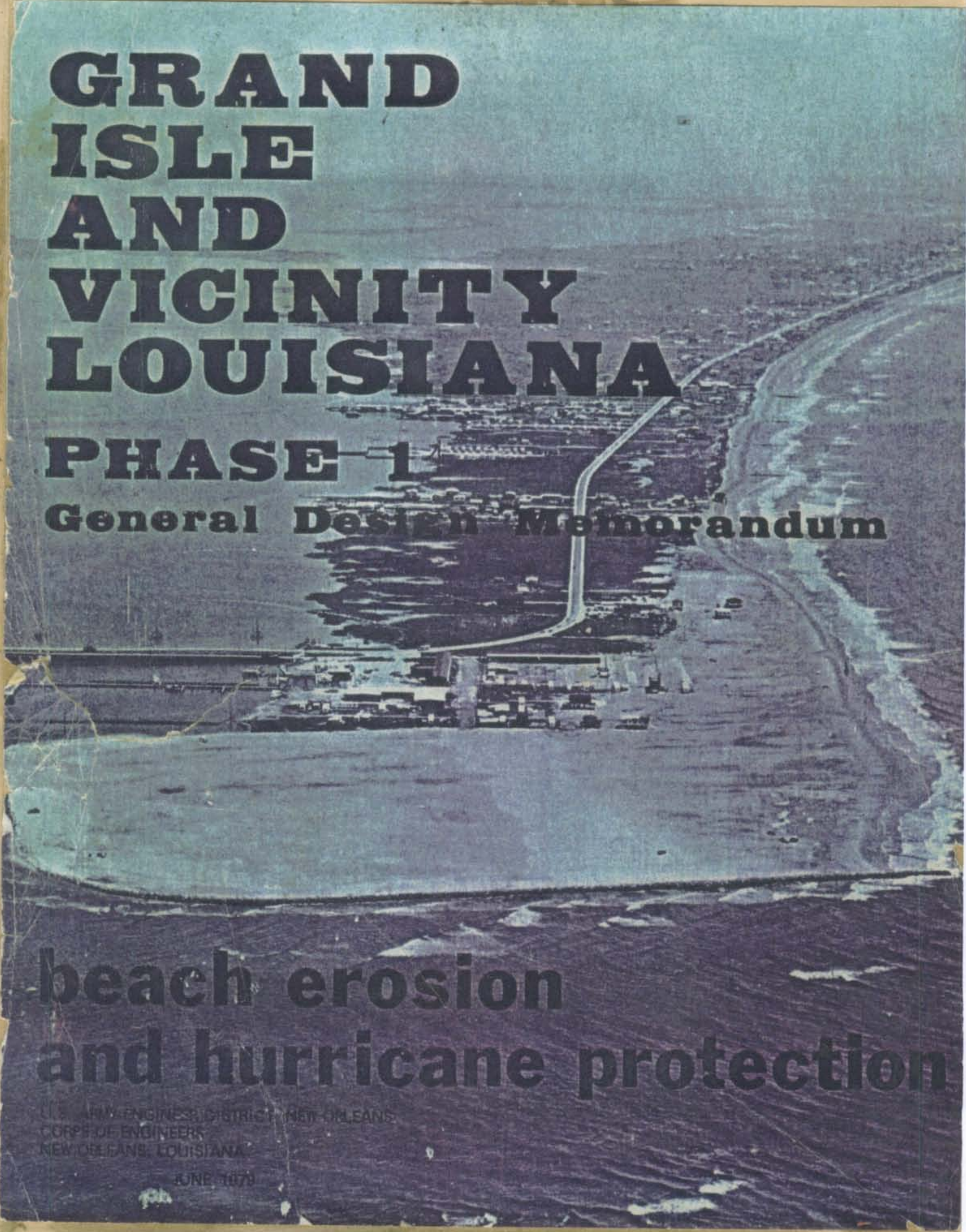
GRAND ISLE AND VICINITY LOUISIANA

PHASE 1

General Design Memorandum



beach erosion and hurricane protection

U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS
NEW ORLEANS, LOUISIANA

JUNE 1979

Syllabus

The purpose of this report is to present the results of studies made to determine if the Grand Isle and Vicinity, Louisiana, project should be constructed as authorized, or if some modifications should be made to better serve the overall national and public interest. The studies have affirmed the validity of the authorized plan in light of current conditions and criteria. The plan still satisfies the overall objectives, has a favorable economic, social, and environmental stance, and is still desired by local interests.

The authorized plan of improvement (plan B) is a combined beach erosion and hurricane protection plan. It provides protection from gulf waves driven by hurricanes that have a frequency of recurrence of up to once in every 50 years. The plan consists of a berm and vegetated dune extending the length of Grand Isle's gulf shore and incorporates an existing jetty to stabilize the western end of the island at Caminada Pass. The dune would have a 10-foot wide crown at an elevation of 11.5 feet mean sea level (m.s.l.), 1 on 5 side slopes, and protective vegetation. The sandfill berm would slope from an elevation of 8.5 feet m.s.l. at the toe of the dune 180 feet gulfward to an elevation of 3 feet m.s.l. and, from this point, would assume its natural slope to the offshore bottom. The jetty has a top width of 6 feet at an elevation of 4 feet m.s.l., 1 on 2 side slopes, and extends approximately 2,600 feet along the western end of the island at Caminada Pass.

This plan will provide beach erosion and hurricane protection desperately needed by the residents of Grand Isle and can be implemented with a minimum of adverse environmental impacts.

The economics of the selected plan are as follows:

Estimated total first cost	$10,900,000
Estimated average annual cost	1,249,000
Estimated average annual benefits	1,888,000
Excess benefits over costs	639,000
Project life	50 yrs.
Interest rate	6 7/8%
Benefit/cost ratio	1.5 to 1

It is recommended this report be approved as a basis to prepare a Phase II GDM for the selected plan.

GRAND ISLE AND VICINITY, LOUISIANA
PHASE I GENERAL DESIGN MEMORANDUM

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THE STUDY AND REPORT

The purpose of this section is to acquaint the reader with this study and report. The following paragraphs discuss the purpose, authority, scope, the authorized plan, the prior studies and reports, the general report characteristics, and its overall organization and content.

PURPOSE

This report presents the result of the Phase I affirmation study on Grand Isle and Vicinity, Louisiana, and provides the basis for proceeding with detailed engineering and design studies of project features recommended in the review report dated 31 October 1972. The purpose of this study is to reevaluate the authorized plan and viable alternatives thereto, in light of current conditions and criteria, and to reaffirm that plan if it is determined that the authorized hurricane protection and beach erosion control improvements are still warranted. This report provides the basis for approval by the Division Engineer for the Lower Mississippi Valley, to proceed with the preparation of the Phase II General Design Memorandum (GDM), which would contain the results of detailed studies of the project features recommended herein.

AUTHORITY

The Senate Public Works Committee on 1 October 1976 and the House Public Works Committee on 23 September 1976 adopted resolutions under the provisions of Section 201 of Public Law 89-298 approving the project for beach erosion and hurricane protection for Grand Isle and Vicinity, Louisiana. These resolutions state, in part, as follows:

> "That pursuant to the provisions of Section 201 of Public Law 298, 89th Congress (79 Stat. 1073), the project for beach erosion and hurricane protection at Grand Isle and Vicinity, Louisiana, is hereby approved substantially in accordance with the recommendations of the Secretary of the Army and the Chief of Engineers in House Document Numbered 94-639, at an estimated Federal cost of $5,709,000."

SCOPE OF THE STUDY

The study area comprises Grand Isle, Louisiana, a barrier island, located in the Gulf of Mexico about 50 miles south of New Orleans. Investigations made for this study include a review of previous hydrologic studies to determine the nature and extent of the erosion problem; field surveys to provide a base for updating of cost estimates; soil borings to locate additional sources of sand, and soil analyses to determine the suitability and availability of sand; design, cost (including real estate investigations), and benefit studies; environmental investigations and studies; consideration of nonstructural alternatives; and consultation with local, state, and other Federal agencies and interested individuals.

All data are of sufficient detail to permit the design of technically sound project features and for the preparation of adequate estimates of project first costs, annual charges, and annual benefits. The report contains sufficient detail to serve as a basis for approval to proceed with detailed engineering and design of the project features recommended herein.

THE REPORT

This report has been prepared in compliance with Engineer Regulation No. 1105-2-30, Phase I AE&D Program.

The report has been arranged in two parts. Part 1, the main report, presents the study results and gives a broad view of the overall project formulation process. Part 2 comprises a group of appendixes consisting of pertinent correspondence and reports of other agencies, and technical appendixes presenting detailed technical information required for an independent evaluation of the validity of the findings presented herein. They are primarily an aid to the technical reviewer. Each appendix is compartmentalized with a title page, table of contents, and text followed by plates.

PRIOR STUDIES AND REPORTS

Prior reports and existing projects on beach erosion control and shore protection, hurricane protection, and navigation pertinent to the study area include:

a. The initial study of Grand Isle, Louisiana, was conducted on a cooperative basis by formal application from the State Board of Engineers of Louisiana, dated 9 July 1935, and approved by the Chief of Engineers on 5 August 1935. The report on the study was made by the Beach Erosion Board and submitted to the Chief of Engineers on 28 July 1936. The study revealed that the gulf shore of Grand Isle had undergone significant material changes, that the area was subject to abrupt temporary losses and gains, and that the littoral currents along the shore were generally from east to west. The board was of the opinion that further erosion along the western end of the island could be expected, with little serious erosion likely to occur on the eastern half. The board believed that the complete protection of Grand Isle against tropical storms would require the construction of a massive seawall at a prohibitive cost. The report recommended, as the most practicable means of securing stabilization of the island, the construction of a single long jetty placed near Caminada Pass, approximately 900 feet west of the bridge and extending into the Gulf of Mexico perpendicular to the shoreline, to the 6-foot depth curve or 1,500 feet from the shore. The Chief of Engineers concurred in the plan presented by the Beach Erosion Board and ruled that no Federal interests were involved.

b. "Grand Isle, Louisiana, Beach Erosion Control Study," was submitted to Congress 17 March 1955, and published as House Document Number 132, 84th Congress, 1st Session. The most suitable plan for stabilization of the gulf shore of Grand Isle, as developed for this study, was determined to be direct placement of suitable material in the attacked areas and periodic replacement, as necessary, and the construction of a jetty near the eastern end of the island. Investigations made during this study revealed that the littoral currents along the shore were generally from west to east. It was also determined that no part of the cost should be borne by the United States.

c. "Grand Isle and Vicinity, Louisiana," project was authorized by the Flood Control Act of 27 October 1965, in accordance with the report published as House Document No. 184, 89th Congress, 1st Session. The project includes the construction of levees on each side of Bayou Lafourche connected to floodgates in Bayou Lafourche at Larose and south of Golden Meadow to provide hurricane protection for the developed areas along Bayou Lafourche from Larose to Golden Meadow, inclusive. The project was initiated in January 1975 and is currently scheduled for completion in 1989.

d. "Bayou Lafourche and Lafourche-Jump Waterway, Louisiana," project was authorized by the River and Harbor Act of 30 August 1935 and modified by the River and Harbor Act of 14 July 1960, in accordance with the report published as House Document No. 112, 86th Congress, 1st Session. The project includes a 12- by 125-foot waterway from the Gulf Intracoastal Waterway to the Gulf of Mexico via a new channel to Leeville and Bayou Lafourche from Leeville to the gulf; a 9- by 100-foot waterway from Leeville to Golden Meadow; and a 12- by 125-foot waterway from Bayou Lafourche at Leeville to the Barataria Bay Waterway at Grand Isle. The channel from Larose to the Gulf of Mexico via Bayou Lafourche has been completed. The rest of the project is in an inactive status due to the lack of rights-of-way and disposal areas.

e. "Barataria Bay Waterway, Louisiana," project was authorized by the River and Harbor Act of 2 March 1919 and modified by the River and Harbor Act of 3 July 1958, in accordance with House Document Number 82, 85th Congress, 1st Session. This project as modified includes the enlargement and realinement of the existing project to provide a 12- by 125-foot waterway from the Gulf Intracoastal Waterway to the Gulf of Mexico at Grand Isle and a 12- by 125-foot channel in Bayou Rigaud along the north shore of Grand Isle. The project was completed in November 1963.

f. "Grand Isle and Vicinity, Louisiana," study was authorized by resolution adopted 26 September 1963 and 5 May 1966 by the Committee on Public Works of the House of Representatives, United States. This study resulted in the authorized plan for which this Phase I GDM was prepared which provides for a vegetated, sandfill dune with a 10-foot wide crown at an elevation of 11.5 feet mean sea level (m.s.l.)[1] and an 180-foot wide sandfill berm. The jetty was constructed by local interest as part of the authorized plan. This dune will provide protection from hurricanes having a frequency of once in 50 years. The District Engineer's report on this study was completed in October 1972.

AUTHORIZED PLAN

The authorized plan provides combined beach erosion control and hurricane protection from gulf waves driven by hurricanes having frequencies of up to approximately once in 50 years. The authorized plan is the same as the plan recommended herein, and is described on page 72.

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[1] All elevations and stages in this GDM are in feet mean sea level unless otherwise noted.

RESOURCES AND ECONOMY OF THE STUDY AREA

This section is intended to give the reader an understanding of the environmental, natural, and human resources of the Grand Isle area, and identifies and analyzes the economic, social, and other factors that have influenced past economic development and current trends in the area. This section also provides a frame of reference to help determine the area's water and related land resource problems and needs and to evaluate the impacts of alternative solutions.

ENVIRONMENTAL SETTING AND NATURAL RESOURCES

LOCATION. Grand Isle is located on the Gulf of Mexico in Jefferson Parish, Louisiana, about 50 miles south of New Orleans and 45 miles northwest of Southwest Pass of the Mississippi River. Grand Isle is the westernmost of the barrier islands lying across the mouth of Barataria Bay. The island extends about 7.5 miles in a generally northeast to southwest direction and is about 0.75 miles in width at the center. Grand Terre Islands are to the northeast and Cheniere Caminada, the mainland, is to the west of Grand Isle.

TERRESTRIAL FLORA. The vegetation on Grand Isle is similar to that found on other barrier islands in coastal Louisiana. The beach is generally devoid of vegetation due to wave action. Low dunes rise behind the beach, covered with sand binding plants such as morning glories. A flat meadow lies inland from the dune and is vegetated with grasses and sedges. Older, well developed, dunes in the center of the island are covered with trees and shrubs. Marshes exist in the low-lying areas on the north side of the island.

AQUATIC FLORA. Filamentous algae and attached diatoms exist on submerged marsh grasses, banks of bays and bayous, and exposed mud flats. These organisms contribute heavily to biological productivity in winter. Free-floating diatoms are common in the bay and gulf.

IMPORTANCE OF VEGETATION. Island plants are utilized for food by native wildlife at all times and during high water such usage is increased. Marshes furnish food, cover and habitat for a wide variety of animals because of interactions between terrestrial, fluvial, and estuarine conditions. One of the most important roles the marshes play is as a spawning/feeding/nursery area for fish and shellfish. Detritus from the marshes forms the basis of a food web that includes most sport and commercial species of fish and shellfish.

ENDANGERED AND THREATENED SPECIES. No plants listed in the "Federal Register" of 16 June 1976 as endangered or threatened species are expected to be found in the project area.

TERRESTRIAL FAUNA. The higher ground has a characteristic fauna such as deer, raccoons, opossums, rats, and mice. Numerous migrant birds utilize the trees and bushes of the islands as a resting stop on their northward or southward flights. A small population of lizards, snakes, toads, and frogs exists. Marshes provide habitat for primary consumers such as fiddler crabs, snails, muskrats, and puddle ducks. Predators come from a variety of groups such as wading birds, mammals and insects.

VECTORS. Species that transmit diseases to man or affect man's comfort include mosquitoes and biting flees and midges.

IMPORTANCE OF TERRESTRIAL FAUNA. A limited amount of trapping is conducted in the marshes. Waterfowl hunting is carried out in ponds. Grand Isle is a popular place for birdwatching during migration.

ENDANGERED AND THREATENED TERRESTRIAL SPECIES. The peregrine falcon is a migrant through the area. One of the two nesting areas for the brown pelican is near Grand Isle. The American alligator is considered threatened in the area.

AQUATIC FAUNA. The major detritus consumers in the bay and nearshore gulf are menhaden and mullet. Shrimp and most zooplankton also utilize detritus. Common predators include dolphins, anchovies, sea trout, drum, and crabs. Birds such as gulls and terns are also predators. Most nektonic species spawn offshore and larval stages migrate through the passes to inshore nursery grounds; major movements are inshore during the spring and offshore during the fall. Benthic organisms burrow in bottom sediments or utilize its upper surface. Benthic assemblages are determined by depth, salinity and grain-size of sediment. Typical organisms in the lower bay include clams, snails, crabs, and worms. The deeper, swifter waters of the pass harbor such species as sea urchins, sand dollars, clams, and snails. Shallow, nearshore bottoms support brittle stars, clams, and hermit crabs. Various crabs and beach hoppers burrow on the beach. Some organisms such as brown and white shrimp and crabs utilize all of these areas.

FISHERIES. Sport fishing is an important tourist attraction at Grand Isle. The Barataria Bay estuary system and adjacent gulf are among the most productive of Louisiana's waters. Between 1963 and 1973 they produced an average annual harvest of 1,083 pounds of harvestable seafood per acre compared to a state average of 378 pounds per acre. Shrimp and menhaden were the major cash crops.

ENDANGERED SPECIES. Three endangered species of whales and three endangered species of sea turtles are possible inhabitants of gulf waters off Grand Isle.

CLIMATOLOGY. The climate of this area is semitropical in nature. It is influenced by the proximity of the Gulf of Mexico with water temperatures along the Louisiana shore ranging from an average of 64° Fahrenheit (F.) in February to 84° F. in August. Southerly winds produce afternoon thundershowers during summer months while winter storms are of the frontal type in which showers generally last the duration of the storm. The area is vulnerable to the destructive forces associated with tropical hurricanes particularly in summer and early fall.

The average annual temperature in the Grand Isle area is 67° F., based on records of 13 to 98 years at stations in or adjacent to the study area. Monthly averages range from 83° F. in July and August to 57° F. in January. The maximum recorded temperature of 104° F. occurred at Houma on 22 June 1915, while a minimum of 5° F. was recorded on 13 February 1899 at the same location. In the period subsequent to 1949, Grand Isle experienced a maximum of 101° F. on 30 August 1954 and a minimum of 16° F. on 11 January 1962.

Precipitation is generally heavy with the greatest rainfalls occurring during the summer months due to frequent afternoon thundershowers. The average annual rainfall for the area is 62.8 inches with monthly averages ranging from 3.5 inches in October to 7.5 inches in July. These figures are based on records of 13 to 98 years from Weather Service stations in or adjacent to the study area. A maximum monthly rainfall of 21.1 inches was recorded at Burrwood in September 1957, while Grand Isle experienced 9.6

inches during the same period. The maximum monthly rainfall of 20.9 inches at Grand Isle occurred in September 1946. Burrwood rainfall during the same period was 16.8 inches. Measurable snow occurs infrequently. The last fall of consequence produced a maximum depth of 2.8 inches on 12 February 1958 at Grand Isle while other locations in the area reported smaller depths. Rainfall and other climatological data for this area are published in monthly and annual pamphlets by the National Weather Service entitled "Climatological Data for Louisiana." A summary of the data is presented in appendix B.

TIDES. The normal tide along the Grand Isle coast is diurnal and has an average range of approximately 1.2 feet, with a maximum range of about 1.9 feet. Normal tidal effects are observed as far inland as 40 miles. Storm and hurricane tides reach elevations of about 10 feet on the coast, and strong northerly winds in the winter depress gulf levels as much as 2.6 feet below m.s.l. Tide gage readings are available at three regular locations with 16 to 23 years of record. All of these locations have recording type gages from which hourly readings may be obtained. In 1956, high water pipes were installed at several points (see plate B-1) to record the maximum elevations reached by tides during tropical storms. Observed stages for regular locations are published annually in "Stages and Discharges of the Mississippi River and Tributaries and Other Streams and Waterways in the New Orleans District" by the US Army Engineer District, New Orleans.

FLOOD PROTECTION AND DRAINAGE SYSTEMS. Grand Isle has a low degree of protection against flooding by tropical storms and hurricanes. A sand dune along the beach front affords some protection against flooding from the Gulf of Mexico, and a few discontinuous low levees afford minor protection from flooding by high tides in

Barataria Bay. No drainage structures of significance exist and the island depends solely upon gravity drainage. The natural flow on the island is generally from the gulf to the bay.

WATER QUALITY. As is shown on plate A-1, dredged material borrow sites 1 and 2 are located just offshore of Grand Isle within the Gulf of Mexico. On 30 March 1978, samples of surface water and bottom sediment were taken at each of the two borrow areas and analyzed. Surface water samples exceeded 1976 EPA marine water quality criteria for the parameters mercury and zinc at both locations. All other parameters fell within established criteria for marine water.

For each sample location, a standard elutriate mixture was prepared to assess the potential which the proposed deposition of dredged material has on reintroduction of pollutants into the water column. Dredged material, composed predominantly of sand will be deposited principally for beach nourishment. Although restoration is specifically accepted for ocean dumping, elutriate test results for this project were compared with EPA marine water quality criteria in order to estimate the potential short duration impact which runoff from the fill operation would have on nearshore water quality. This data indicates that the standard elutriate mixture exceeded EPA marine water quality criteria for the parameters mercury, and nickel, at some or all of the sites tested. Mercury levels were exceeded at both our sites in both the ambient water samples and the elutriate samples. Nickel concentrations were exceeded at one of the two elutriate sites. No EPA criteria have been developed for zinc in marine waters; however, zinc was released in moderate amounts during the elutriate test.

The proposed dredging operation will cause a short term increase in turbidity from suspended solids both at the borrow sites and along the beach of Grand Isle. An examination of the elutriate values indicates that very minor increases in mercury, cadmium, zinc, and nickel, may occur from runoff from the proposed beach fill; however, only mercury and nickel may exceed criteria limits. These increased chemical concentrations should be effectively diluted in the surf zone along the shoreline. No significant pollutional stress to either the water near the dredge sites or the Gulf of Mexico along the shoreline should be induced by the dredging operation. During dredging there will be some short term temporary adverse impacts to contact recreation activities due to the increased turbidity in the immediate vicinity of the construction.

DEVELOPMENT AND ECONOMY

This subsection presents information on the development and uses of the environmental, natural, and human resources of the study area, particularly trends and projections.

PROJECTED POPULATION AND EMPLOYMENT. The population within the corporate limits of Grand Isle, which includes the eastern end of Cheniere Caminada, has increased from 1,190 in 1950 to 2,074 in 1960, and to 2,236 in 1970. The projected population for 1980 is 3,900 and for 2030 will be 12,600. The reduction in the growth rate between 1960 and 1970 was due to the widespread damage brought by Hurricane Betsy in 1965. Immediately following Betsy, it was estimated that the population had been reduced to about 500 people.

TABLE 1

POPULATION PROJECTIONS

Years	Projected Population
1970	2,236[1]
1980	3,900
1990	6,100
2000	8,400
2010	10,500
2020	11,500
2030	12,600

[1]1970 Census data for Grand Isle and Vicinity

In line with past trends, Grand Isle will continue to be a base of operation for large offshore petroleum and sulphur industries. It is also an important commercial fishing, sport fishing and recreational area for residents of Louisiana and nearby states. Of the 2,340 acres on the island, there are 682 acres devoted to residential and commercial development, 247 acres in industrial usage, and 231 acres in Government and public lands. This latter acreage includes 126 acres of state-owned beach designated as state parks--23 acres on the western end and 103 acres on the eastern end.

INDUSTRY. Industries within the area include a shipyard for repair of shrimp and oyster fishing vessels and other work boats, an ice plant, seafood unloading facilities, and oil storage and barge loading facilities. Extensive facilities for oilfield servicing and for operation of an offshore sulphur mine are located on the eastern end of Grand Isle. Numerous deep sea sport fishing charter vessels and commercial shrimping boats operate out of Grand Isle. Additionally, the Louisiana Superport will be located in the Gulf of Mexico south of Grand Isle.

MINERAL PRODUCTION. Extensive oil and gas fields exist in the offshore areas in the Gulf of Mexico. In terms of value, petroleum, natural gas, and natural gas liquids are dominant. Representatives of the oil companies indicate that future increases in the size of oil company installations are not anticipated.

TRANSPORTATION. The island can be reached by traveling US Highway 90 and Louisiana Highway 1 from New Orleans and by traveling Louisiana Highway 1 from Baton Rouge. Louisiana Highway 1 (two-lane asphalt and concrete) follows the west bank of Bayou Lafourche from Donaldsonville to Leeville, crossing Bayou Lafourche at this point, then continuing to the eastern end of Grand Isle. The elevation of the highway between Grand Isle and Golden Meadow ranges from approximately 2.5 to 5.0 feet. Above Golden Meadow the elevation of the highway crown increases gradually to about 7 feet at Larose. Louisiana Highway 308 (two-lane, blacktop) extends from Donaldsonville to Golden Meadow on the east bank of Bayou Lafourche. The only railroad service in the area consists of freight facilities of the Southern Pacific Line which extend down the east bank of Bayou Lafourche to the mills at Valentine. The island is also accessible by water and air. Oil companies have heliports and seaplane ramps at the eastern end of the island. There is also a private landing strip located several miles from Grand Isle on Cheniere Caminada.

UTILITIES. Natural gas, electric power, and telephone service are available to the area. Water supply is provided by Lafourche Parish Water District No. 1.

RECREATION. Grand Isle is a significant recreation and sport fishing center and is the major beach area on the Gulf of Mexico in Louisiana. The state park (126 acres in two tracts), is one of only two state-maintained public beaches on the gulf within the state. The island has suffered in the past as a recreation resource because of inadequate facilities such as trash pick-up, maintenance, shortage of potable water, and sanitary facilities. The beach, located along the gulf shoreline, is approximately 7 miles in length and varies from 25 to 400 feet in width. The existing beach is of adequate size if developed, protected, and nourished to offer a quality resource to the expected visitor load. The old wooden highway bridge across Caminada Pass was not demolished after construction of the new concrete bridge. With the center span removed, the remaining bridge spans are now used as fishing piers accessible from both ends and available to the public at no cost. At the present time a raised pavilion/bathhouse, a few picnic tables, and offstreet parking adjacent to the East and West Park roadways are the only other recreation facilities at Grand Isle. Despite these limited facilities, an estimated 349,000 visitors currently use the park beach. This estimate is based on fees collected and random sampling of day use. Visitation data for the period 1971 through 1977 are given below:

1971	1972	1973	1974	1975	1976	1977
428,560	511,351	597,952	278,966	378,426	396,358	348,950

Visitation has been sporadic in the past due to erosion of the beach which is intensified during the passage of a hurricane. Visitation showed a considerable reduction after Hurricane Carmen in 1974. Upon completion of beach repairs in 1975 under Public Law 288 visitation increased during 1975 and 1976. The reduced visitation in 1977 was primarily caused by shortages of fresh water at Grand Isle which required the closing of the West End Park. However, improvements to the water supply system by local interests are scheduled for the immediate future. Facilities being considered for future development at the East End Park include the provision of 300 tent sites, 50 trailer camp sites with water, electric hook-ups and a waste station, beach swimming areas, a visitor interpretative center with concessions, a raised deck with an 800-foot fishing pier, a crab and fishing pier with a fish cleaning station, boardwalk areas, picnic areas, entrance control point, park maintenance building and designated parking areas. Development on the west end will be limited to the provision of access, designated parking areas, and sanitary facilities.

OWNERSHIP AND ACCESSIBILITY OF SHORE. The total length of shoreline fronting the gulf is about 39,000 feet of which 8,000 feet are public state parks; 6,000 feet at the eastern end and 2,000 feet at the western end. There are 2,500 feet of road and street ends open to the beach. The remaining 28,500 feet of the gulf frontage is private but accessible to the general public.

PROBLEMS AND NEEDS

Beach erosion and hurricane protection are the primary problems and needs of the study area. Grand Isle is subject to severe damage from hurricanes because it is a fully exposed barrier island that fronts on the Gulf of Mexico. Hurricanes from the south, southeast, and southwest which approach the coastline in the vicinity of the study area cause widespread flooding and damage by the penetration of the hurricane surges inland across Grand Isle. Flooding has been experienced from both the gulf side and the bay side of the island. Hurricanes passing west of Grand Isle produce high stages along the gulf side of the island, inundating the entire island. Large waves associated with these hurricanes strike the flooded improvements causing widespread devastation. The force of these waves is the most significant cause of damage on the island. Hurricanes passing east or south of the island raise the stage of Barataria Bay due to surges entering from the gulf. As the winds change direction, floodwaters and waves from the bay are swept toward the island. Hurricanes have produced stages of 9 feet at Grand Isle. The Standard Project Hurricane for the area would produce a stage of about 10 feet at Grand Isle. Probable maximum hurricanes for the area would produce stages averaging about 17 feet over most of the study area.

Erosion of the gulf shore is also a serious and continuing problem. The sand beach area which is being eroded is particularly attractive to recreationists and is adjacent to the most heavily-developed portion of the island. In addition to the loss of the valuable and scenic beach front, many homes, business establishments, Louisiana Highway 1, and other public improvements are subject to damage resulting from erosion of the island.

Severe erosion of the western end of the island resulted in the loss of approximately 35 acres (March 1968 to May 1971) of land between the western tip of the island and groin number 1 (see plate 2). Before this erosion was halted by emergency work, it had stranded eight houses in the Gulf of Mexico and caused several housetrailers to be moved from their gulf front lots (see photographs 1 and 2).

FACTORS PERTINENT TO THE PROBLEM

ISLAND FORMATION. Approximately 4,000 to 5,000 years ago, sea level approached its present stand, having risen about 450 feet as a result of the melting of the Pleistocene continental glaciers. At that time, the Mississippi River began migrating back and forth across the gulfward advancing deltaic front. Approximately 1,200 years ago, the Mississippi River began to occupy the Lafourche course and to develop a delta to the south of what is now Lafourche and Terrebonne Parishes. When the Mississippi River abandoned the Lafourche course in favor of its present course to the Gulf of Mexico about 600 years ago, the effects of subsidence and erosion became the dominant process within the abandoned Lafourche delta. The gulfward edge of the abandoned delta began a landward retreat, forming arcuate, sandy delta margin islands with well-developed beaches that are the result of reworking and winnowing of the deltaic-front materials. Grand Isle, which flanks the seaward end of the abandoned Lafource delta, is an example of these delta margin islands, having originated as a baymouth spit initially attached to the marshes at its western end.

Photograph 1 Critically eroding West End of Grand Isle

January 1971

Photograph 2 West End of Grand Isle after Completion of Emergency Work.

August 1972

LITTORAL MATERIALS. Generally Grand Isle consists of a series of low, arcuate sand beach ridges curving bayward away from the gulfward facing edge. The thickness of the fine beach sand varies from 15 to 30 feet and is underlain by a considerable thickness of silty sands. Borings taken on the island and in the surrounding area indicate that the material becomes finer with depth and with distance landward and gulfward of the island. Additional information concerning the availability of sand and characteristics of the materials comprising Grand Isle and the surrounding area are contained in appendix A.

The main source of sediments for development of Grand Isle has been the recent materials winnowed and reworked through erosion of delta-front material of the old Lafourche delta located to the west of Grand Isle. The granular size of this material currently being supplied to the island is so small that it is quickly carried away by wave action and by the prevailing west-to-east littoral current. As a result, the gulfward facing beach at Grand Isle is receding at varying rates with maximum recession occurring on the western half of the island. Possible sources of sand for beach replenishment include Cheniere Caminada on the mainland, locations just offshore at the western and eastern ends of the island, and just north of the western edge of Grand Isle in Caminada Bay.

HURRICANES OF RECORD. The Grand Isle area has experienced numerous severe hurricanes, but only a limited history of storms exists because records and factual documentation are lacking. Prior to 1893, there were no official meteorological records. Available historical records are mainly from newspaper accounts and, because the area was sparsely developed, accounts were limited only to dramatic stories of damage and loss of life.

Very little factual information is recorded for three storms that struck during the period between 1831 and 1886. The first, in 1831, inundated "Barataria Island" (probably Grand Isle) to a depth of 6 feet, destroying a fishing village and causing 150 fatalities. In 1856, a tropical storm struck the area causing extensive flooding. A storm in 1886 caused 3 feet of water to flow over Cheniere Caminada.

The worst storm with respect to fatalities occurred in 1893. This storm struck without warning, allowing no time for evacuation. Approximately 1,150 persons were drowned on Cheniere Caminada and 18 on Grand Isle as winds over 100 miles per hour (m.p.h.) lashed the coast. A central pressure of 28.65 inches of mercury was recorded. One hundred and fifty luggers were sunk and a shrimp processing factory was destroyed. Fort Livingston was severely damaged except for the lighthouse.

Another severe storm in 1909 caused considerable destruction of property because of high tides. On 20 September the storm struck the coast on a northwesterly track. The central pressure of the storm was 28.94 inches of mercury and winds of 50 m.p.h. were reported east of the area and 80 m.p.h. west of the area. The wind direction during the approach of the storm was such that a large amount of water was pushed ahead of the storm. Grand Isle experienced a very high tide and was covered by 2 feet of water. Manila, in Barataria Bay, was washed out completely.

The first hurricane in 1915 occurred on 17 August and had a central pressure of 28.14 inches of mercury. This hurricane approached the coast on a northwesterly track and although it struck approximately 250 miles to the west, it caused severe flooding along the entire central coast of Louisiana. The Barataria

Bay area was struck by 8-foot waves. Grand Isle was inundated to a depth of 6 feet in some parts. This storm illustrated that flooding of land areas by tides can result from storms which pass a considerable distance away.

The second hurricane of 1915 struck on 29 September and passed over the study area on a northerly track with high winds. Burrwood, to the east, reported winds of 94 m.p.h. maximum velocity for 5 minutes with gusts up to 106 m.p.h. There was extensive flooding in the coastal area. Grand Isle had tides of 9 feet and was almost a total loss. Most of the livestock that survived the August storm drowned during this storm. Although 275 deaths were reported on the lower coast, the loss of life was minimized by the excellent warnings that were issued. The Weather Service in New Orleans analyzed the storm potential in time to warn the coastal areas by telegraph and telephones.

On 26 August 1926, a storm having a central pressure of 28.31 inches of mercury passed through the western part of the area but did not cause any appreciable damage.

On 7 August 1940, a storm with a central pressure of 28.76 inches of mercury passed approximately 25 miles south of the area on a westerly track. Neither winds nor tides caused much damage but the rainfall associated with the storm produced considerable damage.

On 24 September 1956, Hurricane Flossy struck the area causing tidal damage in the outlying islands and marshy mainland. The central pressure in this storm was 28.76 inches of mercury. Grand Isle was again flooded to a depth of several feet when water, which had been driven behind the island through Barataria

Bay, moved into Caminada Bay and inundated the island from the back side with stages of 8 feet at the rear and 3.9 feet at the front.

Hurricane Carla, 9-14 September 1961, passed inland approximately 400 miles west of the study area. Carla, with a minimum central pressure of 27.50 inches of mercury and a large radius, was one of the most severe gulf hurricanes of this century, and caused high tides and attendant extensive inundation of the low lands along coastal Louisiana. Along this coastline, sustained winds generally were less than 50 miles per hour and tides ranged from about 3.5 to 7.5 feet. Louisiana Highway 1, which serves as the only vehicle escape route for residents of Grand Isle, was inundated from 9 to 13 September at several locations.

Hurricane Hilda crossed the Louisiana coast about 100 miles west of Grand Isle during the evening on 3 October 1964. At the time of entry on the coast, winds were 98 m.p.h. and the central pressure was 28.00 inches. Hilda caused heavy damage to offshore and coastal oil installations in the vicinity of Grand Isle and generated surge heights of 4.0 feet at Grand Isle and 5.5 feet to the east and west of the island. The hurricane caused considerable damage to the beach at Grand Isle and cut through the western end of the island and Cheniere Caminada.

The most destructive storm of record for the Louisiana coast and one of the greatest storms of the century, Hurricane Betsy, struck just west of Grand Isle on the night of 9 September 1965. Winds of 100 m.p.h. with gusts up to 160 m.p.h. were reported at Grand Isle while the island experienced a maximum surge height of 8.8 feet. The central pressure was 27.79 inches of mercury. The entire island was inundated and practically all buildings with the exception of three were either swept away, demolished, or severely damaged by the onrushing surge and waves. The entire beach and adjacent sand dunes were swept back over the island by the high surge. The coastal highway was covered with 3 feet of sand in some places and was severely eroded in others. Aerial photographs 3 and 4 depict some of the damage caused by Hurricane Betsy.

In 1974, Hurricane Carmen caused an estimated $1,083,000 in damages in Jefferson Parish including moderate damages to Grand Isle. The sand dune running the length of the island was washed inland by the tides causing silt and sand to be deposited over an extensive area. Following Carmen, the placement of 300,000 cubic yards of sand was required to restore the natural dunes. This work was completed in 1975 under Public Law 288, at a total cost of $1,088,000. The dune restoration was performed according to specifications prepared by the US Army Corps of Engineers. The dune was rebuilt to a crest elevation of 7 feet, a top width of 10 feet, a gulfside side slope of 1V on 10H to an elevation of 4 feet, a 1V on 25H to existing slope and a landside slope of 1V on 4H.

On 4 September 1977, Hurricane Babe approached the mouth of the Mississippi River; drifted westward offshore; then moved northward during the night; and crossed the coast near Point au Fer on the morning of the 5th, some 85 miles west of Grand Isle. Hurricane Babe was a minimal hurricane with winds of 75 m.p.h. for only a brief period. Highest gusts at the Grand Isle Coast Guard Station were from the southeast at 53 m.p.h. at 1:30 a.m. on 5 September. Bayou Petite Caillou at Cocodrie had a high water mark of 8.66 feet. Leeville had a recorded stage of 4.0 feet and the highest stage recorded on the landside of Grand Isle at the Bayou Rigaud gage was 3.7 feet. The restored sand dune built

Photograph 3 Damage on Grand Isle after Hurricane Betsy

September 1965

Photograph 4 Damage on Grand Isle after Hurricane Betsy

September 1965

after Hurricane Carmen was breached and destroyed for a length of 3,000 feet.

Other minor hurricanes struck Grand Isle in 1895, 1897, 1900, 1923, 1936, 1941, 1948, 1949, two in 1957, one in 1969, and one in 1971. The damage from these storms was either slight or was not documented.

HURRICANE CHARACTERISTICS. A hurricane is a well-developed cyclonic storm, usually of tropical origin. Hurricane characteristics include violent, counter-clockwise winds in the northern hemisphere, producing tremendous waves and surges and torrential rainfall. Size and duration vary with each hurricane. They generally extend over thousands of square miles, reach a height of 30,000 feet or more, and last about 9 to 12 days from origin to dissipation.

Hurricanes originate exclusively in the shifting zone of equatorial calms called the "doldrums" which lie between the two trade wind systems. Early in the hurricane season, June and July, there is a tendency for the storms to develop in the western Carribean Sea, while late in the season, September and October, storms are more likely to develop in the Atlantic Ocean. While still in the initial stages of development, the storms are affected by the trade winds and begin to move toward the west or northwest. In the vicinity of 30 degrees N. latitude, they recurve and begin to move in a northeasterly direction at an accelerated speed. This is only a very general path that hurricanes follow and actually there are many deviations. Hurricanes have been known to circle back and cross over their paths.

Normal barometric pressures in the tropics are about 30 inches of mercury, whereas the pressures recorded in hurricane centers range between 27 and 29 inches or sometimes even lower. The wind system of a hurricane follows a counter-clockwise circular pattern with the wind direction deflecting about 30 degrees inward toward the center of the storm. At the outer limits of the storm, the winds are light to moderate; at about 35 miles from the center, they reach a maximum 5-minute average velocity of about 100 m.p.h. although higher averages have occurred. Gusts as high as 175 m.p.h. have been reported. At the center, winds are relatively calm. This calm area, called the "eye" of the storm, ranges between 7 and 20 miles in diameter. The point of lowest barometric pressure is located in the vicinity of or within the eye. The lowest recorded barometric pressure for hurricanes occurring along the gulf coast is 26.35 inches.

The hurricane surge which inundates low coastal lands is the most destructive of the hurricane characteristics. It alone accounts for three-fourths of the lives lost from hurricanes. It is the product of meteorological and beach, shore, and inland topographic conditions. All other factors being equal, a higher surge will be produced if the hurricane path is perpendicular to shore, the velocity of forward movement is fast, or the diameter of the storm is very large. Maximum surge heights experienced along the gulf coast range between 10 and 25 feet.

The waves generated by hurricane winds cause extensive damage to shore structures. At sea, the waves are high and turbulent, particularly in the right front quadrant and near the eye of the storm. Near shore, wave heights which have diminished some since origin, begin to increase again because of the shoaling effect of the shallow water. Further, breaking waves can run up and overtop shore structures whose crowns are higher than the wave heights. The force expended when waves break causes the most damage to shore structures.

Rainfall accompanying a hurricane usually is heavy and sometimes torrential. However, its distribution during the passage of a hurricane is not uniform. The rain may begin long before arrival of the storm. Prior to the passage of the eye, rainfall generally reaches its maximum rate, and after the eye has passed it ceases almost entirely. Rainfall is particularly heavy in the right front quadrant. Some hurricanes, however, are accompanied by little or no rainfall over considerable lengths of their paths.

STANDARD PROJECT HURRICANE. A standard project hurricane (SPH) is one that may be expected from the most severe combination of meteorological conditions that are considered reasonably characteristic of the region. The general SPH that is characteristic of the Louisiana coast was developed in cooperation with the National Weather Service and corresponds to one having a frequency of once in 100 years in the northern gulf. This frequency is adjusted for application to the individual study area. A detailed coverage of derivation procedures and frequency computations is presented in appendix B. The specific SPH for the study area has a central pressure index (CPI) of 27.5 inches, maximum wind velocity over water of 100 m.p.h. at a radius of 35 miles, a forward speed ranging between 5 and 18 m.p.h., and a recurrence frequency of once in about 200 years. However, each location in the study area requires a particular path to produce critical effects. For critical flooding of Grand Isle from the gulf, a path similar to the September 1915 hurricane, but transposed to the west, is required. A path similar to that of Hurricane Flossy, September 1956, is critical for flooding Grand Isle from Barataria Bay. The parameters of Hurricane Betsy, September 1965, exceeded those of an SPH in all respects except CPI, and would have been more critical to Grand Isle had the path been more to the west. An occurrence of a hurricane on a critical path with SPH characteristics would produce a stage of 9.9 feet in the study area. Detailed data related to these hurricanes are presented in appendix B.

PROBABLE MAXIMUM HURRICANE. The probable maximum hurricane (PMH) is one that may be expected from the most severe combination of critical meteorological conditions that are reasonably possible for the region. It has an infinite recurrence period. The specific PMH for the study area has a CPI of 26.9 inches and a maximum wind velocity of 146 m.p.h. at a radius of 35 miles for forward speeds ranging between 5 and 40 m.p.h. Critical hurricane paths are identical to the ones used for the SPH. An occurrence of a hurricane with PMH characteristics would produce a maximum surge height of about 17 feet at Grand Isle. Detailed data are presented in appendix B.

HURRICANE FREQUENCIES. Hurricane frequencies for Grand Isle were computed, using both the observed and synthetic data, and the results obtained by both methods were in close agreement. A detailed discussion of methods used in the computation of hurricane stage-frequencies is presented in appendix B. Computed stage-frequency relationships for the Grand Isle area are shown in table 2.

TABLE 2

STAGE-FREQUENCY

Frequency	Stage (feet)
Probable Maximum Hurricane	17.0
Standard Project Hurricane	9.9
100-year	9.3
50-year	8.5

SHORE HISTORY. Prior to 1951 no major effort had been made by any entity other than individual private property owners to control beach erosion. Protection was provided privately by vertical bulkheads extending only across the gulfward front of individual lots. The bulkheads were incongruous and irregular and were constructed to suit the means and needs of the individual owner. These isolated structures were generally ineffective, as they created accelerated erosion immediately gulfward of the bulkhead and caused the structure to fail gulfward with no beneficial effect on the regimen of the shore.

In 1951 and 1952, the Louisiana Department of Highways made the first major effort to stabilize the shore with groin fields at two locations where erosion threatened Louisiana Highway 1 along the front of the island. Fourteen timber groins were constructed by the Department of Highways at an initial cost of $480,000. Four groins, numbered 1 through 4 from west to east on plates 2 and 3, were constructed between station 342+00 and station 315+00, and 10 groins numbered 5 through 14, on plates 3 and 4, were constructed between stations 200+43 and 129+29. Groins numbered 1 through 8 are 500 feet in length and those numbered 9 through 14 are 250 feet in length. These timber sheet pile groins are supported by round timber piles spaced on 5-foot centers. The groins are spaced between 800 and 1,000 feet apart with a horizontal shore section constructed to an elevation of 4 feet. The horizontal offshore section was constructed to elevation 2 feet with a transition slope upward to the shore section. The longer groins were placed on the western side of the field. At the time of construction, it was thought that the predominant direction of littoral drift was east to west, based on a previous cooperative study in 1935. However, a later study (1954) demonstrated that the groin fields were ineffective and, in fact, the direction of littoral drift was from west to east. No maintenance has been performed on any of these groins since their initial construction. They are partially destroyed at the offshore ends as a result of erosion, undermining, rust, marine borers, and general rotting of the timber members. At this time no future maintenance is planned by local interests to restore the groins. Recommendations in the 1954 report provided for the placement of 1,200,000 cubic yards of suitable material within the two groin fields described above and for the construction of a jetty adjacent to Barataria Pass.

The State of Louisiana, Office of Public Works, placed 1,150,000 cubic yards of sand as artificial nourishment within the groins in 1954 and 1955 at a cost of $188,000. Approximately 350,000 cubic yards of sand were placed between groin numbers 1 through 4 and 800,000 cubic yards between numbers 5 and 14. Field surveys were taken in June 1954 prior to nourishment and in March 1955 after nourishment had been completed. Comparative profiles made in March 1955 indicated only a 745,000-cubic yard gain over the June 1954 survey. This indicates that 405,000 cubic yards of artificial nourishment were lost from the groin system in less than 1 year. However, the downdrift beach east of each set of groins indicated a marked gain in width and volume due to the lost material being carried eastward and being deposited along shore by littoral drift. Aerial photographs 5 and 6 depict the shoreline after nourishment was completed. Results of this effort to stabilize the beach were satisfactory but in 1956 Hurricane Flossy struck, first driving a surge over the island from the gulf side thus filling Barataria and Caminada Bays to the rear of the island, then driving a surge over the island from the bay side to the gulf side. The low dunes along the beach front were not of sufficient height to prevent sheet flow over the island and erosion and scour occurred adjacent to many structures causing them to fail.

Photograph 5 Groins 1 through 4 after Artificial Beach Nourishment

March 1956

Photograph 6 Groins 7 through 14 after Artificial Beach Nourishment

March 1956

Louisiana Highway 1 was undermined at many places along its length. Many residences and business establishments were totally destroyed and much of the artificial nourishment previously placed was carried away, either onshore, into the back bays, or offshore. Aerial photographs 7 and 8 show the damage caused by Hurricane Flossy.

In October 1956, Humble Oil and Refining Company constructed a timber groin on the east side of property owned by the company and placed material dredged from the offshore bottom on the west side of the groin. The groin projected 500 feet gulfward from the shoreline at station 83+00 and was similar to those previously constructed by the Louisiana Department of Highways. The shoreward 300 feet of groin was constructed to an elevation of 4 feet with a transition to elevation 2 feet for the remaining 200 feet offshore. Material used to fill the groin was dredged from the offshore bottom at a point 2,000 feet offshore. This groin appears to have been more effective than those constructed by the Louisiana Department of Highways. However, this groin is in the fillet of material trapped by the east end jetty, thus the efficacy of this groin cannot be analyzed. No maintenance has been performed to date and this groin is in good condition.

Subsequent to Hurricane Flossy in 1956, the Louisiana Office of Public Works, with emergency Federal funds, placed an estimated 140,000 cubic yards of sand along 4 1/2 miles of beach in 1957 at a cost of $76,000. Initial estimates of quantities indicated 350,000 cubic yards of artificial nourishment would be needed to build the dune line; however, preconstruction surveys revealed that natural swell action following Hurricane Flossy had restored and rebuilt the beach and a much smaller quantity of material was needed to reestablish the barrier dune.

Photograph 7 Grand Isle after Sheet Flow from Hurricane Flossy

October 1956

Photograph 8 Grand Isle after Sheet Flow from Hurricane Flossy

October 1956

The Louisiana Office of Public Works constructed a jetty approximately 1,000 feet west of the eastern end of the island in 1958 and 1959 at a cost of $150,000. The jetty is approximately 935 feet long, and built perpendicular to the shoreline at station 16+00. It was founded on a timber mattress and had a 6-foot crown width at elevation 3 feet and 1 on 1.5 side slopes. The 1954 cooperative study indicated that this jetty would trap a large quantity of sand at the expense of the downdrift shoreline adjacent to Barataria Pass. Within a period of 4 years following its construction, the jetty had trapped more than 1 million cubic yards west of the jetty. However, the effects of the jetty extended eastward where 30 acres of the island were completely lost. Aerial photograph number 9 taken in February 1960 and number 10 taken in September 1962 show the jetty and shoreline changes which took place in that time interval.

The Louisiana Office of Public Works placed 350,000 cubic yards of sand within the 10 groins near the center of the island in 1961 and 1962 to repair the damage done by Hurricane Carla in 1961 and supplement repairs for damages done by Flossy and several tropical storms since 1956. The cost of this work was approximately $115,000 (see table B-10, appendix B). A significant loss occurred within the eastern groin field (station 133+10 to station 196+80), during this period while the adjacent shore on both sides of the groin field was relatively stable.

In 1964, the Louisiana Bonding and Building Commission together with the Louisiana Office of Public Works, extended the jetty adjacent to Barataria Pass 1,400 feet. Aerial photograph 11 shows the new 1,400-foot section extending gulfward from the end of the original jetty. Essentially the same cross section was used for the extension as was used in the initial construction

Photograph 9 Accretion on Southwest side of newly constructed jetty on East End of Grand Isle

February 1960

Photograph 10 East end jetty approximately 3 years after construction

September 1962

Photograph 11 East end jetty after its extension in 1964

August 1965

except for a 400-foot segment which had to be founded on a shell bedding when the contractor ran out of lumber mattresses. The extended jetty began immediately to trap sand which otherwise would have flanked the shorter jetty around its outer end. A large shoal formation east of the jetty began to erode again but the erosion was only temporary. Within 1 year the jetty had trapped sufficient sand to essentially fill the offshore bottom on the west side of the jetty and littoral drift began to flank the jetty again. The accretion caused by the jetty extended 9,000 feet to the west along shore and amounted to 1,250,000 cubic yards. The cost of this work was approximately $200,000.

In 1965 Hurricane Betsy caused extensive damage to the entire island. The dune line along the island, with the exception of a short segment within the westward groin field, was destroyed. Aerial photographs 3 and 4 show changes caused by Hurricane Betsy along the western 5 miles of beach. The jetty was flanked at its shoreward end, the 400-foot segment of jetty founded on shell bedding failed, and the large shoal formation east of the jetty was scoured away by the inward flow of storm-driven tide. Following Betsy 550,000 cubic yards of sand were borrowed from the accreted area west of the jetty to restore the natural dunes which had been destroyed previously. This work was done in 1966 under Public Law 875-81 by the Louisiana Office of Public Works under a reimbursable agreement with the Federal Government through the Office of Emergency Planning. The total cost of the work was $447,000. The dune restoration was performed according to specifications developed by the US Army Corps of Engineers. The dune was reconstructed to a crest elevation of 8 feet, a top width of 10 feet, a gulfside side slope of 1 on 4 to elevation 5 feet, a 1 on 25 berm slope to elevation 3 feet, and a 1 on 15 beach slope to existing ground. The landside slopes were 1 on 4 from top of crown to elevation 5 feet, and 1 on 15 from elevation 5 feet to existing ground. Along the western 6,000 feet of the island the shoreline had receded as much as 450 feet, prior to the emergency construction described on page 49, and this erosion had completely consumed the dune section within this reach and left several beach homes stranded in the gulf waters. Along the remainder of the island, natural species of beach grass and shrubbery have been established and now help trap or prevent loss of wind-blown sand.

Repair of the jetty was also completed in 1966 with funds provided through the Office of Emergency Planning, when it was determined that the jetty would not function properly if it were not tied into the shore and repaired where failure had occurred. The cost for the tie-in and repair work was $25,000 and $83,500, respectively. The Corps of Engineers contracted for the jetty repair work which was completed in April 1966.

As previously stated, a large shoal east of the jetty was severely eroded by Hurricane Betsy. As a result of this damage, erosion east and north of the landward end of the jetty continued at a rapid rate and began to threaten the construction and continued existence of the new US Coast Guard Loran Station on the eastern end of the island, photograph 12. The US Coast Guard, using limited funds ($27,000) and manpower, constructed a revetment on the northeast side of the station in August 1967. The revetment was constructed along approximately 1,000 feet of existing shoreline between elevations minus 1 and 2.5 feet. The material used was a pliable nylon container sewn to form individual quilted compartments or pockets. A sand-cement mixture was shot under pressure into the individual compartments after the 30- by 15-foot blankets were placed on a prepared slope. Each blanket was placed so that some overlapping occurred at each side of each blanket.

Photograph 12 East end jetty and threatened U. S. Coast Guard Station

April 1969

The cement hardened to form a rigid shell of concrete which conformed to the contours of the graded bank slope. Inspection of the revetment in December 1968 revealed that approximately 900 feet had failed as a result of wave overtopping, uplift pressure, and leaching of the foundation which, in turn, left an unsupported shell which subsequently cracked and broke up under wave action.

With the failure of that revetment and continued erosion at the Coast Guard station, the US Coast Guard requested assistance in the design and subsequent construction of a more permanent-type structure along the problem shore. As a consequence of detailed studies by the New Orleans District, a rubble mound revetment which would tie into the existing jetty was determined to be the most feasible method of controlling erosion. This revetment was constructed by the New Orleans District for the Coast Guard to elevation 6 feet along approximately 1,400 feet of pre-erosion shoreline in an effort to restore the original property purchased by the Federal Government in 1965. Approximately 7.6 acres of property had been lost since the purchase. Aerial photograph 13 shows the completed revetment and the remnants of the former one. The cost of the revetment (completed in February 1970) was $176,000. This revetment was designed to protect against a 5-foot wave accompanying a storm surge having a 10-year recurrence interval and has performed satisfactorily to date. No maintenance has been necessary since construction.

After passage of Hurricane Carmen in September 1974, the sand dune at Grand Isle was restored along the length of the island, as described on page 26. This work was performed between the months of August 1975 and May 1976. Minor storms occurred during that period and difficulty was encountered in maintaining the designed cross section, which did not include the 200-foot beach berm

Photograph 13 East end of Grand Isle after construction of U. S. Coast Guard revetment

January 1971

recommended herein. In fact, the dune was built very close to the shoreline at some locations. The winter storms that occurred during and soon after construction overtopped the crest of the dune which was built to an elevation of 7 feet, causing significant damages to the portion of the dune located between stations 250+00 and 315+32, from the Grand Isle library westward to groin number 4. In addition, in September 1977, Hurricane Babe crossed the Louisiana shoreline in the vicinity of Point Au Fer, about 85 miles west of Grand Isle. The 53 m.p.h. winds associated with this storm destroyed 3,000 feet of the "restored" dune built in 1975 and 1976.

PREAUTHORIZATION CONSTRUCTION BY LOCAL INTERESTS. In view of the imminent danger to property on the western end of the island and the fact that the Corps of Engineers had no authority or funds available to construct emergency works of the magnitude required to halt the erosion, the Louisiana legislature appropriated $1 million for the emergency work in 1971. The construction of a jetty along the western end of Grand Isle and placement of sandfill on its landside, in accordance with the authorized plan, was completed in July 1972 by contract of the Louisiana Office of Public Works. By letter dated 17 June 1971 the Louisiana Office of Public Works requested that monies spent by the state for this emergency pre-authorization construction be credited toward the non-Federal share of the first cost of the proposed Federal project, when and if a Federal project is approved.

SHORE PROCESSES PERTINENT TO THE PROBLEM

LITTORAL TRANSPORT. The predominant direction of littoral transport along the central portion of the island between stations 95+00 and 350+00 is from west to east. This direction is largely determined from observations of the wind and wave climate, from studies of refraction and diffraction diagrams, from recent experience with artificial nourishment, and from observations of accretion on the west side of littoral barriers and erosion on the east side. Between stations 350+00 and 397+00 on the western end of the island, the littoral current direction is variable according to the prevailing tide, being eastward during ebb flow and westward during flood flow. This tidal current is reinforced or reduced according to the wave direction of approach prevailing at any time. This is determined from current observations made in 1935, from visual observations and aerial photographs made since 1950, and from studies of bar formation cycles in Caminada Pass and alongshore east of the pass. Aerial photographs taken in February 1965 at low tide show two separate channels through Caminada Pass--one channel following the western shore of the pass and another following the eastern shore of the pass. A large bar formation is present between the two channels, as shown on photograph 14.

Along the eastern third of the island between stations 95+00 and 16+00, the predominant direction of littoral transport is toward the east. At present the direction of the ebb current is easterly about 120 degrees and the jetty extends 2,400 feet offshore from the 1958 shoreline. Waves approaching from the east occur less than 3 percent of the time and are intercepted by the jetty; therefore, these waves have little effect on shore processes. Before construction of the jetty, the direction varied with the tidal flow, being eastward during south or southwesterly wave action and flood tide and being westward during ebb tide, opposing the littoral currents caused by south or southwesterly wave action. Southeasterly wave action tended to reinforce alongshore flood currents near the passes and reduce the alongshore ebb currents. This determination is a result of wave refraction and diffraction studies for waves approaching from deep water directly onshore.

Photograph 14 Offshore bar at entrance to Caminada Pass (White Water Area) and partially attached onshore bar at West end of Grand Isle

February 1965

The only major littoral barrier of consequence in the study area other than the two passes is the jetty. Prior to its construction, the shore showed a general recession. Within 3 years after initial construction, more than 1 million cubic yards had been trapped by the jetty. This would indicate an average littoral transport rate exceeding 300,000 cubic yards annually had occurred along the island. After the 1,400-foot extension in 1964, an additional 1.25 million yards of accretion occurred along the eastern 2 miles of shore in 4 years including that lost as a result of Hurricane Betsy. Again this average would be in excess of 300,000 cubic yards per year.

The variability of littoral transport along the front of Grand Isle is dependent upon two factors--the absence or presence of a trailing sand spit joining the western lip of Caminada Pass and extending into Caminada Bay (photograph 15) and the absence or presence of an onshore bar east of Caminada Pass extending eastward parallel to the shoreline for several thousand feet, photograph 14. The trailing sand spit is shown extending into Caminada Bay on the aerial mosaic, plate 2. During each hurricane or tropical storm, some material is lost to abnormal flow through the pass. Following the storm, littoral material is trapped in the trailing spit until its deficiencies are satisfied. The onshore bar forms as an offshore bar approximately in the center of Caminada Pass, as shown in photograph 16, and migrates eastward readjusting to conform to the eastern lip of the pass and the gulf shoreline, as shown in photograph 17. This offshore bar is estimated to store 1 million cubic yards over a cyclic period of 3 years before the bar finally attaches itself to the western 4,000 feet of shoreline, as shown in photograph 18. The onshore bar then proceeds to erode and nourish the downdrift shoreline. During the bar formation and subsequent to its migration toward the east, it is evident that littoral

Photograph 15 Trailing sand spit along Western Lip of Caminada Pass

January 1971

Photograph 16 Center bar formation (Light Area) and channel along Western side of Caminada Pass

January 1971

Photograph 17 Offshore bar in process of becoming attached to West end of Grand Isle

May 1956

Photograph 18 West end of Grand Isle after attachment of bar

April 1969

transport along the island shoreline is reduced. Photograph 1 shows the eastern lip of Caminada Pass near the western tip of the island in a critical state of erosion.

SUPPLY OF LITTORAL MATERIALS. Experience gained from studies made after construction of the jetty at the eastern end of the island indicates that there is not a quantitative deficiency of littoral material at present. The source of littoral material to the west of Grand Isle is not yet depleted and is likely to continue to provide material for a number of years in the future. In addition, the jetty has been used effectively as a littoral trap to intercept and store material until it is needed. More than 1 million cubic yards of suitable material were available for beach restoration following Hurricane Betsy, although only 550,000 cubic yards were needed. Since 1954, more than 2 million cubic yards from various sources have been placed on the beach in efforts to restore it and stabilize problem reaches.

MANNER OF MOVEMENT OF LITTORAL MATERIAL. Problem conditions in the recent past have been caused primarily by hurricanes and tropical storms, but occasionally frontal storms associated with low pressure systems and Arctic air masses have raised water levels 2.5 feet or more above normal high tide and have caused limited local erosion. Table B-10, appendix B, summarizes the movement of littoral materials within the limits of the surveyed ranges between stations 72+00 and 337+00. The most significant erosion losses occurred during Hurricane Betsy in the open stretch between the two groin fields, i.e., between stations 235+26 and 259+00. With the exception of Betsy, the most significant erosion occurred within the eastward groin field between stations 133+40 to 173+45, a reach which has the shortest groins. Groin numbers 9 through 14 are 250 feet and groins 5 through 8 are 500 feet long. Moderate to severe storms in

1958, 1959, 1960, 1961, 1963, 1964, 1965, 1969, and 1970, were primarily responsible for eroding the beach. The eastern 2 miles of the island has experienced accretion and is relatively stable. The rapid recession of the shoreline along the western 4,000 feet of the island is the result of storms during August, September, and October 1970 which have caused rapid surge inflow into Caminada Bay through Caminada Pass. The unusually high alongshore currents caused by the surge rapidly eroded the unstable lip of Caminada Pass causing a loss of 15 acres in 4 months.

The island is low, ranging between elevations 3 and 5 feet. Storm surges and consequent wave action and free flow (sheet flow) work together to either drag beach material off the beach and deposit it offshore or carry the material inland and deposit it north of the highway. Results of this action are depicted vividly in photographs taken following Hurricanes Flossy and Betsy. The predominant direction of movement of beach material is determined solely by the height of the storm surge. Less severe storms which generate surges to elevations less than about 4.5 tend to degrade the beach and deposit the material offshore. Severe hurricanes, which generate surges greater than 4.5 feet, cause sheet flow and wave action to occur over the island. Both methods of degradation occur for such severe hurricanes.

