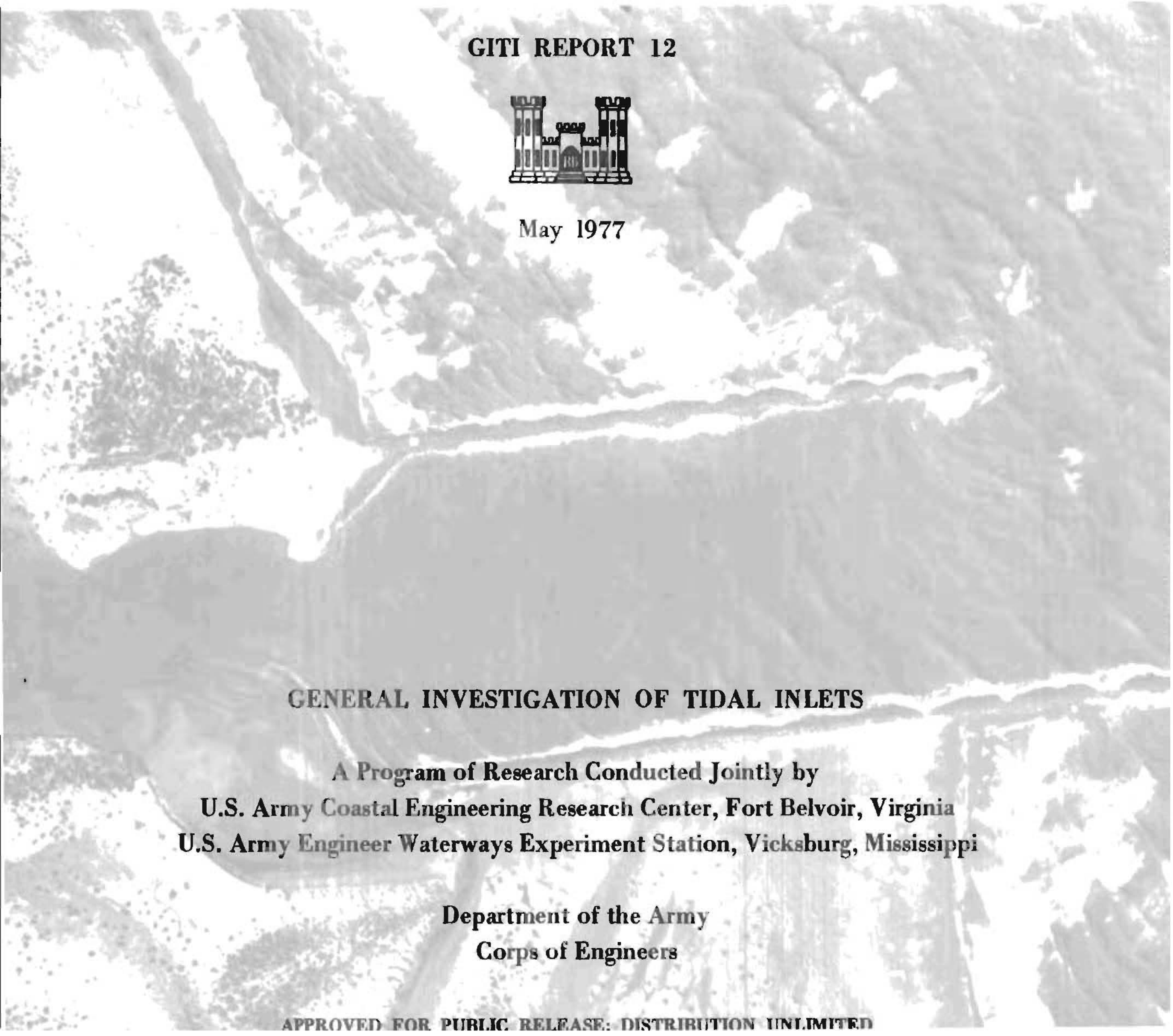
A Case History of Port Mansfield Channel, Texas

by

James M. Kieslich



GITI REPORT 12

May 1977

GENERAL INVESTIGATION OF TIDAL INLETS

A Program of Research Conducted Jointly by
U.S. Army Coastal Engineering Research Center, Fort Belvoir, Virginia
U.S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi

Department of the Army
Corps of Engineers

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Cover Photo: Port Mansfield Channel Entrance, Texas, 28 October 1970

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER
GITI Report 12

2. GOVT ACCESSION NO.

3. RECIPIENT'S CATALOG NUMBER

4. TITLE (and Subtitle)
A CASE HISTORY OF PORT MANSFIELD CHANNEL, TEXAS

5. TYPE OF REPORT & PERIOD COVERED
Final Report

6. PERFORMING ORG. REPORT NUMBER

7. AUTHOR(s)
James M. Kieslich

8. CONTRACT OR GRANT NUMBER(s)

9. PERFORMING ORGANIZATION NAME AND ADDRESS
Department of the Army
Coastal Engineering Research Center (CERRE-SP)
Kingman Building, Fort Belvoir, Virginia 22060

10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
F31019

11. CONTROLLING OFFICE NAME AND ADDRESS
Department of the Army
Coastal Engineering Research Center
Kingman Building, Fort Belvoir, Virginia 22060

12. REPORT DATE
May 1977

13. NUMBER OF PAGES
66

14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)

15. SECURITY CLASS. (of this report)
UNCLASSIFIED

15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Inlet hydraulics
Longshore sediment transport
Port Mansfield Channel, Texas
Tidal inlets
Tidal prism

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report presents a case history and analysis of Port Mansfield channel, an artificial, jettied inlet between the Gulf of Mexico and Laguna Madre, Texas. Deposition has occurred in the channel entrance since its opening. Seaward migration of the updrift beach and shoaling in the channel entrance indicate that sand is bypassing the jettied entrance. Short-term predictions of inlet stability using the O'Brien prism-area relationship (Jarrett, 1976), Escoffier's (1940) stability criteria, and

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered) the Bruun and Gerritsen (1960) ratio of tidal prism to the gross annual longshore transport rate, correctly predict the unstable nature of the channel. Tidal exchange volumes and velocities are not large enough to maintain the design cross-sectional area in the presence of the existing longshore transport.

FOREWORD

This report was prepared as one in a series of reports from the Corps of Engineers' General Investigation of Tidal Inlets (GITI). The GITI research program is under the technical surveillance of the Coastal Engineering Research Center (CERC) and is conducted by CERC, the U.S. Army Engineer Waterways Experiment Station (WES), other Government agencies, and private organizations.

The report was prepared by J.M. Kieslich, Civil Engineer, formerly of CERC, under the general supervision of Dr. R.M. Sorensen, Chief, Coastal Structures Branch, Research Division, CERC. The field data were collected by the U.S. Army Engineer District, Galveston, for the Engineering Development Division, CERC. The assistance of D.W. Berg in making the field data available, and of J.R. Weggel in providing the wave energy data, is greatly appreciated. Special appreciation is extended to C. Mason who provided guidance in productive areas of research. Review of the manuscript by C. Mason, D.W. Berg, R.M. Sorensen, and R.P. Savage is acknowledged. Review of the final draft by the civilian members of the Coastal Engineering Research Board, Dean M.P. O'Brien, Dr. R.G. Dean, and Dr. R.L. Wiegel is appreciated.

Technical Directors of CERC and WES were T. Saville, Jr., and F.R. Brown, respectively.

Comments on this publication are invited.

Approved for publication in accordance with Public Law 166, 79th Congress, approved 31 July 1945, as supplemented by Public Law 172, 88th Congress, approved 7 November 1963.

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PREFACE

1. The Corps of Engineers, through its Civil Works program, has sponsored, over the past 23 years, research into the behavior and characteristics of tidal inlets. The Corps' interest in tidal inlet research stems from its responsibilities for navigation, beach erosion prevention and control, and flood control. Tasked with the creation and maintenance of navigable U.S. waterways, the Corps dredges millions of cubic yards of material each year from tidal inlets that connect the ocean with bays, estuaries, and lagoons. Design and construction of navigation improvements to existing tidal inlets are an important part of the work of many Corps' offices. In some cases, design and construction of new inlets are required. Development of information concerning the hydraulic characteristics of inlets is important not only for navigation and inlet stability, but also because inlets, by allowing for the ingress of storm surges and egress of flood waters, play an important role in the flushing of bays and lagoons.

2. A research program, the General Investigation of Tidal Inlets (GITI), was developed to provide quantitative data for use in design of inlets and inlet improvements. It is designed to meet the following objectives:

> To determine the effects of wave action, tidal flow, and related phenomena on inlet stability and on the hydraulic, geometric, and sedimentary characteristics of tidal inlets; to develop the knowledge necessary to design effective navigation improvements, new inlets, and sand transfer systems at existing tidal inlets; to evaluate the water transfer and flushing capability of tidal inlets; and to define the processes controlling inlet stability.

3. The GITI is divided into three major study areas: (a) inlet classification, (b) inlet hydraulics, and (c) inlet dynamics.

a. Inlet Classification. The objectives of the inlet classification study are to classify inlets according to their geometry, hydraulics, and stability, and to determine the relationships that exist among the geometric and dynamic characteristics and the environmental factors that control these characteristics. The classification study keeps the general investigation closely related to real inlets and produces an important inlet data base useful in documenting the characteristics of inlets.

b. Inlet Hydraulics. The objectives of the inlet hydraulics study are to define tide-generated flow regime and water level fluctuations in the vicinity of coastal inlets and to develop techniques for predicting these phenomena. The inlet hydraulics study is divided into three areas: (1) idealized inlet model study, (2) evaluation of state-of-the-art physical and numerical models, and (3) prototype inlet hydraulics.

(1) The Idealized Inlet Model. The objectives of this model study are to determine the effect of inlet configurations and structures on discharge, head loss and velocity distribution for a number of realistic inlet shapes and tide conditions. An initial set of tests in a trapezoidal inlet was conducted between 1967 and 1970. However, in order that subsequent inlet models are more representative of real inlets, a number of "idealized" models representing various inlet morphological classes are being developed and tested. The effects of jetties and wave action on the hydraulics are included in the study.

(2) Evaluation of State-of-the-Art Modeling Techniques. The objectives of this part of the inlet hydraulics study are to determine the usefulness and reliability of existing physical and numerical modeling techniques in predicting the hydraulic characteristics of inlet-bay systems, and to determine whether simple tests, performed rapidly and economically, are useful in the evaluation of proposed inlet improvements. Masonboro Inlet, North Carolina, was selected as the prototype inlet which would be used along with hydraulic and numerical models in the evaluation of existing techniques. In September 1969 a complete set of hydraulic and bathymetric data was collected at Masonboro Inlet. Construction of the fixed-bed physical model was initiated in 1969, and extensive tests have been performed since then. In addition, three existing numerical models were applied to predict the inlet's hydraulics. Extensive field data were collected at Masonboro Inlet in August 1974 for use in evaluating the capabilities of the physical and numerical models.

(3) Prototype Inlet Hydraulics. Field studies at a number of inlets are providing information on prototype inlet-bay tidal hydraulic relationships and the effects of friction, waves, tides, and inlet morphology on these relationships.

c. Inlet Dynamics. The basic objective of the inlet dynamics study is to investigate the interactions of tidal flow, inlet configuration, and wave action at tidal inlets as a guide to improvement of inlet channels and nearby shore protection works. The study is subdivided into four specific areas: (1) model materials evaluation, (2) movable-bed modeling evaluation, (3) reanalysis of a previous inlet model study, and (4) prototype inlet studies.

(1) Model Materials Evaluation. This evaluation was initiated in 1969 to provide data on the response of movable-bed model materials to waves and flow to allow selection of the optimum bed materials for inlet models.

(2) Movable-Bed Model Evaluation. The objective of this study is to evaluate the state-of-the-art of modeling techniques, in this case movable-bed inlet modeling. Since, in many cases, movable-bed modeling is the only tool available for predicting the response of an inlet to improvements, the capabilities and limitations of these models must be established.

(3) Reanalysis of an Earlier Inlet Model Study. In 1975, a report entitled, "Preliminary Report: Laboratory Study of the Effect of an Uncontrolled Inlet on the Adjacent Beach," was published by the Beach Erosion Board (now CERC). A reanalysis of the original data is being performed to aid in planning of additional GITI efforts.

(4) Prototype Dynamics. Field and office studies of a number of inlets are providing information on the effects of physical forces and artificial improvements on inlet morphology. Of particular importance are studies to define the mechanisms of natural sand bypassing at inlets, the response of inlet navigation channels to dredging and natural forces, and the effects of inlets on adjacent beaches.

4. This study presents the results of an office study of available field data collected at Port Mansfield channel, Texas, from construction in 1957 to 1975. The study constitutes a part of Prototype Dynamics discussed above.

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CONVERSION FACTORS, U. S. CUSTOMARY TO METRIC (SI) UNITS OF MEASUREMENT

U.S. customary units of measurement used in this report can be converted to metric (SI) units as follows:

Multiply	by	To obtain
inches	25.4	millimeters
	2.54	centimeters
square inches	6.452	square centimeters
cubic inches	16.39	cubic centimeters
feet	30.48	centimeters
	0.3048	meters
square feet	0.0929	square meters
cubic feet	0.0283	cubic meters
yards	0.9144	meters
square yards	0.836	square meters
cubic yards	0.7646	cubic meters
miles	1.6093	kilometers
square miles	259.0	hectares
acres	0.4047	hectares
foot-pounds	1.3558	newton meters
ounces	28.35	grams
pounds	453.6	grams
	0.4536	kilograms
ton, long	1.0160	metric tons
ton, short	0.9072	metric tons
degrees (angle)	0.1745	radians
Fahrenheit degrees	5/9	Celsius degrees or Kelvins[1]

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[1] To obtain Celsius (C) temperature readings from Fahrenheit (F) readings, use formula: $C = (5/9)(F - 32)$. To obtain Kelvin (K) readings, use formula: $K = (5/9)(F - 32) + 273.15$.

A CASE HISTORY OF PORT MANSFIELD CHANNEL, TEXAS

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James M. Kieslich

I. INTRODUCTION

The Willacy County Navigation District in September 1957 dredged a 43,000-foot-long (13,106 meters) channel from the Gulf Intracoastal Waterway near Port Mansfield, Texas, through the lagoon and barrier island system to the Gulf of Mexico (Fig. 1). A pair of parallel jetties was constructed at the gulf entrance to the channel. Since the initial dredging, the channel has shoaled at the gulf end and the beaches on both sides of the channel entrance have undergone significant changes.

This report presents the results of an analysis of the behavior and characteristics of Port Mansfield channel, and provides useful information to engineers concerned with inlet design procedures, and to scientists involved in studies of coastal and tidal inlet processes.

II. REGIONAL SETTING

The predominant feature of the lower Texas coast is the almost continuous chain of barrier islands (Fig. 1). Padre Island, 115 miles (185 kilometers) in length, is the longest of these natural coastline features, extending from Corpus Christi Bay to Brazos Santiago Pass. In the Port Mansfield channel area, Padre Island is about 5,000 feet (1,524 meters) wide and varies in elevation from 2 to 16 feet (0.61 to 4.88 meters) above mean low water (MLW). Sand dunes back the gulf beaches in this area and extensive grass fields and mudflats comprise the area separating the sand dunes from the interior bay, Laguna Madre.

Laguna Madre is a narrow lagoon extending for 118 miles (189.90 kilometers) from the Encinal Peninsula at Baffin Bay to Port Isabel, Texas; depths in the lagoon range from 1 to 9 feet (0.30 to 2.74 meters). The lagoon is effectively divided into two bays by extensive mudflats 20 miles (32.19 kilometers) north of Port Mansfield channel. Generally, the only connection between these bays is the Gulf Intracoastal Waterway dredged through the mudflats. The southern bay covers an area of about 280 square miles (725 square kilometers) and the northern part, including Baffin Bay, covers about 215 square miles (557 square kilometers).

Port Mansfield channel is located in an area known as the Lower Rio Grande Valley which has a subtropical, semiarid climate, characterized by short, mild winters and long, hot summers. The average annual temperature is approximately 74° Fahrenheit (23° Celsius), although daily temperatures of 100° Fahrenheit (38° Celsius) are not uncommon in the western regions of the valley during the summer (Orton, 1967).

The average annual rainfall in the Port Mansfield area is 18 inches (45.72 centimeters), with the greatest amounts of precipitation from

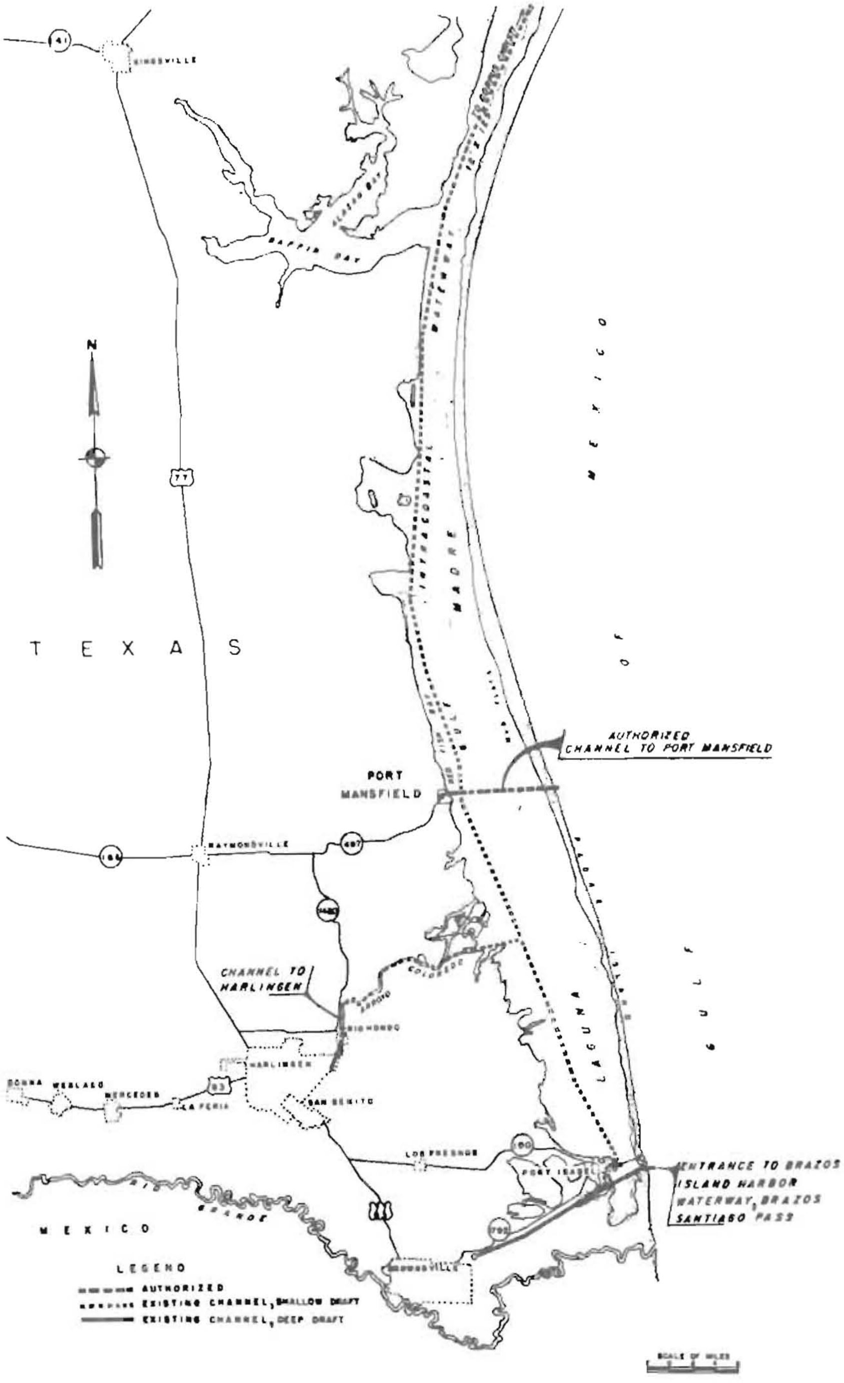


Figure 1. Port Mansfield regional setting (Hansen, 1960).

thunderstorms and hurricanes. The maximum average monthly rainfall of 4.65 inches (11.81 centimeters) occurs in September; the minimum average monthly rainfall is 1.15 inches (2.92 centimeters) in February (Orton, 1967).

The predominant wind directions in the Lower Rio Grande Valley are southeast, south-southeast, north, and north-northeast. Winds from the south and south-southeast occur 41 percent of the time and have a minimum monthly frequency of occurrence of 26 percent during December (Orton, 1967). Winds from the north and north-northeast are generally associated with the passage of strong frontal systems which occur primarily between November and February.

Hurricanes are important agents in the climatic complex of the lower Texas coast; the greatest effects to the nearshore environment result from wind-driven waves and storm surges. Hurricanes Carla (1961) and Beulah (1967) played a major role in sediment transport in the Port Mansfield channel area.

The dominant direction of wave approach at Port Mansfield channel is from the southeast, with a mean significant deepwater wave height, $\overline{H}_s$, of 3.5 feet (1.07 meters) and a mean significant wave period, $\overline{T}_s$, of 6 seconds (Bretschneider and Gaul, 1956). The second major direction of wave approach is from the northeast, with a mean deepwater $\overline{H}_s$ of 3.5 feet (1.1 meters) and a mean $\overline{T}_s$ of 5.5 seconds. These two predominant directions of wave approach correlate with the predominant local wind directions discussed earlier. The mean significant deepwater wave height and period for each major onshore direction are shown in Figure 2.

