and Sea Bluff Beaches is dependent upon the relative supply and demand for beach space within the study area. The relevant primary market area is West Haven, Connecticut. A secondary market area extends throughout the State of Connecticut.

Swimming Supply - Connecticut

According to the Connecticut State Comprehensive Outdoor Recreation Plan (SCORP) 1978-1983 there is a major deficit in swimming supply in Connecticut. Although communities along Long Island Sound generally have a satisfactory level of opportunity, inland metropolitan areas suffer from shortages. The overall result is a deficiency of public swimming opportunity in Connecticut amounting to approximately 50,000 to 100,000 units of instant capacity. (Instant capacity refers to capacity required to handle average summer weekend day usage. Capacity is measured in terms of 75 square feet of beach area per person.)

Overall, there are 458 miles of coastal frontage on Long Island Sound in Connecticut. Of this coastal frontage, 84.5 miles are sandy beaches. The beaches vary greatly in length, width, and sand quality. Approximately one-third of the beaches are less than 1,500 feet in length. The pattern of ownership of these sandy beaches is displayed in Table 4-1.

TABLE 4-1

OWNERSHIP OF SANDY BEACHES
STATE OF CONNECTICUT

Private	Mileage
Individuals	28.0
Associations	24.0
Conservation Groups	1.3
Commercial	0.7
TOTAL	54.0
Public	
State	7.0
Municipal	23.5
TOTAL	30.5

The public beaches are comprised of three State facilities and 62 local saltwater facilities. The three State facilities account for approximately one-third of all public saltwater recreational opportunities in Connecticut. The capacity of the State saltwater beaches is an estimated 60,500 people.

Local saltwater beaches have an estimated capacity of 126,700 people. Of the 24 towns on Long Island Sound, 13 restrict beach use to residents only. This restricted beach space amounts to 16 percent of the state's total saltwater swimming capacity. The distribution of beach space among Connecticut's cities and towns is displayed in Table 4-2.

There are a total of 107 public swimming facilities in Connecticut. Only 65, however, provide saltwater recreation. Public saltwater swimming capacity accounts for 70 percent of all public swimming capacity in the state. Detailed information on existing public swimming capacity in Connecticut is displayed in Table 4-3.

TABLE 4-2

DISTRIBUTION OF SANDY BEACH

Town	Coastal Frontage (Miles)	Sandy Beach (Miles)	Sandy Beach Percent Frontage
Greenwich	27.2	1.7	6.2
Stamford	15.0	3.4	23.3
Darien	16.5	.3	1.8
Norwalk	17.0	.6	3.5
Westport	18.9	5.9	31.2
Fairfield	10.4	3.2	30.8
Bridgeport	18.0	2.5	13.9
Stratford	13.2	4.9	37.1
Milford	19.3	8.7	45.1
West Haven	7.9	4.4	55.7
New Haven	18.0	1.3	7.2
East Haven	3.4	2.3	67.6
Branford	18.6	3.4	18.3
Guilford	14.8	1.4	9.4
Madison	8.5	6.1	71.8
Clinton	8.7	4.0	45.9
Westbrook	7.4	3.9	52.7
Old Saybrook	18.6	4.9	26.3
Old Lyme	17.1	4.3	25.1
East Lyme	19.9	6.3	31.7
Waterford	22.4	4.0	17.8
New London	9.1	2.1	23.1
Groton	26.9	3.8	14.1
Stonington	37.9	1.0	2.6

Source: Coastal Area Management, Coastal Recreational Demand, Opportunities, and Limitations in Connecticut's Coastal Area. 1978. Re: Report 25.

TABLE 4-3

EXISTING INSTANT SWIMMING CAPACITY

IN CONNECTICUT

Type	#Freshwater Facilities	Estimated Capacity	#Saltwater Facilities	Estimated Capacity	Total Capacity
State	19	34,600	3	60,500	95,100
Local	56	34,165	32	96,350	130,515
(Unrestricted)	(47 Towns)		(12 Towns)		
Local	30	8,520	30	30,350	38,700
(Restricted: Residents Only)	(26 Towns)		(13 Towns)		
TOTAL	105	77,285	65	187,200	264,385

Plans for Improvement - State Beaches

The SCORP planning process has recommended that development of coastal swimming facilities receive priority attention. Few shoreline beaches on Long Island Sound remain undeveloped. The state's only major unrealized opportunity for new coastal swimming is at Silver Sands State Park in Milford. The potential for an estimated 10,000 user day capacity exists at the park. According to State officials, the development would require a landfill covering and would require special State allocations for the $16 million cost. Discussions with the Connecticut Department of Environmental Protection indicates that primarily because of funding problems, the Silver Sands proposal will not be completed in the near future.

Plans call for the continued maintenance of the existing three State beaches. At Hammonasset priority will be placed on maintaining the sand dunes but no additional capacity will be created. At Rocky Neck, minor improvements will be made and any additional capacity created will be minimal. At Sherwood Island State Park, an erosion control plan will be undertaken and capacity for nearly 7,000 people will be created. It is noteworthy that approximately 75 percent of the Sherwood Island State Park users are visitors from the State of New York.

Erosion control plans under consideration in Old Saybrook and Milford would increase beach capacity by 1356* and 1200, respectively. Thus, the beach capacity of other state beaches is assumed to increase by 9556.

*Assumes largest beach option is built.

West Haven Beaches

The city of West Haven is located in south-central Connecticut. The city is in the vicinity of two large State beach areas. Sherwood Island State Park is located about 20 miles to the southwest, while Hammonsasset State Park is approximately 20 miles to the northeast. According to SCORP, West Haven itself has 4.4 miles of sandy beach frontage. The frontage is comprised of city beaches which extend from South Street toward New Haven Harbor to the north. The city owns the entire shoreline and leases approximately 100 feet above Prospect Beach to a fish and game club. Characteristics of the beaches are displayed in Table 4-4.

TABLE 4-4

WEST HAVEN BEACH CHARACTERISTICS

Beach	Square Feet	Parking Capacity
Okinawa	30,000	N.S.
Sea Bluff	46,000	75
Prospect	150,000	175
Savin Rock	175,000	Minimal

As can be seen from the table, parking capacity is presently very limited. Prospect Beach has two public lots which are free for West Haven residents. Nonresidents pay a minimal fee. The lots provide sanitary facilities and are located at Dawson Avenue and South Street. There appears to be some potential for expansion of these lots but additional parking would be limited to about 200 additional automobiles.

Regulations prohibit onstreet parking adjacent to the beach areas. Parking is permitted on the streets that are located a few blocks away from the beaches. Additionally there is potential parking space in a high school lot near Sea Bluff Beach. Near Bradley Point, a plan for creating passive recreation on a 17 acre parcel has been proposed. Part of this plan could entail developing a small amount of additional parking. The city currently has a study underway which is investigating potential parking facilities along the entire shoreline. Access to the beach area is also provided by a bus service which runs along the shoreline streets. Also pedestrian access is excellent.

Plans for Improvement - West Haven Beaches

In addition to the proposals for Okinawa and Sea Bluff Beaches, investigations are underway for Prospect and Savin Rock Beaches in West Haven. The Prospect Beach investigation is a Corps of Engineers study. The Savin Rock Beach project is being investigated by the city of West Haven and the State of Connecticut. Preliminary plans call for the creation of 471,000 square feet of sandy beach area. The Prospect Beach plan calls for the creation of 650,000 square feet of beach space.

The Corps proposals at Sea Bluff Beach would increase usable beach space from 46,000 square feet at present to between 137,000 and 151,000 square after implementation. At Okinawa Beach the proposal calls for the creation of from 60,000 to 87,000 square feet of beach area. Current beach space at Okinawa Beach is 20,500 square feet.

Other Local Beaches

As part of this economic analysis, a survey of other cities and towns was undertaken in order to determine current regional beach supply, possible beach alternatives, and potential plans of improvement. A summary of the findings of the survey is provided in Table 4-5.

Demand - West Haven Beaches

The estimation of present demand for beach space in West Haven is hindered by the fact that detailed attendance figures are not available. Head counts have been taken on occasion. Examples are provided in Table 4-6. Data from 1977 indicates that attendance at Savin Rock Beach is about equal to one third of total attendance in West Haven. Life guards and police estimate that on the weekend of August 1-2, 1981 around 10,000 people were on the entire West Haven beach area. It appears that this unusually large turnout was due to the fact that Lighthouse Beach in New Haven was temporarily closed during that time period. For the most part, it appears that attendance is below capacity. It has been hypothesized that attendance is relatively low because of the poor condition of the beaches. According to city officials, a drainage problem at Prospect Beach has cut attendance by one-half to two-thirds in recent years. Another possible reason for the low attendance figures involves the degree of reliability associated with past head counts.

Because of the belief that past head counts may understate true demand, an effort was made to derive demand using alternative information. Investigation of the Connecticut SCORP indicates that instant demand for swimming is equal to 10 to 12 percent of the state's population. "Instant Demand" is basically equivalent to peak day use or demand likely to be experienced for swimming on a summer weekend day. The 10 to 12 percent range refers to all swimming (saltwater, freshwater, pools, public, private, etc.).

In order to estimate present demand for public beach space in West Haven, several assumptions and procedures were required. The 10 to 12 percent range discussed in the preceding paragraph was applied to West Haven. Because the current investigation is concerned only with demand for public beach space, the lower end of the range, or 10 percent figure, was selected as an appropriate measure of public beach demand in West Haven. Since the Connecticut Office of Policy and Management lists West Haven's population in 1980 as 53,850, base potential instant demand can be considered to be 10 percent of that population or 5,385.

TABLE 4-5

CONNECTICUT PUBLIC BEACH SUPPLY SURVEY

City or Town	Number Public Beaches	Number Parking Spaces	Attendance	Facilities	Erosion Problem	Plans for Improvement
Greenwich	4	?	1,658,000 A	R,S	Y	?
Stamford	4	1,175	10,000 Wd	R,S	Y	Y
Bridgeport	2	?	?	R,S	Y	?
Stratford	2	135	30,000 A	R,S,Pl	Y	Y
Milford	5	650	5,000 D	R,S	Y	?
New Haven	1	2,000	40,000 A	R,S,B	Y	?
East Haven	1	200	10,000 W	R	Y	N
Branford	2	300	?	R,P,Pl	Y	N
Guilford	1	300	?	R,P	Y	Y
Madison	3	320	?	R,Pl,B	Y	Y
Clinton	2	225	5,000 A	R, Pl,S	N	Y
Old Saybrook	1	53	325 D	R,S	Y	N
East Lyme	2	?	71,500 A	R	Y	N
Waterford	2	100	48,000 A	R,P	?	N
Groton	1	270	90,000 A	R,S	N	Y

A - Annually
Wd - Weekend
D - Day
W - Week

R - Restroom or Bathhouse
S - Snackbar
Pl - Playground
B - Boatramp

Y - Yes
N - No

TABLE 4-6

ATTENDANCE ESTIMATES
WEST HAVEN BEACHES

	Sea Bluff Beach	Prospect Beach
Thursday, August 7, 1980	165	125
Friday, August 8, 1980	130	110
Saturday, August 9, 1980	200	180
Sunday, August 10, 1980	245	205
Weekend of June 27-28, 1981	650	150
Week of June 19 - July 3, 1981	425	120
Weekend of July 4-5, 1981	200	25
Week of July 6-10, 1981	500	150
Weekend of July 11-12, 1981	650	150
Week of July 13-17, 1981	550	175
Weekend of July 18-19, 1981	600	150
Week of July 20-24, 1981	450	200
Weekend of July 25-26, 1981	600	150
Week of July 27-31, 1981	650	200

Information from the SCORP reveals that most Connecticut residents do the bulk of their swimming in their home community, particularly along the coast where the percentage often exceeds 90 percent. Applying this information to West Haven results in a modification to the base potential instant demand. The 5,385 figure is multiplied by .9 to arrive at a new base demand of 4,847.