FUTURE SHORE CONDITIONS. The findings presented in the 1954 report concerning the cyclic shoreline changes along the eastern lip of Caminada Pass have been verified by studies of aerial photographs and actual observation. In the spring of 1968 an offshore bar was visible at low tide along the eastern lip of Caminada Pass. By the spring of 1969, this offshore bar had migrated eastward and had become integral with the 1968 shoreline, as shown on photograph 18. In August 1970 this bar began to erode and by February 1971 had completely disappeared. At about the same time aerial photographs flown in January 1971 showed an offshore bar in the early stages of development forming in the center of Caminada Pass (photograph 16).

The island will continue to experience high surges and wave action. It is unlikely that man's efforts to control the weather will meet with measurable success in the near future.

The data presented on shoreline changes dating back to 1877 indicate that the island has changed configurations about a relatively stable midpoint or node--the eastern half accreting while the western half is eroding and vice versa. Construction of the jetty at the eastern end is affecting the pattern along the eastern third of the island by tending to stabilize that segment. The remainder of the island including the node about which long term changes have occurred will continue to recede at an average rate as shown in table 3. Such erosion would soon endanger the alongshore highway and stifle economic growth of the region. Littoral material from the abandoned Lafourche delta to the west of Grand Isle will likely continue to nourish the island for another 50 to 100 years. However, the occurrence of a severe hurricane such as Betsy at the same time that the eastern lip of Caminada Pass had depleted its cyclic nourishment could have disastrous results. Total erosion of the western 2,500 feet of the island could cause total loss of any vehicular connection with the mainland.

TABLE 3

EXPERIENCED AND PREDICTED RATES OF SHORELINE EROSION
in feet, referenced to mean high water

Ranges	Total change 1932-1953	Annual rate	Total change 1958-1970	Annual rate	Predicted annual rate
72+00	-180	-9	+635	+58	0
80+00	-280	-13.5	+335	+30.5	0
88+00	-360	-18	+190	+17.5	0
95+57	-300	-14.5	+139	+13	-5
133+10	-220	-10.5	-32	-3	-10
141+50	-240	-11.5	-48	-4.5	-11
149+40	-250	-12	-52	-5	-12
157+45	-240	-11.5	-40	-4	-12
165+25	-260	-12.5	0	0	-12
173+45	-230	-11	-27	-2.5	-12
181+15	-200	-9.5	-45	-4	-12
188+85	-140	-7	-3	-.5	-10
196+80	-160	-8	-14	-1.5	-8
235+26	-170	-8	+9	+1	-8
243+00	-150	-8	-4	-.5	-8
251+00	-180	-9	+20	+2	-9
259+00	-170	-8	+8	+1	-8
320+80	-90	-4.5	-38	-3.5	-5
329+00	-50	-2.5	-120	-11	-10
337+00	-20	-1	-178	-16	-16

Note: Positive numbers indicate accretion; negative numbers indicate erosion.

IMPROVEMENTS DESIRED

At the initial public meeting held for this study in Grand Isle, Louisiana, on 8 December 1966, the following improvements were requested:

- A representative of the Louisiana Office of Public Works requested that the 2,700-foot stone jetty on the eastern end of the island be enlarged and extended and that the beach be periodically nourished as needed;

- The Mayor of Grand Isle, expressing the consensus of Grand Isle residents, requested that a beach nourishment program and a system of rock groins or jetties tied into existing sandbars be constructed in lieu of a high (20- to 30-foot) levee;

- A resident of Grand Isle requested that a stone breakwater with a crown elevation of 8 or 9 feet be constructed to extend the length of Grand Isle at a distance of about 200 yards off the gulf shore;

- A representative of the tourist industry indorsed the request for the seawall, with a modification to include several stone jetties; and

- Numerous individuals, the Mayor of Grand Isle, and representatives of Grand Isle, Jefferson Parish, and the State of Louisiana, through letters and at informal meetings, requested immediate assistance to stop the rapid erosion of the western end of Grand Isle.

- Additional requests were made by a few individuals at the second and final public meeting for any form of beach erosion and hurricane protection.

FORMULATING A PLAN

These plan formulation studies are to review the economic, environmental, and social impacts of alternative plans on which to base the selection of the plan of improvement that best satisfies the needs of the study area, and to determine the extent to which the selected plan maximizes national and regional economic development, or maintains or enhances environmental quality, and improves social well-being. This section discusses the logic of the plan selection process and rationale for arriving at the selected plan.

The Water Resources Council's Principles and Standards (P&S) for Planning Water and Related Land Resources require that Federal and Federally-assisted water and related land planning be directed to achieve National Economic Development (NED) and Environmental Quality (EQ) as equal national objectives.

Current public and organizational concerns indicate that the primary "planning objectives" in the study area should satisfy the need for beach erosion control and hurricane protection. A study of the problems associated with the study area substantiate these findings.

FORMULATION AND EVALUATION CRITERIA

Plan formulation and evaluation were based on technical, economic, and various intangible criteria. Such criteria permit the selection of a plan which best responds to the problems and needs of the area and is economically and engineeringly feasible and environmentally and socially acceptable. These criteria are discussed in subsequent paragraphs.

Alternative plans of improvements were formulated and evaluated in accordance with applicable guidelines of the National Environmental Policy Act of 1969; Section 122 of the River and Harbor Act of 1970; Section 103 of the Water Resources Planning Act of 1965; Water Resources Development Act of 1974; and Engineer Regulations of the 1105-series, which provide for implementation of P&S for planning water and related land resources.

TECHNICAL CRITERIA. The following technical criteria were used to formulate viable plans and evaluate those deserving further considerations. These criteria also were used to eliminate certain methods of protection that were not practicable and, therefore, did not merit further consideration or analysis.

Technical criteria required that the selected plan be consistent with local and regional land use plans for the study area.

- Topography of area, geologic stratifications, experience with emergency works, wave surge, and hurricane characteristics were the determining factors for adaptability of structural solutions.

- Recorded data on past hurricanes were utilized to determine the "design hurricane."

ECONOMIC CRITERIA. The economic criteria applied in formulation and evaluation of plans are as follows:

- It is anticipated that the economy of Grand Isle will continue to depend on the offshore petroleum industry, on commercial fishing, and on recreation-oriented services throughout the project life.

- The economic justification of each plan considered was based on a comparison of the average annual benefits with the average annual costs. Benefits and costs were expressed in comparable monetary terms by discounting of benefits and costs to present values as of 1980. The magnitude of the discounted future benefits and of all costs was a function of the project life and the current Federal interest rate. The project life and interest rate used were 50 years (1980-2030) and 6 7/8 percent, respectively. The base year in the analysis was 1980; and the economic life of the plans evaluated extends from 1980 to 2030.

- Except where overriding intangible benefits and/or costs dictate otherwise, a plan is properly formulated and economically justified if: (1) average annual benefits exceed average annual costs; (2) each separable segment or purpose provides benefits at least equal to its costs; (3) the scale of development provides maximum net benefits; and (4) there are no more economical means of accomplishing the same purpose which would be precluded from development if the plan were undertaken.

- The plan selected should be that plan which maximizes economic efficiency and optimizes the scale and timing of development while achieving the planning objectives, subject to any modifications dictated by overriding intangible benefits and/or costs.

ENVIRONMENTAL AND OTHER CRITERIA. The following environmental and other criteria were considered in plan formulation and evaluation:

- Special consideration should be given to avoid alteration of habitat critical to threatened and endangered species.

- Degradation of water quality should be minimized to the fullest extent possible.

- Recreational features should conform to state standards.

- Damage to historic and archeological resources should be avoided when possible.

- Destruction of wetlands should be minimized as directed by Executive Order 11990 dated May 1977.

- Destruction of nearshore water bottoms should also be minimized.

- The selected plan will address the environmental needs of the study area that are justifiable by tangible and intangible values and desires of local interests also will be considered.

- The planning objectives, to reduce beach erosion and hurricane flood damages at Grand Isle, represent the problems and needs. All plans that address these objectives were reviewed during this Phase I affirmation study.

- The first stage of the plan formulation process consisted of a preliminary evaluation of the possible structural and nonstructural solutions that address the objectives of beach erosion control and hurricane protection. The technical, economic, environmental, and other criteria set forth previously were used to evaluate each solution considered. This screening resulted in the discarding or holding of solutions for further evaluation. Groins, levees, bulkheads, segmented offshore breakwaters, a breakwater, floodwalls, and extension of the eastern jetty at Grand Isle, were among the alternatives considered. Also various armorings of the dune, such as cellular concrete revetment and longard tubes in combination with the beach nourishment or instead of the beach fill were considered. These alternatives were discarded due to restraints imposed by technical or economic criteria that rendered these solutions infeasible. A nonstructural alternative, implemented by local interests to reduce the extent of hurricane damages, is the existing ordinance that requires all residential buildings to provide a clear distance of at least 8 feet between the existing ground and first floor of buildings.

Four structural solutions that withstood the restrictions of the technical, economic, environmental, and other criteria were retained for detailed evaluation. The evaluation of these plans led to the identification of the NED plan and EQ plan and resulted in the selection of the plan recommended in this report.

POSSIBLE SOLUTIONS

The possible solutions evaluated in the preliminary stages of plan formulation are described below:

BEACH FILL. The beach at Grand Isle could be widened by artificial placement of fill material to the extent required to afford the desired protection against further destructive erosion. A wider beach would move the wave breaking point seaward for a given design and tidal elevation. The widened beach could be stabilized by periodic artificial beach nourishment. Such a widened and stabilized beach would be beneficial in view of increased recreational use as well as the provision of some protection to onshore installations against water attack. This solution was retained for detailed consideration.

<u>BEACH FILL WITH GROINS</u>. During preliminary studies, use of a groin system was investigated. In order for groins to be effective, without nourishment, waves must approach the shore at an angle a large percentage of the time. Waves approach Grand Isle predominantly directly onshore and, therefore, render a groin system ineffective. Studies of the timber groins constructed by the Louisiana Department of Highways in 1951 and 1952 indicate that these have not provided any benefits to the beach area. These groins were constructed in two fields located approximately 2.5 miles apart. Comparison of aerial photographs and beach surveys over the last 20 years indicates that the shoreline between the two fields of groins behaves the same way as the shoreline within the fields. When the shoreline between the two fields was eroding, the shoreline within the fields was also eroding, and when the shoreline between the fields was enjoying relative stability, so was the shoreline within the field. Approximately 2 or 3 years following the construction of the groins, about 1.2 million cubic yards of sand was dredged onto the beach as an emergency measure to provide erosion protection to the Grand Isle beach front, including the area within the fields of groins. In addition, we find that the two fields of groins did nothing to help prevent the severe erosion caused by Hurricanes Flossy in 1956, Carla in 1961, Hilda in 1964, or Betsy in 1965, or to trap sand and rebuild the beach following these hurricanes. Each time the beaches had to be rebuilt by direct placement of sand. In order for a groin system with periodic nourishment to provide an adequate degree of shoreline stability, groins would have to be constructed approximately 250 feet apart, beginning at Caminada Pass and extending eastward along 6 miles of beach front,

and would have to be about 600 feet long. The systems of groins would cost in excess of $18 million, the initial cost for the sandfill would be about $2,250,000, and the required periodic nourishment would cost $90,000 annually. The groins would require replacement at 20-year intervals. This solution was economically not justified and, therefore, was deleted from further consideration.

BEACH FILL AND DUNE. Hurricane wave protection would be provided by a beach with a berm elevation above that required for the prevention of destruction by erosion and by construction of a dune of sufficient height to remain above the limits of the wave uprush. The plan comprising construction of a sand beach, together with maintenance of the dune that was restored to an elevation of 7 feet under the authority of Public Law 93-288, was developed to provide an interim method that responds to the Water Resources Council's Principles and Standards. That plan was identified as the EQ plan in the addendum to the survey report, contained in House Document Number 94-639, dated 29 September 1976. Field observations in connection with studies for this report indicated that overtopping of a 7-foot dune is a more frequent occurence than once in 10 years, as described in the addendum. A 4- to 5-foot storm stage is almost an annual event and a 3-foot runup from offshore waves will cause a 7-foot dune to be overtopped. If a major storm occurs, overtopping would be significant and the dune would be breached by currents paralleling the land side of the dune. In September 1977, when a minor hurricane (Hurricane Babe) passed approximately 85 miles west of Grand Isle, it completely destroyed the restored dune. At that time, the highest recorded stage of 3.68 feet was recorded at Bayou Rigaud on the landward side of Grand Isle. To prevent overtopping, the crest elevation of the dune and the cross section of the beach berm are both major factors. The authorized plan incorporates a high dune crest elevation with a large beach berm to prevent overtopping from major storms or hurricanes.

LEVEES AND BULKHEADS. A plan to provide complete hurricane protection for the island would require construction of a levee system along the bay side, with concrete bulkheads at the various docking facilities. Sand dunes along the gulf front would also have to be constructed and tied in with the levee system to constitute an unbroken barrier to water action from the gulf, passes, and bays. This system would have to be designed to protect the island from a storm which would produce tides about 6 feet in excess of those which occurred during Hurricane Betsy. This plan would cost over $45 million and is economically infeasible. Any lower degree of protection would give a false sense of security in the event that a hurricane should occur which was more severe than the design storm. Occurrence of a storm greater than the design hurricane would be disastrous, as the island could flood from overtopping and would be completely isolated by inundation of the only escape route. No further consideration was given to this type of protective measure.

BREAKWATER. An offshore breakwater to prevent significant hurricane surges would have to reach a height of at least 13 feet above m.s.l. The cost to build a structure of this magnitude would be in excess of $51 million. A breakwater at an elevation of 8 or 9 feet above m.s.l., as requested by local interests, would not prevent damage from significant hurricane surges nor would it entirely prevent erosion of the island. The beach would still have to be initially widened and require periodic nourishment. This breakwater would reduce the amount of nourishment required, but not sufficiently to justify its construction. In addition, the breakwater would function as a complete littoral barrier and would possibly have detrimental effects upon Grand Terre Islands. This solution also was dropped from further consideration.

EXTENSION OF JETTY AT EASTERN END OF THE ISLAND. Extension of the jetty at the eastern end of the island, as requested by the Louisiana Office of Public Works, was considered during preliminary studies. It was determined that extension of this jetty would not appreciably prevent erosion of the central sections of the island, and that in the initial years after its extension, it would cause a detrimental effect on Grand Terre Islands by interrupting the west to east littoral transport. The proposal was not economically justified. In addition, since sufficient beach is now available at the eastern end of the island, no further consideration was given to the extension of this jetty.

JETTY AT WESTERN END OF THE ISLAND AT CAMINADA PASS. A stone jetty to stabilize the western end of the island at Caminada Pass was investigated and is included as an integral part of each of the plans considered in detail. As previously noted, construction of a jetty along the western end of the isle, in accordance with the authorized plan, was completed by local interests in July 1972.

REVETMENT WITH SPUR DIKES AT THE WESTERN END OF THE ISLAND AT CAMINADA PASS. A stone revetment along the western end of the island with a series of stone dikes perpendicular to Caminada Pass was also investigated as a method of stabilizing the western end. This revetment was found to be economically infeasible and deleted from detailed consideration.

PLANS CONSIDERED FURTHER

The most suitable means to prevent erosion consists of widening the beach by artificial placement of beach fill together with periodic beach nourishment. Stabilization of the beach would be accomplished by construction of a jetty at the western end of the island. Such a widened beach would provide benefits from increased recreational use and from prevention of damage caused by beach erosion. Benefits from hurricane wave damage protection would be obtained by raising the berm elevation and by providing a dune along the gulf front with a crown elevation at or above the limits of wave uprush from the design hurricane. Four plans of protection have been considered in detail and are described in the following paragraphs. A discussion of the design criteria is given in appendixes A, B, and C, and the plans and typical cross sections are shown on plates 2, 3, and 4.

PLAN A - BEACH EROSION PROTECTION. This plan would restore and stabilize the beach at Grand Isle to provide recreational use and protection from beach erosion damage, but does not address the need for hurricane protection. A 200-foot wide beach with a shoreward elevation of 3 feet and a gulfward elevation of 2 feet (1 on 200 slope) is the minimum section required to restore and stabilize Grand Isle's gulf shore. The beach would assume its natural slope from an elevation of 2 feet to the offshore bottom. It would be located gulfward of the existing dune line and would extend the length of Grand Isle's gulf shore, approximately 39,000 feet. A jetty approximately 2,600 feet long with a crown elevation of 4 feet, a crown width of 6 feet, and side slopes of 1 on 2 with fill placed on the Grand Isle side would stabilize the western end of Grand Isle at Caminada Pass. Material for the beach fill and periodic nourishment would have the characteristics of the sand native to the beach. Borings indicate that suitable sources for initial fill and periodic nourishment are available in sufficient quantities offshore near each end of the island (plate A-1). It is estimated that about 500,000 cubic yards of usable material would be required to provide a beach having the minimum section described above. Maximization of net benefits by analysis of other beach widths was not warranted for plan A since the 200-foot wide beach berm was the minimum width required for beach stabilization and provides an adequate beach for recreation.

PLAN B - COMBINED BEACH EROSION AND HURRICANE PROTECTION (DUNE ELEVATION 11.5). This combined beach erosion and hurricane protection plan provides protection from gulf waves driven by hurricanes having frequencies of up to approximately once in 50 years. The plan provides for a vegetated, sandfill dune with a 10-foot wide crown at an elevation of 11.5 feet and side slopes of 1 on 5, and a 180-foot wide sandfill berm sloping from an elevation of 8.5 feet at the toe of the dune gulfward to an elevation of 3 feet. The berm would assume its natural slope from an elevation of 3 feet to the offshore bottom. The jetty described under plan A would be included in the plan to stabilize the western end of the island at Caminada Pass. The fill required to establish the dune and beach berm is estimated to be approximately 1,500,000 cubic yards. This material is available in sufficient quantities from the sources described in plan A.

PLAN C - COMBINED BEACH EROSION AND HURRICANE PROTECTION (DUNE ELEVATION 13). This plan would provide protection from beach erosion and from waves driven by hurricanes having frequencies of up to once every 100 years. It provides for a vegetated, sandfill dune with a 10-foot wide crown at an elevation of 13 feet with side slopes of 1 on 5 and a 180-foot wide sandfill berm sloping gulfward from an elevation of 10 feet at the toe of the dune to an elevation of 3 feet (slopes: 1 on 70 for 70 feet, 1 on 5 for 10 feet, and 1 on 25 for 100 feet). The berm would assume its natural slope from an elevation of 3 feet to the offshore bottom. The jetty described under plan A is also included in this plan. The fill required to establish this dune and berm is estimated at about

1,900,000 cubic yards, and is available in sufficient quantities from the sources described in plan A.

PLAN D - COMBINED BEACH EROSION AND HURRICANE PROTECTION (DUNE ELEVATION 15). This plan provides protection from beach erosion and from waves driven by hurricanes having frequencies of up to once every 200 years. It consists of a vegetated, sandfill dune with a 10-foot wide crown at elevation 15 feet and side slopes of 1 on 5 and a berm of the same elevation and dimensions as described for plan C. The jetty described under plan A is also included in plan D. The fill to establish this dune and berm is estimated at approximately 2,300,000 cubic yards and is available in sufficient quantities from the sources described in plan A.

NONSTRUCTURAL. The residents of Grand Isle have, through experience, become aware of the hurricane threat. The majority of the houses are built with first-floor elevations at or above 12 feet. The Town of Grand Isle has an ordinace that requires all residential buildings in the corporate limits to be constructed on piles with no less than 8 feet of penetration and requires that a clear distance of at least 8 feet be provided between the existing ground and first-floor of the buildings. The town officials have an evacuation plan for the Grand Isle area requiring evacuation of the area through Louisiana Highway 1, the only escape route, before the Weather Service issues evacuation advisories. The issuance of an evacuation order well in advance of tidal flooding is required because the grade of Louisiana Highway 1 from Grand Isle to Golden Meadow is low; it varies between elevation 2.5 feet and 5 feet m.s.l. None of the plans discussed above will prevent stillwater flooding, and an adequate warning system as well as plans and routes for rapid evacuation are essential supplements to any of these plans in order to prevent loss of life and damage to movable property.

NO ACTION. Failure to construct the project being recommended herein would continue to allow improvements on Grand Isle to be subject to damages from erosion and hurricane-driven gulf waves and would also retard the residential, commercial, and recreational development of the island.

PLAN SELECTION

Selection of the recommended plan was carried out in accordance with the Water Resources Council's Principles and Standards. At this point in the formulation process the screening of plans has been simplified by the elimination of a number of competing alternatives and plan selection was made from plans A through D, which were considered in detail.

A comparison of alternative plans A through D reveals that plan A would provide erosion control, but does not address the need for hurricane protection. Of the remaining plans which fully address the study objectives, plan B has the least detrimental impacts on the environment and is the plan preferred by local interests. Plan B would protect Grand Isle from damages caused by erosion and hurricane-driven gulf waves and, by stabilizing Grand Isle, would protect the valuable estuarine areas. It was, therefore, identified as the EQ plan. Plan C provides the maximum net benefits and was identified as the NED plan. Plan D is the most costly plan, and also has the most detrimental effects on the environment. Therefore, it could not serve as the NED or EQ plan. Although plans C and D provide a little more protection, they are not acceptable to the local residents. These plans are more costly and restrict the view of the beach to a greater degree than plan B. Plan B is the most suitable overall plan for the study area. Tables 4, 5, and 6 provide a comparison of the benefits and costs of the alternative plans. Table 7 provides a summary of the beneficial and adverse effects of the alternative plans.

TABLE 4
SUMMARY OF AVERAGE ANNUAL CHARGES

	PLAN A Beach erosion protection	PLAN B Combined beach erosion and hurricane protection (dune elev. @11.5)	PLAN C Combined beach erosion and hurricane protection (dune elev. @ 13)	PLAN D Combined beach erosion and hurricane protection (dune elev. @ 15)
	$	$	$	$
First costs[1]				
Federal	870,000	6,760,000	8,040,000	9,030,000
Non-Federal	2,600,000	4,140,000	4,560,000	5,070,000
TOTAL	3,470,000	10,900,000	12,600,000	14,100,000
Annual costs				
Interest and amortization (6 7/8 percent)				
Federal	62,000	482,000	574,000	644,000
Non-Federal	185,000	295,000	325,000	362,000
TOTAL	247,000	777,000	899,000	1,006,000
Initial and periodic beach nourishment				
Federal	48,000	33,000	30,000	33,000
Non-Federal	310,000	424,000	427,000	424,000
TOTAL	358,000	457,000	457,000	457,000
Dune and jetty maintenance				
Federal	-	-	-	-
Non-Federal	3,000[2]	15,000	16,000	17,000
TOTAL	3,000	15,000	16,000	17,000
Total annual costs				
Federal	110,000	515,000	604,000	677,000
Non-Federal	498,000	734,000	768,000	803,000
TOTAL	608,000	1,249,000	1,372,000	1,480,000

[1]Does not include $105,000 preauthorization study costs.
[2]Jetty maintenance only.

TABLE 5

SUMMARY OF AVERAGE ANNUAL BENEFITS

Type of Benefit	PLAN A Beach erosion protection	PLAN B Combined beach erosion and hurricane protection (dune elev. @11.5)	PLAN C Combined beach erosion and hurricane protection (dune elev. @ 13)	PLAN D Combined beach erosion and hurricane protection (dune elev. @ 15)
	$	$	$	$
Erosion prevention				
Existing development	355,000	355,000	355,000	355,000
Future development	74,000	74,000	74,000	74,000
Subtotal	429,000	429,000	429,000	429,000
Inundation reduction				
Existing development	-	611,000	823,000	838,000
Future development	-	48,000	61,000	62,000
Subtotal		659,000	884,000	900,000
Intensification	-	67,000	67,000	67,000
Area redevelopment	42,000	128,000	159,000	186,000
Recreation	180,000	605,000	605,000	605,000
TOTAL	651,000	1,888,000	2,144,000	2,187,000

TABLE 6
ECONOMIC ANALYSIS

	PLAN A Beach erosion protection	PLAN B Combined beach erosion and hurricane protection (dune elev. @11.5)	PLAN C Combined beach erosion and hurricane protection (dune elev. @ 13)	PLAN D Combined beach erosion and hurricane protection (dune elev. @ 15)
	$	$	$	$
AVERAGE ANNUAL BENEFITS:				
Erosion prevention	429,000	429,000	429,000	429,000
Inundation reduction	-	659,000	884,000	900,000
Intensified land use	-	67,000	67,000	67,000
Recreation	180,000	605,000	605,000	605,000
Area redevelopment	42,000	128,000	159,000	186,000
Total	651,000	1,888,000	2,144,000	2,187,000
AVERAGE ANNUAL CHARGES:				
Interest and amortization	247,000	777,000	899,000	1,006,000
Initial and periodic beach nourishment	358,000	457,000	457,000	457,000
Dune and jetty maintenance	3,000	15,000	16,000	17,000
Total	608,000	1,249,000	1,372,000	1,480,000
ANNUAL NET BENEFITS:	43,000	639,000	772,000	707,000
BENEFIT/COST RATIO:	1.07	1.5	1.6	1.5

TABLE 7

SUMMARY COMPARISON OF ALTERNATIVE PLANS

Item	Plan A	Recommended Plan (Plan B) (EQ Plan)	Plan C (NED Plan)	Plan D	No Action
I. PLAN DESCRIPTION	This plan would provide recreational use and protection from beach erosion damage. A 200-foot wide beach along Grand Isle's gulf shore, with a shoreward elevation of 3 and a gulfward elevation of 2, is the minimum section required for erosion control. A jetty approximately 2,600 feet long has been included to stabilize the western end of Grand Isle.	This combined beach erosion and hurricane protection plan protection from gulf waves driven by hurricanes having frequencies of up to approximately once in 50 years. The plan provides for a vegetated sandfill dune with a 10-foot wide crown at an elevation of 11.5 and side slopes of 1 on 5, and a 180-foot wide sandfill berm sloping from an elevation of 8.5 at the toe of the dune gulfward to an elevation of 3. The jetty described under plan A would stabilize the western end of the island.	This plan would provide protection from waves driven by hurricanes having frequencies of up to once every 100 years. It provides for a vegetated sandfill dune with a 10-foot wide crown at an elevation of 13 with side slopes of 1 on 5 and a 180-foot wide sandfill berm sloping gulfward from an elevation of 10 at the toe of the dune to an elevation of 3. The jetty described under plan A is also included in this plan.	This plan provides protection from beach erosion and from waves driven by hurricanes having frequencies of up to once every 200 years. It consists of a vegetated, sandfill dune with a 10-foot wide crown at elevation 13 and side slopes of 1 on 5 and a berm of the same elevation and dimensions as described for plan C. The jetty described under plan A is also included in plan D.	No action would allow improvements on Grand Isle to continue to be subjected to damage from erosion and hurricane-driven gulf waves and retard the residential, commercial, and recreational development of the island.
II. IMPLEMENTATION RESPONSIBILITY					
A. First Cost (Oct 78 Price level)					
1. Federal	$ 870,000	$ 6,760,000	$ 8,040,000	$ 9,030,000	-
2. Non-Federal	2,600,000	4,140,000	4,560,000	5,070,000	-
3. Total	3,470,000	10,900,000	12,600,000	14,100,000	-

TABLE 7 - SUMMARY COMPARISON OF ALTERNATIVE PLANS (Cont'd)

Item	Plan A	Recommended Plan (Plan B) (EQ Plan)	Plan C (NED Plan)	Plan D	No Action
B. Annual Cost (Average Annual)					
1. Federal	$110,000	$ 515,000	$ 604,000	$ 677,000	-
2. Non-Federal	498,000	734,000	768,000	803,000	-
3. Total	608,000	1,249,000	1,372,000	1,480,000	-
III. PLAN EVALUATION					
A. Tangible Benefits	651,000	1,888,000	2,144,000	2,187,000	-
B. Tangible Costs	608,000	1,249,000	1,372,000	1,480,000	-
C. Net Benefits	43,000	639,000	772,000	707,000	-
D. NED Benefit/Cost Ratio	1.07	1.5	1.6	1.5	-
E. Acceptability	Not likely to be accepted by local sponsors	Preferred by local interests	Same as plan A	Same as plan A	Same as plan A
F. Primary Benefit Category (Inundation Reduction)					-
G. Geographic Scope	Grand Isle, La.	Same as plan A	Same as plan A	Same as plan A	Same as plan A

TABLE 7 - SUMMARY COMPARISON OF ALTERNATIVE PLANS (Cont'd)

Item	Plan A	Recommended Plan (Plan B) (EQ Plan)	Plan C (NED Plan)	Plan D	No Action
IV. SIGINIFICANT IMPACTS					
A. National Economic Development					
1. Beneficial Effects	$651,000	$1,888,000	$2,144,000	$2,187,000	-
2. Adverse Effects	608,000	1,249,000	1,372,000	1,480,000	-
3. Net Effects	43,000	639,000	772,000	707,000	-
B. Environmental Quality					
1. Beneficial Effects	This plan would restore and stabilize the beach and provide protection from beach erosion damages	This plan would eliminate erosion losses over the project life and preserve Grand Isle as part of the barrier island system. Also would provide reduction of flood conditions from hurricane-driven gulf waves	Similar to plan B, but more hurricane protection	Similar to plan B, but more hurricane protection	
2. Adverse Effects	Same as plan B, but to a lesser degree	There will be increased turbidity during dredging	Same as plan B, but to a greater degree	Same as plan B, but to a greater degree	No action would allow improvements on Grand Isle to continue to be subjected to damage from erosion and hurricane-driven gulf waves and retard the residential, commercial, and recreational development of the island

TABLE 7 - SUMMARY COMPARISON OF ALTERNATIVE PLANS (Cont'd)

Item	Plan A	Recommended Plan (Plan B) (EQ Plan)	Plan C (NED Plan)	Plan D	No Action
C. Social Well-Being					
1. Beneficial Effects	Increased employment and income opportunities but to a lesser degree than plans B, C, and D	Increased employment and income opportunities	Same as plan B	Same as plan B	
		Provide reduction of flood conditions from hurricane-driven gulf waves with recurrence of once in 50 years.	Same as plan B, but once in 100 years storm	Same as plan B, once in 200 years storm	
		Improve security of life and health	Same as plan B	Same as plan B	
2. Adverse Effects		Relocation of some beach front structures will be necessary due to the alinement of the dune.	Same as plan B	Same as plan B	
					Continued shoreline erosion and hurricane surge damage
D. Regional Development					
1. Beneficial Effects	$ 651,000	$ 1,888,000	$ 2,144,000	$ 2,187,000	-
2. Adverse Impacts	608,000	1,249,000	1,372,000	1,480,000	-
3. Net Effects	43,000	639,000	772,000	707,000	-

THE SELECTED PLAN

This section describes the plan selected for recommendation. All meaningful effects of the plan, both favorable and unfavorable, are presented. A general description of the project's main components, their function and significant design, construction, and operation and maintenance aspects are also discussed.

PLAN DESCRIPTION

The selected plan, the combined beach erosion and hurricane wave protection plan which is preferred by local interests, is described on page 72 (plan B). In addition to providing beach erosion control, this plan would provide, for the greater part, protection from damage caused by wave action from hurricanes having frequencies of up to about once every 50 years. The design storm, when compared with the meteorological effects of the standard project hurricane derived by the Weather Service and in light of the low probable occurrence of a storm of greater intensity, was considered to be appropriate. The dune elevation of 11.5 feet is acceptable to local interests as it would not totally obscure the beach or gulf view from houses located gulfward of the highway that are built in accordance with existing building codes--first-floor elevation 8 feet above the existing ground. A lower dune and smaller berm would not provide hurricane protection and would greatly increase the possibility of breaching, which could result in extensive wave damage to improvements on the island and major destruction of the beach section itself.

CONSTRUCTION BY LOCAL INTEREST

The construction of a jetty along the western end of Grand Isle and placement of sandfill on its landside, which is included as part of the authorized plan B, was completed in July 1972 by contract of the Louisiana Office of Public Works. The authorized project provides that local interests be allowed a credit for this work, limited to $1 million, toward the non-Federal share of the project first cost.

PLAN ACCOMPLISHMENTS

The selected plan would reduce present and future erosion and prevent the loss of an estimated 338 acres of land located adjacent to the gulf shoreline and would provide erosion prevention benefits of $429,000 annually. The plan would prevent an estimated $659,000 in annual damages from hurricane driven waves generated on the gulf side of the island. Implementation of the selected plan would provide $67,000 in average annual land use intensification benefits on an estimated 894 acres of land. An estimated $605,000 in annual recreation benefits would also be realized. In addition, area redevelopment benefits of $128,000 would accrue to otherwise under-employed labor resources during construction of the project.

DESIGN HURRICANE

DESIGN CRITERIA ADOPTED. The design hurricane adopted for this study is one which has an average recurrence interval on the order of once in 50 years in the study area. A design for a more frequent and, consequently, less severe hurricane would not provide the degree of protection desired by local interests, and damage as a result of a less frequent (more severe) hurricane, such as a

SPH, could be disastrous. Although the Design Hurricane (Des H) selected is not so severe as the SPH, the difference in stillwater level, elevation 8.5 feet for the Des H and 9.9 feet for the SPH, is only 1.4 feet. The estimated recurrence interval for the SPH in the study area is approximately once in 200 years on the average. Hurricane parameters accompanying the Des H include a central pressure of 28.15 inches of mercury, a maximum overwater wind velocity of 87 m.p.h. at a 35-mile radius, and a forward speed of 13 m.p.h.

DESIGN WAVE CHARACTERISTICS. For the Des H chosen, the deepwater wave height and wave period are 8.2 feet and 7.3 seconds, respectively. For the purpose of design, the incident wave is assumed to approach directly onshore from a southeasterly direction. Wave runup on the protective barrier for the design wave is 2.2 feet. Details on the methods of determining surge heights, wave characteristics, and wave runup are given in appendix B.

ENVIRONMENTAL IMPACTS

BENEFICIAL. The major benefits of the proposed improvements will be: (1) reduction of inundation by high intensity gulf waves associated with hurricanes; (2) intensified land use; (3) erosion prevention; (4) higher quality recreational use; and (5) area redevelopment. The social well-being of residents and summer users will be improved as fear of flooding decreases. The creation of new beach will satisfy 7 percent of the peak day demands for beach use in the market area which will result in greater economic stability for residents and desirable community growth. Preservation of Grand Isle by prevention of beach erosion and hurricane wave overtopping will aid in the preservation of the estuaries and marshes in the Barataria Bay system.

ADVERSE

a. Impacts on water bottoms and beach. The most significant impact of dune building is the return of about 5/6 of the construction sand to the gulf. The exact disposition of this sand is difficult to ascertain; however, most will probably be deposited over shallow water bottoms in front of Grand Isle. Some of these acres will be similarly covered during each of nine maintenance dredgings. Fast-moving organisms will be able to escape; however, slow-moving or soft animals will be destroyed. The sand that stays to form the dune and berm will cover approximately 140 acres of shallow water bottoms and 190 acres of beach, destroying most of the existing organisms. These areas will be impacted during construction and during each of the nine maintenance dredgings. Dredging the sand will disrupt about 190 acres of nearshore water bottoms during construction and during each of the nine maintenance dredgings.

b. Impacts of temporary turbidity. Dredging will cause temporarily heightened turbidity in the vicinity of the borrow pits and just off the beach. This turbidity will lower primary productivity of phytoplankton in the area.

c. Impacts of pollutants released by dredging. Elutriate tests indicated that zinc, nickel, and mercury will be released during dredging. Little is known about effects of small concentrations of these metals in marine environment, but concentrations of zinc similar to those at sites 1 and 2 kill freshwater minnows and water fleas. Therefore, there may be some detrimental impacts to organisms due to the release of zinc. Mercury and nickel levels only slightly exceeded EPA criteria and should cause no problems.

d. <u>Recolonization</u>. The 81-acre western borrow pit will be utilized for 6 months and the 106-acre eastern pit for 2 years. Each pit will be totally removed from productivity during the entire period of dredging. As the pits fill in after dredging, colonization by benthic organisms will commence. In shallow water areas such as these, the benthic community should reach predredging levels of individual and species diversity within 6 months.

e. <u>Total impact of dredging and dune building</u>. The total impact of the project depends on the number of acres removed from benthic and planktonic productivity and the number of months this reduction occurs. The areas affected will be removed from productivity for varying amounts of time during construction and subsequent nourishment. A summary of the impacts of alternatives is shown in table 7 on page 79.

ECONOMICS
OF THE SELECTED PLAN

The estimated first cost of the selected plan, based on costs for similar work in the New Orleans District and on October 1978 price levels is $10,900,000. The detailed estimates of first costs for the selected plan and for all the plans considered in detail are given in appendix C.

ESTIMATES OF ANNUAL CHARGES

The average annual cost for the selected plan, based on a 50-year project life and an interest rate of 6 7/8 percent is $1,249,000. A breakdown of the annual cost is given in table 4.

COMPARISON OF COSTS. The cost of $10,900,000 represents a decrease of $3,700,000 from the latest PB-3 effective 18 May 1978. A comparison of the latest approved PB-3 and the Phase I GDM is shown below:

	PB-3 eff. 18 May 78 $	Phase I GDM eff Dec 78 $	Difference $
Lands and damages	4,930,000	2,740,000	-2,190,000
Breakwaters and seawalls	1,000,000	1,0~~35~~00,000	~~+35,000~~ 0
Beach replenishment	7,686,000	6,126,000	-1,560,000
Engineering and design	498,000	~~430~~ 368,000	~~-68,000~~ -130,000
Supervision and administration	486,000	~~569,000~~ 486,000	+83,000
Total	14,600,000	10,900,000	-3,700,000

REASONS FOR THE DIFFERENCES

a. Lands and damages. Rights-of-way were reduced.

b. Breakwater and seawall. One million dollars is the credit authorized for the jetty constructed by local interest and the $1,035,000 is the estimated cost of the jetty less engineering and design and supervision and administration.

c. Beach replenishment. After detailed studies it was determined that the beach fill necessary to construct the project could be reduced 410,000 cubic yards.

d. Engineering and design and supervision and administration. These items reflect a more accurate estimate of these costs.

ESTIMATES OF BENEFITS

The estimated average annual benefits for the selected plan amount to $1,888,000. The quantified benefits result from erosion prevention, inundation reduction, intensified land use, recreation, and area redevelopment. Detailed benefit analyses are presented in appendix D. Annual benefits by categories for all plans considered are summarized in table 5.

EROSION DAMAGE PREVENTION. Damages that result from erosion were classified as residential, commercial, public, highways, utilities, and land. Projections of advancing erosion, using rates as shown in appendix B were made for the 50-year project life to determine the area that would be eroded in the absence of the project. The existing improvements in the area comprising fishing camps, small businesses, etc., were determined by detailed field surveys in 1970 and verified during studies for this report. Total costs which would be incurred as a result of erosion were determined by computing the costs associated with existing development and adding the costs associated with future development, projected in accordance with the growth rates specified in appendix D. Erosion damages prevented to existing and future development over the life of the project are estimated to be $429,000 annually.

HURRICANE WAVE DAMAGE PREVENTION. The beneficial effects of the project insofar as preventing flood damages consist solely in the prevention of damages incident to high intensity waves which originate on the gulf side of the island. Stage-damage curves were developed based on existing and future development for various years within the project life for four conditions--rising water only, rising water and bay-waves only, rising water and all waves (without project), and rising water and gulf waves (with plan B in place). Integration of the stage-damage relationships for the four conditions with the stage-frequency curve provided the basis for construction of the damage-probability curves. The average annual damages for each of the conditions were computed over the period 1980-2030. The average annual flood damages prevented on existing and future development with the recommended plan in place are $659,000. Details of the computation are shown in appendix D.

INTENSIFIED LAND USE. These benefits are the result of providing protection from repeated occurrences of damaging hurricane-driven gulf waves. Market values of real property and associated improvements are expected to increase upon implementation of the selected plan. This is reflected in the benefits derived from intensified land use. None of this increase can be attributed to the beach erosion feature since the low elevation and flat slope of plan A, the beach erosion plan, will not provide appreciable wave protection. The computation of the increases in the market value of land was based on analyses of land values within the project area. Average annual benefits from intensified land use are estimated to be $67,000.

RECREATIONAL BENEFITS. Recreational benefits will result from increased usage of the state park and the increased willingness to pay due to the availability of a fully developed beach. The net worth of these benefits can be evaluated in terms of increased usage and the fees the public is willing to pay under existing conditions as compared to those they would be willing to pay under improved conditions. It is estimated that the existing visitation and the visitation with the Office of State Parks interim development plan in place would be valued at $1.00 per visitor-day. The increased visitation with the Corps plan in place was estimated to be valued at $1.75 per visitor-day for the state parks (evaluated as use with minimum facilities). Annual public recreational benefits of $605,000 are expected to be realized from construction of the recommended plan of improvement.

REDEVELOPMENT BENEFITS. Since the recommended improvements are located in Jefferson Parish, Louisiana, and the parish is currently classified by the Economic Development Administration as an area with substantial unemployment and underemployment; area redevelopment benefits are applicable to the benefit-cost analysis under current directives. The average annual redevelopment benefits are estimated to be $128,000.

JUSTIFICATION OF IMPROVEMENTS

The selected plan (plan B), which provides for construction of a jetty, and a beach with a dune and large berm (as described on page 72), is the most economical means of providing this degree of hurricane protection as no less costly alternative is available. This plan has a benefit-cost ratio of 1.5 to 1 (see table 6). Although this plan provides slightly less than maximum tangible excess benefits (see appendix D) over cost, it enjoys a high degree of acceptability by local interests. The plan was endorsed by the Louisiana Office of Public Works, the Town of Grand Isle (the assuring agency), the Grand Isle Civic Improvement Association, and others who attended the intermediate and final public meetings, because the dune elevation specified for this plan would not obstruct their view of the gulf. Also, the recommended plan would provide almost complete (90 percent) protection from hurricane-driven gulf waves. It should be noted, however, that significant damages can occur from tidal flooding or from waves originating on the bay side of the island. It is estimated that with the recommended improvements in place, residual damages would amount to nearly 75 percent of the total damages that would be experienced without any improvements.

DIVISION OF RESPONSIBILITIES

This section will present information on various Federal and non-Federal responsibilities for the selected plan and cost apportionment.

ALLOCATION AND APPORTIONMENT OF COSTS

ALLOCATION OF COSTS. The recommended plan is a combined beach erosion and hurricane protection plan. First costs have been allocated to these functions by use of the separable-costs remaining-benefits method as described in appendix E. This procedure results in $9,030,000 being allocated to hurricane protection and $1,870,000 to shore protection.

APPORTIONMENT OF COSTS. All costs for the recommended plan have been apportioned between Federal and non-Federal interests in accordance with the cost-sharing formula adopted in the Flood Control Act of 1958 for Narragansett Bay, Rhode Island; New Bedford, Massachusetts; and Texas City, Texas, projects. The costs allocated to shore protection were apportioned between Federal and non-Federal interests in accordance with the provisions of Public Law 826, 84th Congress, as amended. Apportionment ratios are derived in appendix E and resulting cost apportionments for all plans considered are shown in table 4. For the recommended plan, the Federal first cost is $6,760,000, and the non-Federal first cost is $4,140,000.

FEDERAL RESPONSIBILITIES

The Federal Government would provide 25 percent of the costs allocated to the shore protection function, estimated at $470,000 (.25 x $1,870,000); and not more than 70 percent of the hurricane protection function, estimated at $6,290,000 ($9,030,000 less non-Federal requirement for rights-of-way, currently estimated at more than 30 percent or $2,740,000).

NON-FEDERAL RESPONSIBILITIES

Non-Federal interests would provide 75 percent of the costs allocated to the shore protection function, estimated at $1,400,000 (.75 x $1,870,000) and not less than 30 percent of the hurricane protection function, estimated at $2,740,000 (currently estimated real estate costs are in excess of 30 percent). Local interests will provide the following items of local cooperation:

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

b. Accomplish without cost to the United States all relocations and alterations of buildings, streets, utilities, and other structures and improvements made necessary by the construction of the project;

c. Hold and save the United States free from claims for damages due to the construction works;

d. Assure maintenance, repairs, and periodic beach nourishment of the project after completion as may be required to serve the intended purposes in accordance with regulations prescribed by the Secretary of the Army, except that the Federal Government will contribute for an initial period of 10 years, a sum currently estimated at $33,000 toward the annual cost of beach nourishment associated with beach erosion prevention, subject to determination on the basis of conditions of public use and ownership at the time of construction of the nourishment project;

e. Provide an additional cash contribution for the hurricane protection function in an amount sufficient to bring the local investment in cash and value of rights-of-way to 30 percent of all final first costs allocated to this function; which cash contribution is presently estimated at zero;

f. Provide a cash contribution or perform equivalent work for the beach erosion control function, presently estimated at $400,000, the final amount to be determined at the time of project construction in accordance with cost-sharing procedures for beach erosion control defined in the report;

g. Obtain approval by the Chief of Engineers, prior to commencement of any work on shore and beach protection phases of the project if undertaken separately from the recommended combined project, of detailed plans and specifications for the work contemplated and also the arrangements of prosecuting such work, excluding the preauthorization jetty construction;

h. Assure continued public ownership of the shore upon which the amount of Federal participation in the beach protection phase is based, and its administration for public use during the economic life of the project and assure continued availability for public use of privately-owned shores where Federal aid is based on such use;

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

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

k. At least annually inform interests affected that the project will not provide any substantial protection from flooding, from hurricane waves from the bay side, or from hurricane surges higher in elevation than that of Hurricane Betsy of 9 September 1965;

l. Comply with provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646;

m. Agree to the requirements of the Flood Control Act of 1970, Section 221, whereby damages will be paid for noncompliance of assurances furnished for the project and such assurances shall be enforcable by the United States in the appropriate District Court of the United States.

The Louisiana Office of Public Works will be requested to provide a letter indicating their intent to fulfill the above items of local cooperation. The requirements of local cooperation are the same as previously authorized, except that the cash contribution or equivalent work for the beach erosion function has been increased from $120,000 to $400,000.

VIEWS OF FEDERAL AGENCIES AND NON-FEDERAL INTERESTS

During the Phase I GDM study, the draft report of the review of the authorized plan of improvement was coordinated with the following:

FEDERAL AGENCIES

US Department of the Interior
- Office of Environmental Project Review*
- Fish and Wildlife Service
- Bureau of Mines*
- Bureau of Land Management*
- Bureau of Outdoor Recreation*
- Geological Survey*
- National Park Service*
- Southwestern Power Administration*

US Environmental Protection Agency*

US Department of Commerce
- National Weather Service*
- Deputy Assistant for Environmental Affairs*
- Regional Representative of the Secretary of Commerce*
- National Oceanic and Atmospheric Administration
- National Marine Fisheries Service*
- Maritime Administration
- Economic Development Administration*

US Department of Agriculture
- Forest Service*
- Soil Conservation Service
- Farmers Home Administration*

US Department of Transportation
- Federal Highway Administration
- Coast Guard*
- Federal Railroad Administration*

US Department of Housing and Urban Development
- Regional Office-Dallas, Texas*
- New Orleans Area Office*

US Department of Health, Education, and Welfare
- Bureau of Tropical Diseases*

Advisory Council on Historic Preservation*

Federal Power Commission*

NON-FEDERAL INTERESTS

State of Louisiana-Office of Public Works
Louisiana Department of Wildlife and Fisheries
State Parks and Recreation Commission*
Louisiana Coastal Commission*
Governor's Council on Environmental Quality*
Regional Planning Commission for Jefferson, Orleans, and St. Bernard Parishes*
Assistant Attorney General, State of Louisiana*
Louisiana State Planning Office*
Jefferson Parish Council, President*
Honorable Wayne C. Guidry*
Grand Isle Civil Improvement Association*
Ecology Center of Louisiana, Inc.*
Orleans Audubon Society*

Several agencies indicated the culverts at the East End State Park be installed to allow tidal interchange between the gulf and the lagoon (borrow pit) to maintain the existing ecology of the area. Other general comments were: requests for dune crossover bridges, concern because of possible increased development, and recommendations that construction and nourishment be done at times that will be least damaging to the fish and wildlife resources of the area. See appendix G, Pertinent Correspondence.

On 24 February 1979 a public meeting was held in Grand Isle to present the results of the review of the authorized plan. At the meeting there was concern over the dune and berm concept. A majority of the speakers including the Mayor of Grand Isle indicated they accept the dune and berm, but would prefer more permanent protection such as would be provided by an offshore stone breakwater. Others expressed concern about the adverse impact on general recreation and fishing that would occur during construction and maintenance of the project.

*No comments received.

The State of Louisiana, Office of Public Works, the agency with overall state responsibility for coordinating water resources projects between Federal, state and local interests, has been advised that Federal participation in the implementation of the proposed plans will be dependent upon fulfillment of the items of local cooperation listed in the "Recommendations" section of this report. By letter dated 14 May 1979 they furnished adequate assurances that the state will fulfill the necessary requirements of local cooperation. A copy of this letter and other pertinent letters are included in Appendix G of this report.

STATEMENT OF FINDINGS

a. I have reviewed and evaluated, in light of the overall public interest, the documents concerning the proposed action, as well as the stated views of other interested agencies and the concerned public, relative to the various practicable alternatives for providing beach erosion and hurricane protection for Grand Isle, Louisiana.

b. The possible consequences of these alternatives have been studied according to their environmental, social well-being, and economic effects, with respect to both regional and national economic development and engineering feasibility.

c. In evaluation, the following points were considered pertinent:

(1) From an environmental standpoint, I have found that the benefits to the environment and to man greatly outweigh the adverse environmental effects. The recommended plan would protect Grand Isle and its improvements from damages caused by erosion and hurricane-driven gulf waves and, by stabilizing Grand Isle, would protect the valuable estuarine marshland located on the bay side of the island from the direct attack of gulf waves. It was, therefore, identified as the EQ plan. Adverse environmental effects which would occur only during construction would be minor and temporary.

(2) I have found that the social well-being of the residents of Grand Isle and of the many recreationists who contribute to the local economy will be greatly benefitted by the recommended project. Alleviation of the fear of damages caused by hurricane-driven waves will result in increased development of Grand Isle as

a resort area and increase the standard of living of the residents of the project area.

(3) I have not recommended the best economic solution in order to provide a plan esthetically and economically acceptable by local interests.

(4) Relative to engineering feasibility, I have not maximized net hurricane protection benefits due to the reluctance of local interests to accept the higher costs and greater obstruction of the view of the Gulf of Mexico incidental to the plan that maximizes benefits.

d. I find that the proposed action, as recommended, is based on thorough analysis and evaluation of various practicable alternative courses of action for achieving the stated objectives; that wherever adverse effects are found to be involved they cannot be avoided by following reasonable alternative courses of action which would achieve the Congressionally specified purposes; that where the proposed action has an adverse effect, this effect is either ameliorated or substantially outweighed by other considerations of national policy; that the recommended action is consonant with national policy statutes, and administrative directives; and that on balance the total public interest should be best served by implementation of the recommendation.

<u>CONCLUSIONS</u>. It is concluded that Grand Isle, Louisiana, has suffered severe damages in the past due to beach erosion and the action of waves accompanying storms and hurricanes, and that it is likely to suffer similar damages in the future.

It is further concluded that the best protection against such damages that is acceptable by local interests can be obtained by construction of improvements outlined under plan B, which will provide both beach erosion protection and protection from hurricane-driven gulf waves for the entire area of Grand Isle. The total estimated first cost of plan B is $10,900,000 of which $6,760,000 is the Federal first cost. This plan provides a high degree of protection and is economically justified, having a benefit-cost ratio of 1.5 to 1.

RECOMMENDATIONS

It is recommended that this Phase I General Design Memorandum be approved as a basis to prepare a Phase II General Design Memorandum for the selected plan as described on page 72, subject to local interests satisfying all of the requirements of local cooperation listed on page 94.

THOMAS A. SANDS
Colonel, CE
District Engineer

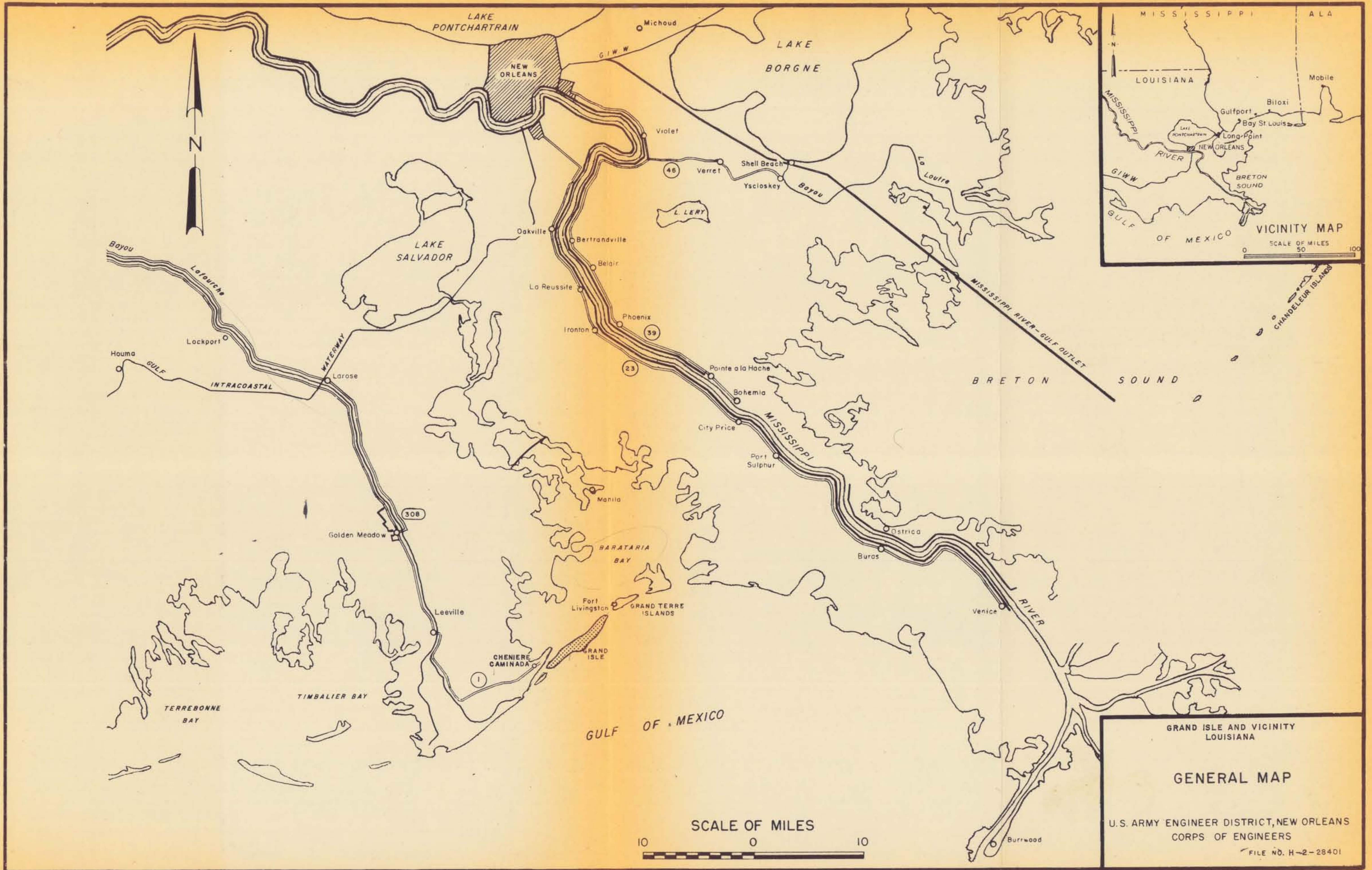
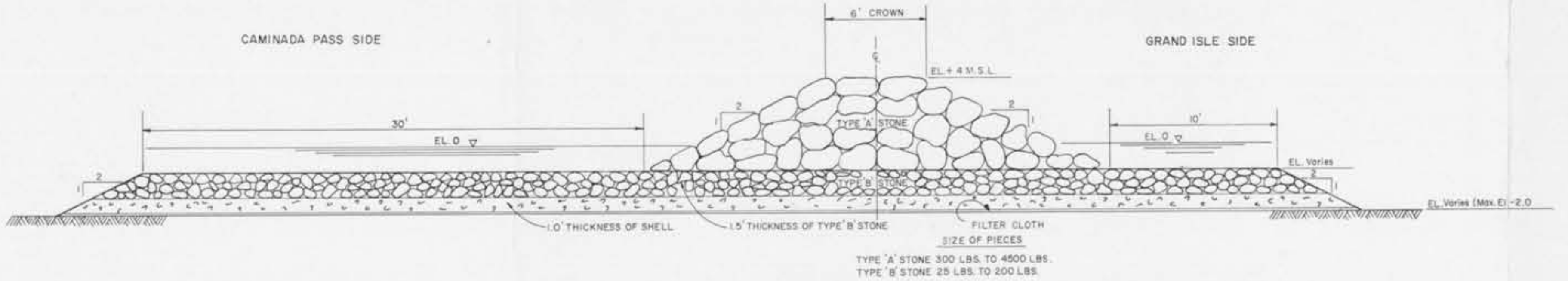

LAKE PONTCHARTRAIN
Michoud
LAKE BORGNE
NEW ORLEANS
G.I.W.W.
Violet
46
Verret
Shell Beach
Ycloskey
Bayou
La Loutre
L. LERY
N
Oakville
Bertrandville
Belair
La Reussite
Phoenix
39
Ironton
23
Pointe a la Hache
Bohemia
City Price
Port Sulphur
MISSISSIPPI
RIVER
Ostrica
Buras
Venice
Burrwood
MISSISSIPPI RIVER—GULF OUTLET
BRETON SOUND
CHANDELEUR ISLANDS
LAKE SALVADOR
Bayou Lafourche
Lockport
Houma
GULF INTRACOASTAL WATERWAY
Larose
308
Golden Meadow
Leeville
1
CHENIERE CAMINADA
GRAND ISLE
Fort Livingston
GRAND TERRE ISLANDS
BARATARIA BAY
Manila
TERREBONNE BAY
TIMBALIER BAY
GULF OF MEXICO
SCALE OF MILES
10
0
10
MISSISSIPPI
ALA
LOUISIANA
Mobile
Biloxi
Gulfport
Bay St. Louis
LAKE PONTCHARTRAIN
Long Point
NEW ORLEANS
MISSISSIPPI RIVER
GIWW
BRETON SOUND
GULF OF MEXICO
VICINITY MAP
SCALE OF MILES
0
50
100
GRAND ISLE AND VICINITY
LOUISIANA
GENERAL MAP
U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS
FILE NO. H-2-28401

PLATE 1

LEGEND

- - - - - 1953 TRAVERSE
— — — — CENTERLINE OF AUTHORISED AND CONSIDERED PLANS
(1) LOUISIANA HIGHWAY

390+09
385+23
04 76



TYPICAL JETTY SECTION

SCALE IN FEET

500 0 500 1000 1500

GRAND ISLE AND VICINITY
LOUISIANA
PHASE [illegible] GDM

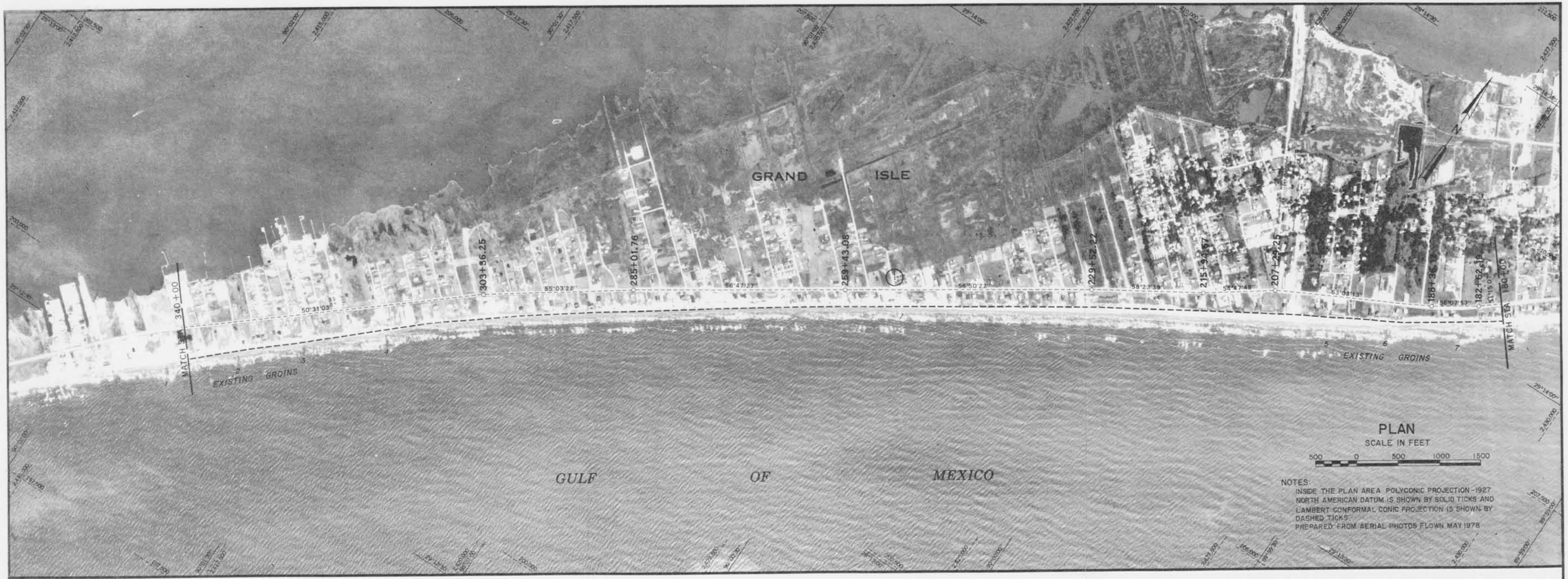
PLAN AND JETTY CROSS SECTION

SCALE AS SHOWN

U. S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS

FILE NO. H-2-28578

PLATE 2



LEGEND

1953 TRAVERSE
CENTERLINE OF AUTHORISED AND CONSIDERED PLANS
(1) LOUISIANA HIGHWAY

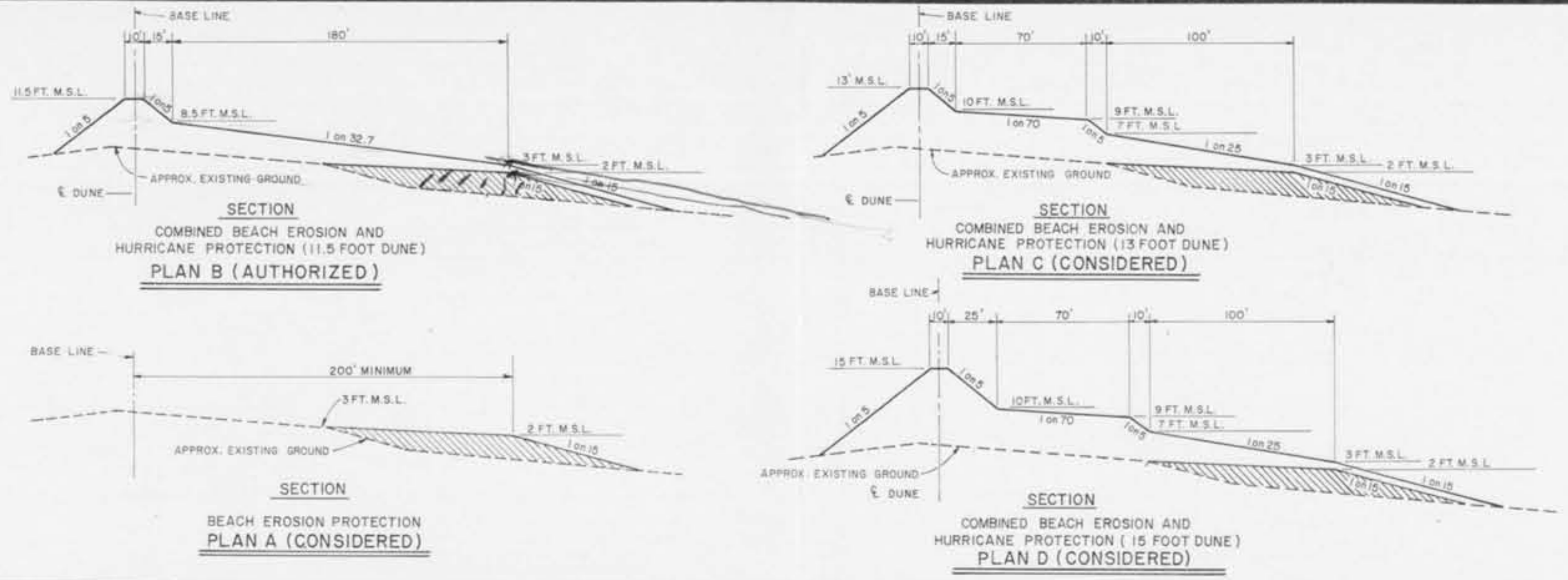
GRAND ISLE AND VICINITY
LOUISIANA
PHASE I GDM

BEACH PLAN

SCALE AS SHOWN

U. S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS

FILE NO. H-2-28578



LEGEND

- - - - - 1953 TRAVERSE
— — — CENTERLINE OF AUTHORISED AND CONSIDERED PLANS
(1) LOUISIANA HIGHWAY

GRAND ISLE AND VICINITY
LOUISIANA
PHASE I GDM

PLAN AND BEACH CROSS SECTIONS

SCALE AS SHOWN

U. S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS

FILE NO. H-2-28578

PART 2

APPENDIXES

APPENDIX A

Geology and Soils

GRAND ISLE AND VICINITY, LOUISIANA
PHASE I GENERAL DESIGN MEMORANDUM

APPENDIX A
GEOLOGY AND SOILS

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GRAND ISLE AND VICINITY, LOUISIANA
PHASE I GENERAL DESIGN MEMORANDUM

APPENDIX A

GEOLOGY AND SOILS

1. PHYSIOGRAPHY

The study area is located on the deltaic plain of the Mississippi River, a region of extremely low relief. Specifically, the area is situated on the northeast side of the distal end of the remnants of an ancient lobate delta of the Mississippi River known as the Lafourche delta. The principal physiographic features of the delta are the ancient course of the Lafourche stage Mississippi River; delta margin islands flanking the ancient delta; beaches along the gulfward margin of the mainland and islands facing the gulf; marshlands and inland bodies of water that lie landward of the shoreline beaches; and sand ridges--called chenieres--which locally parallel the coastline on the mainland.

