A SURVEY OF THE ECONOMIC AND ENVIRONMENTAL ASPECTS OF AN ONSHORE DEEPWATER PORT AT GALVESTON, TEXAS

PART II
ENVIRONMENTAL CONSIDERATIONS

by

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FOREWORD

This report, "A Survey of the Economic and Environmental Aspects of an Onshore Deepwater Port at Galveston, Texas" is the result of a brief, organized effort aimed at assessing the nature and magnitude of the two principal factors expected to play significant roles in decisions made concerning onshore deepwater port facilities. It is hoped that a survey of this type, while not providing many definitive answers--since it involved no original field studies, will nevertheless help to clarify some areas of speculation, and thereby bring the study sponsors closer to a decision point in these key areas.

Part I of the study considers the economic aspects of the project, and was prepared by Daniel M. Bragg of the Industrial Economics Research Division. Part II discusses some of the environmental implications of the project, and was co-authored by Roy W. Hann, Jr., and Wesley P. James of the Environmental Engineering Division.

The discussion and conclusions of this report are based upon extensive literature reviews, and interviews with knowledgeable persons in several pertinent areas of expertise. The authors are grateful to these many individuals, too numerous to mention, who provided information and suggestions which helped shape the final report.

This project was partially supported by an institutional grant 04-3-158-18 made to Texas A&M University through the National Sea Grant Program, National Oceanic and Atmospheric Administration, U. S. Department of Commerce, and by a grant from the Galveston Wharves Board of the City of Galveston, Texas.

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SUMMARY

The development of a deep draft port for the Galveston area is a project of major consequences.

A project of its type and magnitude has broad implications for the environment. It will require a significant modification of some environmental features in the vicinity and, without proper planning and control, it could cause undesirable changes in the environmental conditions of the area.

On the other hand, some of the environmental changes which will occur when this project is implemented could have possibly significant positive effects on Galveston Bay. For instance, if flushing of the lower Bay improves as a result of having a deepened and widened channel, pollutional levels for conservative or slowly degrading materials could be reduced with the associated improvement in environmental quality in the lower bay area.

It is recognized that almost all environmental modifications incur some net environmental cost or degradation which is offset by the substantial benefit to man which results from the project.

In the study described in this report a framework was established for a comprehensive environmental study which should be undertaken in the early stages of planning for the proposed port. Those environmental factors deemed to be of greatest significance were itemized in order to emphasize their importance as a part of future project planning.

The study followed an environmental assessment matrix which identified the project activities such as construction, operation, and maintenance for the offshore, Galveston Bay entrance, and terminal areas, as compared with environmental elements such as physical, chemical, and geological features, biological features and cultural factors.

Major environmental issues which were evident to the study team included:

1. The modification to the Galveston Bay entrance and the resultant beneficial and harmful impacts on the Galveston Bay-Gulf interchange.
2. The removal of the established bottom in the offshore area and the disposal of the dredged material on bottom areas.
3. The change in sediment transport along the coast and the resultant impact on beaches.
4. The chance of better oil spill control and containment in the harbor area compared to the increased danger of spills of oil from collision in nearshore areas.
5. The exponential increase in environmental change with the increasing depth of the project.

Recommendations were presented for followup studies to more carefully examine environmental components of the project.

This report does not include an attempt to judge the environmental merit of the enlargement of the Galveston Channel. Such assessment is possible only after the results of more detailed studies are available.

It does, however, serve to guide the planners and decision makers in the next stages of the project.

The study team acknowledges the magnitude of environmental change inherent in the project but also has confidence in the scientific and engineering community to design major projects of human need to minimize the environment's harm resulting therefrom.

INTRODUCTION

TAMU

INTRODUCTION

This section has been prepared to outline environmental aspects associated with the proposed deep draft channel from a terminus near Pelican Island to the 100 foot depth contour some 57 miles offshore in the Gulf of Mexico.

The report in its present stage of development is in no way a complete environmental assessment of the proposed project. It does, however, present some of the major environmental factors which would be affected by the project and outlines ways that the impact on the environmental components could and should be evaluated.

This project is an environmental modification of significant proportions. Such environmental modifications can have both environmental costs in the form of environmental degradation or environmental benefits in the form of environmental enhancement.

The project also has the potential for environmental pollution from accidental oil spills, dredge spoil disposal and other project activities, which must be considered as environmental degradation and cost. The environmental costs many times exceed the environmental benefits and must be offset by other social or economic benefits to make the project feasible; however, judgments in these areas are beyond the scope of this report, which will be confined to technical environmental considerations.

ENVIRONMENTAL CONSIDERATIONS

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The project consists of the expansion and lengthening of the present dredged channel, from the Gulf of Mexico to the vicnity of Pelican Island behind Galveston Island. The new channel would have a bottom width of approximately 1,200 feet and would be deepened (and lengthened accordingly) from 60 feet to 100 feet in 5 phases.

Figure 1 shows the tentative alignment of the channel superimposed on a contour map of the Gulf of Mexico area near Galveston.

A turning basin and terminal area approximately 2,000 feet wide and two miles long would be constructed north of Pelican Island. A plan of the present Galveston Bay-Houston Ship Channel entrance area showing the position of the proposed channel, turning basin and terminal area relative to existing channels and land areas (i.e., Galveston, and Pelican Islands, Texas City and the Bolivar Peninsula) is shown in Figure 2.

ENVIRONMENTAL EVALUATION METHODOLOGY

The environmental evaluation of a complex project such as the one being considered herein requires detailed knowledge of the environmental components in the potential impact area, detailed knowledge of the project and project components to be carried out and a logical plan for evaluating the effect of each project component on each environmental element.