It should be noted that the demand derived thus far refers only to demand from West Haven residents. A 1977 survey shows that approximately 30 percent of the beach users in West Haven are nonresidents. It can, therefore, be assumed that the figure of 4,847 represents 70 percent of the peak day public beach demand in West Haven. Total peak day demand, therefore, amounts to 4,847 divided by .7 or 6,924.

It is projected that demand will increase as population increases. According to Connecticut Office of Policy and Management figures the population of West Haven is expected to grow from 53,850 in 1980 to 56,000 in the year 2,000. If resident beach demand increases at the same rate and continues to grow at that rate for the life of the project, peak day resident demand would grow from 4,847 in 1980 to 5,404 in the year 2035. If it is assumed that because of the limited parking available that non-resident demand would continue to comprise only 30 percent of total demand, then total peak day demand would increase from 6,924 in 1980 to 7720 in 2035. However, if parking were not a constraint, West Haven beaches would be able to satisfy excess demand from elsewhere in the state and effective demand would be limited only by the available beach capacity.

Benefit Analysis

The recreational benefits are based on a swimming season extending from June to early September. Allowing for inclement weather, there are approximately 60 days available for beach use. Approximately 25 of these days can be considered peak days (weekends and holidays). The remaining 35 days are classified as average days.

Recreation benefits are developed in compliance with the NED Manual of Procedures, Subpart K-Recreation. There are three methodologies used to determine recreation value: (1) travel cost (2) contingent value, and (3) unit day value. The travel cost method is not used in this study as most of the current beach goers reside in the vicinity of the beach. Thus, there would not be enough variation in the independent variable to estimate a demand function. The travel cost method uses distance traveled as a surrogate for price in estimating the demand relationship for a recreational activity.

The contingent value method obtains estimates of changes in NED benefits by directly asking individuals about their willingness to pay. This method is limited by the requirement of having all survey forms subject to the clearance procedures of OMB. Since a list of approved

survey questions needed to apply this technique to swimming does not currently exist, the amount of time required to obtain specific survey authority precludes its use. Additionally, this method is very expensive and would make study costs too high a proportion of total project costs.

The unit day value method was chosen based on its simplicity, ease of application, and its ability to measure increases in efficiency (benefits) at the study site. The improvements at the site affect less than 750,000 user days which is a criterion of use. Additionally, the study cost of this approach is more reasonable when compared to overall project costs.

The estimated value of recreational use is determined using the unit day value approximation of willingness to pay. The value of a beach visit has been estimated at $2.54 under present conditions and at $2.68 under the with-project condition. With project recreational value increases due to improvements in carrying capacity and environmental quality. In the without project condition erosion would result in overcrowding which would be eliminated with the project. Environmental quality will improve with the project as sandfill will cover the rubble and debris that currently exists on the beach. The methodology followed in developing these estimates is displayed in Tables 4-7, 4-8, and 4-9.

Annual recreational benefits are determined by subtracting recreation value under the without-project condition from recreation value with the project. Characteristics of the without-project condition for both beaches are displayed in Tables 4-10. The with-project conditions are described in Tables 4-11-4-13 for Okinawa Beach and Tables 4-16-4-18 for Sea Bluff Beach. Average annual recreation benefits are displayed in Tables 4-14 and 4-15 for Okinawa Beach and Tables 4-19 and 4-20 for Sea Bluff Beach. Benefits are evaluated for Okinawa Beach under plans for a 50-, 75- and 100-foot berm width assuming

Scenario 1) No project at Sea Bluff Beach.
Scenario 2) Project implemented at Sea Bluff Beach of 50-, 75- and 100-foot berm width.

However, if excess demand exists it is immaterial which scenario is chosen as benefits would be identical. Under the without-project condition, future beach capacity appears adequate to handle average day usage and therefore benefits are taken only for peak days. The without-project condition includes anticipated improvements to Savin Rock Beach (0.5 mile northeast of Okinawa Beach) and Prospect Beache (immediately southwest of Sea Bluff Beach). For simplification purposes it is assumed that Sea Bluff and Okinawa Beaches will continue to erode at the rate of 2 linear feet per year. Also, for simplification purposes under the without-project condition, it is assumed that available beach space will be used to capacity on peak days.

created at Okinawa and Sea Bluff Beaches would be fully utilized to satisfy the unmet demand.

If the option that provides the most additional beach space were implemented at Okinawa and Sea Bluff Beaches, beach capacity would increase by 2200. Anticipated projects at Prospect and Savins Rock Beaches would increase capacity by 11,253. Thus, capacity in West Haven would increase by 13,453. The total increase in capacity at state beaches is estimated to be 23,009 which is far short of the estimated demand for beach space in Connecticut.

Okinawa Beach

West Haven beach supply is shown in Table 4-10, assuming that Savin Rock Beach and Prospect Beach are built in 1987 and continued erosion at Sea Bluff and Okinawa Beaches. Tables 4-11, 4-12, and 4-13 depict beach supply under the with-project conditions having a 50-, 75-, and 100 foot berm, respectively

TABLE 4-7

GUIDELINES FOR ASSIGNING POINTS FOR GENERAL RECREATION

Reproduced from: Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies, U.S. Water Resources Council, March 10, 1983, page 85. (U.S. Government Printing Office, Washington, DC)

Change 2
9 Jul 83

Table VIII-3-2—Guidelines for Assigning Points For General Recreation

Criteria	Judgment factors				
(a) Recreation experience [1]	Two general activities [2]	Several general activities	Several general activities; one high quality value activity [3]	Several general activities; more than one high quality high activity	Numerous high quality value activities; some general activities
Total points: 30 Point value:	0–4	5–10	11–16	17–23	24–30
(b) Availability of opportunity [4]	Several within 1 hr. travel time; a few within 30 min. travel time	Several within 1 hr. travel time; none within 30 min. travel time	One or two within 1 hr. travel time; none within 45 min. travel time	None within 1 hr. travel time	None within 2 hr. travel time
Total points: 18 Point value:	0–3	4–6	7–10	11–14	15–18
(c) Carrying capacity	Minimum facility development for public health and safety	Basic facilities to conduct activity(ies)	Adequate facilities to conduct without deterioration of the resource or activity experience	Optimum facilities to conduct activity at site potential	Ultimate facilities to achieve intent of selected alternative
Total points: 14 Point value:	0–2	3–5	6–8	9–11	12–14
(d) Accessibility	Limited access by any means to site or within site	Fair access, poor quality roads to site; limited access within site	Fair access, fair road to site; fair access, good roads within site	Good access, good roads to site; fair access, good roads within site	Good access, high standard road to site; good access within site
Total points: 18 Point value:	0–3	4–6	7–10	11–14	15–18
(e) Environmental quality	Low esthetic factors [6] exist that significantly lower quality [7]	Average esthetic quality; factors exist that lower quality to minor degree	Above average esthetic quality; any limiting factors can be reasonably rectified	High esthetic quality; no factors exist that lower quality	Outstanding esthetic quality; no factors exist that lower quality
Total points: 20 Point value:	0–2	3–6	7–10	11–15	16–20

[1] Value for water-oriented activities should be adjusted if significant seasonal water level changes occur.
[2] General activities include those that are common to the region and that are usually of normal quality. This includes picnicking, camping, hiking, riding, cycling, and fishing and hunting of normal quality.
[3] High quality value activities include those that are not common to the region and/or Nation and that are usually of high quality.
[4] Likelihood of success at fishing and hunting.
[5] Value should be adjusted for overuse.
[6] Major esthetic qualities to be considered include geology and topography, water, and vegetation.
[7] Factors to be considered to lowering quality include air and water pollution, pests, poor climate, and unsightly adjacent areas.

TABLE 4-8

POINT VALUES

(Revised Table VIII-3-1 (FY1985) Conversion of Points to Dollar Values)

ACTIVITY CATEGORIES	0	10	20	30	40	50	60	70	80	90	100
General Recreation (Points from Table VIII-3-2)	1.70	2.00	2.30	2.60	3.00	3.60	3.90	4.20	4.50	4.80	5.10
General Fishing & Hunting (Points from Table VIII-3-2)	2.50	2.70	3.00	3.20	3.60	3.90	4.30	4.60	4.80	5.00	5.00
Specialized Fishing & Hunting (Points from Table VIII-3-3)	11.80	12.10	12.40	12.70	13.00	14.20	15.40	16.60	17.80	19.00	20.20
Specialized Recreation Other than Fishing & Hunting (Points from Table VIII-3-3)	6.70	7.80	7.80	8.40	9.00	10.10	11.20	13.50	15.70	18.00	20.20

NOTE: See ER 1105-2-40, Change 2, 9 Jul 83, pages A-67 & A-68 for Table VIII-3-2 and VIII-3-3.

TABLE 4-9

WEST HAVEN BEACHES RECREATIONAL VALUES

	Without-Project	With-Project
Recreation Experience	2	2
Availability of Opportunity	2	2
Carry Capacity	3	5
Accessibility	14	14
Environmental Quality	7	9
Total points	28	32
Unit Day Value	$2.54	$2.68

TABLE 4-10

BEACH SUPPLY WITH NO OKINAWA BEACH OR SEA BLUFF BEACH IMPROVEMENTS
(Sq. Ft.)

Assumes Savin Rock and Prospect Beach proposals are to be implemented in 1987.

Beach	1982	1983	1984	1985	1986	1987
Savin Rock	175,000	161,000	147,000	133,000	119,000	471,000
Prospect	150,000	140,000	130,000	120,000	110,000	650,000
Okinawa	32,000	31,000	30,000	20,500	19,500	18,500
Sea Bluff	50,000	48,000	46,000	44,000	42,000	40,000
	407,000	380,000	353,000	317,500	290,500	1,179,500

TABLE 4-11

BEACH SUPPLY WITH 50-FOOT BERM AT OKINAWA BEACH
(Sq. Ft.)

Assumes Savin Rock and Prospect Beach proposals are implemented in 1987; Okinawa Proposal implemented in 1986; erosion continues at Sea Bluff Beach at the rate of 200 square feet per year.

Beach	1982	1983	1984	1985	1986	1987
Savin Rock	175,000	161,000	147,000	133,000	119,000	471,000
Prospect	150,000	140,000	130,000	120,000	110,000	650,000
Okinawa	32,000	31,000	30,000	20,500	60,000	60,000
Sea Bluff	50,000	48,000	46,000	44,000	42,000	40,000
	407,000	380,000	353,000	317,500	331,000	1,221,000

TABLE 4-12

BEACH SUPPLY WITH 75-FOOT BERM AT OKINAWA BEACH
(Sq. Ft.)

Assumes Savin Rock and Prospect Beach proposals are implemented in 1987; Okinawa Beach proposal is implemented in 1986; erosion continues at Sea Bluff Beach at the rate of 2000 square feet per year.