Elevations range from 4 to 6 feet mean sea level (m.s.l.) along the crests of the chenieres and beach ridges to about 1 or 2 feet above sea level in the marshlands. The inland bays and lakes are very shallow.

2. GENERAL GEOLOGY

Only the geologic history in the last 4,000 to 5,000 years is significant for this study. During that time, the rise in sea level ceased, many lobate deltas were formed, and a gulfward growth of the land mass began. As the land mass advanced seaward, the course of the Mississippi River, and its associated deltas, shifted many times depositng a front of fine-grained alluvium over the entire area. After each change in the course of the Mississippi and its corresponding delta, the effects of subsidence and erosion became the dominant process within the abandoned delta. The gulfward edge of the abandoned delta began a landward retreat forming arcuate sandy delta margin islands with well-developed beaches consisting primarily of the coarser sediments of the reworked distributary deposits. Grand Isle, which flanks the gulfward end of the abandoned Lafourche delta, is an example of these delta margin islands.

3. INVESTIGATIONS PERFORMED

Thirty-eight general type soil borings (borings 1 through 14, 1B through 9B, 1H through 3H, and A through L), extending to depths between 30 and 60 feet, were made in the general vicinity of Grand Isle at the locations shown on plate A-1. Surface samples were taken at the shoreline of the beach, at the 6-foot depth line, and at the 12-foot depth line. A total of 52 surface samples were taken. Tests performed on the borings included visual classification, water content, and mechanical sieve analyses. The results of these tests and the boring logs are shown on plates A-1, A-2, and A-3.

4. SUBSURFACE CONDITIONS

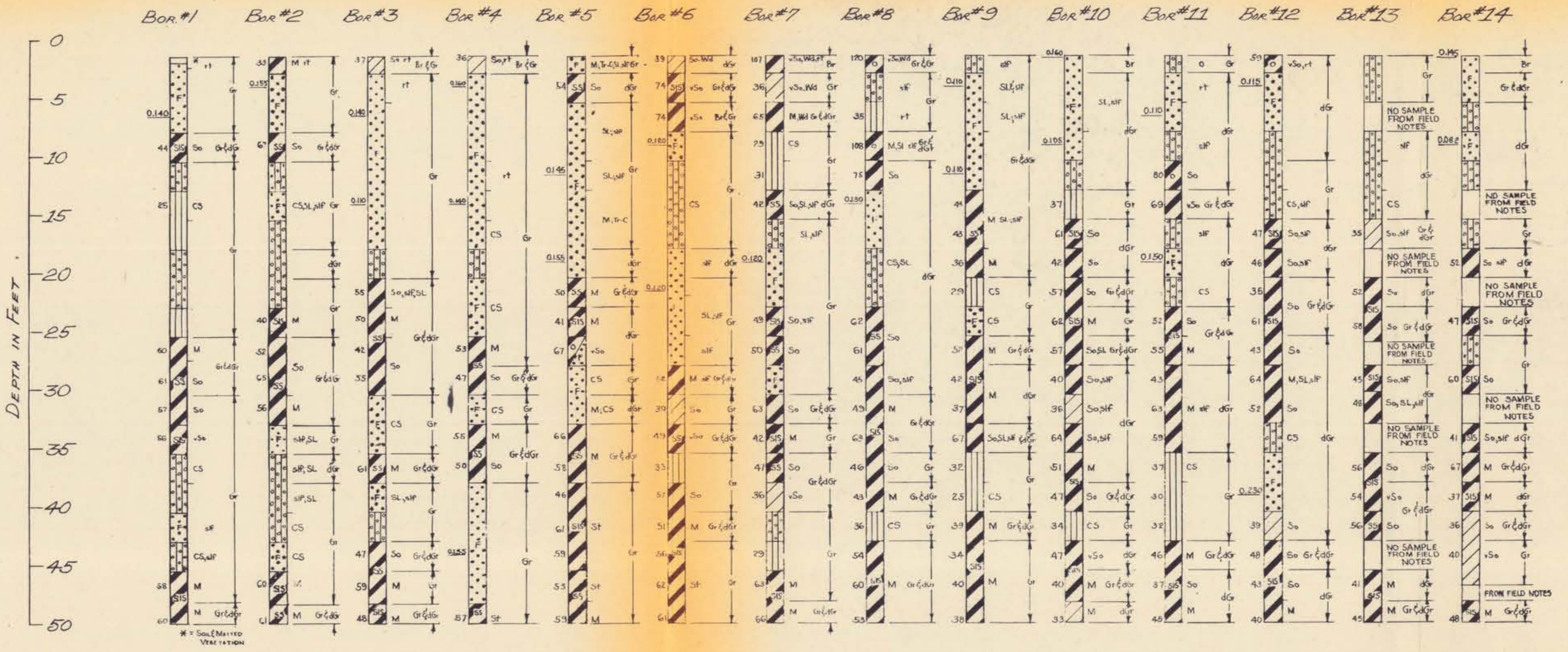
The subsurface at Grand Isle consists of Recent deposits approximately 450 feet thick. The Recent deposits are underlain by material of Pleistocene age. Generally, the Recent consists of fine beach sand varying in thickness from about 15 to 20 feet along the modern beach, to approximately 30 feet just northward of the modern beach. The fine sand is underlain by silty sands to a maximum depth of about 60 feet in the eastern half of the island, north of the modern beach. Generally this sandy material wedge thins to about 20 feet at the western or Caminada Pass end of the island. The extensive depth of the sand at Grand Isle is the result of progressive settlement of the sand as the beach deposits accumulated. Underlying the sandy materials are prodelta deposits of medium clays.

5. CONCLUSIONS AND RECOMMENDATIONS

Based on available geologic and soil investigations, it is estimated that approximately 7.6 million cubic yards of sand should be available for borrow in the areas shown on plate A-1. This estimate reflects borrow available for construction based on the suitability of material in the vicinity of borings 1B and 7B. The assumed 5 to 1 loss ratio applied to this quantity will provide the actual quantity of 1.5 million cubic yards required for construction of the recommended sand dune. The borrow area dimension located in the vicinity of boring 1B is 1,500 x 2,600 x 40 feet and in the vicinity of boring 7B is 1,500 x 2,200 x 15 feet. Borings 1B and 7B contain sands with median (D_{50}) sizes that fall within the range of the (D_{50}) size of the present beach material and would offer the most resistance to displacement by wave erosion and littoral currents.

Though borings A, E, G, J, and K also indicate the availability of suitable material for sand dune construction, current oyster leases make it undesirable to plan use of the materials located in the proximity of these borings at this time.

Based on available geologic and soils information, no unusual problems should be encountered in constructing a sand dune to an elevation of 11.5 feet with wave berm as shown on plate 2. Erosion protection (vegetation) will be required.



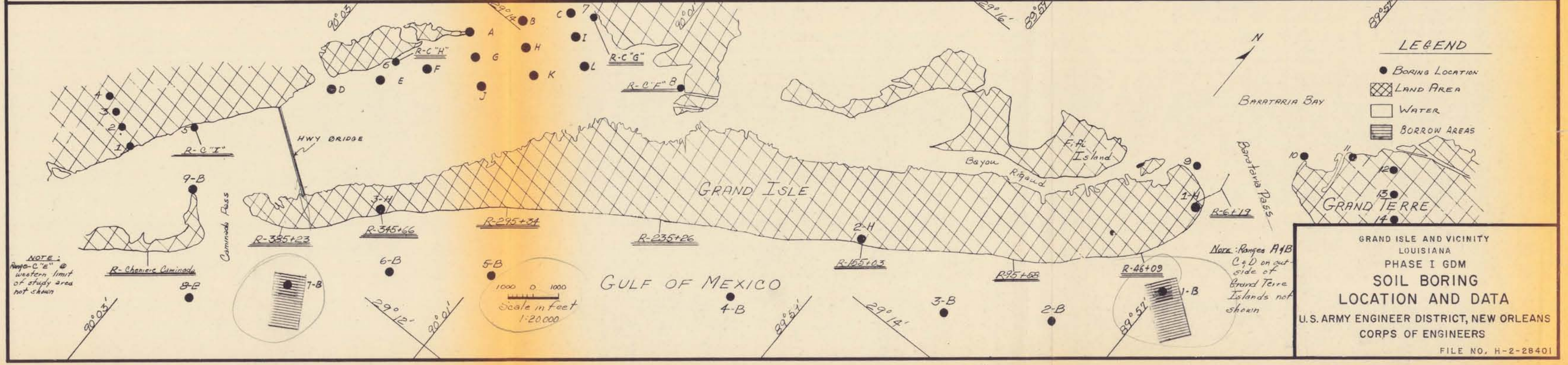
ANALYSIS OF BEACH SAMPLES

LOCATION	CLASS	D-50(mm)
R-C "F" @ beach	SM-1-S	0.1250
R-C "F" 250' off	SM-1	0.1150
R-C "G" @ beach	Matt Veg.	No MA.
R-C "G" 200' off	SP	0.1400
R-C "G" 350' off	SM-1-S	0.1600
R-C "H" @ beach	ML-1	0.0605
R-C "H" 150' off	ML-1	0.0490
R-C "I" @ beach	SM-1	0.1250
R-C "I" 150' off	SP	0.1500
R-C "I" 300' off	SP	0.1300
R-A @ beach	SP	0.1650
R-A 6' depth	SP	0.1250
R-A 12' depth	ML-1	0.0740
R-B @ beach	SP	0.1700
R-B 6' depth	SM-1	0.0740
R-B 12' depth	SM-1-S	0.1200
R-C @ beach	SP	0.1750
R-C 6' depth	ML-2-S	0.0620
R-C 12' depth	ML-2-S	0.0640
R-D @ beach	SP	0.1750
R-D 6' depth	SM-1-S	0.1005
R-D 12' depth	ML-2	0.0550
R-6+19 @ beach	SP	0.1300
R-6+19 6' depth	SM-1-S	0.0970
R-6+19 12' depth	SP	0.1250
R-46+09 @ beach	SP	0.1400
R-46+09 6' depth	SP	0.1255
R-46+09 12' depth	ML-1	0.0670

LOCATION	CLASS	D-50(mm)
R-95+48 @ beach	SP	0.1750
R-95+48 6' depth	SP	0.1050
R-95+48 12' depth	SM-1-S	0.1200
R-155+03 @ beach	SP	0.1900
R-155+03 6' depth	SP	0.1200
R-155+03 12' depth	SM-1	0.1050
R-235+26 @ beach	SP	0.1250
R-235+26 6' depth	SP	0.1300
R-235+26 12' depth	SM-1-S	0.1050
R-295+34 @ beach	SP	0.1700
R-295+34 6' depth	SP	0.1350
R-295+34 12' depth	SM-1	0.0890
R-345+66 @ beach	SP	0.1800
R-345+66 6' depth	SP	0.1400
R-345+66 12' depth	ML-1	0.0790
R-385+23 @ beach	SP	0.1800
R-385+23 6' depth	SP	0.1800
R-385+23 12' depth	ML-1	0.0780
R-Chen Cam. @ beach	SP	0.1800
R-Chen Cam. 6' depth	SP	0.1250
R-Chen Cam. 12' depth	SM-1-S	0.0750
R-C "E" @ beach	SP	0.1750
R-C "E" 6' depth	SP	0.1700
R-C "E" 12' depth	SM-1-S	0.0940

CLASS	% SAND
SP	90-100
SM-1-S	80-90
SM-1	60-80
ML-1	45-60
ML-2-S	20-45

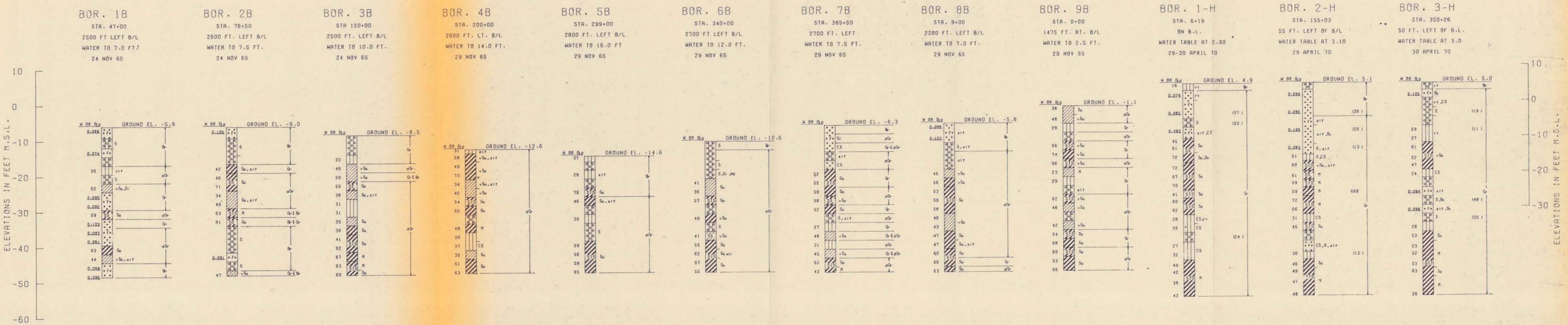
Bor. 1 - 14 were made in March, 1964 using an open bottom sampler.
Underlined figures to left of boring indicate D50 size in mm.
Bor. 1-B - 9-B were made in November, 1965. See Plate 2 for logs.
Bor. 1-H - 3-H were made in April, 1970. See Plate 2 for logs.



GRAND ISLE AND VICINITY
LOUISIANA
PHASE I GDM
SOIL BORING
LOCATION AND DATA
U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS

FILE NO. H-2-28401

APPENDIX A PLATE A-1



NOTE:

1. Borings 1-B thru 9-B made in Nov. 1965 with a $1\frac{7}{8}$" I.D. Core Barrel Sampler.

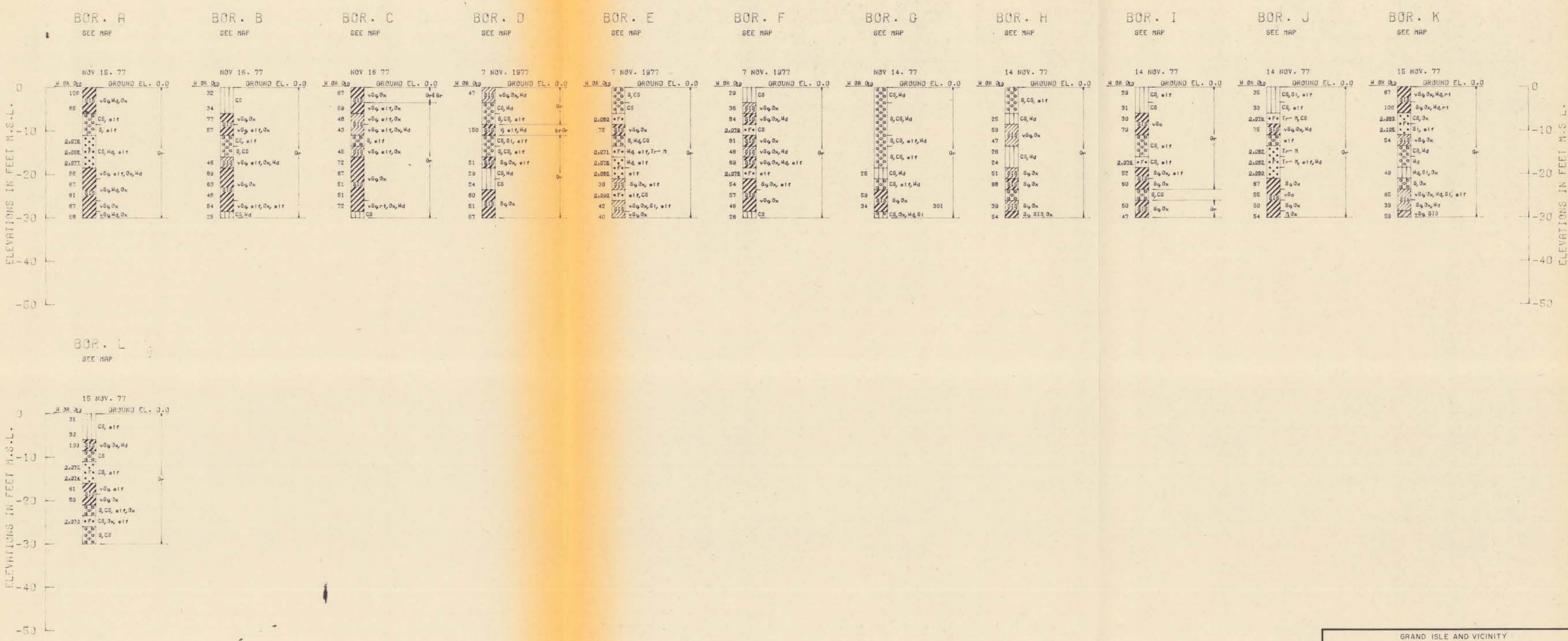
2. Borings 1-H thru 3-H made in Apr. 1970 with a $1\frac{7}{8}$" I.D. Core Barrel Sampler & a $1\frac{3}{8}$" Split Spoon Sampler.

GRAND ISLE AND VICINITY
LOUISIANA
PHASE II GDM

SOIL BORING DATA

U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS

FILE NO. H-2-28401



GRAND ISLE AND VICINITY
LOUISIANA

PHASE I GDM

SOIL BORING DATA

U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
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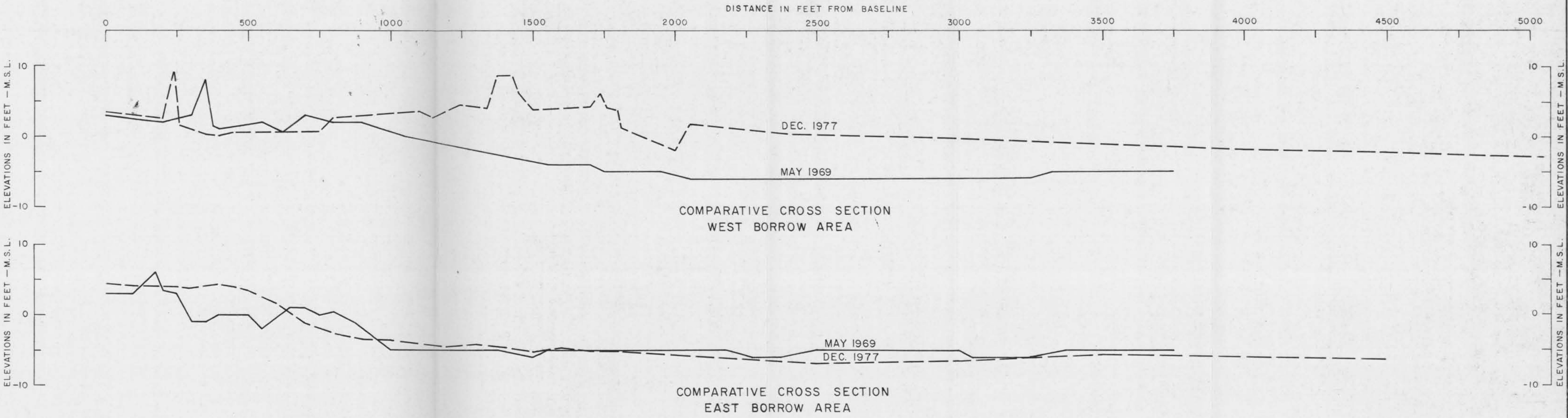


GRAND ISLE AND VICINITY, LOUISIANA

PHASE I GDM
COMPARATIVE CROSS SECTIONS

U. S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS

FILE NO. H-2-28401

UNIFIED SOIL CLASSIFICATION

MAJOR DIVISION		TYPE	LETTER SYMBOL	SYMBOL	TYPICAL NAMES
COARSE - GRAINED SOILS More than half of material is larger than No. 200 sieve size.	GRAVELS More than half of coarse fraction is larger than No. 4 sieve size.	CLEAN GRAVEL (Little or No Fines)	GW		GRAVEL, Well Graded, gravel-sand mixtures, little or no fines
			GP		GRAVEL, Poorly Graded, gravel-sand mixtures, little or no fines
		GRAVEL WITH FINES (Appreciable Amount of Fines)	GM		SILTY GRAVEL, gravel-sand-silt mixtures
			GC		CLAYEY GRAVEL, gravel-sand-clay mixtures
	SANDS More than half of coarse fraction is smaller than No. 4 sieve size.	CLEAN SAND (Little or No Fines)	SW		SAND, Well-Graded, gravelly sands
			SP		SAND, Poorly-Graded, gravelly sands
		SANDS WITH FINES (Appreciable Amount of Fines	SM		SILTY SAND, sand-silt mixtures
			SC		CLAYEY SAND, sand-clay mixtures
FINE - GRAINED SOILS More than half the material is smaller than No. 200 sieve size.		SILTS AND CLAYS (Liquid Limit < 50)	ML		SILT & very fine sand, silty or clayey fine sand or clayey silt with slight plasticity
			CL		LEAN CLAY; Sandy Clay; Silty Clay; of low to medium plasticity
			OL		ORGANIC SILTS and organic silty clays of low plasticity
		SILTS AND CLAYS (Liquid Limit > 50)	MH		SILT, fine sandy or silty soil with high plasticity
			CH		FAT CLAY, inorganic clay of high plasticity
			OH		ORGANIC CLAYS of medium to high plasticity, organic silts
HIGHLY ORGANIC SOILS			Pt		PEAT, and other highly organic soil
WOOD			Wd		WOOD
SHELLS			SI		SHELLS
NO SAMPLE					

NOTE: Soils possessing characteristics of two groups are designated by combinations of group symbols

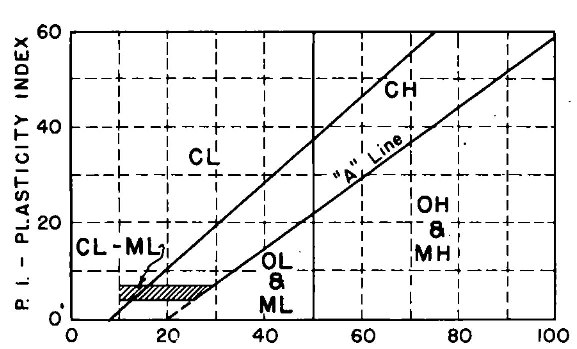
DESCRIPTIVE SYMBOLS

COLOR

COLOR	SYMBOL
TAN	T
YELLOW	Y
RED	R
BLACK	BK
GRAY	Gr
LIGHT GRAY	lGr
DARK GRAY	dGr
BROWN	Br
LIGHT BROWN	lBr
DARK BROWN	dBr
BROWNISH-GRAY	br Gr
GRAYISH-BROWN	gy Br
GREENISH-GRAY	gn Gr
GRAYISH-GREEN	gy Gn
GREEN	Gn
BLUE	Bl
BLUE-GREEN	Bl Gn
WHITE	Wh
MOTTLED	Mot

CONSISTENCY FOR COHESIVE SOILS

CONSISTENCY	COHESION IN LBS./SQ.FT. FROM UNCONFINED COMPRESSION TEST	SYMBOL
VERY SOFT	< 250	vSo
SOFT	250 - 500	So
MEDIUM	500 - 1000	M
STIFF	1000 - 2000	St
VERY STIFF	2000 - 4000	vSt
HARD	> 4000	H



PLASTICITY CHART

For classification of fine-grained soils

MODIFICATIONS

MODIFICATION	SYMBOL
Traces	Tr-
Fine	F
Medium	M
Coarse	C
Concretions	cc
Rootlets	rt
Lignite fragments	lg
Shale fragments	sh
Sandstone fragments	sds
Shell fragments	slf
Organic matter	O
Clay strata or lenses	CS
Silt strata or lenses	SIS
Sand strata or lenses	SS
Sandy	S
Gravelly	G
Boulders	B
Slickensides	SL
Wood	Wd
Oxidized	Ox

NOTES:

FIGURES TO LEFT OF BORING UNDER COLUMN "W OR D_{10}"

Are natural water contents in percent dry weight

When underlined denotes D_{10} size in mm *

FIGURES TO LEFT OF BORING UNDER COLUMNS "LL" AND "PL"

Are liquid and plastic limits, respectively

SYMBOLS TO LEFT OF BORING

▽	Ground-water surface and date observed
(C)	Denotes location of consolidation test **
(S)	Denotes location of consolidated-drained direct shear test **
(R)	Denotes location of consolidated-undrained triaxial compression test **
(Q)	Denotes location of unconsolidated-undrained triaxial compression test **
(T)	Denotes location of sample subjected to consolidation test and each of the above three types of shear tests **
FW	Denotes free water encountered in boring or sample

FIGURES TO RIGHT OF BORING

Are values of cohesion in lbs./sq. ft. from unconfined compression tests

In parenthesis are driving resistances in blows per foot determined with a standard split spoon sampler ($1\frac{3}{8}$" I.D., 2" O.D.) and a 140 lb. driving hammer with a 30" drop

Where underlined with a solid line denotes laboratory permeability in centimeters per second of undisturbed sample

Where underlined with a dashed line denotes laboratory permeability in centimeters per second of sample remoulded to the estimated natural void ratio

* The D_{10} size of a soil is the grain diameter in millimeters of which 10% of the soil is finer, and 90% coarser than size D_{10}.

**Results of these tests are available for inspection in the U.S. Army Engineer District Office, if these symbols appear beside the boring logs on the drawings.

GENERAL NOTES:

While the borings are representative of subsurface conditions at their respective locations and for their respective vertical reaches, local variations characteristic of the subsurface materials of the region are anticipated and, if encountered, such variations will not be considered as differing materially within the purview of clause 4 of the contract.

Ground-water elevations shown on the boring logs represent ground-water surfaces encountered on the dates shown. Absence of water surface data on certain borings implies that no ground-water data is available, but does not necessarily mean that ground water will not be encountered at the locations or within the vertical reaches of these borings.

Consistency of cohesive soils shown on the boring logs is based on driller's log and visual examination and is approximate, except within those vertical reaches of the borings where shear strengths from unconfined compression tests are shown.

REVISION	DATE	DESCRIPTION	BY
3	5-3-71	ADDED UPPER LIMIT LINE (P.I.=0.9(LL-8)) ON PLASTICITY CHART	LMVED-G LETTER D'T'D 29 APRIL 1971
2	6-8-64	SYMBOL FW, NOTE REVISED	ORAL FROM L.M.V.G.G. 5 JUNE 1964
1	9-17-63	1ST PAR OF GENERAL NOTES REVISED	L M V D MULTIPLE LETTER, DATED 5 SEPT., 1963

SOIL BORING LEGEND

U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS
FILE NO. H-2-21800

APPENDIX B

Hydrology and Hydraulic

GRAND ISLE AND VICINITY, LOUISIANA

PHASE I GENERAL DESIGN MEMORANDUM

APPENDIX B
HYDROLOGY AND HYDRAULICS

TABLE OF CONTENTS

TABLES

GLOSSARY OF TERMS

ACCRETION - May be either NATURAL or ARTIFICIAL. Natural accretion is the gradual buildup of land over a long period of time solely by the action of the forces of nature, on a BEACH by deposition of waterborne or airborne material. Artificial accretion is a similar buildup of land by reason of an act of man, such as the accretion formed by a groin, breakwater, or beach fill deposited by mechanical means. Also AGGRADATION.

ADVANCE (OF A BEACH) - (1) A continuing seaward movement of the shoreline. (2) A net seaward movement of the shoreline over a specified time. Also PROGRESSION.

ARTIFICIAL NOURISHMENT - The process of replenishing a beach by artificial means, e.g., by the deposition of dredged materials.

ATMOSPHERIC PRESSURE ANOMALY - The difference between atmospheric pressure at any point within a hurricane and normal pressure at the periphery of the hurricane.

BAR - An offshore ridge or mound of sand, gravel, or other unconsolidated material submerged, at least at high tide; especially at the mouth of a river or estuary, or lying a short distance from and usually parallel to the beach.

BARRIER BEACH - A bar essentially parallel to the shore, the crest of which is above high water. Also OFFSHORE BARRIER.

BAY - A recess in the shore or an inlet of a sea or lake between two capes or headlands, not as large as a gulf but larger than a cove. Also BIGHT, EMBAYMENT.

BAYOU - A minor sluggish waterway or estuarial creek, tributary to, or connecting, other streams or bodies of water. Its course is usually through lowlands or swamps.

BEACH - The 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.

BEACH BERM - A nearly horizontal portion of the beach or backshore formed by the deposit of material by wave action. Some beaches have no berms, others have one or several.

BEACH EROSION - The carrying away of beach materials by wave action, tidal currents, littoral currents, or wind.

BEACH WIDTH - The horizontal dimension of the beach as measured normal to the shoreline.

BOTTOM - The ground or bed under any body of water; the bottom of the sea.

BREAKER DEPTH - The stillwater depth at the point where the wave breaks. Also BREAKING DEPTH.

BREAKWATER - A structure protecting a shore area, harbor, anchorage, or basin from waves.

BULKHEAD - A structure separating land and water areas, primarily designed to resist earth pressures. Also see SEAWALL.

CHANNEL - (1) A natural or artificial waterway of perceptible extent which either periodically or continuously contains moving water, or which forms a connecting link between two bodies of water. (2) The part of a body of water deep enough to be used for navigation through an area otherwise too shallow for navigation. (3) A large strait, as the English Channel. (4) The deepest portion of a stream, bay, or strait through which the main volume or current of water flows.

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.

CONTINENTAL SHELF - The zone bordering a continent extending from the line of permanent immersion to the depth (usually about 100 fathoms) where there is a marked or rather steep descent toward the greater depths.

CONTOUR - (1) A line connecting the points on a land or submarine surface that have the same elevation. (2) In topographic or hydrographic work, a line connecting all points of equal elevation above or below a datum plane.

CONVERGENCE - (1) In refraction phenomena, the decreasing of the distance between orthogonals. This denotes an area of increasing wave height and energy concentration. (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.

CREST LENGTH, WAVE - The length of a wave along its crest. Sometimes called CREST WIDTH.

CREST OF WAVE - (1) The highest part of a wave. (2) That part of the wave above stillwater level.

CURRENT - A flow of water.

CURRENT, COASTAL - One of the offshore currents flowing generally parallel to the shoreline with a relatively uniform velocity (as compared to the littoral currents). They are not related genetically to waves and resulting surf but may be composed of currents related to distribution of mass in ocean waters (or local eddies), wind-driven currents and/or tidal currents.

CURRENT, EBB - The movement of the tidal current away from shore or down a tidal stream.

CURRENT, FLOOD - The movement of the tidal current toward the shore or up a tidal stream.

CURRENT, LONGSHORE - The inshore current moving essentially parallel to the shore, usually generated by waves breaking at an angle to the shoreline.

CURRENT, TIDAL - A current caused by the tide-producing forces of the moon and the sun, which is a part of the same general movement of the sea manifested in the vertical rise and fall of the tides.

DEEP WATER - Water of depth such that surface waves are little affected by conditions on the ocean bottom. It is customary to consider water deeper than one-half the surface wave length as deep water.

DEPTH - The vertical distance from the stillwater level (or datum as specified) to the bottom.

DIFFRACTION OF WATER WAVES - The phenomenon by which energy is transmitted laterally along a wave crest. When a portion of a train of waves is interrupted by a barrier, such as a breakwater, the effect of diffraction is manifested by propagation of waves into the sheltered region within the barrier's geometric shadow.

DIKE (DYKE) - A wall or mound built around a low-lying area to prevent flooding.

DIURNAL TIDE - A tide with one high water and one low water in a tidal day.

DIVERGENCE - (1) In refraction phenomena, the increasing of distance between orthogonals. This denotes an area of decreasing wave height and energy concentration. (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.

DOWNDRIFT - The direction of predominant movement of littoral materials.

DUNES - Ridges or mounds of loose, wind-blown material, usually sand.

DURATION - In wave forecasting, the length of time the wind blows in essentially the same direction over the FETCH (generating area).

EBB TIDE - A nontechnical term referring to that period of tide while ebbing or at ebb; falling tide.

ENERGY COEFFICIENT - The ratio of the energy in a wave per unit crest length transmitted forward with the wave at a point in shallow water to the energy in a wave per unit crest length transmitted forward with the wave in deep water. On refraction diagrams this is equal to the ratio of the distance between a pair of orthogonals at a selected point to the distance between the same pair of orthogonals in deep water. Also the square of the REFRACTION COEFFICIENT.

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.

FATHOM - A unit of measurement used for soundings. It is equal to 6 feet (1.83 meters).

FETCH - In wave forecasting, the horizontal distance (in the direction of the wind) over which the wind blows.

FLOOD TIDE - A nontechnical term referring to that period of tide between low water and the succeeding high water; a rising tide.

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 ordinary low water mark; that is, ordinarily traversed by the uprush and backrush of the waves as the tides rise and fall.

FREEBOARD - The additional height of a structure above design high water level to prevent overflow. Also, at a given time the vertical distance between the water level and the top of the structure. On a ship, the distance from the waterline to main deck or gunwale.

GENERATING AREA - In wave forecasting, the continuous area of water surface over which the wind blows in essentially a constant direction. Sometimes used synonymously with FETCH LENGTH. Also FETCH.

GROIN (British, GROYNE) - A shore protective structure (built usually perpendicular to the shoreline) to trap littoral drift or retard erosion of the shore. It is narrow in width, and its length may vary from less than one hundred to several hundred feet (extending from a point landward of the shoreline out into the water). Groins may be classified as permeable or impermeable--impermeable groins having a solid or nearly solid structure; permeable groins having openings through them of sufficient size to permit passage of appreciable quantities of littoral drift.

HEIGHT OF WAVE - The vertical distance between a crest and the preceding trough. Also see SIGNIFICANT WAVE HEIGHT.

HIGH TIDE, HIGH WATER (HW) - The maximum height reached by each rising tide. See TIDE.

HIGH WATER LINE - In strictness, 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.

HURRICANE TERMINOLOGY

HURRICANE - An intense cyclonic windstorm of tropical origin in which winds tend to spiral inward toward a core of low pressure, with maximum surface wind velocities that equal or exceed 75 m.p.h. (65 knots) for several minutes or longer at some points. Tropical storm is the term applied if maximum winds are less than 75 m.p.h. Hurricanes of the Western Pacific Ocean are called typhoons.

HURRICANE PARAMETERS:

CENTRAL PRESSURE INDEX (CPI) - The central pressure index is the estimated minimum barometric pressure in the eye (approximate center) of a particular hurricane. The CPI is considered the most stable index to intensity of hurricane wind velocities in the periphery of the storm; the highest wind velocities corresponding to the lowest CPI.

CPI FREQUENCY - Estimated average frequency of occurrence in events per hundred years of a specified CPI in a designated geographical zone; derived from statistical analyses of recorded hurricanes supplemented by meteorological studies.

RADIUS OF MAXIMUM WINDS - Distance from the eye of the hurricane, where surface wind velocities are zero, to the place where surface wind velocities are maximum.

FORWARD SPEED - Rate of movement (propagation) of the hurricane eye in m.p.h. or knots.

HURRICANE PATH OR TRACK - Line of movement (propagation) of the eye through an area.

HURRICANE WIND PATTERN or ISOVEL PATTERN - An actual or graphical representation of near-surface wind velocities covering the entire area of a hurricane at a particular instant. Isovels are lines connecting points of simultaneous equal wind velocities, usually referenced 30 feet above the surface, in knots or m.p.h.; wind directions at various points are indicated by arrows or deflection angles on the isovel charts. Isovel charts are usually prepared at each hour during a hurricane, but for each half hour during critical periods.

HURRICANE STAGE HYDROGRAPH - A continuous graph representing water level stages that would be recorded in a gage well located at a specified point of interest during the passage of a particular hurricane, assuming that effects of relatively short-period waves are eliminated from the record by damping features of the gage well. Unless specifically excluded and separately accounted for, hurricane surge hydrographs are assumed to include effects of astronomical tides, barometric pressure differences, and all other factors that influence water level stages within a properly designed gage well located at a specified point.

HYPOTHETICAL HURRICANE ("HYPO-HURRICANE") - A representative of a hurricane, with specified characteristics, that is assumed to occur in a particular study area, following a specified path and timing sequence.

TRANSPOSED - A hypo-hurricane based on the storm transposition principle is assumed to have wind patterns and other characteristics basically comparable to a specified hurricane of record, but is transposed to follow a new path to serve as a basis for computing a hurricane surge hydrograph that would be expected at a selected point. Moderate adjustments in timing or rate of forward movement may be made also, if these are compatible with meteorological considerations and study objectives.

HYPO-HURRICANE BASED ON GENERALIZED PARAMETERS - Hypo-hurricane estimates based on various logical combinations of hurricane characteristics require consideration in estimating hurricane surge magnitudes corresponding to a range of probabilities and potentialities. The Standard Project Hurricane is most commonly used for this purpose, but estimates corresponding to more severe or less severe assumptions are important in some project investigations.

STANDARD PROJECT HURRICANE (SPH) - A hypothetical hurricane intended to represent the most severe combination of hurricane parameters that is reasonably characteristic of a specified region, excluding extremely rare combinations. It is further assumed that the SPH would approach a given project site from such direction, and at such rate of movement as to produce the highest hurricane surge hydrograph, considering pertinent hydraulic characteristics of the area. Based on this concept and extensive meteorological studies and probability analyses, a tabulation of "Standard Project Hurricane Index Characteristics" mutually agreed upon by representatives of the Corps of Engineers and the U. S. Weather Bureau is available.

PROBABLE MAXIMUM HURRICANE - A hypo-hurricane that might result from the most severe combination of hurricane parameters that is considered reasonably possible in the region involved, if the hurricane should approach the point under study along a critical path and at optimum rate of movement. This estimate is substantially more severe than the SPH criteria.

DESIGN HURRICANE - A representation of a hurricane with specified characteristics that would produce hurricane surge hydrographs and coincident wave effects at various key locations along a proposed project alinement. It governs the project design after economics and other factors have been duly considered. The design hurricane may be more or less severe than the SPH, depending on economics, risk, and local considerations.

JETTY - (1) (U.S. usage) 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. (2) (British usage) Jetty is synonymous with "wharf" or "pier."

KNOT - (Abbreviation kn.) The unit of speed used in navigation. It is equal to 1 nautical mile (6,076.115 feet) per hour.

LANDFALL - The arrival of a hurricane center at the coastline.

LENGTH OF WAVE _ The horizontal distance between similar points on two successive waves measured perpendicularly to the crest.

LITTORAL DRIFT - The sedimentary material moved in the littoral zone under the influence of waves and currents.

LITTORAL TRANSPORT - Th movement of littoral drift in the littoral zone by waves and currents. Includes movement parallel to the shore (longshore transport) and perpendicular (or offshore) transport.

LONGSHORE CURRENT - Current in the surf zone moving essentially parallel to the shore, usually generated by waves breaking at an angle to the shoreline.

LOW TIDE (LOW WATER, LW) - The minimum height reached by each falling tide. See TIDE.

LOWER WATER DATUM - An approximately to the plane of mean low water that has been addopted as a standard reference plane.

MEAN DIAMETER, GEOMETRIC - Th diameter equivalent of the arithmetic mean of the logarithmic frequency distribution. In the analysis of beach sands it is taken as that grain diameter determined graphically by the intersection of a straight line through selected boundary sizes (generally points on the distribution curve where 16 and 84 percent of the sample is coarser by weight) and a vertical line through the median diameter of the sample.

MEAN HIGH WATER (MHW) - The average height of the high waters over a 19-year period. For shorter period of observations, corrections are applied to eliminate known variations and reduce the results to the equivalent of a mean 19-year value. All high water heights are included in the average where the type of tide is either semidiurnal or mixed. Only the higher high water heights are included in the average where the type of tide is diurnal. So determined, mean high water in the latter case is the same as mean higher high water.

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. All low water heights are included in the average where the type of tide is either semidiurnal or mixed. Only lower low water heights are included in the average where the type of tide is diurnal. So determined, mean low water in the latter case is the same as mean lower low water.

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.

MEAN TIDE LEVEL - Also called half-tide level. A plane midway between mean high water and mean low water.

NAUTICAL MILE - The length of a minute of arc, 1/21,600 of an average great circle of the earth. 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.

NODAL ZONE - An area at which the predominant direction of the LITTORAL TRANSPORT changes.

NOURISHMENT - The process of replenishing a beach. It may be brought about naturally, by littoral transport, or artificially by the deposition of dredged materials.

OFFSHORE - (1) In beach terminology, 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.

OFFSHORE WIND - A wind blowing seaward from the land in the coastal area.

ONSHORE - A direction landward from the sea.

ONSHORE WIND - A wind blowing landward from the sea in the coastal area.

ORTHOGONAL - On a refraction diagram, a line drawn perpendicular to the wave crests.

OVERTOPPING - Passing of water over the top of a structure as a result of wave runup or surge action.

PASS - In hydrographic usage, a navigable channel through a bar, reef, or shoal, or between closely adjacent islands.

POTENTIAL ENERGY OF WAVES - In a progressive oscillatory wave, the energy resulting from the elevation or depression of the water surface from the undisturbed level. This energy advances with the wave form.

PREDICTED NORMAL TIDE - The predicted stillwater elevation of the ocean and its tidal arms at a given time and place when unaffected by abnormal phenomena; i.e., resulting only from the gravitational attraction of the moon, sun, and other astronomical bodies acting upon the rotating earth. (This term is preferable to "astronomical," whose other meaning, fabulously large, could be misleading to the uninformed.)

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.

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.

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 alinement with the underwater contours. (2) The bending of wave crests by currents.

REFRACTION DIAGRAM - A drawing showing positions of wave crests and/or orthogonals in a given area for a specific deepwater wave period and direction.

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.

RIDGE, BEACH - An essentially continuous mound of beach material that has been shaped up by wave or other action. Ridges may occur singly or as a series of approximately parallel deposits. British usage, FULLS.

RUNUP - The rush of water up a structure on the breaking of a wave. Also UPRUSH. The amount of runup is the vertical height above stillwater level that the rush of water reaches.

SCOUR - Removal of underwater material by waves and currents, especially at the base or toe of a shore structure.

SETUP, WAVE - Superelevation of the water surface over normal surge elevation due to onshore mass transport of the water by wave action alone.

SHORE - The strip of ground bordering any body of water. A shore of unconsolidated material is usually called a beach.

SHORELINE - The intersection of a specified plane of water with the shore or beach (e.g., the highwater 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.

SIGNIFICANT WAVE - (1) A statistical term denoting waves with the average height and period of the one-third highest waves of a given wave group. The composition of the higher waves depends upon the extent to which the lower waves are considered. Experience so far indicates that a careful observer who attempts to establish the character of the higher waves will record values which approximately fit the definition. (2) A wave of significant wave period and significant wave height.

SIGNIFICANT WAVE HEIGHT - The average height of one-third highest waves of a given wave group. Note that the composition of the highest waves depends upon the extent to which the lower waves are considered. In wave record analysis, the average height of the highest one-third of a selected number of waves, this number being determined by dividing the time of record by the significant period. Also CHARACTERISTIC WAVE HEIGHT.

SIGNIFICANT WAVE PERIOD - An arbitrary period generally taken as the period of the one-third highest waves within a given group. Note that the composition of the highest waves depends upon the extent to which the lower waves are considered. In wave record analysis, this is determined as the average period of the most frequently recurring of the larger well-defined waves in the record under study.

SLOPE - The degree of inclination to the horizontal. Usually expressed as a ratio, such as 1:25 or 1 on 25, indicating 1 unit vertical rise in 25 units of horizontal distance; or a decimal fraction (0.04); degrees (2°18'); or percent (4%). It is sometimes described by such adjectives as steep, moderate, gentle, mild, or flat.

SPIT - A small point of land or a narrow shoal projecting into a body of water from the shore.

SPRING TIDE - A tide that occurs at or near the time of new and full moon and which rises highest and falls lowest from the mean level.

STILLWATER LEVEL - The elevation of the surface of the water if all wave action were to cease.

STORM SURGE - That rise above normal water level on the open coast due only to the action of wind stress on the water surface. Storm surge resulting from a hurricane also includes that rise in level due to atmospheric pressure reduction as well as that due to wind stress. (See SETUP, WIND.)

STORM TIDE - See WIND SETUP.

SURF - The wave activity in the area between the shoreline and the outermost limit of breakers.

SURGE - (1) The name applied to wave motion with a period intermediate between that of the ordinary wind wave and that of the tide, say from 1/2 to 60 minutes. It is of low height; usually less than 0.3 foot. Also SEICHE. (2) In fluid flow, long interval variations in velocity and pressure, not necessarily periodic, perhaps even transient in nature.

TIDAL RANGE - The difference in height between consecutive high and low waters.

TIDE - The periodic rising and falling of the water that results from gravitational attraction of the moon and sun 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.

TIDE, DIURNAL - A tide with one high water and one low water in a tidal day.

TIDE, EBB - That period of tide between a high water and the succeeding low water; falling tide.

TIDE, FLOOD - That period of tide between low water and the succeeding high water; a rising tide.

TROUGH OF WAVE - The lowest part of a wave form between successive crests. Also that part of a wave below stillwater level.

WAVE - A ridge, deformation, or undulation of the surface of a liquid.

WAVE DIRECTION - The direction from which a wave approaches.

WAVE FORECASTING - The theoretical determination of future wave characteristics, usually from observed or predicted meteorological phenomena.

WAVE HEIGHT COEFFICIENT - The ratio of the wave height at a selected point to the deepwater wave height. The refraction coefficient multiplied by the shoaling factor.

WAVE STEEPNESS - The ratio of a wave's height to its length.

WAVE TRAIN - A series of waves from the same direction.

WIND, OFFSHORE - A wind blowing seaward over the coastal area.

WIND, ONSHORE - A wind blowing landward over the coastal area.

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 WIND TIDE and 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.

WIND WAVES - (1) Waves being formed and built up by the wind. (2) Loosely, any wave generated by wind.

GRAND ISLE AND VICINITY, LOUISIANA
PHASE I GENERAL DESIGN MEMORANDUM

APPENDIX B
HYDROLOGY AND HYDRAULICS

SECTION I - FACTORS PERTINENT TO THE PROBLEM

1. CLIMATOLOGY

TABLE B-1
TEMPERATURE AND PRECIPITATION RECORDS

Station (Louisiana)	Map index no.[1]	Period of record as of 1961: Precipitation	Period of record as of 1961: Temperature	Collecting agency
Alvin Callender Field	2	1956 to 1960	1956 to 1960	U.S. Weather Bureau (now National Weather Service)
Burrwood	9	1907 to 1965	1907 to 1965	do
Delta Farms	5	1911 to 1944	1911 to 1944	do
Golden Meadow	7	1954 to 1967	1954 to 1967	do
Grand Isle	8	1940 to 1970	1949 to 1970	do
Houma	4	1890 to 1970	1889 to 1970	do
New Orleans	1	1836 to 1970	1871 to 1970	do
Paradis	3	1911 to 1970	1954 to 1970	do
Diamond	6	1891 to 1919 1958 to 1970	1891 to 1919 1958 to 1970	do do

[1]Plate B-1

TABLE B-2
TEMPERATURE DATA (DEGREES FAHRENHEIT)

	Burrwood	Delta Farms	Houma	New Orleans	Grand Isle
Maximum recorded	99	101	104	102	101
Minimum recorded	10	16	5	7	16

TABLE B-3

TEMPERATURE NORMALS (DEGREES FAHRENHEIT)

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Annual
1. Mean monthly													Mean
Burrwood	57.5	58.2	61.5	67.9	75.1	81.1	82.7	82.8	80.5	74.3	65.1	59.7	70.5
Houma	56.5	58.6	62.4	68.9	75.1	80.2	81.6	81.6	78.3	70.4	61.0	57.2	69.3
New Orleans	56.0	58.2	62.8	69.7	76.8	82.3	83.4	83.5	80.2	72.6	62.0	57.1	70.4
2. Maximum monthly													Maximum
Burrwood	65.2	66.6	69.8	75.8	81.8	87.5	89.0	89.4	87.1	80.9	72.5	67.2	77.7
Houma	66.4	69.4	73.0	79.3	84.8	89.7	90.7	91.2	88.2	82.2	72.5	67.1	79.5
New Orleans	63.5	66.6	71.1	77.7	83.8	89.4	90.3	90.5	87.2	80.1	70.5	64.7	77.2
3. Minimum monthly													Minimum
Burrwood	49.0	50.1	54.1	61.4	68.8	74.4	76.1	76.8	74.9	68.8	59.2	52.3	63.8
Houma	46.1	48.2	52.2	58.4	64.1	70.1	71.8	71.4	68.5	58.7	49.4	46.5	58.8
New Orleans	48.3	47.2	54.8	61.8	68.4	74.4	75.8	76.2	73.4	65.4	54.8	48.3	62.3

Seasonal Normals	Spring	Summer	Fall	Winter
	68.8	81.9	69.3	58.9

TABLE B-4
PRECIPITATION DATA (INCHES)

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Annual
1. Mean monthly													Mean
Burrwood	4.08	4.31	4.22	4.01	4.08	4.25	6.69	7.52	7.67	3.40	4.15	3.97	58.35
Houma	4.11	4.09	5.27	4.48	4.81	6.39	8.43	7.62	6.63	3.76	3.99	4.81	64.39
Paradis	4.84	5.23	6.21	5.07	5.36	6.01	7.44	6.50	5.96	3.35	4.07	5.54	65.58
2. Maximum monthly													Maximum
Burrwood	14.81	12.98	10.87	14.81	17.57	14.62	15.51	18.99	21.06	15.97	16.17	11.04	86.01
Houma	12.36	10.87	16.49	10.64	15.44	15.00	19.71	15.20	18.70	11.62	17.53	13.62	87.53
Paradis	13.45	13.17	16.40	12.97	18.00	18.00	14.64	12.17	16.40	16.15	13.85	13.65	90.10
3. Minimum monthly													Minimum
Burrwood	0.62	0.45	0.40	T	T	0.02	0.59	1.51	0.16	0.0	0.08	0.96	33.34
Houma	0.45	0.05	T	0.0	0.15	0.10	0.21	2.29	0.30	0.0	0.16	0.06	33.03
Paradis	1.37	1.12	0.25	0.0	0.46	0.0	0.24	0.79	0.0	0.0	0.25	0.30	36.79

Average Seasonal	Spring	Summer	Autumn	Winter
	4.8	6.8	4.8	4.6

T = Trace

2. LITTORAL FORCES

a. Wave climate.

(1) Height, period, and direction. Surf statistics were gathered for Grand Isle and vicinity only between 1954 and 1957, a relatively short period of time. These observations were made during a cooperative study by the U. S. Coast Guard and the Corps of Engineers Beach Erosion Board. These studies (1) (2) (3)[1] indicated that waves approach Grand Isle from the southeast 59 percent of the time, from the south 23 percent of the time, from the southwest 15 percent of the time, from the east less than 3 percent of the time, and from the northeast less than 1 percent of the time. The predominant wave heights and periods are 1 to 3 feet and 6 to 7 seconds, respectively, as shown in table B-5. Hurricane waves for one observation during Tropical Storm Brenda were 3 to 4 feet higher than normal and had wave periods of 1.5 seconds shorter duration than normal. The maximum wave heights observed during the period of observation were 9 feet with wave periods between 4 and 6 seconds inclusive. (3)

(2) Effects of refraction and diffraction. Wave refraction diagrams constructed for three directions of approach--south, southeast, and east--are shown on plate B-2. A wave period of 6.5 seconds was taken from observed data in reference (4) and used as a basis for computation of refraction and diffraction. The mean high-water shoreline and offshore contours at the 1 and 2 fathom depth were taken from the 1964 survey made by the Corps of Engineers. Contours at greater depths were taken from the 1957 survey by the U. S. Coast and Geodetic Survey. The procedure used in constructing the diagram is as outlined in section 1.261, paragraph a, of reference (4). Critical areas as determined from the refraction diagrams extend from stations 320+00 to 300+00, from 290+00 to 150+00, and from 133+00 to 85+00 along the 1953 baseline. A constant energy ratio was assumed between orthogonals in deep water. The ratios of the deepwater orthogonal spacing to the orthogonal spacing at the shoreline, $\sqrt{\frac{B_o}{B}}$, versus the baseline distance is plotted in the form of a bar graph on plate B-3. Areas where the ratio $\sqrt{\frac{B_o}{B}}$ is greater than unity are areas of wave energy concentrations.

(3) Direction and magnitude of wave energy. Table B-5 indicates that 59 percent of the time the alongshore wave energy component is directly onshore, that 38 percent (23%+15%) of the time the alongshore component of wave energy is toward the northeast for waves approaching from the south or southwest, and less than 3 percent of the time the component is toward the southwest. Plate B-3 demonstrates the relationship between wave energy arriving at the shore from different directions and readily indicates that for the same wave period more energy is present at the shoreline during southeasterly waves than

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[1]Publications, memorandums, references, etc., pertinent to the study are listed in SectionIV - Bibliography, and are identified in this presentation by numerals inclosed in parentheses.

TABLE B-5

YEARLY STATISTICAL SURF DATA FOR GRAND ISLE (3)

Durations given in average hours per year for 1955-1957
Height and period groupings include lower values but not the upper

Surf Height (feet)	Direction	3-4	4-5	5-6	6-7	7-8	8-9	Total
0-1	NE					1		1
	E				1			1
	SE			17	159	137	8	321
	S			15	147	168	11	341
	SW			6	36	34		76
	Total			38	343	340	19	740
1-2	NE			5	23	8		36
	E			12	53	53	1	119
	SE		3	186	1347	622	15	2173
	S			30	571	313	6	920
	SW			4	192	279	24	499
	Total		3	237	2186	1275	46	3747
2-3	NE				11	3		14
	E			4	46	3	4	57
	SE		10	239	898	242	5	1394
	S		4	53	291	63	2	413
	SW		4	39	295	113		451
	Total		18	335	1541	424	11	2329
3-4	NE							
	E		4	10	7			21
	SE		11	223	275	33		542
	S			38	78	11		127
	SW	1	1	41	75	6		124
	Total	1	16	312	435	50		814
4-5	NE				1			1
	E			5	5			10
	SE		2	116	49	8		175
	S		5	2	11	6		24
	SW	3	9	25	6	1		44
	Total	3	16	148	72	15		254
5-6	NE							
	E			1				1
	SE		12	43	1			56
	S		3	1	1	3		8
	SW	3	5	19		1		28
	Total	3	20	64	2	4		93
6-7	NE							
	E							
	SE			7	1	1		9
	S			7				7
	SW		5	4		1		10
	Total		5	18	1	2		26
7-8	NE							
	E							
	SE			5				5
	S							
	SW		1					1
	Total		1	5				6
8-9	NE							
	E							
	SE		1	1				2
	S							
	SW							
	Total		1	1				2

6816

7630

Total 7630 / 8,011 hrs.

from other wave directions. For waves approaching from the south a high concentration of wave energy occurs beginning in the vicinity of the last groin, station 130+00, and extending eastward to the vicinity of station 85+00. A general decrease in wave energy occurs as waves approaching from the east move toward shore.

b. Currents. In 1935(5) tidal currents through Barataria and Caminada Passes were measured on two different occasions for a spring tide at flood and one at ebb. Alongshore currents were measured simultaneously at two ranges approximately 10,000 feet away from each pass along the island shore. Results of these measurements indicated that Barataria Pass influenced alongshore currents at the point of measurement, station 100+00, but that Caminada did not appear to influence currents at station 300+00 to any significant degree. Current measurements were not made for this study; however, visual observations of tidal currents in the vicinity of Caminada Pass on 10 September 1970 and 12 November 1970 indicated that the influence of tidal currents extends eastward approximately 2,500 feet to station 375+00 where an offshore sandbar paralleling the shoreline has been cut through by high tides. The recessed area between the sandbar and the shoreline was seen to act as a channel during tidal activity. Aerial photographs and local erosion of the shore adjacent to the pass indicate that the pass is realining itself towards a more easterly direction. The 1970 tidal current tables(6) predict maximum tidal currents during spring ebb and flood tides of approximately 3.5 and 3.2 feet per second, respectively, in both Barataria and Caminada Passes. The entrance direction of flood tide in Barataria Pass is 315° and of ebb tide is 120°. The entrance direction of flood and ebb tide in Caminada Pass is 295° and 120°, respectively.

c. Winds. Observations(5) at the U. S. Coast Guard's Barataria Station from 1 December 1919 to 26 March 1936 indicate that the wind blew from the east 19 percent of the time, from the southeast 17.3 percent of the time, and from the south 12.4 percent of the time. Observations (7) from the same source from January 1944 to December 1951, inclusive, indicate that the wind blew from the east 12.1 percent of the time, from the southeast 26.4 percent of the time, and from the south 9 percent of the time. More recent observations made at Grand Isle from 1960 to 1963 indicate that winds blew from the east 11.70 percent of the time, from the southeast 18.66 percent of the time, and from the south 13.94 percent of the time. Table B-6 lists total wind duration in percent of time for the eight cardinal points and for calms for the three periods of record. Plate B-4 shows wind roses for the two more recent periods of record.

TABLE B-6
AVERAGE SURFACE WIND DURATION AT GRAND ISLE (5) (7)
(IN PERCENT OF TIME)

Wind direction	Period in Years		
	1919 to 1936	1944 to 1951	1960 to 1963
N	11.9	8.90	12.42
NE	11.9	15.90	16.86
E	19.0	12.0	11.7
SE	17.3	26.35	18.66
S	12.4	9.05	13.94
SW	7.1	12.25	10.91
W	5.6	4.15	6.22
NW	8.2	11.10	9.41
Calm	6.6	0.20	0.27

Onshore winds which cause wind-borne transport of beach material to occur include those from three directions--east, southeast, and south. Offshore winds include those from the west, northwest, and north. The island is alined generally in a northeast to southwest direction and winds blowing from these directions generally parallel the shore. Surveys of natural dunes on Grand Isle and Cheniere Caminada to the west have shown that dunes have grown to heights of 9 and 14 feet, respectively. Other proof of wind-borne transport was demonstrated recently when the dune line along the gulf shore was restored following total destruction by Hurricane Betsy in September 1965. Contract specifications called for reconstruction of the dune to elevation 8.0, including a 10-foot crown width and 1 on 4 side slopes to elevation 5.0. Grade stakes were set firmly along the alinement and the dune was constructed according to specifications except that the dune was constructed to approximately elevation 9.0 instead of 8.0. The only material available for fill was located west of the east end jetty. This material was poorly graded and ranged in size from medium sand to silt. A field visit within 2 months after the dune restoration work had been completed demonstrated that the loose sand on the crown had been blown shoreward. A comparison of surveys made at that time showed that the average elevation of the dune crown was 2 feet lower than the elevation to which it had been originally constructed, and the wind-blown sand had been deposited on the shoreward toe of the dune section.

d. Tides. The tides at Grand Isle are diurnal in nature (8) and have a mean tidal range of 1.2 feet and a maximum spring range of 1.9 feet. The maximum surge height of record was 9.0 feet and occurred during the September 1915 hurricane. The minimum low water of record was -1.7 feet and occurred on two occasions--3 February 1951 and 13 January 1964. Table B-7 shows the annual highs and lows for the period of record, 1947 to 1970, at the U. S. Coast and Geodetic Survey gage in Bayou Rigaud immediately north of Grand Isle. Other station locations are shown in table B-8.