The tides at Port Mansfield channel are chiefly diurnal, with some mixed semidiurnal periods. The average diurnal tidal range at the gulf entrance to Port Mansfield channel is 1.40 feet (0.43 meter). The mean tide level is 0.7 foot (0.21 meter) above MLW. Tidal ranges in Laguna Madre are generally less than 0.5 foot (0.15 meter) except near inlets. Sustained winds from the south can cause water levels in Laguna Madre to increase 1 to 2 feet (0.30 to 0.61 meter) above normal level for 2 weeks or longer (Hansen, 1960).

III. CHANNEL DESIGN AND CONSTRUCTION

Port Mansfield channel was originally dredged through Padre Island in September 1957 to: (a) Provide a navigable outlet to the Gulf of Mexico for commercial and recreational vessels, and (b) enhance the seasonal migrations of fish populations between the Laguna Madre and the Gulf of Mexico (Texas Game and Fish Commission, 1956).

The channel was dredged 10 feet (3.05 meters) deep, with a bottom width of 100 feet (30.48 meters), from the Gulf Intracoastal Waterway to the gulf side of Padre Island (Fig. 3); from this point to the 16-foot (4.88 meters) depth contour in the Gulf of Mexico, the channel was dredged 16 feet deep and 250 feet (76.2 meters) wide at the bottom. Material

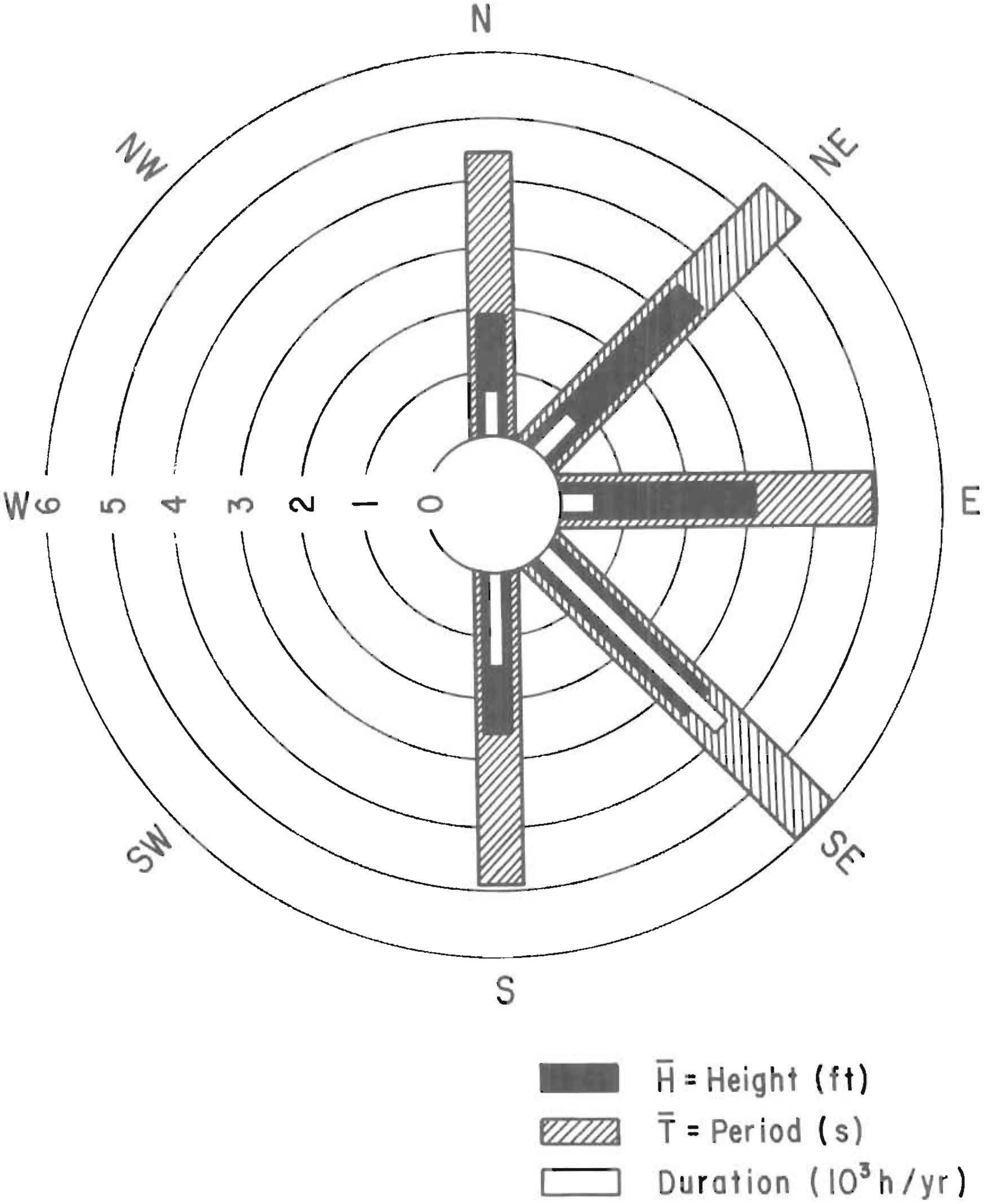


Figure 2. Summary of annual average deepwater wave statistics for Port Mansfield, Texas.

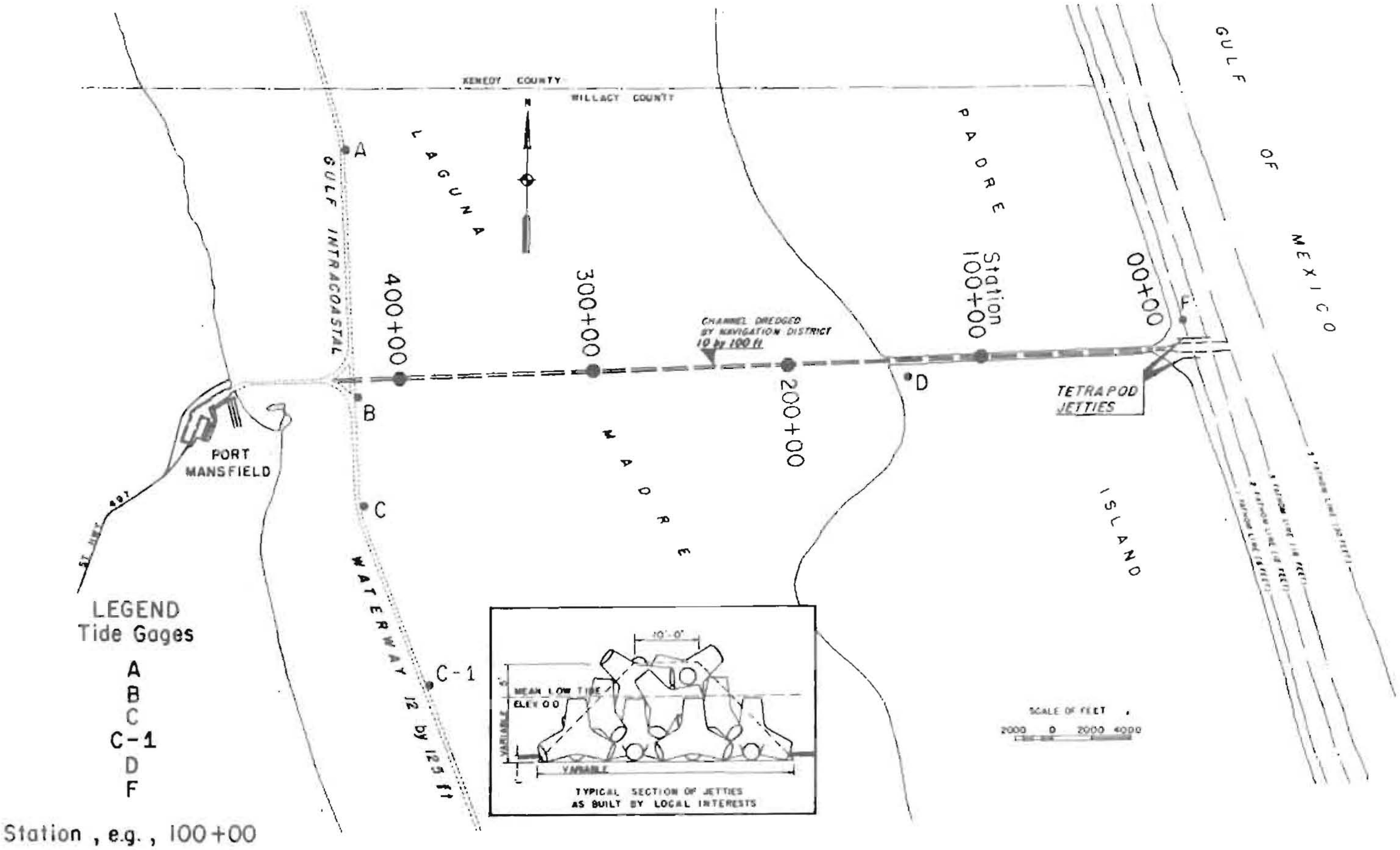


Figure 3. Local interests improvements, Port Mansfield (Hansen, 1960).

removed from Laguna Madre was placed in equally spaced piles 750 feet (228.6 meters) south of the channel (Fig. 4), anticipating its use as fill material for a proposed causeway connecting Padre Island with the mainland (Texas Game and Fish Commission, 1956). A 1-mile-wide gap in the dredged material near the Gulf Intracoastal Waterway was designed to provide for the free flow of water within Laguna Madre and also to permit easy passage for migrating fish (Texas Game and Fish Commission, 1956).

The material dredged from Padre Island was used to construct levees on the island along the north and south sides of the channel. The levees had a minimum crest elevation of 8 feet (2.44 meters) above MLW and were offset 700 feet (213.36 meters) from the channel centerline to provide protection from deposition resulting from storm tides (U.S. Army Engineer District, Galveston, 1958). The photo in Figure 4 shows the levees. Gulf entrance jetties were constructed parallel to, and offset 500 feet (152.40 meters) from the channel centerline (Fig. 5). The north jetty extended seaward approximately 1,600 feet (487.68 meters) to the 15-foot (4.57 meters) depth contour; the south jetty, about 900 feet (274.32 meters) long, extended to the 10-foot (3.05 meters) depth contour (Hansen, 1960). The crown elevation of both jetties was approximately 5 feet (1.52 meters) above MLW (Hansen, 1960). Precast concrete tetrapods weighing 5, 8, and 16 tons were used to construct each jetty because their porosity (about 50 percent) enhanced migration of small fish through the jetty (Texas Game and Fish Commission, 1956). Local interests considered longshore transport rates to be small enough to warrant porous jetty structures (U.S. Army Engineer District, Galveston, 1958).

Shortly after the project was completed in September 1957, storm wave action and scouring currents caused the landward ends of both the north and south jetties to be flanked, greatly decreasing their effectiveness. Surveys made in February 1958 to determine the extent of damage to the channel entrance indicated extensive subsidence of the jetties resulting from channels scoured 2 to 4 feet (0.61 to 1.22 meters) below the natural bottom along both sides of the north jetty and along the channel side of the south jetty (Hansen, 1960). At the shoreline, the north jetty crown was from 3 to 7 feet (0.91 to 2.13 meters) underwater with settlement progressively greater seaward (Hansen, 1960). The entire south jetty had also subsided although many of the tetrapods remained above water. This rapid subsidence was attributed to the tetrapods being placed on the sandy gulf bottom without a stone blanket to distribute the load and prevent erosion (Hansen, 1960). The extensive subsidence of the tetrapods coupled with the high-void ratio, permitted rapid shoaling of the channel entrance. The channel entrance was completely closed by January 1961.

On 9 September 1959, Congress authorized Federal improvements and maintenance of the Port Mansfield channel and jetty system. Construction on the new channel began in 1960, and the ocean entrance was widened and deepened. From stations -10+00.00 to -05+00.00 (negative stations are seaward of the 1957 shoreline), the authorized project dimensions were a

Figure 4. Port Mansfield channel, 15 March 1957.

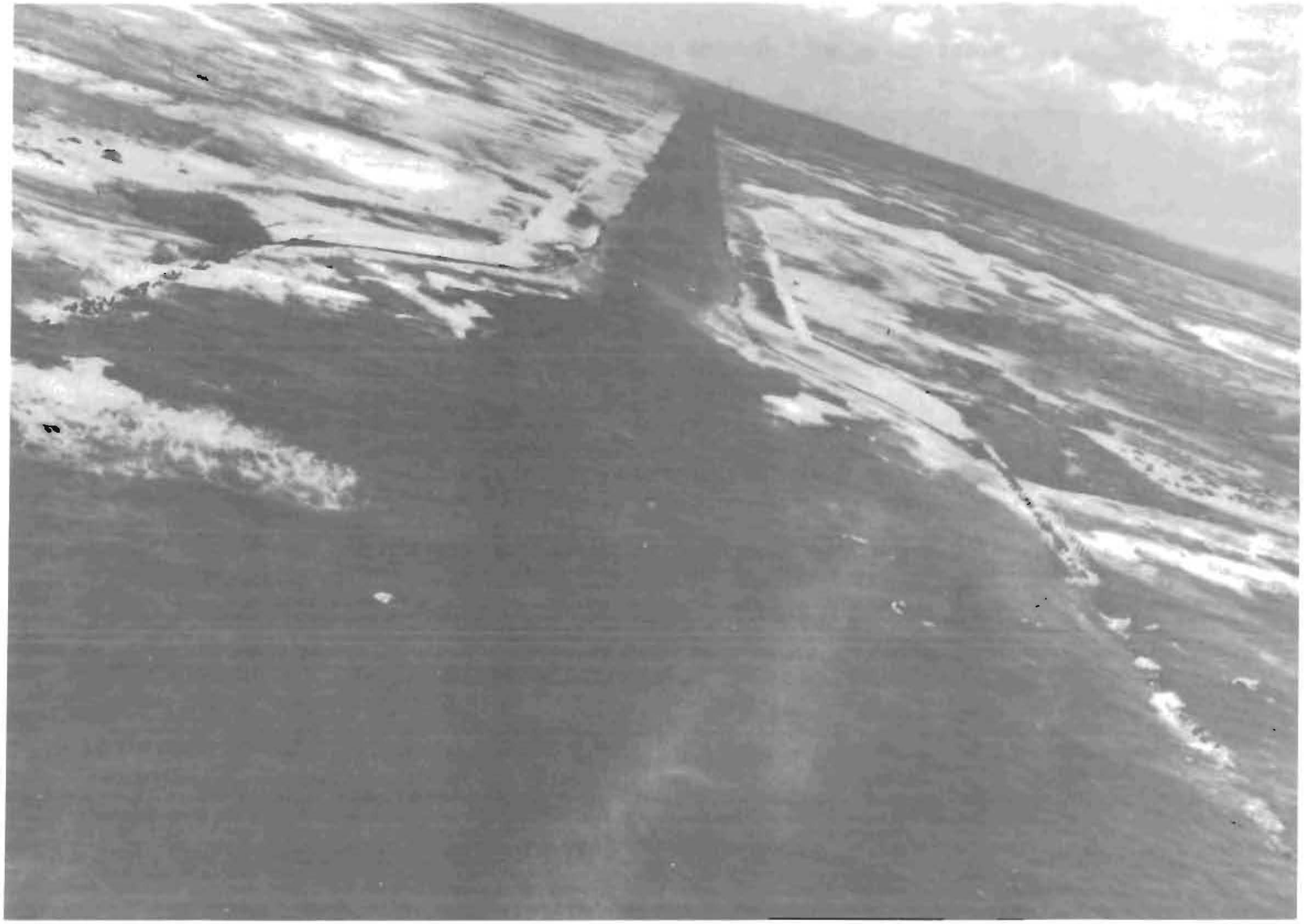


Figure 5. Port Mansfield channel entrance, November 1957.

28-foot (8.53 meters) depth and a 250-foot (76.2 meters) bottom width (Fig. 6); between stations 30+00.00 and -05+00.00 the dimensions were a 28-foot (8.53 meters) depth and a 100-foot (30.48 meters) bottom width. The channel flared to a bottom width of 300 feet (91.44 meters) near station 20+00.00 to provide a turning basin. All design dimensions were determined for commercial navigation requirements and hydraulic and stability criteria were secondary or nonexistent. From stations 30+00.00 to 400+00.00, the channel was dredged to a depth of 18 feet (5.49 meters) with 2,300,00 cubic yards (1,758,580 cubic meters) of sand removed. The sand dredged from Laguna Madre was placed in the disposal area designated in 1957. The material placed on Padre Island was used to repair the storm protection levees which parallel the channel. Sand dredged from the channel entrance was placed in the Gulf of Mexico beyond the 25-foot (7.62 meters) depth contour where it was felt that little of the dredged material would return to the channel.

Impermeable, rubble-mound jetties replaced the tetrapods which by 1962 had settled completely into the sandy gulf bottom. The new north jetty was offset 450 feet (137.16 meters) from the channel centerline and extended 2,300 feet (701.04 meters) seaward from station 08+50.00 (Fig. 6); the new south jetty was offset 550 feet (167.64 meters) from the channel centerline and extended 2,270 feet (691.9 meters) from station 03+30.00. Length of the north jetty was determined by its requirements as a breakwater; length of the south jetty was primarily determined by anticipating the amount of sand that would accumulate on the beach adjacent to the jetty during a 10-year period (Hansen, 1960). The channel entrance was opened in May 1962. In 1965, riprap revetment was tied into the toes of the north and south jetties to prevent wave-induced erosion of the shoreline inside the jetties.

IV. INLET HYDRAULICS

The characteristics and configuration of Port Mansfield channel are controlled by wave action and by the flow of water between the gulf and Laguna Madre. The quantity of water exchanged and the velocities attained within the channel are dependent upon the gulf tidal range, bay geometry, and channel hydraulic resistance characteristics.

The quantity of water exchanged through the inlet, the maximum current velocities attained over a tidal cycle, and the ratio of the bay to ocean tidal amplitude are used in this section to determine the efficiency of the inlet in filling and draining the bay. The capability of the inlet to fill the bay is investigated by establishing Keulegan's (1967) coefficient of repletion for the inlet-bay system. Records of tide gages installed in the Laguna Madre are used to define the surface area of the bay influenced by the tide. Velocity data obtained over four separate tidal cycles permit accurate determination of the tidal prism for the periods of measurement.

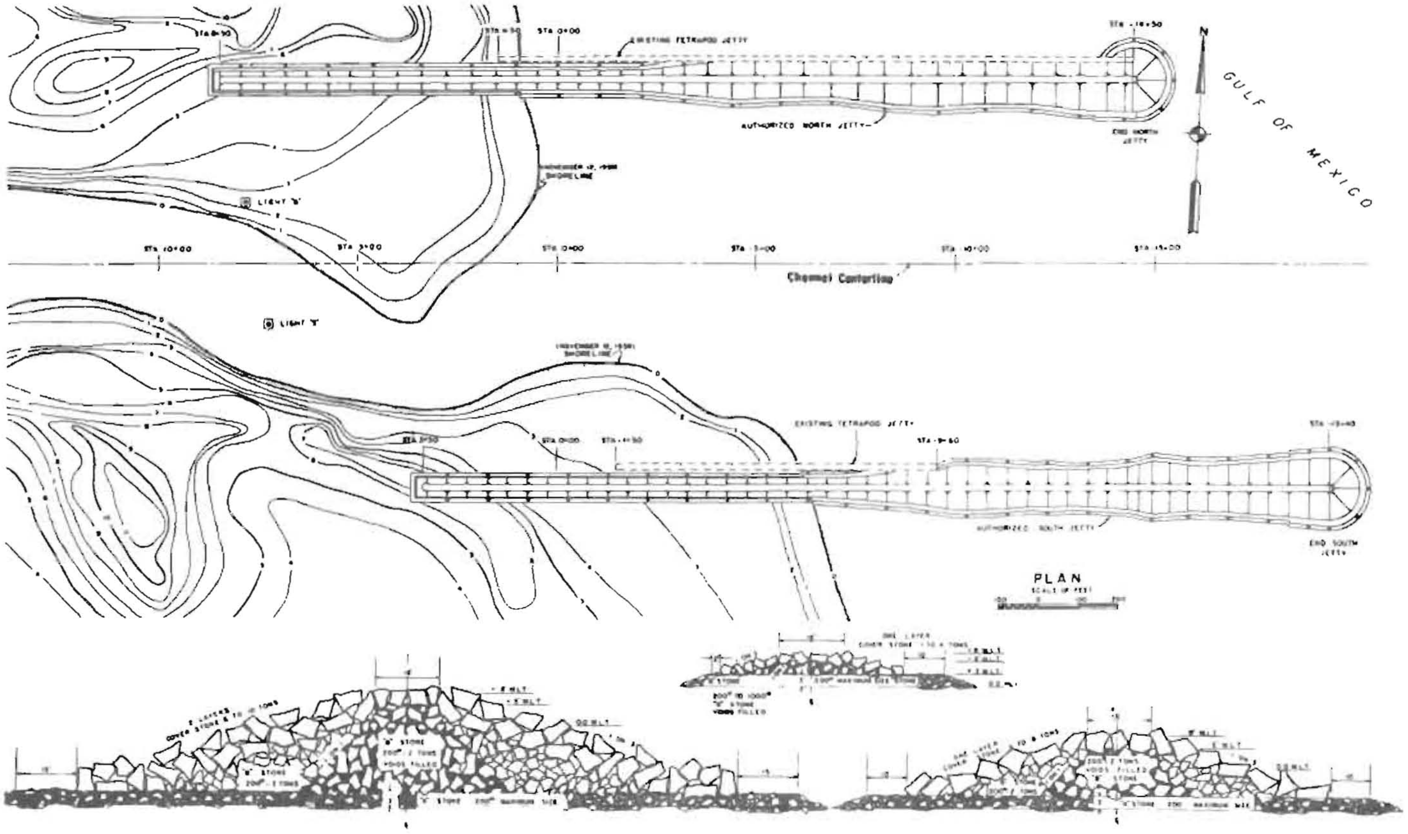


Figure 6. Typical jetty cross section and plan (Hansen, 1960).