Beach	1982	1983	1984	1985	1986	1987
Savin Rock	175,000	161,000	147,000	133,000	119,000	471,000
Prospect	150,000	140,000	130,000	120,000	110,000	650,000
Okinawa	32,000	31,000	30,000	20,500	74,000	74,000
Sea Bluff	50,000	48,000	46,000	44,000	42,000	40,000
	407,000	380,000	353,000	317,500	345,000	1,235,000

TABLE 4-13

BEACH SUPPLY WITH 100-FOOT BERM AT OKINAWA BEACH
(Sq. Ft.)

Assumes Savin Rock and Prospect Beach proposals are implemented in 1987; Okinawa Beach proposal is implemented in 1986; erosion continues at Sea Bluff Beach at the rate of 2000 square feet per year.

Beach	1982	1983	1984	1985	1986	1987
Savin Rock	175,000	161,000	147,000	133,000	119,000	471,000
Prospect	150,000	140,000	130,000	120,000	110,000	650,000
Okinawa	32,000	31,000	30,000	20,500	87,000	87,000
Sea Bluff	50,000	48,000	46,000	44,000	42,000	40,000
	407,000	380,000	353,000	317,500	358,000	1,248,000

Recreation benefits at Okinawa Beach are determined assuming no project at Sea Bluff Beach. In both cases, it is assumed that the State of Connecticut will provide 471,000 square feet of beach space at Savin Rock Beach and that the Corps will provide 650,000 square feet of beach space at Prospect Beach.

Additions to each beach must be analyzed incrementally assuming that the other beach is to be built. Thus, each option is evaluated assuming three berm widths at the other beach. Incremental analysis is necessary because benefits are dependent upon the relationship between supply and demand for beach space in West Haven. As long as demand exceeds supply, then benefits can be taken on increased beach space. Thus, the affect on total beach supply of any option that increases beach supply must be considered in relation to demand for beach space in West Haven.

Full utilization of all beach capacity would occur only if parking is adequate to handle contemplated demand. Discussion with West Haven city officials indicates a recognition and acceptance of the regional nature of the West Haven beaches. Given the fact that West Haven is located near the junction of two major highways, Interstate Routes I-91 and I-95, and that many other Connecticut beaches are private or restricted to residents only, it is expected that improved Okinawa and Sea Bluff Beaches would draw to a great extent from inland metropolitan areas such as the Capitol and Central Connecticut Regions which are seriously deficient in swimming opportunity.

West Haven officials indicate an intention to provide sufficient parking to handle the expected inflow (see attached letter). The parking study that is currently underway will determine to what extent this

intention can be fulfilled. Before construction of the projects could occur, definite assurances would be required from the city regarding parking or other methods of getting people to the beach.

In Tables 4-14 and 4-15 the beach area described in the previous tables is projected into the future under without- and with-project conditions. Beach area is converted to capacity by assuming that each beach user has 75 square feet of space and that the turnover rate is 1.0. Annualized recreational value is then determined for the without-project condition and the three berm sizes under consideration for Okinawa Beach. The benefit of each project is the difference in recreational value with the project and without. Following the determination of benefits is a discussion of parking spaces needed to insure that the potential benefits are realized.

TABLE 4-14

OKINAWA BEACH RECREATION BENEFIT (PEAK DAYS)
(No project at Sea Bluff Beach)

Year	Without-Project Beach Area (Sq. Ft.)	Capacity[1] (# People)	With 50-Foot Berm Beach Area (Sq. Ft.)	Capacity (# People)
1986	290,500	3,873	331,000	4,413
1987	1,179,500	15,727	1,221,000	16,280
2007	1,121,000	14,947	1,181,000	15,747
2036	1,121,000	14,947	1,181,000	15,747

Without-Project

Year	# Users/ Unit Day		Unit Day Value		# Days		Total
1986	3,873	x	$2.54	x	25	=	$245,936
1987-2036	14,947	x	$2.68	x	25	=	1,001,449
1987	780	x	2.54	x	25	=	49,530
2007	0	x	2.54	x	25	=	0

Average Annual Recreation Value = $966,200. This represents the recreational value from 14,947 users of improved Savin Rock and Prospect Beaches, discounted by 1 year, combined with the discounted recreational value from 780 users of unimproved Sea Bluff and Okinawa Beaches that would be gradually lost between 1987-2007.

With 50-Foot Berm at Okinawa Beach

Year	# Users/ Unit Day		Unit Day Value		# Days		Total
1986	800	x	2.68	x	25	=	$53,600
1986	3,613	x	2.54	x	25	=	229,426
1987-2036	15,747	x	$2.68	x	25	=	$1,055,049
1987	533	x	2.54	x	25	=	33,846
2007	0	x	2.54	x	25	=	0

Average Annual Recreation Value: $1,010,800

Benefit: $1,010,800 - $966,200 = $44,600

[1]For purposes of the analysis, capacity = demand. Capacity is measured at 75 square feet per person. The 75-square-foot guideline has been used in similar Federal studies and is also used by the State. Beach area and capacity refer to entire West Haven shoreline.

A beach with a 50-foot berm width would result in a total of 60,000 square feet of beach space at Okinawa. This corresponds to a capacity of 800 people. If it is assumed that half the beach users would need parking facilities, at the rate of four persons per car a total of 100 parking spaces would be needed in the Okinawa Beach vicinity in order to obtain the full benefit.

TABLE 15

OKINAWA BEACH RECREATION BENEFIT (PEAK DAYS)
(No Project at Sea Bluff Beach)

Year	With 75-Foot Berm		With 100-Foot Berm	
	Beach Area (Sq. Ft.)	Capacity[1] (# People)	Beach Area (Sq. Ft.)	Capacity (# People)
1986	345,000	4,600	358,000	4,773
1987	1,235,000	16,467	1,248,000	16,640
2007	1,195,000	15,933	1,208,000	16,107
2035	1,195,000	15,933	1,208,000	16,107

[1]For purposes of the analysis, capacity = demand. Capacity is measured at 75 square feet per person. The 75-square-foot guideline has been used in similar Federal studies and is also used by the State. Beach area and capacity refer to entire West Haven shoreline.

With 75-Foot Berm at Okinawa Beach

Year	#Users/Unit Day		Unit Day Value		#Days		Total
1986	3,613	x	2.54	x	25	=	$229,426
1986	987	x	2.68	x	25	=	$66,129
1987-2036	15,934	x	$2.68	x	25	=	1,067,578
1987	533	x	$2.54	x	25	=	33,846
2007	0	x	$2.54	x	25	=	0

Average Annual Recreation Value: $1,023,300

Benefit: $1,023,300 - 966,200[2] = $57,100

With 100-Foot Berm at Okinawa Beach

Year	#Users/Unit Day		Unit Day Value		#Days		Total
1986	3,613	x	2.54	x	25	=	$229,426
1986	1,160	x	2.68	x	25	=	77,720
1987-2036	16,107	x	2.68	x	25	=	$1,079,169
1987	533	x	2.54	x	25	=	33,846
2007	0	x	2.54	x	25	=	0

Average Annual Recreation Value: $1,034,900

Benefit: $1,034,900 - 966,200[2] = $68,700

A beach with a 75-foot berm width would result in a total of 74,000 square feet of beach space at Okinawa Beach. This corresponds to a capacity of 987 people. If it is assumed that half the beach users would need parking facilities, at the rate of four persons per car a total of 123 parking spaces would be needed in the Okinawa Beach vicinity in order to obtain the full benefit.

A beach with a 100-foot berm width would result in a total of 87,000 square feet of beach space at Okinawa Beach. This corresponds to a capacity of 1160 people. If it is assumed that half the beach users would need parking facilities, at the rate of four persons per car a total of 145 parking spaces would be needed in the Okinawa Beach vicinity in order to obtain the full benefit.

Sea Bluff

The analysis for Sea Bluff Beach is similar to that of Okinawa Beach. With-project beach supply is presented in Tables 16 through 18. Project benefits are present in Tables 19 and 20.

[2] See Table 14 for derivation of without-project recreation value.

TABLE 4-16

BEACH SUPPLY WITH 50-FOOT BERM AT SEA BLUFF BEACH
(Sq. Ft.)

Assumes Savin Rock and Prospect Beach proposals are implemented in 1987; Sea Bluff Beach proposal to be implemented in 1986; erosion continues at Okinawa Beach at the rate of 1000 square feet per year.

Beach	1982	1983	1984	1985	1986	1987
Savin Rock	175,000	161,000	147,000	133,000	119,000	471,000
Prospect	150,000	140,000	130,000	120,000	110,000	650,000
Okinawa	32,000	31,000	30,000	20,500	19,500	18,500
Sea Bluff	50,000	48,000	46,000	44,000	137,000	137,000
	407,000	380,000	353,000	317,500	385,500	1,276,500

TABLE 17

BEACH SUPPLY WITH 75-FOOT BERM AT SEA BLUFF BEACH
(Sq. Ft.)

Assumes Savin Rock and Prospect Beach proposals are implemented in 1987; Sea Bluff Beach proposal to be implemented in 1986; erosion continues at Okinawa Beach at the rate of 1000 square feet per year.

Beach	1982	1983	1984	1985	1986	1987
Savin Rock	175,000	161,000	147,000	133,000	119,000	471,000
Prospect	150,000	140,000	130,000	120,000	110,000	650,000
Okinawa	32,000	31,000	30,000	20,500	19,500	18,500
Sea Bluff	50,000	48,000	46,000	44,000	147,000	147,000
	407,000	380,000	353,000	317,500	395,500	1,286,500

TABLE 18

BEACH SUPPLY WITH 100-FOOT BERM AT SEA BLUFF BEACH
(Sq. Ft.)

Assumes Savin Rock and Prospect Beach proposals are implemented in 1987; Sea Bluff Beach proposal to be implemented in 1986; erosion continues at Okinawa Beach at the rate of 1000 square foot per year.

Beach	1982	1983	1984	1985	1986	1987
Savin Rock	175,000	161,000	147,000	133,000	119,000	471,000
Prospect	150,000	140,000	130,000	120,000	110,000	650,000
Okinawa	32,000	31,000	30,000	20,500	19,500	18,500
Sea Bluff	50,000	48,000	46,000	44,000	151,000	151,000
	407,000	380,000	353,000	317,500	399,500	1,290,500

TABLE 19

SEA BLUFF BEACH RECREATION BENEFIT (PEAK DAYS)
(Assumes no project at Okinawa)

Year	With 50-Foot Berm at Sea Bluff Beach Area (Sq. Ft.)	Capacity[1] (# People)
1986	385,000	5,133
1987	1,276,500	17,020
2007	1,258,000	16,773
2036	1,258,000	16,773

Sea Bluff Beach Benefits

With 50-Foot Berm at Sea Bluff Beach

Year	#Users/Unit Day		Unit Day Value		#Days		Total
1986	1,827	x	2.68	x	25	=	$122,409
1986	3,313	x	$2.54	x	25	=	210,376
1987-2036	16,774	x	$2.68	x	25	=	1,123,858
1987	247	x	$2.54	x	25	=	15,685
2007	0	x	$2.54	x	25	=	0

Average Annual Recreation Value: $1,069,200

Benefit: $1,069,200 - 966,200[2] = $103,000

A 50-foot berm width would result in a total of 137,000 square feet of beach space at Sea Bluff Beach. This corresponds to a capacity of 1827 people. If it is assumed that half the beach users would need parking facilities, at the rate of four persons per car a total of 228 parking spaces would be needed in the Sea Bluff Beach vicinity in order to obtain the full benefit.

[1]For purposes of the analysis, capacity = demand. Capacity is measured at 75 square feet per person. The 75-square-foot guideline has been used in similar Federal studies and is also used by the State. Beach area and capacity refer to entire West Haven shoreline.