SECTION II - SHORE HISTORY

3. SHORELINE AND OFFSHORE DEPTH CHANGES

a. Shoreline changes. Shoreline changes were determined at the mean high-water shoreline for the purpose of this discussion. Shoreline changes from available surveys prior to 1954 were analyzed in connection with previous cooperative studies in 1935-36 and 1953-54 (see plate B-5). The 1935 study revealed that between 1877 and 1935 a decided change in the orientation of the mean high-water shoreline with respect to a node at the center of the island had occurred. The eastern end showed, in general, considerable accretion, while the western end showed erosion. The growth at the eastern end of the island between the survey of 1853 and that of 1935 was from about 1,250 to 1,800 feet while the recession at the western end near Caminada Pass between the surveys of 1877 and 1935 amounted to a maximum of about 1,500 feet. Between 1853 and 1877 the extreme eastern end near Barataria Pass advanced very nearly to its 1935 location, but from about 1,500 feet west of the pass to the center of the island a marked advance between the 1877 and the 1935 location occurred. This advance varies fairly regularly from zero near the eastern end of the island to a maximum of 1,000 feet approximately 8,000 feet to the west and thence to zero at the center of the island.

The recession in the western half had been almost simultaneous with the advance of the eastern half, varying from zero in the center to a maximum of approximately 1,500 feet at a point 14,000 feet west of the center. A recession at Caminada Pass between 1877 and 1935 amounted to about 1,000 feet. The later surveys of 1932 and 1935 showed that during this 3-year period a slight accretion had taken place along the shoreline of the island except for a distance of several thousand feet from either end where slight erosion had taken place. At Barataria Pass this recession amounted to approximately 250 feet.

For the remainder of this discussion, points of accretion or erosion will be referenced to groin numbers or stationing along the 1953 baseline as shown in table B-9. From 1935 to 1953 a general recession of the mean high-water line occurred except for 6,000 feet at the western end between stations 397+00 and 337+00 where accretion took place. Here the shoreline of a barrier beach or trailing spit was at one point 1,000 feet gulfward of the 1935 shoreline. The eastern end of the barrier beach joined and was continuous with the

TABLE B-7
EXPERIENCED ANNUAL HIGHS AND LOWS IN
BAYOU RIGAUD AT GRAND ISLE
(through 1977)

Station 884+00 Zero of gage = minus 4.70 ft. m.s.l.

Year	High		Date	Low		Date
	Gage	m.s.l.		Gage	m.s.l.	
1947	9.0	4.3	19 Sept	3.5	-1.2	27 Dec
1948	-	-		3.5	-1.2	24, 25 Jan
1949	7.8	3.1	4 Sept	3.5	-1.2	1 Jan
1950	7.1	2.4	13 Feb	3.4	-1.3	10 Dec
1951	6.5	1.8	28 Mar	3.0	-1.7	3 Feb
1952	6.8	2.1	16 Jul	3.5	-1.2	7 Feb, 16 Dec
1953	7.0	2.3	25,26 Sept	3.2	-1.5	12 Jan, 17 Dec
1954	7.2	2.5	16,17 Sept	3.2	-1.5	19,20 Dec
1955	6.8	2.1	20 May	3.4	-1.3	19 Jan
1956	9.3	4.6	24 Sept	3.1	-1.6	29 Dec
1957	7.9	3.2	27 Jun	3.4	-1.3	1 Jan
1958	7.0	2.3	5,6 Sept	3.4	-1.3	2,3 Feb
1959	6.6	1.9	18 Jun	3.7	-1.0	2 Mar
1960	6.3+	1.6	2,3 Sept	3.8	-0.9	18 Dec
1961	8.2	3.5	10 Sept	3.4	-1.3	16 Jan
1962	6.5	1.8	25 Sept	3.5	-1.2	12 Dec
1963	6.5	1.8	17 Sept	3.5	-1.2	24 Jan
1964	7.0+	2.3	19 Mar	3.0	-1.7	13 Jan
1965	12.2	7.4	9 Sept	3.4	-1.3	25 Feb
1966	7.3	2.6	7 May	3.5	-1.2	4,5 Feb
1967	6.8	2.1	12,20 Jun	3.9	-0.8	5 Jan
1968	6.7	2.0	11 Mar	3.7	-1.0	14 Jan
1969	7.4	2.7	6,9 Dec	3.8	-0.9	1 Jan, 22,26 Dec
1970	7.0	2.3	20,21 May 1,2 Jun	3.3	-1.4	9 Jan
1971	7.6	2.9	2 Dec	3.7	-1.0	4 Mar
1972	8.5	3.8	27 Oct	3.8	-1.1	15 Feb
1973	8.02	3.32	5 Sep	3.87	-0.83	21 Dec
1974	9.47	4.77	7 Sep	4.17	-0.53	1 Dec
1975	7.59	3.89	30 May	4.22	-0.48	13 Jan
1977	8.38	3.68	5 Sep	-	-	-

TABLE B-8
TIDE GAGING STATIONS

Location	Code no.	Map index no.[1]	Period of record	Type gage	Gage zero feet (m.s.l.)	Collecting agency
Bayou Lafourche						
Belle Pass, La.		13	1956-1957	HWP	4.12	NOD
Leeville, La.	82350	12	1955-1970	Rec.	0.0	NOD
			1956-1965	HWP	4.16	NOD
Bayou Barataria						
Lafitte, La.	82875	11	1955-1970	Staff	0.0	NOD
			1956-1964	HWP	3.54	NOD
Barataria, La.	82750	10	1950-1970	Rec.	-0.78	NOD
Bayou Rigaud						
Grand Isle, La.	88400	15	1947-1970	Rec.	-4.70	USC&GS
Caminada Bay						
Grand Isle, La.		14	1956-1965	HWP	4.40	NOD
Hurricane Gage U.S. Coast Guard Sta. Grand Isle, La.		8	1958-1970	Rec.	0.0	NOD

[1]Plate B-1

HWP = High-water pipe
NOD = U. S. Army Engineer District, New Orleans
USC&GS = U. S. Coast & Geodetic Survey

1953 shoreline of the island proper, decreasing in width until it reached the location of the 1935 shoreline in the vicinity of groin number 2, station 337+00. From this point eastward, the erosion gradually increased reaching a width of 350 feet in 8,600 feet, station 251+00. The width of loss then decreased to about 200 feet at the center of the island in the vicinity of groin number 5, station 200+43. From groin number 5 eastward, the width of loss again increased reaching a maximum width of about 500 feet commencing at station 145+49, groin number 12, and continuing to station 119+00, 1,000 feet beyond groin number 14. From this point to the eastern end of the island the recession was less severe, averaging between 100 and 300 feet. Plate B-6 shows comparative mean high-water shorelines for 1953 and 1964. During this period the barrier beach present in 1953 at the western end of the island dissipated. The island, however, remained essentially unchanged eastward to groin number 1, station 342+00. From groin number 1 eastward to a point 1,500 feet east of groin number 4, station 300+00, the shore accreted to a maximum width of 250 feet between groins numbers 2 and 3. From station 300+00 to station 210+00, near the center of the island, no significant change occurred. From station 210+00 eastward to the vicinity of groin number 8 accretion increased to a maximum width of 100 feet and then decreased from that point to station 133+00 near groin number 14. Between station 133+00 and station 95+57 no significant change occurred, but beginning near station 95+57 and extending eastward approximately 8,000 feet to station 16+00 at the jetty adjacent to Barataria Pass, accretion occurred extensively reaching a maximum width of 1,000 feet in the vicinity of station 35+00. East of the jetty constructed in 1958 and 1959, extensive erosion occurred. The shoreline receded rapidly after construction and by 1964 only a shoal area remained in Barataria Pass east of the jetty. Table B-9 summarizes the rates of erosion or accretion at 20 points along the island shoreline for the periods 1932 to 1953, 1958 to 1970, and August 1965 to October 1965. The period 1932 to 1953 is significant because this period represents the longest time for which accurate surveys are available and represents natural conditions because artificial nourishment was not provided during this period. The period 1958 to 1970 is significant because it represents a period during which a jetty intended to trap material at the eastern end of the island was constructed and a period during which artificial nourishment was provided on two occasions to rectify erosion caused by hurricanes. The period August 1965 to October 1965 is a before-and-after condition for Hurricane Betsy.

b. Offshore depth changes. Comparison of 6- and 12-foot depth contours, below mean low water, for the period covered by the 1878, 1891, and 1935 surveys showed that the 6-foot contour in 1935 had a decided and continuous shoreward movement on the eastern third of the island with relatively little shoreward movement in the center third. The trend of movement in a shoreward direction continued again in greater magnitude on the western third of the island, except at a point near the western end where the 1935 contour moved gulfward with the formation of an offshore bar.

TABLE B-9
SHORELINE CHANGES AT GRAND ISLE

Stations	Total changes in feet by periods[1]		
	1932 to 1953	1958 to 1970	August 1965 to October 1965
72+00	-180	+635	-80
80+00	-280	+335	-40
88+00	-360	+190	-65
95+57	-300	+139	-45
133+10	-220	-32	-65
141+50	-240	-48	-30
149+40	-250	-52	-65
157+45	-240	-40	-70
165+25	-260	0	-65
173+45	-230	-27	-40
181+15	-200	-45	-55
188+85	-140	-3	-30
196+80	-160	-14	-55
235+26	-170	+9	-60
243+00	-150	-4	-115
251+00	-180	+20	-145
259+00	-170	+8	-150
320+80	-90	-38	-25
329+00	-50	-120	-100
337+00	-20	-178	-95

[1]Positive numbers indicate accretion; negative numbers indicate erosion.

During the period 1935 to 1953 the 6-foot contour moved shoreward along the center and eastern thirds of the island an average of 300 feet. On the western end of the island the 1953 6-foot contour advanced approximately 1,400 feet westerly into Caminada Pass. From west to east along the shore of the island the 1953 contour crosses the 1935 contour approximately 1,600 feet from the western tip showing a sharp shoreward retreat from the 1935 position. This shoreward movement reaches a maximum of 1,200 feet within a distance of 400 feet gradually diminishing in an eastward direction for the next 3,000 feet until the contours again cross. The remaining shoreline on the western third of the island shows very little net change in direction of movement between 1935 and 1953.

The 12-foot contour for 1935 showed the same general movement as that indicated by the 6-foot contour in comparison with the respective contours from earlier surveys, except at the western end where there was a relatively greater recession than for the 6-foot contour, and at the eastern third of the island where the 12-foot contour moved outward toward the contour of 1878. A profile made in 1935 near the extreme eastern end indicated that the 12-foot contour continued its outward trend and that offshore from Barataria Pass there was no decided shoreward movement as noted for the 6-foot contour, except for one 300-foot segment near the west-central section of the island.

The latest complete hydrograhic survey of Grand Isle was made in 1964. Plots of the mean high-water shoreline and the 6-foot and 12-foot contours are shown on plate B-6. To facilitate comparison of movement from 1953 to 1964, the 1953 contours have been replotted on plate B-6. The 1964 survey indicates that the 6-foot contour remained essentially the same over the central portion of the island but at the two ends of the island the 6-foot contour moved gulfward significantly. This tendency at the eastern end of the island was to be expected after construction of the jetty. The 6-foot contour from a point 2,500 feet west of groin number 1 to the west end had moved outward in a bar fashion across and through the mouth of Caminada Pass. Along the portion of the island surveyed in 1953, the 1964 12-foot contour showed a definite tendency to move shoreward 1,300 feet on the average.

In 1969 six offshore ranges were surveyed to determine any significant movement since 1964. This number of ranges was insufficient to accurately locate contours along the island front; however, the three ranges surveyed along the western half (station 345+65, station 295+34, and station 235+26) indicated little change had occurred in the location of the 6-foot contour. The survey of one of the three ranges along the eastern half of the island, station 173+45, indicated the 6-foot contour moved 200 feet offshore from its 1964 location. A survey of a second range, station 95+57, indicated the 6-foot contour moved 1,600 feet offshore, and a third, station 46+08, indicated no change had occurred. The 12-foot contour moved offshore from 350 feet to 2,000 feet along the four middle ranges surveyed but the surveys indicated no change had occurred along ranges at stations 345+65 and 46+08.

c. Volumetric accretion or erosion. Table B-10 contains volumetric accretion and erosion above mean high-water datum in cubic yards annually from 1958 to 1964, and bienially from 1966 to 1970. The values in the table are arranged and tabulated in four groups corresponding to selected ranges where successive surveys have been made for the period of study. Plus and minus signs depict accretion and erosion, respectively. Values given for Hurricane Betsy in September 1965 were computed from successive surveys of August and October 1965. The net change for the period 1958 to 1970 for each group and between the ranges in each group is tabulated in the last column of the table. These values are the sums of the annual and biennial volumes excluding volumes of artificial nourishment in 1962 and 1966 and erosion caused by Hurricane Betsy in 1965. The net annual or biennial sum of accretion or erosion is tabulated in each column below values of each group. Because these computations do not include losses below the mean high-water shoreline or volumes at both ends or between each group of ranges, this table only lists changes occurring within the groups of ranges surveyed; however, the table does give an indication of the relative stability or instability of the shoreline as a whole for the period of record. More detailed estimates made immediately following Hurricane Betsy indicated a net loss of 600,000 cubic yards of sand during the hurricane. Since periodic artificial nourishment was begun on the island in 1954, 2,400,000 cubic yards of sand at an average rate of 130,000 cubic yards per year have been placed on the island. Examination of pre- and post-construction surveys and aerial photographs revealed that the annual rate of impoundment above mean high water west of the jetty adjacent to Barataria Pass was approximately 250,000 cubic yards for the years 1960 to 1961. Over an 11-year period from 1959 to 1970, the jetty has trapped 1,250,000 cubic yards above the mean high-water shoreline.

d. Profiles. The slope of the foreshore zone (between mean low water and wave runup at mean high water) varies from 1:15 to 1:40, the average slope being about 1:25. Below mean low water the slopes at the two ends of the island are flatter than at the central portion of the island. Slopes from mean low water out to the 6-foot contour vary from approximately 1:1,000 at the eastern end of the island gradually steepening to about 1:50 near the center of the island and in turn decreasing to about 1:300 near the western end of the island. Slopes between the 6- and 12-foot contours follow the same general tendencies but are flatter--approximately 1:1,200 at the eastern end of the island steepening to about 1:100 near the center and decreasing to 1:300 at the western end of the island. See plates B-7 and B-8 for representative comparative profiles.

TABLE B-10
VOLUMETRIC ACCRETION AND EROSION BETWEEN STATIONS
(in cubic yards above m.h.w.) (see page B-x)

	1953 baseline stations	Survey Period 1958 to 1959	1959 to 1960	1960 to 1961	1961 to 1962	1962 to 1963	1963 to 1964	1964 to Aug 65	Hurricane Betsy‡	1965 to 1966	1966 to 1968	1968 to 1970	Net Change
Group One	72+00												
		+13330	+6840	+7140	*	-3060	+8000	+820	-8740	†	+25560	+9190	+67820
	80+00												
		+6340	+1160	+5600		+2310	+3140	+3700	-8000		+12150	+7780	+42180
	88+00												
		+5220	+4070	-8360		+4350	-1800	+7010	-6030		+3570	+2100	+16160
	95+57												
	TOTAL	+24890	+12070	+4380		+3600	+9340	+11530	-22770		+41280	+19070	+126160
Group Two	133+10												
		-1960	+10420	-18200		-10260	-3050	+3190	-5830		+15940	-14470	-18390
	141+50												
		-2430	-2300	-3050		-10400	-2820	+510	-6800		+13750	-15140	-21880
	149+40												
		-2100	-5010	+1160		-7250	-5270	0	-10810		+9840	-14610	-23240
	157+45												
		-1130	-4880	-2430		-8260	-6460	+2530	-10180		+2890	-10180	-27920
	165+25												
		-790	-3220	-5040		-5770	-6470	+3110	-6990		-3190	-3420	-24790
	173+45												
		-1600	+30	-1880	*	+2250	-3120	+1360	-8200		-4780	+1000	-6740
	181+15												
		-1280	+3340	-60	+5890	+4730	-960	+1000	-7770		-140	-360	+12160
	188+85												
		+1270	+2770	+800	+3770	+4330	-3110	+1330	-3460		+1690	-1250	+11600
	196+80												
	TOTAL	-10020	+1150	-28700	+9660	-30630	-31260	+13030	-60040		+36000	-58430	-99200

TABLE E-10 (contd)

	1953 baseline stations	Survey Period 1958 to 1959	1959 to 1960	1960 to 1961	1961 to 1962	1962 to 1963	1963 to 1964	1964 to Aug 65	Hurricane Betsy‡	1965 to 1966	1966 to 1968	1968 to 1970	Net Change
Group Three	235+26 to 243+00	+630	+1290	-90	+4820	+490	-1340	+3580	-20070		+2290	-3080	+8590
	243+00 to 251+00	+710	-2900	+4180	+5090	+310	-1280	+3410	-20150		+2300	-1700	+10120
	251+00 to 259+00	+1930	-1630	+3560	+6620	+550	+260	+3190	-24070		+3850	-1780	+16550
	TOTAL	+3270	-3240	+7650	+16530	+1350	-2360	+10180	-64290		+8440	-6560	+35260
Group Four	320+80 to 329+00	+10390	+6200	-6010	+6500	-5990	-960	+760	-11310		-6610	0	+4280
	329+00 to 337+00	+7640	+7200	-7290	+7170	-10520	-4410	+150	-22220	†	-3410	-3850	-7320
	TOTAL	+18030	+13400	-13300	+13670	-16510	-5370	+910	-33530		-10020	-3850	-3040

*Change influenced by 350,000 cubic yards of artificial nourishment
†Change influenced by 550,000 cubic yards of artificial nourishment
‡Effects of Hurricane Betsy excluded from net change computation.

SECTION III - ANALYSIS OF THE PROBLEM

4. DESCRIPTION AND VERIFICATION OF PROCEDURES

a. Hurricane memorandums. The Hydrometeorological Branch (HMB), U. S. Weather Bureau (now the National Weather Service), cooperated in the development of hurricane criteria for experienced and potential hurricanes in the study area. The HMB memorandums provided frequency data, isovel and rainfall patterns, pressure profiles, hurricane paths, and other parameters required for the hydraulic computations. Those relative to experienced hurricanes are based on reevaluation of historic meteorologic and hydrologic data. Those relative to potential hurricanes contain generalized estimates of hurricane parameters that are based on the latest research and concept of hurricane theory.

b. Historical storms used for verification. Three observed storms, with known parameters and effects, were used to establish and verify procedures and relationships for determining surge heights. These three storms occurred in September of 1915, 1956, and 1965. Isovel patterns for the hurricanes of September 1915,[9] September 1956,[10] and September 1965[11] are shown on plates B-9, B-10, and B-11, respectively. Tracks of these and other experienced hurricanes are shown on plate B-12.

(1) The hurricane of 28 September to 1 October 1915[9] had a central pressure index (CPI) of 27.87 inches, an average forward speed of 10 knots, and a maximum windspeed[2] of 99 m.p.h. (86 knots) at a radius of 29 nautical miles. This hurricane approached the mainland from the south. At Grand Isle, a high-water elevation of about 9 feet m.s.l.[3] was experienced, while Manila Village, located in Barataria Bay to the rear of Grand Isle, experienced a stage of 8 feet.

(2) Hurricane Flossy[10], 23-24 September 1956, had a CPI of 28.76 inches, a forward speed of 10 knots, and winds of 80 m.p.h. (70 knots) at a radius of 22 nautical miles. This hurricane approached the study area from the south and then veered northeastward. Grand Isle was flooded by waters which, after being driven over the island into Barataria Bay, reversed and inundated the island from the back side to a stage of 8 feet. The hurricane surge on the gulf side of the island was 3.9 feet.

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[2]Windspeeds represent a 5-minute average 30 feet above the water surface unless otherwise indicated.

[3]Mean sea level, the datum to which all elevations are referenced unless otherwise indicated.

(3) On 9 September 1965, Hurricane Betsy[11], the worst storm to strike the Louisiana coast in this century, entered the coast from a southeasterly direction about 10 p.m. Winds at Grand Isle were reported at 105 m.p.h. with gusts ranging up to 160 m.p.h. The storm tides swept over Grand Isle and a stage of 8.8 feet was recorded on the island. Accompanying the storm was a CPI of 27.79 inches, a radius to maximum winds of 32 nautical miles, a forward speed of 17 knots, and a maximum windspeed of 122 m.p.h. over water. Had the path of this storm been about 35 miles to the west, Grand Isle would have experienced a storm of Standard Project Hurricane (SPH) magnitude.

c. Synthetic storms. Computed flood elevations, resulting from synthetic storms, are necessary for frequency and design computations. Parameters for certain synthetic storms and methods for derivation of others were furnished by the National Weather Service. The SPH was used for all locations in the project area changing track and forward speed as appropriate. The Probable Maximum Hurricane (PMH) and Moderate Hurricane (Mod H) were derived from the SPH and differ from it only in wind velocities and CPI's.

(1) The SPH used in the study area was derived by the National Weather Service from a study of 46 hurricanes that occurred in the region over a period of 68 years. Based on subsequent studies of recent hurricanes, the National Weather Service revised the SPH wind field patterns[12][13][14]. Other characteristics of the SPH were not changed. The SPH track critical to the Grand Isle area and isovel patterns at landfall are shown on plate B-13.

(a) The SPH has a frequency of once in 100 years for the Louisiana coastal region. The CPI that corresponds to this frequency is 27.5 inches. CPI probabilities are based on the following relationship[12][15]:

$$P = \frac{100\ (M-0.5)}{Y}$$

where P = percent chance of occurrence per year
M = number of the event (rank)
Y = number of years of record

(b) Radius of maximum winds is a parameter of hurricane intensity. The average radius of 12 hurricanes occurring in the study area is 36 nautical miles. From relationships of CPI and radius of maximum winds of gulf coast hurricanes[15][16], a radius of 30 nautical miles is considered representative for an SPH having a CPI of 27.5 inches.

(c) Different forward speeds are necessary to produce SPH effects at various locations within the study area. An average forward speed of 11 knots was selected for the SPH along the gulf shore of Grand Isle.

(d) Maximum theoretical gradient wind[16] is expressed as follows:

$$V_{gx} = 73 \sqrt{P_n - P_o} - R\ (0.575\ f)$$

where V_{gx} = maximum gradient windspeed in miles per hour
P_n = asymptotic pressure in inches
P_o = central pressure in inches
R = radius of maximum winds in nautical miles
f = Coriolis parameter in units of $hour^{-1}$

The estimated windspeed (V_x)[17] in region of highest speeds is obtained as follows:

$$V_x = 0.885\ V_{gx} + 0.5T$$

where T = forward speed in miles per hour

From these relationships, an average overwater windspeed of approximately 100 m.p.h. was obtained for the SPH.

(2) A CPI of 26.9 inches was recommended for the PMH by the National Weather Service[15]. A hurricane with this CPI actually occurred at 33° N. latitude in 1935 and again in 1969 at 29° N. latitude. Other synthetic storms of different frequency and CPI are derived from the SPH. With the exception of the PMH, other CPI's for desired frequencies are obtained from the graph shown on plate B-14. V_{gx}'s corresponding to any other CPI are determined similarly by use of the method described for the SPH. Variations in CPI's of historic storms were accomplished by the same procedure[16]. Characteristics of synthetic storms and some historic storms are listed in table B-11.

TABLE B-11
HURRICANE CHARACTERISTICS

Hurricane	CPI inches	Radius of max. winds nautical miles	Forward speed knots	V_x m.p.h.
Sept 1915	27.87	29	10	99
Sept 1956	28.76	30	10	80
Sept 1965	27.79	32	20	122
PMH	26.9	30	11	146
SPH	27.5	30	11	100
Mod H	28.3	30	11	83

d. Surges.

(1) Maximum hurricane surge heights for the study area were obtained from computations made for ranges extending from the shore out to the continental shelf by use of a general wind tide formula that is based on the steady state concept of water superelevation[4] [18] [19]. In order to reach agreement between computed maximum surge heights and observed high-water marks, it was necessary to introduce a calibration coefficient or surge adjustment factor into the general equation which, in its modified form, is as follows:

$$S = 1.165 \times 10^{-3} \frac{V^2 F}{D} N\ Z\ \text{Cos}\ \theta$$

where S = wind setup in feet
V = windspeed in statute miles per hour
F = fetch length in statute miles
D = average depth of fetch in feet
θ = angle between direction of wind and the fetch
N = planform factor, generally equal to unity
Z = surge adjustment factor

(2) Water surface elevations along a range were determined by summation of incremental wind setup above the water elevation at the gulf end of the range. Initial elevation at the beginning of each range was determined from predicted normal tide and the setup due to atmospheric pressure anomaly. Typical tidal cycles for the project area are shown on plate B-15. An adjustment was made at the shoreward end of the range to compensate for the difference in pressure setup between both ends of the range. This procedure for the determination of surge heights at the coastline was developed for an area along the Mississippi gulf coast where reliable data were available at several locations for more than one severe hurricane. The procedure was then used for the entire coastal Louisiana region. Due to dissimilar shoreline configurations, different surge adjustment factors were required at each location, but identical factors were used at a particular location for each storm. The value of the factor is apparently a function of the distance between the shoreline and deep water and varies inversely with this distance. Comparative computed maximum elevations and observed high-water elevations for the locations of the 1915 and 1947 hurricanes that were used in the development of the procedure are shown in table B-12.

TABLE B-12
HURRICANE SURGE HEIGHTS

Location	Surge adjustment factor (Z)	1915 Observed	1915 Computed	1947 Observed	1947 Computed
		feet m.s.l.		feet m.s.l.	
Bay St.Louis, Miss.	0.46	11.8	11.8	15.2	15.1
Gulfport, Miss.	0.60	10.2[1]	9.9	14.1	14.3
Biloxi, Miss.	0.65	10.1[1]	9.8	12.2[1]	12.6

[1]Average of several high-water marks.

(3) The incremental step computation was used to check experienced maximum surge heights and establish the surge adjustment factor. For hurricanes critical to Grand Isle from the Gulf of Mexico, the surge adjustment factor was determined to be 0.80. Verification of surge heights for Grand Isle are shown in table B-13.

TABLE B-13
VERIFICATION OF HURRICANE SURGE HEIGHTS

	Surge adjustment factor	Sept 1915 Observed	Sept 1915 Computed	Sept 1956 Observed	Sept 1956 Computed	Sept 1965 Observed	Sept 1965 Computed
		feet m.s.l.		feet m.s.l.		feet m.s.l.	
Grand Isle	0.80	9.0	8.8	3.9	4.1	8.8	9.6

(4) The computed surge height for Hurricane Betsy, September 1965, using the Z factor for Grand Isle, was 0.8 foot higher than the observed surge height. This apparently was the effect of the high forward speed of Betsy. A fast-moving hurricane does not allow enough time for the surge heights to approach the steady state of water superelevation [(4) (18) (19)]. However, it was determined that the Z factors derived from the slow-moving hurricanes should be used for design purposes because this type of hurricane is more nearly representative of hurricanes in the project area.

(5) An example of the setup computation for one increment (ΔF) along a range radiating from a southwesterly direction to Grand Isle for an SPH at the critical hour of the hurricane is as follows:

(a) Initial elevation:

Normal pressure	=	30.14 inches of mercury
Pressure at beginning of range, 98 miles from center	=	29.35 inches of mercury
Deviation from normal pressure	=	0.79 inch of mercury
Pressure setup 0.79 x 1.14 feet	=	0.90 foot of water
Normal predicted tide	=	2.00 feet above mean low water (m.l.w.)
Initial elevation	=	2.90 feet (m.l.w.)

(b) Incremental setup (for setup between adjacent stations on range):

Sta. mile	ΔF miles	V m.p.h.	Cos θ	V^2Cos θ	Avg. V^2Cos θ	Depth feet m.l.w.	D=ΣS+ Avg.D+290 +ΔS/2	ΔS feet	ΣS feet
2.0		84	0.999	7049		20			6.11
	2.0				6639		19.33	0.64	
0.0		79	0.998	6229		0			6.75

$$S = 1.165 \times 10^{-3} \times \frac{6639 \times 2.0}{19.33} \times 1 \times 0.80 = 0.64'$$

(c) Setup for pressure differential:

Normal pressure	=	30.14 inches of mercury
Pressure at end of range, 34.5 miles from center	=	28.64 inches of mercury
Deviation from normal	=	1.50 inches of mercury
(1.50 x 1.14 feet)	=	1.71 feet of water
Deviation at beginning	=	-0.90 foot of water
Differential setup	=	0.81 foot

(d) Final surge height:

Pressure setup at beginning of range	=	0.90 foot
Normal predicted tide	=	2.00 feet m.l.w.
Correction m.l.w. to m.s.l.	=	-0.60 foot
S (wind setup)	=	6.75 feet
Pressure differential setup	=	0.81 foot
Surge height at shore	=	9.86 feet m.s.l.

(6) By using the method shown in paragraph 3d(5) above, a hurricane surge elevation of 9.86 feet was computed for the SPH at Grand Isle.

e. Wave runup.

(1) Wave runup on a protective structure depends on the characteristics of the structure (i.e., shape and roughness), the depth of water at the structure, and the wave characteristics. The vertical height to which water from a breaking wave will run up on a given protective structure determines the top elevation to which the structure must be built to prevent wave overtopping and resultant flooding of the area to be protected. Wave runup is considered to be the ultimate height to which water in a wave ascends on the proposed slope of a protective structure. This condition usually occurs when the surge is at the maximum elevation.

(2) The parameters which determine wave characteristics are the fetch length, the windspeed, duration of wind, and the average depth of water over the fetch. In determining the design wave characteristics, it was assumed that steady state conditions prevail; that is, the windspeed is constant in one direction over the fetch and blows long enough to create a fully developed sea. The windspeed (U) is an average velocity over the fetch (F) and is obtained from the isovel patterns for synthetic hurricanes critical to the location of interest. The depth of fetch (d) is the average surge height minus the average elevation of prominent subsurface features over the fetch.

(3) In order to compute wave runup on a protective structure, the significant wave height (H_s) and wave period (T) in the vicinity of the structure must be known. They were determined as described in paragraph 1.25 of reference (4). The windspeed and depth used in determining H_s and T are average values over a 5-mile fetch. Data used to determine design hurricane wave characteristics in the vicinity of the protective structures are shown in table B-14.

TABLE B-14
DATA USED TO DETERMINE WAVE CHARACTERISTICS
FOR DESIGN HURRICANE

Parameters	Grand Isle
F - Length of fetch	5 miles
U - Windspeed	79 m.p.h.
swl - Stillwater level	8.5 feet
d - Average depth of fetch	25.1 feet
d_t - Depth at toe of levee	11.5 feet

(4) Wave runup was calculated by use of model study data developed by Saville [20][21][22][23] which relates relative runup (R/H'_o), wave steepness (H'_o/T^2), and relative depth (d/H'_o). The significant wave height (H_s) and wave period (T) can be determined from the data in table B-15. The deepwater wave length (L_o) is determined from the equation:

$$L_o = 5.12\ T^2$$

The equivalent deepwater wave height (H'_o) can be determined from table D-1 of reference (4), which relates d/L_o to H/H'_o. When determining runup from the significant wave, H in the term (H/H'_o) is equal to H_s.

TABLE B-15
WAVE CHARACTERISTICS--DESIGN HURRICANE

		Characteristics	Grand Isle
H_s	-	Significant wave height	7.7 feet
T	-	Wave period	7.3 seconds
L_o	-	Deepwater wave length	272.8 feet
d/L_o	-	Relative depth	0.08876
H_s/H'_o	-	Shoaling coefficient	0.9436
H'_o	-	Deepwater wave height	8.2 feet
H'_o/T^2	-	Wave steepness	0.1539

(5) With the terms d/H'_o and H'_o/T^2 known, runup on a protective structure can be computed if the slope of the structure is known. The levee configurations used in these computations had stabilizing berms on the water side (see plate 3). These berms broke the continuity of the levee slope and Saville's [23] method of determining wave runup on composite slopes was used (see plate B-16). In using this method, the actual composite slope is replaced by a hypothetical single constant slope. This hypothetical slope is computed by estimating a value of wave runup and then determining the slope of a line from the point where the wave breaks to the estimated point of runup. The breaking point may be located by subtracting the breaking depth d_b from the stillwater elevation and extending the resulting elevation horizontally to intersect the composite slope. The breaking depth is determined from the equation:

$$d_b = \frac{0.667\ H'_o}{(H'_o/T^2)^{1/3}}$$

Using the slope of this line, which is the hypothetical slope, a value of runup is determined. If the value of runup determined is different from the estimated runup, the process is then repeated using the new value of runup to obtain a new hypothetical slope, which, in turn, determines a new value of runup. This process is repeated until the estimated value of runup agrees with the computed value of runup.

(6) Protective structures exposed to wave runup will be constructed to an elevation that is sufficient to prevent all overflow from the average highest 10 percent of all waves (H_{10}), the significant wave, and waves smaller than the significant wave accompanying the design hurricane. Waves larger than the H_{10} wave will be allowed to overtop the protective structures but such infrequent overtopping will not endanger the security of the structures. During the time of maximum surge height, the berms on the water side of the structures become submerged and waves of lesser height than the significant wave, but of the same period, break farther up the structure slope. Sometimes runup from these smaller waves reaches an elevation higher than that from the significant wave; therefore, runup resulting from these smaller waves must also be computed. The equivalent deepwater wave height for the smaller waves breaking on the berms was computed by the equation:

$$H_o' = \frac{1.84}{T} \quad (d_b)^{3/2}$$

Wave characteristics used in computing runup from the significant wave and smaller waves are shown in table B-16. The height of the H_{10} wave is 1.27 times that of the significant wave[(4)]. The method for computing runup is identical to that of the significant wave except for the difference in wave height and breaking depth.

5. FREQUENCY ESTIMATES

a. Procedure.

(1) Prior to 1900, information of record dealt primarily with loss of life and damage in the more densely populated areas, with practically no reference to water surface elevations caused by hurricanes. Only since 1900 has detailed information been available on flooding in coastal Louisiana and adjacent areas. Subsequent to the widely destructive September 1915 hurricane, Charles W. Okey, Senior Drainage Engineer, Office of Public Roads and Rural Engineering, U. S. Department of Agriculture, made a thorough survey of the coastal areas between Biloxi, Mississippi, and Palacios, Texas. The 1915 investigation is the only known area-wide study containing reliable stages prior to the investigation of Hurricane Flossy, September 1956. Recent data indicate that all localities along the Louisiana coast are about equally prone to hurricane attack.

TABLE B-16
DESIGN STILLWATER LEVEL, WAVE AND WAVE RUNUP DATA,
DESIGN TRACK, GRAND ISLE

Hour	S.W.L. ft.m.s.l.	Wind m.p.h.	Fetch miles	Av.depth feet	d_b feet	T sec.	H_0' feet	Hypothetical slope Vert. to Hor.	Runup el. ft.m.s.l.
FOR SIGNIFICANT WAVE									
-2	8.4	78	5	25.0	10.1	7.2	8.1	1 on 21	10.5
-1	8.5	79	5	25.1	10.2	7.3	8.2	1 on 21	10.7
+2	8.1	77	5	24.7	10.1	7.2	8.1	1 on 21	10.2
+4	6.6	77	5	23.2	9.7	7.0	7.8	1 on 23	8.4
FOR WAVE BREAKING AT ELEVATION 3.0 FEET M.S.L.									
-2	8.4	78	5	25.0	5.4	7.2	3.2	1 on 29	9.2
-1	8.5	79	5	25.1	5.5	7.3	3.3	1 on 28	9.4
+2	8.1	77	5	24.7	5.1	7.2	2.9	1 on 31	8.9
+4	6.6	77	5	23.2	3.6	7.0	1.8	1 on 33	7.2

(2) A procedure was developed to establish synthetic stage-frequency relationships for the study area. A sufficient number of observed hurricane stages are available at Grand Isle from which a dependable observed stage-frequency curve was computed for comparison with the results of the synthetic method. Probabilities for historical data on the curve shown on plate B-17 were calculated by means of the formula:

$$P = \frac{100 (M - 0.5)}{Y}$$

(3) The first requirement in the development of synthetic frequency relationships within the project area was to select representative critical hurricane tracks for the particular locale in question. A track from the south was selected as the critical track for Grand Isle. (See plate B-13). In the process of formulating synthetic frequency relationships, it was necessary to correlate the following hurricane parameters: central pressure indexes, tracks of approach, wind velocities, radii to maximum winds, and forward speeds of translation.

(4) Surge heights were then developed for four storms of different CPI values. Each hurricane was assumed to have the same radius of maximum winds, the same forward speed of translation, and the same adjustment for any land effects. Conversion of wind fields of hurricanes of different CPI's requisite to computing surge heights is covered in paragraph 3c(1). Surge heights for storms with other CPI values were obtained graphically by plotting the above data and reading from the resulting curve.

(5) Hurricane characteristics of area-representative storms were developed in cooperation with the Weather Service. This agency has made a generalized study of hurricane frequencies for a 400-mile zone along the central gulf coast, Zone B, from Cameron, La., to Pensacola, Fla., and has presented the results in two memorandums (12)(15). Frequencies for hurricane central pressure indexes that were presented in the report, as shown on plate B-14, reflect the probability of hurricane recurrence from any direction in the mid-gulf coastal area. In order to establish frequencies for the localities under study, it was assumed that a hurricane whose track is perpendicular to the coast will ordinarily cause high tides and inundation for a distance of about 50 miles along the coast. Thus, the number of occurrences in the 50-mile subzone would be 12.5 percent of the number of occurrences in the 400-mile zone, provided that all hurricanes traveled in a direction normal to the coast. However, the usual track is oblique to the shoreline as shown in table B of Memorandum HUR 7-97(15). The average projection along the coast of this 50-mile swath for the azimuths of 48 Zone B hurricanes is 80 miles. Since this is 1.6 times the width of the normal 50-mile strip affected by a hurricane, the probability of occurrence of any hurricane in the 50-mile subzone would be 1.6 times the 12.5 percent or 20 percent of the probability for the entire mid-gulf Zone B. Thus, 20 percent

of the Zone B frequencies shown on plate B-17 were used to represent the CPI frequencies in the 50-mile subzone that is critical for each study locality.

(6) The azimuths of tracks observed in the vicinity of landfall were divided into quadrants corresponding to the four cardinal points. In Zone B, 29 tracks were from the south, 15 from the east, 3 from the west, and 1 from the north. This indicates that approximately two-thirds of all experienced hurricanes have come from a southerly direction whereas about one-third has come from the east. The average azimuth of tracks from the south is 180° and tracks from the east had an average azimuth of 117°, while the average azimuth of all tracks is 160°.

(7) The location and physical features of Grand Isle are conducive to critical stages for a hurricane approaching from any direction. Therefore, the full 20 percent of the probabilities for mid-gulf Zone B was used for computing synthetic frequencies. Table B-17 illustrates the synthetic stage-frequency computation for Grand Isle.

TABLE B-17
SYNTHETIC STAGE-FREQUENCY
GRAND ISLE

		Frequency*	
CPI	Surge height	Zone B (400 miles)	Grand Isle (50-mile subzone)
in.	ft. m.s.l.	occ/100 years	occ/100 years
(1)	(2)	(3)	(4)
27.5	9.86	1	0.2
27.8	9.48	2	0.4
28.3	7.93	10	2.0
29.0	5.06	40	8.0

$$\text{*Frequency} = \frac{100}{\text{Return period in years}}$$

Col. (4) = 20 percent of Col. (3)

(8) The synthetic frequency curve for Grand Isle was shifted to the experienced frequency plot, maintaining as nearly as possible its general shape. Plate B-18 is a graphical presentation of the shift.

b. Relationships. Based on the above-described procedures, the stage-frequency relationship was established for Grand Isle.

6. WAVE ENERGY-FREQUENCY ESTIMATES

a. Procedure.

(1) Frequency determinations. Since Grand Isle is subject to wave attack from both its gulf and bay sides, it was necessary to develop separate wave energy-frequency curves. The development of a synthetic stage-frequency curve for Grand Isle was discussed in paragraph 5. The wave energy for the peak stage produced by each of these synthetic hurricanes was computed by procedures outlined in paragraph (2) below and then plotted at the frequency correspond'ng to this peak stage shown on the stage-frequency curve. Frequency estimates of the wave energy for the back side of Grand Isle were obtained by multiplying the gulf side probabilities by 50 percent. The use of 50 percent of the gulf side probability was based on the average azimuth of all hurricanes that have crossed the Zone B coastline. The average of all azimuths was found to be 160°. The selection of the average azimuth as the criteria for determining wave energy-frequency for the Barataria Bay side of Grand Isle was based on several conditions that are necessary for generation of waves critical to the backshore area. There are two basic criteria necessary for the generation of waves critical to the backshore of Grand Isle--a superelevation of the bay's normal water surface level and subsequent hurricane winds blowing towards the backshore of the island. Without the superelevation of the water surface level of the bay, the depths and fetch length available in Barataria Bay are insufficient for critical wave generation. By superimposing isovel patterns and the wind field directions associated with the synthetic hurricanes, it was found that storms having azimuths of 160° or less could not produce critical stages at Grand Isle unless these storms passed to the west of the island. A storm passing west of the island with azimuths 160° or less will have wind directions that are always blowing away from the backshore of the island. Storms with azimuths of 160° or less that pass directly over or to the east of the island cannot produce critical surge heights at Grand Isle because the projection of the Mississippi River delta into the Gulf of Mexico acts as a barrier to the storm surge, thus preventing critical stages from occurring at Grand Isle. Storms with tracks that are critical to Grand Isle cause a filling of the bay as the storm approaches the island. Winds at this time begin to blow directly onshore. As the eye of the storm passes the island, the wind direction may reverse causing critical wave generation towards the backshore of Grand Isle. The computational procedure for the bay side of the island is outlined in paragraph (2) below.

(2) Wave energy computations. In the process of determining wave energy many contributing calculations had to be performed. From prediction curves developed by C. L. Bretschneider, significant wave heights and periods for average winds and depths were determined for each of the synthetic hurricanes. These curves are given in reference (4), pages 57 through 62, and their use is explained in paragraph 1.25. For the gulf side of the island the average depths below the stillwater levels for each of the synthetic hurricanes were determined over the last 5 miles of the critical range used in generating the surges. A 5-mile fetch was used because the controlling depth in the foreshore area would cause the higher waves generated in the longer and deeper fetches to break before reaching shore. Using the criteria presented in paragraph 1.25 of reference (4) for each of the synthetic hurricanes, the deepwater wave lengths were obtained from $L_o = gT^2/2\pi$, and the equivalent deepwater significant wave heights by use of the appropriate shoaling coefficients given in Wiegel's tables, appendix D-1[4]. The criteria presented in paragraph 1.21 of reference (4) was used to compute the value of the forward moving wave energy, E_f, associated with the significant wave heights, H_s, for each of the synthetic hurricanes. The computational procedure used for computing wave energy on the bay side of the island was the same as used on the gulf side. The average depths below stillwater level for the bay side of the island were computed by superimposing the gulf side surge heights on the mean low-water depths existing in the bay. An effective fetch of 2 miles was used for determining significant wave heights in the bay. The average depths below stillwater level in the bay preclude using longer fetches because no significant increase in wave height can occur. The average wind velocity for the 2-mile fetch was determined by moving the isovel pattern in the direction of forward motion for the storm track until wind directions became critical to the back shore of the island.

b. Relationships. Plate B-19 shows a plot of the wave energy-frequency curves for both the gulf and bay sides of the island.

7. DESIGN HURRICANE

a. Selection of the design hurricane. Since the project area is sparsely populated, the hurricane that would produce the 50-year stage was selected as the design hurricane (Des H). A design hurricane of lesser intensity which would indicate a lower structural grade and an increased frequency would expose the protected areas to hazards to life and property that would be disastrous in the event a hurricane with the intensity and destructive capability of the Des H or the SPH occurred.

b. Characteristics. The Des H has a CPI of 28.15 inches and a maximum overwater windspeed of 79 m.p.h. at a radius of 30 nautical miles. The forward speed of the hurricane is 11 knots. The 100-year frequency hurricane, used for alternate plan C in this analysis, has a CPI of 27.8 inches and a maximum overwater windspeed of 96 m.p.h. The forward speed and the radius of the maximum winds, 13 m.p.h. and 35 miles, respectively, are identical to those of the Des H.

c. Normal predicted tide. The range of normal predicted tides in the project area is 1.2 feet. The difference in elevation of hurricane surge heights for an occurence of the Des H at high or low tides is only a few tenths of a foot. In determining the elevation of design surge heights, it was assumed that a mean high predicted tide occurs at the initial period of surges.

d. Design tide. The hurricane surge height is the maximum stillwater surface elevation experienced at a given location during the passage of a hurricane. It reflects the combined effects of the hurricane surge, the pressure setup, and the astronomical tide. Design hurricane surge heights were computed for existing conditions.

8. DESIGN CRITERIA

a. Jetty at Caminada Pass. Tidal currents moving through Caminada Pass are the principal cause of erosion of the gulf pass. A study of refraction diagrams for waves approaching from the east or southeast, plate 2, indicates that littoral currents enforce the tidal flood currents near the entrance. The jetty will have two functions: (1) divert tidal currents away from the gulf shoreline east of the pass; and (2) trap littoral drift moving east to west along shore during periods when waves approach from the east or southeast. The desired effects are to retain artificial nourishment initially placed, trap and retain additional westerly drift east of the jetty, and stabilize the shoreline from the eastern lip of Caminada Pass to the vicinity of groin number one. In order to accomplish these effects, the jetty will extend from the Caminada Bay side of the island along the eastern lip of Caminada Pass and thence offshore into the gulf. The total length of jetty will be sufficient to accomplish the desired effects but should not extend offshore to a point where the jetty would interfere with the natural transfer of littoral draft from west to east across Caminada Pass. The prinicpal entrance and exit directions of the flood and ebb tides are 295 degrees and 120 degrees of azimuth measured from true north. The mean tide range is 1.2 feet above mean low water. The jetty will be constructed to +4.0 feet mean sea level datum. At mean high tide the jetty crest will be 3.6 feet above stillwater level and at spring high tide the crest will be 2.9 feet above stillwater level. The jetty will be permeable and will allow wave overtopping to occur.

b. Beach nourishment. A study of tables B-9 and B-10 indicates that erosion is not uniform along the face of Grand Isle. A detailed analysis of table 10, which is based on comparing repetitive surveys of the ranges at Grand Isle, shows that during the period 1958 to 1970 Grand Isle accreted 58,180 cubic yards of sand--excluding Hurricane Betsy in 1965. Subtracting from this accretion the two emergency beach nourishments which occurred during this period (58,180-350,000-550,000 = -841,820 cubic yards) reveals that 841,820 cubic yards of beach fill would be required to maintain the beach at Grand Isle. This can be reduced to an annual rate (841,820 divided by 12 = 70,151.7 cubic yards/year) of about 70,000 cubic yards/year. Considering the project for Grand Isle will include a dune section, this nourishment rate should be increased by 33 percent to allow for dune erosion. This raises the annual nourishment rate (70,000 x 1.33 = 93,100 cubic yards/year) to about 100,000 cubic yards/year.

c. Frequency of nourishment. Predicting beach nourishment frequency is difficult as can be seen from table 10, not only does erosion vary spatially, it also varies temporally. Based on experience with beach nourishment projects in other districts, the immediate scheduling of the first nourishment is important to the overall success of a beach fill project. For this reason, the first nourishment is scheduled at the end of 2 years. For programming purposes, subsequent nourishments will be at 4-year intervals. The experience gained from Hurricanes Flossy, Carla, and Betsy, indicates that major erosion occurs during these unpredictable events which may require revision of the scheduled nourishment program.

d. Design profiles.

(1) The shore protection profile was determined from a study of natural beach slopes and berm widths and elevations in the study area. The natural berm width was increased to stabilize the shoreline at a point approximately 100 feet from its present location.

(2) The hurricane protection profile was determined from an estimate of the quantity of material likely to be eroded during the occurrence of the design storm and from estimates of heights of wave runup for different dune and berm dimensions which would prevent wave overtopping of the dune through the period of maximum design storm tide elevation. The most desirable dimensions are those which provide the lowest practicable dune grade and the widest beach berm fronting the dune. The breaking point of the significant wave was placed approximately 200 feet gulfward of the dune centerline for both plans B, C, and D, so that most of the wave energy will dissipate before reaching the dune. The hurricane protection dune, for the most part, will straddle the existing dunes along the present shoreline.

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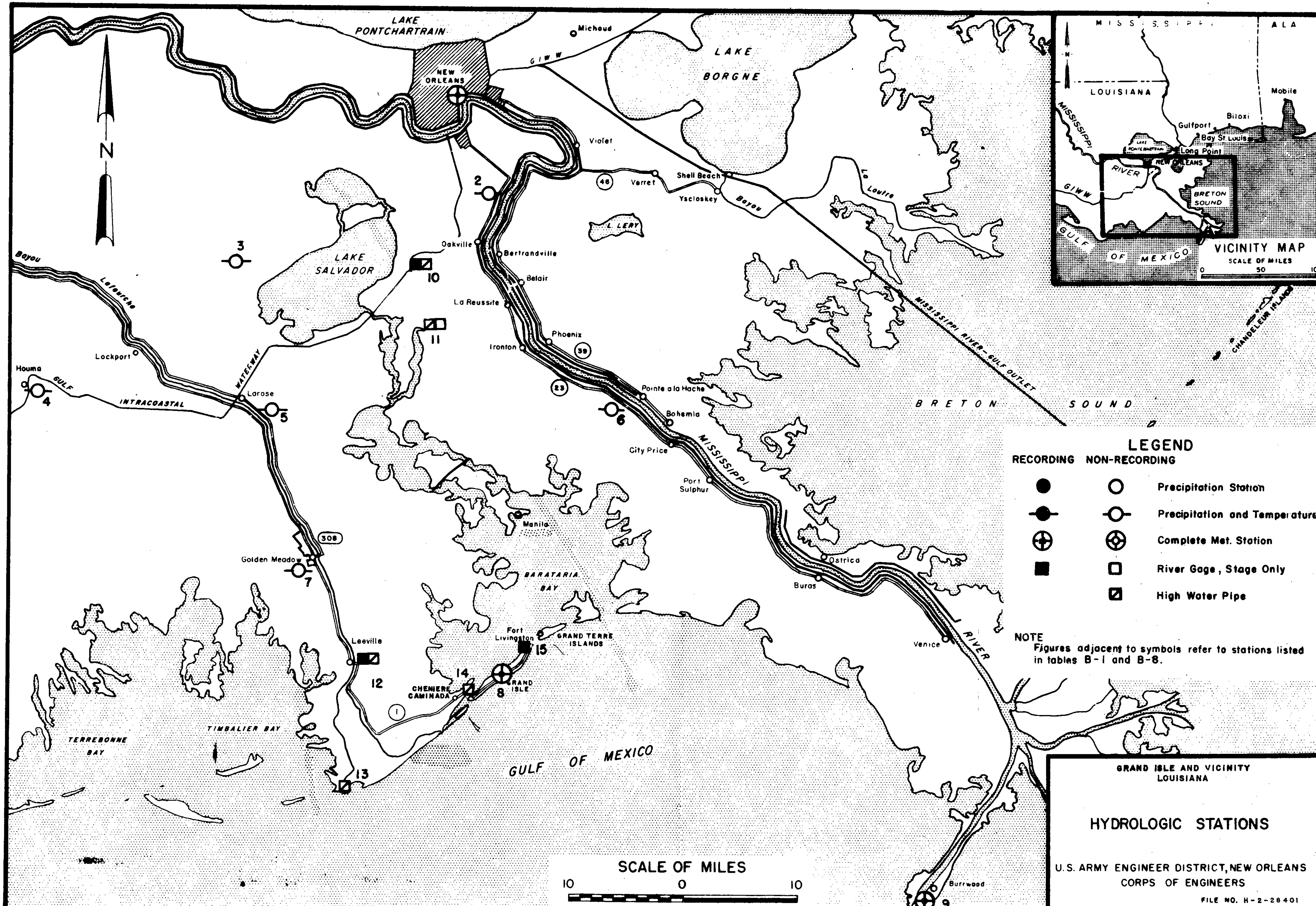
LAKE PONTCHARTRAIN
Michoud
NEW ORLEANS
LAKE BORGNE
GIWW
N
Violet
Shell Beach
Verret
Yscloskey
46
Bayou
La Loutre
L. LERY
LAKE SALVADOR
Oakville
Bertrandville
Belair
La Reussite
Phoenix
Ironton
39
23
Pointe a la Hache
Bohemia
City Price
Port Sulphur
MISSISSIPPI
RIVER
Bayou Lafourche
WATERWAY
Lockport
Houma
GULF INTRACOASTAL
Larose
Golden Meadow
308
Leeville
Manila
BARATARIA BAY
Fort Livingston
GRAND TERRE ISLANDS
CHENIERE CAMINADA
GRAND ISLE
TIMBALIER BAY
TERREBONNE BAY
GULF OF MEXICO
Ostrica
Buras
Venice
Burrwood
BRETON SOUND
MISSISSIPPI RIVER - GULF OUTLET
CHANDELEUR ISLANDS
1
2
3
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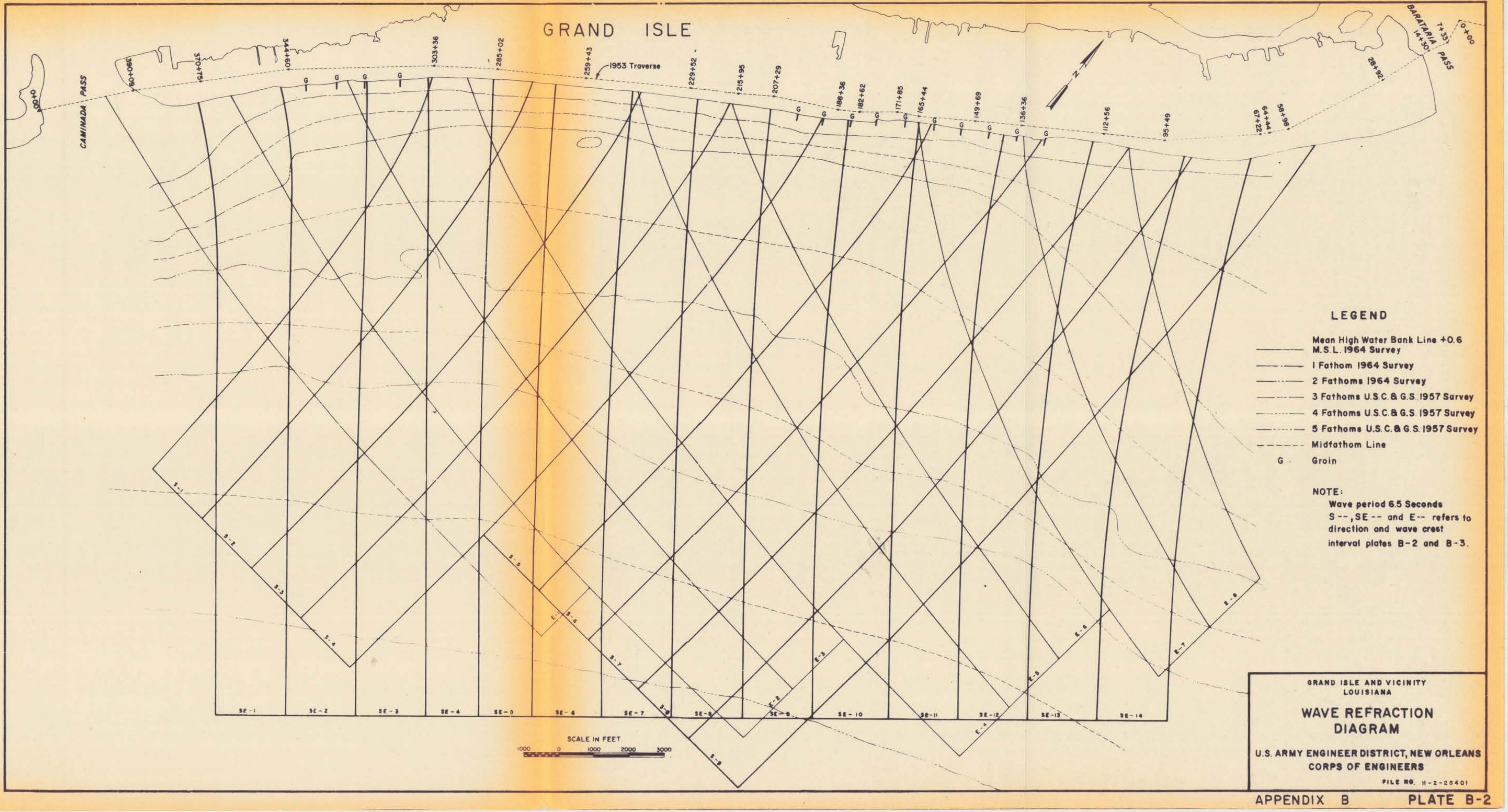
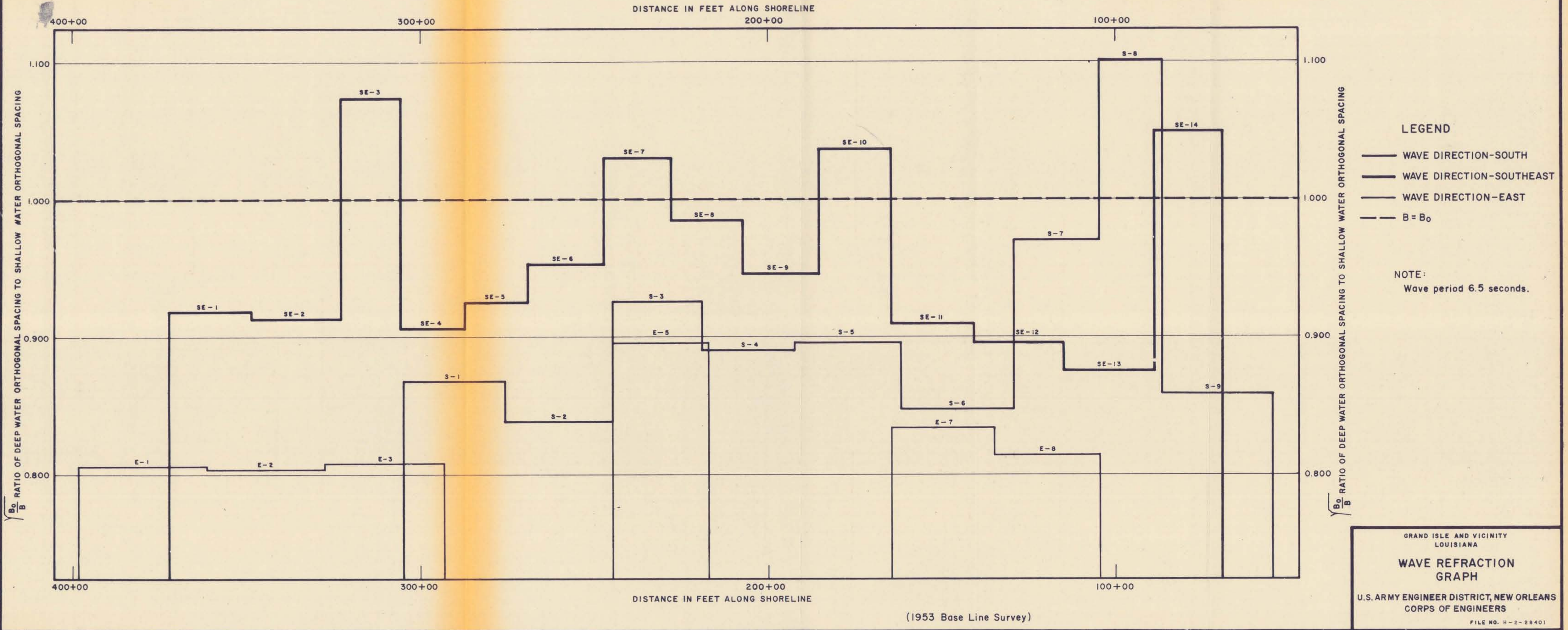
10
11
12
13
14
15
SCALE OF MILES
10 0 10
VICINITY MAP
SCALE OF MILES
0 50 100
MISSISSIPPI
ALA
LOUISIANA
Mobile
Biloxi
Gulfport
Bay St Louis
Long Point
NEW ORLEANS
BRETON SOUND
RIVER
GIWW
GULF OF MEXICO
LEGEND
RECORDING NON-RECORDING
Precipitation Station
Precipitation and Temperature
Complete Met. Station
River Gage, Stage Only
High Water Pipe
NOTE
Figures adjacent to symbols refer to stations listed in tables B-1 and B-8.
GRAND ISLE AND VICINITY LOUISIANA
HYDROLOGIC STATIONS
U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS
FILE NO. H-2-28401


GRAND ISLE
CAMINADA PASS
BARATARIA PASS
1953 Traverse
LEGEND
Mean High Water Bank Line +0.6 M.S.L. 1964 Survey
1 Fathom 1964 Survey
2 Fathoms 1964 Survey
3 Fathoms U.S.C.&G.S. 1957 Survey
4 Fathoms U.S.C.&G.S. 1957 Survey
5 Fathoms U.S.C.&G.S. 1957 Survey
Midfathom Line
G Groin
NOTE:
Wave period 6.5 Seconds
S--, SE-- and E-- refers to direction and wave crest interval plates B-2 and B-3.
SCALE IN FEET
1000 0 1000 2000 3000
GRAND ISLE AND VICINITY
LOUISIANA
WAVE REFRACTION DIAGRAM
U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS
FILE NO. H-2-23401