Several related studies have helped establish a fairly generalized knowledge of the project area, and this forms the basis for much of this report. These include the "Coastal Zone Waste Management Study," carried out for the Governor's office of the State of Texas (4); a study, "Environmental Aspects of a Supertanker Port in the Texas Gulf

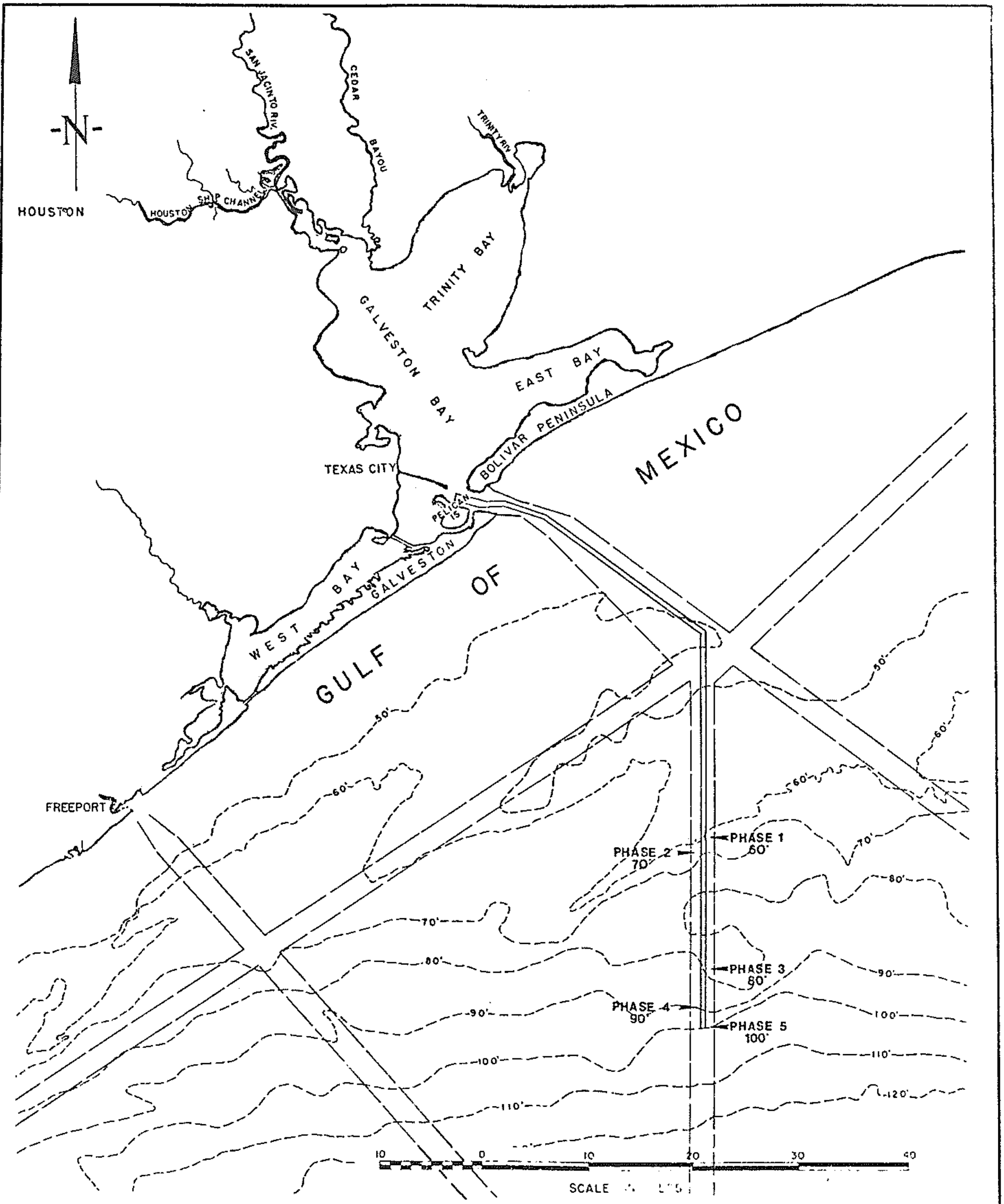

FIGURE 1

PLOT PLAN GALVESTON DEEP DRAFT CHANNEL

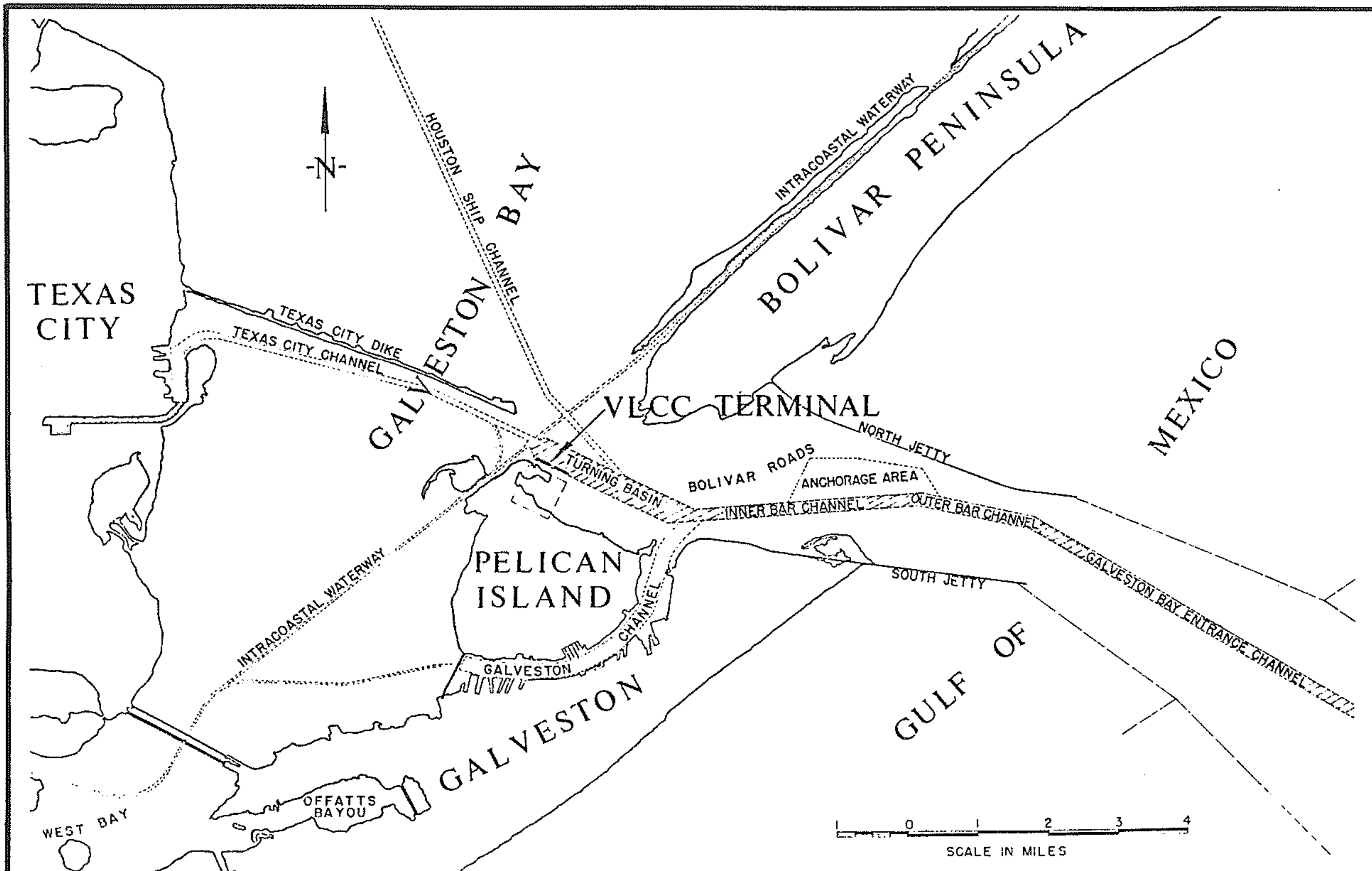

FIGURE 2

PLAN OF TERMINAL AND TURNING BASIN AREA

Coast," for the Council on Environmental Quality (5); and a wide variety of other projects in the bays, estuaries, and near coastal region carried out by Texas A&M University's Environmental Engineering Division, Industrial Economics Research Division and other organizations.

This knowledge, which is summarized in abridged form herein, is not adequate as a substitute for detailed field studies which would accompany advanced planning but it will serve to point out certain critical environmental factors which should receive highest priority in future studies.

Detailed design and construction features, as well as maintenance and operating procedures for the project, are not known at this time; thus, we must make assumptions as to these details for use in preliminary environmental studies. Such assumptions are often adequate, however, if they are based upon the results of similar work or if the impact of each of several alternate approaches is evaluated. For example, minor changes in depth, width or alignment would not significantly alter ultimate results; on the other hand, if two alternate dredging methods are feasible and each is evaluated, then project alternatives can be considered adequately covered.

An environmental impact matrix which can be used in evaluating this project is shown in Table 1. The impact matrix is utilized to provide a systematic way of considering the impact of each construction, maintenance, or operational element on each environmental element. The element components are arbitrary and may be added or deleted as a closer knowledge of the project is obtained.

TABLE 1

ENVIRONMENTAL ASSESSMENT MATRIX

ENVIRONMENTAL ELEMENTS		Offshore Channel – Construction – Dredging	Offshore Channel – Construction – Other	Offshore Channel – Maintenance – Dredging	Offshore Channel – Maintenance – Other	Offshore Channel – Operation – Ship Movement	Offshore Channel – Operation – Oil Spills	Offshore Channel – Operation – Storm Conditions	Entrance Channel – Construction – Dredging	Entrance Channel – Construction – Jetty Mod.	