[2]See Table 14 for derivation of without-project recreation value.

TABLE 4-20

SEA BLUFF BEACH RECREATION BENEFIT (PEAK DAYS)
(Assumes no project at Okinawa Beach)

Year	With 75-Foot Berm		With 100-Foot Berm	
	Beach Area (Sq. Ft.)	Capacity[1] (# People)	Beach Area (Sq. Ft.)	Capacity (# People)
1986	375,500	5,273	399,500	5,327
1987	1,286,500	17,153	1,290,500	17,207
2007	1,268,000	16,907	1,272,000	17,960
2036	1,268,000	16,907	1,272,000	17,960

With 75-Foot Berm at Sea Bluff Beach

Year	#Users/Unit Day		Unit Day Value		#Days		Total
1986	1,960	x	$2.68	x	25	=	$131,320
1986	3313	x	2.54	x	25	=	210,376
1987-2036	16,907	x	$2.68	x	25	=	1,132,769
1987	247	x	$2.54	x	25	=	15,685
2007	0						0

Average Annual Recreation Value: $1,078,100
Benefit: $1,078,100 - 966,200[2] = $111,900

With 100-Foot Berm at Sea Bluff Beach

Year	#Users/Unit Day		Unit Day Value		#Days		Total
1986	2,013	x	2.68	x	25	=	$134,871
1986	3,313	x	$2.54	x	25	=	210,376
1987-2036	16,960	x	$2.68	x	25	=	1,136,320
1987	247	x	$2.54	x	25	=	15,685
2007	0						0

Average Annual Recreation Value: $1,081,700

Benefit: $1,081,700 - 966,200 = $115,500

[1]For purposes of the analysis, capacity = demand. Capacity is measured at 75 square feet per person. The 75-square foot guideline has been used in similar Federal studies and is also used by the State. Beach area and capacity refer to entire West Haven shoreline.

[2]See Table 14 for derivation of without-project recreation value.

A 75-foot berm width would result in a total of 147,000 square feet of beach space at Sea Bluff Beach. This corresponds to a capacity of 1960 people. If it is assumed that half the beach users would need parking facilities, at the rate of four persons per car a total of 245 parking spaces would be needed in the Sea Bluff Beach vicinity in order to obtain the full benefit.

A 100-foot berm width would result in a total of 150,500 square feet of beach space at Sea Bluff Beach. This corresponds to a capacity of 2007 people. If it is assumed that half the beach users would need parking facilities, at the rate of four persons per car a total of 251 parking spaces would be needed in the Sea Bluff Beach vicinity in order to obtain the full benefit.

Protection of Backshore Structures

At current erosion rates, both Sea Bluff and Okinawa Beaches will have no dry beach space in 21 years. It is assumed that city officials will take action to prevent damage to backshore structures. In back of Sea Bluff Beach there is a road and in back of Okinawa Beach there is a park and bicycle path. It is assumed that revetments would be installed to protect these structures. One thousand feet of revetment would be needed in back of Sea Bluff Beach and 700 feet in back of Okinawa Beach. Installation cost is estimated to be $500 per linear foot, amounting to $500,000 for Sea Bluff Beach and $350,000 for Okinawa Beach.

In addition to protecting backshore structures, building up these beaches will reduce the costs associated with flooding such as sand cleanup and road repair. These annual costs are estimated at $4,000 for sand cleanup from the road behind Sea Bluff Beach, road flooding repair costs of $3,000 at Sea Bluff Beach and park flooding repair costs of $1,000 at Okinawa Beach.

Annual cost savings are displayed in Table 4-21

TABLE 21

COST REDUCTIONS TO PROTECT BACKSHORE STRUCTURES

	Sea Bluff Beach	Okinawa Beach
Revetment	$7,900	$5,500
Sand Cleanup	4,000	
Road Repair	3,000	1,000
Total	$14,900	$6,500

Economic Justification

Benefits and costs are summarized in Table 4-22.

TABLE 4-22

ECONOMIC JUSTIFICATION OF
OKINAWA AND SEA BLUFF BEACHES

	Okinawa Beach Berm Widths			Sea Bluff Beach Berm Widths		
	50 Feet	75 Feet	100 Feet	50 Feet	75 Feet	100 Feet
Annual Benefits						
Recreation	$44,600	57,100	68,700	103,000	111,900	115,500
Backshore Structures	6,500	6,500	6,500	14,900	14,900	14,900
Total Annual Benefits	51,100	63,600	75,200	117,900	126,800	130,400
Annual Costs	31,000	41,400	54,200	25,900	41,500	51,600
Net Benefits	20,100	22,200	21,000	92,000	85,300	78,800
Benefit-Cost-Ratio	1.6	1.5	1.4	4.6	3.1	2.5

The NED plans call for a 75-foot berm at Okinawa Beach and a 50-foot berm at Sea Bluff Beach.

It should be noted that the with-and without-conditions both have projects being implemented at Savin Rock and Prospect Beaches. The State of Connecticut and city of West Haven are investigating improvements at Savin Rock Beach and the Corps currently is investigating Prospect Beach. If projects were to be implemented at either or both of the beaches, the economic justification of Okinawa or Sea Bluff Beach would not be affected. According to the SCORP, demand for beach space is strong in inland metropolitan areas of Connecticut. This demand would be sufficient to support improvements at all beaches as long as parking is adequate to handle the expected inflow of people.

OKINAWA AND SEA BLUFF BEACHES

SOCIAL & ECONOMIC IMPACT ASSESSMENT

The city of West Haven is one of fourteen towns and cities which comprise the New Haven Standard Metropolitan Statistical Area (SMSA). West Haven, with a 1980 population of 53,184, is the second largest community in the SMSA, the largest being New Haven with a population of 126,109. West Haven's land area is 11.2 square miles, with a population density of 4,744 persons per square mile. By comparison, the population density for the entire SMSA is 1,267 persons per square mile. Table 4-23 summarizes the population trends for West Haven, the New Haven SMSA and the State of Connecticut.

West Haven's population is largely comprised of persons of Italian background, making up almost half of the ethnic identity of the city. Other major ethnic groups include Russians, Canadians, Germans, Irish and English.

In 1970, there were 17,649 housing units in New Haven. By 1980, this number had increased 18.5 percent to 20,915. The State of Connecticut experienced an 18.1 percent increase in housing units between 1970 and 1980.

TABLE 4-23

POPULATION TRENDS

	West Haven		New Haven SMSA		State of Connecticut	
	Number	Percent Change	Number	Percent Change	Number	Percent Change
1980	53,184	0.6	406,397	14.3	3,107,576	2.5
1970	52,851	22.9	355,538	10.8	3,032,217	19.6
1960	43,002	34.3	320,836	21.2	2,535,234	26.3
1950	32,010	6.6	264,622	9.9	2,007,280	17.4
1940	30,021	16.3			1,709,242	6.4
1930	25,808				1,606,903	

The census tract which approximates the beach area had a 1980 population of 5,909, showing a population decrease of 10 percent from 1970. Housing units, however, increased 2.5 percent to 2,017 units from 1970 to 1980. Approximately 90 percent are owner-occupied single family units.

Historically, the New Haven area was an industrial center. Non-manufacturing industries, however, have grown in recent years reducing the proportion of employment in manufacturing. Although there has been some growth in manufacturing, continued decline of its past dominance is anticipated. Declines are expected in the following manufacturing industries: rubber and miscellaneous plastic products, apparel and leather, fabricated metals and chemicals. These losses would be offset by growth in the electrical and transportation equipment, printing and publishing, primary

metals, machinery and "other manufacturing". The most dramatic increases in the nonmanufacturing sectors have been in services, retail trade, finance, insurance, and real estate sectors.

The 1980 census data shows that the larges number of employed workers in West Haven are in the clerical and administrative support professions, while in New Haven the largest employment group is in the catagory of laborers, equipment operators, and assembly workers. When compared to the city of New Haven and the larger New Haven SMSA, West Haven has a lower percentage of professional and managerial workers and a higher percentage of sales workers and skilled trade workers.

Unemployment in West Haven and New Haven has been consistently higher than the New Haven SMSA or statewide, as the larger percentage of workers in manufacturing has been most directly affected by the steady decline in manufacturing industries in the region.

Unemployment in the region has dropped significantly in the last few months, as illustrated by the data in Table 4-24.

TABLE 4-24

Unemployment Data*

Area	1981	Jun 83	Dec 83
New Haven SMSA	6.7	7.3	4.9
New Haven	7.9	8.5	5.8
West Haven	8.0	8.2	5.5
Connecticut	6.2	6.4	4.5

*Source: Connecticut Department of Labor

This reduction is generally attributed to an upturn in the economy rather than to an increase in employment in any particular sector.

Land use in West Haven is approximately 40 percent residential, with the large majority of homes being single family. Approximately 20 percent of West Haven is classified as vacant land. Commercial development makes up only about 7 percent of the city land area and is most heavily concentrated along the Interstate 95 - Conrail right-of-way spine through the center of town. The coastal section of West Haven is primarily residential. An active Planning and Zoning Commission is striving to control and balance future development.

The shoreline of West Haven is a mix of public and private ownerships. The six main beach areas are owned by the city. These beaches are Sandy Point, Savin Rock, Bradley Rock, Okinawa, Sea Bluff and Prospect. The project area includes Sea Bluff, Bradley Rock and Okinawa Beaches, located in the vicinity of the mouth of the Cove River.

Without Project Conditions

The coastal beaches of West Haven are a combination of natural and manmade sandy beaches areas protected in part by manmade groin structures. The beaches are undergoing rapid deterioration due to beach erosion and storm damage to the groin structures. As beach area is lost, the area available for public use is reduced. Without repair of thses structures or the replenishment of sand, recreation use of the beach areas will decline.

Compounding the impact of the anticipated loss of beach will be an increase in need for beach area brought on by a growth in the local population.

Population projections prepared by the State's Office of Policy and Management in Table 4-25 indicate the rate of anticipated growth locally and regionally.

TABLE 4-25

POPULATION PROJECTIONS

		West Haven, CT	New Haven SMSA
Actual 1980		53,184	406,397
Projected	1990	54,800	436,180
	1995	55,500	443,270
	2000	56,000	451,880
Percent Change 1980 - 2000		5.3%	11.2%

*Source: State of Conn. Population Projections, Conn. Office of Policy and Management 1980.

The city's planning goals include increasing the availability of recreational and cultural opportunities. To satisfy these goals, improvement of recreational facilities and creation of new programs are planned and include improvements along Bradley Rock and Sea Bluff Beaches.

Imminent in the city's plans is the creation of additional parking facilities. The city has already found that improving access to the beach areas provides for greater recreational use. Approximately 60 parking spaces would be provided just north of Sea Bluff Beach with an additional 60 south of the beach. The city is also investigating the purchase of a vacant lot opposite the beach, although access would be greater to Prospect Beach from this point.

Bradley Point, a small peninsula that forms Bradley Rock Beach, has been designated for passive recreation development. The point consists of approximately 17 acres and is an ideal setting for relaxation. A bike path is being planned from the point to join the bike path at Savin Rock. Water safety

programs and youth programs off of the point are being planned by the recreation department.