1. Tide Data.

Six tide gages were operated in 1962 and 1963 at the locations shown in Figure 3. Records from the Laguna Madre gages were analyzed to delineate the effective area of the bay, A , i.e., the surface area of the bay influenced by tidal exchange through the channel. Gages A, B, and C showed little indication of diurnal tidal range, and thus were taken to be the northern, western, and southern limits (respectively) of the tidal prism. Gage C was moved to location C-1 in April 1963 and for some reason the fluctuations of gage C-1 exceeded those at location C (Table 1). Based on these limits the effective area of the bay is approximately 2.2×10^8 square feet (2.04×10^7 square meters). This value may be too large (perhaps as much as double the actual value) since the negligible tidal ranges over several months at gages A, B, and C indicate that the gages are outside the influence of the tidal prism. Lack of additional bay tide gages also precluded definition of the bay area using tidal discharge measurements and bay tidal range records.

Table 1. Mean tidal ranges of Port Mansfield gages.

Gage	Mean range
A	Negligible
B	Negligible
C	Negligible
C-1	0.20 ft (0.06 m)
D	0.85 ft (0.26 m)
F	1.40 ft (0.43 m)

2. Velocity Data.

A current velocity measuring station was established in the land-cut part of Port Mansfield channel near station 100+00.00 (Fig. 3). This current monitoring station was used to obtain current measurements over four separate 25-hour periods during 1962 and 1963. The data are shown in Appendixes A to D and are discussed in this subsection. The tide records did not indicate any significant wind setup in the bay during any of the four measurement periods.

Velocity profiles were taken on 12 and 13 May 1962 following the inlet opening on 5 May. Velocity measurements, a discharge curve, and tidal data for this period are given in Appendix A and summarized in Table 2. The winds during this period were from the southeast with an average speed of about 17 miles per hour (27.36 kilometers per hour). The data show that ebb discharge conditions dominated, with a total ebb-flood discharge ratio of 6.8. The maximum velocity occurred during ebb discharge and was 1.73 feet per second (0.53 meter per second).

Table 2. Summary of velocity surveys for Port Mansfield channel.

Date	Duration (h)		Max velocity (ft/s)		Max discharge rate (ft^3/s)		Tidal prism $ft^3 \times 10^7$		Ratio Ebb-Flood	Area below MSL (ft^2)
	Flood	Ebb	Flood	Ebb	Flood	Ebb	Flood	Ebb		
12 and 13 May 62	5.5	18.5	0.80	1.75	2,500	5,500	3.92	27.0	6.9	3,146
1 and 2 Aug. 62	14.0	10.0	1.10	2.46	3,200	7,200	9.58	18.3	1.9	2,928
18 and 19 Dec. 62	13.0	11.0	2.67	1.33	8,000	4,000	19.60	7.84	0.4	3,000
12 and 13 June 63	10.5	13.5	2.22	2.40	5,500	6,000	13.50	22.2	1.6	2,471

A second series of velocity measurements in the channel was taken during 1 and 2 August 1962, about 3 months after the inlet opening. During this period the prevailing winds were from the southeast, with an average speed of approximately 13 miles per hour (20.92 kilometers per hour). The data for this survey are given in Appendix B. The maximum velocity was 2.46 feet per second (0.75 meter per second) during ebb flow; the total ebb-flood discharge ratio of 1.9 indicated ebb flow again dominated.

The next set of velocity measurements was made 18 and 19 December 1962; the data are given in Appendix C. Winds for this period averaged 12 miles per hour (19.31 kilometers per hour) from the southeast. The maximum velocity over the tidal cycle was 2.67 feet per second (0.81 meter per second) during floodflow. Contrary to previous conditions, the flood discharge exceeded ebb as indicated by an ebb-flood discharge ratio of 0.4.

The final velocity measurements in the channel were taken the following year on 12 and 13 June 1963; data for this survey period are presented in Appendix D. The maximum velocity over the tidal cycle was 2.4 feet per second (0.73 meter per second) during ebb discharge. The ebb discharge again exceeded the flood during this period by a ratio of 1.6.

3. Determination of Keulegan Repletion Coefficient.

One of the most general and easily applied approaches to the problem of tidal flow through inlets was given by Keulegan (1967). Keulegan considered the hydraulic characteristics of a simplified inlet-bay system to be governed by the "so-called storage law," and made the following simplifying assumptions concerning the physical conditions of the inlet-bay system:

(a) The ocean tide is sinusoidal,

(b) the inlet channel is prismatic,

(c) the inlet depth is great compared to the tidal range,

(d) bay walls are vertical,

(e) inertia of the flow is negligible, and no density currents are present,

(f) inflow into the bay from other sources is negligible, and

(g) the length of the bay is much less than the tidal wavelength.

By simultaneous application of the equations of continuity and conservation of energy, Keulegan developed an expression relating the time rate of change in the bay water surface elevation to the instantaneous seawater elevation. The expression contained a factor which he termed *coefficient of filling or repletion* that expressed the inlet's capability to fill and empty the bay during a tidal cycle. This repletion coefficient "summarizes the effects of the channel and the basin dimensions, of the roughness of the walls, and of the period and range of the tidal fluctuations on the limits (and phases) of the water level changes in the basin" (Keulegan, 1967). An accurate determination of the repletion coefficient is important in defining the hydraulics and stability of tidal inlets, because predictions of bay water surface levels are affected by changes in the repletion coefficient, including estimates of velocities through the inlet and the phase lag of the bay tide. The coefficient of repletion, K, is given by:

$$K = \frac{TA_C}{2\pi A_B}\sqrt{\frac{2g}{a_o\ (K_{en} + K_{ex} + fL/4R)}} \qquad (1)$$

where:

A_C = inlet cross-sectional area below MSL (2,886 square feet; mean area from survey in Appendixes A to D),

A_B = bay area in square feet (2.2 by 10^8),

T = tidal period (86,400 seconds; diurnal tide),

g = acceleration of gravity (32.2 feet per second squared),

a_o = ocean tidal amplitude (0.7 foot; gage F),

K_{en} = entrance loss coefficient (0.1),

K_{ex} = exit loss coefficient (1.0),

f = Darcy friction factor (0.03),

L = inlet length (15,000 feet; from channel entrance through tidal flats), and

R = hydraulic radius (14 feet; mean from survey in Appendixes A to D).

Using the given values for Port Mansfield, a Keulegan coefficient of 0.57 is computed, indicating that filling of the bay will be incomplete.

Two types of field observations are available to validate the Keulegan coefficient, K. The first is the ratio of the bay tidal amplitude, a_b, to the ocean tidal amplitude, a_o. The ratio of a_b/a_o is a function of K (Fig. 7) and for $K = 0.57$, $a_b/a_o = 0.60$. Using the a_b determined from gage D of 0.43 foot and a_o from gage F of 0.700 yields an a_b/a_o ratio of 0.61.

A second independent approximation of K can be made using the maximum velocities, V_{max}, over a tidal cycle (O'Brien and Dean, 1972):

$$V'_{max} = \frac{1}{2\pi} \frac{V_{max}}{a_o} \frac{A_C}{A_B} T \quad , \tag{2}$$

where: V'_{max}, a dimensionless maximum velocity coefficient, is a function of K (Fig. 7) and for $K = 0.57$, $V'_{max} = 0.49$. A mean value for all V_{max} of 1.84 feet per second (0.67 meter per second) from Table 2, and a mean A_C of 2,886 square feet (259.7 square meters) for the four survey periods yield a V'_{max} of 0.47. Table 3 shows the percent difference from the measured parameters and those predicted from K.

Table 3. Comparison of predicted and measured hydraulic parameters.

Comparison	a_b/a_o	V'_{max}
Predicted	0.60	0.49
Actual	0.61	0.47
$\left(\text{pct difference, } \frac{\text{actual-predicted}}{\text{actual by } 100}\right)$	2	-4

V. SHORELINE CHANGES AND CHANNEL SHOALING

This section summarizes the inlet channel and adjacent shoreline changes from 1957 to 1975. A detailed discussion of short-term changes and related figures is in Appendix E.

As shown in Figure 8, a fillet of sand on the south (updrift) side of the channel accumulated rapidly from the original shoreline condition (1957) to the time of completion of the impermeable jetties (1962). Thereafter, the rate of migration of the MHW contour-jetty intercept decreased significantly. By 1975 this intercept was 1,250 feet (381 meters) seaward of the original shoreline.

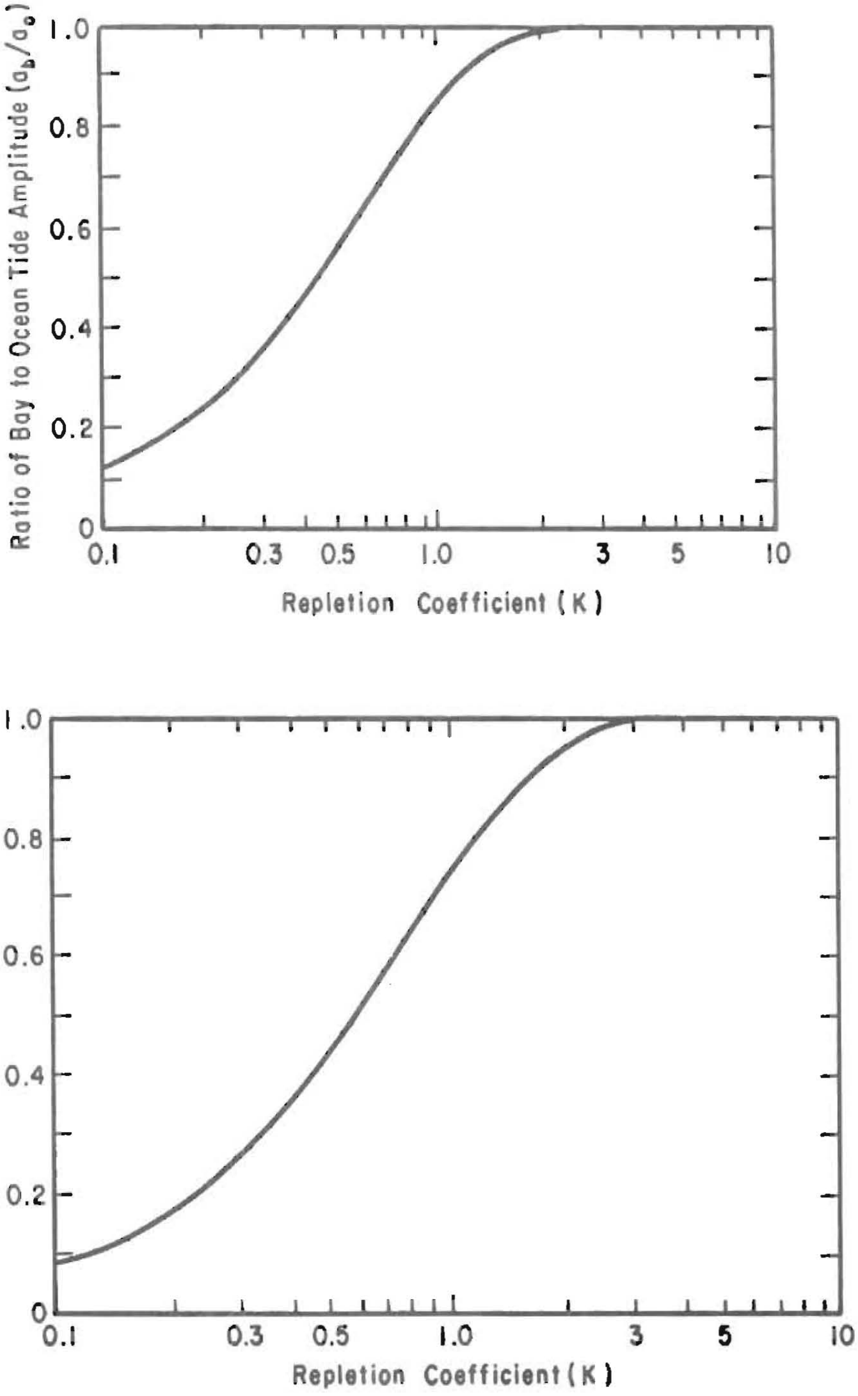
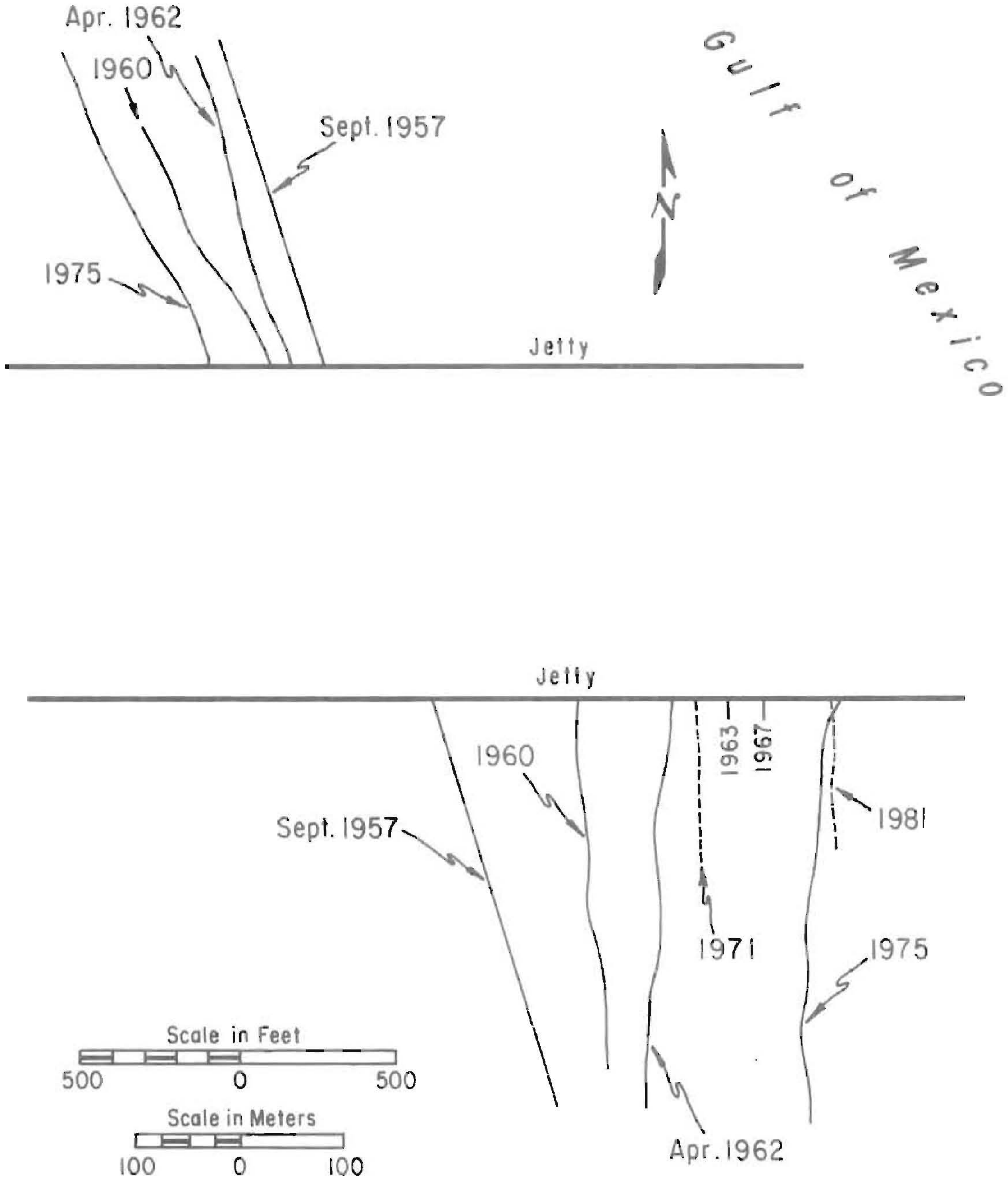


Figure 7. Variation of a_b/a_o and V'_{max} with repletion coefficient, K (O'Brien and Dean, 1972).



Note: 1971 and 1981 predicted locations (Hanson, 1960)

Figure 8. Shoreline contours at MHW, September 1957 to September 1975 (comparison of actual versus predicted shoreline-jetty intercepts).

On the north (downdrift) side of the channel, landward migration of the MHW contour-jetty intercept generally occurred, with a net movement of 320 feet (97.6 meters) between 1957 and 1975. Thus, the familiar pattern of accumulation on the updrift side and erosion on the downdrift side of a jettied inlet is evident at Port Mansfield.

As discussed previously, the length of the south jetty was determined primarily by estimating the amount of material that would accumulate in the fillet during a 10-year period, based on an estimated net northerly transport rate of 300,000 cubic yards (229,380 cubic meters) per year (Hansen, 1960). During the 10 years (1961-1971) after jetty construction started, the advance of the fillet was double the rate predicted, and the actual 1971 MHW line was located at the predicted 20-year position (Fig. 8).

Details of changes in the channel hydrography are discussed in Appendix E using fill and scour maps and aerial photos. In the period between the initial construction of the channel in 1957 and the completion of the Federal project in 1962, slightly over 1 million cubic yards of material accumulated in over 7 miles of channel landward of the gulf shoreline. The greatest rate of deposition occurred in the land-cut part of the channel where material was carried from the gulf by waves and currents (Table 4). An unknown part of the deposition also resulted from wind-blown sand deposits. Farther landward in Laguna Madre, wind-driven wave and currents probably eroded the dredged material that was deposited on the south side of the channel and transported the material into the channel at an average rate of about 5 cubic yards per year per foot of channel. Unfortunately, data are not available to calculate the deposition rate in these areas after 1962. However, maintenance dredging of the seaward part of the channel began in 1962, and the annual dredged volumes are given in Table 5; locations and dates of the dredging are given in Appendix E, Table E-3. Based on these volumes, and assuming that the amount dredged is the minimum amount of deposition in the gulf entrance area, an average annual rate of deposition of 32 cubic yards per year per foot of channel was computed. This deposition is four times the maximum rate of the interior channel regions, and corresponds to a total annual rate of about 355,000 cubic yards (271,433 cubic meters) per year, mostly all littoral material transported to the inlet by wave and current action.

VI. LONGSHORE TRANSPORT

Optimum tidal inlet design and maintenance require adequate knowledge of the longshore transport rate. Estimates of this rate for the Port Mansfield channel area are developed in this section.

Hansen (1960) probably gave the first estimate of the longshore transport rates for the Port Mansfield channel area, which he obtained from maintenance dredging records for Brazos Santiago Pass. Hansen assumed the shoreline orientation and wave energy distribution were the same at both sites, and reported a net northerly transport rate of 300,000 cubic yards per year (229,380 cubic meters per year).

Table 4. Deposition in Port Mansfield Channel, September 1957 to April 1962.

Station	Amount deposited		Deposition rate	
	yd^3	m^3	$yd^3/yr/ft$	$m^3/yr/ft$
10+00 to 150+00 (Padre Island)	512,960	392,209	8.0	6.1
150+00 to 320+00 (eastern Laguna Madre)	370,270	283,108	4.8	3.7
320+00 to 400+00 (western Laguna Madre)	223,120	170,598	6.1	4.7
Total	1,106,350	845,915		
Average			6.2	4.8

Table 5. Annual maintenance dredging in gulfward channel section, 1962 to 1973.

Year	Amount dredged	
	yd^3	m^3
1962	1,238,000[1]	946,000
1963	236,159	180,560
1964	303,140	321,780
1965	201,130	153,780
1966	409,390	313,430
1967	516,190	394,680
1968	395,620	302,490
1969	217,940	166,640
1970	341,590	261,180
1971	394,390	301,550
1972	617,500	472,140
1973	277,900	212,480
Total[1]	3,910,980	2,990,330

[1] Initial channel dredging not included in total maintenance amount.

Another estimate of the longshore transport rate is determined from the longshore component of energy flux in the surf zone, P, which can be approximated by assuming conservation of energy flux in shoaling waves, using the small-amplitude wave theory, and evaluating the energy flux relation at the breaker position (U.S. Army, Corps of Engineers, Coastal Engineering Research Center, 1975).

P is given by:

$$P = \frac{\rho g^2}{64\pi} T H_o^2 K_r^2 \sin 2\alpha_b \quad , \qquad (3)$$

where:

ρ = water density (2 slugs per cubic foot),

g = acceleration due to gravity (32 feet per second squared),

T = wave period (seconds),

H_o = significant wave height (feet),

K_r = refraction coefficient,

α_b = angle between breaker and shoreline (degrees),

and

p = in foot-pound per foot-second.