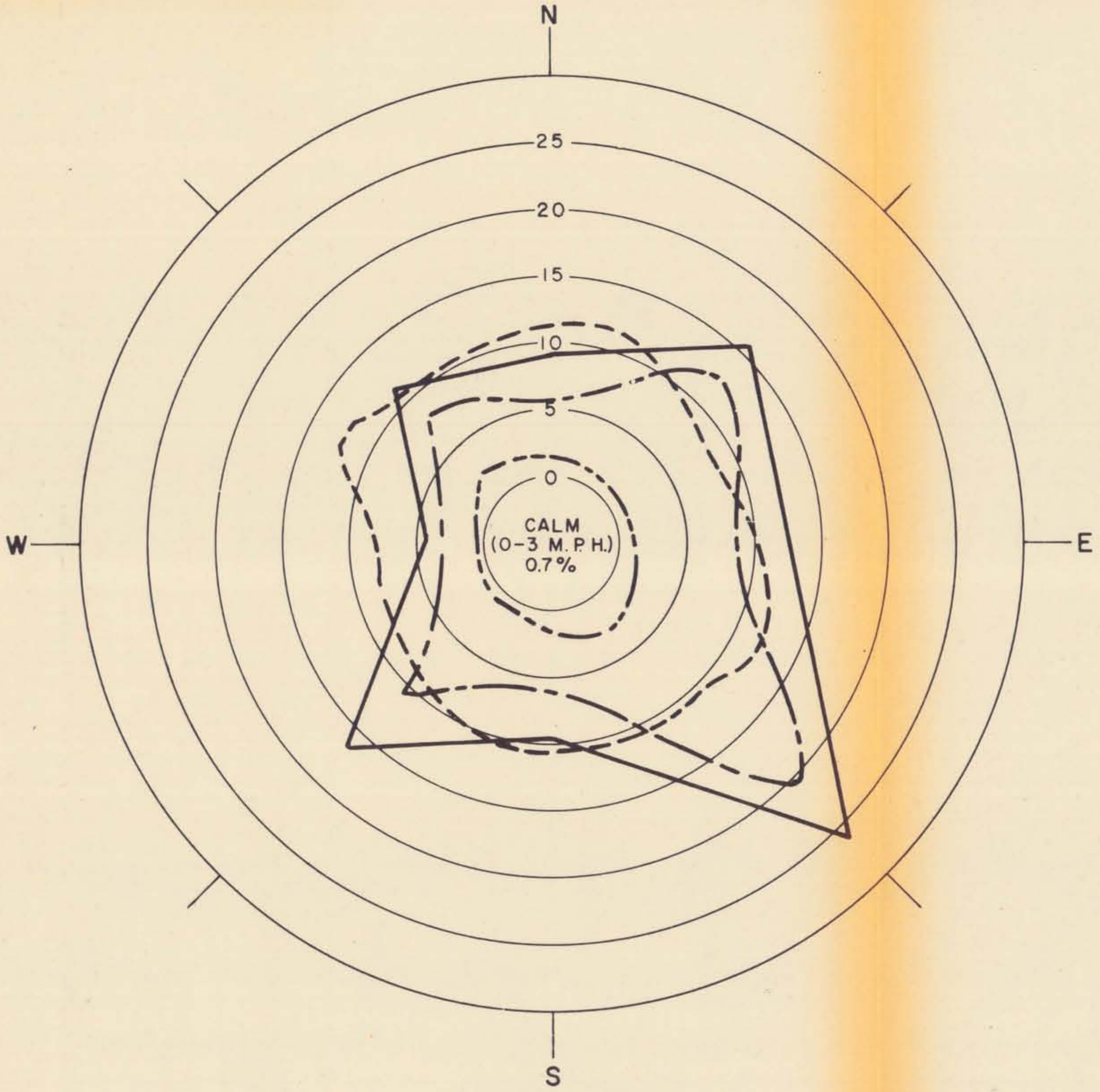


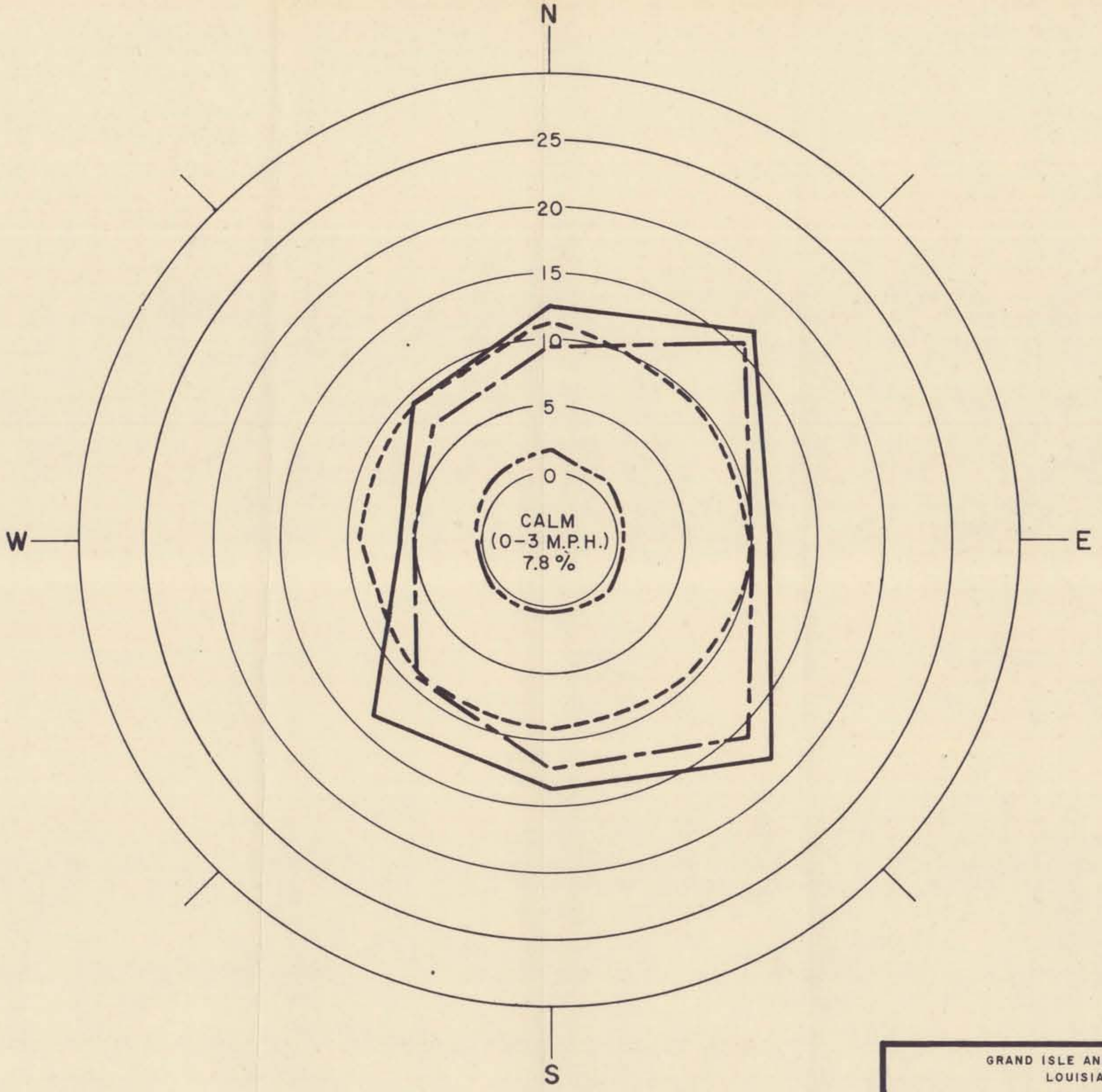
GRAND ISLE AND VICINITY
LOUISIANA

WAVE REFRACTION GRAPH

U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS

FILE NO. H-2-26401





LEGEND

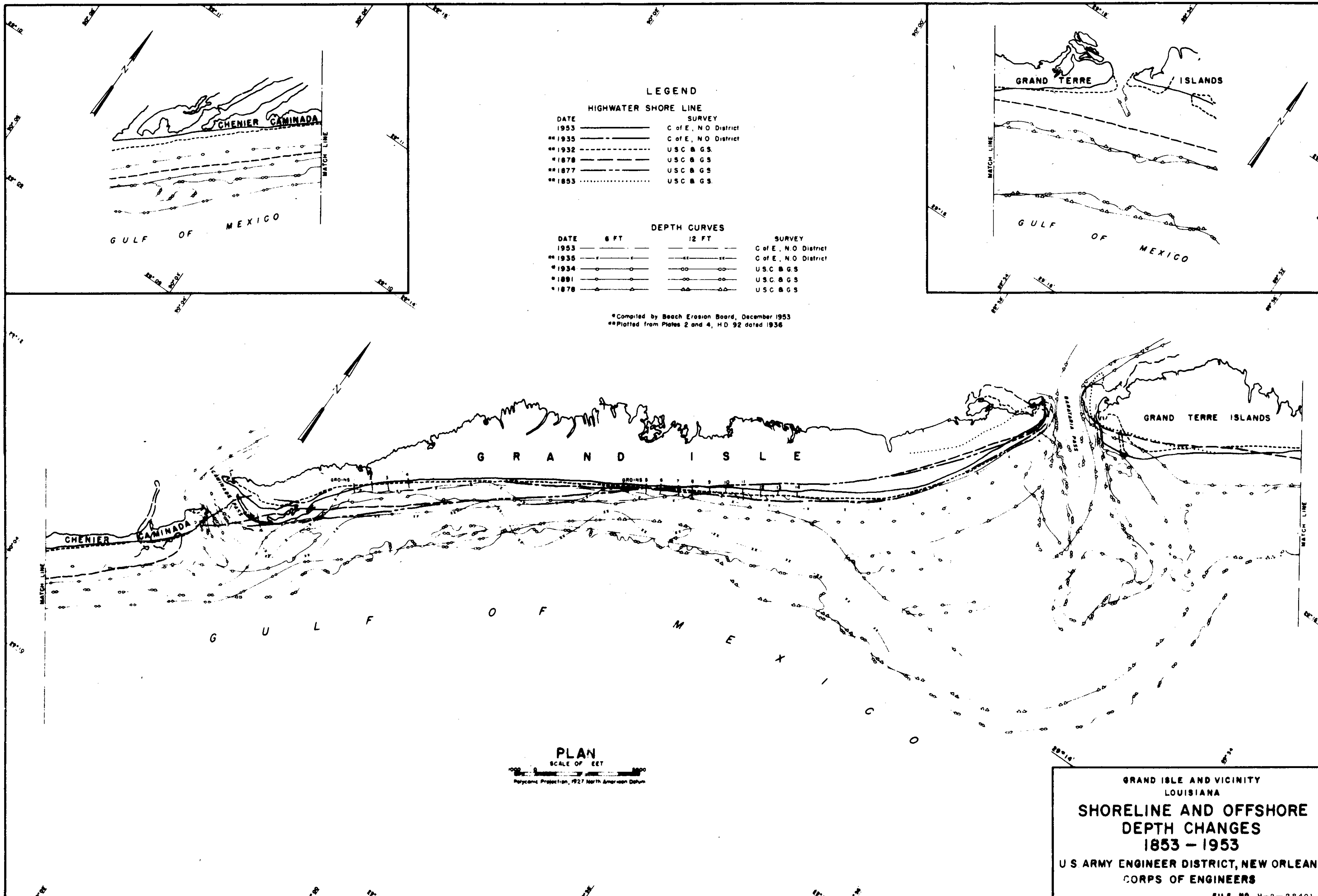
AVERAGE SPEED IN M.P.H.
WIND DURATION IN PERCENT
PERCENT OF TIME WIND BLEW 4-15 M.P.H.
PERCENT OF TIME WIND BLEW 16-31 M.P.H.

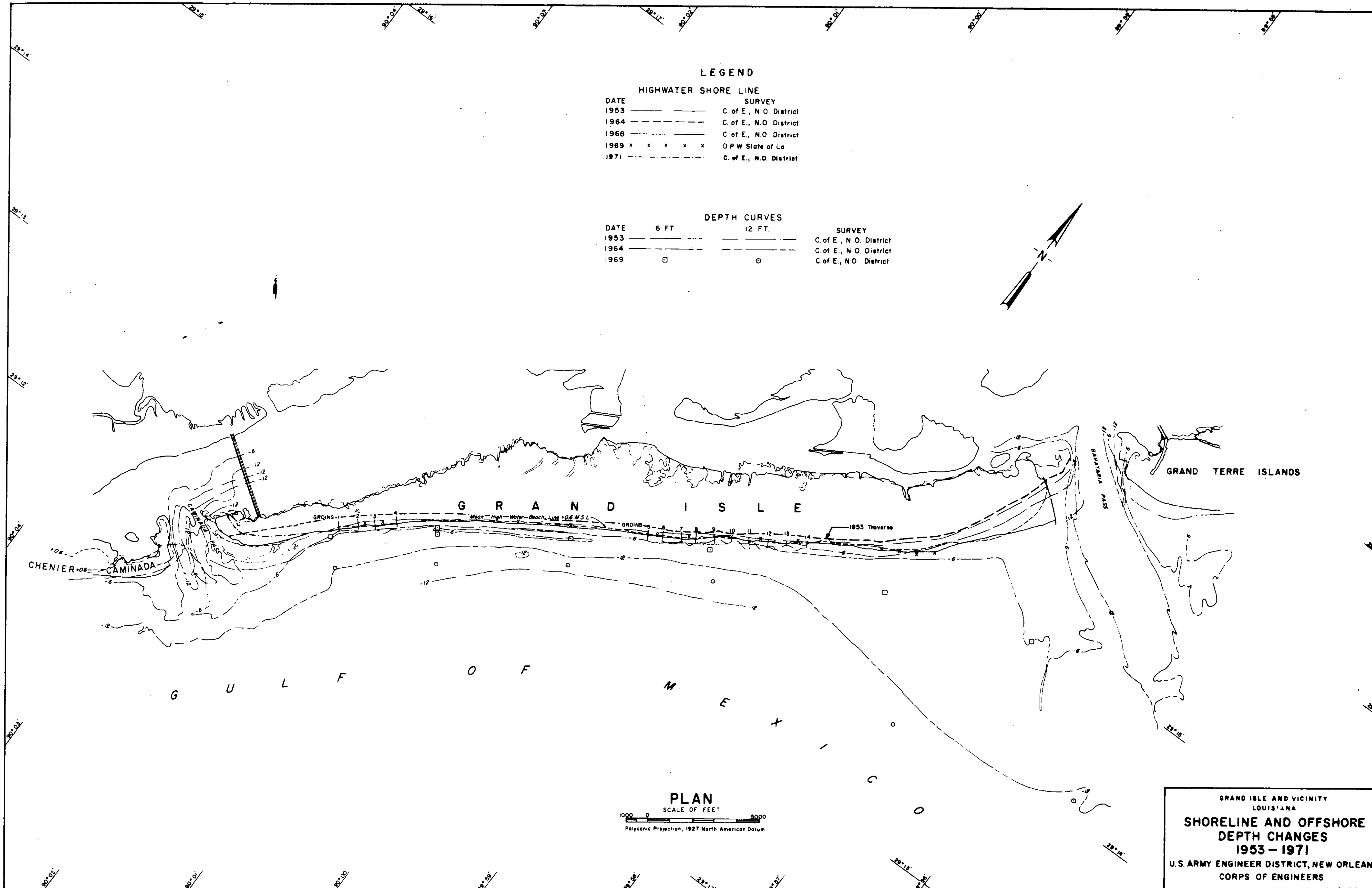
GRAND ISLE AND VICINITY
LOUISIANA

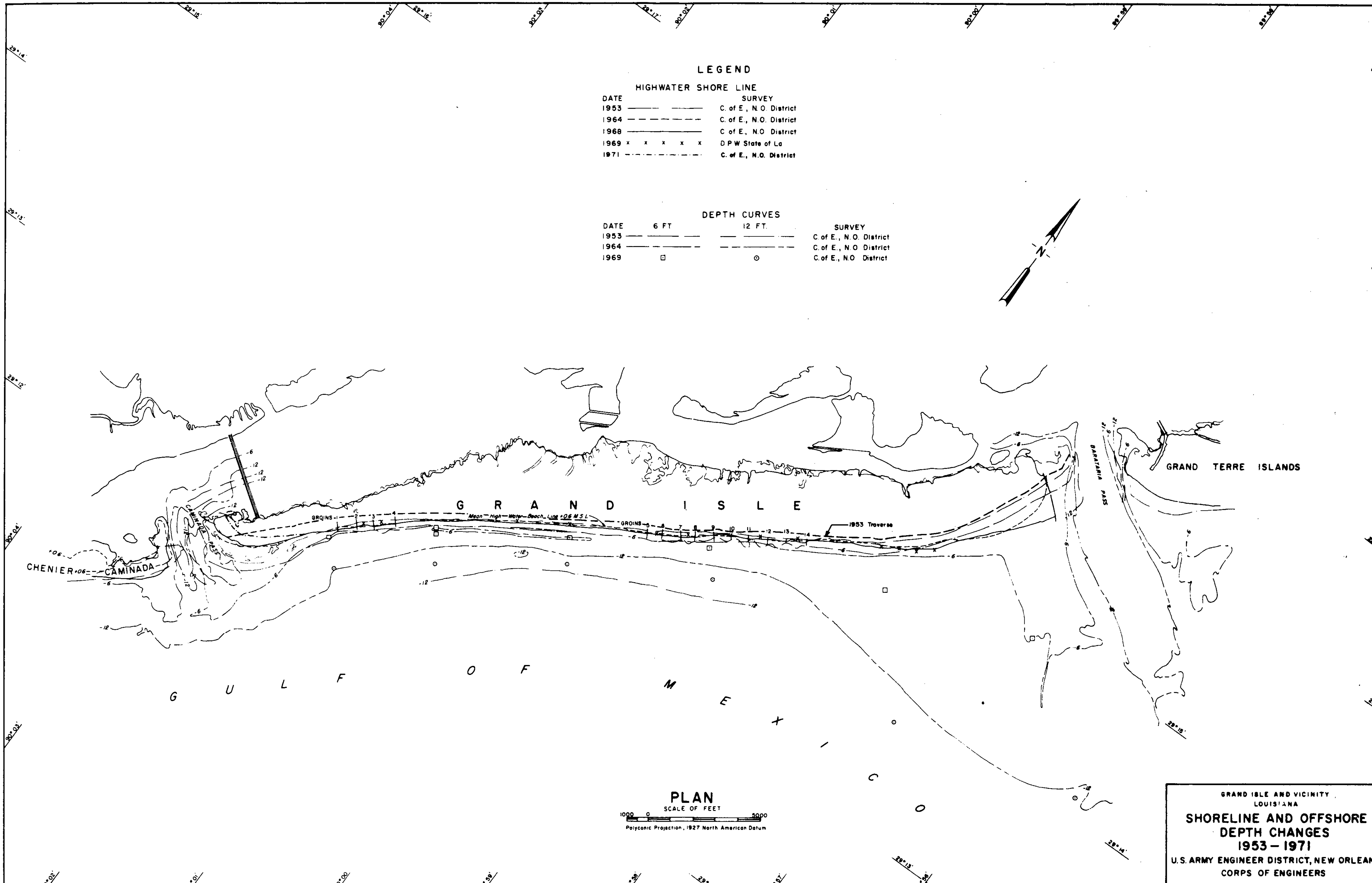
WIND ROSES
U.S. COAST GUARD STATION,
GRAND ISLE, LA.

U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS

FILE NO. H-2-28401


CHENIER CAMINADA
MATCH LINE
GULF OF MEXICO
LEGEND
HIGHWATER SHORE LINE
DATE SURVEY
1953 C of E, N O District
**1935 C of E, N O District
**1932 U S C & G S.
*1878 U S C & G S
**1877 U S C & G S
**1853 U S C & G S.
DEPTH CURVES
DATE 6 FT 12 FT SURVEY
1953 C of E, N.O District
**1935 C of E, N.O District
*1934 U S.C & G.S
*1891 U S.C. & G S
*1878 U S C & G S
*Compiled by Beach Erosion Board, December 1953
**Plotted from Plates 2 and 4, H D 92 dated 1936
GRAND TERRE ISLANDS
MATCH LINE
GULF OF MEXICO
GRAND ISLE
CHENIER CAMINADA
BARATARIA PASS
GRAND TERRE ISLANDS
MATCH LINE
MATCH LINE
GULF OF MEXICO
PLAN
Polyconic Projection, 1927 North American Datum
GRAND ISLE AND VICINITY
LOUISIANA
SHORELINE AND OFFSHORE
DEPTH CHANGES
1853 – 1953
U S ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS
FILE NO. H–2–28401


LEGEND
HIGHWATER SHORE LINE
DATE SURVEY
1953 C. of E., N.O. District
1964 C. of E., N.O District
1968 C. of E., N.O District
1969 D.P.W. State of La
1971 C. of E., N.O. District
DEPTH CURVES
DATE 6 FT 12 FT SURVEY
1953 C. of E., N.O. District
1964 C. of E., N.O. District
1969 C. of E., N.O District
N
GRAND ISLE
GRAND TERRE ISLANDS
BARATARIA PASS
CAMINADA PASS
CHENIER CAMINADA
GROINS
Mean High Water Beach Line +0.6 M.S.L.
1953 Traverse
GULF OF MEXICO
PLAN
SCALE OF FEET
Polyconic Projection, 1927 North American Datum
GRAND ISLE AND VICINITY
LOUISIANA
SHORELINE AND OFFSHORE
DEPTH CHANGES
1953 – 1971
U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS
FILE NO. H-2-28401


LEGEND
HIGHWATER SHORE LINE
DATE
SURVEY
1953 C. of E., N.O. District
1964 C. of E., N.O. District
1968 C of E, N.O District
1969 D P W State of La
1971 C. of E., N.O. District
DEPTH CURVES
DATE 6 FT 12 FT. SURVEY
1953 C of E., N.O. District
1964 C. of E., N.O District
1969 C. of E., N.O District
N
GRAND TERRE ISLANDS
BARATARIA PASS
G R A N D I S L E
CAMINADA PASS
CHENIER CAMINADA
GROINS
Mean High Water Beach Line
1953 Traverse
G U L F O F M E X I C O
PLAN
SCALE OF FEET
Polyconic Projection, 1927 North American Datum
GRAND ISLE AND VICINITY
LOUISIANA
SHORELINE AND OFFSHORE
DEPTH CHANGES
1953 – 1971
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CORPS OF ENGINEERS
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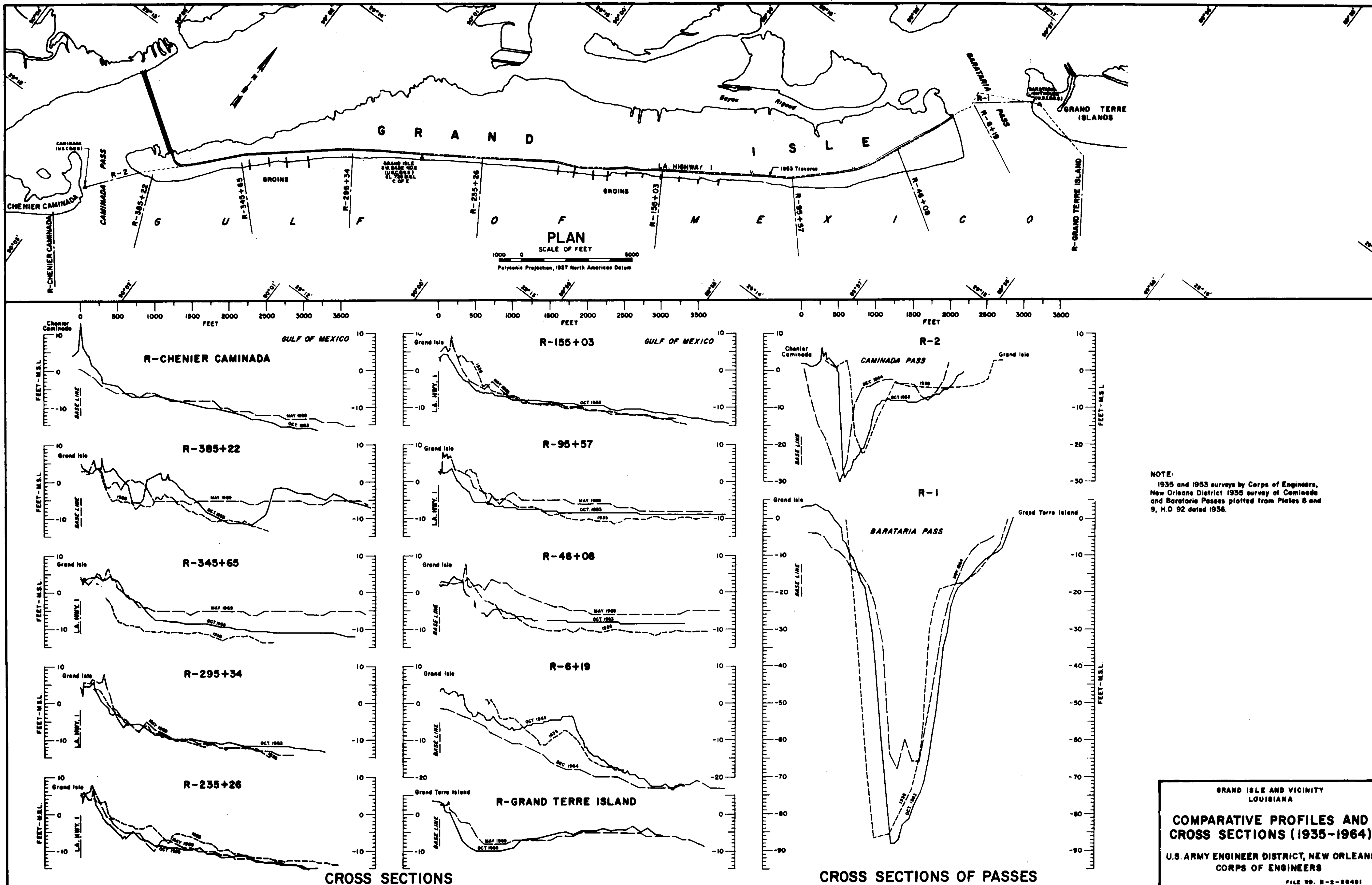
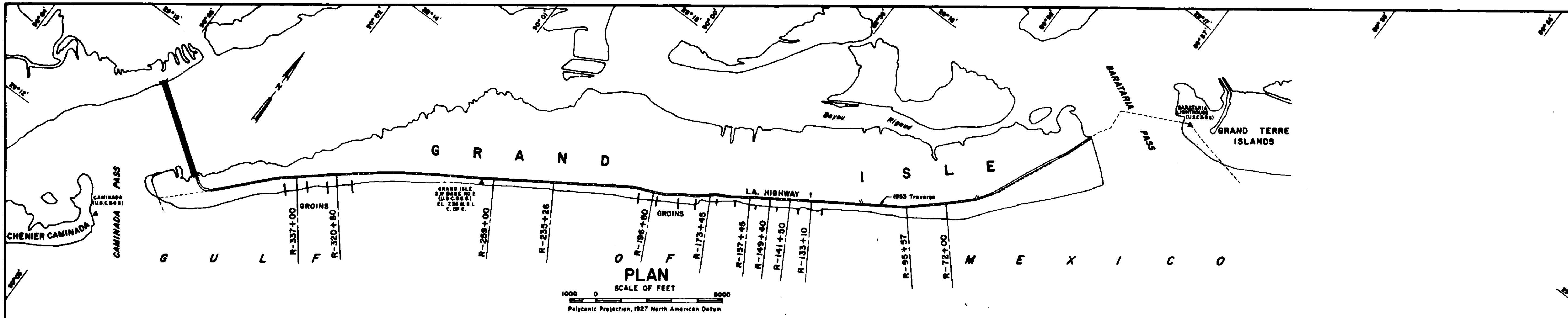


GRAND ISLE AND VICINITY
LOUISIANA

COMPARATIVE PROFILES AND CROSS SECTIONS (1935-1964)

U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS

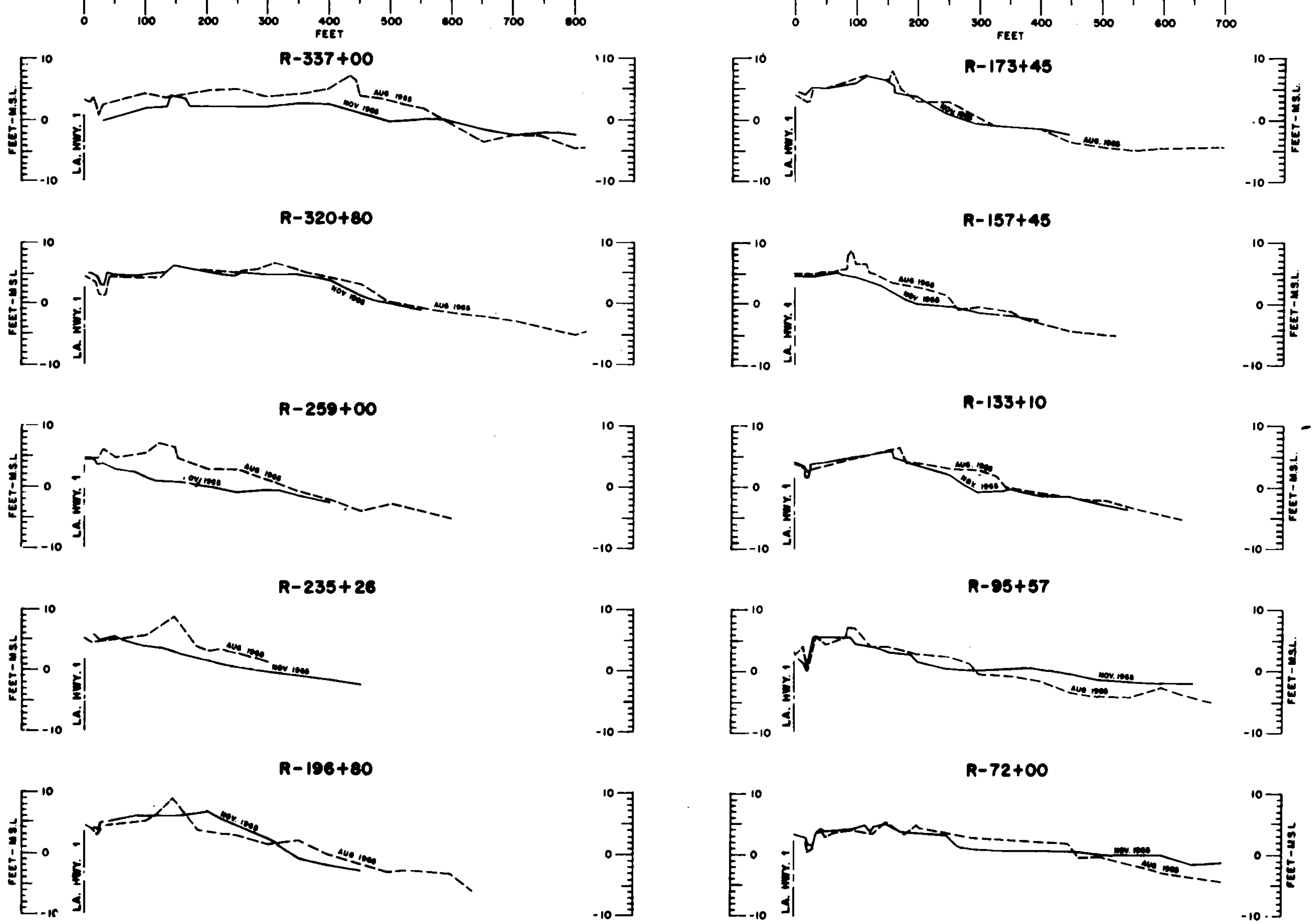
FILE NO. H-2-23401



PLAN

SCALE OF FEET

Polyconic Projection, 1927 North American Datum



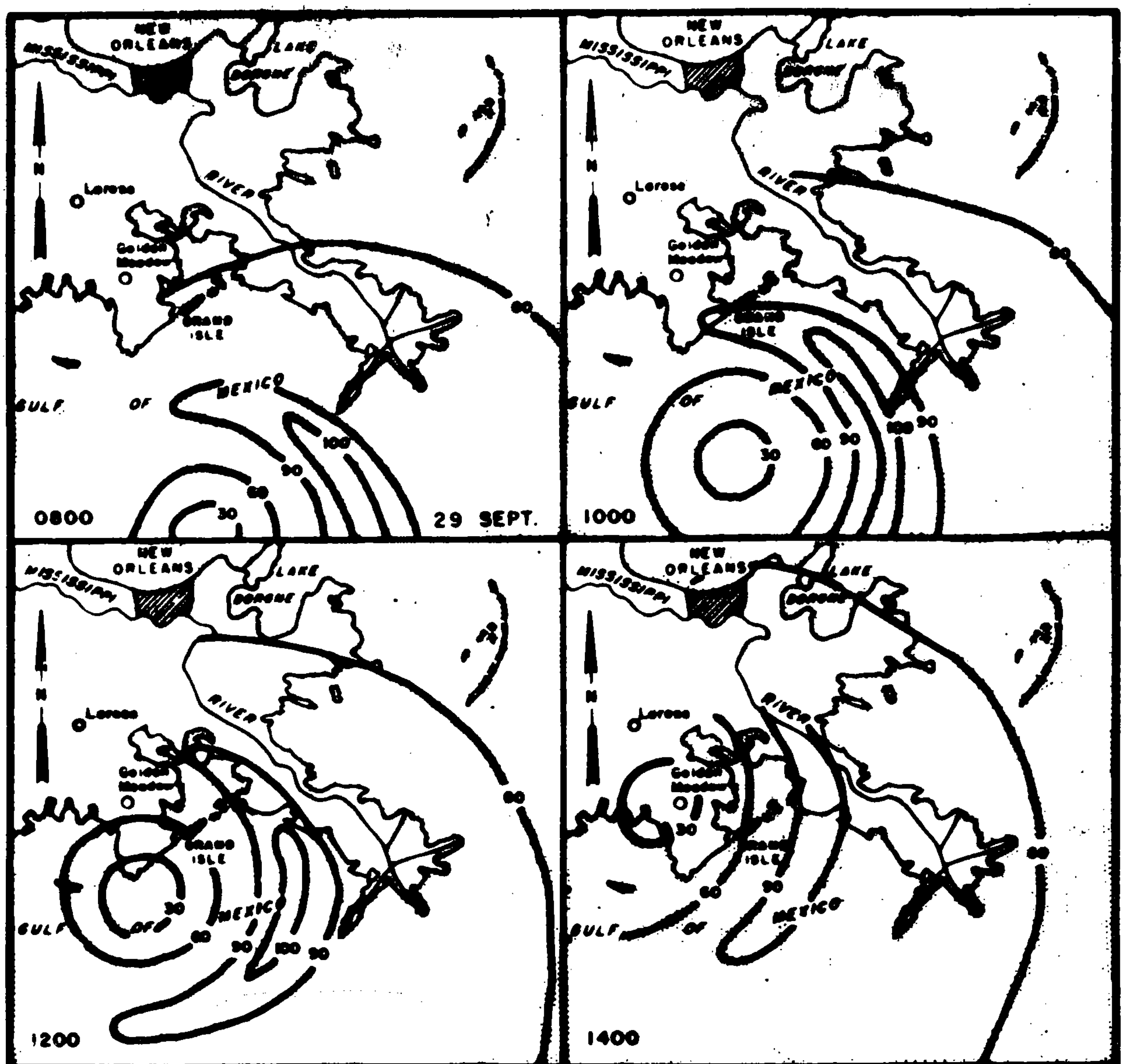
BEFORE & AFTER CROSS SECTIONS — HURRICANE "BETSY"

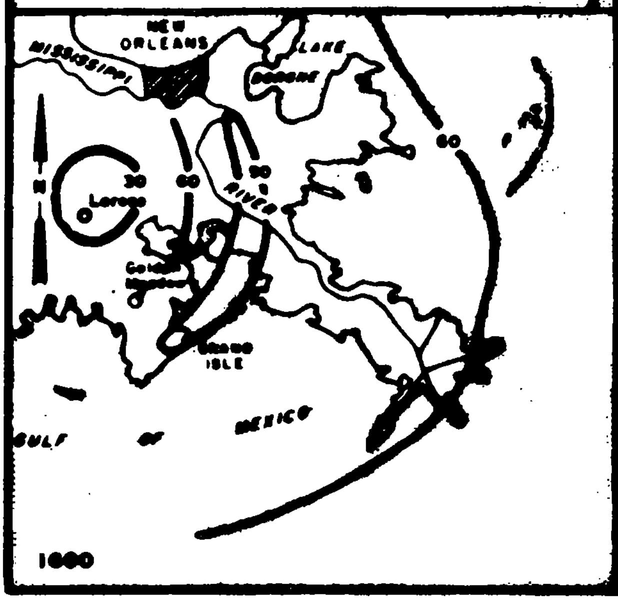
GRAND ISLE AND VICINITY
LOUISIANA

COMPARATIVE PROFILES AND CROSS SECTIONS (1965-1970)

U.S ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS

FILE NO. H-2-26401





LEGEND

30 Average Wind Velocity (MPH)

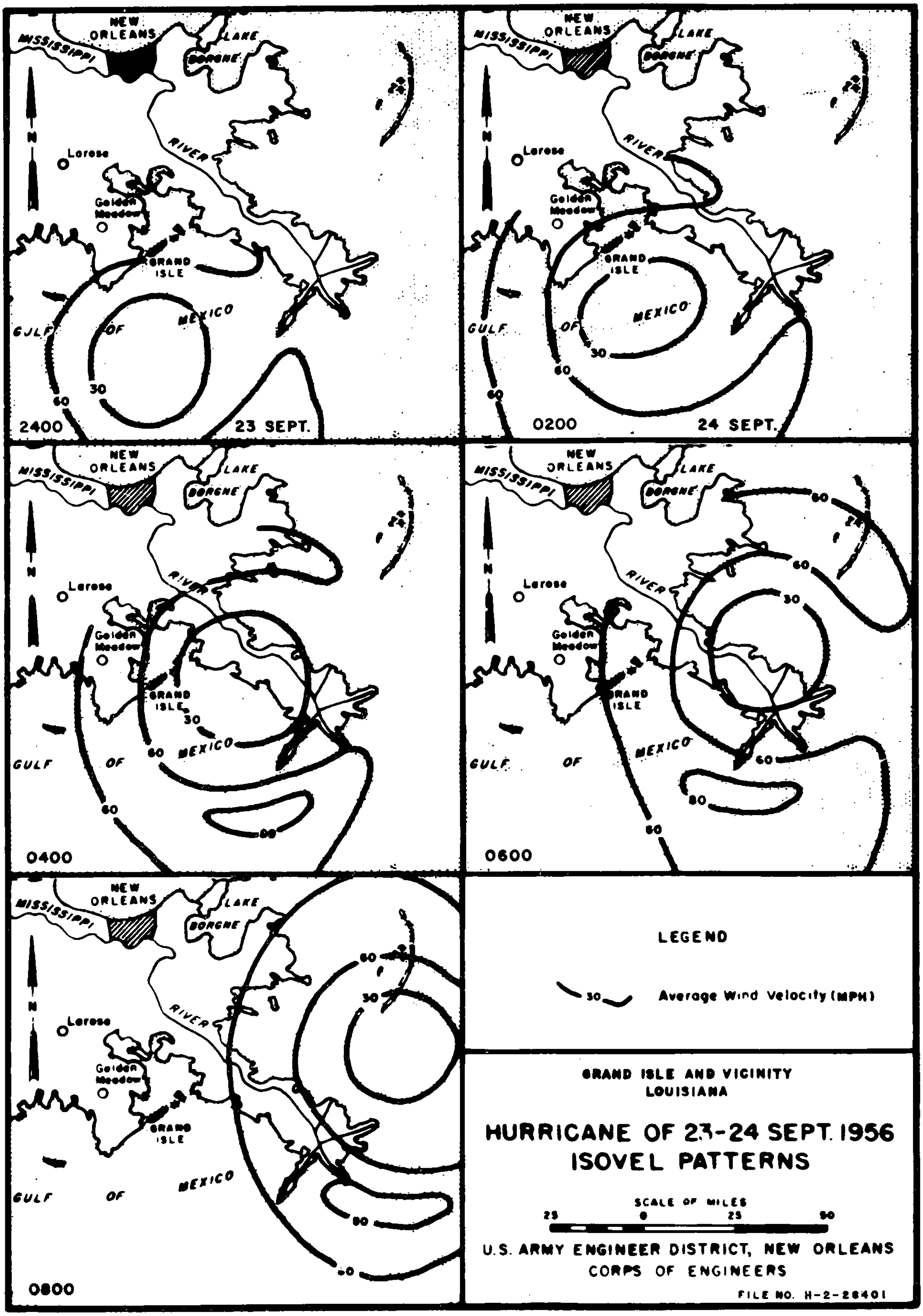
GRAND ISLE AND VICINITY
LOUISIANA

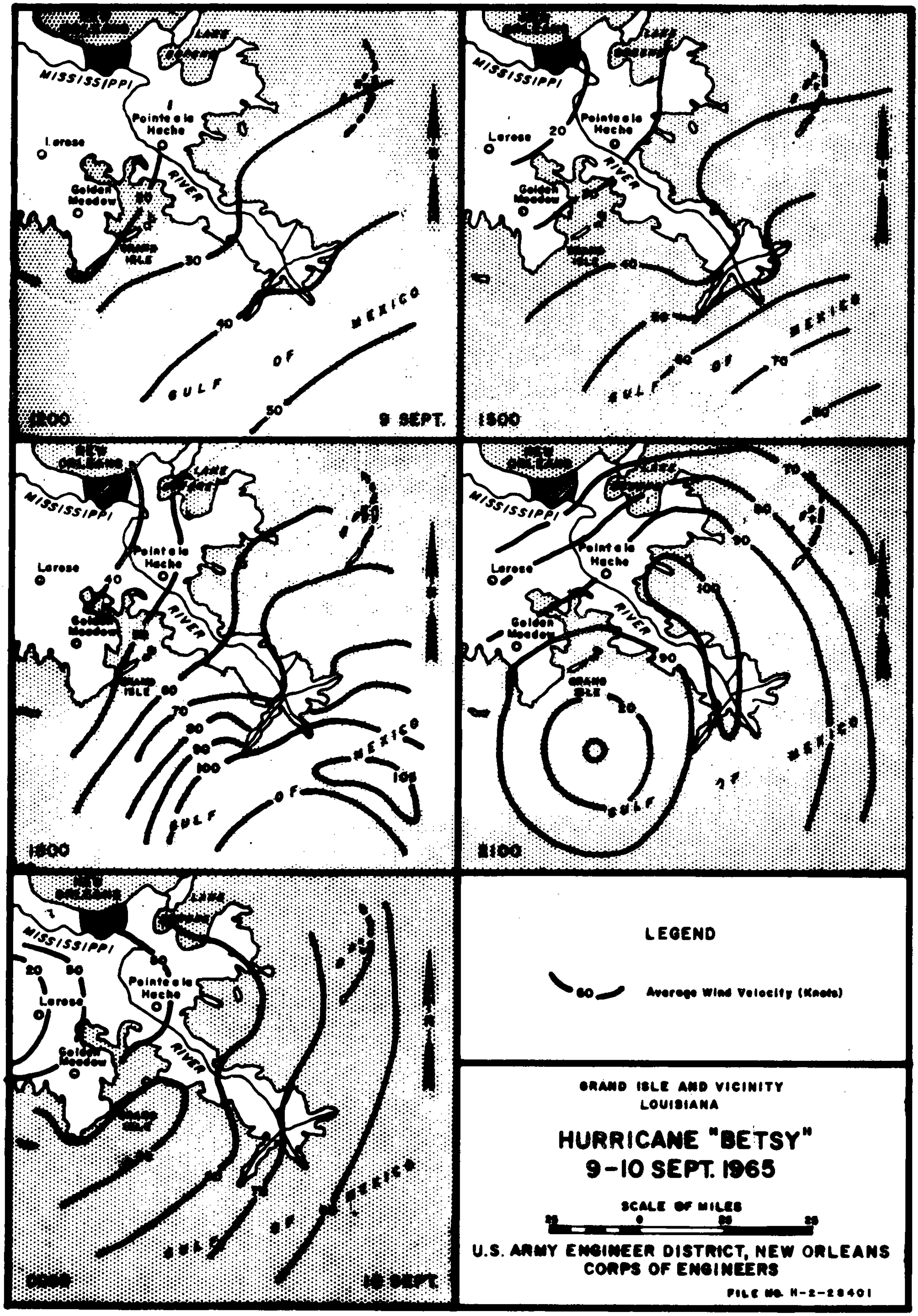
HURRICANE OF 28 SEPT.-1 OCT 1915
ISOVEL PATTERNS

SCALE OF MILES
25 0 25 50

U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS

FILE NO. H-2-20401


NEW ORLEANS
MISSISSIPPI
LAKE BORGNE
RIVER
N
Larose
Golden Meadow
GRAND ISLE
GULF OF MEXICO
30
60
80
2400
23 SEPT.
0200
24 SEPT.
0400
0600
0800
LEGEND
30 Average Wind Velocity (MPH)
GRAND ISLE AND VICINITY
LOUISIANA
HURRICANE OF 23-24 SEPT. 1956
ISOVEL PATTERNS
SCALE OF MILES
25 0 25 50
U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS
FILE NO. H-2-26401



GRAND ISLE AND VICINITY
LOUISIANA

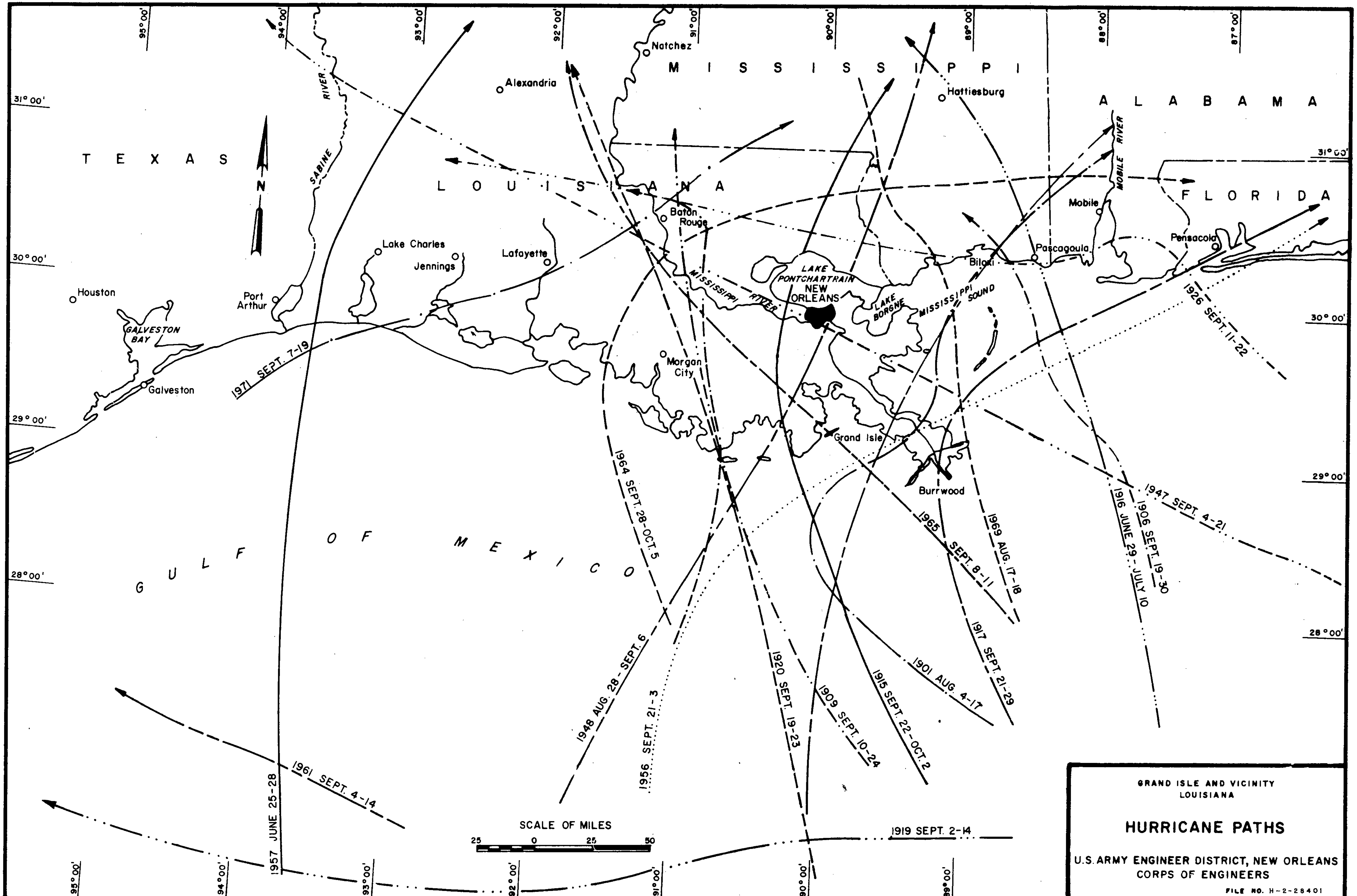
HURRICANE "BETSY"
9-10 SEPT. 1965

SCALE OF MILES

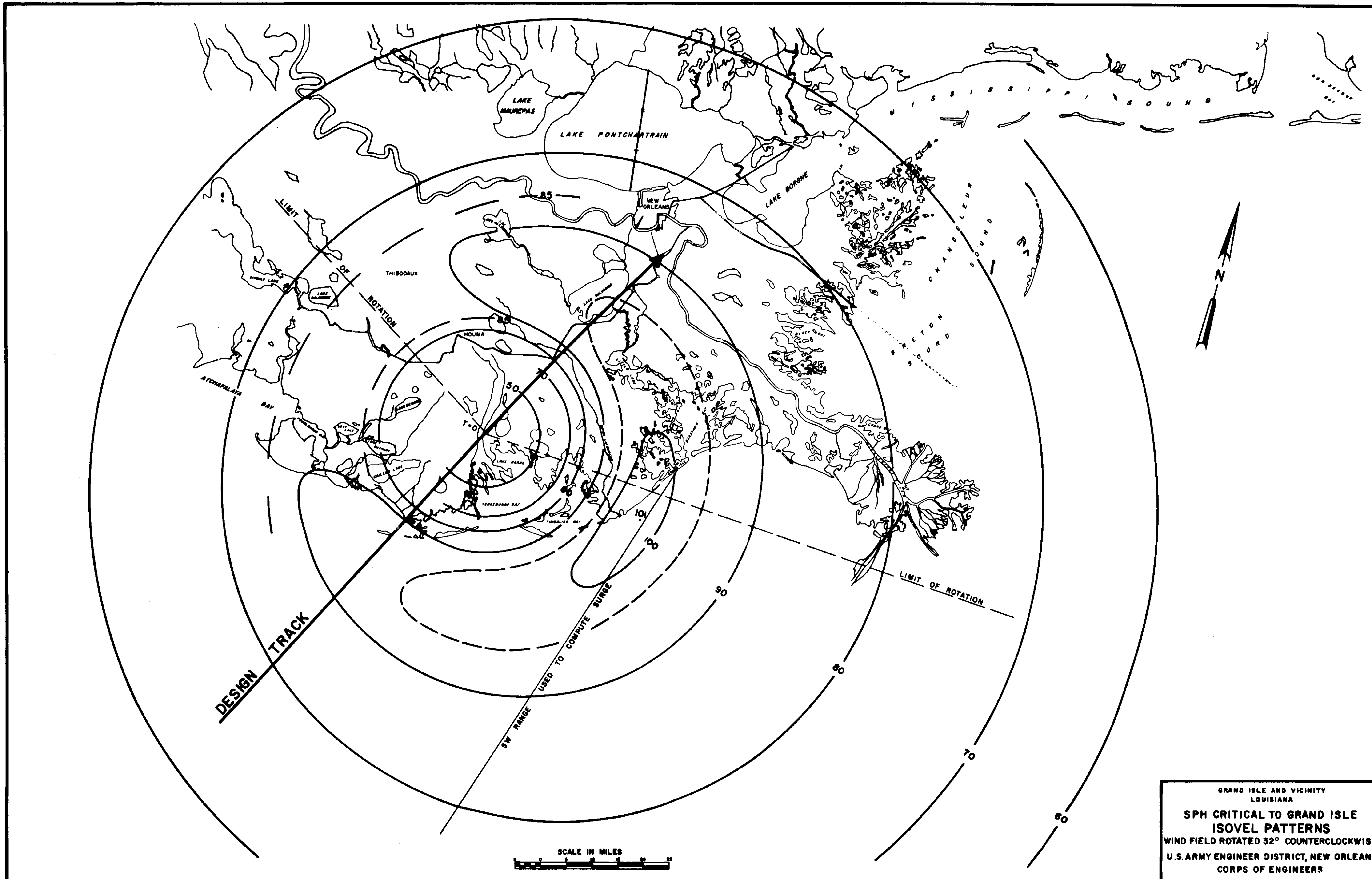
U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS

FILE NO. H-2-23401

APPENDIX B PLATE B-11



APPENDIX B PLATE B-12

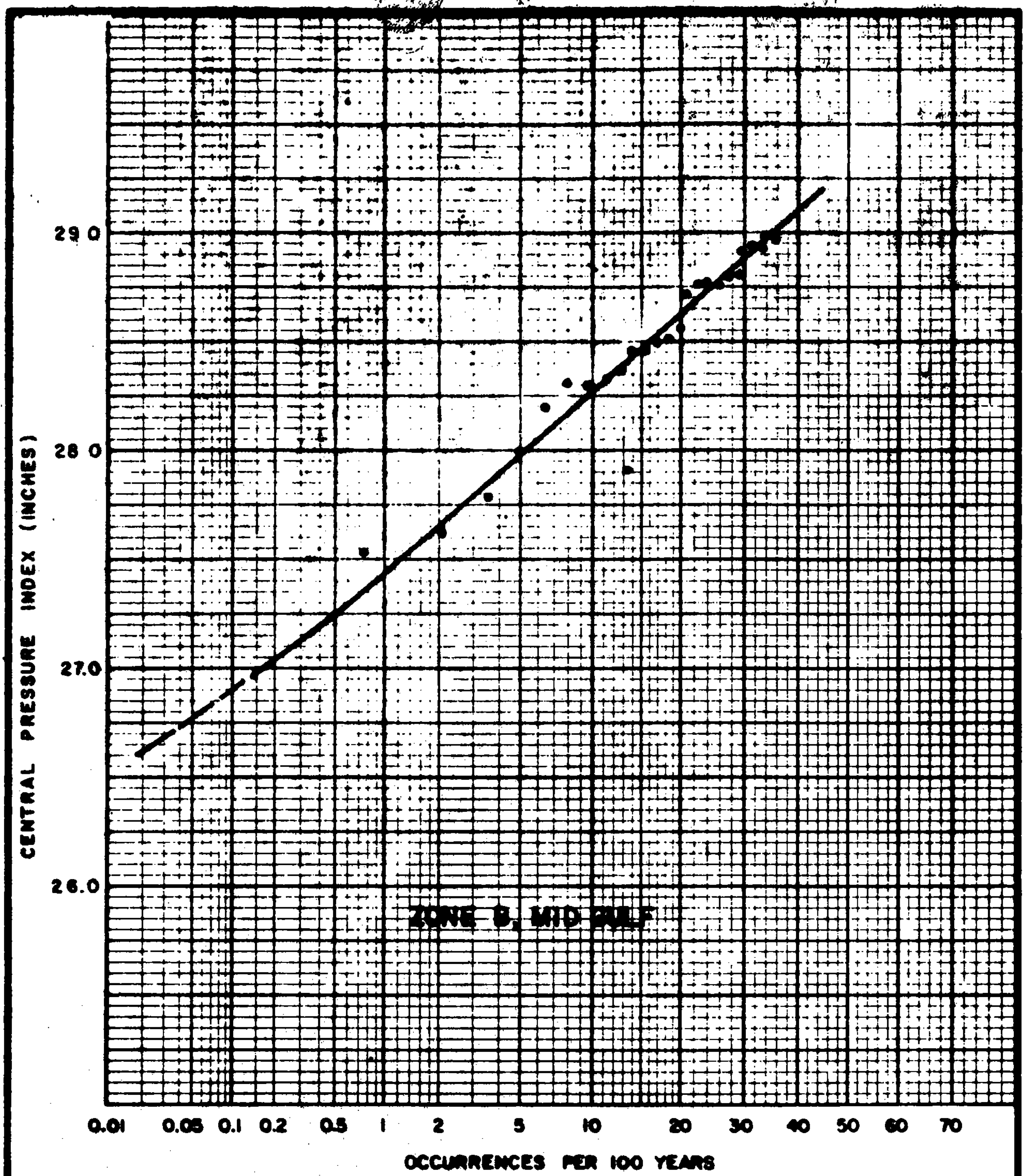


GRAND ISLE AND VICINITY
LOUISIANA

SPH CRITICAL TO GRAND ISLE
ISOVEL PATTERNS
WIND FIELD ROTATED 32° COUNTERCLOCKWISE

U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS

FILE NO. H-2-26401

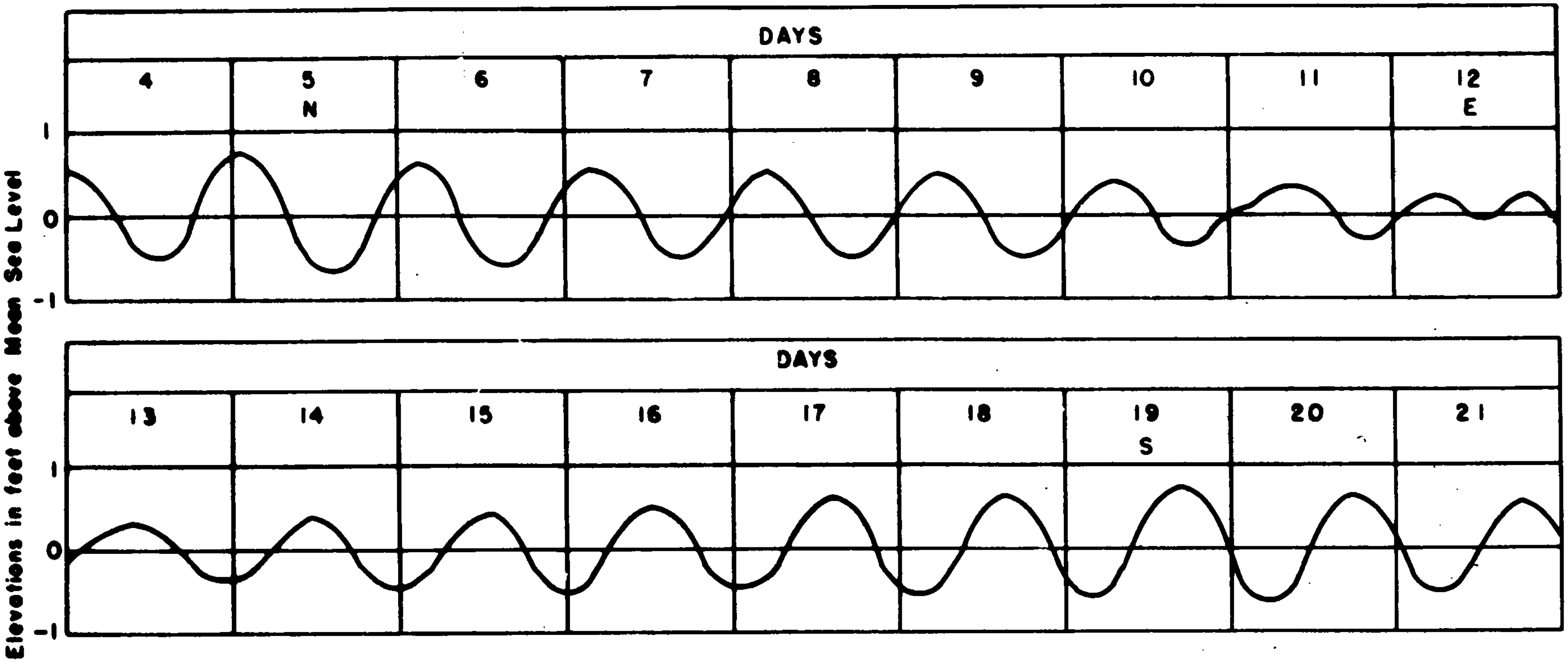


GRAND ISLE AND VICINITY
LOUISIANA

FREQUENCY OF HURRICANE CENTRAL PRESSURES ZONE B, MID GULF

U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS

FILE NO. H-2-28401



LEGEND

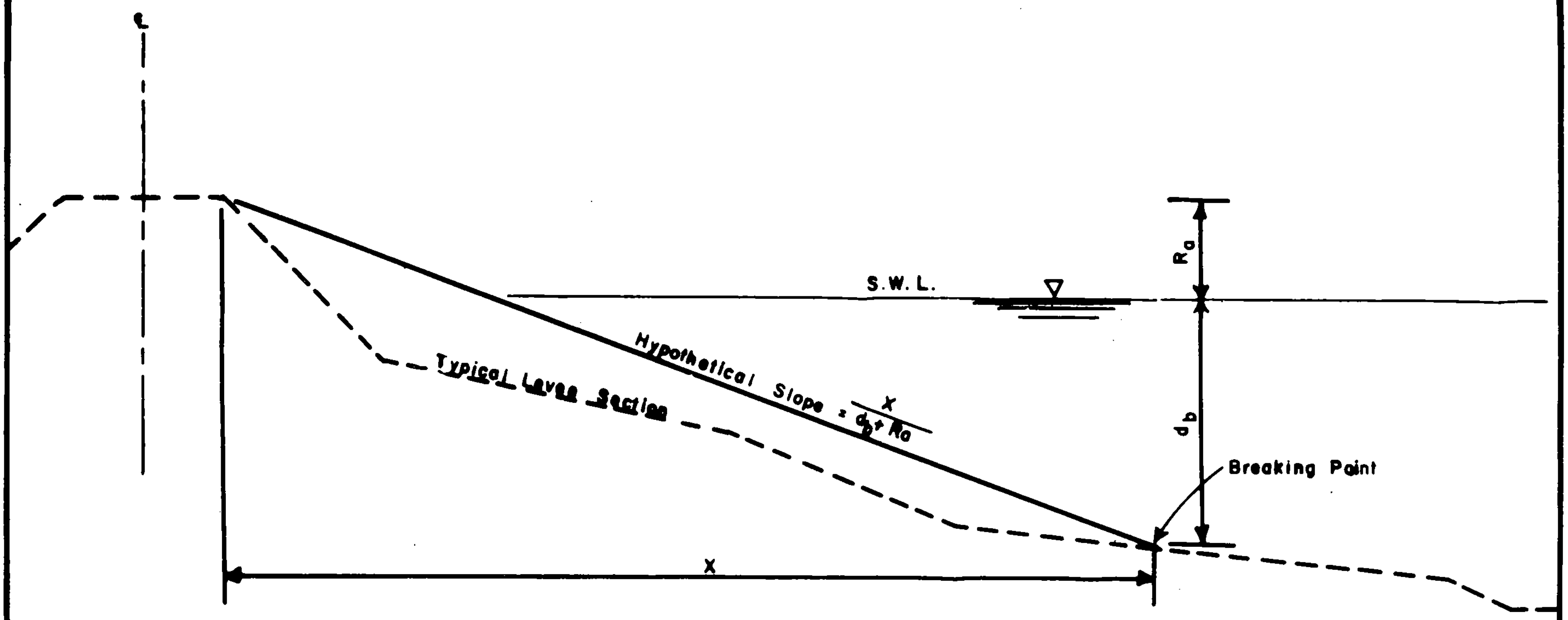
E, moon on the equator
N, S, moon farthest north
or south of the equator