With-Project Conditions

Implementation of the proposed project would result in both short- and long-term impacts. Planned improvements include expansion of the beach areas at Sea Bluff and Okinawa Beaches, and rehabilitation of groin structures by replacement of timbers or placement of rock. During the construction period, which would be approximately 2 months, the local area would experience minor increases in air and noise pollution. Construction would require heavy truck and equipment activity, disrupting local traffic and neighborhoods. Sandfill material, as well as any material required for groin structure rehabilitation, would be trucked in from an inland source. Assuming a maximum required quantity of 30,900 cubic yards of sandfill and 4000 tons of rock, there would be an approximate total of 1900 truck trips to the project site during the construction period. The neighborhood is intensely developed with primarily single-family residences. Haul routes will be specified in the construction contract in order to minimize impacts to the local community.

Construction activity at the work site would not be scheduled during the beach use season. This would avoid disruption of recreation activity and potential safety hazards.

The major direct long-term impact of the project would be a larger beach area and stabilization of the beach. The result is a beach area adequate to meet both present and projected future recreation demand. As the area is already used for recreation, and adjacent land is already heavily developed by single-family residences, no change in land use is anticipated.

APPENDIX 5

GLOSSARY OF TERMS

APPENDIX 5

GLOSSARY OF TERMS

ACCRETION - A buildup of land which may be either natural or artificial. Natural accretion is the buildup of land, solely by the forces of nature, on a BEACH by deposition of waterborne or airborne material. Artificial accretion is a similar buildup of land by an act of man, such as the accretion formed by a groin, breakwater, or beach fill deposited by mechanical means.

ADVANCE (OF A BEACH) - (1) A continuing seaward movement of the shoreline. (2) A net seaward movement of the shoreline over a specified time.

ALONGSHORE - Parallel to and near the shoreline; same as LONGSHORE.

AMPLITUDE, WAVE - The magnitude of the displacement of a wave from a mean value. An ocean wave has an amplitude equal to the vertical distance from stillwater level to wave crest. For a sinusoidal wave, amplitude is one-half the wave height.

AQUIFER - Stratum or zone below the surface of the earth capable of producing water.

ARTIFICIAL NOURISHMENT - The process of replenishing a beach with material (usually sand) obtained from another location.

AWASH - Situated so that the top is intermittently washed by waves or tidal action. Condition of being exposed or just bare at any stage of the tide between high water and chart datum.

BACKSHORE - The zone of a shore or beach lying between the foreshore and the coastline and acted upon by waves only during severe storms, especially when combined with exceptionally high water. It comprises the BERM or BERMS. (See Figure 6-1 located at the end of glossary.)

BACKWASH - (1) The seaward return of the water following the uprush of the waves. (2) Water or waves thrown back by an obstruction such as a ship, breakwater or cliff.

BANK - (1) The rising ground bordering a lake, river or sea; the face of a scarp. (2) An elevation of the sea floor of large area, located on a continental (or island) shelf and over which the depth is relatively shallow but sufficient for safe surface navigation; a group of shoals. (3) In its secondary sense, a shallow area consisting of shifting forms of silt, sand, mud and gravel, but in this case it is only used with a qualifying word such as "sandbank" or "gravelbank".

BAR - A submerged or emerged embankment of sand, gravel or other unconsolidated material built on the sea floor in shallow water by waves and currents, especially at the mouth of a river or estuary or lying a short distance from, and usually parallel to, the beach. See BAYMOUTH BAR.

BARRIER BEACH - A bar essentially parallel to the shore, the crest of which is above normal high water level.

BASEMENT - Rock complex, generally of IGNEOUS and METAMORPHIC rocks, overlain UNCONFORMABLY by SEDIMENTARY strata.

BATHYMETRY - The measurement of depths of water in oceans, seas and lakes; also information derived from such measurements.

BAY - A recess in the shore or an inlet of a sea between two capes or headlands, not as large as a gulf but larger than a cove.

BAYMOUTH BAR - A bar extending partly or entirely across the mouth of a bay.

BEACH - A zone of unconsolidated material that extends landward from the low-water line to the place where there is marked change in material or physiographic form, or to the line of permanent vegetation (usually the effective limit of storm waves). The seaward limit of a beach - unless otherwise specified - is the mean low-water line. A beach includes FORESHORE and BACKSHORE. (See Figure 6-1.)

BEACH BERM - A flat terrace located at the top of the foreshore. Also, a nearly horizontal part of the beach or backshore formed by the deposit of material by wave action. Some beaches have no berms, others have one or several. (See figure 6-1.)

BEACH WIDTH - The horizontal dimension of the beach measured perpendicular to the shoreline.

BED - The smallest division of a stratified series, marked by a more or less well-defined divisional plane from its neighbors above and below.

BED FORMS - Any deviation from a flat bed that is readily detectable by eye, and higher than the largest sediment size present in the parent bed material; generated on the bed of an alluvial channel by the flow.

BEDROCK - Any solid rock exposed at the surface of the earth or overlaid with unconsolidated material.

BERM CREST - The seaward limit of a berm. (See Figure 6-1.)

BLOWOUT - A general term for various saucer-, cup- or trough-shaped hollows formed by wind erosion on a preexisting dune or other sand deposit.

BLUFF - Any high headland or bank presenting a precipitous front.

BOTTOM - The ground or bed under any body of water; the bottom of the sea. (See Figure 6-1.)

BOULDER - A rounded rock more than 10 inches in diameter.

BREAKER - A wave breaking on a shore.

BREAKWATER - A structure protecting a shore area, harbor, anchorage or basin from waves.

CHANNEL - (1) The part of a body of water deep enough to be used for navigation through an area otherwise too shallow for navigation. (2) The deepest part of a stream, bay or strait though which the main volume or current of water flows.

CHART DATUM - The plane or level to which soundings (or elevations) or tide heights are referenced. The surface is called a tidal datum when referred to a certain phase of tide. See also DATUM PLANE.

CLASTIC - Consisting of fragments of rocks or of organic structures that have been moved individually from their place of origin.

CLAY - Fine-grained soil consisting of organic material the grains of which have diameters smaller than 0.005 millimeters. Finer than SILT.

CLIFF - A high, steep face of rock; a precipice. See also MARINE CLIFF and SEA CLIFF.

COAST - A strip of land of indefinite width (may be several miles) that extends from the shoreline inland to the first major change in terrain features. (See Figure 6-1.)

COASTAL AREA - The land and sea area bordering the shoreline. (See Figure 6-1.)

COASTAL PLAIN - A plain composed of horizontal or gently sloping strata of CLASTIC materials fronting the coast.

COASTLINE - (1) Technically, the line that forms the boundary between the COAST and the SHORE. (2) Commonly, the line that forms the boundary between the land and the water.

COBBLE - A rock fragment between 65 and 256 millimeters in diameter, thus larger than a PEBBLE and smaller than a BOULDER, rounded or otherwise abraded in the course of aquenous, eolian or glacial transport.

CONTINENTAL SHELF - The zone bordering a continent and extending from the low-water line to the depth (usually about 100 fathoms) where there is a marked or rather steep descent toward a greater depth.

CONTOUR - A line on a map or chart representing points of equal elevation with relation to a datum.

CONVERGENCE - (1) In refraction phenomena, the decreasing of the distance between ORTHOGONALS in the direction of wave travel. Denotes an area of increasing wave height and energy concentration. Also FOCUSING. (2) In wind-setup phenomena, the increase in setup observed over that which would occur in an equivalent rectangular basin of uniform depth, caused by changes in planform or depth; also the decrease in basin width or depth causing such increase in setup.

COVE - A small, sheltered recess in a coast, often inside a larger embayment.

CREEP - Movement of an individual sand grain as a result of being hit by a windborne sand grain.

CREST OF WAVE - (1) The highest part of a wave. (2) That part of the wave above stillwater level. (See Figure 6-2. located at the end of the glossary.)

CROSSBEDDING - The arrangement of laminations of strata transverse or oblique to the main planes of stratification of the strata concerned; inclined, often lens-shaped beds between the main bedding planes.

CRYSTALLINE - An inexact general term for igneous or metamorphic rocks as opposed to sedimentary rocks.

CULM - STEM of grasses, usually hollow except at the swollen NODES.

CULTURAL EROSION - Erosion caused by effects of man's actions on the land-excavation, traffic (vehicular and foot) and construction (inland and shoreline).

CURRENT - A flow of water due to surface gradient, tidal phenomena, winds and/or differential atmospheric pressures. See EBB CURRENT, FLOOD CURRENT, LITTORAL CURRENT, LONGSHORE CURRENT, AND FIDAL CURRENT.

CURRENT RIPPLE - A ripple mark produced by the action of a current flowing steadily in one direction over a bed of sand. See also RIPPLES (BED FORMS).

CYCLONE - In the northern hemisphere, a storm characterized by strong winds rotating counterclockwise about a center of low atmospheric pressure.

DATUM PLANE - The horizontal plane to which soundings, ground elevations or water surface elevations are referred. Also REFERENCE PLANE. The plane is called a TIDAL DATUM when defined by a certain phase of the tide. On the Atlantic coast of the United States MEAN LOW WATER is the datum ordinarily used on hydrographic charts. A common datum used on topographic maps is based on MEAN SEA LEVEL.

DEEP WATER - Water so deep that surface waves are little affected by the ocean bottom. Generally, water deeper than one-half the surface wave-length is considered deep water.

DEFLATION - The removal of loose material from a beach or other land surface by wind action.

DEFOCUSING - The spreading farther apart of wave rays in shallow water than in deep water; height or amplitude of the breaking wave is less than at points where no defocusing occurs. See also DIVERGENCE.

DEGLACIATION - The uncovering of an area from beneath glacier ice as a result of shrinkage of a glacier.

DELTA - An alluvial deposit, roughly triangular or digitate in shape, formed at a river mouth.

DENUDATION - The stripping of forests and vegetation from the land.

DEPTH - The vertical distance from a specified tidal datum to the sea floor.

DISCOID - Having the form of a disk.

DIVERGENCE - (1) In refraction phenomena, the increasing of distance between ORTHOGONALS in the direction of wave travel. Denotes an area of decreasing wave height and energy concentration. Also DEFOCUSING. (2) In WIND-SETUP phenomena, the decrease in setup observed under that which would occur in an equivalent rectangular basin of uniform depth, caused by changes in planform or depth. Also the increase in basin width or depth causing such decrease in setup.

DOWNDRIFT - The direction of predominant movement of littoral materials.

DRIFT (noun) - (1) Sometimes used as a short form for LITTORAL DRIFT. (2) The speed at which a current runs. (3) Also floating material deposited on a beach (driftwood). (4) A deposit of a continental ice sheet, as a drumlin. See GLACIAL DRIFT

DRIFT DEPOSIT - Any accumulation of glacial origin; glacial or glaciofluvial deposit.

DUNE - Ridge or mound of loose, windblown material, usually sand.

EBB CURRENT - The tidal current away from shore or down a tidal stream; usually associated with the decrease in the height of the tide.

EBB TIDE - The period of tide between high water and the succeeding low water; a falling tide.

EMBAYMENT - An indentation in the shoreline forming an open bay.

EOLIAN SANDS - Sediments of sand size or smaller which have been transported by winds. They may be recognized in marine deposits off desert coast by the greater angularity of the grains compared with waterborne particles.

EQUATORIAL TIDES - Consecutive tides with similar ranges occurring when the moon's orbit is on or close to the equator; morning and afternoon tides are very much alike.

EROSION - The wearing away of land by the action of natural forces. On a beach, the carrying away of beach material by wave action, tidal currents, littoral currents, or by deflation.

EYE - In meteorology, usually the "eye of the storm" (hurricane); the roughly circular area of comparatively light winds and fair weather found at the center of a severe tropical cyclone.

EUSTATIC - Pertaining to simultaneous, world-wide changes in sea level; also related to the amount of water incorporated in ice caps.