Using the wave hindcast data by Bretschneider and Gaul (1956) for the Gulf of Mexico off Brownsville, Texas, and equation (3), the annual longshore components of energy flux were calculated (Table 6). Since Bretschneider and Gaul reported significant wave height, the values in Table 6 were divided by two because values computed using the significant wave height are approximately twice the value of the exact energy flux (U.S. Army, Corps of Engineers, Coastal Engineering Research Center, 1975).

Table 6. Longshore components of wave energy (foot-pound per second per foot of beach).

Components	Values
P (northward)	83.7
P (waves from north)	61.8
P net	21.9

The relationship between longshore transport rate, Q, cubic yards per year, and P is given by (U.S. Army, Corps of Engineers, Coastal Engineering Research Center, 1975):

$$Q = 7500\ P \qquad (4)$$

Table 7 shows the estimated longshore transport rate for Port Mansfield channel using equation (4).

Table 7. Estimated longshore transport rates for Port Mansfield channel.

Direction	Rates	
	yd^3/yr	m^3/yr
Q northward	627,750	480,000
Q southward	463,500	354,392
Q net (to north)	164,250	125,586
Q gross	1,091,250	834,370

VII. INLET STABILITY

The fill and scour maps and aerial photos (Sec. V) indicate the marked tendency of Port Mansfield channel to fill. Annual dredging has been necessary to maintain a navigable channel. With this documentation of actual inlet instability, several analytical methods for predicting channel stability can be tested.

The first of these methods uses observed channel properties to establish equilibrium criteria. Jarrett (1976) found that when a gulf coast inlet was in equilibrium with its hydraulic environment, the area of the throat was related to the tidal prism by:

$$A_C = 5 \times 10^{-4}\ P^{0.84} \quad , \qquad (5)$$

where A_C is the minimum flow area below MSL (square feet), and P is the tidal prism for a spring or diurnal range (cubic feet). The validity of equation (5) may be questionable for *small* gulf inlets such as Port Mansfield Channel, since the associated maximum velocity is significantly less than that of other U.S. coasts due to the diurnal gulf tide.

The four velocity surveys discussed in Section IV yielded an average tidal prism of 1.52×10^8 cubic feet (4.30×10^6 cubic meters). Therefore, according to equation (5), the equilibrium throat area should be 3,730 square feet (347 square meters). A single throat cross section was available for May 1962, immediately after the channel was dredged, and indicated a cross-sectional area of 5,100 square feet (473.79 square meters). Thus, from equation (5) it appears that the channel was dredged too large for the tidal prism to maintain the cross-sectional area, which caused the observed deposition.

Bruun and Gerritsen (1960) presented a second method to channel stability which related the tidal prism, P (in cubic yards), to the net longshore transport, M (in cubic yards per year), by the ratio P/M. Channels having a value of P/M greater than 300 were very stable, and channels with P/M values less than 100 tended to be unstable. Port Mansfield channel with a P/M value of 38 is well within the range of unstable inlets, tending toward deposition, and the channel entrance shoaling is correctly predicted.

The two analytical methods presented will give a gross indication of channel stability. For a detailed analysis of why the channel is unstable, equilibrium criteria proposed by Escoffier (1940) and amplified by O'Brien and Dean (1972) can be used. Escoffier assumed a critical velocity, V_{cr}, existed which was just sufficient to initiate bedload transport in an inlet channel. If the mean velocity at the peak of the ebbtide and floodtide, V_{max}, that developed in the channel was less than V_{cr}, the channel would fill; however, if V_{max} was greater than V_{cr}, the channel would erode. Escoffier's stability concept is shown in Figure 9, where V_{max} is plotted against the inlet cross-sectional area, A_C. Escoffier suggested a value of 3 feet per second for V_{cr}.

Considering the V_{max} versus A_C curve, if the channel area lies on the AB segment of the curve, any decrease in channel area will result in a decrease in V_{max} and a further decrease in channel area toward closure. If the channel area lies on segment CD, the channel will erode toward point E; if the area lies on segment EF, the channel will shoal toward point E. This suggests point E is the stable channel cross-sectional area.

Figure 10 is a V_{max} versus A_C curve for Port Mansfield channel. K values were calculated from equation (1), using the values of the variables listed on page 23, but varying A_C, and substituting (A_C/jetty spacing) for the hydraulic radius, or in effect holding the channel width constant and varying the channel depth. The K values were used in Figure 7 to determine appropriate values of V'_{max}. V_{max} values were then calculated using equation (2).

The critical velocity for Port Mansfield channel may be estimated from Bruun and Gerritsen (1960):

$$V_{cr} = C\sqrt{\tau_s/\rho g} \quad , \qquad (6)$$

where,

C = Chezy coefficient,

τ_s = stability bottom shear stress (0.092 pound per square foot),

ρ = density of seawater (slugs per cubic foot),

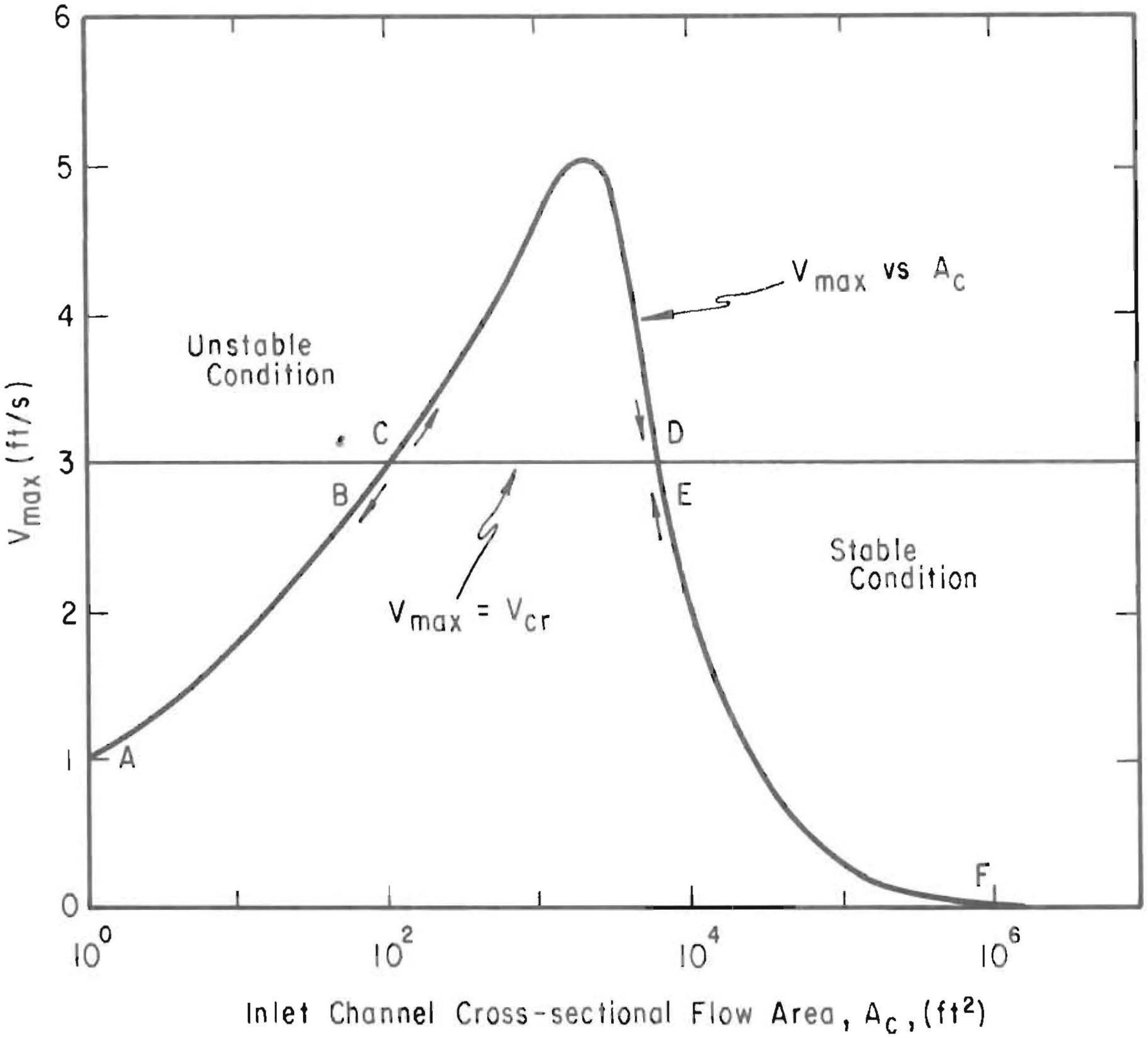


Figure 9. Illustration of Escoffier's (1940) stability concept (O'Brien and Dean, 1972).

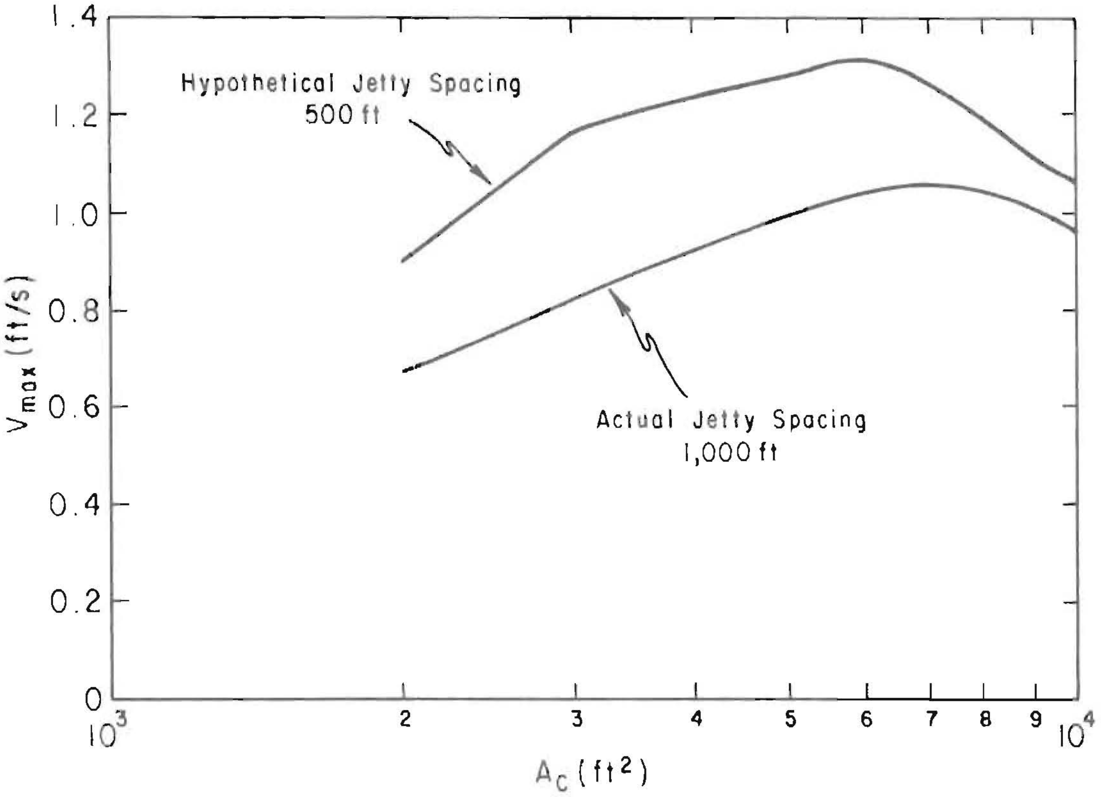


Figure 10. V_{max} versus A_C stability curve for Port Mansfield channel.

and

g = acceleration of gravity (foot per second squared).

Using equation (6) with (Chow, 1959):

$$C = \frac{1.49}{n} R^{1/6} \quad , \tag{7}$$

where,

n = Manning's coefficient (assumed 0.024),

R = hydraulic radius in feet (area at peak of curve in Fig. 10 divided by jetty spacing).

V_{cr} was calculated as approximately 3.2 feet (0.98 meter) per second. This generally agrees with the values suggested by Escoffier (1940) for V_{cr}. Since a V_{cr} value of 3.2 feet per second is much greater than the peak of the actual curve for Port Mansfield (Fig. 10), a stable cross section is impossible to achieve with the present jetty spacing. Even if the jetty spacing was reduced to 500 feet, sufficient velocities could not be developed to provide scour of the channel (Fig. 10, dashline).

The instability of the channel results from the large head loss due to friction in the extremely long channel, e.g., in calculating the channel length required for stability assuming a $V_{max} = V_{cr}$ of 3.2 feet (0.98 meter) per second and equation (2) to solve for V'_{max}. These yield a stability K value of 1.2, and solving for channel length in equation (1) gives a value of 1,755 feet (534.92 meters). Comparing this with the land-cut part (with A_c = 2,886 square feet) of the channel (15,000 feet or 4,572 meters) shows the present channel length is too long and is the major factor prohibiting natural channel stability.

VIII. CONCLUSIONS AND RECOMMENDATIONS

This study documents the hydraulic and sedimentary characteristics of Port Mansfield channel and evaluates its behavior from construction to the present. Port Mansfield channel is unstable; an average annual dredging rate of about 350,000 cubic yards (292,794 cubic meters) per year is necessary to maintain design channel dimensions. The major areas of deposition in the channel are in the Laguna Madre section and at the gulf entrance.

Predictions of inlet stability using the V_{max} versus A_c relationship developed by Escoffier (1940), the prism versus area relationship developed by O'Brien (1969), and the ratio of tidal prism to the net annual longshore transport developed by Bruun and Gerritsen (1960), were found to predict the unstable nature of the channel.

After jetty construction in 1962, the south (updrift) beach accreted significantly for 2 to 3 years, with concurrent erosion on the north (downdrift) beach. However, the accretion and erosion subsequently decreased and the beaches achieved a relatively high degree of stability. Substantial bypassing was achieved, and measurements indicated a corresponding increase in the entrance channel shoaling rates. By 1975, the beach adjacent to the south jetty had migrated seaward 1,250 feet (381 meters) from its 1957 position, while the north beach receded 320 feet (97.6 meters).

The hydraulic capacity of Port Mansfield channel was investigated by computing Keulegan's (1967) coefficient of repletion for the inlet-bay system. The repletion coefficient, 0.57, indicated that because of channel and bay geometry and the gulf tidal characteristics, filling of the bay was incomplete. The volume of water exchanged through Port Mansfield channel was small when compared to the volume of Laguna Madre (<1 percent). Thus, the channel did not significantly affect circulation and water quality in the bay. However, sufficient water is probably exchanged to prevent exceedingly high salinities from developing near the bay end of the channel.

A wave climatology for the inlet area was summarized by calculating a deepwater mean wave height and period for each of the major onshore wave directions. The dominant direction of wave approach at Port Mansfield channel is from the southeast, with a mean significant wave height of 3.5 feet. Using the longshore component of wave energy flux to calculate the longshore transport rate, a net transport rate of 164,250 cubic yards (125,586 cubic meters) per year to the north is predicted, with a gross transport rate of 1,091,250 cubic yards (834,370 cubic meters) per year. A net rate of 300,000 cubic yards (228,000 cubic meters) per year was given by Hansen (1960).

With the present jetty spacing and channel length, a stable channel cross section is impossible to achieve. Velocities developed in the channel are insufficient to provide natural scour because of large head losses resulting from friction in the extremely long channel. The intercepted longshore transport greatly exceeds the channel's sediment transport capability, resulting in extensive shoaling. To hydraulically optimize the channel, the cross section would have to be reduced to about 7,000 square feet but the resulting average depth of 7 feet would conflict with navigation requirements.

To reduce dredging costs, studies are necessary to determine the feasibility of extending the south jetty or providing a mechanical bypassing system for transferring sediment to the downdrift beach.

LITERATURE CITED

BRETSCHNEIDER, C.L., and GAUL, R.D., "Wave Statistics for the Gulf of Mexico Off Brownsville, Texas," TM-85, U.S. Army, Corps of Engineers, Beach Erosion Board, Washington, D.C., Sept. 1956.

BRUUN, P., and GERRITSEN, F., *Stability of Coastal Inlets*, North Holland Publishing Co., Amsterdam, 1960.

CHOW, V.T., *Open Channel Hydraulics*, McGraw-Hill, New York, 1959.

ESCOFFIER, F.F., "The Stability of Tidal Inlets," *Shore and Beach*, Vol. 8, No. 4, 1940, pp. 114-115.

HANSEN, E.A., "Studies of a Channel through Padre Island, Texas," *Journal of the Waterways and Harbor Division*, ASCE, Vol. 86, No. WW3, 1960, pp. 63-82.

HAYES, M.O., "Hurricanes as Geological Agents: Case Studies of Hurricanes Carla 1961 and Cindy 1963," Bureau of Economic Geology Report of Investigations 00.61, 1967.

JARRETT, J.T., "Tidal Prism-Inlet Area Relationships," GITI Report 3, U.S. Army, Corps of Engineers, Coastal Engineering Research Center, Fort Belvoir, Va., and U.S. Army Engineer Waterways Experiment Station, Vicksburg, Miss., Feb. 1976.

KEULEGAN, G.H., "Tidal Flow in Entrances Water Level Fluctuations of Basins in Communication with Seas," CTH Technical Bulletin No. 14, 1967.

O'BRIEN, M.P., and DEAN, R.G., "Hydraulics and Sedimentary Stability of Coastal Inlets," *Proceedings of the 13th Coastal Engineering Conference*, 1972.

ORTON, R., et al., "Climate Guide: The Lower Rio Grande Valley of Texas," MP-841, Texas Agricultural Experiment Station, 1967.

TEXAS GAME AND FISH COMMISSION, "Texas Game and Fish," Jan. 1956.

U.S. ARMY, CORPS OF ENGINEERS, COASTAL ENGINEERING RESEARCH CENTER, *Shore Protection Manual*, Vols. I, II, and III, 2d ed., Stock No. 008-022-00077, U.S. Government Printing Office, Washington, D.C., 1975, 1,160 pp.

U.S. ARMY ENGINEER DISTRICT, GALVESTON, "Review of Reports on Gulf Intracoastal Waterway, Tributary Channel to Port Mansfield, Texas," Galveston, Tex., May 1958.

WATTS, G.M., "Data Collection at Port Mansfield, Texas, Entrance Channel," Report to Tidal Hydraulics Committee, Oct. 1960.

APPENDIX A

VELOCITY MEASUREMENTS, DISCHARGE CURVE, AND TIDAL DATA FOR 12 AND 13 MAY 1962.

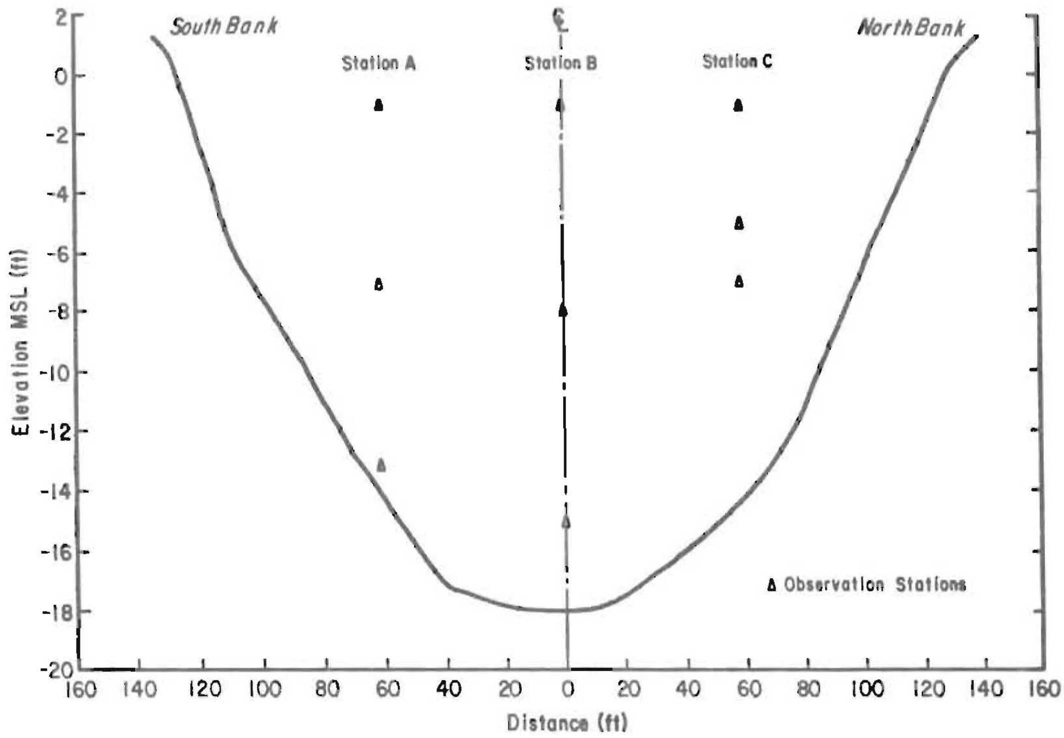


Figure A-1. Cross section of Port Mansfield channel, station 10+000, 12 May 1962.