Entrance Channel – Construction – Other	Entrance Channel – Maintenance – Dredging	Entrance Channel – Maintenance – Other	Entrance Channel – Operation – Ship Movement	Entrance Channel – Operation – Oil Spills	Entrance Channel – Operation – Storm Conditions	Terminal Area – Construction – Platform or Piers	Terminal Area – Construction – Pipelines	Terminal Area – Construction – Dredging	Terminal Area – Construction – Onshore Terminal	Terminal Area – Construction – Secondary Construction	Terminal Area – Maintenance – Piers	Terminal Area – Maintenance – Pipelines	Terminal Area – Maintenance – Ships	Terminal Area – Maintenance – Other	Terminal Area – Operation – Structure	Terminal Area – Operation – Primary Ship Movement	Terminal Area – Operation – Secondary Ship Movement	Terminal Area – Operation – Oil Spills	Terminal Area – Operation – Ballasting Operations	Terminal Area – Operation – Storm Conditions
Physical, Chemical & Geological Features	1. Offshore Waters																														
	2. Offshore Sediments																														
	3. Nearshore Waters																														
	4. Nearshore Sediments																														
	5. Beaches																														
	6. Barrier Island																														
	7. Coastal Wetlands																														
	8. Bay and Estuarine Water																														
	9. Bay and Estuarine Sediments																														
	10. Bay and Estuarine Circulation																														
Biological Features – Plants	11. Phytoplankton																														
	12. Marsh and Grass																														
	13. Other																														
Biological Features – Animals	14. Oysters																														
	15. Shrimp																														
	16. Crab																														
	17. Zooplankton																														
	18. Fish																														
	19. Reptiles																														
	20. Mammals																														
	21. Birds, Shore																														
	22. Birds, Waterfowl																														
Biological Features – Other	23. Communities																														
	24. Food Chains																														
Cultural Factors – Land Use	25. Barren																														
	26. Grazing																														
	27. Wildlife Refuge																														
	28. Parks																														
	29. Resort																														
	30. Residential and Commercial																														
Cultural Factors – Aesthetics	31. Scenic Views																														
	32. Unique Physical Features																														
	33. Historical or Archaelogical Sites																														
Cultural Factors – Activities	34. Thermal, Cooling																														
	35. Mining																														
	36. Ship Transportation																														
	37. Recreation, Beach swimming																														
	38. Recreation, Fishing																														
	39. Recreation, Duck hunting																														
	40. Commercial Fishing																														