EUTROPHICATION - Process occurring in a lake making it rich in dissolved nutrients, but dificient in oxygen.

FAN - An accumulation of debris brought down by a stream descending a steep ravine and debouching in the plain beneath, where the detrital material spreads out in the shape of a fan.

FATHOM - A unit of measurement used for soundings. It is equal to 6 feet (1.83 meters).

FETCH - The continuous area of open water over which the wind blows in a constant direction. In enclosed bodies of water, it would ususally coincide with the longest axis in the general wind direction. Sometimes used synonymously with FETCH LENGTH.

FETCH LENGTH - The horizontal distance (in the direction of the wind) over which the wind blows to generate SEAS or create a WIND SETUP.

FLOOD CURRENT - The tidal current toward shore, usually associated with the increase in the height of the tide.

FLOOD PLAIN - That portion of a river valley, adjacent to the river channel, that is built of sediments during the present regiment of the stream and that is covered with water when the river overflows its banks at flood stages.

FLOOD TIDE - The period of tide between low water and the succeeding high water; a rising tide.

FLUVIAL - Of or pertaining to rivers; produced by river action, as a fluvial plain.

FOCUSING - The closing together of wave rays in shallow water; height of breaking wave is greater than at points where there is no focusing. See also CONVERGENCE

FOREDUNE - The front dune immediately behind the backshore.

FORESHORE - The part of the shore lying between the crest of the seaward berm (or upper limit of wave wash at high tide) and the orinary low-water mark that is ordinarily traversed by the uprush and backrush of the waves as the tides rise and fall. (See Figure 6-1.)

FOSSIL - The remains or traces of animals or plants that have been preserved by natural causes in the earth's crust exclusive of organisms that have been buried since the beginning of historic time.

FOSSILIFEROUS - Containing organic remains.

FRONTAL MARGIN - The leading edge of a glacier.

FULCRUM POINT - Point at which there is no net erosion or accretion; erosion occurs on one side of the fulcrum point, accretion on the other.

GALE - Continuous winds with velocities in excess of 32 miles per hour.

GENERATION OF WAVES - (1) The creation of waves by natural or mechanical means. (2) The creation and growth of waves caused by a wind blowing over a water surface for a certain period of time.

GLACIAL - Pertaining to, characteristic of, produced or deposited by or derived from a glacier.

GLACIAL DRIFT - Sediment (a) in transport in glaciers, (b) deposited by glaciers, and (c) predominantly of glacial origin, made in the sea or in bodies of glacial meltwater. See DRIFT.

GLACIATION - Alteration of the earth's solid surface through erosion and deposition by glacier ice.

GLACIER - A mass of ice with definite lateral limits, with motion in a definite direction and originating from the compacting of snow by pressure.

GLACIO- -A combining form frequently used with other words to denote formation by or relationship to glaciers.

GLACIOFLUVIAL - Pertaining to streams flowing from glaciers or to the deposits made by such streams.

GLACIOLACUSTRINE - Produced by or belonging to glacial lakes.

GRADIENT (GRADE) - With reference to winds or currents, the rate of increase or decrease in speed, usually in the vertical; or the curve that represents this rate. The change in a variable quantity, as temperature, per unit distance.

GRANITE - Loosely used for any light-colored, coarse-grained igneous rock. Actually an igneous rock consisting of essentially alkalic feldspar and quartz.

GRANITIC - Pertaining to or composed of granite or granite-like rock.

GRAVEL - Accumulation of rounded, waterworn PEBBLES. The word gravel is generally applied when the size of the pebbles does not much exceed that of an ordinary hen's egg; fragment size ranges from 76 to 4.76 millimeters; may or may not contain interstitial sand ranging from 50 to 70 percent of the total mass.

GROIN - A shore protection structure built (usually perpendicular to the shoreline) to trap littoral drift or retard erosion of the shore. Groins are usually constructed of rock, timber, or sheet piles. See LOW PROFILE GROIN and TERMINAL GROIN.

GROIN SYSTEM - A series of groins acting together to protect a section of beach. Commonly called a groin field.

GROUNDWATER - Subsurface water occupying the zone of saturation. In a strict sense, the term is applied only to water below the WATER TABLE.

GULF - A large embayment in a coast; the entrance is generally wider than the length.

HANGING VALLEY - A tributary valley whose floor is higher than the floor in the area of intersection.

HARBOR - Any protected water area affording a place of safety for vessels.

HEADLAND (HEAD) - A high, steep-faced promontory extending into the sea.

HIGH TIDE, HIGH WATER (HW) - The maximum elevation reached by each rising tide. See TIDE.

HIGH-WATER MARK - In the strict sense, the intersection of the plane of mean high water with the shore. The shoreline delineated on the nautical charts of the U.S Coast and Geodetic Survey is an approximation of the high-water line. For specific occurrences, the highest elevation on the shore reached during a storm or riding tide, including meteorological effects.

HOLLOW - A small ravine; a low tract of land encompassed by hills.

HOOK - A spit or norrow cape of sand or gravel which turns landward at the outer end.

HURRICANE - An intense tropical cyclone in which winds tend to spiral inward toward a core of low pressure, with maximum surface wind velocities that equal or exceed 75 miles per hour (65 knots) for several minutes or longer at some points. TROPICAL STORM is the term applied if maximum winds are less than 75 miles per hour.

HURRICANE PATH OR TRACK - Line of movement (propagation) of the eye through an area.

HYDROLOGY - The science that relates to the water of the earth.

IGNEOUS - Formed by solidification from a molten or partially molten state.

INLET - (1) A short, narrow waterway connecting a bay, lagoon or similar body of water with a large parent body of water. (2) An arm of the sea (or other body of water) that is long compared to its width and that may extend a considerable distance inland.

IN-MIGRATION - The net increase in population due to an excess of people moving in over people moving out.

INSHORE (ZONE) - The zone of variable width extending from the low-water line through the breaker zone. (See Figure 5-1.)

JETTY - On open seacoasts, a structure extending into a body of water and designed to prevent shoaling of a channel by littoral materials and to direct and confine the stream or tidal flow. Jetties are built at the mouth of a river or tidal inlet to help deepen and stabilize a channel.

KAME - A conical hill or short irregular ridge of gravel or sand deposited in contact with glacial ice.

KETTLE - A pit or depression in drift made by the wasting away of a detached mass of glacier ice that had been either wholly or partly buried in the drift.

KINETIC ENERGY (OF WAVES) - In a progressive oscillatory wave, a summation of the energy of motion of the particles within the wave.

KNOT - The unit of speed used in navigation. It is equal to 1 nautical mile (6,076,115 feet or 1,852 meters) per hour; about 1.15 statute miles per hour.

LAGOON - A shallow body of water, as a pond or lake, usually connected to the sea.

LANDFILL - A system of trash and garbage disposal in which the waste is buried between layers of earth.

LEACHATE - Highly concentrated effluent resulting from the leaching of landfills.

LEE - Shelter, or the part sheltered (or turned away) from the wind or waves.

LENGTH OF WAVE - The horizontal distance between similar points on two successive waves measured perpendicularly to the crest (See Figure 6-2.)

LIFT - A section of sand or snow fence designed to catch and hold windblown sand to increase the height of a dune.

LITHOLOGY - The physical character of a rock, generally determined megascopically or with the aid of a low-power magnifier.

LITTORAL - Of or pertaining to a shore, especially of the sea.

LITTORAL CURRENT - Any current in the littoral zone caused primarily by wave action, e.g., longshore current, rip current.

LITTORAL DEPOSITS - Deposits of littoral drift.

LITTORAL DRIFT - The sedimentary material moved in the littoral zone under the influence of waves and currents.

LITTORAL TRANSPORT - The movement of littoral drift in the littoral zone by waves and currents. Includes movement parallel (longshore transport) and perpendicular (onshore and offshore transport) to the shore.

LITTORAL TRANSPORT RATE - Rate of transport of sedimentary material parallel or perpendicular to the shore in the littoral zone. Usually expressed in cubic yards (meters) per year. Commonly used as synonymous with LONGSHORE TRANSPORT RATE.

LITTORAL ZONE - An indefinite zone extending seaward from the shoreline to just beyond the breaker zone.

LOBE - A projection of a glacial margin or of a body of glacial drift beyond the main mass of ice or drift.

LONGSHORE - Parallel to and near the shoreline.

LONGSHORE CURENT - The littoral current in the breaker zone moving essentially parallel to the shore, usually generated by waves breaking at an angle to the shoreline.

LONGSHORE ENERGY FLUX - It is equal to the component of wave energy flux per unit length of shoreline which is parallel to the shoreline. See WAVE ENERGY FLUX.

LONGSHORE TRANSPORT - The movement of sedimentary material parallel to the shore. The rate of longshore transport is usually expressed in cubic yards (meters) per year. Commonly used as synonymous with LITTORAL TRANSPORT.

LOW PASS FILTER - A device (electronic or digital) that attenuates the higher frequency components of a signal but that leaves the amplitude of the lower frequency components unaffected.

LOW PROFILE GROIN - A groin placed (usually midway along the proposed project) at or just below the proposed or existing ground. See GROIN.

LOW TIDE (LOW WATER, LW) - The minimum elevation reached by each falling tide. See TIDE.

LOW-WATER MARK - The intersection of any standard low tide datum plane with the shore.

MARINE CLIFF - A cliff, sometimes composed of unconsolidated sediments, facing the ocean and formed by wave action.

MARSH - An area of soft, wet or periodically inundated land, generally treeless and usually characterized by grasses and other low growth.

MASS TRANSPORT - The net transfer of water by wave action in the direction of wave travel. See ORBIT.

MEAN HIGH WATER (MHW) - The average height of the high waters over a 19-year period. For shorter periods of observations, corrections are applied to eliminate known variations and reduce the results to the equivalent of a mean 19-year value.

MEAN LOW WATER (MLW) - The average height of the low waters over a 19-year period. For shorter periods of observations, corrections are applied to eliminate known variations and reduce the results to the equivalent of a mean 19-year value.

MEAN SEA LEVEL - The average height of the surface of the sea for all stages of the tide over a 19-year period, usually determined from hourly height readings.

MELT WATER - Water resulting from the melting of snow or of glacial ice.

METAMORPHIC ROCK - Includes all those rocks that have formed in the solid state in response to pronounced changes of temperature, pressure and chemical environment, which generally take place below the zones of weathering and cementation.

MIGRATE - To translocate (as a dune, spit or inlet, more or less as a unit) under the continued action of wind, waves and currents.

MORAINE - Drift deposited chiefly by direct glacial action and having constructional topography independent of control by the surface on which the drift lies.

MORPHOLOGY - The observation of the form of lands.

MUD - A fluid-to-plastic mixture of finely divided particles of solid material and water.

MUD FLAT - An accumulation of mud that is exposed at low tide and covered by shallow water at high tide.

NAUTICAL MILE - Generally 1 minute of latitude is considered equal to 1 nautical mile. The accepted United States value as of 1 July 1959 is 6,076.115 feet or 1,852 meters, approximately 1.15 times as long as the statute mile of 5,280 feet. Also geographical mile.

NEAP TIDE - A tide occurring near the time of quadrature of the moon with the sun. The neap tidal rage is usually 10 to 30 percent less than the mean tidal range.

NEARSHORE (ZONE) - An indefinite zone extending seaward from the shoreline well beyond the breaker zone. (See Figure 5-1.)