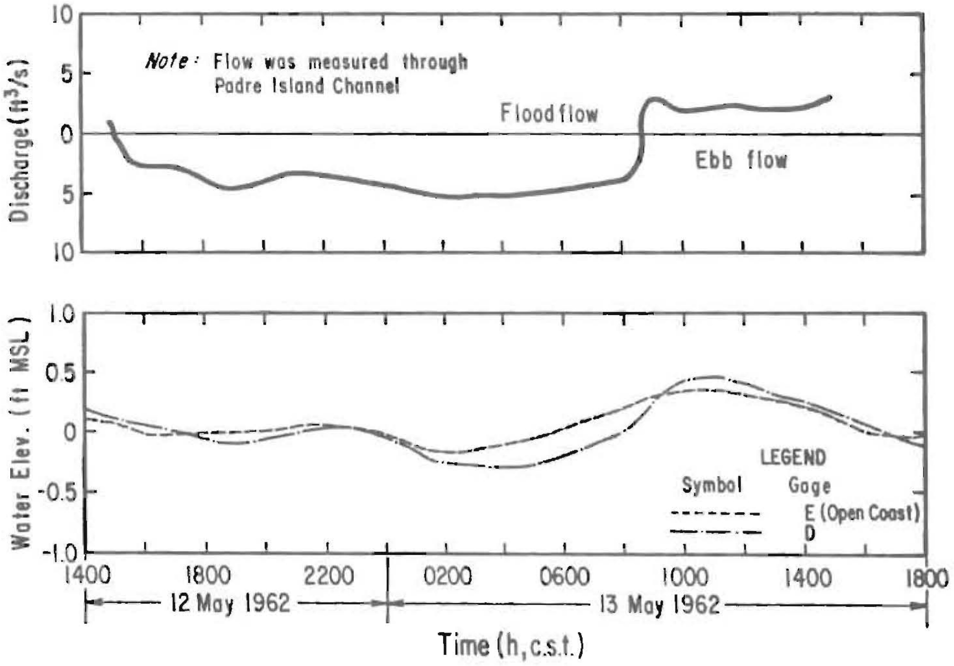


Figure A-2. Observed tidal levels and flow, Port Mansfield channel, 12 and 13 May 1962.

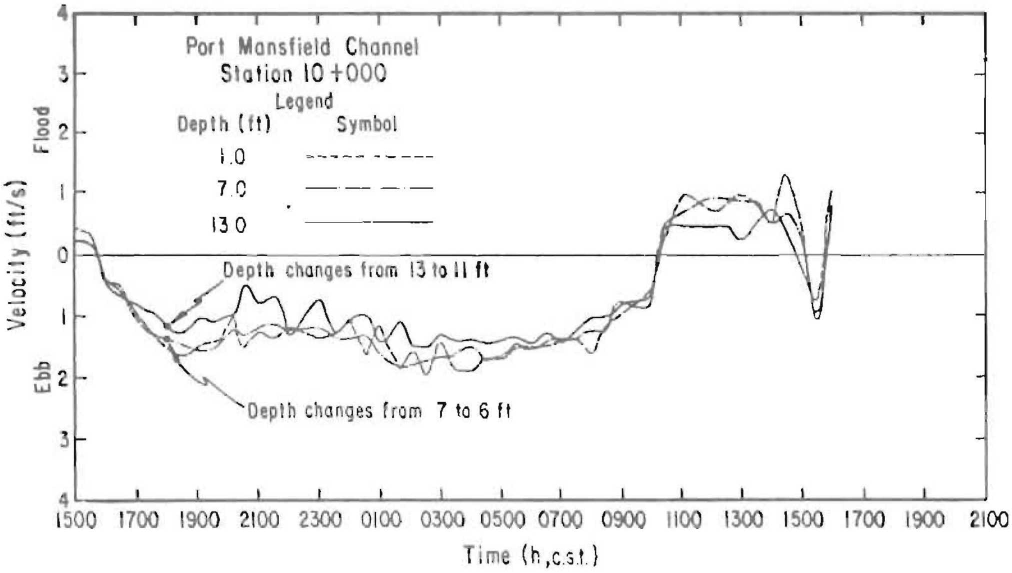


Figure A-3. Plot of velocity versus time at station A, 12 and 13 May 1962.

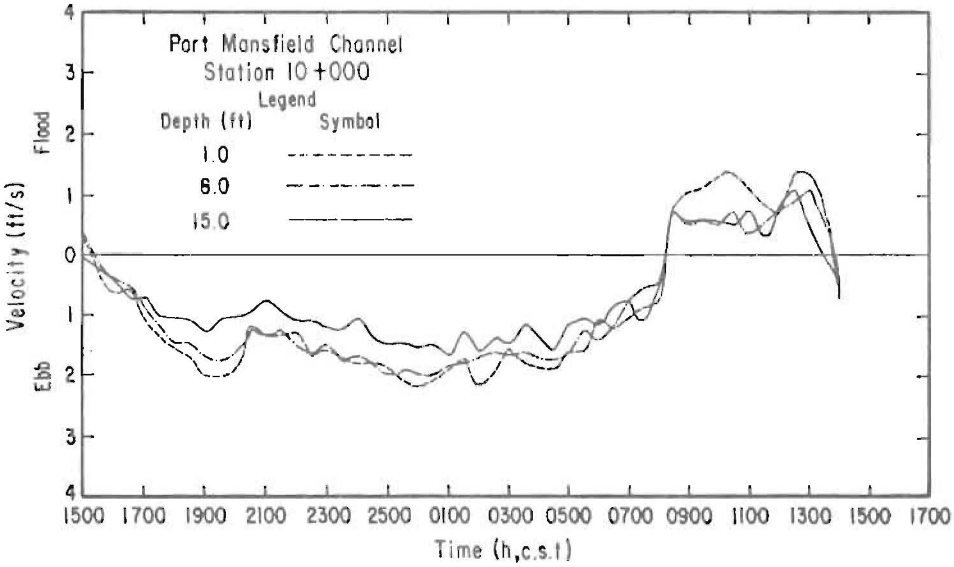


Figure A-4. Plot of velocity versus time at station B, 12 and 13 May 1962.

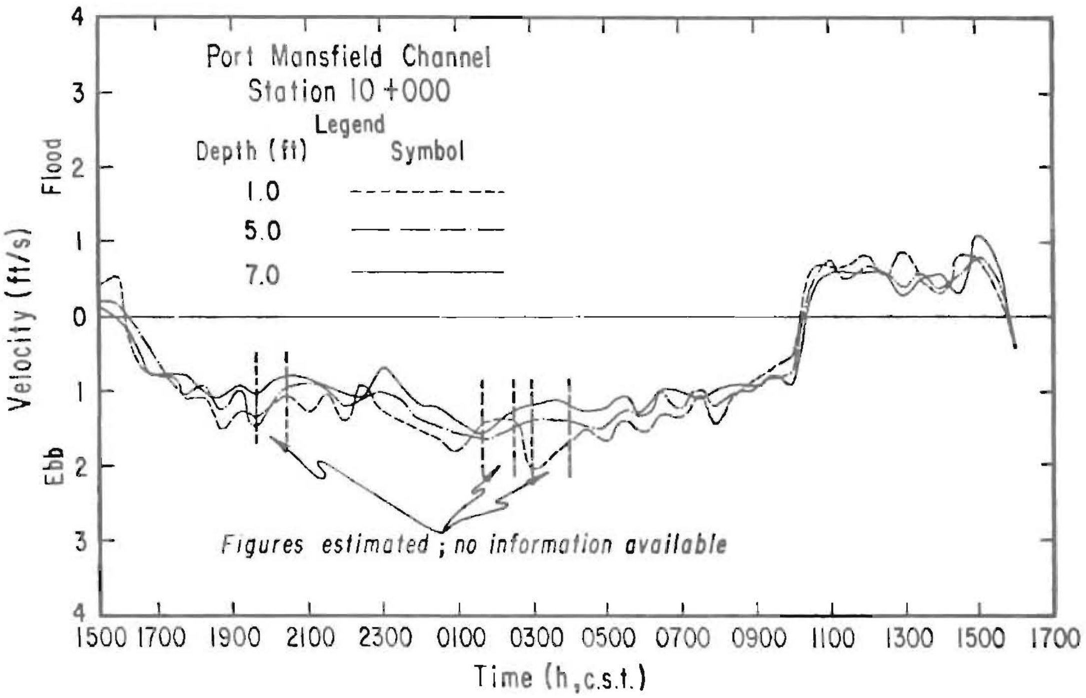


Figure A-5. Plot of velocity versus time at station C, 12 and 13 May 1962.

APPENDIX B

VELOCITY MEASUREMENTS, DISCHARGE CURVE, AND TIDAL DATA FOR 1 AND 2 AUGUST 1962.

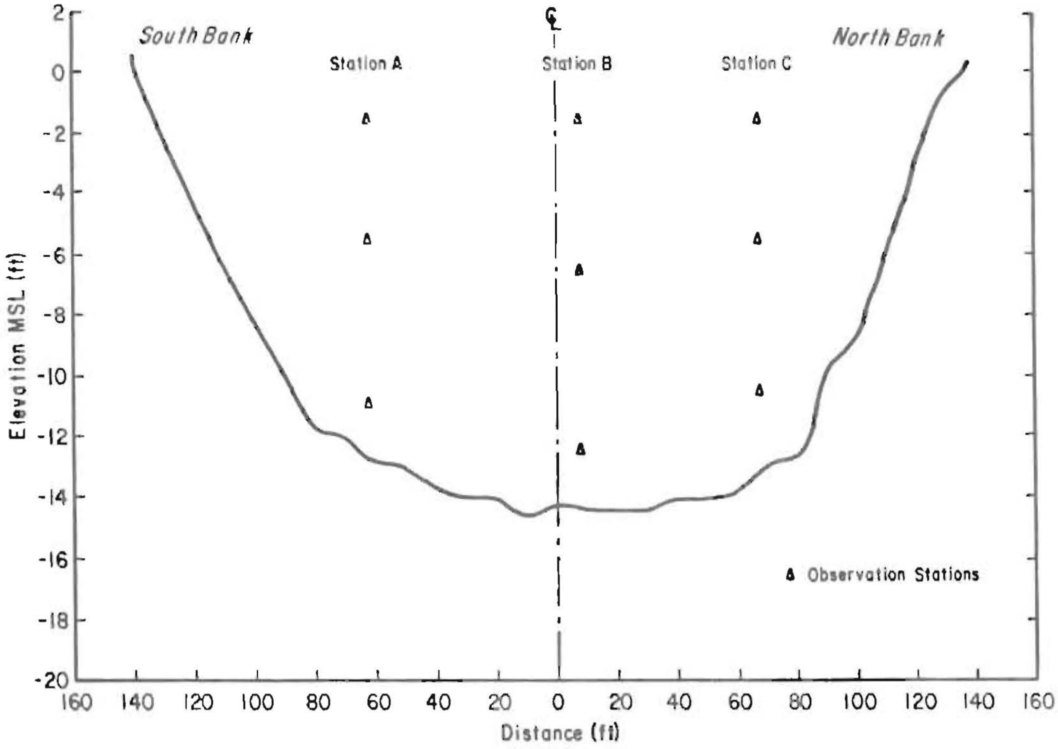


Figure B-1. Cross section of Port Mansfield channel, station 10+000, 2 August 1962.

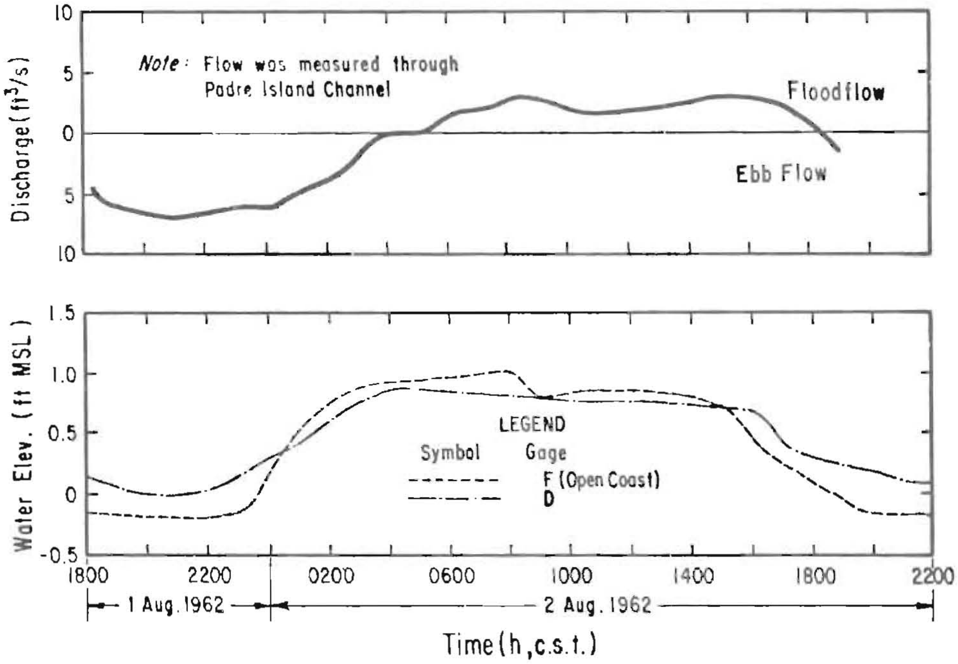


Figure B-2. Observed tidal levels and flow, Port Mansfield channel, 1 and 2 August 1962.

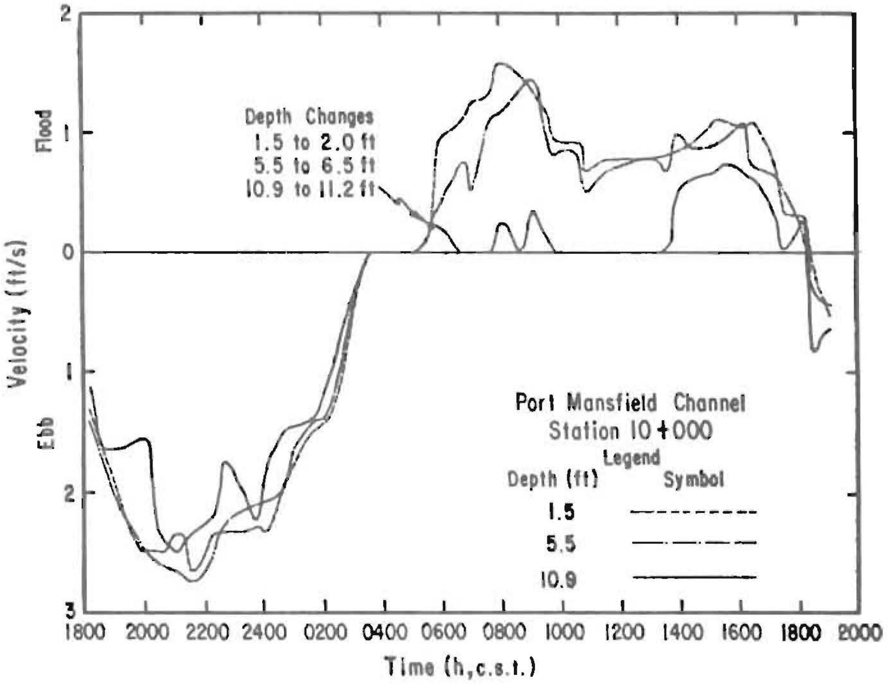


Figure B-3. Plot of velocity versus time at station A, 1 and 2 August 1962.

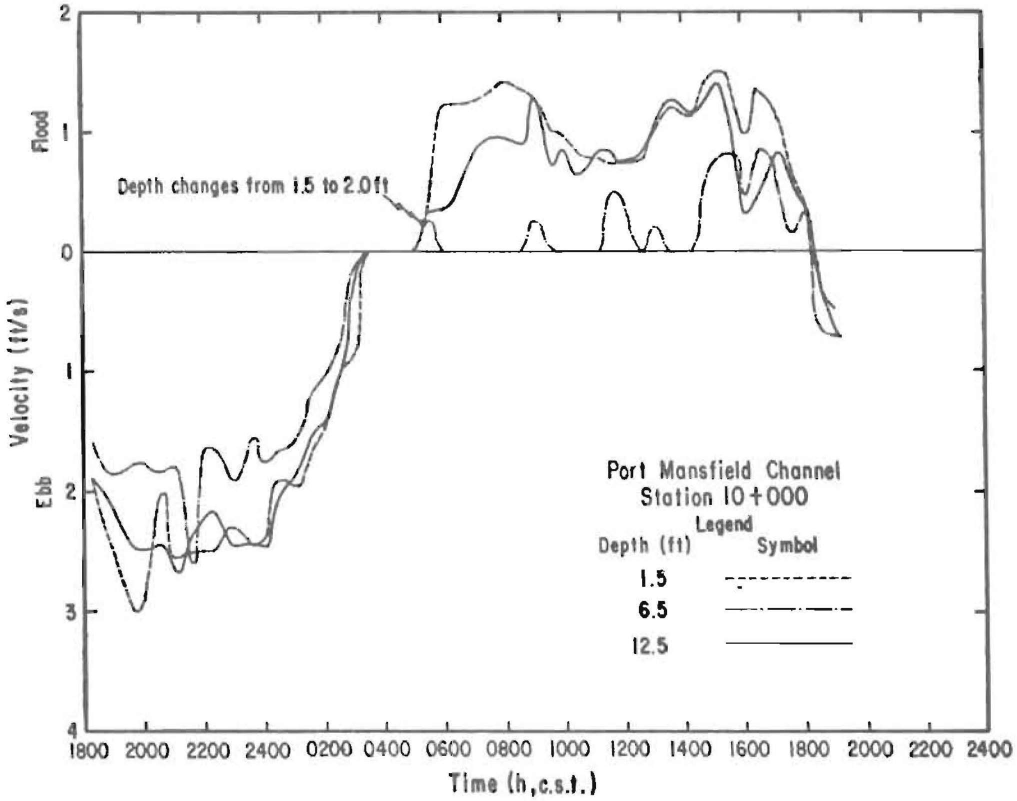


Figure B-4. Plot of velocity versus time at station B, 1 and 2 August 1962.

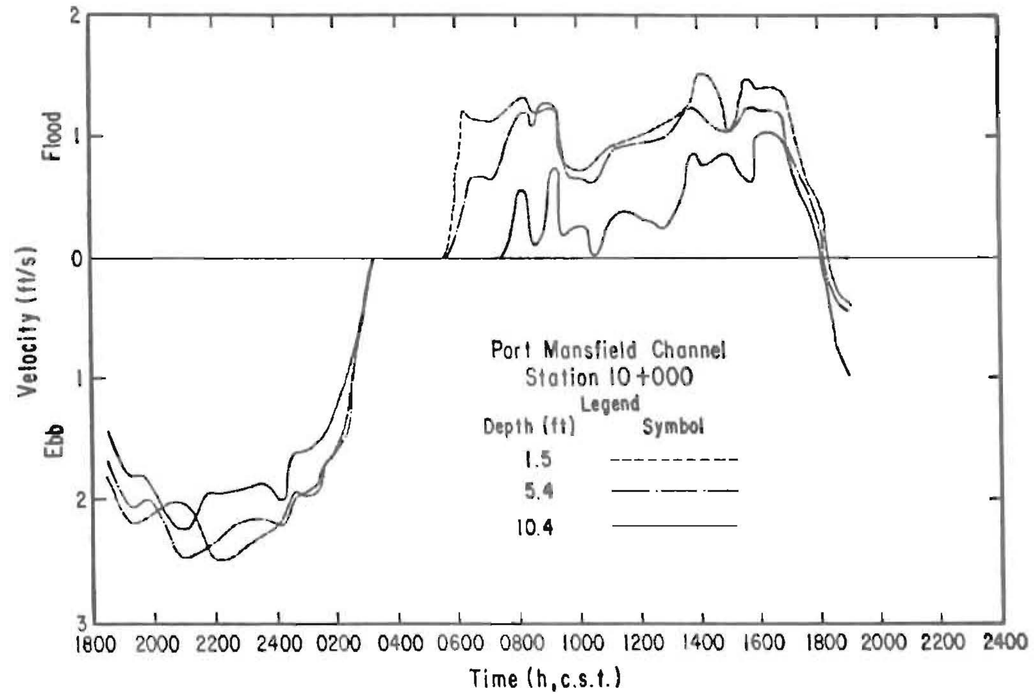


Figure B-5. Plot of velocity versus time at station C, 1 and 2 August 1962.

APPENDIX C

VELOCITY MEASUREMENTS AND DISCHARGE CURVE FOR 18 AND 19 DECEMBER 1962.