GRAND ISLE AND VICINITY
LOUISIANA

TYPICAL TIDAL CYCLES

U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS

FILE NO. H-2-28401



LEGEND

R_a = assumed runup
d_b = breaking depth of wave
X = horizontal distance from breaking point to elevation at runup
S.W.L. = stillwater level

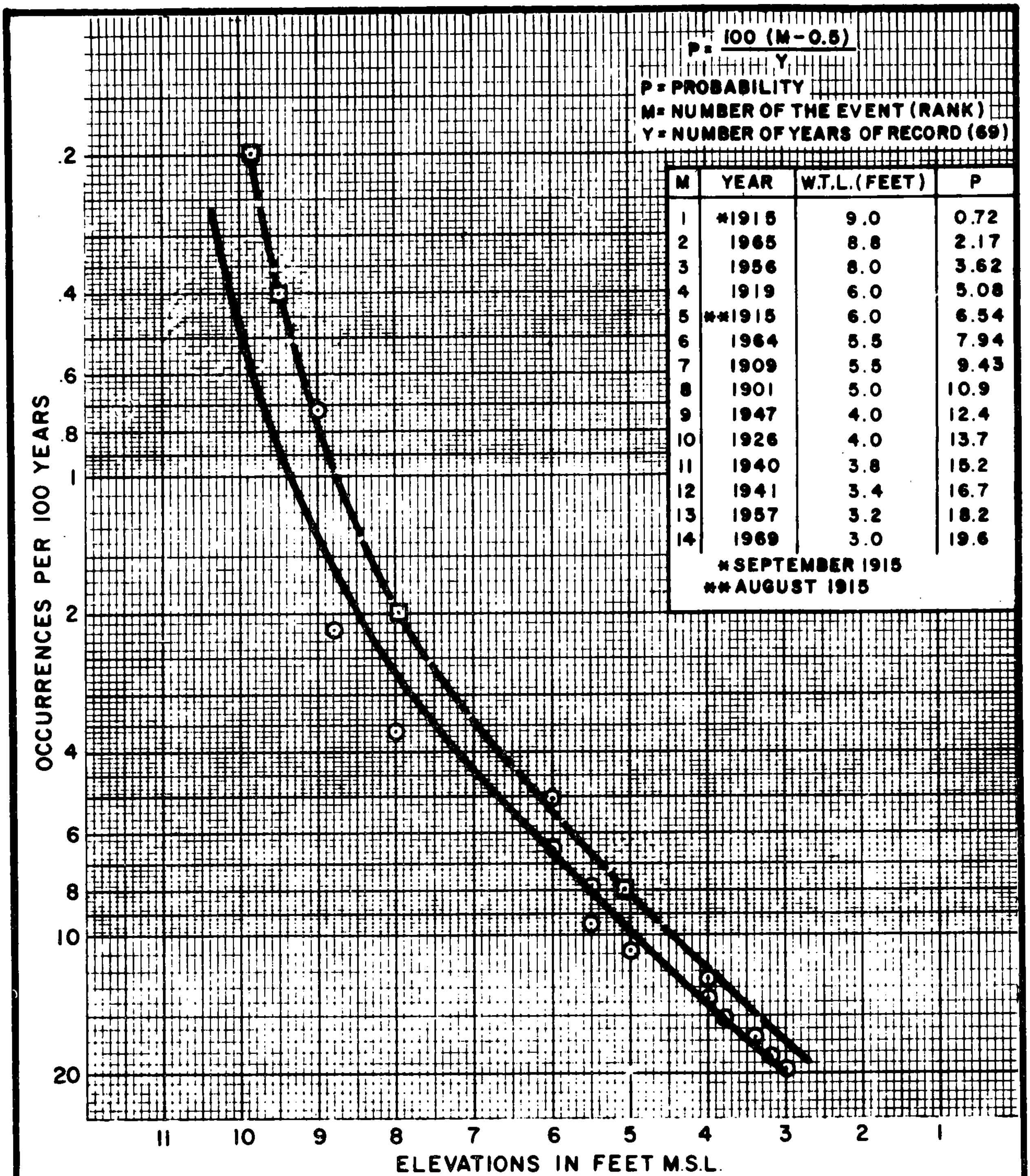
GRAND ISLE AND VICINITY
LOUISIANA

DETERMINATION OF HYPOTHETICAL SLOPE

U.S. ARMY ENGINEER DISTRICT NEW ORLEANS
CORPS OF ENGINEERS

FILE NO. H-2-28401

PLATE B-16



M	YEAR	W.T.L. (FEET)	P
1	*1915	9.0	0.72
2	1965	8.8	2.17
3	1956	8.0	3.62
4	1919	6.0	5.08
5	**1915	6.0	6.54
6	1964	5.5	7.94
7	1909	5.5	9.43
8	1901	5.0	10.9
9	1947	4.0	12.4
10	1926	4.0	13.7
11	1940	3.8	15.2
12	1941	3.4	16.7
13	1957	3.2	18.2
14	1969	3.0	19.6

*SEPTEMBER 1915
**AUGUST 1915

LEGEND

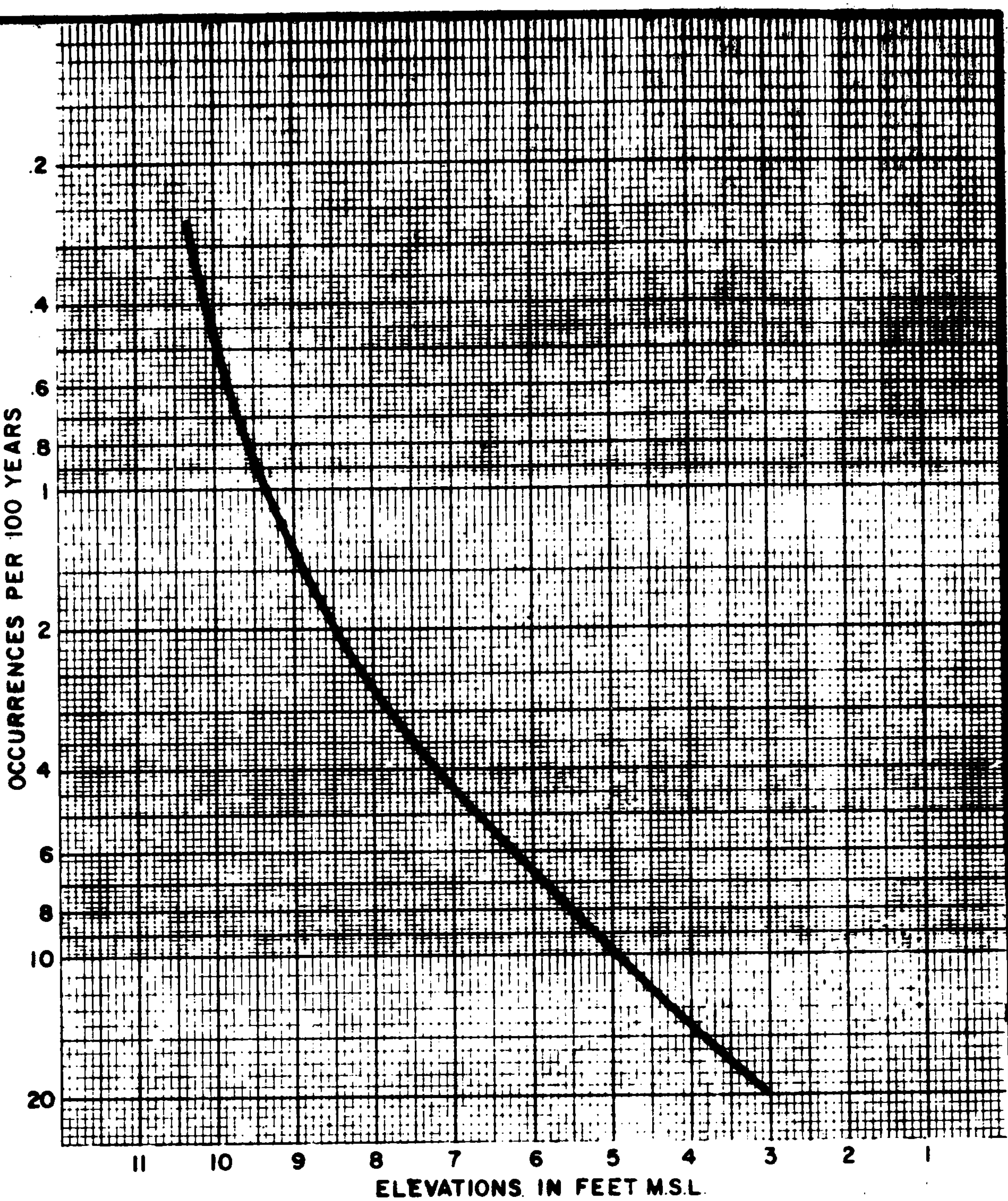
- SYNTHETIC STAGE FREQUENCY
- SHIFTED TO EXPERIENCED FREQUENCY PLOT
- EXPERIENCED STAGE FREQUENCY
- 20% ZONE B SYNTHETIC STAGE FREQUENCY

GRAND ISLE AND VICINITY
LOUISIANA

STAGE – FREQUENCY

U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS

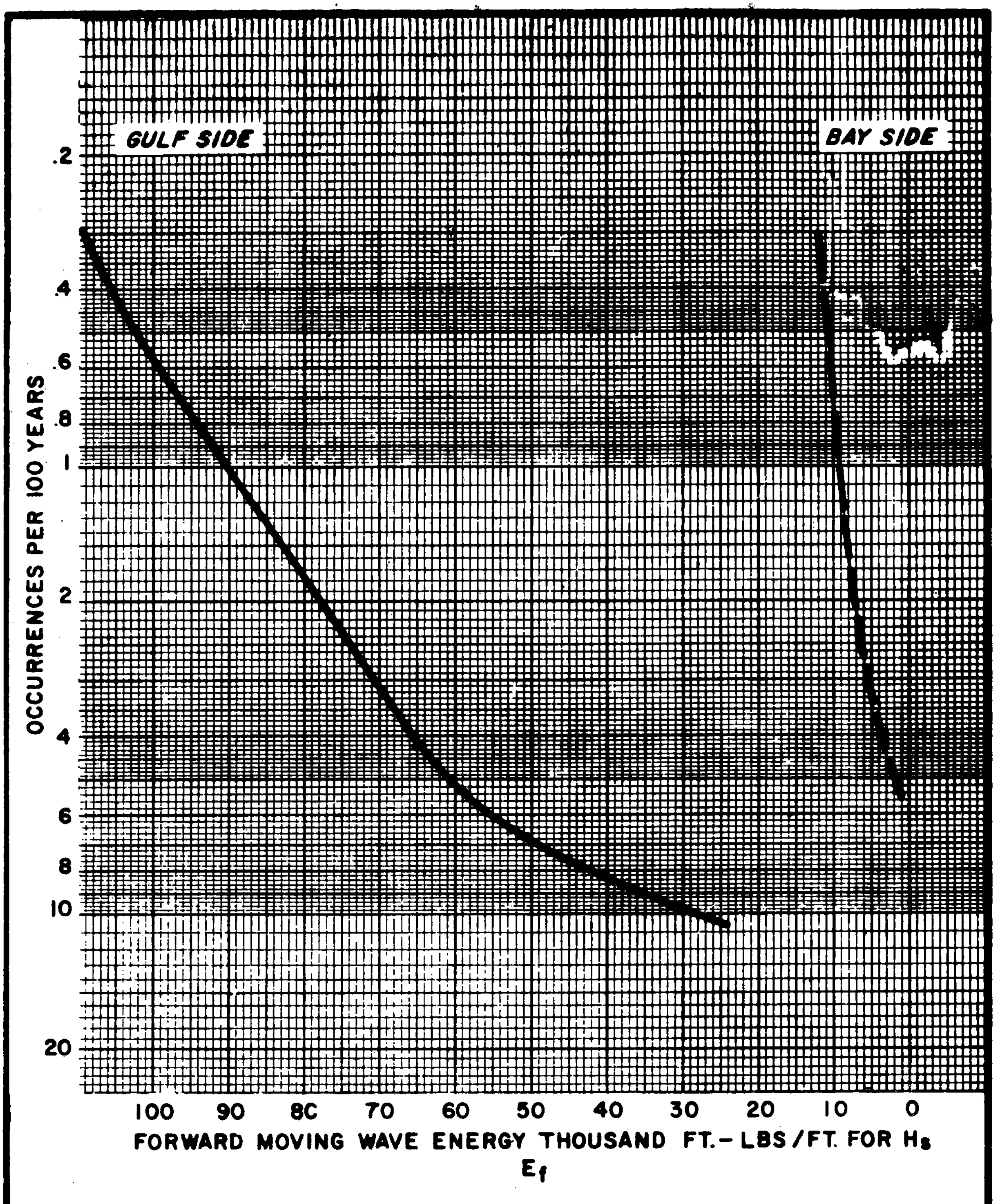
FILE NO. H-2-28401



GRAND ISLE AND VICINITY
LOUISIANA

STAGE – FREQUENCY

U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS
FILE NO. H-2-23401



GRAND ISLE AND VICINITY
LOUISIANA

WAVE ENERGY - FREQUENCY

U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS

FILE NO. H-2-24401

APPENDIX C

Design and Cost Estimates

GRAND ISLE AND VICINITY, LOUISIANA
PHASE I GENERAL DESIGN MEMORANDUM

APPENDIX C
DESIGN AND COST ESTIMATES

TABLE OF CONTENTS

TABLES

APPENDIX C

DESIGN AND COST ESTIMATES

1. DESIGN

a. General. Plan A, the beach erosion protection plan, and plans B, C, and D, the combined beach erosion and hurricane protection plans, are described in the main report. Design criteria for the four plans are discussed in paragraph 8 of appendix B, and the alinements and cross sections of their features are given on plates 2 and 4.

b. Plan A - Beach erosion protection

(1) Beach fill. Plan A would require sandfill from the 3-foot contour gulfward to provide the minimum section. Sandfill would not be placed where the minimum section exists such as near the east end jetty where considerable accretion has occurred. Sand fill quantities were computed by superimposing the minimum section on December 1977 profile data.

(2) Jetty

(a) General. The jetty for plan A is also included in plans B, C, and D. This jetty was designed to stabilize the western end of the island and maintain a minimum beach width (see paragraph 8a of appendix B).

(b) Armor stone. The size for the cover layer of armor stone required was determined as prescribed in Technical Report No. 4 of the Coastal Engineering Research Center, "Shore Protection, Planning, and Design." The stone size was determined by the Hudson rubble mound stability formula:

$$W_{50} = W_r H_b / K_{RR} (S_r - 1)^3 \cot a$$

where:

W_{50} = Minimum weight of 50% of stone (lbs).

W_r = Unit weight of stones (165 lbs./cu.ft.)

H_b = Design wave height of structure (4.68 ft.)

K_{RR} = Stability coefficient of stone (1.7)

S_r = Special gravity of stone (2.58)

cot a = cotangent of angle of slope, measured from horizontal (2)

$$W_{50} = \frac{(165)\ (4.68)^3}{(1.7)\ (2.58-1)^3\ (2)} = 1{,}260 \text{ lbs.}$$

(c) Easement. An easement was not required for the jetty since it was constructed in the state-owned waters of Caminada Pass.

c. Plans B, C, and D - Combined beach erosion and hurricane protection

(1) Dune and berm

(a) Alinement. The alinement for the dune of plans B, C, and D would be generally along the existing dune line except at the East and West State Parks where the alinement would be modified as shown on plates 2 and 4 to provide protection for the supportive recreational facilities. The alinement of the dune along the island proper is the most gulfward alinement that would provide wave run up protection. At the east end of the island along the jetty and revetment and at the west end of the island along the jetty at Caminada Pass the dune would be located at least 200 feet landward of the structures to provide the minimum berm for the dissipation of hurricane waves. The berm would be located immediately gulfward of the dune.

(b) Dune vegetation. It was determined during the final stages of the Phase I GDM that the procedure for providing dune vegetation should be modified. Phase II studies will include development of a dune stabilization plan which incorporates planting seedlings rather than using the currently proposed seeding and asphalt mulch preparation that was outlined previously. It is believed that this plan will better insure success in stabilizing the proposed dune than the seeding plan. Based on the preliminary report received from Dr. W. W. Woodhouse, Jr., the district's coastal vegetation consultant, and experience with planting in the gulf region, it is suggested that two species already present on Grand Isle, bitter panicum and sea oats, should receive primary interest in selecting the appropriate vegetation. Although the cost of the plan to use seedlings is expected to exceed the seeding cost, preliminary estimates fall well within the 25 percent contingencies that have been allowed for in the Phase I GDM cost estimate.

(c) Sandfill. The design criteria for the dune and berm sections are discussed in paragraph 8d of appendix B. The quantity of sandfill required for each of the three combined protection plans was estimated from the cross sections of the plans superimposed on December 1977 profile data.

(d) Easement. The easement required for the dune and berm would be the same for each of the three combined protection plans since any alinement landward of that required for the smallest dune (plan B) would involve more numerous and costly relocations. The easement cost for the dune and berm was computed from a line 50 feet landward from the centerline of the dune gulfward to the mean high tide level. The lands within the state parks on each end of the island were not included in the easement cost.

(e) Drainage. Drainage on Grand Isle is from the natural dune ridge on the gulf side of the island, which is generally the alinement of the existing and recommended dunes, to the bayside of the island. Therefore, no drainage structures through the dune are necessary.

(f) Culverts at East End State Park. During coordination of the draft Phase I GDM and the public meeting held 24 February 1979 at Grand Isle, Louisiana, several agencies expressed a desire that tidal interchange between a lagoon (old borrow pit) located on the East End State Park and the adjacent gulf waters be maintained so as not to change the ecology of the area. This would allow for continued use of the area by many fish species and numerous shorebirds. The shallow water area will still be utilized as a source of bait for the many surf fishermen that use the area. The preliminary cost for a culvert system to maintain tidal interchange combined with the cost of the proposed vegetation plan fall within the Phase I 25 percent contingencies cost figures of $1,225,000. The combined costs of the culvert systems and the added cost for the vegetation plan are expected to be under $500,000.

(2) Jetty. The jetty for plans B, C, and D is described in paragraph 1.b. of this appendix.

2. COST ESTIMATES

a. General. Estimates of first cost and the corresponding annual charges for plans A, B, C, and D, are given in tables C-1, C-2, C-3, and C-4, respectively. Unit costs are based on costs for similar work in the New Orleans District, adjusted to October 78 levels.

b. Estimates of first costs

(1) Sandfill. Unit costs for sandfill for the four plans, excluding the amounts used during preauthorization construction, are based on dredging and pumping the fill from the borrow areas located on Plate A-2. Fill for preauthorization construction was dredged and pumped from Caminada Pass on the western end of the island.

(2) Jetty. The jetty included as an integral part of each plan was constructed as an emergency measure, prior to project authorization, by contract of the State of Louisiana, Office of Public Works. Actual costs for this emergency work were less than the Government estimate (see tables C-1 through C-4).

(3) Easement costs. The unit easement cost for plan A was not assigned a value since the rights-of-way required for this plan are within state-owned lands. Unit easement costs for plans B, C, and D were estimated from the fee value of the individual lands involved.

c. Estimates of annual costs

(1) Initial and 4-year periodic replenishment. The placement of an estimated 100,000 cubic yards of sandfill per year is required for the combined dune and berm plans. To reduce unit costs, periodic beach replenishment would be accomplished by the placement of 200,000 cubic yards during the second year and 400,000 cubic yards at 4-year intervals (see paragraph 8.b. of appendix B). For the berm only plan (plan A) 70,000 cubic yards of sandfill per year is required. Fill for these replenishments would be dredged from the borrow areas located offshore on each end of the island. Computation of annual cost for the periodic maintenance is given in tables C-1 and C-2.

(2) Dune maintenance. Annual dune maintenance includes fertilization of dune vegetation, occasional placement of sandfill, and shaping. A lump sum estimate for this work is included in the cost estimates given in tables C-2, C-3, and C-4, for the combined beach erosion and hurricane protection plans.

TABLE C-1
COST ESTIMATE - PLAN A

BEACH EROSION PROTECTION

FIRST COST				
Item	Quantity	Unit	Unit cost	Cost
			$	$
PREAUTHORIZATION CONSTRUCTION BY NON-FEDERAL INTERESTS:				
Jetty				
Riprap	30,700	ton	11.50	353,000
Shell	7,100	cu.yd.	7.00	50,000
Filter Cloth	197,300	sq.ft.	0.19	37,000
Sandfill	~~640,000~~ 1,000,000	cu.yd.	0.93	595,000
Subtotal				1,035,000
Engineering and design (± 6%)				62,000
Supervision and administration (± 8%)				83,000
Total - preauthorization construction				1,180,000[1]
POST-AUTHORIZATION CONSTRUCTION:				
Mobilization and Demobilization	L.S.	--	--	350,000
Sandfill				
Center portions	147,000	cu.yd.	3.65	537,000
East & West portions	343,000	cu.yd.	2.10	720,000
Subtotal	490,000			1,607,000
Contingencies (± 25%)				402,000
Subtotal			X 1.4	2,009,000
Engineering and design (± 6%)			696,000	120,000
Supervision and administration (± 8%)				161,000
Total - post-authorization construction				2,290,000
SUMMARY OF FIRST COSTS:				
Preauthorization construction				1,180,000
Post-authorization construction				2,290,000
Total first cost				3,470,000[2]

ANNUAL COSTS	
INTEREST AND AMORTIZATION:	
First cost	3,470,000
Amortization factor	.07132[3]
Interest and amortization	247,000

TABLE C-1 (Continued)

Item	Quantity	Unit	Unit cost $	Cost $
INITIAL BEACH NOURISHMENT (for 2nd year only)				
Mobilization and Demobilization	L.S.	--	--	350,000
Sandfill				
East & West portions	98,000	cu.yd.	2.10	206,000
Center portion	42,000	cu.yd.	3.65	153,000
Subtotal				709,000
Contingencies (± 25%)				177,000
Subtotal				886,000
Engineering and Design (± 6%)				53,000
Supervision and administration (± 8%)				71,000
Total cost of initial nourishment				1,010,000
Present worth of initial nourishment cost $1,010,000 brought back 2 years = $1,010,000 (0.87548) =				884,000
PERIODIC BEACH NOURISHMENT (4-year intervals beginning after initial nourishment)				
Mobilization and Demobilization	L.S.	--	--	350,000
Sandfill				
East & West portions	196,000	cu.yd.	2.10	412,000
Center portion	84,000	cu.yd.	3.65	307,000
Subtotal				1,069,000
Contingencies (± 25%)				267,000
Subtotal				1,336,000
Engineering and Design (± 6%)				80,000
Supervision and administration (± 8%)				107,000
Total cost of one periodic nourishment				1,523,000
Present worths of periodic nourishment cost $1,523,000 brought back at years 6, 10, 14, . . . 46 = $1,523,000 (2.71932) =				4,142,000
Total of present worths				5,026,000
Amortization factor				0.07132
Annual cost of initial and periodic nourishment				358,000
SUMMARY OF ANNUAL COSTS:				
Interest and Amortization				247,000
Initial and periodic nourishment				358,000
Jetty maintenance				3,000
Total annual costs				608,000

[1]Does not include cost of aids to navigation; actual cost of preauthorization construction was $1 million excluding engineering and design.
[2]Does not include $105,000 preauthorization study costs.
[3]Amortization over 50-year period at 6 7/8%.

TABLE C-2
COST ESTIMATE - PLAN B

COMBINED BEACH EROSION AND HURRICANE PROTECTION
(dune elevation at 11.5 feet, m.s.l.)

FIRST COST

Item	Quantity	Unit	Unit cost	Cost
			$	$
PREAUTHORIZATION CONSTRUCTION BY NON-FEDERAL INTERESTS:				
Jetty				
Riprap	30,700	ton	11.50	353,000
Shell	7,100	cu.yd.	7.00	50,000
Filter Cloth	197,300	sq.ft.	0.19	37,000
Sandfill	640,000	cy.yd.	0.93	595,000
Subtotal				1,035,000
Engineering and design (± 6%)				62,000
Supervision and administration (± 8%)				83,000
Total - preauthorization construction				1,180,000[1]
POST-AUTHORIZATION CONSTRUCTION:				
Mobilization and Demobilization	L.S.	--	--	350,000
Retention dike	37,000	l.f.	5.00	185,000
Sandfill				
Western portion	660,000	cu.yd.	2.10	1,386,000
Center portion	450,000	cu.yd.	3.65	1,642,000
Eastern portion	380,000	cu.yd.	2.10	798,000
Shaping	400,000	cu.yd.	1.00	400,000
Dune Vegetation				
Fertilizing & Seeding	155	ac.	550.00	85,000
Asphalt Emulsion	155	ac.	350.00	54,000
Subtotal				4,900,000
Contingencies (± 25%)				1,226,000
Subtotal				6,126,000
Engineering and design (±6%)				368,000
Supervision and administration (±8%)				486,000
Total - post authorization construction				6,980,000

TABLE C-2 (Continued)

Item	Quantity	Unit	Unit cost $	Cost $
RIGHTS-OF-WAY[2]				
Lands and Improvements				1,860,000
Severance				20,000
Contingencies (± 25%)				515,000
Resettlement (P.L. 91-646)				15,000
Acquisition Cost (275 Tracts)				
Acquisition by Others	275	tract	800	220,000
Hired Labor	275	tract	400	110,000
Total - Rights-of-way				2,740,000
SUMMARY OF FIRST COSTS:				
Preauthoriztion Construction				1,180,000
Post-authorization Construction				6,980,000
Rights-of-way				2,740,000
Total first cost				10,900,000[3]

ANNUAL COSTS				
INTEREST AND AMORTIZATION:				
First Cost				10,900,000
Amortization factor				.07132[4]
Interest and amortization				777,000
INITIAL BEACH NOURISHMENT (for 2nd year only)				
Mobilization and Demobilization	L.S.	--	--	350,000
Sandfill				
East & West portions	140,000	cu.yd.	2.10	294,000
Center portion	60,000	cu.yd.	3.65	219,000
Subtotal				863,000
Contingencies (± 25%)				217,000
Subtotal				1,080,000
Engineering and design (± 6%)				65,000
Supervision and administration (± 8%)				85,000
Total cost of initial nourishment				1,230,000
Present worth of periodic nourishment cost $1,230,000 brought back 2 years = $1,230,000 (0.87548) =				1,077,000

TABLE C-2 (Continued)

Item	Quantity	Unit	Unit cost	Cost
			$	$
PERIODIC BEACH NOURISHMENT (4-year internals beginning after initial nourishment):				
Mobilization and Demobilization	L.S.	--	--	350,000
Sandfill				
East & West portions	280,000	cu.yd.	2.10	588,000
Center portion	120,000	cu.yd.	3.65	438,000
Subtotal				1,376,000
Contingencies (± 25%)				344,000
Subtotal				1,720,000
Engineering and design (± 6%)				103,000
Supervision and administration (± 8%)				138,000
Total cost of one periodic nourishment				1,961,000
Present worths of periodic nourishment cost $1,961,000 brought back at years 6, 10, 14, . . . 46 = $1,961,000 (2.71932) =				5,333,000
+ .87548				
Total of present worths				6,410,000
Amortization factor				.07132
Annual cost of initial and periodic nourishment				457,000
DUNE MAINTENANCE:				
Annual maintneance such as fertilization and minor replacement (3 times per year @ $25/acre)	155	a.c.	75.00	12,000
SUMMARY OF ANNUAL COSTS:				
Interest and Amortization				777,000
Initial and Periodic Beach Nourishment				457,000
Jetty[5] and Dune Maintenance				15,000
Total annual costs				1,249,000

[1]Does not include cost of aids to navigation; actual cost of preauthorization construction was $1 million excluding engineering and design.
[2]Unit costs for perpetual and construction easements are based on 75% and 20% of the fee value of the land, respectively.
[3]Does not include $105,000 preauthorization study costs.
[4]Amortization over 50-year period at 6 7/8%.
[5]Jetty maintenance is the same as for Plan A.

TABLE C-3
COST ESTIMATE - PLAN C

COMBINED BEACH EROSION AND HURRICANE PROTECTION
(dune elevation at 13.0 feet, m.s.l.)

FIRST COST				
Item	Quantity	Unit	Unit cost $	Cost $
PREAUTHORIZATION CONSTRUCTION BY NON-FEDERAL INTERESTS:				
Jetty				
Riprap	30,700	ton	11.50	353,000
Shell	7,100	cu.yd.	7.00	50,000
Filter Cloth	197,300	s.f.	0.19	37,000
Sandfill	640,000	cu.yd.	0.93	595,000
Subtotal				1,035,000
Engineering and design (± 6%)				62,000
Supervision and administration (± 8%)				83,000
Total - preauthorization construction				1,180,000[1]
POST-AUTHORIZATION CONSTRUCTION:				
Mobilization and Demobilization	L.S.	--	--	350,000
Retention dike	37,000	l.f.	5.00	185,000
Sandfill				
Western portion	850,000	cu.yd.	2.10	1,785,000
Center portion	580,000	cu.yd.	3.65	2,117,000
Eastern portion	490,000	cu.yd.	2.10	1,029,000
Shaping	480,000	cu.yd.	1.00	480,000
Dune Vegetation				
Fertilizing & Seeding	175	ac.	550.00	96,000
Asphalt Emulsion	175	ac.	350.00	61,000
Subtotal				6,103,000
Contingencies (± 25%)				1,526,000
Subtotal				7,629,000
Engineering and design (± 6%)				448,000
Supervision and administration (± 8%)				603,000
Total - post-authorization construction				8,680,000

TABLE C-3 (Continued)

FIRST COST				
Item	Quantity	Unit	Unit cost	Cost
			$	$
RIGHTS-OF-WAY[2]				
Lands and Improvements				1,860,000
Severance				20,000
Contingencies (± 25%)				515,000
Resettlement (P.L. 91-646)				15,000
Acquisition Cost (275 Tracts)				
Acquisition by Others	275	tract	800	220,000
Hired Labor	275	tract	400	110,000
Total - Rights-of-way				2,740,000
SUMMARY OF FIRST COSTS:				
Preauthorization Construction				1,180,000
Post-authorization Construction				8,680,000
Rights-of-way				2,740,000
Total first cost				12,600,000[3]
ANNUAL COSTS				
INTEREST AND AMORTIZATION:				
First Cost				12,600,000
Amortization factor				.07132[4]
Interest and amortization				899,000
INITIAL AND PERIODIC BEACH NOURISHMENT:				457,000[5]
DUNE MAINTENANCE:				
Annual maintenance such as fertilization and minor replacement (3 times per year @ $25/acre)	175	a.c.	75	13,000
SUMMARY OF ANNUAL COSTS:				
Interest and Amortization				899,000
Initial and Periodic Beach Nourishment				457,000
Jetty[6] and Dune Maintenance				16,000
Total annual costs				1,372,000

[1]Does not include cost of aids to navigation; actual cost of preauthorization construction was $1 million excluding engineering and design.
[2]Unit costs for perpetual and construction easements are based on 75% and 20% of the fee value of the land, respectively.
[3]Does not include $105,000 preauthorization study costs.
[4]Amortization over 50-year period at 6 7/8%.
[5]Initial and periodic nourishment is the same as in Plan B. Computation of annual cost is given in table C-2.
[6]Jetty maintenance is the same as for Plan A.

TABLE C-4
COST ESTIMATE - PLAN D

COMBINED BEACH EROSION AND HURRICANE PROTECTION
(dune elevation at 15.0 feet, m.s.l.)

FIRST COST

Item	Quantity	Unit	Unit cost	Cost
			$	$
PREAUTHORIZATION CONSTRUCTION BY NON-FEDERAL INTERESTS:				
Jetty				
Riprap	30,700	ton	11.50	353,000
Shell	7,100	cu.yd.	7.00	50,000
Filter Cloth	197,300	sq.ft.	0.19	37,000
Sandfill	640,000	cu.yd.	0.93	595,000
Subtotal				1,035,000
Engineering and design (± 6%)				62,000
Supervision and Administration (± 8%)				83,000
Total - preauthorization construction				1,180,000[1]
POST-AUTHORIZATION CONSTRUCTION:				
Mobilization and Demobilization	L.S.	--	--	350,000
Retention dike	37,000	l.f.	5.00	185,000
Sandfill				
Western portion	1,010,000	cu.yd.	2.10	2,121,000
Center portion	690,000	cu.yd.	3.65	2,518,000
Eastern portion	580,000	cu.yd.	2.10	1,218,000
Shaping	570,000	cu.yd.	1.00	570,000
Dune Vegetation				
Fertilizing & Seeding	190	ac.	550.00	104,000
Asphalt Emulsion	190	ac.	350.00	66,000
Subtotal				7,132,000
Contingencies (± 25%)				1,785,000
Subtotal				8,917,000
Engineering and design (± 6%)				547,000
Supervision and administration (± 8%)				716,000
Total - post=authorization construction				10,180,000

TABLE C-4 (Continued)

Item	Quantity	Unit	Unit cost $	Cost $
RIGHTS-OF-WAY[2]				
Lands and Improvements				1,860,000
Severance				20,000
Contingencies (± 25%)				515,000
Resettlement (P.L. 91-646)				15,000
Acquisition Cost (275 Tracts)				
Acquisition by Others	275	tract	800	220,000
Hired Labor	275	tract	400	110,000
Total - rights-of-way				2,740,000
SUMMARY OF FIRST COSTS:				
Preauthorization construction				1,180,000
Post-authorization construction				10,180,000
Rights-of-way				2,740,000
Total first cost				14,100,000[3]
ANNUAL COSTS				
INTEREST AND AMORTIZATION:				
First Cost				14,100,000
Amortization factor				.07132[4]
Interest and amortization				1,006,000
INITIAL AND PERIODIC BEACH NOURISHMENT:				457,000[5]
DUNE MAINTENANCE:				
Annual maintenance such as fertilization and minor replacement (3 times per year @ $25/acre)	190	a.c.	75.00	14,000
SUMMARY OF ANNUAL COSTS:				
Interest and Amortization				1,006,000
Initial and Periodic Beach Nourishment				457,000
Jetty[6] and Dune Maintenance				17,000
Total annual costs				1,480,000

[1]Does not include cost of aids to navigation; actual cost of preauthorization construction was $1 million excluding engineering and design.
[2]Unit costs for perpetual and construction easements are based on 75% and 20% of the fee value of the land, respectively.
[3]Does not include $105,000 preauthorization study costs.
[4]Amortization over 50-year period at 6 7/8%.
[5]Initial and periodic nourishment is the same as in Plan B. Computation of annual cost is given in table C-2.
[6]Jetty maintenance is the same as for Plan A.

APPENDIX D

Benefit Analysis

GRAND ISLE AND VICINITY, LOUISIANA
PHASE I GENERAL DESIGN MEMORANDUM

APPENDIX D
BENEFIT ANALYSIS

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APPENDIX D
BENEFIT ANALYSIS

1. DESCRIPTION OF PROJECT AREA

Grand Isle is located along the Gulf of Mexico in Jefferson Parish, Louisiana, approximately 50 miles due south of the City of New Orleans. It is one of the many low, irregular islands separated by bays, lagoons, and bayous which form a part of the Louisiana gulf shoreline. Extending some 7.5 miles in a generally northeast to southwest direction, Grand Isle is only about 0.75 miles in width at the center. The entire island is low, having a maximum elevation of about 8 feet above mean sea level (m.s.l.)[1] along the existing dune and a natural ground elevation varying from 5 feet to slightly above sea level. The only land access from the mainland is by means of Louisiana Highway 1 which crosses Caminada Pass at the western end of the island.

2. ECONOMIC DEVELOPMENT IN THE PROJECT AREA

Grand Isle is a base of operations for large offshore petroleum and sulphur industries and is a commercial fishing and sport fishing center. It is also an important recreational area for residents of Louisiana and nearby states. Of the 2,340 acres on the island, there are 682 acres devoted to residential and commercial development, 247 acres in industrial usage, and 231 acres in Government and public lands. This latter acreage includes 126 acres of state-owned beach designated as a state park. The remaining 1,180 acres on the island are as yet undeveloped.

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[1] Unless otherwise specified, all elevations herein are in feet referred to mean sea level datum.

Table D-1 shows the estimated improvement values on the island by categories as obtained in a 1970 field survey (updated in 1978).

TABLE D-1
VALUE OF IMPROVEMENTS (1978)
Grand Isle and Vicinity, Louisiana

Item	No.	Buildings	Contents	Total
		$	$	$
Residential--1 story	824	17,294,000	8,647,000	25,941,000
" 2 story	117	3,422,000	1,678,000	5,100,000
Mobile homes	355	2,880,000	1,440,000	4,320,000
Public		470,000	94,000	564,000
Commercial		3,557,000	1,778,000	5,335,000
Industrial				38,684,000
Coast Guard				6,825,000
Other				439,000
				87,208,000

3. DESCRIPTION OF WATER RESOURCES PROBLEMS IN THE PROJECT AREA

Damage and destruction are occurring on Grand Isle due to beach erosion and hurricane tidal overflows. An elaboration on these two types of damages follows.

a. Hurricanes

(1) Grand Isle is subject to severe damage from hurricane tides as it lies fully exposed fronting on the Gulf of Mexico and is surrounded on other sides by large water bodies. Advancing tropical storms push gulf water inland and, in so doing, inundate the improvements on the island. Large waves driven by the hurricane winds strike the flooded improvements wreaking widespread devastation. The force of these waves is a significant cause of damage on the island.

(2) All storms passing within an effective distance of Grand Isle drive massive volumes of gulf water over and/or around the island into the bay areas to the north. These hurricane-generated tidal movements are accompanied by gulf wave action. As the wind direction in which hurricanes turn in the northern hemisphere is a counter-clockwise one, storms which move inland to the east of the island create, during part of their passage, high tides and wave action in the bays. In these cases, floodwaters with accompanying bay wave action are driven back over the island into the gulf. Conversely, storms which pass to the west of the island have the effect of causing high tides and wave action to approach the island from the Gulf of Mexico side only. There is no historical evidence to suggest that hurricanes will travel more frequently to either the east or west side of the island; therefore, it can be reasonably assumed that an equal number will pass in either direction. Because of the shallower depths and the existence of numerous small islands that break up their force, waves striking the island from the bay side are of much smaller magnitude and lesser energy levels than gulf waves resulting from hurricanes of corresponding intensities. Consequently, the bay waves are by comparison considerably less destructive.

(3) The passage of Hurricane Flossy (September 1956) was to the south and east of Grand Isle causing its complete inundation. The floodwaters were driven from the interior bays in a southerly direction over the top of the island and into the Gulf of Mexico. Maximum stages experienced during this storm were about 8 feet. Flood damages were sustained by nearly 400 homes, camps, businesses, schools, and churches; total flood losses were estimated to be $1,750,000 (1956 price levels).

(4) In September 1965 the eye of Hurricane Betsy passed slightly to the west of Grand Isle placing the island directly in the path of very severe winds and tidal overflow originating from the gulf. Stages of approximately 9 feet covered the area causing flood damages estimated at $11,500,000 (1965 price levels). The combined effects of wind and tide destroyed approximately 85 percent of the improvements on the island excluding industrial development.

b. Erosion

(1) Erosion of the gulf shoreline, a serious problem on Grand Isle, is constantly in process and is most severe on the western end of the island. The sand beach is a particularly attractive recreational feature that offers an open view of the gulf in addition to other esthetic considerations. The most developed portion of the island lies adjacent to the beach area.

(2) Historical data on erosion rates at Grand Isle, by range, are shown in appendix B, table B-9. These rates were used as a basis for projecting the area to be eroded during the project life.

(3) Erosion of the island causes the loss of valuable and scenic beach front, and damages to homes, business establishments, Louisiana Highway 1, and other public improvements. Continued uncontrolled erosion also causes losses associated with the relocation and/or abandonment of existing facilities.

(4) Construction of a rock jetty on the eastern end of the island has halted erosion in that area. The jetty has trapped materials suspended in the eastward littoral current; as a result, considerable accretion of land, rather than decrement, has taken place.

4. PROJECTED GROWTH RATES

Numerous factors bear on the projected economic growth for the island. These factors are enumerated below and are largely based on information gained through numerous field interviews with businessmen, local officials, and residents at the project location.

a. The population of Grand Isle increased from 1,190 in 1950 to 2,074 in 1960 and to 2,236 in 1970. Thus, experienced growth rates were 5.7 percent annually for the period 1950 to 1960 and 0.75 percent annually during the last decade. The reduction in the overall growth rate for the second 10-year period was due to the widespread damage wrought by Hurricane Betsy in 1965, during which some 85 percent of the total developments other than industrial were destroyed. Immediately following Betsy, it is estimated that the population was reduced to about 500 people. However, redevelopment of the island was rapid following Hurricane Betsy. Just prior to that storm, the total value of all improvements on Grand Isle was approximately $33 million. Immediately after Betsy this figure was reduced to about $21 million. The estimated value of such improvements in 1978, as developed by the surveys for this report, was some $87 million, as is shown in table D-1. This phenomenal recovery in the development of the area following a disaster is indicative of its tremendous growth potential.

b. The size of the oil company installations on the island will remain essentially constant in the future, as indicated by the representatives of companies with supportive facilities located at Grand Isle. Technology is forthcoming which will facilitate exploration and mining of fields located in very deep water off the Louisiana coast. Large stores of crude oil are available which are as yet untapped, and a higher rate of recovery of known stores of these valuable minerals will ensue with the advanced technology. However, it is anticipated that the Louisiana Superport will be located in the Gulf of Mexico south of Grand Isle. Although the construction of the port facilities may have an immediate impact on the economy of the island, the impact should be short-lived as the labor requirements for construction should terminate some 3 to 5 years after construction begins. Thereafter, the effects on Grand Isle will be negligible as the port, once construction has been completed, will not be a labor-intensive facility.

c. Grand Isle offers one of the few viable gulf beaches located in the State of Louisiana, and provides opportunities for excellent fishing and boating. New, improved facilities were constructed on the island in the wake of Hurricane Betsy, offering a much better environment for summer visitors. In the face of the large demand for such facilities in the market areas, the recreation-oriented economic activity on the island is expected to sustain continued growth.

d. The improvement of the beach front will attract, as it has in the past, permanent residents who will supply the facilities, goods, and services which the visitors require. Thus, a direct relationship will exist between the increase in population and the amount of investment required in physical plant for these purposes.

e. The very rapid growth in population accompanying the recovery from Betsy leveled off during the early to middle 1970's. It is conservatively estimated that the overall growth rate for the period 1970 to 1980 will approximate that for the period 1950 to 1960. This rate will yield a population of about 3,900 persons in 1980. Subsequently, growth rates will further decline as the base for growth expands and the area available for growth is depleted. By 2010 it is estimated that the population growth rate for Grand Isle will approximate that projected by BEA for Water Resources Subarea 0809 (WRSA 0809). The anticipated population growth for Grand Isle is shown in table D-2.

TABLE D-2
POPULATION PROJECTIONS DATA
Grand Isle and Vicinity, Louisiana

Years	Annual growth rate	Growth factor	Projected population
1970			2,236[1]
1980	5 3/4	1.74	3,900
1990	4 1/2	1.56	6,100
2000	3 1/4	1.38	8,400
2010	2 3/16	1.25	10,500
2020	1	1.10	11,500
2030	1	1.10	12,600

[1] 1970 Census data

5. EXTENT AND SCOPE OF PROPOSED PROJECT

a. The proposed project (plan B) consisting of a widened beach and sand dune along the gulf side of the island, as shown on plates 2, 3, and 4 will largely eliminate the damages resulting from beach erosion as well as greatly lessen the damages attendant to hurricane tidal overflows. Flooding will still occur from rising water accompanying hurricanes, but the damage from wave action originating on the gulf side of the island will be greatly mitigated. The Town of Grand Isle has local ordinances which require residential-type structures to be built on pilings with floor levels at least 8 feet above ground level, thus further reducing future prospective flood damges from hurricanes both with and without the proposed project in place. Additionally, existing Flood Insurance Administration (FIA) regulations require as a minimum that all first floor elevations of buildings be built to the 100-year flood elevation or approximately 9.3 feet m.s.l.

b. Four plans of improvement were analyzed during the detailed study. They are Plan A - beach erosion protection, Plan B - combined beach erosion and hurricane protection (dune elevation--11.5 feet), Plan C - combined beach erosion and hurricane protection (dune elevation--13.0 feet), and Plan D - combined beach erosion and hurricane protection (dune elevation--15.0 feet). Plan A provides protection from erosion only, whereas plans B, C, and D provide erosion protection plus protection from gulf-wave damage caused by hurricanes having return frequencies of approximately once in 50 years, once in 100 years, and once in 200 years, respectively.

6. BENEFITS

a. General. The base year for this economic evaluation is 1980. Since the project life has been determined to be 50 years, benefits were evaluated for the period 1980-2030 using the current 6 7/8 percent interest rate. Benefits are discussed in the following paragraphs and are categorized by type: erosion prevention, inundation reduction, intensification, recreation, and area redevelopment. A summary of benefits is given in table D-10.

b. Beach erosion prevention benefits

(1) Damages which will occur without project as a

result of beach erosion were classified generally as residential, commercial, public, highways, utilities, and land.

(2) Based on the erosion rates shown in table B-9, projections of advancing erosion were made for the period of project life (1980-2030) and the area to be eroded was determined. The existing improvements in the area to be eroded, as shown in table D-3, were determined by detailed field surveys made in the year 1970 and updated in 1978. Portions of the area are substantially developed and property investment has grown rapidly. In addition to the camps, there are many trailer homes as well as a few commercial establishments. Main line utilities which service the island also are located in the erosion area; Louisiana Highway 1 extends the full length of the island from the bridge over Caminada Pass on the western end to the coast guard station on the eastern boundary. Trunk line utilities for electricity, water, gas, and telephone service are located in the highway rights-of-way. All services, except electric, are located below ground level.

(3) Through contacts with public officials, local builders, other businessmen, and residents, it was determined that the majority of the buildings and residences would be moved rather than abandoned as they became endangered by erosion. Accordingly, losses associated with the first eight categories listed in table D-3 involved the cost of moving the buildings and improvements plus the loss of piling, septic tanks, etc., which would not be salvaged. Data concerning these dollar losses were obtained through interviews with representatives of companies which specialize in moving buildings on Grand Isle. Information relating to the location of utilities in the affected area was obtained by interviews with the personnel of the Louisiana Power and Light Company,

the Lafourche Telephone Company, and the officials of the town of Grand Isle who administer the water and gas services. The future expansion that will take place in the erosion area during the life of the project, allowing for the anticipated erosion, was determined by projecting all existing development other than highways and utilities in accordance with the population growth rates shown in table D-2. Growth for both the utilities and the highways within the area to be eroded was projected at rates equaling half of those shown in table D-2.

TABLE D-3
1978 DEVELOPMENT SUBJECT TO EROSION DAMAGE BY YEAR 2030
Grand Isle and Vicinity, Louisiana

Category	Quantity	Unit
Camps	229	each
Trailers	89	"
Motels	9	"
Library	1	"
Restaurants	5	"
Post Office	1	"
Grocery store	5	"
Parking lot	1	"
Road	4.1	miles
Main and lateral gas lines	8.7	"
Main and lateral water lines	8.7	"
Powerlines and poles	8.4	"
Telephone lines	6.3	"
Land	338	acres

(4) Inasmuch as future development is anticipated for an area that is reducing in size, the length of the period in which growth will take place in any specific area depends on its location within the erosion area. Furthermore, it follows that those specific areas located closer to the beach front will have less time in which future development will take place. For this reason, the analysis of erosion damages was facilitated by dividing the

overall erosion area into 50 subareas or strips. A period of time was assigned during which each of the subareas would be subject to future development and that growth was restricted accordingly. Similarly, each subarea was assigned a time frame in which it would be eroded. Damages were then determined for each of the subareas by bringing back to present value the total development in the subarea when erosion took place and amortizing this value over the life of the project (50 years).

(5) To arrive at the average annual damage without the project, the total costs over the life of the proposed project, incurred as a result of erosion, were determined and reduced to an average annual value. This was accomplished by computing the costs associated with the development summarized in table D-3 and adding to this total the costs associated with future development, projected in accordance with the growth rates previously presented. In the case of utilities and highway losses, the projected growth rates were one-half the previously indicated population growth rates. Future growths of these facilities will generally be in the form of feeder and lateral utility lines to new buildings expected to be built in the area. Although new main lines to supply increased capacity will be necessary in the future, these are being planned for the north side of the island and thus lie beyond the area subject to erosion during the project life.

(6) The costs associated with the relocation of a typical camp and of a small commercial establishment are shown in the following tabulations:

Economic losses associated with camp relocations

Cost of moving and setting on new piling	$8,200
Loss of old piling	585
Loss of septic tank and drain field	975
Loss of walkways	390
Loss of gravel driveways	59
	$10,209
Rounded	($10,200)

Economic losses associated with relocations of restaurants and grocery stores

Cost of moving and setting on new piling	$18,720
Cost to move and set up equipment	3,900
Loss of old piling	780
Loss of septic tank and drain field	1,170
Loss of walkways	95
Loss of parking lot	585
	$25,250

(7) The costs associated with the prevention of loss by the relocation of residential, commercial, and public structures situated in the erosion area (table D-3) are tabulated below:

Category	Quantity	Relocation costs (1978)
Camps	229	$2,336,000
Trailers	89	174,000
Motels	9	291,000
Library	1	32,000
Restaurants	5	126,000
Post Office	1	21,000
Parking lot	1	6,000
Grocery store	5	126,000
Total		$3,112,000

(a) Projecting the relocation costs of $3,112,000 for 1978 conditions was accomplished by use of the growth factor shown in table D-2. Relocation costs (1980 conditions) = $3,112,000 x 1.1183 = $3,480,000. Assuming equal distribution of this development throughout the 50 strips comprising the total erosion area (see paragraph 6b (4) above), the average cost per strip, with conditions of 1980 base year development, equals $3,480,000 divided by 50 equals $69,600.

(b) Computation of the average annual erosion losses to residential, commercial, and public structures, over the project life period of 1980 to 2030, are shown in table D-4.

(8) The costs associated with the two major relocations of Louisiana State Highway 1 and the utilities adjacent thereto (table D-3) are shown in the following tabulation:

Category	1995 Relocation Quantity	1995 Relocation Cost	2010 Relocation Quantity	2010 Relocation Cost
	miles	$	miles	$
Road	1.7	282,000	2.4	398,000
Main & lateral gas lines	3.4	75,000	5.3	119,000
Main & lateral water lines	3.4	182,000	5.3	472,000
Powerlines & poles	3.5	69,000	4.9	96,000
Telephone lines	2.3	154,000	4.0	276,000
Total		762,000		1,361,000

(a) Projecting the relocation costs (1970 conditions, 1978 price levels) to reflect anticipated growth to the years in which the major relocations would occur was accomplished by the use of growth factors based on one-half of the annual growth rates shown in table D-2.

Item	Growth Factors 1970-80	1980-90	1990-95	1970-95	Costs 1970	1995
1995 setback	1.3277	1.2492	1.0873	1.8034	$762,000*	$1,374,000
				1970-2010	1970	2010
2010 setback		(not shown)		2.1860	$1,361,000	$2,975,000

*1970 Conditions, 1978 Price Levels

TABLE D-4
COMPUTATION OF AVERAGE ANNUAL EROSION DAMAGES TO
RESIDENTIAL, COMMERCIAL, AND PUBLIC STRUCTURES (1980-2030)
Grand Isle and Vicinity, Louisiana

End of year when eroded	Strip No.	Cost of relocations 1980	Growth rate	Years of growth	Growth factor	Cost of relocations when eroded	Present value factor	Present value
		$				$		$
1980	1	69,600	4.5	0	1.0000	69,600	1.0000	69,600
		.	.	.	.	.	.	.
		.	.	.	.	.	.	.
1989	10	69,600	4.5	9	1.4861	103,426	.5497	56,852
1990	11	69,600	3.25	10	1.534	106,906	.5143	54,913
		.	.	.	.	.	.	.
		.	.	.	.	.	.	.
1999	20	69,600	3.25	19	2.046	144,211	.2827	40,260
2000	21	69,600	2.1875	20	2.091	147,343	.2645	38,498
		.	.	.	.	.	.	.
		.	.	.	.	.	.	.
2009	30	69,600	2.1875	29	2.540	179,080	.1454	25,706
2010	31	69,600	1.0	30	2.566	180,821	.1361	24,299
		.	.	.	.	.	.	.
		.	.	.	.	.	.	.
2019	40	69,600	1.0	39	2.806	197,734	.0748	14,606
2020	41	69,600	1.0	40	2.834	199,752	.0700	13,803
		.	.	.	.	.	.	.
		.	.	.	.	.	.	.
2029	50	69,600	1.0	49	3.100	218,405	.0385	8,300
			Sum =					1,719,440
			Amortization factor					.07132
			Total average annual cost for relocation of structures					122,630
							Rounded	(123,000)
			Average annual cost for relocating existing structures				(1980)	70,000
			Average annual cost for relocating future structures					53,000

(b) Computations of the average annual damages, based on the present worth values of the relocations costs in the base year 1980, are as follow:

1995 setback	$1,374,000 x .36886 =	$506,814
2010 setback	$2,975,000 x .13606 =	404,779
Total present worth value		$911,593
Amortization factor		x .07132
Total average annual costs--highway and utilities relocations		$ 65,015
	Rounded	($ 65,000)

(c) The average annual costs for relocating the existing roads and utilities are computed in the following:

Setback	Costs*	Growth factors	(Base year) 1980 cost	Year eroded	Present value factor (6 7/8%)	Amortization factor	Average annual costs existing development
	$		$				$
First	762,000	1.3277	1,011,707	1995	.36886 (15 years)	.07132	26,615
Second	1,361,000	1.3277	1,807,000	2010	.13606 (30 years)	.07132	17,535
							44,150
						Rounded	(44,000)

*1970 Conditions, 1978 Price Levels

(d) The annual costs for relocating future road and utility improvements are $65,000 less $44,000, or $21,000.

(9) The computation of average annual damages resulting from the loss of land is shown below.

(a) Total value of land to be eroded:

Area to be eroded	Unit value	Total
233 acres	$35,000 per acre	$8,155,000
105 acres	21,000 per acre	2,205,000
338 acres		$10,360,000

(b) Average area of individual strips to be eroded:

338 acres divided by 50 strips equals 6.76 acres

(c) Assignment of dollar values to each of the 50 strips to be eroded and computation of present value of future erosions:

Strip numbers	Value per strip	Sum of present value factors	Total present value
1 through 23	$35,000 x 6.76 = $236,600	12.17684	$2,881,040
24 and 25	$21,000 x 6.76 = $141,960	.41946	59,547
26 through 50	$27,422 x 6.76 = $185,373	2.38969	442,984
			$3,383,571

(d) Computation of average annual land loss:

$3,383,571 x .07132 = $241,316
Rounded ($241,000)

(10) Construction of any of the three plans would eliminate losses resulting from erosion shown above. Erosion losses prevented are summarized in table D-5.

TABLE D-5
AVERAGE ANNUAL EROSION LOSSES PREVENTED
Grand Isle and Vicinity, Louisiana

Item	Existing development $	Future development $	Total $
Residential, commercial, and public structures	70,000	53,000	123,000
Roads and utilities	44,000	21,000	65,000
Land	241,000	-	241,000
Total	355,000	74,000	429,000

(11) The breakdown of public and private benefits is shown in the computations which follow:

PUBLIC

Item	Average annual benefits
Loss of land (68 acres)	$48,200[1]
Relocation of library and post office	2,500[2]
Relocation of highway (4.1 miles)	21,800[3]
Relocation of main & lateral water lines (8.7 miles)	18,600[4]
Total average annual public benefits	$91,100
Rounded	($91,000)

[1]West End Park	= 12 acres
Highway (4.1 mi. with 60-foot right-of-way)	= 30 "
Other roads (53 x 50 ft. x 400 ft.)	= 24 "
Other	= 2 "
	68 acres

Percent of total area eroded that is public = 68 acres divided by 338 acres equals 20 percent.
Loss of land = 20% x $241,000 = $48,200

[2]Cost for moving library and post office = $53,000 divided by $3,112,000 = 2%
Average annual loss = 2% x $123,000 = $2,500

(Footnotes 3 and 4 continued on page D-18).

[3] (1995)	$282,000 x 1.8034 x .36886 x .07132 =	$13,379
(2010)	$398,000 x 2.1860 x .13606 x .07132 =	8,443
		$21,822
	Rounded	($21,800)

[4] (1995)	$182,000 x 1.8034 x .36886 x .07132 =	$ 8,634
(2010)	$472,000 x 2.1860 x .13606 x .07132 =	10,012
		$18,646
	Rounded	($18,600)

PRIVATE

Private benefits consist of the following items which constitute 80 percent of the total erosion prevention benefits:

229	camps
89	trailers
9	motels
5	restaurants
5	grocery stores & parking lots
8.7	miles main and lateral gas lines
8.4	miles powerlines & poles
6.3	miles telephone lines
270	acres

Total shore protection benefits	$429,000
Less public benefits	91,000
Total average annual private benefits	$338,000

(a) A disaggregation of the erosion losses in the private and public sectors that will be prevented by the project is shown in table D-6.

TABLE D-6
AVERAGE ANNUAL EROSION LOSSES PREVENTED
IN PRIVATE AND PUBLIC SECTORS
Grand Isle and Vicinity, Louisiana

Item	Existing Development $	Future Development $	Total $
Public	78,000	13,000	91,000
Private	277,000	61,000	338,000
Total	355,000	74,000	429,000

c. Inundation reduction

(1) Inundation reduction benefits were reanalyzed in order to bring them into conformity with the more recent guidelines established in ER 1105-2-351 and to comply with the Water Resources Council's Principles and Standards. This necessitated that all inundation reduction benefits accruing to future structures would consider, as a minimum, floor elevations equal to the 100-year rising water flood elevation, approximately 9.3 feet m.s.l. The following paragraphs outline the bases for the determination of the benefits to be derived from flood damages prevented with project installation.

(2) Stage-frequency data. The stage-frequency relationship for Grand Isle is shown on plate D-1. The same curve is applicable for both "with" and "without" project conditions as the project will not materially alter the flood stages (rising water) occurring on the island.

(3) Stage-damage data. Stage-damage curves were developed, based on existing and future development, for various years within the project life (1980-2030). These curves (plates

D-2 through D-5) are shown for four conditions: (1) rising water only, (2) rising water and bay waves only, (3) rising water and all waves--without project, and (4) rising water and all waves--with plan B in place. Computations for all of these conditions were necessary so that the effects of bay waves (those originating from the bay areas on the backside of the island) and gulf waves (those formed on the gulf or front side) could be identified and evaluated separately. The intensity and damaging effects of gulf waves exceed by a substantial margin those caused by waves originating on the bay side. Thus, for storm occurrences in which damaging waves are generated from each direction, damages inflicted by the gulf waves are considered to be the limiting factor for establishing the overall losses due to both causes. The beneficial effects of the project insofar as preventing flood damages consist solely in the prevention of damages incident to high-intensity waves which originate on the gulf side of Grand Isle. Outlined in the following paragraphs are the basis for determining damages for each of the four flood conditions.

(a) Stage-damage curves for the condition of rising water only (plate D-2) were derived by use of depth-damage curves which were developed for use in several flood insurance studies that were prepared by the New Orleans District. These depth-damage curves indicate the percent damages that would occur to buildings and contents as related to flood depths over floors. Basic consideration included that the flooding would be by salt water and that attending low-flow velocities would create no serious scour conditions. Information on the depth-damage curves was combined with field survey data relating to numbers, types, values, and floor elevations of improvements to determine residential and commercial losses. Industrial damages, loss of business profits and salaries, damages to utilities, governmental and other facilities, costs of cleanup, and other miscellaneous costs were determined from field interviews, onsite appraisals, and available historical flood damage data.

(b) Stage-damage curves depicting the condition of rising water and bay waves only (plate D-3) were derived mainly from flood damages that occurred on Grand Isle during Hurricane Flossy (1956) as related to the then-existing developments. Supplementary flood damage data for losses that occurred during Hurricane Camille (1969) in the areas surrounding Lake Pontchartrain also were used in these determinations.

(c) Stage-damage relationships representing the conditions of rising water and all waves--without project (plate D-4) were based primarily on flood damages that occurred on Grand Isle during Hurricane Betsy (1965), as related to the then-existing developments. Supplementary flood damage data acquired following Hurricane Flossy (1956), Audry (1957), Carla (1961), Hilda (1964), and Camille (1969) along the Louisiana coast also were used where judgement aspects were involved.

(d) Construction of the proposed dune along the front side of the island will materially reduce the damaging effects of tidal waves originating from that direction. Stage-damage relationships for the condition of rising water and all waves with plan B in place (plate D-5) were developed from information contained in the curves discussed in paragraphs (a), (b), and (c), immediately above. By subtracting damages occurring for specific flood elevations for rising water only from damages caused by rising water and all waves--without project, losses resulting from gulf waves only--without project were determined. Hydraulic studies were made to determine the modified wave energy levels that would attend hurricanes of various intensities for with-project conditions (see plate D-6). The results of these investigations indicated that the reduction in wave damages will range from a high of 100 percent at a stage of about 8.5 feet (frequency of about 50 years) to 0 percent at a stage of 14.0 feet. Thus, at the latter stage and at higher ones, the project will become ineffective for the reduction of flood damages. Stage-damage relationships for with project conditions were then constructed by the following:

1. Computing bay waves only damage. This was accomplished by substracting rising water only damages from rising water and bay waves only damages for appropriate flood elevations.