NODAL POINT - The point where the predominant direction of the LONGSHORE TRANSPORT changes. The point at which the longshore current of sediment transport changes sign.

NODE - Joint of a STEM where a leaf is borne or may be borne. Buds are also commonly borne at the node.

NORTHEASTER - Any east coast storm (except a hurricane) of the middle Atlantic and New England States that produces strong onshore winds.

NOURISHMENT - The process of replenishing a beach. It may be brought about naturally by longshore transport or artificially by the deposition of dredged materials.

NUTRIENT - A nutritive substance or ingredient, referring here to organic nutrients in the soil and underlying sediments both above and in the water table.

OFFSHORE - (1) The comparatively flat zone of variable width, extending from the breaker zone to the seaward edge of the Continental Shelf. (2) A direction seaward from the shore. (See Figure 6-1.)

OFFSHORE WIND - A wind blowing from land to sea in the coastal area.

ONSHORE - A direction from sea to land.

ONSHORE WIND - A wind blowing from sea to land in the coastal area.

ORBIT - In water waves, the path of a water particle affected by the wave motion. In deep-water waves the orbit is nearly circular and in shallow-water waves the orbit is nearly elliptical. In general, the orbits are slightly open in the direction of wave motion giving rise to MASS TRANSPORT.

ORTHOGONALS - On a wave-refraction diagram, a line drawn perpendicular to the wave crests. Also WAVE RAY.

OUTFALL - A structure extending into a body of water for the purpose of discharging sewage, storm runoff or cooling water.

OUTWASH - Materials deposited by meltwater streams beyond active glacier ice.

OUTWASH PLAIN - Fan-shaped overlapping deltas deposited by streams flowing from the glacier.

OVERTOPPING - Passing of water over the top of a structure as a result of wave runup or surge action.

PAMET - An outwash channel carved in glacial drift and having irregularities resulting from melting of blocks of stagnant ice.

PAMET SAG - Depression in the edge of the scarp caused by its intersection by a pamet.

PARABOLIC DUNE - A dune having (in ground plan) approximately the form of a parabola, with the concave side toward the wind.

PEAT - A dark-brown or black residuum produced by the partial decomposition of various plants (mosses, trees, etc.) that grow in marshes and similar wet places.

PEBBLES - Smooth rounded stones ranging in diameter from 2 to 64 millimeters.

PHASE SHIFT - A shift to the right of a sine wave.

PHI GRADE SCALE - A logarithmic transformation of the Wentworth grade scale for size classification of sediment grains based on the negative logarithm to the base 2 of the particle diameter. Measured in Phi units.

PITTED OUTWASH PLAIN - An outwash plain of gravel or sand with kettle holes.

PLEISTOCENE - The earlier of the two epochs comprising the Quaternary period. Also called Glacial epoch and formerly called Ice Age.

POINT - The extreme end of a cape or the outer end of any land area protruding into the water, usually less prominent than a cape.

PROFILE, BEACH - The intersection of the ground surface with a vertical plane; may extend from the top of the dune line to the seaward limit of sand movement. (See Figure 6-1.)

PROGLACIAL LAKE - Lake occupying a basin in front of a glacier generally in direct contact with the ice.

PROGRADATION - A seaward advance of the beach berm.

PROPAGATION OF WAVES - The transmission of waves through water.

QUARTZITE - A granulose metamorphic rock consisting essentially of quartz.

RADIOCARBON DATING - The determination of the age of a material by measuring the propagation of the isotope C^{14} (radiocarbon) in the carbon it contains. The method is suitable for the determination of ages up to a maximum of about 30,000 years.

RECESSION (OF A BEACH) - (1) A continuing landward movement of the shoreline. (2) A net landward movement of the shoreline over a specified time. Also RETROGRESSION.

RECESSIONAL MORAINE - A moraine formed during a temporary decrease in the rate of glacial retreat.

RECHARGE - The processes by which water is absorbed and is added to the zone of saturation. Also, the quantity of water that is added to the zone of saturation.

RECURVED SPIT - A SPIT having one end more or less strongly curved inward (landward).

REFRACTION (OF WATER WAVES) - (1) The process by which the direction of a wave, moving in shallow water at an angle to the contours, is changed. The part of the wave advancing in shallower water moves more slowly than that part still advancing in deeper water, causing the wave crest to bend toward alignment with the underwater contours. (2) The bending of wave crests by currents.

RETROGRADATION - The cutting back of a beach toward land.

RETROGRESSION (OF A BEACH) - (1) A continuing landward movement of the shoreline. (2) A net landward movement of the shoreline over a specified time. Also RECESSION, RETROGRADATION.

REVETMENT - A facing of stone, concrete, etc., built to protect a scarp, embankment or shore structures against erosion by wave action or currents.

RIP CURRENT - A strong surface current flowing seaward from the shore. It usually appears as a visible band of agitated water and is the return movement of water piled up on the shore by incoming waves and wind. With the seaward movement concentrated in a limited band, its velocity is somewhat accentuated.

RIPPLES (BED FORMS) - Small bed forms with wavelengths less than 1 foot and heights less than 0.1 foot.

RIPRAP - A layer, facing or protective mound of stones randomly placed to prevent erosion, scour or sloughing of a structure or embankment; also the stone so used.

RUBBLE - (1) loose angular waterworn stones along a beach. (2) Rough, irregular fragments of broken rock.

RUBBLE-MOUND STRUCTURE - A mound of randomly shaped and randomly placed stones protected with a cover layer of selected stones or specially shaped concrete armor units. (Armor units in primary cover layer may be placed in orderly manner or dumped at random.)

SALTATION - That method of sand movement of randomly shaped and randomly placed stones protected with a cover layer of selected stones or specially shaped concrete armor units. (Armor units in primary cover layer may be placed in orderly manner or dumped at random.)

SALTATION - That method of sand movement in a fluid in which individual particles leave the bed by bounding nearly vertically and, because the motion of the fluid is not strong or trubulent enough to retain them in suspension, return to the bed at some distance downstream. The travel path of the particles is a series of hops and bounds.

SALT MARSH - A mud flat that has reached sea level enabling salt-tolerant plants to grow, thus producing a tough, erosion-resistant vegetal mat that reaches approximately the level of high tide.

SAND - Detrital material ranging in size from 2 to 1/16 millimeters in diameter.

SANDFILL - Sand added to a beach as a shore-protection measure.

SCARP - A more or less continuous line of cliffs or steep slopes facing in one general direction that are caused by erosion or faulting. (See Figure 6-1.)

SCARP, BEACH - An almost vertical slope along the beach caused by erosion by wave action. It may vary in height from a few inches to several feet, depending on wave action and the nature and composition of the beach. (See Figure 6-1.)

SCOUR - Removal of underwater material by waves and currents, especially at the base or toe of a shore structure.

SEA CLIFF - A cliff situated at the seaward edge of the coast and formed by wave action.

SEAS - Waves caused by wind at the place and time of observation.

SEAWALL - A structure separating land and water areas, primarily designed to prevent erosion and other damage due to wave action.

SEDIMENT - Solid material, both mineral and organic, that is in suspension, is being transported or has been moved from its site of origin by air, water or ice and has come to rest on the earth's surface either above or below sea level.

SEDIMENTARY ROCKS - Rocks formed by the accumulation of sediment in water (aqueous deposits) or from air (eolian deposits). The fragments or particles are of various sizes (conglomerate, sandstone, shale), of the remains or products of animals or plants (certain limestones and coal), of the product of chemical action or of evaporation (salt, gypsum, etc.) or of mixtures of these materials. A characteristic feature of sedimentary deposits is a layered structure known as bedding or stratificaiton. Each layer is a bed or stratum. Sedimentary beds as deposited lie flat or nearly flat.

SEPTAGE - The solid waste from on-site septic systems.

SHALLOW WATER - (1) Commonly, water of such a depth that surface waves are noticeably affected by bottom topography. It is customary to consider water of depths less than one-half the surface wavelengths as shallow water. See DEEP WATER. (2) More strictly, in hydrodynamics with regard to progressive gravity waves, water in which the depth is less than 1/25 the wave-length. Also called very shallow water.

SHINGLE - (1) Loosely and commonly, any beach material coarser than ordinary gravel, especially any having flat or flattish pebbles. (2) Strictly and accurately, beach material of smooth, well-rounded pebbles that are roughly the same size. The spaces between pebbles are not filled with finer materials. Shingle often gives out a musical sound when stepped on.

SHOAL (noun) - A detached elevation of the sea bottom, comprised of any material except rock or coral, which may endanger surface navigation.

SHOAL (verb) - (1) To become shallow gradually. (2) To cause to become shallow. (3) To proceed from a greater to a lesser depth of water.

SHORE - The narrow strip of land in immediate contact with the sea, including the zone between high and low water lines. A shore of unconsolidated material is usually called a beach. (See Figure 6-1.)

SHORELINE - The intersection of a specified plane of water with the shore or beach (e.g., the high-water shoreline would be the intersection of the plane of mean high water with the shore or beach.) The line delineating the shoreline on U.S. Coast and Geodetic Survey nautical charts and surveys approximates the mean high-water line.

SHORELINE-BREAKER ANGLE - The angle that a breaking wave makes with the shoreline.

SILICIFIED - Replaced by or having the interstitial spaces filled with fine-grained silica.

SILT - A very fine-grained sediment, most of the particles of which are between 1/16 and 1/256 millimeters in diameter.

SLIP FACE - The steep, leeward side of a migrating dune.

SLUMP - The downward slipping of a mass of rock or unconsolidated material of any size, moving as a unit or as subsidiary units, usually with backward rotation of a more or less horizontal axis parallel to the cliff or slope from which it descends.

SORTING - (1) In a genetic sense the term may be applied to the dynamic process by which material having some particular characteristic, such as similar size, shape or specific gravity, is selected from a larger heterogeneous mass. (2) In a descriptive sense the term may be used to indiate the degree of similarity, in respect to some particular characteristic, of the component parts in a mass of material.

SORTING COEFFICIENT - A mathematical measure of the degree of sorting of a sediment.

SPIT - A small point of land or a narrow shoal projecting into a body of water from the shore.

SPUR - A short section of sand fence attached to and perpendicular to a longer section that is parallel to the beach.

STEM - The ascending axis of a plant, whether above or below ground, which ordinarily grows in an opposite direction to the root or descending axis.

STILLWATER LEVEL - The elevation that the surface of the water would assume if all wave action were absent.

STRATIFIED - Formed or lying in beds, layers or strata.

STRATIFIED DRIFT - Drift exhibiting both sorting and stratification, implying deposition from a fluid medium such as water or air.

STRATIGRAPHIC - Of, relating to or determined by stratigraphy. The study and correlation of stratified rocks according to origin, composition, distribution and succession of strata.

SURFICIAL GEOLOGY - The study of materials formed on, situated at or occurring on the earth's surface (especially unconsolidated residual, alluvial or glacial deposits lying on the bedrock).

SURF ZONE - The area between the outermost breaker and the limit of wave uprush.

SWASH - The rush of water up onto the beach face following the breaking of a wave.

SWELL - Wind-generated waves that have traveled out of their generating area. A swell characteristically exhibits a more regular and longer period and has flatter crests than waves that are near their area of generation.

TERMINAL GROIN - A groin placed (usually at the beginning or end of a proposed project) about 1 foot above the surface. See GROIN.

TERMINAL MORAINE - A moraine formed across the course of a glacier at its farthest advance, at or near a relatively stationary edge or at places marking the termination of important glacial advances.