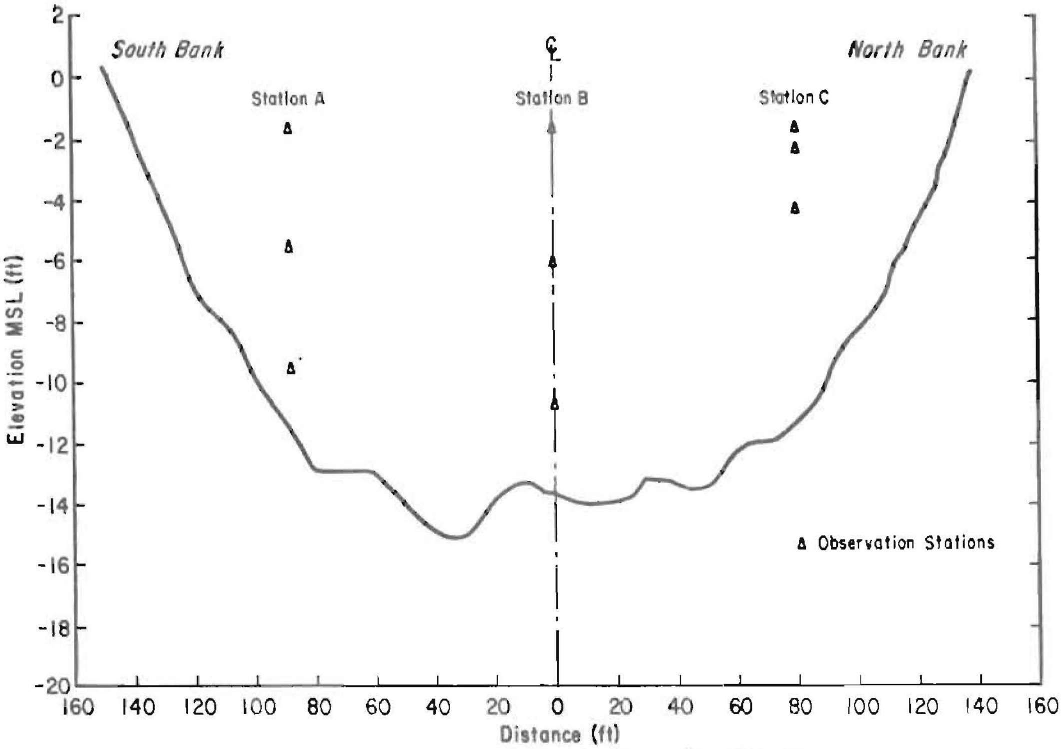


Figure C-1. Cross section of Port Mansfield channel, station 10+000, 11 December 1962.

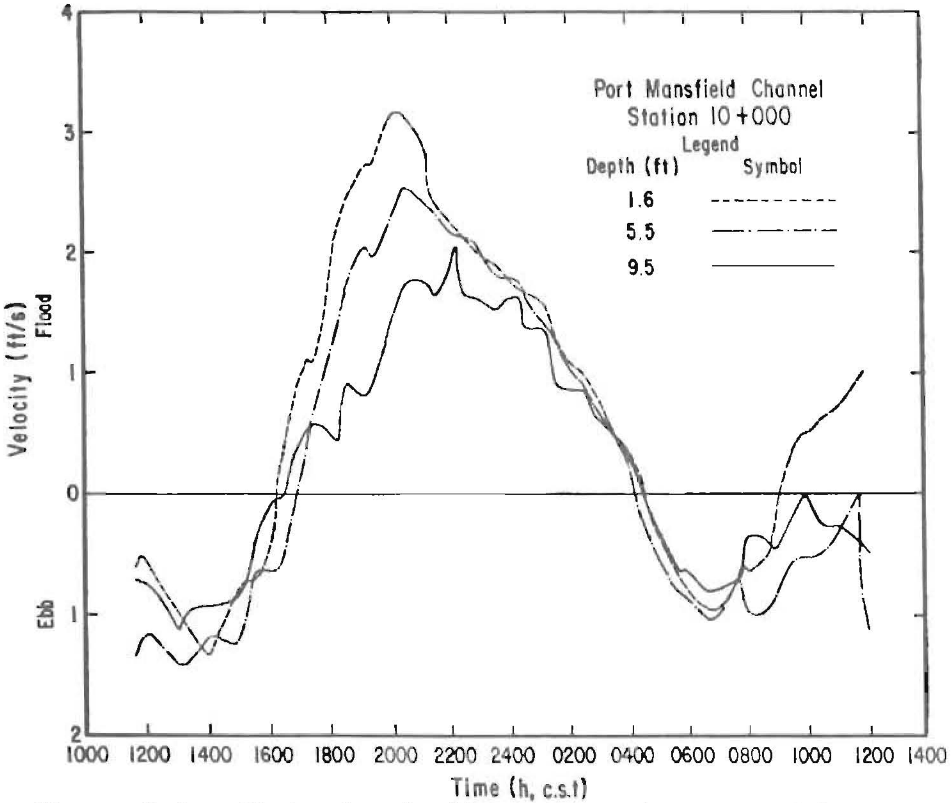


Figure C-2. Plot of velocity versus time at station A, 18 and 19 December 1962.

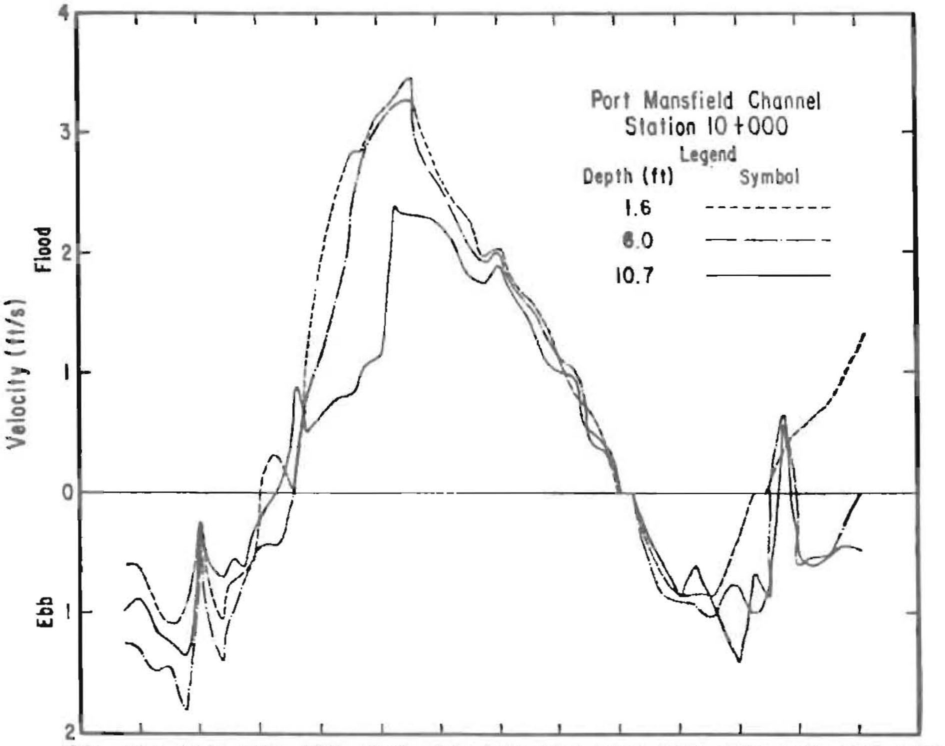


Figure C-3. Plot of velocity versus time at station B, 18 and 19 December 1962.

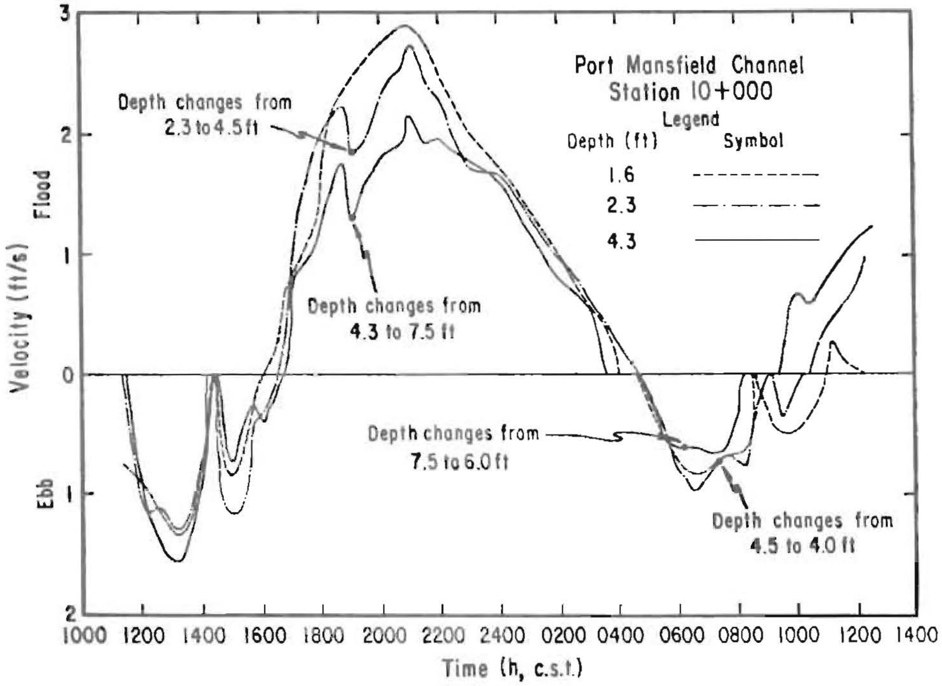


Figure C-4. Plot of velocity versus time at station C, 18 and 19 December 1962.

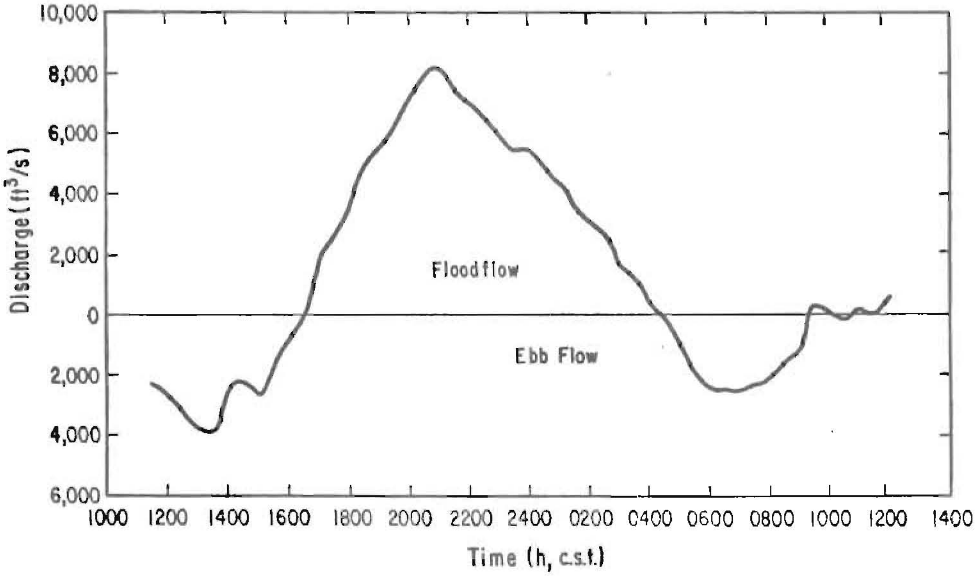


Figure C-5. Plot of discharge versus time,
18 and 19 December 1962.

APPENDIX D

VELOCITY MEASUREMENTS, DISCHARGE CURVE, AND TIDAL DATA FOR 12 AND 13 JUNE 1963.

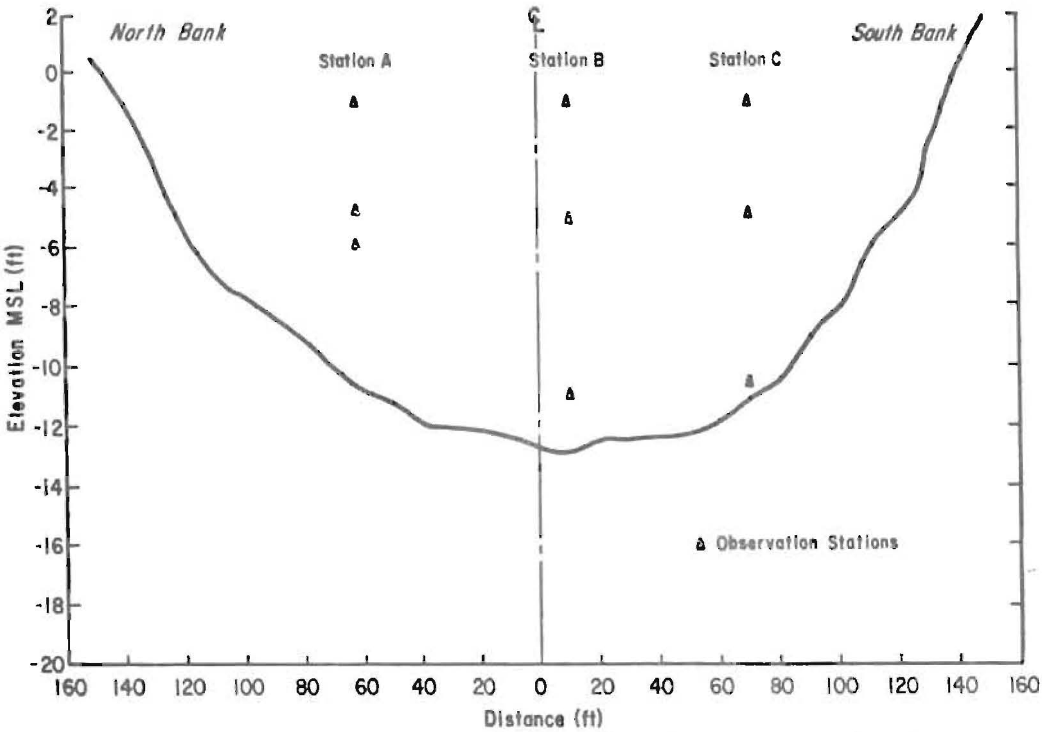


Figure D-1. Cross section of Port Mansfield channel, station 10+000, 12 June 1963.

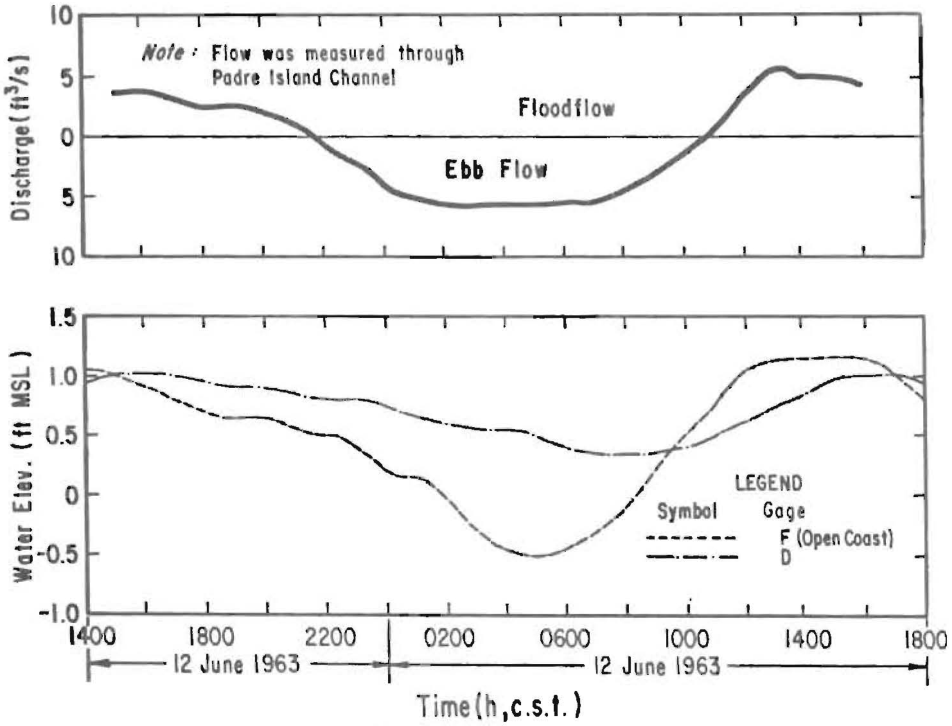


Figure D-2. Observed tidal levels and flow, Port Mansfield channel, 12 and 13 June 1963.

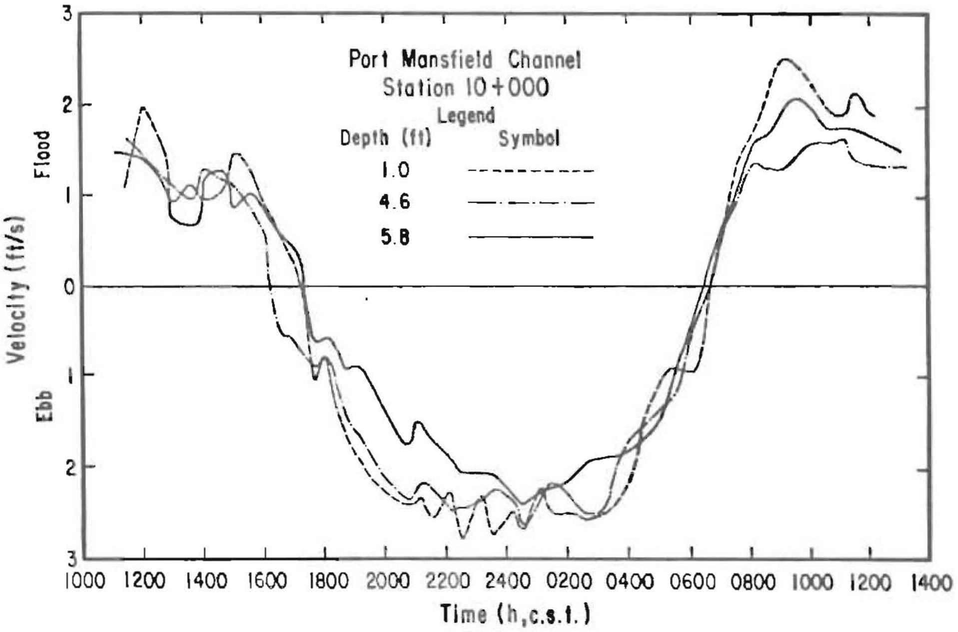


Figure D-3. Plot of velocity versus time at station A, 12 and 13 June 1963.

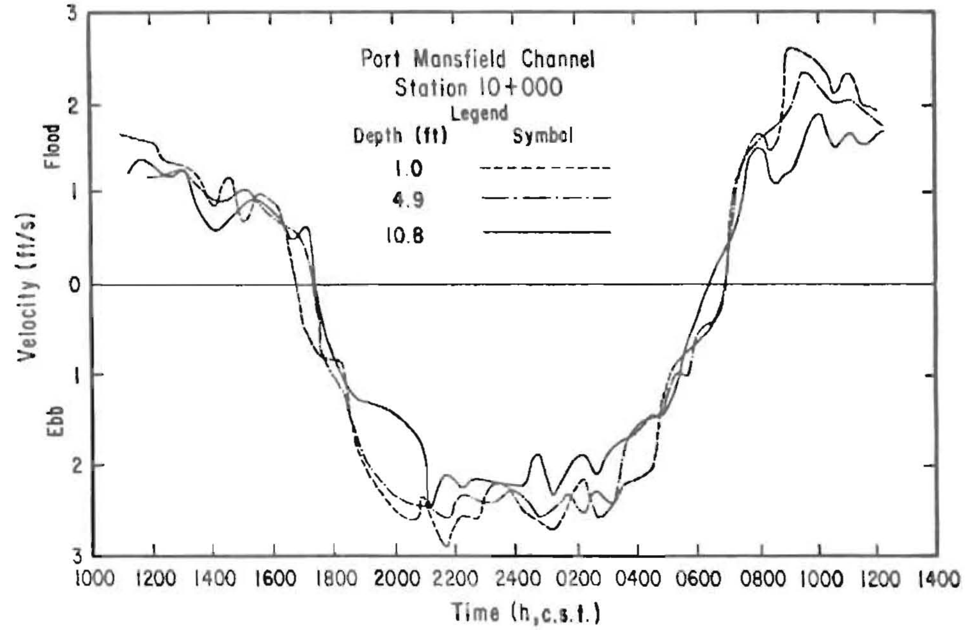


Figure D-4. Plot of velocity versus time at station B, 12 and 13 June 1963.

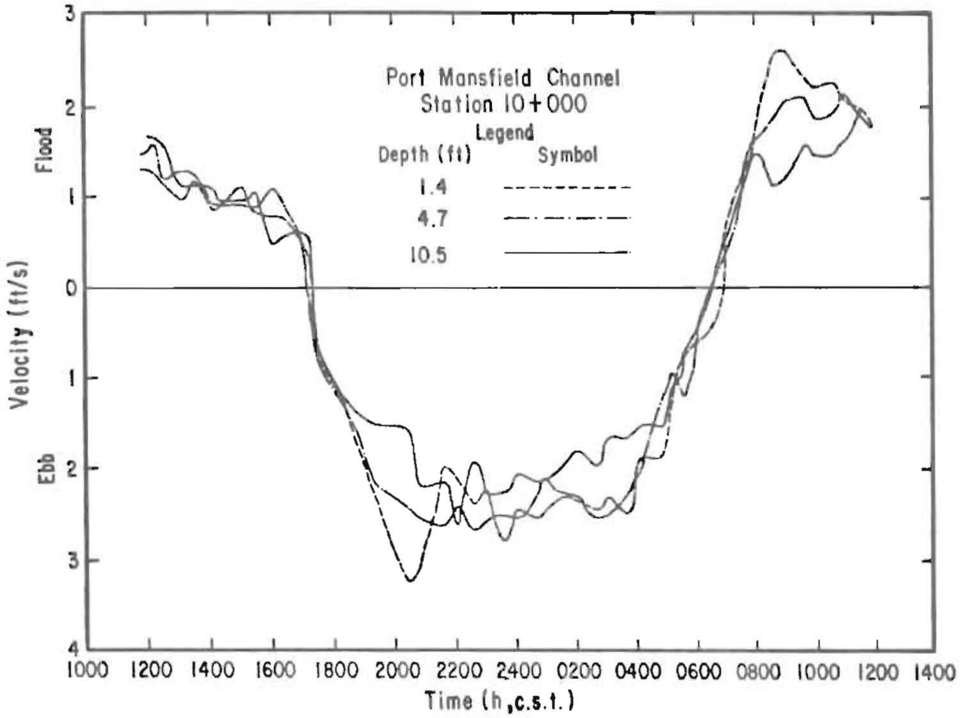


Figure D-5. Plot of velocity versus time at station C, 12 and 13 June 1963.