2. Adding 50 percent of the bay waves only damages determined in 1 above to rising water only damages because bay waves occur with only one-half of the hurricane occurrences. This would represent the conditions that would exist if all gulf wave damages were prevented.

3. Determining gulf waves only damages for without-project conditions by subtracting rising water only damages from those damages occurring with rising water all waves--without project. As is discussed in paragraph 6.c.(3) above, gulf waves are considered to be the limiting factor for establishing overall wave losses.

4. Computing residual gulf waves only damages for with-project conditions (applying residual damage factors discussed in (d) above to gulf waves only damages determined in 3 above).

5. Adding residual gulf waves only damages (those in excess of the bay waves only damages) to the losses computed in 2 above. This represents the condition of all residual losses with the project in place.

(4) Damage frequency data. Integration of the stage-damage relationships for the four conditions (plates D-2 through D-5) with the stage-frequency curve (plate D-1) provided the basis for constructing the damage-probability curves (plates D-7 through D-10). The areas inclosed under these curves represent the average annual damages for each of the conditions described above.

(5) Annual flood damages. From the determination in paragraph (4) above, the average annual damages for each of the four conditions were computed over the period 1980-2030. A sample calculation follows for damages attributable to rising water and all waves--without-project condition. Computations for losses for the remaining conditions--rising water only, rising water and bay waves, and rising water and all waves--with project--were made in the same manner.

COMPUTATION OF AVERAGE ANNUAL DAMAGES
RISING WATER AND ALL WAVES--WITHOUT PROJECT
(6 7/8%)

(1)	Constant	$2,264,000
(2)	$\frac{2{,}396{,}000-\$2{,}264{,}000}{10 \text{ yrs.}}$ 35.00736 x .07132	32,957
(3)	2,396,000-2,264,000 x 13.52761 x .51433 x .07132 =	65,501
(4)	$\frac{2{,}516{,}000-2{,}396{,}000}{10 \text{ yrs.}}$ x 35.00736 x .51433 x .07132 =	15,410
(5)	2,516,000-2,396,000 x 12.56647 x .26453 x .07132 =	28,450

(6) $\frac{2,606,000-2,516,000}{10 \text{ yrs.}}$ x 35.00736 x .26453 x .07132 = 5,944

(7) 2,606,000-2,516,000 x 10.69772 x .13606 x .07132 = 9,343

(8) $\frac{2,648,000-2,606,000}{10 \text{ yrs.}}$ x 35.00736 x .13606 x .07132 = 1,427

(9) 2,648,000-2,606,000 x 7.06434 x .06998 x .07132 = 1,481

(10) $\frac{2,693,000-2,648,000}{10 \text{ yrs.}}$ x 35.00736 x .06998 x .07132 = 786

$2,425,299

Rounded ($2,425,000)

(6) Flood-damage summation. A tabulation of the average annual flood damages estimated to occur over the project life for with- and without-project conditions is shown in table D-7. As is explained in paragraph 6.c.(3) on page D-23, the only flood damages that will be prevented by the project are those resulting from high intensity, gulf waves.

TABLE D-7
AVERAGE ANNUAL FLOOD DAMAGES SUMMATION
Grand Isle and Vicinity, La.

Condition	Damages: Present development ($)	Damages: Future development ($)	Total ($)
Without Project:			
Rising water only	1,118,000	86,000	1,204,000
Rising water & bay waves	1,607,000	114,000	1,721,000
Rising water & all waves	2,264,000	161,000	2,425,000
With Project (Plan B):			
Rising water & all waves	1,408,000	100,000	1,508,000

(7) Computation of inundation reduction benefits-Plan B. Flood damages to be prevented by the project (plan B) consist solely of those resulting from the elimination of hurricane-

driven waves that are generated on the gulf side of the island. The procedures used in making this determination are shown below.

Average annual damage, rising water and all waves--without project		$2,425,000
Less average annual damage, rising water and all waves--with project		-1,508,000
Average annual benefits due to prevention of gulf wave damage		$ 917,000
Less damage due to bay waves:		
Average annual damage rising water & bay waves	$1,721,000	
Less average annual damage, rising water only	-1,204,000	
Average annual damage due to bay waves (100% occurrence)	$ 517,000	
Less average annual damage due to bay waves (50% actual expected occurrence)*		$ -258,500
Net average annual flood damage prevented on existing and future development		$ 658,500
Net average annual flood damage prevented on existing development		$ 611,000
Net average annual flood damage prevented on future development		$ 47,500
	Rounded	(48,000)

*Only those hurricanes with tracks south and east of Grand Isle cause damage from bay waves. Such hurricanes constitute 50 percent of the expected total occurrences.

(8) Computation of inundation reduction benefits-plans C and D. Flood damages that would be prevented if plans C or D were constructed were determined using the same rationale as

that used in the above plan B. With plan C in place residual flood damages would be $1,541,000 annually and hurricane-wave damages prevented would amount to $884,000 annually, whereas with plan D in place, the corresponding figures would be $1,525,000 and $900,000 annually.

d. Intensification

(1) For approximately 1.5 million residents of southeast Louisiana and for other thousands of recreationists who enjoy surf bathing, surf fishing, and gulf side sand beaches with an unrestricted view of the open waters of the Gulf of Mexico, only the Grand Isle beach front affords access to these recreational activities. Louisiana, with more than 360 miles of gulf shoreline, has almost no beach front on the Gulf of Mexico. Louisiana residents must travel out of state to find surf-side recreational opportunities comparable to those available on Grand Isle. Sports fishermen flock to Grand Isle for incomparable salt-water fishing at the many oil rigs off the Louisiana coastline. Commercial fishermen, shrimpers, and oystermen use Grand Isle as a base of operations.

(2) The intensification benefit may be equated with the value of a plan in enabling existing and future (noninduced) activities to utilize their resources more intensively; i.e., the land has greater utility with the project, thus the land can command a higher price. Therefore, the intensification can be equated with the change in the market value of land. The benefit was computed as the related net return on the increase in land values resulting solely from project installation. The increased value was then reduced to an equivalent value by use of an 8 percent assumed rate of return. Care was taken in this reanalysis to identify, isolate, and exclude from the computed increase in land

value any increments which would result from subsequent construction of improvements requisite to full utilization of the area. Only those increases directly attributable to the removal of the threat of erosion and to the reduction of hurricane-driven wave losses were used in the intensification determination. The reanalysis was completed in order to bring intensification benefits into conformance with the guidelines established in ER 1105-2-351 and with Principles and Standards requirements.

(3) The market value of land reflects the net income opportunities of the land, capitalized at an appropriate interest rate consistent with investment conditions. The repeated recurrences of damages from hurricane-driven waves generated from the Gulf of Mexico are reflected in the existing market price of land on Grand Isle. Relief from such damages with the project in place will encourage the higher use of currently undeveloped land than that which is feasible without the project. This will be reflected in the increased market value of land as attributable to project construction.

(4) Because there is no alternative, representative, floodfree land within the State of Louisiana for comparison purposes, values assigned to land for pre-project and post-project conditions of necessity were based on analyses of land values solely within the project area as determined by Corps realty specialists.

(5) The increased value created by the project installation will be real and tangible and constitutes a definite and measurable gain. Higher market value reflecting potential intensified land use to be realized upon project completion can be equated, in monetary form, to return on the increase in market value without discounting.

(6) Computations for land-use intensification are shown below and are based on an 8 percent annual return on the increase in land values that will result from construction of plans B, C, and D.

(7) The annual benefits resulting from land use intensification (table D-8) represent less than 4 percent of the total average annual benefits which are summarized in table D-10.

TABLE D-8
LAND USE INTENSIFICATION COMPUTATION

Acres	Unit value pre-project	Unit value post-project	Total value pre-project	Total value post-project	Increase in value
			$	$	$
7	11,000	11,400	77,000	79,800	2,800
70	10,000	10,000	700,000	700,000	-
52	13,000	13,150	676,000	683,800	7,800
86	21,000	21,500	1,806,000	1,849,000	43,000
24	21,000	21,200	504,000	508,800	4,800
10	39,000	41,060	390,000	410,600	20,600
16	46,400	67,900	742,400	1,086,400	344,000
23	25,000	35,100	575,000	807,300	232,300
606	21,000	21,300	12,726,000	12,907,800	181,800
894			18,196,400	19,033,500	837,100
		Annual rate of return			x .08
		Annual return on increased value			66,968
				Rounded	(67,000)

e. Recreation benefits. The proposed construction at Grand Isle together with the implementation of the state plan for development of recreation facilities at the east park of Grand Isle, would provide a high quality swimming beach for present as well as future users and would allow the 600,000-visitor capacity to be reached by 1980 and continue through the 50-year project life. It is estimated that all of the visitors would use the beach, directly or indirectly, satisfying about 7 percent of the peak day demands for beach use in the market area.

The estimated annual beach use at Grand Isle's east park beach was computed considering the constraints set by the Louisiana State Parks and Recreation Commission of 600,000 maximum annual visitors that use the park during the average 153-day period between 1 May and 30 September. The estimated 10,000 peak day use is based on 6 weekend days or holidays of beach use at the peak capacity (60,000), 40 weekend days at half of the peak capacity (200,000), 80 weekdays at one-third of the peak capacity (266,700), and 28 days at one-fourth capacity (70,000). The estimate is within the guidelines established in paragraph 6.e. of EM 1120-2-108. Because of the large unsatisfied demand for beach facilities in the market area, it is estimated that the 600,000 visitor ceiling would be attained upon availability of the beach in 1980 and continue throughout the project life.

The annual recreation benefit attributed to the construction of the authorized plan is derived from two sources: (1) increased usage of the state park and (2) the increased willingness to pay due to the availability of a fully developed beach.

The current average annual visitation at the East End State Park over the last 7 years is approximately 445,000 visitors. Visitation for 1974 was not included because the park was closed due to Hurricane Carmen. It is anticipated that 445,000 will be the annual visitation in the future without the project. With implementation of Plan B, visitation in base year and throughout the project life will be 600,000 annually. The portion of the recreation benefit attributed to increased usage was based on the differences of the estimated maximum usage (600,000) and the current average annual visitation (445,000).

The benefit derived from the increased willingness to pay is based on a value per visit of $1 under existing conditions and

TABLE D-9
RECREATION BENEFITS
GRAND ISLE STATE PARK[1]

	Average annual visitation	Value per visitor-day $	Value $
WITHOUT PROJECT	445,000	1.00	445,000
PLAN A - BEACH EROSION PROTECTION (with State Park Interim Development Plan)			
Total with Plan A	500,000	1.25	625,000
Less value without project			445,000
Total attributable to Plan A			180,000
PLAN B, C, OR D - COMBINED BEACH EROSION AND HURRICANE PROTECTION (with State Park Optimum Development Plan)			
Total with Plan B, C, or D	600,000	1.75	1,050,000
Less value without project			445,000
Total attributable to Plans B, C, or D			$605,000

[1]Increased use of the private sector of beach by the public was not included in this analysis due to the inability to predict future private capital investment upon which this use is predicted.

$1.75 for a fully developed publicly-owned beach facility. These combined recreation benefits will amount to $605,000. Table 9 is a tabulation of the recreation benefits attributable to the project.

To realize these benefits an estimated 825 parking spaces are required. Using the peak day capacity of 10,000, 100 percent visitor participation using the beach at the east end park, and using the turnover rate of three, the maximum visitors at any time would be 3,300. The average number of occupants per vehicle is four; therefore, the parking spaces needed number 825.

At the present time, Grand Isle's East End Park has offstreet parking adjacent to existing park roadways. The current state master plan for development of recreational facilities, to be implemented at this location with the provision of hurricane protection improvements, include the addition of one parking area for 100 vehicles, parking space for 300 tent camper vehicles, and 50 trailer camper vehicles, plus overflow parking for a minimum of 200 vehicles on certain grass areas during days of peak use. Parking facilities are considered adequate for the realization of the recreation benefits to be derived by project implementation.

The recreation benefits to be derived by implementation of plan A, based on a value per visit of $1.00 currently being used at the state park and $1.25 for a publicly-owned beach with minimum facilities (no hurricane protection) to be derived by an estimated 500,000 visitors, amounts to $180,000.

(1) Recreation demand. The market area for the East and West End State Parks at Grand Isle, Louisiana is generally the same as Region 1 of the State Comprehensive Outdoor Recreation Plan[1] (SCORP) for Louisiana. The market area includes the New Orleans Standard Metropolitan Statistical Area (SMSA) and locations as shown on plate D-12. This large metropolitan area, with a 1970

[1] Includes St. Tammany, Orleans, Jefferson, St. Bernard, and Plaquemines Parishes

population of 1,046,705, is the most significant contributor to the recreation beach demands in the market area.

(a) Past experience has shown that the peak hour use of beaches accessible to large metropolitan areas averages about 6 percent of the population, and peak day use is about twice the peak hour use. On this basis, the 1970 peak day beach demand based on the New Orleans population would be 125,600 (1,046,705 x .06 x 2). Based on SCORP data, existing beaches in the market area including Old Spanish Fort beach, located in eastern New Orleans; Pontchartrain beach, located on the south shore of Lake Pontchartrain; and Howze beach, located on the north shore of the lake satisfied approximately 17 percent of the 1970 peak day beach demands in the market area. However, no new beach construction is being planned by non-Federal interest to satisfy future demands. The OBERS series projections for the New Orleans SMSA are as follows:

Year	Population
1980	1,101,200
1985	1,139,000
1990	1,178,000
2000	1,221,700
2010	1,258,700
2020	1,281,000
2030	1,304,000

These projected SMSA populations average approximately 80 percent of the OBERS projections for BEA Area OPOS (Mississippi Delta) which includes the market area for the East and West End State Parks at Grand Isle. Peak day beach demands for the projected New Orleans population would be 132,100 (1,101,200 x .06 x 2) in 1980, and 156,500 (1,304,000 x .06 x 2) in the year 2030.

(b) The Louisiana State Parks and Recreation Commission has indicated that annual visitation at Grand Isle must be limited to 600,000 visitors to prevent deterioration of the park, based on soil and vegetative conditions of the area. Hence, the potential of a recreation beach at this park is limited to satisfying a small portion, on the order of 8% and 6% of the peak day demands for beach use in the market area in 1980 and 2030, respectively. Since the demand for beach use is so large, the competing beach facilities satisfy only 17 percent of the demand, and no new beach construction is being planned by non-Federal interests, it is reasonable to assume that an annual visitation of 600,000 will be realized the first year of project life.

f. Area redevelopment benefits

(1) Area redevelopment benefits have been included in the benefit-cost analysis for this affirmation report as Jefferson Parish was qualified by the Economic Development Administration in 1974 as being economically depressed due to substantial unemployment.

(2) Redevelopment benefits are those resulting from all new wages earned during construction of the project which will accrue to otherwise underemployed labor resources. Total labor costs are estimated to be 45 percent of construction costs; an estimated 65 percent of which represents new wages which will be spent within the area, ($6,126,000 x .45 x .65 = $1,791,900). This amount was amortized at an interest rate of 6 7/8 percent for 50 years and represents an average annual benefit of $128,000.

(3) Redevelopment benefits previously credited to operation and maintenance expenditures are no longer considered to

be project benefits. This is in conformance with the Water Resources Council's Principles and Standards for planning, which states that ". . . redevelopment benefits attributable to operation and maintenance expenditures will not be considered as a project benefit for projects authorized after 25 October 1973. . ."

g. Summary of benefits. Average annual benefits for the recommended plan (plan B) are tabulated in table D-10.

TABLE D-10
AVERAGE ANNUAL BENEFITS, PLAN B
Grand Isle and Vicinity, Louisiana

	Average annual benefits $
Erosion prevention:	
on existing development	355,000
on future development	74,000
Inundation reduction:	
on existing development	611,000
on future development	48,000
Intensification	67,000
Recreational	605,000
Area redevelopment	128,000
TOTAL	1,888,000

h. Maximization of net benefits

(1) Studies conducted during the preliminary evaluation indicated that alternative solutions such as a groin system with beachfill, a ring levee system with bulkheads, or an offshore

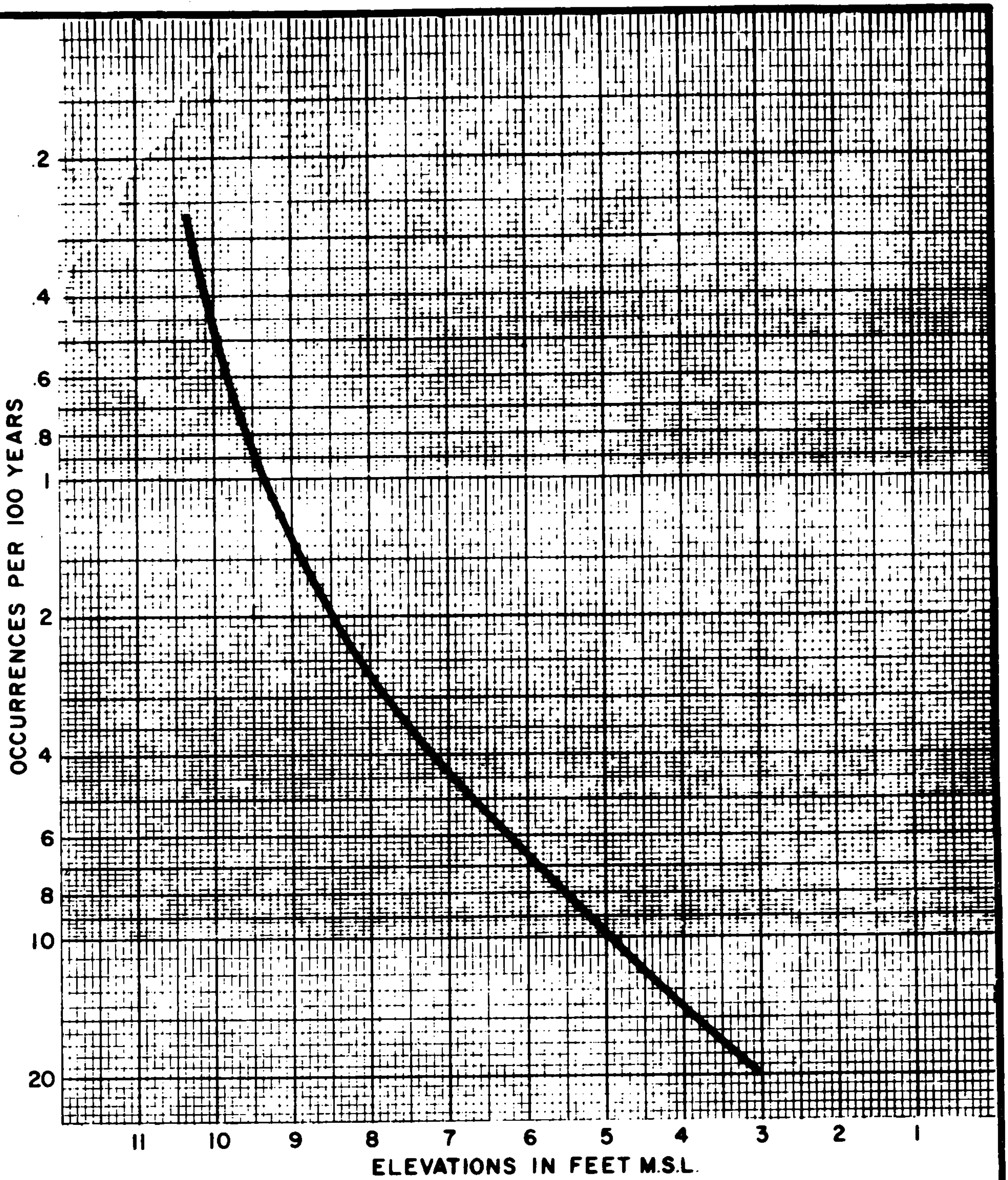
breakwater are impracticable either because of the high costs associated with construction and maintenance or the small amount of benefits attributed to the plan, or both.

(2) Various plans for beach erosion protection alone (prevention of erosion) were not analyzed because plan A provides the minimum design section required to restore and stabilize the beach. It also provides sufficient area to accomodate the 600,000 recreational visitation ceiling set by the Louisiana Parks and Recreation Commission.

(3) Based on preliminary and detailed designs for the study, cost estimates and benefits as shown in table D-11 were determined for three plans providing combined beach erosion and hurricane protection differing only in scale. These data were plotted to determine the point at which net benefits are at a maximum, see plate D-11. This graphical representation shows that all three of the plans are close the the point of maximum excess benefits.

TABLE D-11
SUMMARY OF AVERAGE ANNUAL BENEFITS AND CHARGES
PLANS B, C, AND D
Grand Isle and Vicinity, Louisiana

Plan	Annual charges $	Annual benefits $	Benefit-to-Cost ratio
B	1,249,000	1,888,000	1.5 to 1
C	1,372,000	2,144,000	1.6 to 1
D	1,480,000	2,187,000	1.5 to 1

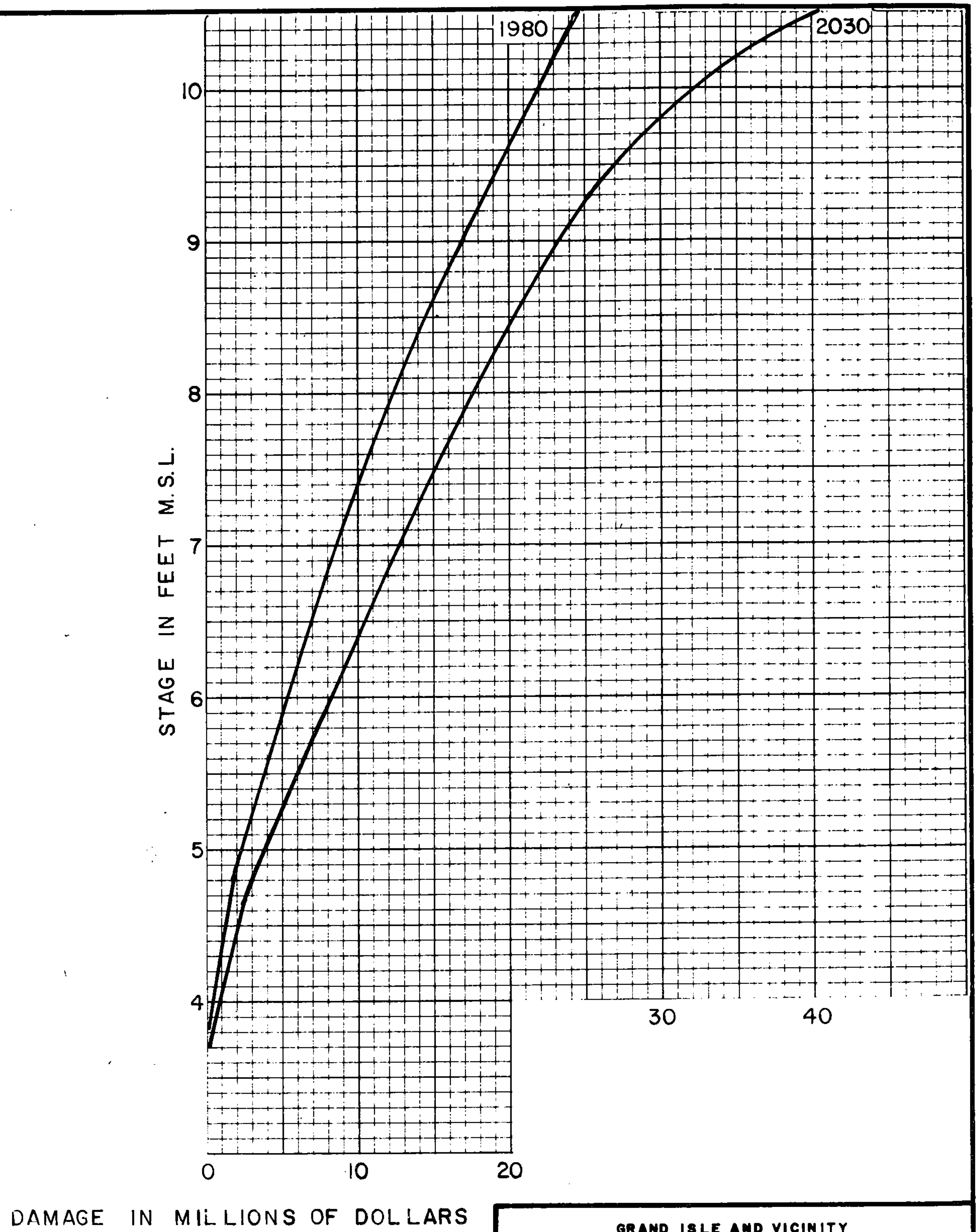


GRAND ISLE AND VICINITY
LOUISIANA

STAGE — FREQUENCY

U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS

FILE NO. H-2-28401

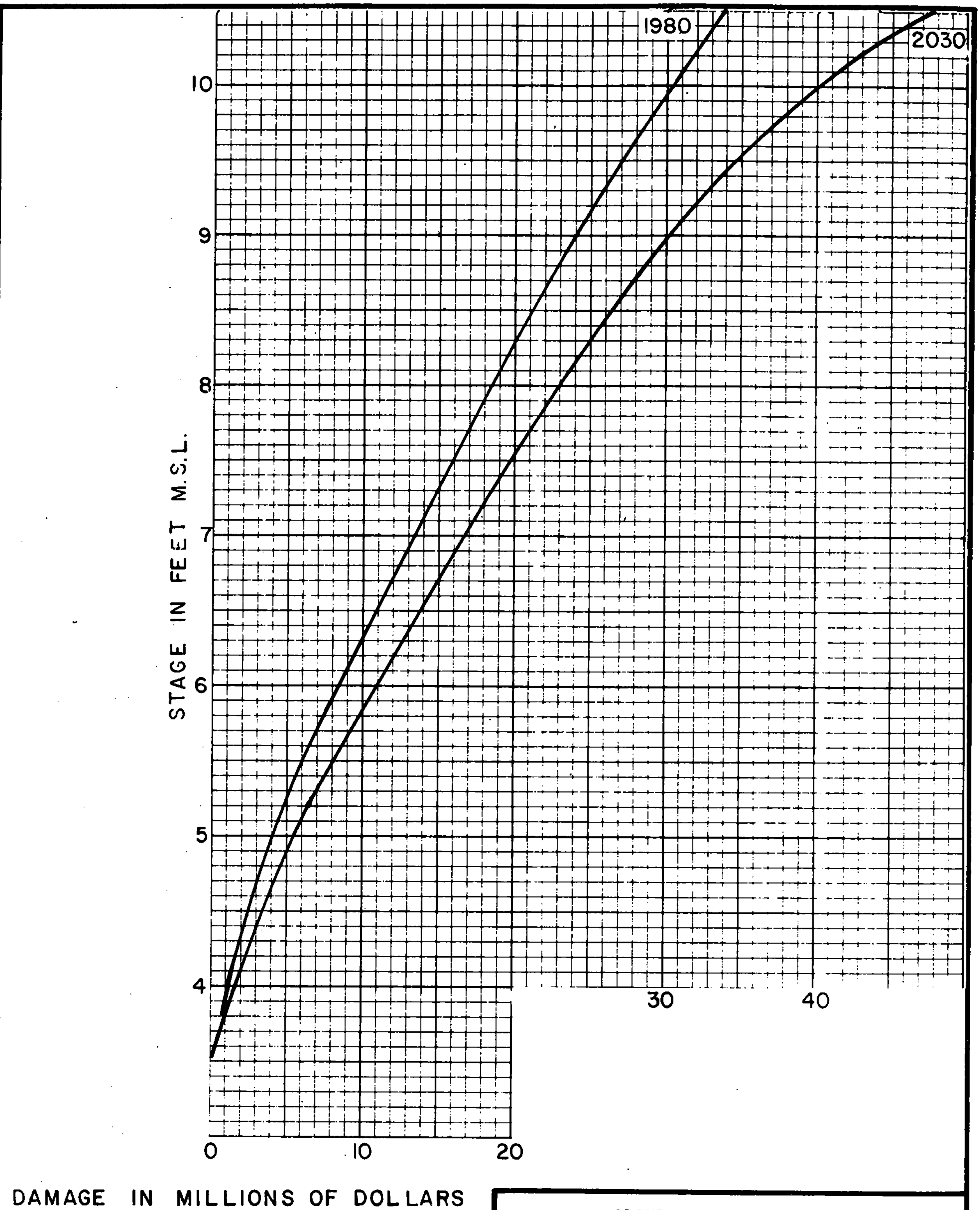


GRAND ISLE AND VICINITY
LOUISIANA

STAGE - DAMAGE CURVES
RISING WATER ONLY

U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS

FILE NO. H-2-28401

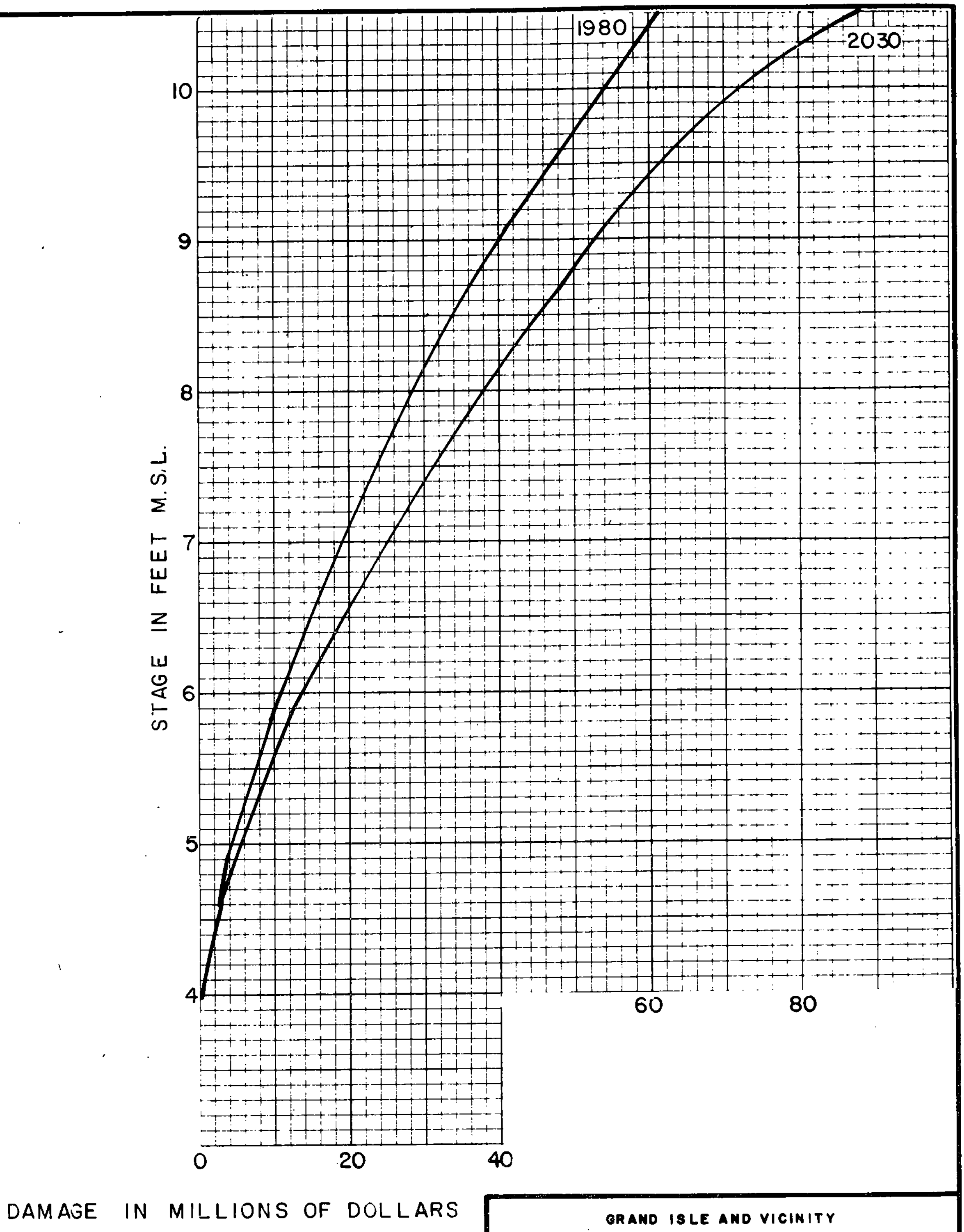


GRAND ISLE AND VICINITY
LOUISIANA

STAGE – DAMAGE CURVES
RISING WATER AND BAY WAVES ONLY

U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS

FILE NO. H-2-28401

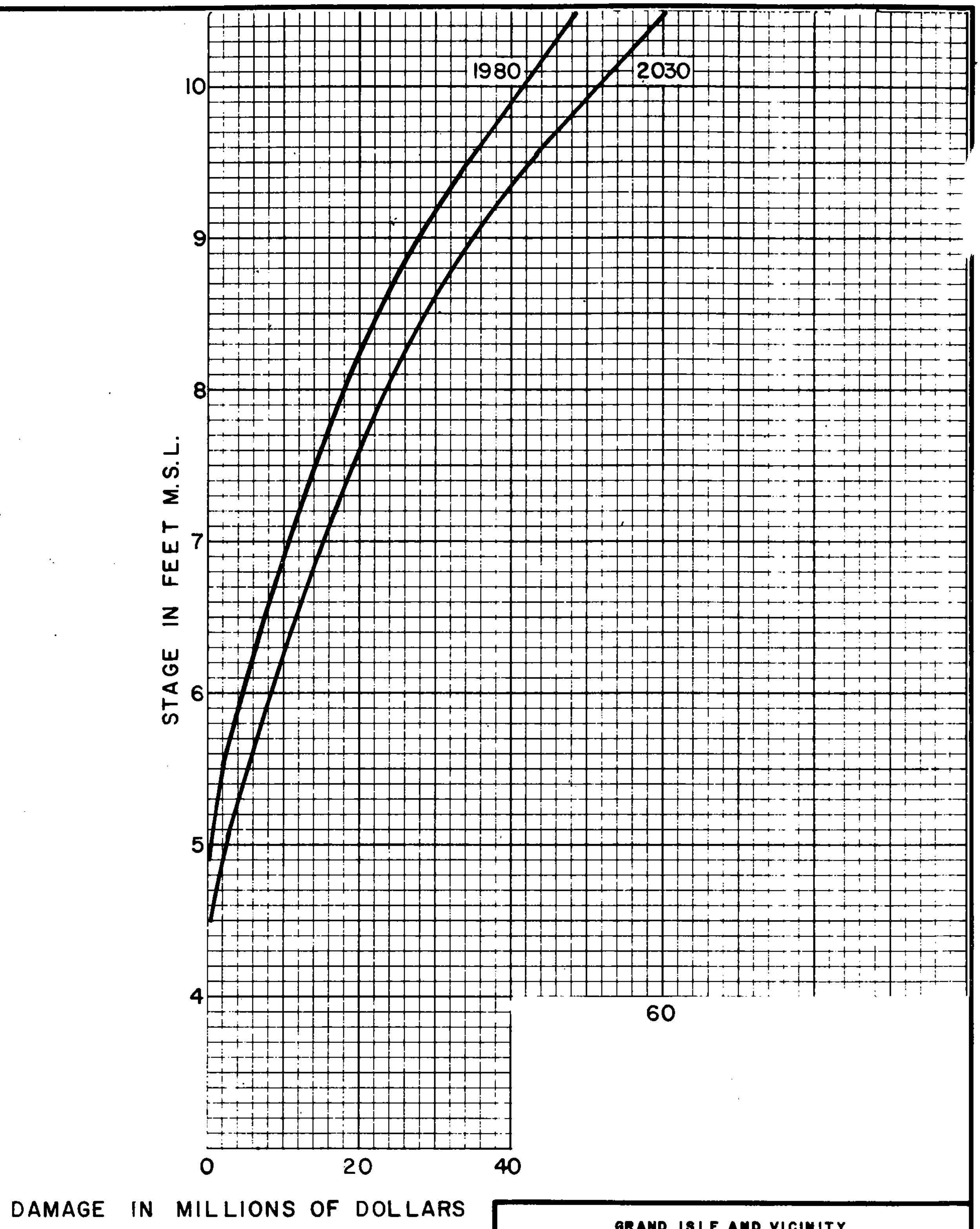


GRAND ISLE AND VICINITY
LOUISIANA

STAGE-DAMAGE CURVES
RISING WATER AND ALL WAVES-
WITHOUT PROJECT

U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS

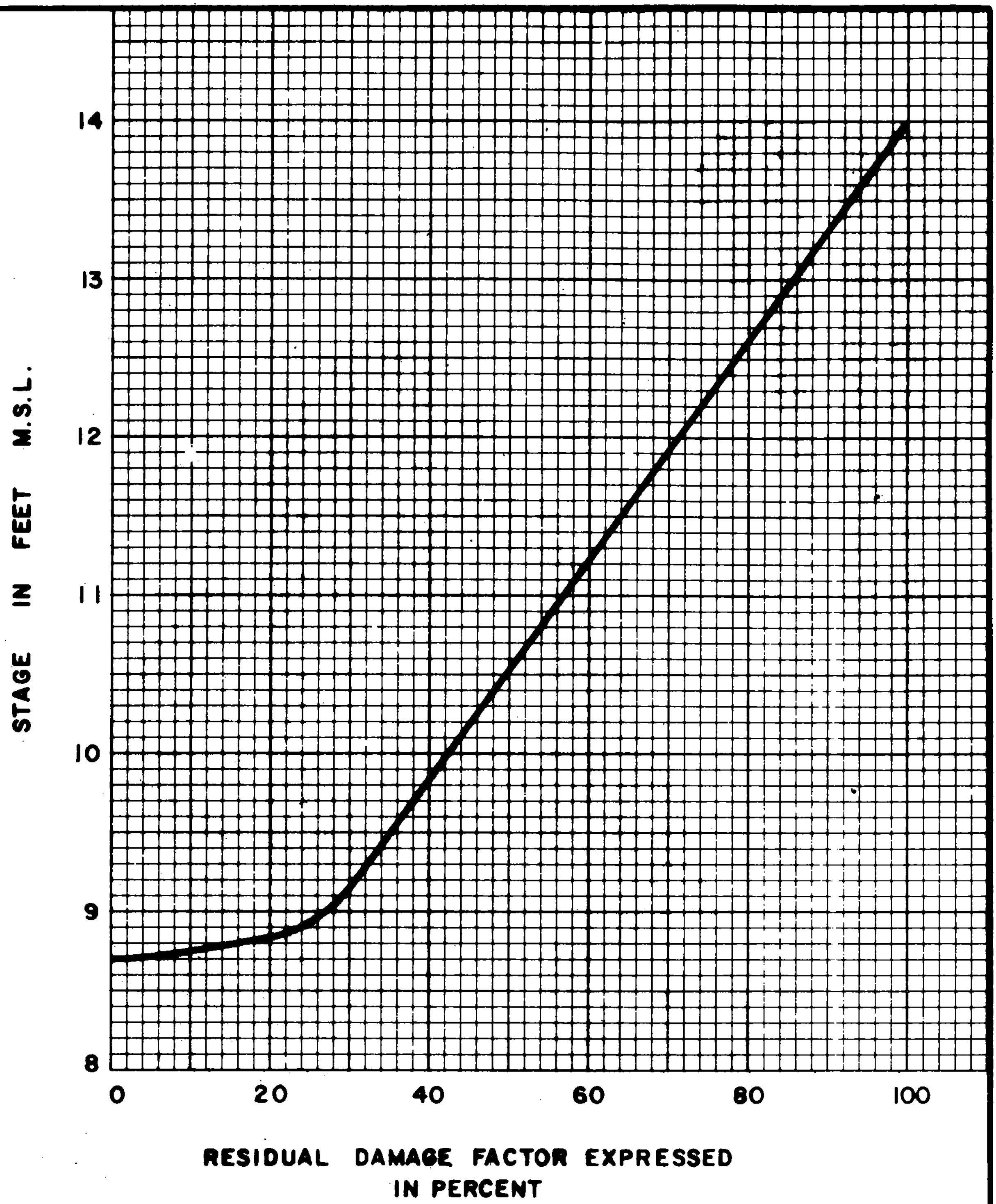
FILE NO. H-2-28401



GRAND ISLE AND VICINITY
LOUISIANA

STAGE – DAMAGE CURVES
RISING WATER AND ALL WAVES–
WITH PLAN B IN PLACE
U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS

FILE NO. H-2-28401

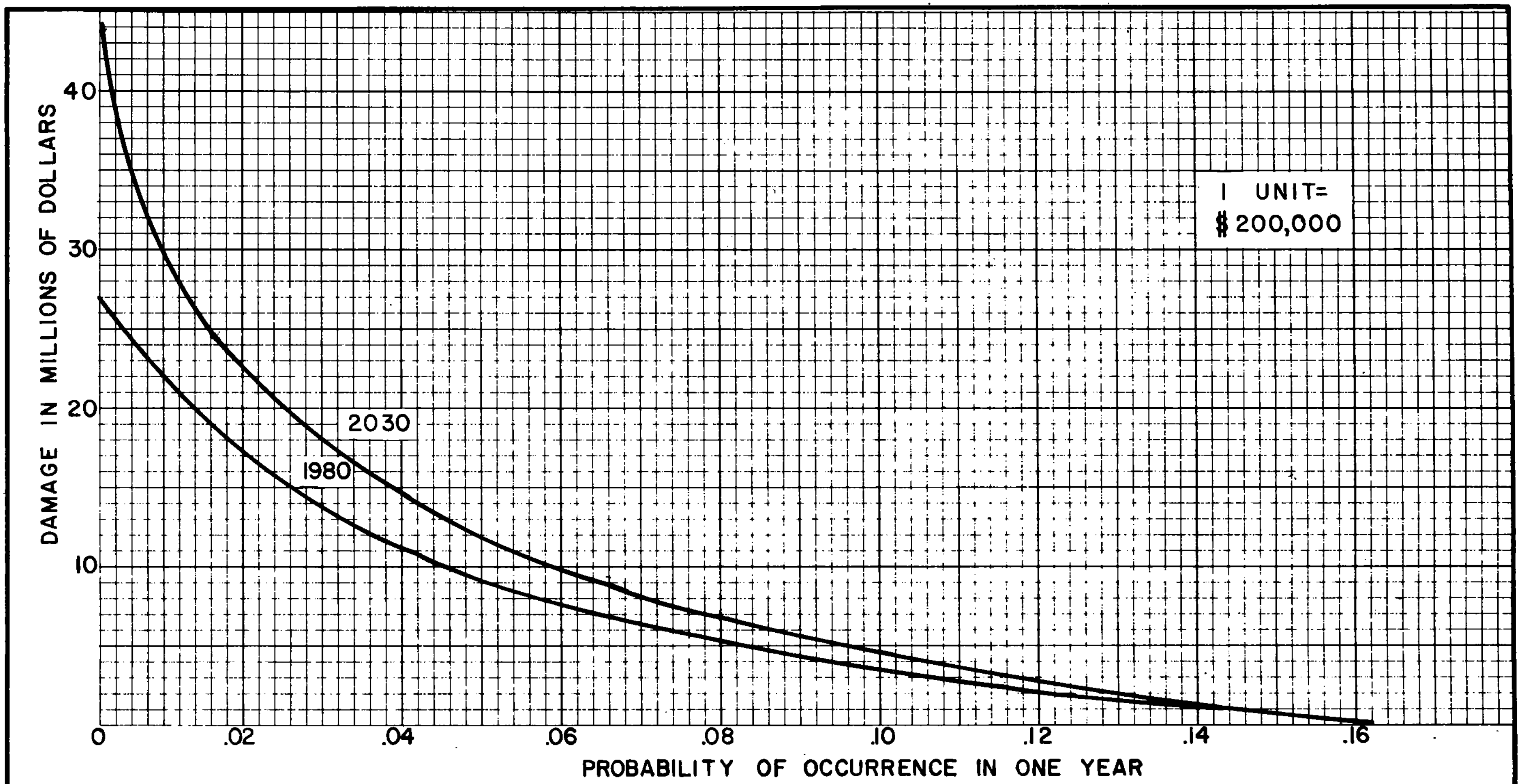


GRAND ISLE AND VICINITY
LOUISIANA

GULF WAVE DAMAGE FACTORS WITH PLAN B IN PLACE

U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS

FILE NO. H-2-28401



AVERAGE ANNUAL DAMAGES:

1980 5.59□ x $200,000 = $1,118,000

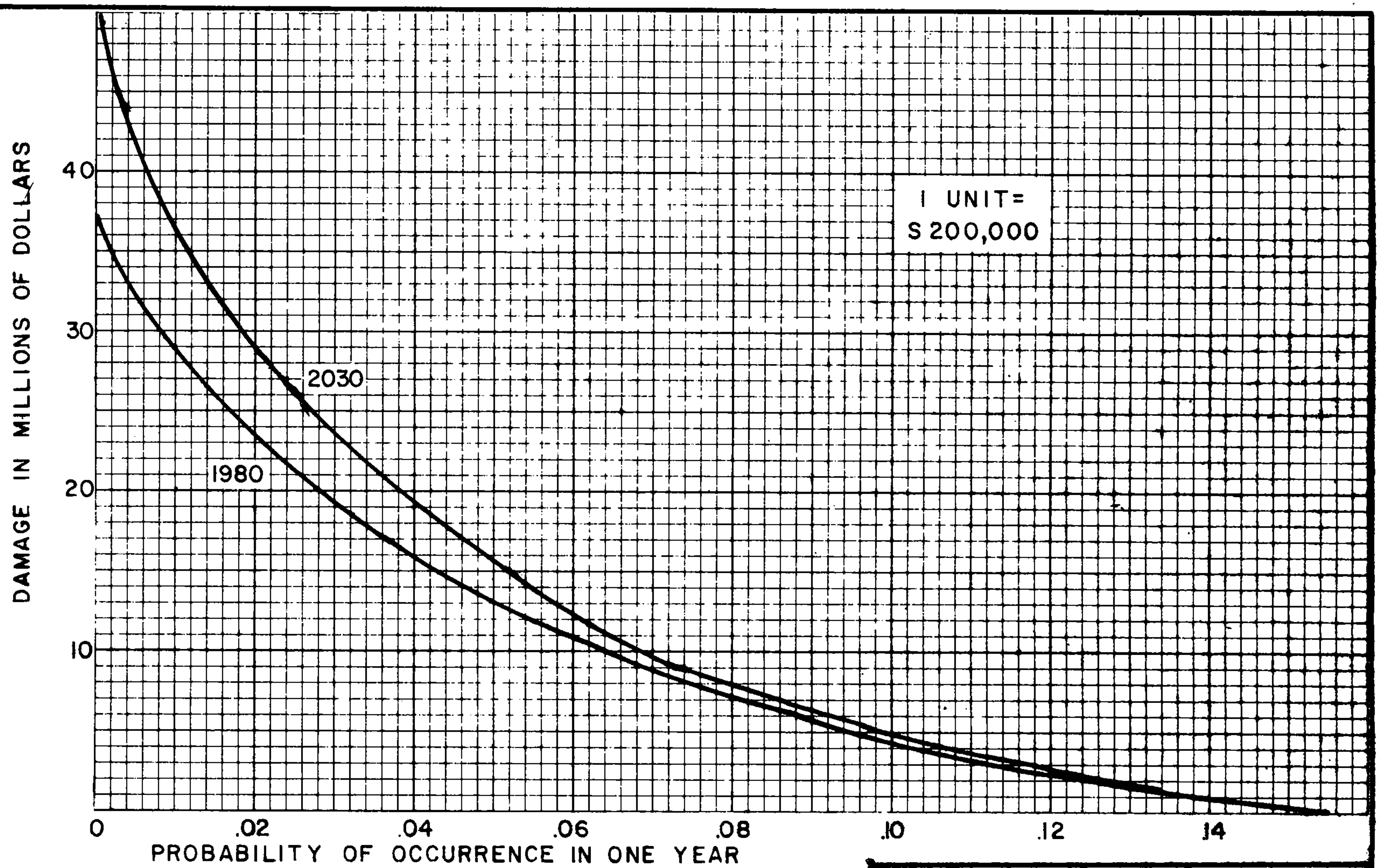
2030 7.46□ x $200,000 = $1,492,000

GRAND ISLE AND VICINITY
LOUISIANA

DAMAGE-PROBABILITY CURVES
RISING WATER ONLY

U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS

FILE NO. H-2-28401



AVERAGE ANNUAL DAMAGE:

1980 8.035 □ x $ 200,000 = $1,607,000

2030 9.760 □ x $ 200,000 = $1,952,000

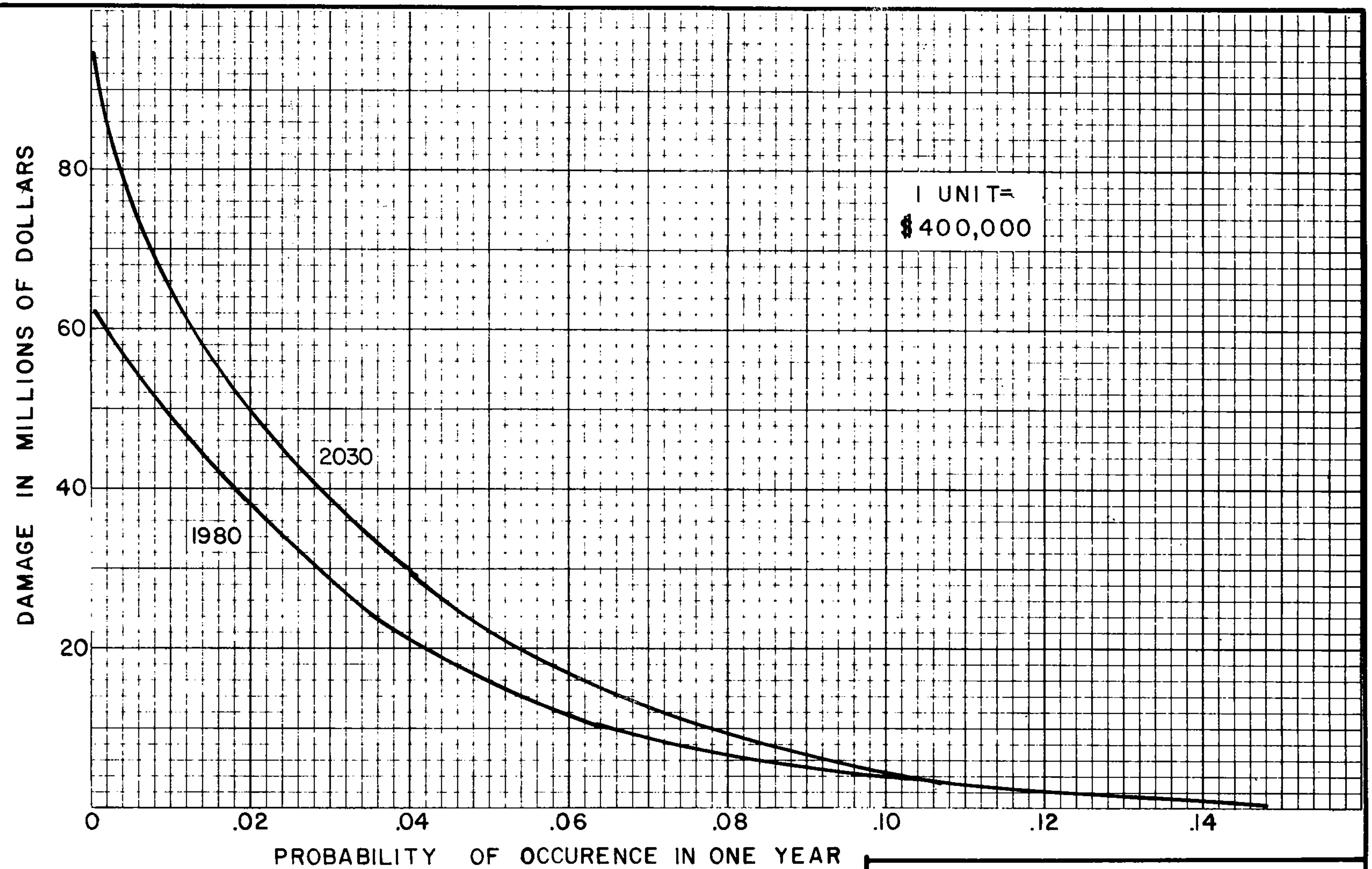
GRAND ISLE AND VICINITY
LOUISIANA

DAMAGE–PROBABILITY CURVES
RISING WATER AND BAY WAVES ONLY

U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS

FILE NO. H-2-28401

APPENDIX D PLATE D-8



AVERAGE ANNUAL DAMAGE:

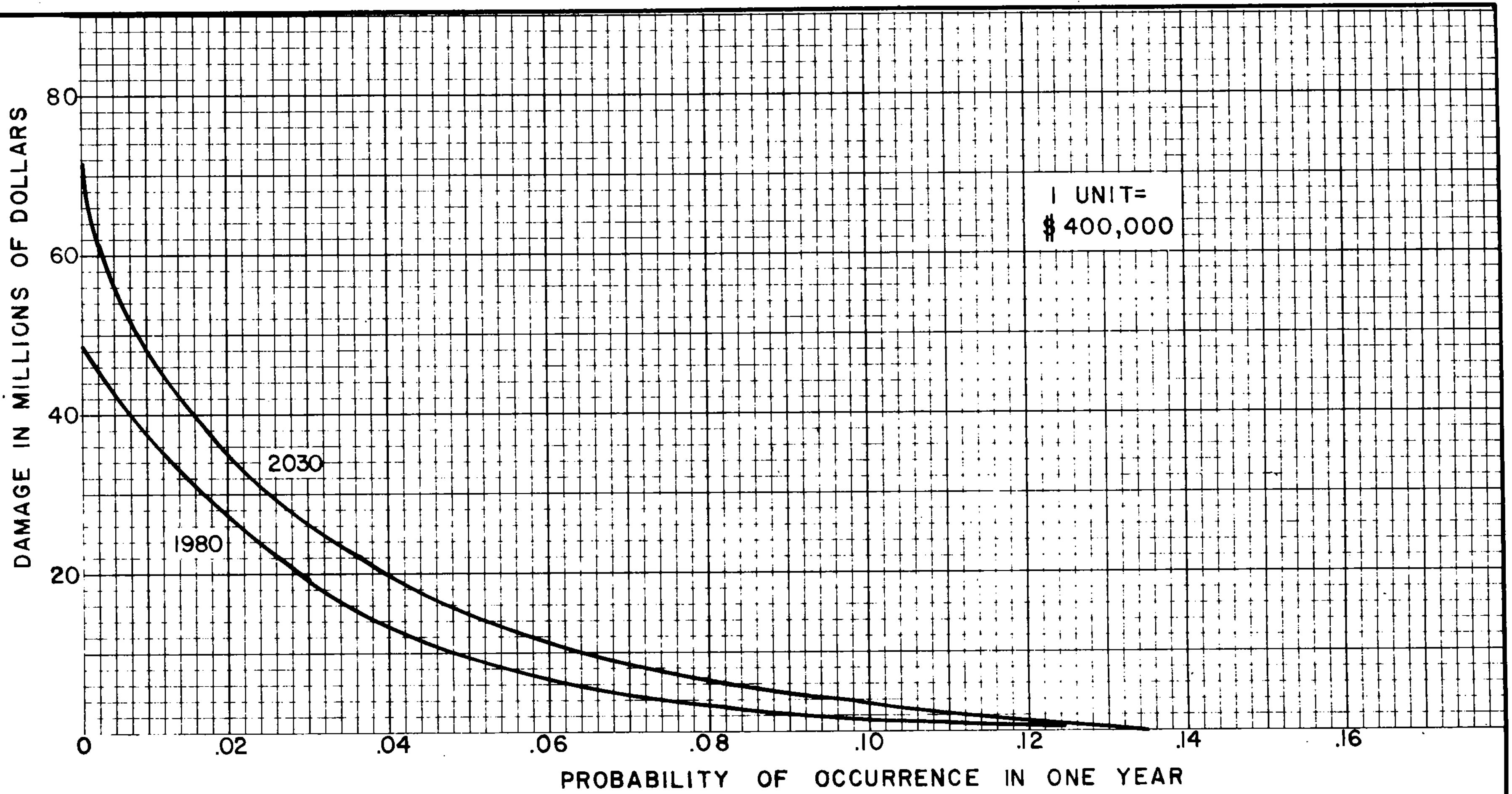
1980	5.66 □ x $400,000 =	$2,264,000
2030	7.40 □ x $400,000 =	$2,960,000

GRAND ISLE AND VICINITY
LOUISIANA

DAMAGE-PROBABILITY CURVES
RISING WATER AND ALL WAVES-
WITHOUT PROJECT

U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS

FILE NO. H-2-28401



AVERAGE ANNUAL DAMAGES:

1980 3.52 □ x $400,000 = $1,408,000

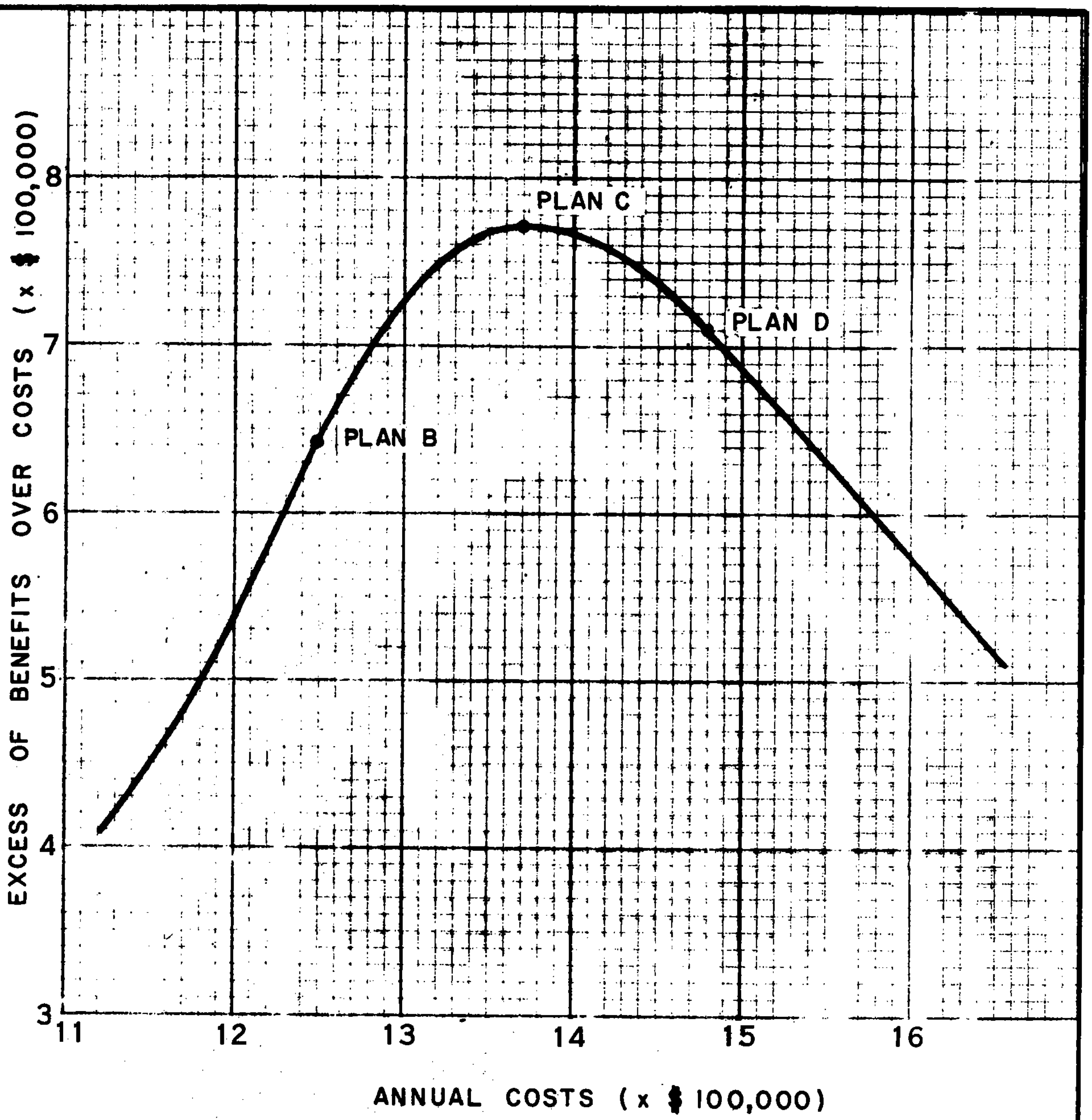
2030 4.88 □ x $400,000 = $1,952,000

GRAND ISLE AND VICINITY
LOUISIANA

DAMAGE-PROBABILITY CURVES
RISING WATER AND ALL WAVES
WITH PLAN B IN PLACE

U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS

FILE NO. H-2-28401

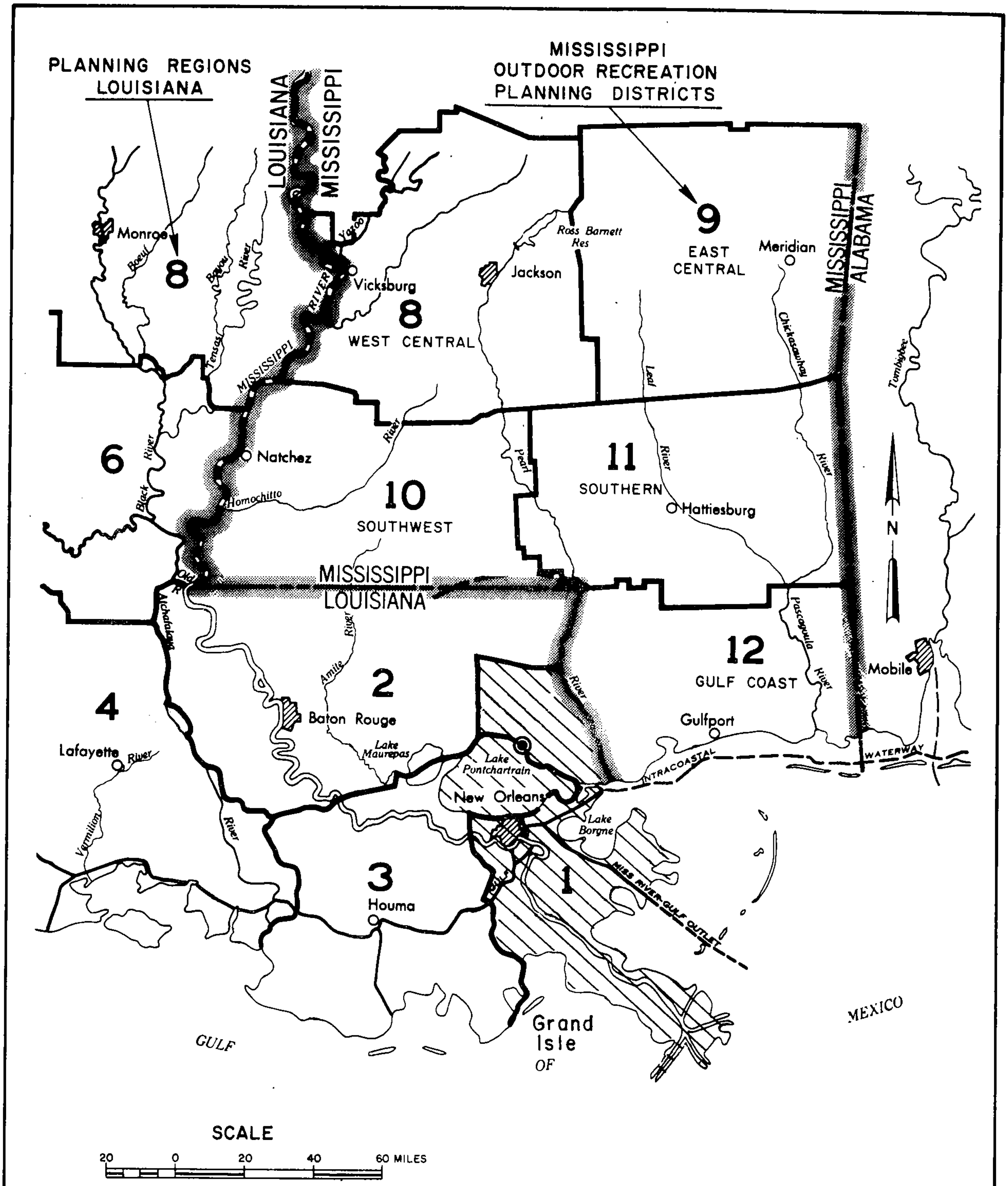


GRAND ISLE AND VICINITY
LOUISIANA

MAXIMIZATION OF NET BENEFITS

U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS

FILE NO. H-2-28401



GRAND ISLE AND VICINITY
LOUISIANA

RECREATION MARKET AREA

U. S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS

FILE NO. H-2-28401

APPENDIX D
PLATE D-12

APPENDIX E

Allocation and Apportionment of Costs

GRAND ISLE AND VICINITY, LOUISIANA
PHASE I GENERAL DESIGN MEMORANDUM

APPENDIX E
ALLOCATION AND APPORTIONMENT
OF COSTS

TABLE OF CONTENTS

APPENDIX E

ALLOCATION AND APPORTIONMENT OF COSTS

1. COST ALLOCATION

a. Plan A provides beach erosion protection for Grand Isle's gulf shore and all costs for this plan are allocated to that function.

b. Plans B, C, and D provide both beach erosion and hurricane-wave protection. Costs of the various plans are allocated below to their beach erosion control and hurricane protection functions by the separable costs-remaining benefits method, which is outlined in appendix I to EM 1160-2-101, dated 1 January 1958.