TIDAL CURRENT - The alternating horizontal movement of water associated with the rise and fall of the tide caused by the astronomical tide producing forces. See also FLOOD CURRENT AND EBB CURRENT.

TIDAL, RANGE - The difference in height between consecutive high and low (or higher high and lower low) waters.

TIDE - The periodic rising and falling of the water that results from gravitational attraction of the moon and sun and other astronomical bodies acting upon the rotating earth. Although the accompanying horizontal movement of the water resulting from the same cause is also sometimes called the tide, it is preferable to designate the latter as TIDAL CURRENT, reserving the name TIDE for the vertical movement.

TILL - Unsorted, unstratified sediment carried or deposited by a glacier.

TOPOGRAPHY - The configuration of a surface, including its relief, the position of its streams, roads, buildings, etc.

TROPICAL CYCLONE - See HURRICANE.

TROPICAL STORM - A tropical cyclone with maximum winds less than 75 miles per hour.

TURBULENT FLOW - That type of flow in which the stream lines are thoroughly confused through heterogeneous mixing of flow as opposed to laminar flow in which the stream lines remain distinct from one another over their entire body.

UNCONFORMABLY - Not succeeding the underlying strata in immediate order of age and in parallel position.

UNSTRATIFIED - Not formed or deposited in beds or strata.

WASHOVER - Small delta built on the landward side of a bar separating a lagoon from the open sea. A washover results from storm waves breaking over low parts of the bar and depositing sediment on the lagoon side.

WASHOVER CHANNEL - Depression leading across a low dune from the ocean side to the washover on the lagoon side. Formed when a wave breaches a low dune.

WATER TABLE - The upper surface of a zone of saturation, except where that surface is formed by an impenetrable body.

WAVE - A ridge, deformation or undulation of the surface of a liquid.

WAVE DIRECTION - The direction from which a wave approaches.

WAVE ENERGY FLUX - The rate at which energy is transmitted in the direction of wave propagation across a plane perpendicular to the direction of wave advance and extending down the entire depth.

WAVE FRONT - On a wave refraction diagram, a line drawn parallel to the wave crests or perpendicular to the wave rays. (See Figure 6-3.)

WAVE HEIGHT - The vertical distance between a crest and the preceding trough.

WAVELENGTH - The horizontal distance between similar points on two successive waves measured perpendicular to the crest. (See Figure 6-2.)

WAVE PERIOD - The time for a wave crest to traverse a distance equal to one wavelength. The time for two successive wave crests to pass a fixed point.

WAVE RAY - On a wave-refraction diagram, a line drawn perpendicular to the wave crests. Also ORTHOGONAL. (See Figure 6-3.)

WAVE RAY-SHORELINE ANGLE - The angle that an incoming wave ray makes with the shoreline.

WAVE SETUP - Superelevation of the water surface over normal surge elevation due to onshore mass transport of the water by wave action alone.

WAVE TROUGH - The lowest part of a wave form between successive crests. Also that part of a wave below stillwater level.

WEATHERED - Altered by a group of processes, such as the chemical action of air and rain water and of plants and bacteria and the mechanical action, change in character, decay and finally crumble into soil.

WIND SETUP - (1) The vertical rise in the stillwater level on the leeward side of a body of water caused by wind stresses on the surface of the water. (2) The difference in stillwater levels on the windward and the leeward sides of a body of water caused by wind stresses on the surface of the water. (3) Synonymous with STORM SURGE. STORM SURGE is usually reserved for use on the ocean and large bodies of water. WIND SETUP is usually reserved for use on reservoirs and smaller bodies of water.

WINDWARD - The direction from which the wind is blowing.

WISCONSIN - Fourth Pleistocene epich of glaciation.

SOURCES

Definitions in this glossary came from the following sources:

American Geological Institute, 1962. Dictionary of Geological Terms, Dolphin books, Doubleday & Company, Inc., Garden City, New York.

U.S. Army Coastal Engineering Research Center, 1975. Shore Protection Manual. Three Volumes. U.S. Army Coastal Engineering Research Center, Kingman Building, Fort Belvoir, Virginia.

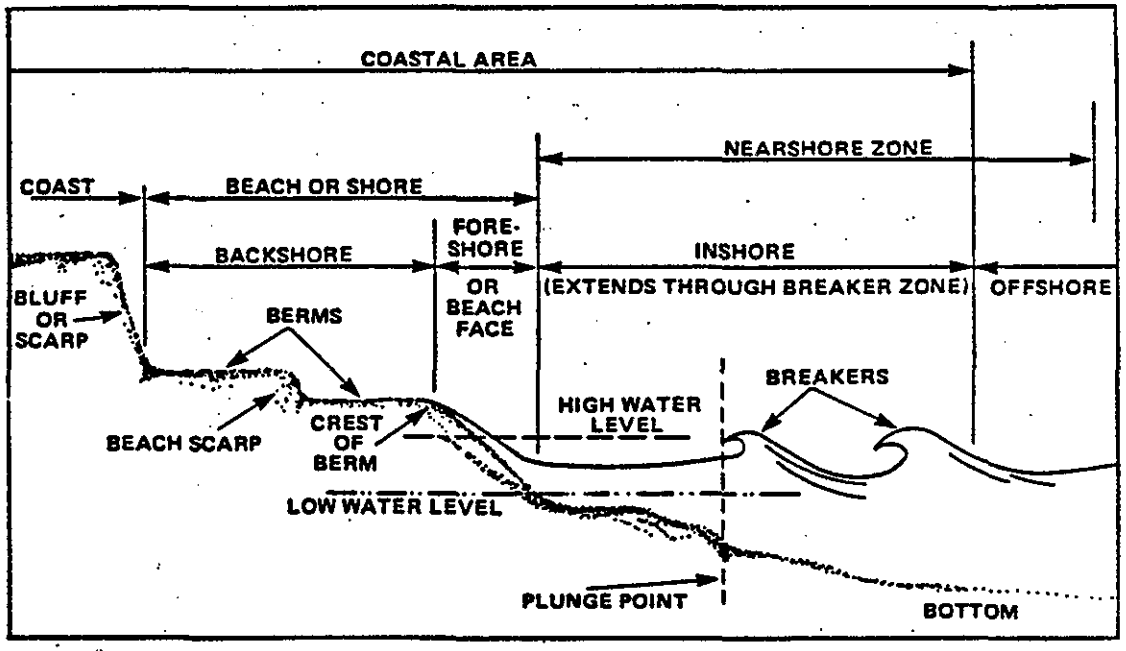

Figure 6-1. Beach Profile-Related Terms (after U.S. Army Coastal Engineering Research Center, 1975)

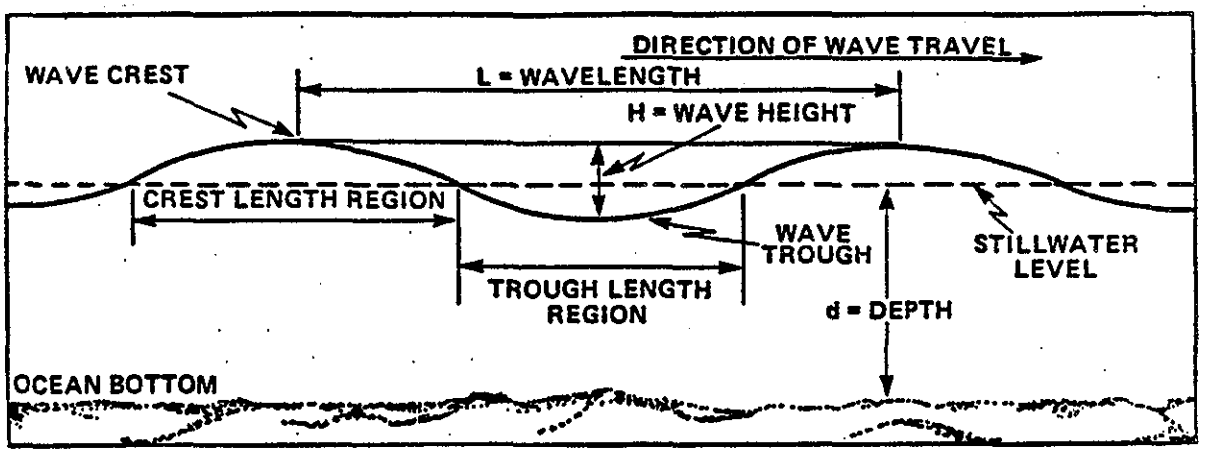

Figure 6-2. Wave Characteristics and Direction of Water Particle Movement (after Wiegel, 1953).

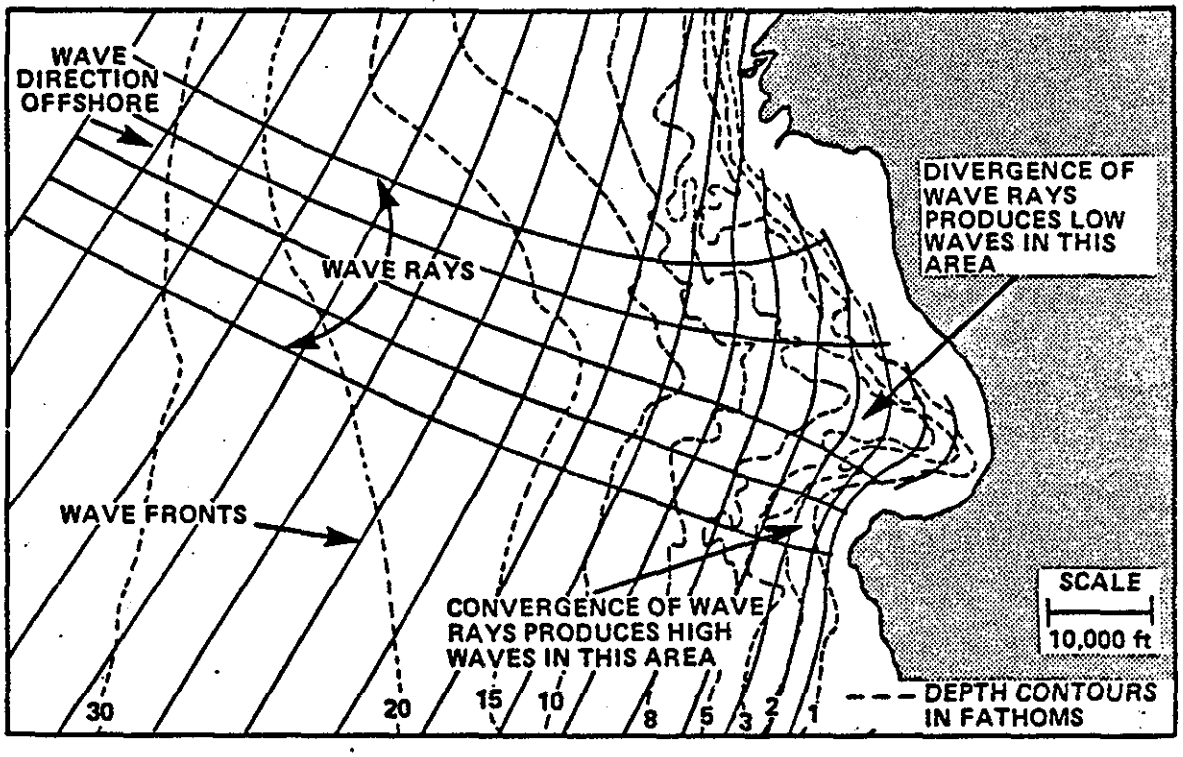

Figure 6-3. Refraction Diagram (after Wiegel, 1953)