PROJECT ACTIVITIES: OFFSHORE CHANNEL, ENTRANCE CHANNEL, TERMINAL AREA

The matrix may be used as a guideline for an environmental project or report and/or it may be used with numerical values at each of the grid intersections to indicate relative significance or impact ranging from zero (for insignificant or trivial) through successive stages of importance, i.e., (1, 2, 3, 4, 5) where the highest number represents the greatest level of impact.

For this study the project has been arbitrarily broken into three segments, namely the offshore channel, the entrance channel and the turning basin terminal complex. The general areas included under each of these headings are shown in Figure 3. Dividing up the project area in this manner was done because:

- the work outside of the jetties will primarily impact the offshore coastal environment and the beach areas of the barrier islands such as Galveston Island and the Bolivar Peninsula;
- the modification of the entrance channel is a major environmental change which affects the bay-gulf water interchange; and
- the terminal-turning basin area will have a local direct impact as well as a secondary impact generated by pipelines and other secondary sources of environmental pollution.

These divisions cannot be separated by hard and fixed boundaries since, for example, the cross section and volume of the turning basin is considered part of the entrance channel for its role in bay-gulf interchange while, at the same time, it is part of the terminal complex with regard to potential oil spills from cargo transfer operations.

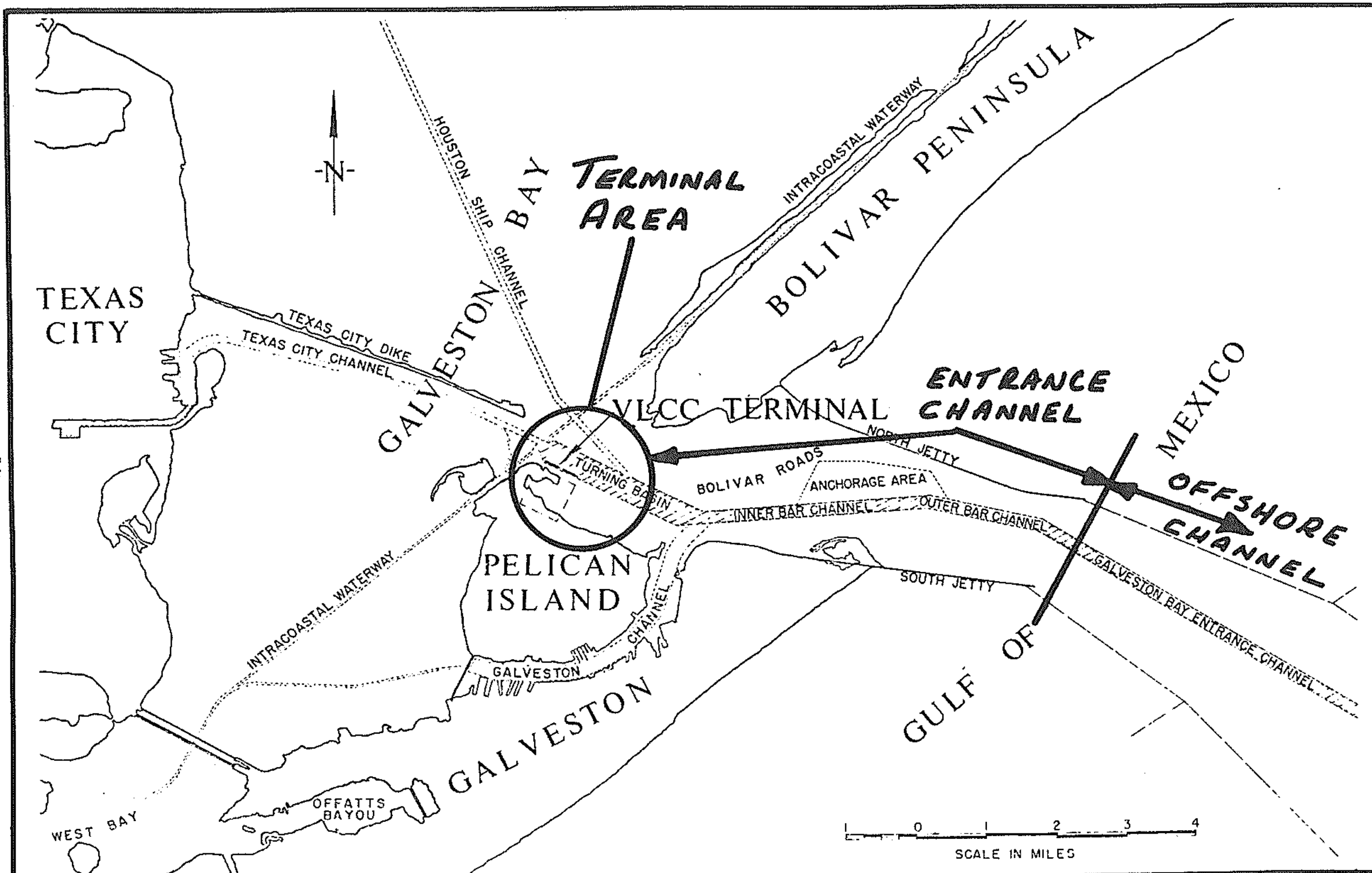

FIGURE 3

PROJECT NOMENCLATURE FOR ENVIRONMENTAL STUDY

GENERAL BACKGROUND DATA ON THE PROJECT AREA

This section presents briefly a few significant environmental features which will be useful to the reviewer in considering the statements presented later in the report. Figures 4, 5, and 6 show critical environmental elements observed from NASA photographs in the general project area. Figure 4 shows the Texas coastal zone from the east end of Matagorda Bay to San Luis Pass on the west end of Galveston Island. This zone is one of the few on the Texas coastline where bays are not located behind barrier islands. Both the Brazos and San Bernard Rivers flow directly into the Gulf of Mexico without passing through a bay system.

Figure 5 shows Galveston Island, West Bay and the coastal marsh area, which makes up the inland coast of the West Bay, Texas City, LaMarque and Bolivar Peninsula areas. Both Galveston Island and the Bolivar Peninsula are primarily sandy barrier islands with heavily-used recreational beaches on the Gulf side and marsh areas on the Bay side.

Figure 6 gives an overall perspective of the entire Galveston Bay and east Bolivar Peninsula areas. The dominant environmental features in these areas are the Gulf beaches and the coastal marshes around East and Trinity Bays.

The entire Galveston Bay system includes over 500 square miles of shallow waters which are biologically highly productive. It is estimated that the majority of the finfish and shellfish inhabiting the Texas coastal region either spends a part of their lives in Galveston Bay or are dependent upon biological species which do.