(1) Cost Allocation of Recommended Plan B

Line	Item	Shore Protection	Hurricane Protection	Combined Project
1.	Average annual benefits	609,000	1,151,000	1,760,000
	Combined project costs			
2.	Interest and amortization			777,000
3.	Periodic nourishment			457,000
4.	Other maintenance			15,000
5.	Totals			1,249,000
	Alternative project costs			
6.	Interest and amortization	247,000	777,000	
7.	Periodic nourishment	358,000	457,000	
8.	Other maintenance	3,000	15,000	
9.	Totals	608,000	1,249,000	
	Separable costs of each			
10.	Interest and amortization	0	530,000	
11.	Periodic nourishment	0	99,000	
12.	Other maintenance	0	12,000	
13.	Totals	0	641,000	

(1) Cost Allocation of Recommended Plan B (Cont'd)

Line	Item	Shore Protection	Hurricane Protection	Combined Project
14.	Remaining benefits	609,000	510,000	
15.	Limit on remaining benefits	608,000	510,000	
16.	Ratios	54%	46%	
17.	Interest and amortization	133,000	114,000	247,000
18.	Periodic nourishment	193,000	165,000	358,000
19.	Other maintenance	2,000	1,000	3,000
20.	Totals	$328,000	$280,000	$608,000
	Allocated combined costs			
2.	Interest and amortization	133,000	644,000	777,000
3.	Periodic nourishment	193,000	264,000	457,000
4.	Other maintenance	2,000	13,000	15,000
5.	Totals	$328,000	$921,000	$1,249,000
21.	First costs	$1,870,000	$9,030,000	$10,900,000

(2) Cost Allocation of Plan C

Line	Item	Shore Protection	Hurricane Protection	Combined Project
1.	Average annual benefits	609,000	1,376,000	1,985,000
	Combined project costs			
2.	Interest and amortization			899,000
3.	Periodic nourishment			457,000
4.	Other maintenance			16,000
5.	Totals			$1,372,000
	Alternative project costs			
6.	Interest and amortization	247,000	899,000	
7.	Periodic nourishement	358,000	457,000	
8.	Other maintenance	3,000	16,000	
9.	Totals	$608,000	$1,372,000	
	Separable costs of each			
10.	Interest and amortization	0	652,000	
11.	Periodic nourishment	0	99,000	
12.	Other maintenance	0	13,000	
13.	Totals	0	$764,000	
14.	Remaining benefits	609,000	612,000	
15.	Limit on remaining benefits	608,000	608,000	
16.	Ratios	50%	50%	

(2) Cost Allocation of Plan C (Cont'd)

Line	Item	Shore Protection	Hurricane Protection	Combined Project
	Allocated joint costs			
17.	Interest and amortization	123,500	123,500	247,000
18.	Periodic nourishment	179,000	179,000	358,000
19.	Other maintenance	1,500	1,500	3,000
20.	Totals	$304,000	$304,000	$608,000
	Allocated combined costs			
2.	Interest and amortization	123,500	775,500	899,000
3.	Periodic nourishment	179,000	278,000	457,000
4.	Other maintenance	1,000	15,000	16,000
5.	Totals	$303,500	$1,068,500	$1,372,000
21.	First costs	$1,730,000	$10,870,000	$12,600,000

(3) Cost Allocation of Plan D

Line	Item	Shore Protection	Hurricane Protection	Combined Project
1.	Average annual benefits	609,000	1,392,000	2,001,000
	Combined project costs			
2.	Interest and amortization			1,006,000
3.	Periodic nourishment			457,000
4.	Other maintenance			17,000
5.	Totals			$1,480,000
	Alternative project costs			
6.	Interest and amortization	247,000	1,006,000	
7.	Periodic nourishment	358,000	457,000	
8.	Other maintenance	3,000	17,000	
9.	Totals	$608,000	$1,480,000	
	Separable costs of each			
10.	Interest and amortization	0	759,000	
11.	Periodic nourishment	0	99,000	
12.	Other maintenance	0	14,000	
13.	Totals	0	$872,000	
14.	Remaining benefits	609,000	520,000	
15.	Limit on remaining benefits	608,000	520,000	
16.	Ratios	54%	46%	

(3) Cost Allocation of Plan D (Cont'd)

Line	Item	Shore Protection	Hurricane Protection	Combined Project
	Allocated joint costs			
17.	Interest and amortization	133,000	114,000	247,000
18.	Periodic nourishment	193,000	165,000	358,000
19.	Other maintenance	2,000	1,000	3,000
20.	Totals	$328,000	$280,000	$608,000
	Allocated combined costs			
2.	Interest and amortization	133,000	873,000	1,006,000
3.	Periodic nourishment	193,000	264,000	457,000
4.	Other maintenance	2,000	15,000	17,000
5.	Totals	$328,000	$1,152,000	$1,480,000
21.	First costs	$1,860,000	$12,240,000	$14,100,000

2. COST APPORTIONMENT

a. Beach erosion. Costs allocated to shore and beach protection are apportioned between Federal and non-Federal interests in accordance with provisions of Public Law 826, 84th Congress, as amended. The cost to be shared in beach erosion control projects exclude both the costs of lands, easements and rights-of-way which are entirely local.

(1) The following is a breakdown of shore by category based on ownership and use:

	Shore category	Linear feet of frontage
I	Federally owned	-
II	Publicly owned, non-Federal park	8,000
III	Publicly owned, non-Federal	2,500
IV	Privately owned, with public benefits	28,500
V	Privately owned, no public benefits	-
	Total	39,000

(2) Category IV - Benefits. In order to determine the Federal share of costs for category IV frontage, it is necessary to determine the ratio of public benefits along category IV shore to total benefits along category IV shore. The following is a breakdown of annual public benefits applicable to the private sector of shore frontage. (See appendix D for details.)

(a) Public benefits (annual).

Relocation of approximately 4.1 miles of La. Hwy. 1	$21,800
Relocation of approximately 8.7 miles of water lines (mains and laterals)	18,600
Relocation of library and post office	2,500
Loss of land (56 acres)	39,700
Total public benefits (category IV)	$82,600
Rounded	$83,000

(b) Private benefits (annual). The following items were considered in the benefit determination for the private sector:

Camps	229
House trailers	89
Motels	9
Restaurants	5
Grocery store and parking lot	5
Gas lines (main and laterals)	8.7
Powerlines and poles	8.4
Telephone lines	6.3
Land (acres)	270

Total shore protection benefits (excluding recreation)	$420,000
Less public benefits private sector	$ 83,000
Total private benefits (category IV)	$337,000

(3) Computation of cost apportionment of first cost and annual maintenance.

(a) The Federal share of the first cost of construction and periodic nourishment for the first 10 years for the shore protection plan and the shore protection function of the combined plan is computed below in accordance with ER 1120-2-110. This computation is based on the assumption that the cost per unit length of benefited shore is reasonably uniform.

Federal share of total construction cost, in percent =

$$\left\{\left[\frac{\text{Category I frontage}}{\text{Total frontage}}\right] + \left[\frac{\text{Category II frontage}}{\text{Total frontage}} \times 0.7\right] + \left[\left(\frac{\text{Category III frontage}}{\text{Total frontage}}\right) + \left(\frac{\text{Category IV frontage}}{\text{Total frontage}} \times \frac{\text{Public benefits along Category IV frontage}}{\text{Total benefits along Category IV frontage}}\right)\right] \times 0.5\right\} \times 100$$

$$= \left\{\left[0\right] + \left[\frac{8,000}{39,000} \times 0.7\right] + \left[\left(\frac{2,500}{39,000}\right) + \left(\frac{28,500}{39,000} \times \frac{83,000}{420,000}\right)\right] \times 0.5\right\} \times 100$$

= 24.8 percent

Use 25 percent

b. Hurricane protection. Costs allocated to hurricane protection are apportioned between Federal and non-Federal interests in accordance with the cost-sharing formula adopted in the Flood Control Act of 1958 for the Narraganset Bay, Rhode Island and Massachusetts; New Bedford, Massachusetts; and Texas City, Texas, projects. First costs, including cost of construction and the costs of lands, easements, rights-of-way, and relocations, but excluding the costs of preauthorization surveys, shall be apportioned at least 30 percent to non-Federal interests and not to exceed 70 percent to the Federal Government. Lands, easements, rights-of-way, and relocations, if any, are to be provided by non-Federal interests without costs to the United States and will be credited to the local contribution. Maintenance, operation, and replenishment costs are a responsibility of non-Federal interests.

c. Apportionment of first costs of the plans, as shown in table E-1 is computed below:

Plan A

Federal cost = .25 (first cost) = .25 (3,470,000) = $870,000

Non-Federal cost = .75 (first cost) = .75 (3,470,000) = $2,600,000

Combined Shore and Hurricane Protection

Plans (plans B, C, and D)

Federal cost = .25 (shore protection portion) + .70 (hurricane protection portion)

Non-Federal cost = .75 (shore protection portion) + .30 (hurricane protection portion)

Plan B

Federal cost = .25 ($1,870,000) + 6,290,000[1] = $6,760,000

Non-Federal cost = .75 ($1,870,000) + 2,740,000[1] = $4,140,000

Plan C

Federal cost = .25 ($1,730,000) + .70($10,870,000) = $8,040,000

Non-Federal cost = .75 ($1,730,000) + .30($10,870,000) = $4,560,000

Plan D

Federal cost = .25 ($1,860,000) + .70($12,240,000) = $9,030,000

Non-Federal cost = .75 ($1,860,000) + .30($12,240,000) = $5,070,000

d. Annual costs for the periodic beach nourishment of the beach erosion protection plan and the portion of periodic beach nourishment allocated to the beach erosion protection function of the combined plans are apportioned between Federal and non-Federal interests for the first 10 years of the project at the same ratio as the first costs of the beach erosion protection plan. Periodic beach nourishment would be accomplished three times during

1/Estimated real estate costs are in excess of 30 percent.

the first 10 years of the project (years 2, 6, and 10). For plan B 54 percent of the cost would be allocated to shore protection function, 50 percent of plan C, and 54 percent for plan D. The computation of the apportionment of annual costs for periodic beach nourishment is given below.

Plan A

Federal cost = .25(cost of initial nourishment)(Present worth factor for year 2)(Interest and amortization factor) + .25(cost of succeeding nourishments)(Sum of the present worth factors for years 6 and 10)(Interest and amortization factor) = .25($1,010,000) (.87548)(.07132) + .25($1,523,000)(.67103 + .51433)(.07132) = $48,000.

Non-Federal cost = .75(cost of initial nourishment)(Present worth factor for year 2)(Interest and amortization factor) + .75(cost of succeeding nourishments)(Sum of the present worth factors for years 6 and 10)(Interest and amortization) + (Cost of succeeding nourishments)(Sum of the present worth factors for years 14, 18, 22, . . . 42, 46)(Interest and amortization) = .75($1,010,000) (.87548)(.07132) + .75($1,523,000)(.67103 + .51433)(.07132) + ($1,523,000)(.39422 + .30215 + .23159 + ...06126 + .04696) (.07132) = $47,298 + $96,566 + 166,619 = $310,483 ($310,000 rounded).

Plan B

Federal costs = .25(Portion of cost of initial nourishment allocated to shore protection)(Present worth factor for year 2) (Interest and amortization factor) + .25(Portion of cost of succeeding nourishments allocated to shore protection)(Sum of present worth factors for years 6 and 10)(Interest and amortization factor) = .25($664,200)(.87548)(.07132) + .25($1,058,940)(.67103 + .51433)(.07132) = $10,368 + 22,381 = $32,749 ($33,000 rounded)

Non-Federal cost = (Portion of cost of initial nourishment allocated to shore protection)(.75)(Present worth factor for year 2)(Interest and amortization factor) + (Portion of cost of succeeding nourishments allocated to shore protection) (Interest and amortization factor)[(.75)(Sum of present worth factor for years 6 and 10) + (Sum of present worth factors for years 14, 18, 22, . . 42, 46)] + (Portion of cost of initial nourishment allocated to hurricane protection)(Present worth factor for year 2)(Interest and amortization factor) + (Portion of cost of succeeding nourishments allocated to hurricane protection)(Interest and amortization factor)(Sum of the present worth factors for years 6, 10, 14. . . 42, 46)=($664,200)(.75)(.87548)(.07132) + ($1,058,940 x .07132) [(.75)(1.18536) + (1.53396)] + ($565,800)(.87548)(.07132) + ($902,060) (.07132)(2.71932) = $31,104 + 182,992 + 35,328 + 174,947 = $424,371 ($424,000 rounded)

Plans C and D

The Federal and non-Federal costs for periodic beach nourishment were computed for plans C and D in a like manner as for plan B above. Federal and non-Federal charges were $30,000 and $427,000, respectively, for plan C and $33,000 and $424,000, respectively, for plan D.

e. The annual cost of dune and jetty maintenance are totally non-Federal responsibilities for each of the plans.

APPENDIX F

System of Accounts

GRAND ISLE AND VICINITY, LOUISIANA
PHASE I GENERAL DESIGN MEMORANDUM

APPENDIX F
SYSTEM OF ACCOUNTS

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TABLES

APPENDIX F

SYSTEM OF ACCOUNTS

1. SYSTEM OF ACCOUNTS TABLES

The system of accounts is made up of two tables. Table 1 presents a summary comparison of all alternatives analyzed in detail. Table 2 presents the effects of each plan on the study area, rest of the nation, and total effect. Table 1 is shown on pages F-2 through F-6. Table 2 is shown on pages F-7 through F-17.

2. EFFECT ASSESSMENT AND DISPLAY

All alternatives considered in the final stage of the planning process are evaluated in terms of their beneficial and adverse effects on national economic development, environmental quality, social well-being, and regional economic development. These effects are then displayed in system of accounts tables for each alternative, and a summary table is constructed for comparison of the significant effects of each alternative.

Impacts from plans considered in the final planning stage were assigned to the following areas.

a. Study area - Grand Isle, Louisiana

b. Rest of nation - The rest of the nation not included in the study area

TABLE 1--SUMMARY COMPARISON OF ALTERNATIVE PLANS

Item	Plan A	Recommended Plan Plan B (EQ Plan)	Plan C (NED Plan)	Plan D	No Action
I. PLAN DESCRIPTION	This plan would provide recreational use and protection from beach erosion damage. A 200-foot wide beach along Grand Isle's gulf shore, with a shoreward elevation of 3 and a gulfward elevation of 2, is the minimum section required for erosion control. A jetty approximately 2,600 feet long has been included to stabilize the western end of Grand Isle.	This combined beach erosion and hurricane protection plan would provide protection from gulf waves driven by hurricanes having frequencies of up to approximately once in 50 years. The plan provides for a vegetated sandfill dune with a 10-foot wide crown at an elevation of 11.5 feet and side slopes of 1 on 5, and a 180-foot wide sandfill berm sloping from an elevation of 8.5 feet at the toe of the dune gulfward to an elevation of 3 feet. The jetty described under plan A would stabilize the western end of the island.	This plan would provide protection from waves driven by hurricanes having frequencies of up to once every 100 years. It provides for a vegetated sandfill dune with a 10-foot wide crown at an elevation of 13 with side slopes of 1 on 5 and a 180-foot wide sandfill berm sloping gulfward from an elevation of 10 at the toe of the dune to an elevation of 3. The jetty described under plan A is also included in this plan.	This plan provides protection from beach erosion and from waves driven by hurricanes having frequencies of up to once every 200 years. It consists of a vegetated, sandfill dune with a 10-foot wide crown at elevation 15 and side slopes of 1 on 5 and a berm of the same elevation and dimensions as described for plan C. The jetty described under plan A is also included in plan D.	No action would allow improvements on Grand Isle to continue to be subjected to damage from erosion and hurricane-driven gulf waves and retard the residential, commercial, and recreational development of the island.
II. IMPLEMENTATION RESPONSIBILITY					
A. First Cost (Present Value)					
1. Federal	$ 870,000	$ 6,760,000	$ 8,040,000	$ 9,030,000	-
2. Non-Federal	2,600,000	4,140,000	4,560,000	5,070,000	-

TABLE 1--SUMMARY COMPARISON OF ALTERNATIVE PLANS (continued)

Item	Plan A	Recommended Plan Plan B (EQ Plan)	Plan C (NED Plan)	Plan D	No Action
3. Total	$3,470,000	$10,900,000	$12,600,000	$14,100,000	-
B. Annual Cost (Average Annual)					
1. Federal	110,000	515,000	604,000	677,000	-
2. Non-Federal	498,000	734,000	768,000	803,000	-
3. Total	608,000	1,249,000	1,372,000	1,480,000	-
III. PLAN EVALUATION					
A. Tangible Benefits	651,000	1,888,000	2,144,000	2,187,000	-
B. Tangible Costs	608,000	1,249,000	1,372,000	1,480,000	-
C. Net Benefits	43,000	639,000	772,000	707,000	-
D. NED Benefit/Cost Ratio	1.07	1.5	1.6	1.5	-
E. Acceptability	Not likely to be accepted by local sponsors	Preferred by local interest	Same as plan A	Same as plan A	Same as plan A
F. Primary Benefit Category (inundation reduction)					-
G. Geographic Scope	Grand Isle, La.	Same as plan A	Same as plan A	Same as plan A	Same as plan A

TABLE 1--SUMMARY COMPARISON OF ALTERNATIVE PLANS (Continued)

Item	Plan A	Recommended Plan Plan B (EQ Plan)	Plan C (NED Plan)	Plan D	No Action
IV. SIGNIFICANT IMPACTS					
A. National Economic Development					
1. Beneficial Effects	$651,000	$1,888,000	$2,144,000	$2,187,000	-
2. Adverse Effects	608,000	1,249,000	1,372,000	1,480,000	-
3. Net Effects	43,000	639,000	772,000	707,000	-
B. Environmental					
1. Beneficial Effects	This plan would restore and stabilize the beach and provide protection from beach erosion damages	This plan would eliminate erosion losses over the project life and preserve Grand Isle as part of the barrier island system. Also would provide reduction of flood conditions from hurricane-driven gulf waves	Similar to plan B, but more hurricane protection	Similar to plan B, but more hurricane protection	

TABLE 1--SUMMARY COMPARISON OF ALTERNATIVE PLANS (Continued)

Item	Plan A	Recommended Plan Plan B (EQ Plan)	Plan C (NED Plan)	Plan D	No Action
2. Adverse Effects	Same as plan B, but to a lesser degree	There will be increased turbidity during dredging and destruction of some beach organisms in the construction areas	Same as plan B, but to a greater degree	Same as plan B, but to a greater degree	No action would allow improvements on Grand Isle to continue to be subjected to damage from erosion and hurricane-driven gulf waves and retard the residential, commercial, and recreational development of the island
C. Social Well-Being					
1. Beneficial Effects	Increased employment and income opportunities, but to a lesser degree than plans B, C, and D	Increased employment and income opportunities	Same as plan B	Same as plan B	
		Provide reduction of flood conditions from hurricane-driven gulf waves with recurrence of once in 50 years	Same as plan B, but once in 100 years storm	Same as plan B, but once in 200 years storm	
		Improve security of life and health	Same as plan B	Same as plan B	

TABLE 1--SUMMARY COMPARISON OF ALTERNATIVE PLANS (Continued)

Item	Plan A	Recommended Plan Plan B (EQ Plan)	Plan C (NED Plan)	Plan D	No Action
2. Adverse Effects		Relocation of some beach front structures will be necessary due to the alinement of the dune	Same as plan B	Same as plan B	Continued shoreline erosion and hurricane surge damage
D. Regional Development					
1. Beneficial Effects	$651,000	$1,888,000	$2,144,000	$2,187,000	-
2. Adverse Impacts	608,000	1,249,000	1,372,000	1,480,000	-
3. Net Effects	43,000	639,000	772,000	707,000	-

TABLE 2--SYSTEM OF ACCOUNTS

	Alternatives				
	Plan A	Recommended Plan Plan B (EQ Plan)	Plan C (NED Plan)	Plan D	No Action
PLAN DESCRIPTION	This plan would provide recreational use and protection from beach erosion damage. A 200-foot wide beach along Grand Isle's gulf shore, with a shoreward elevation of 3 and a gulfward elevation of 2, is the minimum section required for erosion control. A jetty approximately 2,600 feet long has been included to stabilize the western end of Grand Isle.	This combined beach erosion and hurricane protection plan would provide protection from gulf waves driven by hurricanes having frequencies of up to approximately once in 50 years. The plan provides for a vegetated sandfill dune with a 10-foot wide crown at an elevation of 11.5 feet and side slopes of 1 on 5, and a 180-foot wide sandfill berm sloping from an elevation of 8.5 feet at the toe of the dune gulfward to an elevation of 3 feet. The jetty described under plan A would stabilize the western end of the island.	This plan would provide protection from waves driven by hurricanes having frequencies of up to once every 100 years. It provides for a vegetated sandfill dune with a 10-foot wide crown at an elevation of 13 with side slopes of 1 on 5 and a 180-foot wide sandfill berm sloping gulfward from an elevation of 10 at the toe of the dune to an elevation of 3. The jetty described under plan A is also included in this plan.	This plan provides protection from beach erosion and from waves driven by hurricanes having frequencies of up to once every 200 years. It consists of a vegetated, sandfill dune with a 10-foot wide crown at elevation 15 and side slopes of 1 on 5 and a berm of the same elevation and dimensions as described for plan C. The jetty described under plan A is also included in plan D.	No action would allow improvements on Grand Isle to continue to be subjected to damage from erosion and hurricane-driven gulf waves and retard the residential, commercial, and recreational development of the island.

TABLE 2--SYSTEM OF ACCOUNTS (Continued)

	Location of Impacts (Plan A)		Location of Impacts (Plan B)		Location of Impacts (Plan C)		Location of Impacts (Plan D)		Location of Impacts (No Action)	
	Within the Study Area **	Within the Rest of the Nation	Within the Study Area	Within the Rest of the Nation	Within the Study Area	Within the Rest of the Nation	Within the Study Area	Within the Rest of the Nation	Within the Study Area	Within the Rest of the Nation
1. National Economic Development										
a. Average Annual Benefits										
(1) Erosion Prevention	$429,000		$429,000		$429,000		$429,000			
(2) Flood Damage Prevented			659,000		884,000		900,000			
(3) Intensification			67,000		67,000		67,000			
(4) Recreation		$180,000 (2,3,6,9)		$605,000 (2,3,6,9)		$605,000 (2,3,6,9)		$605,000 (2,3,6,9)		
(5) Area Redevelopment		42,000 (1,6,9)		128,000 (1,6,9)		159,000 (1,6,9)		186,000 (1,6,9)		
Total	$429,000 (2,3,6,9)	$222,000	$1,155,000 (2,3,6,9)	$733,000	$1,380,000 (2,3,6,9)	$764,000	$1,396,000 (2,3,6,9)	$791,000	None	None
b. Average Annual Costs										
(1) Interest and Amortization		$247,000		$777,000		$899,000		$1,006,000		None
(2) Periodic Beach Nourishment		358,000		457,000		457,000		457,000		
(3) Dune and Jetty Maintenance		3,000		15,000		16,000		17,000		
Total		$608,000 (1,6,9)		$1,249,000 (1,6,9)		$1,372,000 (1,6,9)		$1,480,000 (1,6,9)		

TABLE 2--SYSTEM OF ACCOUNTS (Continued)

	Location of Impacts (Plan A)		Location of Impacts (Plan B)		Location of Impacts (Plan C)		Location of Impacts (Plan D)		Location of Impacts (No Action)	
	Within the Study Area **	Within the Rest of the Nation	Within the Study Area	Within the Rest of the Nation	Within the Study Area	Within the Rest of the Nation	Within the Study Area	Within the Rest of the Nation	Within the Study Area	Within the Rest of the Nation
c. First Costs***		$3,470,000		$10,900,000		$12,600,000		$14,100,000		None
d. Net NED Annual Benefits (Losses)	$429,000	($386,000)	$1,555,000	($516,000)	$1,380,000	($608,000)	$1,396,000	($689,000)	None	None
2. Environmental Quality										
a. Environmental Quality Enhanced			Prevention of damage to flora and fauna caused by hurricane waves		Similar to plan B		Similar to plan B			
	Increased sport fishing opportunities provided by jetty		Similar to plan A		Similar to plan A		Similar to plan A			
	Similar to plan B, but to a lesser degree		Erosion on Grand Terre Islands retarded by new sand added to transport system		Similar to plan B		Similar to plan B			
	Prevention of widening of Caminada Pass		Similar to plan A		Similar to plan A		Similar to plan A			

TABLE 2--SYSTEM OF ACCOUNTS (Continued)

	Plan A: Within the Study Area **	Plan A: Within the Rest of the Nation	Plan B: Within the Study Area	Plan B: Within the Rest of the Nation	Plan C: Within the Study Area	Plan C: Within the Rest of the Nation	Plan D: Within the Study Area	Plan D: Within the Rest of the Nation	No Action: Within the Study Area	No Action: Within the Rest of the Nation
b. Environmental Quality Degraded	330 acres of nearshore habitat covered by sand lost during dune construction with attendant destruction of benthic organisms. Recovery time = 6 months.		400 acres affected		490 acres affected		590 acres affected		No action would allow improvements on Grand Isle to continue to be subjected to damage from erosion and hurricane-driven gulf waves and retard the residential, commercial, and recreational development of the island.	
	Covering of 60 acres of nearshore habitat during each of nine maintenance actions will cause loss of benthic organisms. Recovery time = 6 months.		70 acres affected		90 acres affected		105 acres affected			

TABLE 2--SYSTEM OF ACCOUNTS (Continued)

Location of Impacts (Plan A): Within the Study Area **	Location of Impacts (Plan A): Within the Rest of the Nation	Location of Impacts (Plan B): Within the Study Area	Location of Impacts (Plan B): Within the Rest of the Nation	Location of Impacts (Plan C): Within the Study Area	Location of Impacts (Plan C): Within the Rest of the Nation	Location of Impacts (Plan D): Within the Study Area	Location of Impacts (Plan D): Within the Rest of the Nation	Location of Impacts (No Action): Within the Study Area	Location of Impacts (No Action): Within the Rest of the Nation
Similar to plan B		Covering of 140 acres of nearshore habitat with berm and dune destruction of benthic organisms. This will slowly erode until maintenance is necessary (every 5 years) when it will again be covered.		Similar to plan B		Similar to plan B			
Destruction of benthic organisms in 160 acres of borrow pits during construction. Productivity reduced for 1 to 2 years plus 6 months recovery		190 acres of affected. Construction time 2 1/2 years plus 6 months recovery		230 acres affected. Construction time 3 years plus 6 months recovery		270 acres affected. Construction time 3 1/2 years plus 6 months recovery			

TABLE 2--SYSTEM OF ACCOUNTS (Continued)

Location of Impacts (Plan A)		Location of Impacts (Plan B)		Location of Impacts (Plan C)		Location of Impacts (Plan D)		Location of Impacts (No Action)	
Within the Study Area **	Within the Rest of the Nation	Within the Study Area	Within the Rest of the Nation	Within the Study Area	Within the Rest of the Nation	Within the Study Area	Within the Rest of the Nation	Within the Study Area	Within the Rest of the Nation
Nine maintenance dredgings will destroy organsism in 160 acres of borrow, for 6 months during each maintenance plus 6 months recovery time		190 acres affected		200 acres affected		220 acres affected			
Similar to plan B		Temporary turbidity during construction and maintenance cause reduction in phytoplankton productivity.		Similar to plan B		Similar to plan B			
Similar to plan B		Pollutants released during construction and maintenance can cause adverse impacts		Similar to plan B		Similar to plan B			

TABLE 2--SYSTEM OF ACCOUNTS (Continued)

	Location of Impacts (Plan A)		Location of Impacts (Plan B)		Location of Impacts (Plan C)		Location of Impacts (Plan D)		Location of Impacts (No Action)	
	Within the Study Area **	Within the Rest of the Nation	Within the Study Area	Within the Rest of the Nation	Within the Study Area	Within the Rest of the Nation	Within the Study Area	Within the Rest of the Nation	Within the Study Area	Within the Rest of the Nation
	Similar to plan B, but 120 acres affected		Destruction of 190 acres beach dwelling organisms by construction and maintenance of dune		Similar to plan B, but 200 acres affected		Similar to plan B, but 220 acres affected			
	Same as plan B		Maintenance dredging will destroy benthic organisms in borrow pits		Same as plan B		Same as plan B			
3. Social Well-Being										
a. Beneficial Impacts										
(1) Employment	Increased employment and income opportunities (1,2,3,6,8,9)		Same as plan A, but to a slightly greater degree		Same as plan A, but to a slightly greater degree		Same as plan C, but to a slightly greater degree		None	None

TABLE 2--SYSTEM OF ACCOUNTS (Continued)

	Location of Impacts (Plan A): Within the Study Area **	Location of Impacts (Plan A): Within the Rest of the Nation	Location of Impacts (Plan B): Within the Study Area	Location of Impacts (Plan B): Within the Rest of the Nation	Location of Impacts (Plan C): Within the Study Area	Location of Impacts (Plan C): Within the Rest of the Nation	Location of Impacts (Plan D): Within the Study Area	Location of Impacts (Plan D): Within the Rest of the Nation	Location of Impacts (No Action): Within the Study Area	Location of Impacts (No Action): Within the Rest of the Nation
(2) Flooding	This plan provides no protection from hurricane-driven gulf waves		Provide reduction of flood conditions from hurricane-driven gulf waves (2,3,6,8,9)	None	Same as plan B, but slightly greater	None	Same as plan C, but slightly greater	None		
(3) Economic Stability	Greater economic stability due to erosion prevention (2,3,5,9)	None	Greater erosion stability due to prevention of some erosion and hurricane damages (2,3,5,9)	None	Same as plan B, but slightly greater	None	Same as plan B, but slightly greater	None		
b. Adverse Impacts	None	None	None	None	None	None	None	None		None
(1) Economic Stability									Will allow continued erosion and hurricane damages to Grand Isle development as under conditions with no improvements (2,3,5,9)	

TABLE 2--SYSTEM OF ACCOUNTS (Continued)

	Location of Impacts (Plan A)		Location of Impacts (Plan B)		Location of Impacts (Plan C)		Location of Impacts (Plan D)		Location of Impacts (No Action)	
	Within the Study Area **	Within the Rest of the Nation	Within the Study Area	Within the Rest of the Nation	Within the Study Area	Within the Rest of the Nation	Within the Study Area	Within the Rest of the Nation	Within the Study Area	Within the Rest of the Nation
(2) Economic Growth									Will retard further residential, industrial, or recreational growth in Grand Isle. (2,3,5,9)	
(3) Transportation*									Will lead to the eventual destruction of the only highway to Grand Isle (3,5,9)	
4. Regional Development										
a. Average Annual Benefits										
(1) Net NED Benefits	$429,000 (1,2,3,6,7,9)	None	$1,155,000 (1,2,3,6,7,9)	None	$1,380,000 (1,2,3,6,7,9)	None	$1,396,000 (1,2,3,6,7,9)	None	None	None

TABLE 2--SYSTEM OF ACCOUNTS (Continued)

	Location of Impacts (Plan A)		Location of Impacts cPlan B)		Location of Impacts (Plan C)		Location of Impacts (Plan D)		Location of Impacts (No Action)	
	Within the Study Area **	Within the Rest of the Nation	Within the Study Area	Within the Rest of the Nation	Within the Study Area	Within the Rest of the Nation	Within the Study Area	Within the Rest of the Nation	Within the Study Area	Within the Rest of the Nation
(2) Other	Not evaluated	Not evaluated	Same as plan A	Same as plan A	Same as plan A	Same as plan A	Same as plan A	Same as plan A		
b. Average Annual Losses										
(1) Net NED Losses		$386,000 (1,2,3,6,7,9)		$516,000 (1,2,3,6,7,9)		$608,000 (1,2,3,6,7,9)		$689,000 (1,2,3,6,7,9)	None	None
(2) Other	Not evaluated	Not evaluated	Same as plan A	Same as plan A	Same as plan A	Same as plan A	Same as plan A	Same as plan A		

INDEX OF FOOTNOTES

*Items specifically required in Section 122 and ER 1105-2-240.

**The study area referred to herein comprises the Town of Grand Isle.

***All average annual charges and first costs are located within the Nation since only a minimal portion (probably less than 1 percent) of such costs will be borne by Grand Isle taxpayers.

Timing

[1]Impact is expected to occur prior to or during plan implementation.

[2]Impact is expected with 15 years following plan implementation.

[3]Impact is expected in a larger time frame (15 or more years following implementation).

INDEX OF FOOTNOTES (Continued)

Uncertainty

[4]The uncertainty associated with the impact is 50 percent or more.

[5]The uncertainty is between 10 percent and 50 percent.

[6]The uncertainty is less than 10 percent.

Exclusivity

[7]Overlapping entry; fully monetized in NED account.

[8]Overlapping entry; not fully monetized in NED account.

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.

APPENDIX G

Pertinent Correspondence

GRAND ISLE AND VICINITY, LOUISIANA
PHASE I GENERAL DESIGN MEMORANDUM

APPENDIX G
PERTINENT CORRESPONDENCE

TABLE OF CONTENTS

State of Louisiana
Department of Transportation and Development

Edwin Edwards
Governor

George A. Fischer
Secretary

Office of Public Works
P. O. Box 44155 Capitol Station Baton Rouge, Louisiana 70804

February 26, 1979

Colonel Thomas A. Sands
District Engineer
New Orleans District, Corps of Engineers
P. O. Box 60267
New Orleans, Louisiana 70160

RE: LMNPD-RE, December 26, 1978
Grand Isle & Vicinity Project
Jefferson Parish, Louisiana

Dear Colonel Sands:

We were pleased to receive the Draft Phase I General Design Memorandum for the referenced project for our review and comments. We also received as an enclosure with the same letter a draft revised Environmental Impact Statement to reflect revisions and update of water quality and biological data as well as cultural resources survey information. This document will supplement the final EIS submitted to the Council on Environmental Quality (CEQ) in October 1976.

In regard to the GDM, the draft Phase I document appears to accurately reflect the authorized project adopted by the provisions of Section 201 of Public Law 89-298 for the Grand Isle and Vicinity project for hurricane protection and beach erosion. The Plan "B" as described therein provides the project features the State of Louisiana and Jefferson Parish have requested. While this GDM provides only for a broad view of the overall formulation process and presents the study results, we, of course, request that the Office of Public Works, DOTD, being made a part of and an actual participant in the Detailed Design Memorandum to be prepared prior to commencing construction and of course contingent upon funding and local cooperation.

The technical aspects of the report are well defined and we feel adequately existing conditions. The detailed survey data provided by this office since about 1953 has allowed the development of reasonably accurate beach erosion data to determine annual losses and beach recession rates. We do not have any substantial comments to make except as related to the Humble groin. On page 37 of your report you indicate the "groin has trapped material on either side thus benefiting the shoreline for several hundred feet in either direction". This statement does not reflect the actual groin performance since the littoral drift in this area is well defined as being west to east. The material at this site is primarily the result of the east end jetty entrapment and accretion which is affecting this reach. No doubt that without the east end jetty the Humble groin would act the same as the groin field immediately west of this location.

My major comments and concern are in relation to the cost estimate of Non-Federal Interests as outlined in Appendix C. The credit or costs indicated do not reflect current day costs for the construction work and engineering work performed. In order to properly reflect the work accomplished it will be necessary to update these costs to the same time frame as used in computing the federal project costs. The construction of the west end jetty and beach fill was accomplished in 1971-1972 time frame at a cost of $1,065,474.47 as outlined in our letter to Colonel Hunt in February 1973 and again to General W. C. Gribble in April 1974. The current value of this work is more on the order of $2,440,570.00, using current day construction costs and including E & D and S & A at the percentages shown in your tabulation. Since these costs will be reflected in the participation required of local interest, it is necessary that due credit be given. The costs of non-federal works should, of course, be updated further at the time local cost sharing is computed and required to be furnished.

The draft revised Environmental Impact Statement reflects current conditions and anticipated impacts. We concur in your statement and have no comments to make relative to this document.

We appreciate your action in completing these documents and assure you of our interests in expediting the remaining planning process to enable construction to commence. Devastation to this primary industrial and recreation site is more critical with each passing day and investments endangered are more critical to the national interests since energy related activities are becoming more pronounced.

Sincerely yours,

ROY AGUILLARD
ASSISTANT SECRETARY

RA:sl

COMMENTS ON: State of Louisiana, Department of Transportation and Development, Office of Public Works

Paragraph 3. Page 37 of the GDM has been changed to reflect the Office of Public Works' comment.

Paragraph 4. The project as authorized by Congress limits the credit for the west end jetty (preauthorization construction) to $1,000,000. The final amount of local cost sharing will be determined at the time of project construction.

Engr. Div.
H

United States Department of the Interior

FISH AND WILDLIFE SERVICE
111 East Main Street
Lafayette, Louisiana
70501

February 5, 1979

District Engineer
U.S. Army Corps of Engineers
P.O. Box 60267
New Orleans, Louisiana 70160

Dear Sir:

In response to your letter of January 10, 1979, the Fish and Wildlife Service has reviewed the draft Phase I General Design Memorandum (GDM) for the project "Grand Isle and Vicinity, Louisiana". The project was authorized by Section 201 of Public Law 89-298, 89th Congress. These comments are submitted in accordance with provisions of the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661 et seq.).

The referenced project includes provisions for beach erosion control and hurricane protection in the area between Caminada Pass and Barataria Pass. This plan would provide a vegetated sandfill dune with a 10-foot-wide crown (elevation 11.5 feet m.s.l.) and side slopes of 1 on 5, and a 180-foot-wide sandfill berm sloping gulfward from an elevation of 8.5 feet m.s.l. at the toe of the dune to an elevation of 3 feet m.s.l., with a natural slope thereafter. The dune and berm will extend from Caminada Pass approximately 7.5 miles to the jetty located adjacent to Barataria Pass. Approximately 1,500,000 cubic yards of sandfill required for construction will be hydraulically dredged from two borrow areas located in the Gulf of Mexico about 1,500 feet offshore from the ends of the island.

We find that, of the various plans considered, the selected plan is the least damaging to the fish and wildlife resources of the area. However, we are concerned about possible project effects on the lagoon located on the east end of Grand Isle within the Grand Isle State Park. This feature is shown on Plate 4 of the draft GDM. Fish and Wildlife Service biologists have observed that the lagoon has tidal interchange with Barataria Pass under and/or through the existing jetty. The lagoon is approximately 25 acres in size and is surrounded by a margin of regularly flooded saltmarsh (wetland type 18[1]). Vegetation in the marsh is predominantly saltmarsh cordgrass (Spartina alterniflora). Many estuarine fish species and numerous shorebirds have been observed utilizing the lagoon by Fish and Wildlife Service biologists. This shallow water area is a source of bait for the many surf fishermen that use the area.

In order to reduce adverse impacts on fish and wildlife resources, it is recommended that the following measures be incorporated into detail design for the project:

1) tidal interchange between Barataria Pass and the lagoon at the east end of Grand Isle should be preserved by installation of a culvert(s) through and/or under the proposed dune and the existing jetty at or near the point of present tidal exchange; and

2) dune construction and maintenance should avoid deposition of dune material in the aforementioned lagoon.

We appreciate the opportunity to review the draft Phase I GDM for this project.

Please advise us of your action on our recommendations.

Sincerely yours,

Cary W. Kerlin

Cary W. Kerlin
Field Supervisor

cc: EPA, Dallas, Texas
NMFS, Galveston, Texas
NMFS, St. Petersburg, Florida
La. Dept. of Wildlife and Fisheries, New Orleans, La.
Area Office, Jackson, Miss.

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1. Shaw, S. P. and C. G. Fredine. 1971. Wetlands of the United States. U.S. Department of the Interior, U.S. Fish and Wildlife Service, Circular 39, 67pp.

COMMENT ON: United States Department of the Interior, Fish and Wildlife Service

Paragraph 5. The authorized plan has been modified to include culverts with positive cut-offs to allow tidal interchange between the shallow lagoon and the gulf. The alinement of the dune to the south of the lagoons is such that no material will be deposited in them. The dune, however, will cross between Barataria Pass and the eastern end of the lagoons at the point of tidal interchange. Design at this crossing will be such that disposition of material from the dune construction and maintenance will be held to a minimum. (See plate 4, Main Report)

Roy WRIGHT [handwritten initials]

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Duval Building
9450 Koger Boulevard
St. Petersburg, FL 33702

February 14, 1979

Colonel Thomas A. Sands
District Engineer, New Orleans District
Department of the Army, Corps of Engineers
P.O. Box 60267
New Orleans, LA 70130

Dear Colonel Sands:

In response to your letter of December 26, 1978, the National Marine Fisheries Service has reviewed the draft environmental impact statement (DEIS) and the Phase I, General Design Memorandum (GDM) for the project "Grand Isle and Vicinity, Louisiana." Our comments on the DEIS have been submitted to our Washington office for inclusion in the Department of Commerce response which you should receive shortly. In regard to the Phase I GDM we offer the following comments.

We concur that the selected plan (Plan B) would be the least environmentally damaging project alternative in regard to fishery resources. Major adverse impacts resulting from implementation of Plan B would be alteration of about 140 acres of nearshore water bottoms caused by sand deposition from the dredging, increased turbidity and release of pollutants during dredging, and disruption of about 190 acres of offshore shallow water bottoms (borrow areas) from which the construction sand will be dredged. In addition, similar impacts would occur during each of the scheduled nine maintenance dredgings.

Although the selected plan would be the least environmentally damaging, we believe that impacts associated with this plan should be further reduced. Specifically, we recommend that a methodology be developed which would reduce the amount of sand run-off back into the Gulf during both construction and maintenance dredging. Also, we are concerned that the dredging for post-construction dune and beach nourishment would impact the immigration of early life stages of commercially and recreationally important fish and shellfish from the Gulf through the tidal passes at each end of the island to Barataria and Caminada Bays. Accordingly, we recommend that no maintenance or nourishment dredging be performed within one mile of either tidal pass from January 1 through August 30.

We are also concerned with possible effects the project may have on two shallow water lagoons located on the east end of Grand Isle (plate 4). These lagoons and associated marshlands apparently will be altered if the dune is aligned as proposed. The larger lagoon, located within Grand Isle State Park, apparently has tidal exchange with Barataria Pass under and/or through the existing jetty. The smaller lagoon, located just west of Grand Isle State Park, apparently has some tidal exchange on the beach front. Construction of the dune as proposed would apparently eliminate tidal exchange to both areas and partially fill both lagoons. Therefore, we recommend that tidal exchange to these areas be maintained, possibly by installing culverts at or near the points of present tidal exchange, and that the dune be realigned to avoid any filling in the two lagoons.

We appreciate the opportunity to review and comment on the draft Phase I GDM for this project.

Sincerely,

William H. Stevenson
Regional Director

COMMENT ON: United States Department of Commerce, National Oceanic and Atmospheric Administration

Paragraph 3. During Phase II detailed studies measure to minimize the loss of sand to the sea will be examined. The dune and berm construction and replenishment will consider the time of construction in regards to environmental and social impacts. The authorized plan has been modified to include culverts with positive cut-offs to allow tidal interchange between the shallow lagoon and the gulf.

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL OCEAN SURVEY
Rockville, Md. 20852

OA/C52x6:JLR

MAR 7 1979

Mr. James F. Roy
Chief, Planning Division
Department of the Army
New Orleans District
Corps of Engineers
Post Office Box 60267
New Orleans, Louisiana 70160

Dear Mr. Roy:

The draft Phase I General Design Memorandum (GDM) for the Grand Isle and Vicinity, Louisiana, beach erosion and hurricane protection project has been reviewed within the areas of National Ocean Survey (NOS) responsibility and expertise, and in terms of the impact of the proposed action on NOS activities and projects.

The following comment is offered for your consideration.

Geodetic control survey monuments may be located in the proposed project area. If there is any planned activity which will disturb or destroy these monuments, NOS requires not less than 90 days' notification in advance of such activity in order to plan for their relocation. NOS recommends that funding for this project includes the cost of any relocation required for NOS monuments.

Sincerely,

for Gordon Hill, Deputy
Allen L. Powell
Rear Admiral
Director
National Ocean Survey

COMMENT ON: United States Department of Commerce, National Oceanic and Atmospheric Administration

Paragraph 2. The required 90 days notification will be given in the event that any activity might disturb or destroy any Geodetic control survey monuments. The cost of any required relocation will be funded by this project.

UNITED STATES DEPARTMENT OF COMMERCE
Maritime Administration
Central Region Office
No. 2 Canal Street
New Orleans, La. 70130

January 17, 1979

Colonel Thomas A. Sands
District Engineer
U. S. Army Corps of Engineers
P. O. Box 60267
New Orleans, LA 70160

Dear Colonel Sands:

We have reviewed the drafts of Phase I General Design Memorandum, and Environmental Statement for Grand Isle and Vicinity, Louisiana. We further appreciate your giving us this opportunity, however, at this time we have no comments to offer.

Sincerely,

F. X. McNERNEY
Central Region Director

Engr. Div. PD-F

UNITED STATES DEPARTMENT OF AGRICULTURE

SOIL CONSERVATION SERVICE

Post Office Box 1630, Alexandria, La. 71301

March 5, 1979

Colonel Thomas A. Sands
District Engineer
New Orleans District
Dept. of Army, Corps of Engineers
P. O. Box 60267
New Orleans, La. 70160

Dear Colonel Sands:

Re: Draft Phase I General Design Memorandum, Grand Isle and Vicinity, Louisiana

Thank you for the opportunity to review this draft General Design Memorandum. My staff and I found this to be a well prepared, accurate document.

Two suggestions are made for improvement:

1. Discuss the recreational aspect of the study area in the "Resources and Economy of the Study Area" Section.

2. Change Louisiana State Parks and Recreation Commission to Office of State Parks (page 91).

Sincerely,

Alton Mangum
Alton Mangum
State Conservationist

cc: Director, Office of Federal Activities, EPA, Washington, D.C.

Director, Environmental Services Div., SCS, Washington, D.C.

Office of the Coordinator of Environmental Quality Activities Washington, D.C.

COMMENT ON : United States Department of Agriculture, Soil Conservation Service

Paragraph 2. The recreational aspects of the study area are discussed on page 15, 16, and 17 of the GDM. Page 91 has been changed to reflect the current name, "Office of State Parks."

Mr. Wright

DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT
REGIONAL OFFICE
1100 COMMERCE STREET
DALLAS, TEXAS 75202

REGION VI

January 18, 1979

IN REPLY REFER TO:

Mr. James F. Roy, Chief
Planning Division
New Orleans District
Corps of Engineers
Department of the Army
P.O. Box 60267
New Orleans, Louisiana 70160

Dear Mr. Roy:

This will acknowledge receipt of the draft Phase I General Design Memorandum (GDM) for the Grand Isle and Vicinity, Louisiana, project regarding beach erosion and hurricane protection.

By copy of this letter we are transmitting the subject document to our New Orleans Area Office and asking that office to furnish you directly any comments that it might wish to make concerning the proposed action.

Sincerely,

for Otis M. [signature]
Victor J. Hancock
Environmental Clearance Officer

AREA OFFICES
DALLAS, TEXAS • LITTLE ROCK, ARKANSAS • NEW ORLEANS, LOUISIANA • OKLAHOMA CITY, OKLAHOMA • SAN ANTONIO, TEXAS
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DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT
NEW ORLEANS AREA OFFICE
PLAZA TOWER, 1001 HOWARD AVENUE
NEW ORLEANS, LOUISIANA 70113

REGION VI

February 15, 1979

IN REPLY REFER TO:
6.3SS

Mr. James F. Roy
Chief
Planning Division
N. O. District Corps of Engineers
P.O. Box 60267
New Orleans, Louisiana 70160

Dear Mr. Roy:

Subject: Grand Isle and Vicinity, Louisiana, Phase I, General Design Memorandum

The subject draft Phase I General Design Memorandum has been reviewed as requested in your letter of January 10, 1979 and the environmental concerns of this office have been disclosed adequately without significant adverse impact. Therefore, no comments are offered at this time.

We thank you for the opportunity to review and comment on this project which is of considerable local interest.

Sincerely,

Florence Quail acting area manager
Terrence R. Duvernay
Area Manager

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
REGION SIX

750 Florida Boulevard
Baton Rouge, Louisiana 70801

F

January 15, 1979

IN REPLY REFER TO

Mr. James F. Roy, Chief
Planning Division
Corps of Engineers
P. O. Box 60267
New Orleans, Louisiana 70160

Dear Mr. Roy: Re: LMNPD-F

Reference is made to your January 10, 1979, letter transmitting a copy of the draft Phase I General Design Memorandum (GDM) for the Grand Isle and Vicinity, Louisiana, project regarding beach erosion and hurricane protection and requesting FHWA review and comments.

Our review of the draft indicates that the authorized plan of improvement (Plan B) will not conflict with or adversely impact any of the Federal-aid highways in the area.

Sincerely yours,

M. C. Reinhardt
Division Administrator

PD-F

State of Louisiana

WILLIAM C. HULS
SECRETARY

JAMES M. HUTCHISON
DEPUTY SECRETARY

DEPARTMENT OF NATURAL RESOURCES
DIVISION OF STATE LANDS

ORY G. PORET
DIRECTOR

February 26, 1979

Colonel Thomas A. Sands
District Engineer
U. S. Army Engineer
District of New Orleans
Corps of Engineers
Post Office Box 60267
New Orleans, Louisiana 70160

Dear Colonel Sands:

Attached is a prepared statement relating to the authorized plan for beach erosion and hurricane protection for Grand Isle and vicinity, Louisiana.

I ask that this statement be made part of the records of the proposed project.

Sincerely,

ORY G. PORET
DIRECTOR

Attachment

cc: Mr. William C. Huls
Department of Natural Resources

Mr. Roy Aguillard
Office of Public Works

POST OFFICE BOX 44124, BATON ROUGE, LOUISIANA 70804
NATURAL RESOURCES BUILDING

Statement Presented To: New Orleans District, Corps of Engineers
Grand Isle and Vicinity Hurricane Protection Project
February 20, 1979

I am Ory Poret, Director, Division of State Lands, Department of Natural Resources. The Division of State Lands, Department of Natural Resources, is the State agency which is charged with accountability, management, and administration of State-owned lands, including State-owned waterbottoms. It is principally from this point of interest that this statement is submitted. Mr. William Huls, Secretary for the Department of Natural Resources, concurs in this statement as submitted.

In the past, this agency has concurred with and recommended construction of the beach erosion and hurricane protection project at Grand Isle. At this time, we are pleased to re-affirm the project as it presently is defined and renew our commitment of support for its construction completion at the earliest possible time. Our approval must be conditioned, however, on the requirement that approved surveys or some suitable record is established prior to any construction of the project which will identify mean high water for purposes of permanently establishing the extent of State-owned water bottoms prior to construction so that those areas will be permanently established as State-owned areas. It is requested that the New Orleans District, Corps of Engineers provide such information to the Division of State Lands prior to initiating construction. Further, this agency will require the opportunity to review such data to consider its adequacy. We would reserve the right to request additional information if in our judgment it is necessary.

Our request is in no way intended to slow down or prevent any portion of the Grand Isle Beach Erosion and Hurricane Protection Project. We recognize the work as being badly needed and are of the opinion that it will serve to provide benefits for many years. If there is any way in which this agency can collaborate or assist you to expedite the project, please advise.

COMMENT ON : State of Louisiana, Department of Natural Resources, Division of State Lands

Paragraph 2 of the Attached Statement. Mean high water will be established prior to construction of the project.

PD-F

STATE OF LOUISIANA
STREAM CONTROL COMMISSION
P. O. DRAWER FC
UNIVERSITY STATION
BATON ROUGE. LOUISIANA 70893

January 30, 1979

Department of the Army
New Orleans District
Corps of Engineers
Post Office Box 60267
New Orleans, Louisiana 70160

Attention: Colonel Thomas A. Sands, CE
District Engineer

Gentlemen:

Re: Proposed erosion and hurricane protection project to stabilize the western end of the island at Caminada Pass, Grand Isle, Louisiana

We have examined the attachments to your letter dated January 25, 1979, above reference project, and are of the opinion that water quality standards of the State of Louisiana will not be violated provided turbidity during dredging in public waters is kept to a practicable minimum.

Under Louisiana statutory authorization contained in Title 56, Chapter 3, Part 1 of Section 1439(b), and provisions of Sections 401 and 404 of Public Law 92-500, Water Pollution Control Act Amendments of 1972, the Louisiana Stream Control Commission certifies that it is reasonable to expect that water quality standards of Louisiana provided for under Section 303 of Public Law 92-500 will not be violated.

Enclosed is copy of a public notice to be run by you one (1) time in the official state journal, the Baton Rouge STATE TIMES, at your expense.

Very truly yours,

Robert A. Lafleur
Executive Secretary

fbr
Enclosure
cc: Corps of Engineers
New Orleans District
Attention: Permit Section

PUBLIC NOTICE TO RUN IN THE OFFICIAL
JOURNAL OF THE STATE OF LOUISIANA

Notice is hereby given that Department of the Army, New Orleans District, New Orleans, Louisiana,

has applied to the Department of the Army, Corps of Engineers, New Orleans District, for a permit for proposed erosion and hurricane protection project to stabilize the wester end of the Island at Caminada Pass, Grand Isle, Louisiana,

and is now applying to the Louisiana Stream Control Commission for water quality certification as provided in Revised Statute 56:1439(5) that there is reasonable assurance that construction of this project will be conducted in a manner which will not violate applicable water quality standards. Comments concerning the application can be filed with the Commission or its executive secretary within ten days from the date of this notice.

Robert A. Lafleur, Executive Secretary

COMMENT ON: State of Louisiana, Stream Control Commission

Paragraph 3. The required public notice has been run as certified on page G-25.

NOTICE

Notice is hereby given that Department of the Army, New Orleans District, New Orleans, Louisiana, has applied to the Department of the Army, Corps of Engineers, New Orleans District, for a permit for the proposed beach erosion and hurricane protection project for Grand Isle, Louisiana, and is now applying to the Louisiana Stream Control Commission for water quality certification as provided in Revised Statute 56:1439(5) that there is reasonable assurance that construction of this project will be conducted in a manner which will not violate applicable water quality standards. Comments concerning the application can be filed with the Commission or its executive secretary within ten days from the date of this notice.

ROBERT A. LAFLEUR
Executive Secretary
ST—6100—Mar. 23—1t

CAPITAL CITY PRESS

Publisher of

STATE-TIMES

PROOF OF PUBLICATION

The hereto attached notice was published in the STATE-TIMES, a daily newspaper of general circulation, published in Baton Rouge, Louisiana, and the Official Journal of the State of Louisiana, the City of Baton Rouge and the Parish of East Baton Rouge, in the issues of:

March 23, 1979

Susan Smith
Advertising Representative

Sworn and subscribed before me by the person whose signature appears above in Baton Rouge, La. on this

23 day of March 1979 AD.

[signature]
Notary Public

My Commission Expires: Indefinite

THE Chamber
New Orleans and the River Region
West Bank Council

February 8, 1979

Colonel Thomas A. Sands, CE
District Engineer
Department of the Army
New Orleans District, Corps of Engineers
Post Office Box 60267
New Orleans, Louisiana 70160

Dear Colonel Sands:

The West Bank Council of The Chamber/New Orleans and the River Region supports the authorized plan for beach erosion and hurricane protection for Grand Isle, Louisiana.

Our Board of Directors' has reviewed the material included with the Corps of Engineers release dated January 22, 1979, announcing a public meeting and would like to add its endorsement and urge that the project proceed without further delays.

Sincerely,

Lloyd A. Hymel

Lloyd A. Hymel
Chairman
West Bank Council

LAH/JSV:jae

Camp and Gravier Streets / P.O. Box 30240 / New Orleans, La. 70190 / Tel. (504) 524-1131
Jefferson • Orleans • Plaquemines • St. Bernard • St. Charles • St. James • St. John

OSTEP

OFFICE OF SCIENCE, TECHNOLOGY & ENVIRONMENTAL POLICY

Edwin W. Edwards, Governor • • Lee W. Jennings, Director

Janaury 3, 1978

Mr. Thomas A. Sands
Colonel, CE
District Engineer
Department of the Army
New Orleans District
Corps of Engineers
P.O. Box 60267
New Orleans, LA 70160

RE: Grand Isle and Vicinity
Louisiana
Beach erosion and hurricane protection

Dear Mr. Sands:

The above-referenced matter concerning environmental quality has been received and reviewed by the staff of the Office of Science, Technology and Environmental Policy. From the information contained in the package sent to our office, the staff of OSTEP issues a no objection on this particular project. The rules and regulations governing this project should continue to be in full compliance with all State and Federal regulatory agencies.

The staff of OSTEP appreciates this opportunity to participate in the review process.

Sincerely,

William J. Mollere
Manager, Administration and Operations

WJM/cdh

cc: Mr. George Gullett, Environmental Coordinator
Office of Planning and Technical Assistance
Department of Urban and Community Affairs

STATE CAPITOL BUILDING POST OFFICE BOX 44095 BATON ROUGE LA 70504 (504) 389-2549

NATIONAL SPACE TECHNOLOGY LABORATORIES NSTL STATION, MISSISSIPPI 39529 (601) 688-3003

LEON NAQUIN & SON INC.
ELECTRICAL CONTRACTORS
P. O. BOX 307
THIBODAUX, LOUISIANA 70301

February 26, 1979

Department of Army
New Orleans District
Corps of Engineers
P.O. Box 60267
New Orleans, LA 70160

RE: Public Meeting
Grand Isle, Louisiana
Beach Erosion and Hurricane
Protection

Gentlemen:

I attended the meeting held at Grand Isle on February 24th and made a statement at that time.

I voiced my concurrence in the sand dune as planned but at the same time indicated that I did not believe that the problem of erosion had been adequately addressed.

As I appreciate it there are two types of erosions present on the island. Erosion produced by wave action as a result of hurricane winds and as a result of rough weather. The other type of erosion is due to the west to east littoral current which deposits and strips sand to and from the beach.

I don't feel that the question posed at the end of my statement was adequately answered.

I fail to see how the proposed berm and sand dune will prevent this latter mode of erosion. It seems to me that by extending the effective beach area farther into the Gulf, the erosion caused by the littoral currents would, in fact, be accelerated.

Another matter I would like to have cleared up is the amount of approximately $1,700,000 for "rights of way." Specifically what is this to be used for? Does it mean that beach front property from owners will have to be given up?

PHONE 446-8846
AREA CODE: 504

LEON NAQUIN & SON, INC.
ELECTRICAL CONTRACTORS
P. O. BOX 307
THIBODAUX, LOUISIANA 70301

Will "dune cross over bridges" be provided at each existing beach access lane or only at certain specific lanes?

During the hearing I noticed that several persons had a rather thick book with maps, profiles etc. relating to the project. I would certainly like to have a copy, if the book is a preliminary Phase I document I would like to have a copy as soon as it is in its final form.

Yours very truly,

LEON NAQUIN & SON, INC.

BY: Clyde J. Naquin
President

CJN/jbc

PHONE 446-8846
AREA CODE: 504