APPENDIX E

SHORELINE CHANGES AND CHANNEL SHOALING DATA

Appendix E presents details of changes in the channel hydrography using fill and scour maps and aerial photos. The fill and scour maps are based on channel cross sections taken at 100-foot (30.5 meters) intervals from stations 10+00.00 to 400+00.00. The maps were constructed by plotting the difference in elevation between two cross sections taken at the same location at different times. Isolines of deposition and erosion were drawn and volumetric changes within the channel were determined for various channel reaches. Discussion of changes in shoreline configuration is based on periodic beach profile surveys taken adjacent to the gulf entrance jetties.

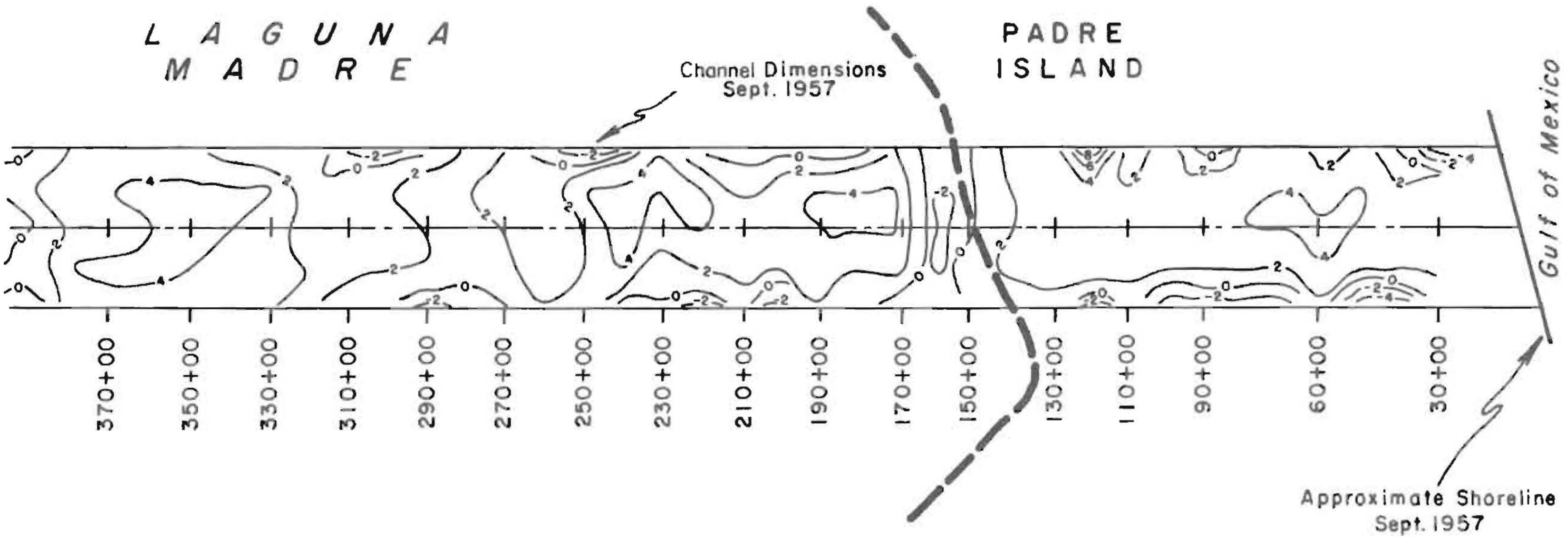
1. 1957 to 1959.

Figure E-1 shows a fill and scour map of Port Mansfield channel from stations 30+00.00 to 400+00.00 (Fig. 3) for September 1957 to June 1959. Shoreline surveys from September 1957 to April 1962 are shown in Figure E-2.

The channel was cut through Padre Island on 23 September 1957 with the adjacent gulf shoreline located near station 00+00.00. Two survey periods (September 1957 to June 1959 and December 1957 to June 1959) were used to document changes in the entire channel. Since cross sections were not obtained at the channel entrance immediately after dredging, the fill and scour map in Figure E-1 extends only from stations 30+00.00 to 400+00.00. The first survey of the channel to include the entrance was taken in December 1957. However, because of the rapid deposition which had occurred between September and December 1957, the December survey could not be used as the base survey for the entire channel. Watts (1960), in a report to the Committee on Tidal Hydraulics, gave a deposition rate of 26 cubic yards (19.88 cubic meters) per foot of channel per year from stations 07+25.00 to 40+00.00 for December 1957 to June 1959. Deposition rates for various channel reaches from stations 30+00.00 to 400+00.00 for September 1957 to June 1959, including the total amount of material deposited, are shown in Table E-1.

Table E-1. Deposition rates for sections of Port Mansfield channel, September 1957 to June 1959.

	Deposition rate/ft of channel/yr		Total	Deposited
Station	yd^3	m^3	yd^3	m^3
30+00.00 to 150+00.00	8.6	6.5	175,240	133,989
150+00.00 to 160+00.00	-5.0	3.8 (Erosion)	-8,444	6,456
160+00.00 to 320+00.00	9.2	6.9	249,194	190,534
320+00.00 to 400+00.00	13.2	10.0	180,194	137,776
Overall avg.	9.5	7.2		
Total			640,628	489,842



Note: Negative values indicate erosion; positive values indicate deposition in feet. Stations are plotted on centerline.

Figure E-1. Fill and scour map of Port Mansfield channel from September 1957 to June 1959.

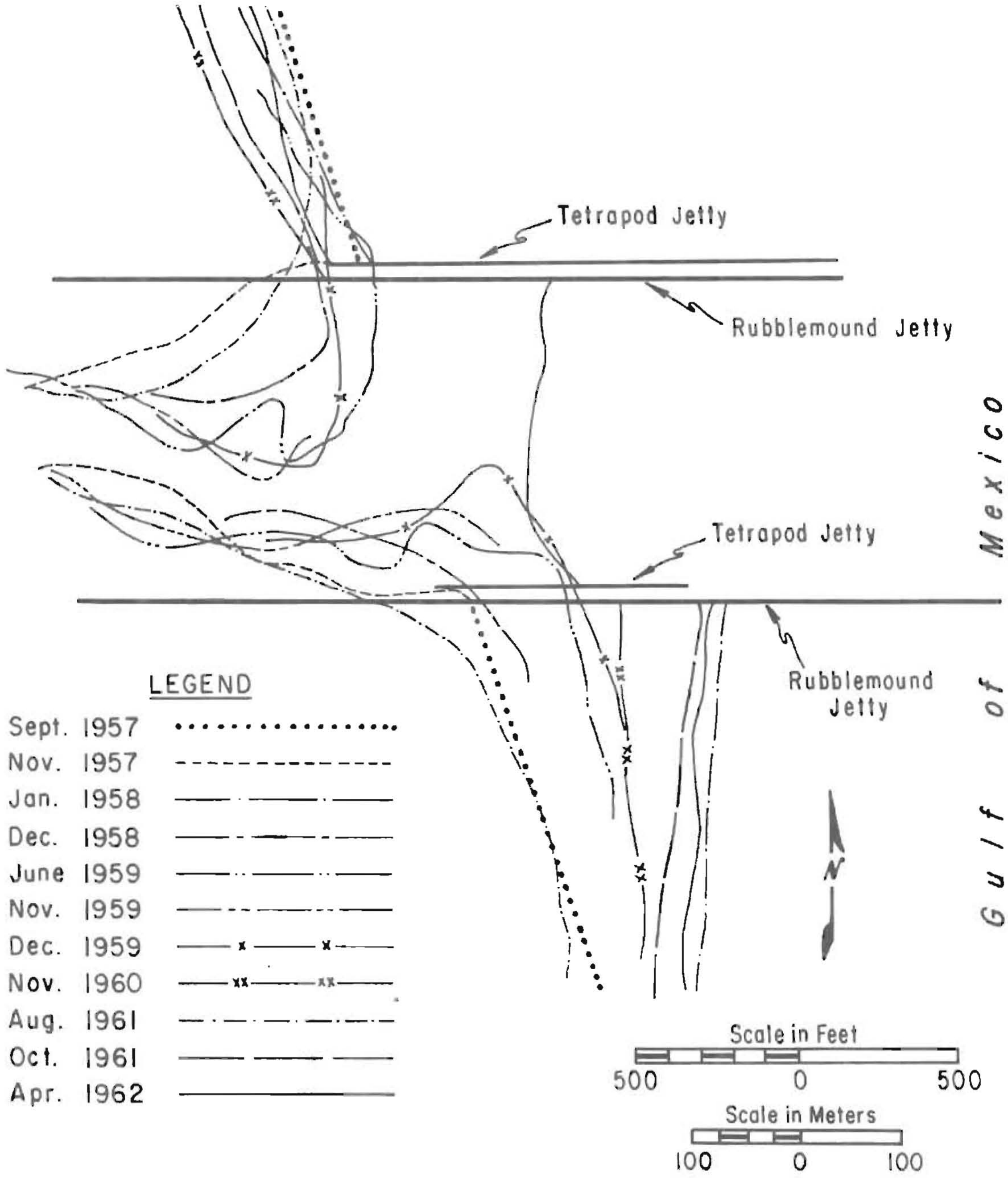
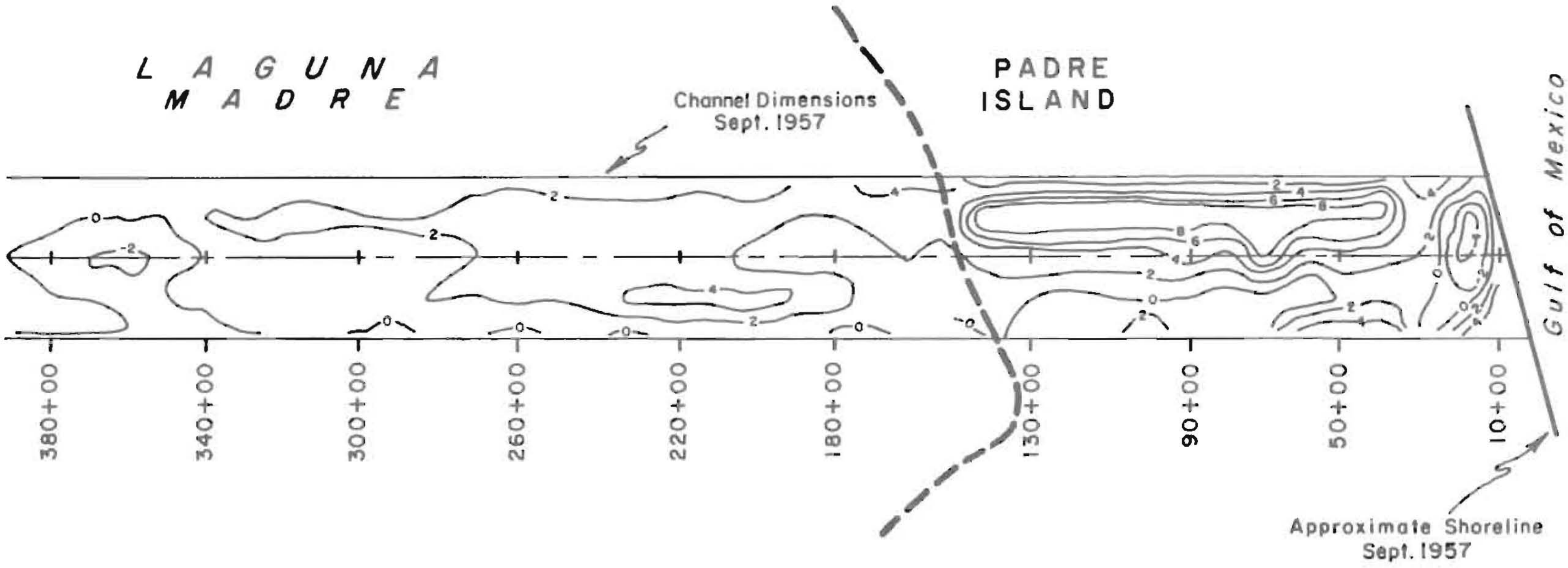


Figure E-2. Mean sea level shoreline surveys from September 1957 to April 1962.



Note: Negative values indicate érosion; positive values indicate deposition in feet. Stations are plotted on centerline.

Figure E-3. Fill and scour map of Port Mansfield channel from June 1959 to April 1962.

In general, the deposition rates for the channel increased towards the mainland with an average deposition rate of 9.5 cubic yards (7.26 cubic meters) per foot of channel per year from stations 30+00.00 and 400+00.00. The deposition between stations 30+00.00 and 150+00.00 is assumed to be largely material carried into the channel from the gulf by waves or currents. However, since this was the land-cut part of the channel, the large migrating sand dunes on Padre Island also may have contributed windblown sand to the channel. Short-term field studies indicate a rate of 4 cubic yards per year per foot of beach for windblown sand transport in this area (D.W. Woodard, personal communication, 1976). Except for local erosion of the channel banks, the only erosion within the channel was between stations 150+00.00 and 160+00.00.

The largest shoaling rate in the channel occurred in the Laguna Madre section, from stations 320+00.00 to 400+00.00. This deposition apparently resulted from wind-driven waves or currents in Laguna Madre, which may have actively eroded the spoil banks south of the channel.

The extensive recession of the shoreline between September 1957 and January 1958 (Fig. E-2) was initiated by storms that occurred in November 1957 (Hansen, 1960). The shore ends of the north and south jetties were flanked by 124 feet (37.80 meters) and 288 feet (87.78 meters), respectively.

After the period of severe recession, the beach south of the jetties accreted significantly through December 1959, with the mean sea level (MSL) contour advancing about 728 feet (221.89 meters) seaward along the south jetty. North of the inlet, the beach accreted from the January 1958 condition, with an advance of the MSL contour of generally less than 100 feet (30.5 meters).

Within the channel entrance the influx of littoral material was accelerated by the continuous subsidence of the tetrapod jetties and the channel entrance began to meander southward near the base of the jetties.

2. <u>1959 to 1962</u>.

Figure E-3 shows a fill and scour map for the Port Mansfield channel from stations 10+00.00 to 400+00.00 for June 1959 to April 1962. Deposition rates for various channel reaches from stations 10+00.00 to 400+00.00 for June 1959 to April 1962, including the total amount of material deposited, are shown in Table E-2.

Table E-2. Deposition rates for sections of Port Mansfield channel, June 1959 to April 1962.

	Deposition rate/ft of channel/yr		Total	Deposited
Stations	yd³	m³	yd³	m³
10+00.00 150+00.00	8.5	6.50	337,722	258,222
150+00.00 320+00.00	2.7	2.06	129,520	999,031
320+00.00 400+00.00	1.9	1.45	42,925	32,820
Overall avg.	4.4	3.36		
Total			510,167	390,074

The shoaling rate for the entire channel from stations 10+00.00 to 400+00.00 was 4.4 cubic yards (3.36 cubic meters) per foot of channel per year. This is a significant decrease from the 9.5 cubic yards (7.26 cubic meters) per foot of channel per year experienced between 1957 and 1959. Depositional rates in the channel decreased toward the mainland, again a significant change from the previous survey periods. The extensive deposition along the northern part of the channel between stations 110+00.00 and 150+00.00 resulted from a meander in the channel entrance. Since the channel entrance was closed for 47 percent of the survey period, this deposition may have resulted from windblown sand from Padre Island, which during open-entrance conditions, is distributed along the channel by tidal currents. By 1960, the meander and a corresponding reduction in flow area significantly reduced the tidal exchange through the inlet. The inlet throat in 1960 was limited to depths of 4 to 5 feet (1.22 to 1.52 meters). The reduction in both flow area and tidal currents is likely to have resulted in a decreased supply of littoral material to interior regions of the channel as shown by the progressive landward decrease in deposition in Table E-2. The channel was completely closed by January 1961, and construction of the new jetties was underway.

The channel entrance (Fig. E-4) was briefly opened in October 1961 by a combination of storm surge currents and wave action from Hurricane Carla (Hayes, 1967). The new jetties were under construction at the time, and completed parts were not damaged. However, considerable erosion and displacement of filler and core stone occurred at the incompleted areas; most cover-stone (armor) material remained undisturbed. The effect of Carla on the Port Mansfield shoreline area is shown in Figure E-2. The general recession of the south (October 1961) MSL contour averaged about 80 feet (24.38 meters) from the August 1961 position, while the north (October 1961) MSL contour retreated about 160 feet (48.77 meters).

The entrance channel jetties and dredging of the channel were completed by May 1962; the postconstruction condition is shown in Figure E-5.

3. 1962 to 1965.

The extensive deposition which occurred in the channel entrance (from stations -40+00.00 to 00+00.00) between May 1962 and February 1963 is shown in Figure E-6. Annual shoreline changes from April 1962 (before the inlet opening in May) to August 1965 are shown in Figure E-7.

Over the 10-month period after the inlet opening, 132,000 cubic yards (100,927 cubic meters) of material were deposited within the regions shown in Figure E-6, with an average shoaling rate of 4.7 cubic yards (3.59 cubic meters) per foot of channel per month. The heavy deposition near station 00+00.00 probably resulted from wave-induced erosion of the channel banks. A bar across the channel between the offshore ends of the jetties was another area of significant deposition. A further investigation of channel shoaling during this period proved impractical due to the periodic dredging of the channel entrance (Table E-3).

The November 1962 shoreline inside the channel entrance shows a recession of approximately 648 feet (197.51 meters) on the south bank and

January 1961 (pre-Carla)

October 1961 (post-Carla)

Figure E-4. Photos of Port Mansfield channel entrance, before and after Hurricane Carla.

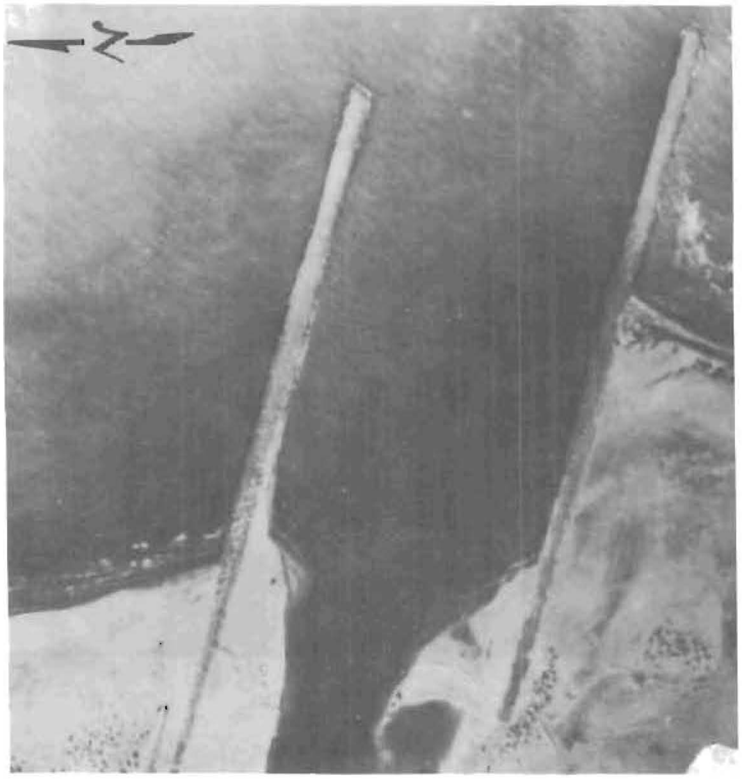
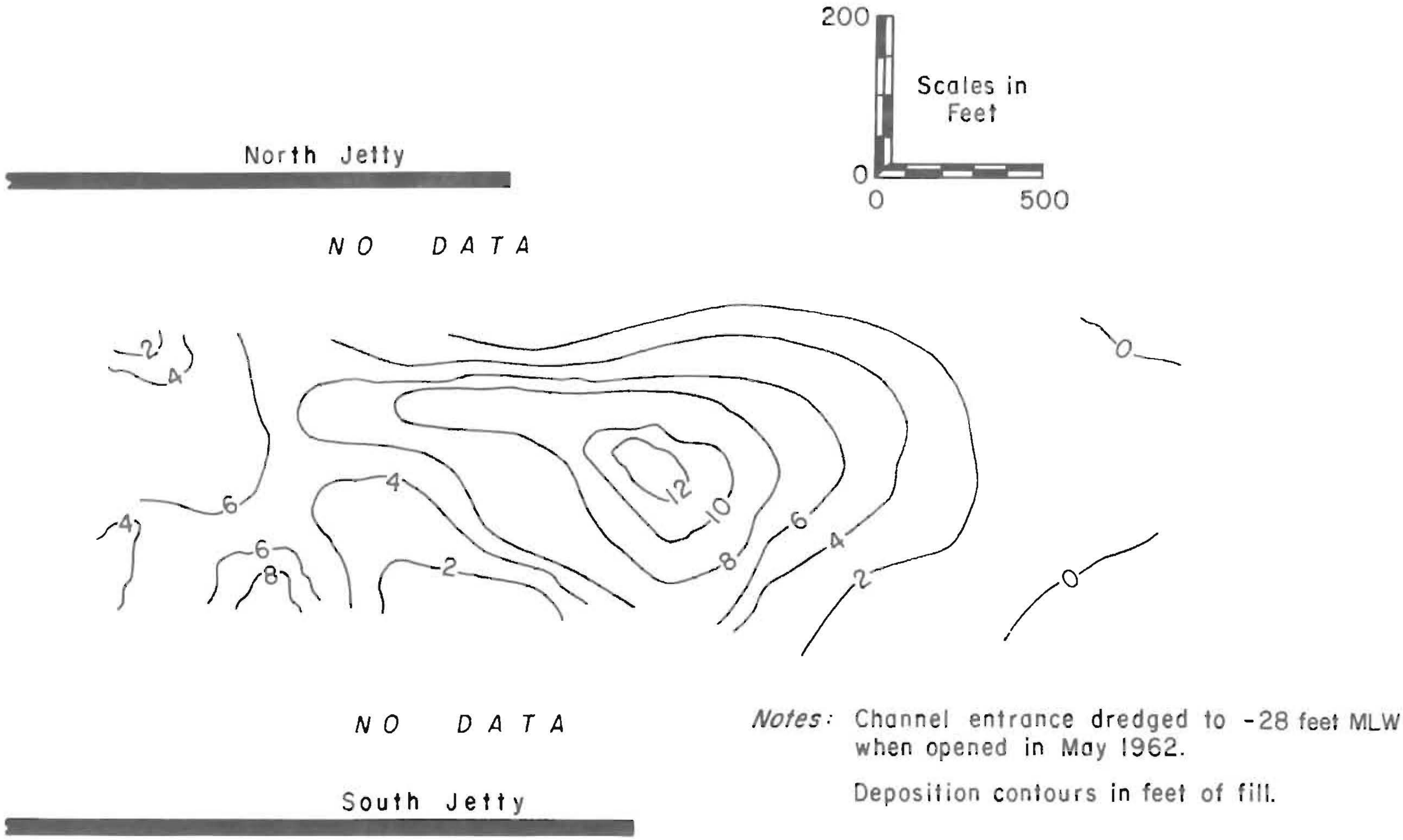


Figure E-5. Port Mansfield channel entrance, January and July 1962.