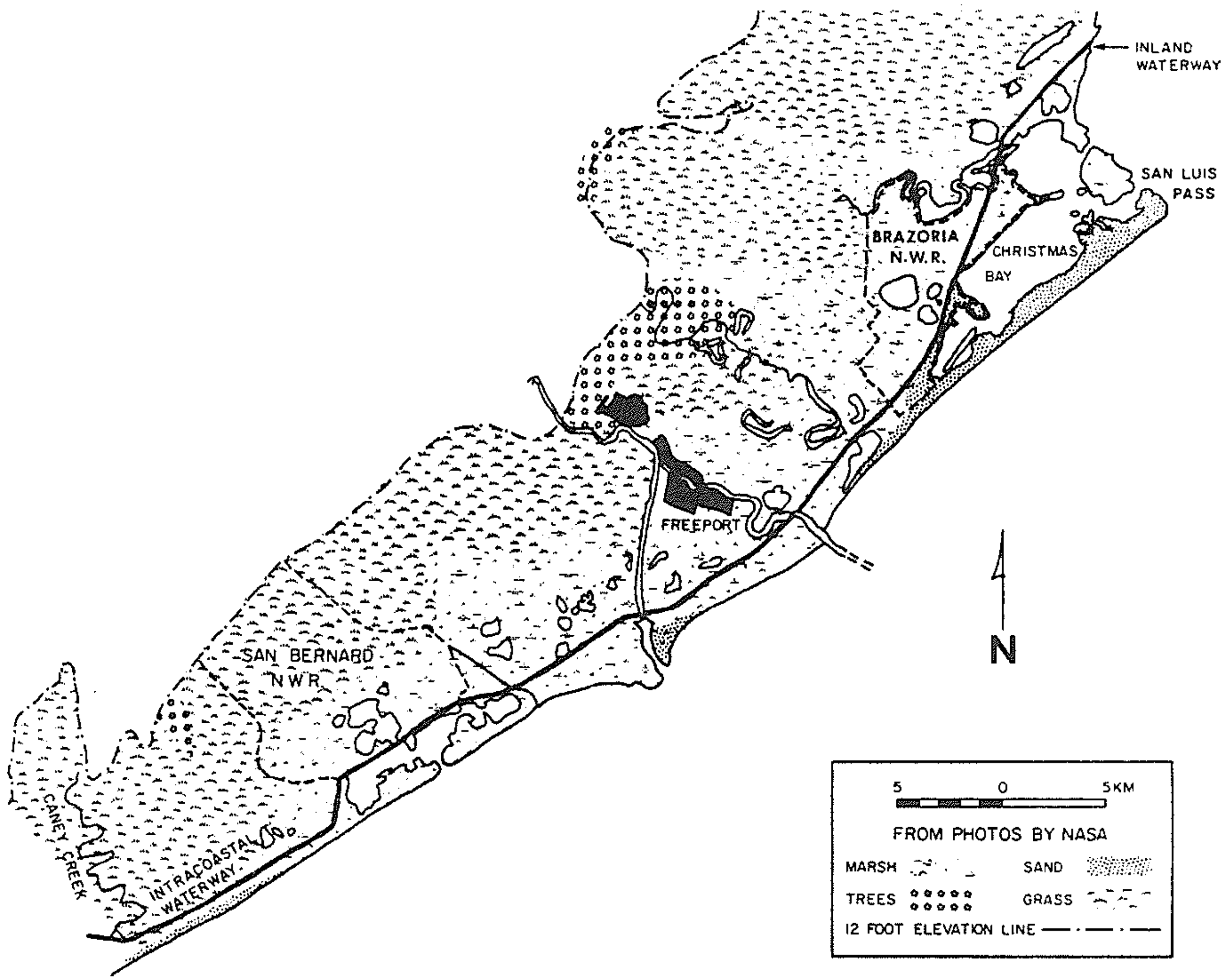

FIGURE 4

ENVIRONMENTAL ELEMENTS OF THE FREEPORT AREA

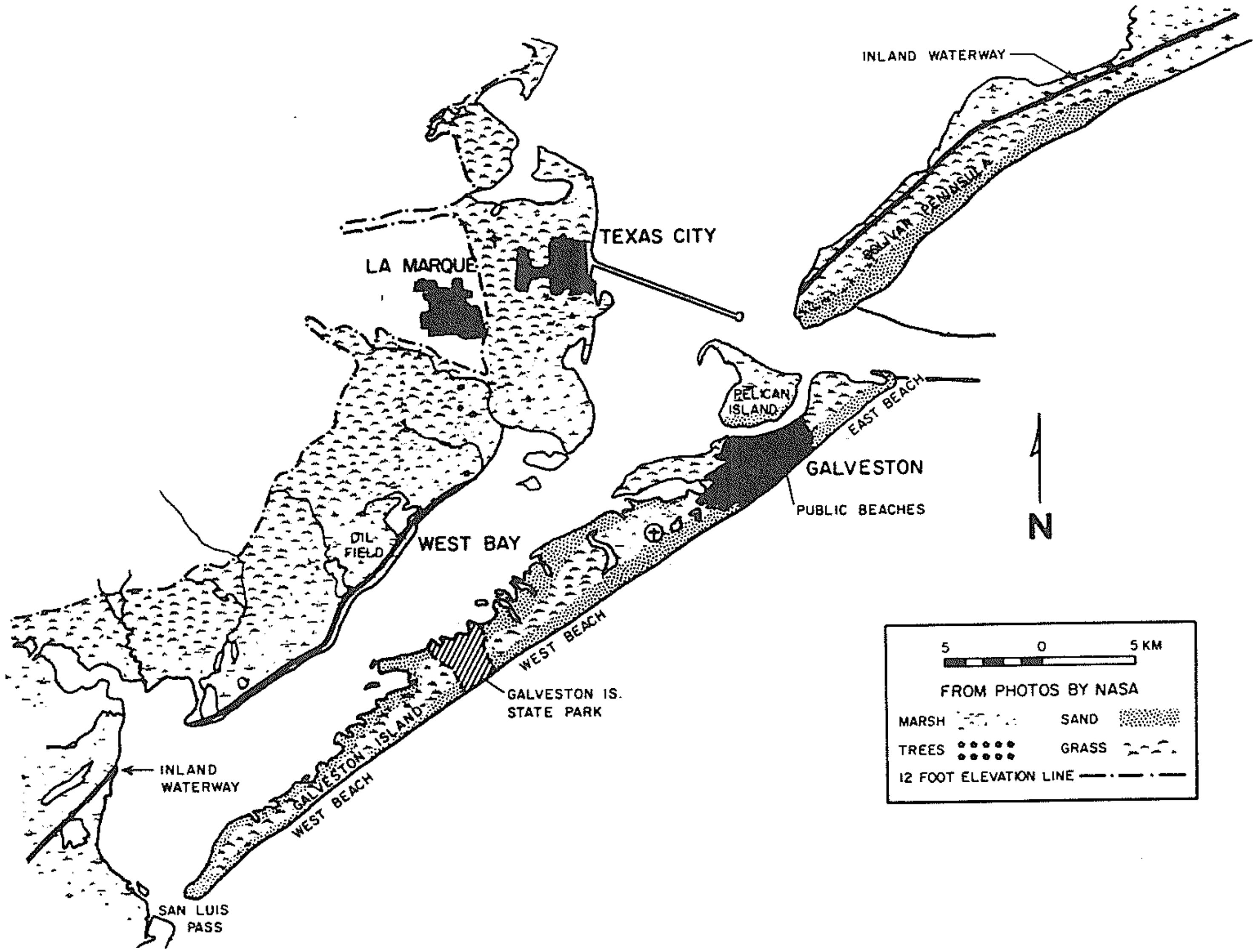

FIGURE 5

ENVIRONMENTAL ELEMENTS OF THE GALVESTON ISLAND AREA

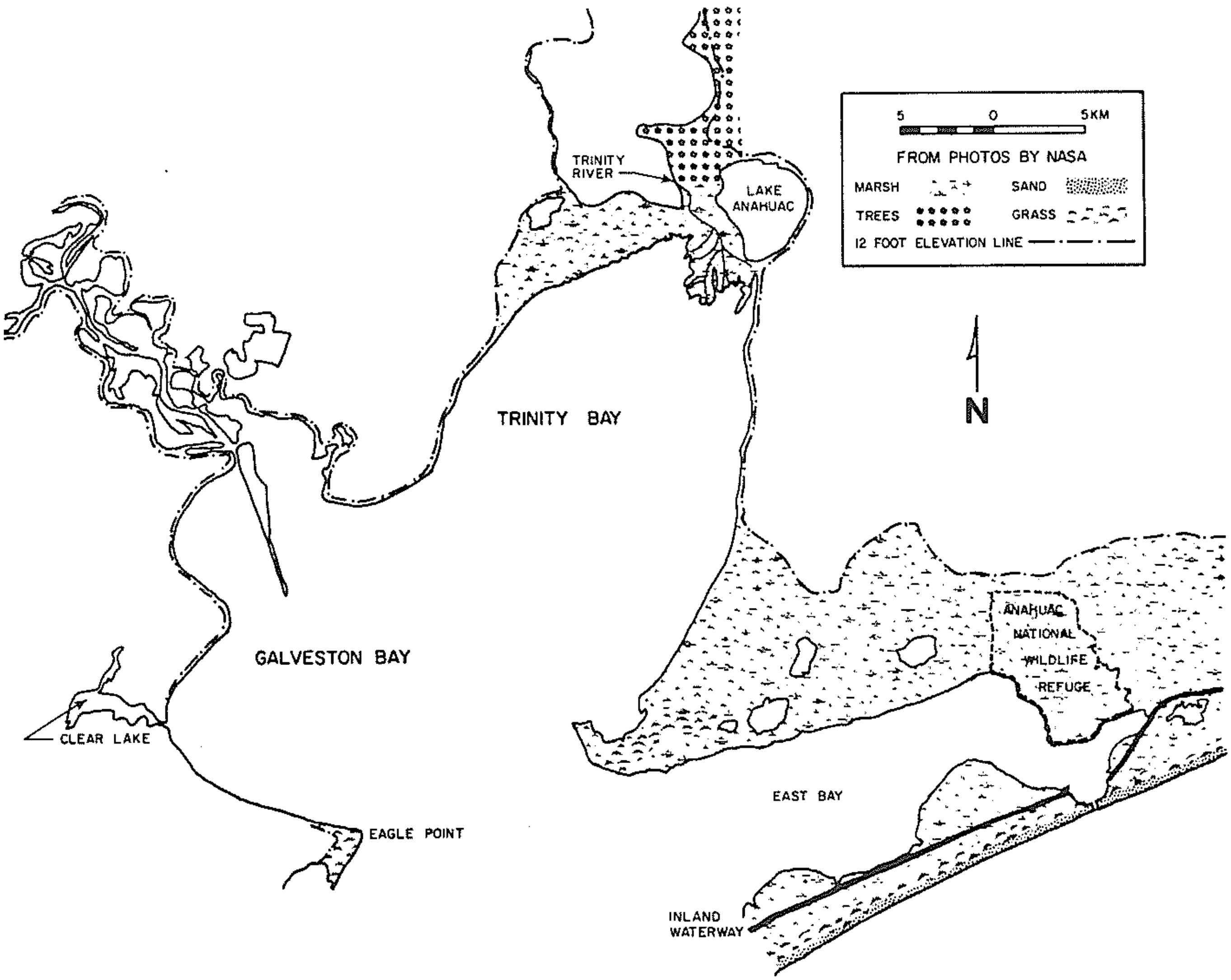

FIGURE 6

ENVIRONMENTAL ELEMENTS OF THE GALVESTON BAY AREA

The continental shelf stretching seaward from the Galveston area is a highly productive marine region. Although shrimp constitute the largest money crop, there is a trend toward increased activity in both sport and commercial finfishing. Whereas the fishery areas off the United States east and west coasts are considered to be fully utilized in the production of seafood, Gulf coast fishing--particularly for finfish--is still relatively undeveloped.

Figure 7 shows major shrimping areas off the Texas and Louisiana coast. The project area for the deep draft channel may be seen to fall into a major white shrimp zone. Various fish trawls made as part of other studies attest to the productivity of this entire coastal zone for finfish as well as shrimp.

Tables 2 and 3 are summaries of wind and tide information off Galveston and other Texas cities. It may be noted that the currents (Table 2) off both Galveston and Sabine are westerly for most of the year. Also, more than 50 percent of the time, the winds off these same two locations are from the southeastern quarter (Table 3).

Figure 8 is a summary of bottom sediment composition over part of the Texas coast. It may be noted that the seashore zone is primarily sand and shelly sand, while approximately five miles offshore the bottom becomes more muddy in nature.