Notes: Channel entrance dredged to -28 feet MLW when opened in May 1962.

Deposition contours in feet of fill.

Figure E-6. Channel entrance deposition, May 1962 to February 1963.

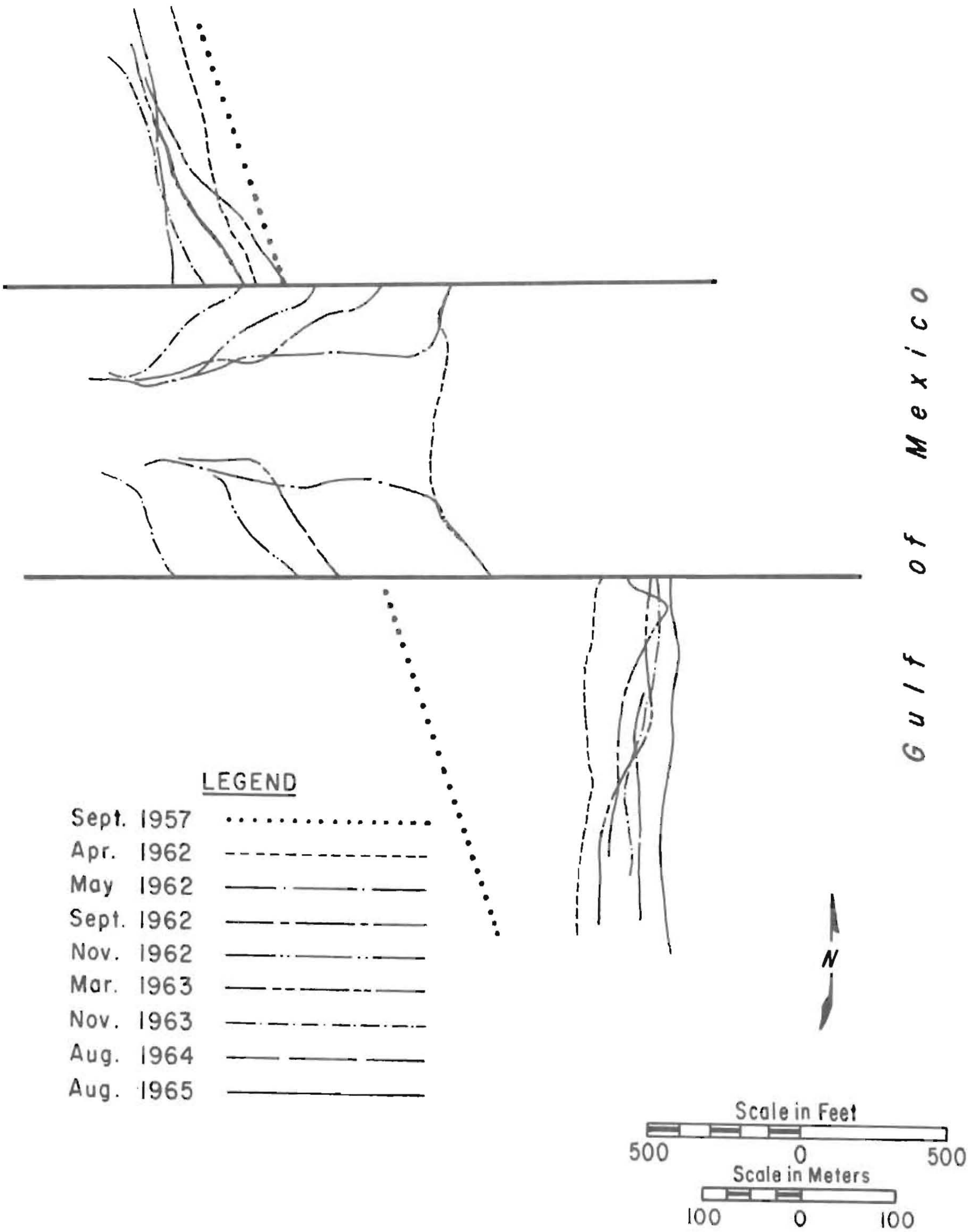
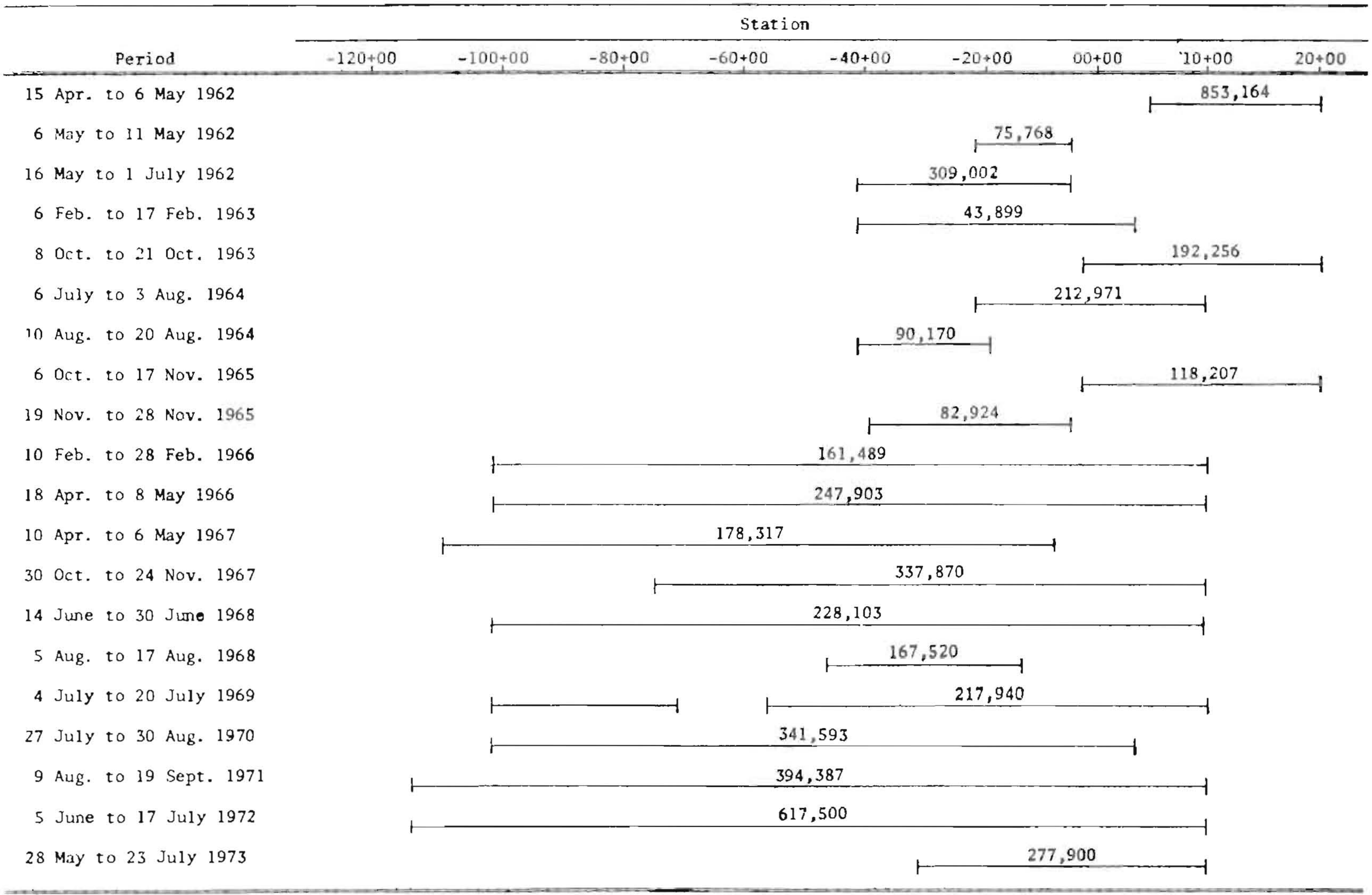


Figure E-7. Mean sea level shoreline surveys from April 1962 to August 1965.

Table E-3. Dredging history of the Port Mansfield channel entrance.



Period	Station
15 Apr. to 6 May 1962	853,164
6 May to 11 May 1962	75,768
16 May to 1 July 1962	309,002
6 Feb. to 17 Feb. 1963	43,899
8 Oct. to 21 Oct. 1963	192,256
6 July to 3 Aug. 1964	212,971
10 Aug. to 20 Aug. 1964	90,170
6 Oct. to 17 Nov. 1965	118,207
19 Nov. to 28 Nov. 1965	82,924
10 Feb. to 28 Feb. 1966	161,489
18 Apr. to 8 May 1966	247,903
10 Apr. to 6 May 1967	178,317
30 Oct. to 24 Nov. 1967	337,870
14 June to 30 June 1968	228,103
5 Aug. to 17 Aug. 1968	167,520
4 July to 20 July 1969	217,940
27 July to 30 Aug. 1970	341,593
9 Aug. to 19 Sept. 1971	394,387
5 June to 17 July 1972	617,500
28 May to 23 July 1973	277,900

---

[1] Cubic yards.

472 feet (143.87 meters) on the north bank from the opening conditions in May 1962. This recession resulted from waves breaking within the channel entrance.

Recession of the channel banks between the jetties was so severe that jetty flanking became a distinct possibility. Therefore, stone revetment to protect the banks was tied into the toes of the jetties in April 1965.

Figure E-7 shows an advance of the MSL contour of approximately 240 feet (73.15 meters) along the outside of the south jetty between 1962 and 1965, and a general recession adjacent to the north jetty. The fillet south of the channel achieved approximate equilibrium conditions in the position of the MSL contour.

4. 1967 to 1975.

The annual shoreline changes from August 1967 to September 1975 are shown in Figure E-8. A general recession of the shoreline between August and October 1967 occurred; the north shoreline receded 200 feet (60.96 meters) and the south shoreline retreated about 100 feet (30.48 meters). These changes were caused by storm surge and waves and currents associated with the passage of Hurricane Beulah across the southern tip of Texas on 20 September 1967. Although the effect of Beulah on the channel itself was not quantitatively documented, strong ebb currents prevailed for several days afterward due to heavy rains in the interior. Therefore, considerable scour of the channel probably occurred.

After the severe erosion caused by Hurricane Beulah, both the north and south beaches accreted. By August 1968, the north beach shoreline advanced seaward about 200 feet (61 meters) near the jetty while the south beach shoreline advanced generally less than 50 feet (15.2 meters). The 1969 survey shows little change in the south beach shoreline, although the north beach receded about 150 feet (45.7 meters) except at the jetty. By 1971, the south beach had accreted a maximum of 120 feet (36.6 meters), and the north beach continued to erode with a recession of about 420 feet (128 meters) near the jetty. The 1972 survey indicated general erosion of both north and south beaches in the immediate vicinity of the jetties. The 1973-75 surveys showed little change in the MSL shoreline position adjacent to the south jetty. The shoreline advance on the south beach was less than 60 feet (18.3 meters) during this period. The MSL shoreline position immediately adjacent to the north jetty fluctuated, with no net change in the shoreline position form 1972 to 1975.

The influence of the jetty system on the shorelines adjacent to the inlet is shown in Figure E-9. Note that the same general trends in erosion and accretion occur over 9,000 feet (2,743 meters) from the channel on both the north and south beaches.

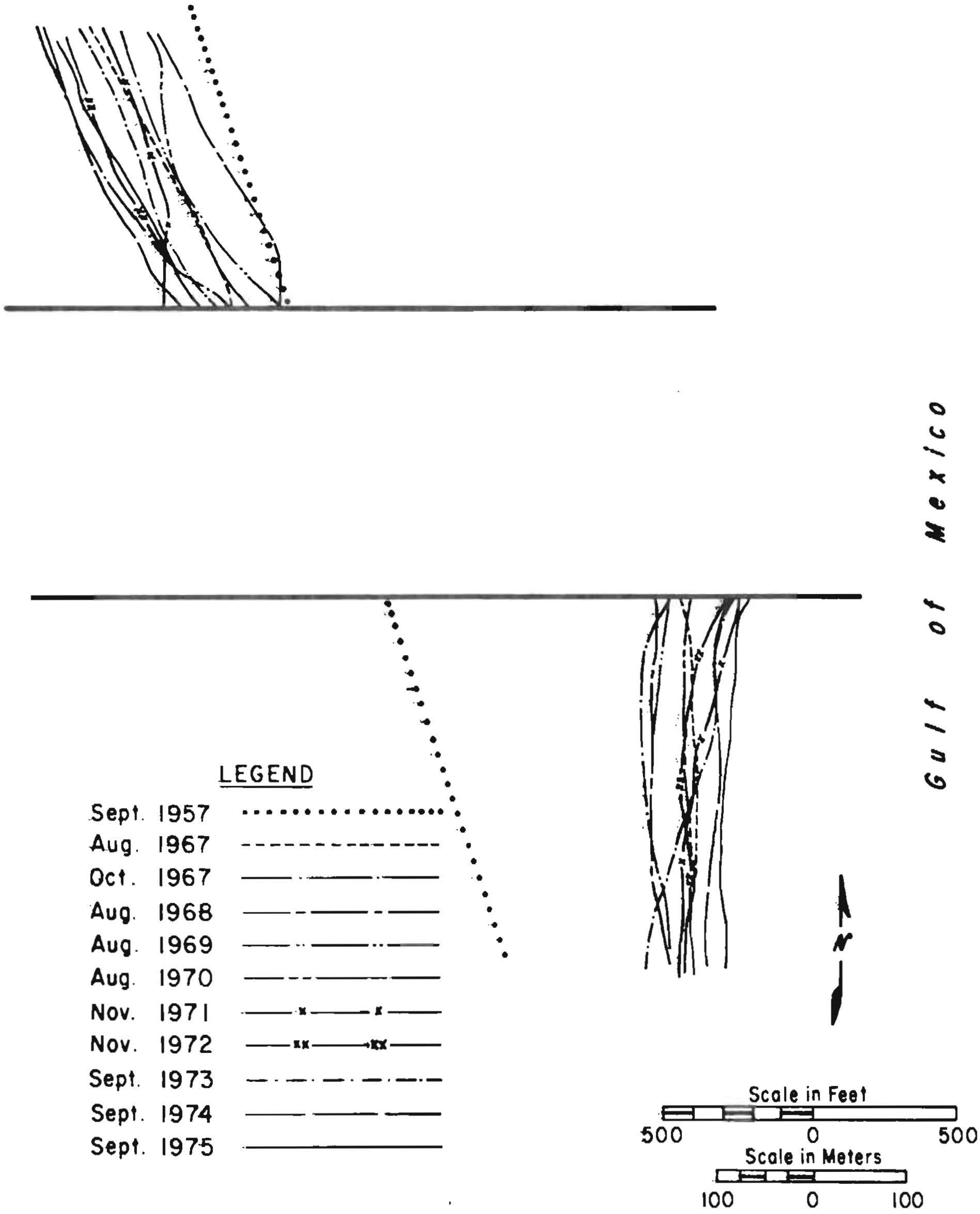


Figure E-8. Mean sea level shoreline surveys form August 1967 to September 1975.

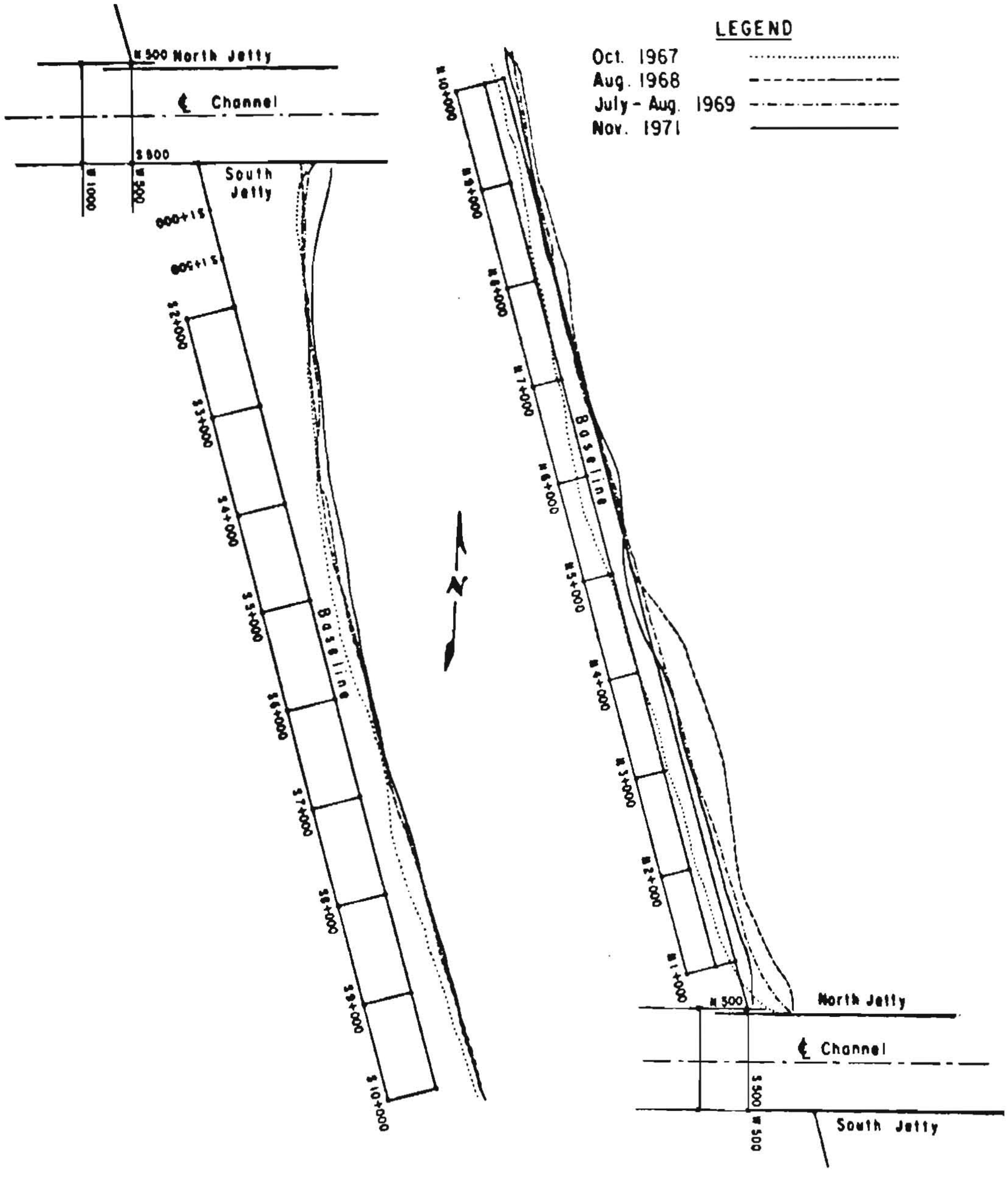


Figure E-9. Influence of jetty system on adjacent shorelines.

Kieslich, James M.

A case history of Port Mansfield Channel, Texas / by James M. Kieslich. Fort Belvoir, Va. : U.S. Coastal Engineering Research Center, 1977.
68 p. : ill. (GITI report 12)
Bibliography : p. 37.

Report presents a case history and analysis of Port Mansfield channel, an artificial, jettied inlet between the Gulf of Mexico and Laguna Madre, Texas; and the results of an office study of available field data at the channel from construction in 1957 to 1975.

1. Channels (Hydraulic engineering) - Texas. 2. Port Mansfield Channel, Texas. 3. Sediment Transport. 4. Tidal prisms. 5. Tidal inlets. I. Title. II. Series: U.S. Army, Corps of Engineers. GITI report no. 12.

GB454 .I5 U581r no. 12 551.4

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