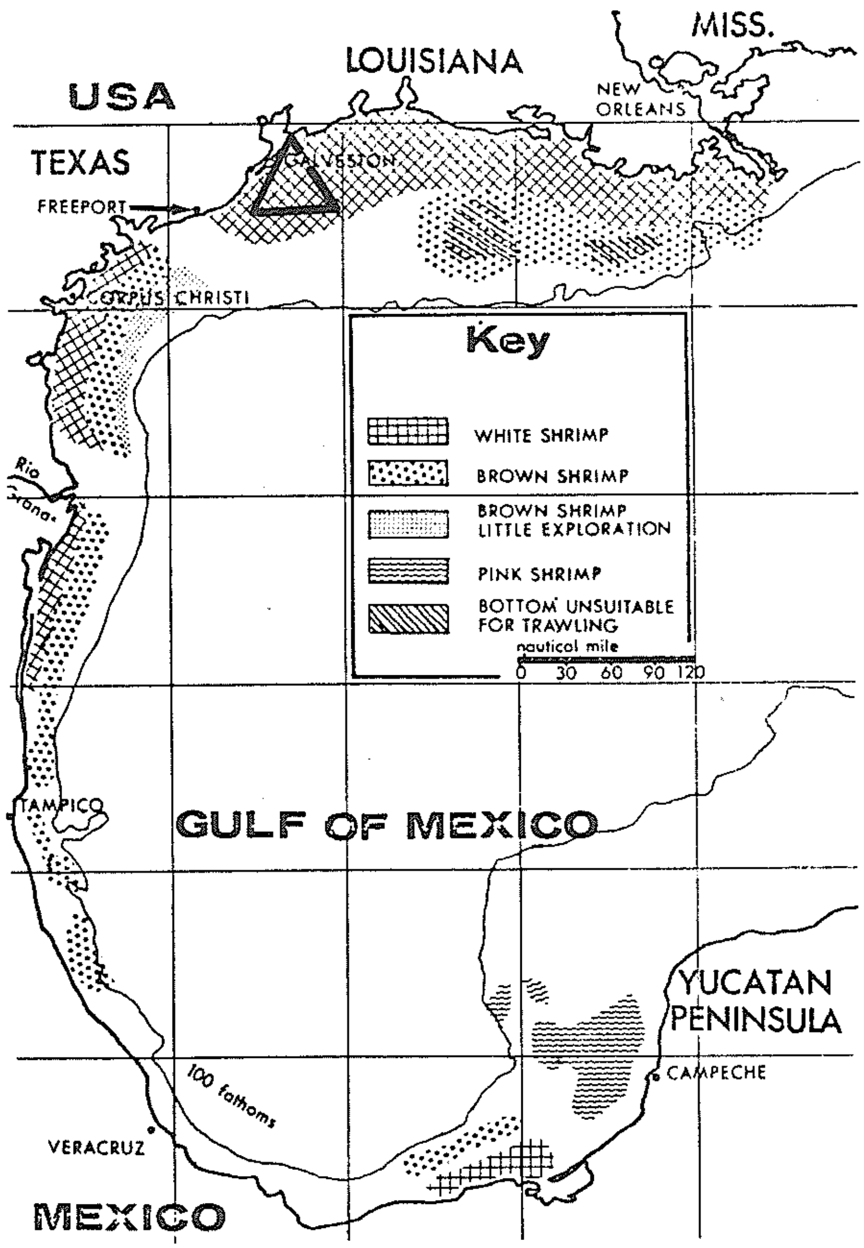

FIGURE 7

SHRIMPING AREAS OF THE WESTERN GULF OF MEXICO

TABLE 2

CURRENTS OFF THE TEXAS COAST

Item[1]	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
I.	$\phi > 29°$, λ 93-94° Off Sabine											
Vel.	.82	.75	.73	.62	.78	.48	.39	.52	.64	.62	.68	.59
Dir.	W	W	W	W	WNW	W	WNW	WNW	W	WNW	WNW	WNW
No. 0	119	147	211	194	248	262	243	390	240	217	191	169
II.	$\phi > 29°$, λ 94-95° Off Galveston											
Vel.	.35	.38	.37	.44	.38	.27	.18	.30	.36	.41	.25	.35
Dir.	W	W	W	W	W	W	NNW	WNW	W	WSW	W	W
No. 0	113	127	159	169	181	177	152	179	156	139	157	114
III.	ϕ 28-29°, λ 95-96 Off Freeport-Matagorda											
Vel.	.06	.29	.15	.17	.27	.26	.23	.10	.13	.25	.19	.17
Dir.	WSW	SW	NE	N	NNE	NNW	NE	SW	W	NW	SSW	
No. 0	6	16	13	16	16	16	23	20	15	15	10	7
IV.	ϕ 27-28°, λ 96-97° Off Corpus Christi											
Vel.	.14	.21	.19	.30	.21	.25	.20	.28	.24	.22	.20	.35
Dir.	WNW	WSW	WNW	NW	NNW	WNW	N	NW	W	NNW	WNW	SW
No. 0	24	33	46	15	45	54	59	60	58	29	39	34
V.	ϕ 26-27°, λ 95-97° Off Mansfield											
Vel.	.26	.57	.16	.12	.24	.53	.85	---	---	----	.59	
Dir.	N	NNE	NNW	N	NNW	NNE	NNE	---	---	---	N	
No. 0	3	10	5	2	6	5	6	---	---	---	3	

[1]Item
I. Segment
Vel. Knots
Dir. Towards
No. 0 No. of observations

SOURCE: "Control American Waters: Current Charts." H. O. Misc. No. 10, 690-1, 1942, Data to 1935.

TABLE 3

WIND DIRECTION AND VELOCITY
ON THE TEXAS COAST

WIND DIRECTION	Galveston Area PERCENT FREQUENCY	Galveston Area MEAN SPEED Knots	Galveston Area MEAN SPEED M/Sec	Corpus Christi Area PERCENT FREQUENCY	Corpus Christi Area MEAN SPEED Knots	Corpus Christi Area MEAN SPEED M/Sec
N	7.4	14.6	7.5	7.8	17.4	9.0
NNE	4.2	14.1	7.2	4.9	15.5	8.0
NE	8.2	12.8	6.6	7.3	12.8	6.6
ENE	4.7	12.9	6.6	4.6	12.2	6.3
E	11.8	11.5	5.9	10.9	10.8	5.6
ESE	7.8	11.4	5.8	8.8	12.2	6.3
SE	15.8	11.4	5.8	19.3	12.4	6.4
SSE	8.5	12.0	6.2	11.3	13.4	6.9
S	11.0	10.9	5.6	11.1	12.4	6.4
SSW	3.2	10.6	5.4	2.4	11.7	6.0
SW	3.3	9.5	4.9	1.9	10.1	5.2
WSW	1.4	9.6	4.9	0.6	9.9	5.1
W	2.7	10.3	5.3	1.3	10.0	5.0
WNW	1.7	12.4	6.4	0.9	12.8	6.6
NW	3.3	13.7	7.0	2.5	14.6	7.5
NNW	2.3	15.0	7.7	2.5	16.7	8.6

Source: Summary of Synoptic Meteorological Observations - North American Coastal Marine Areas, Vol. 6.

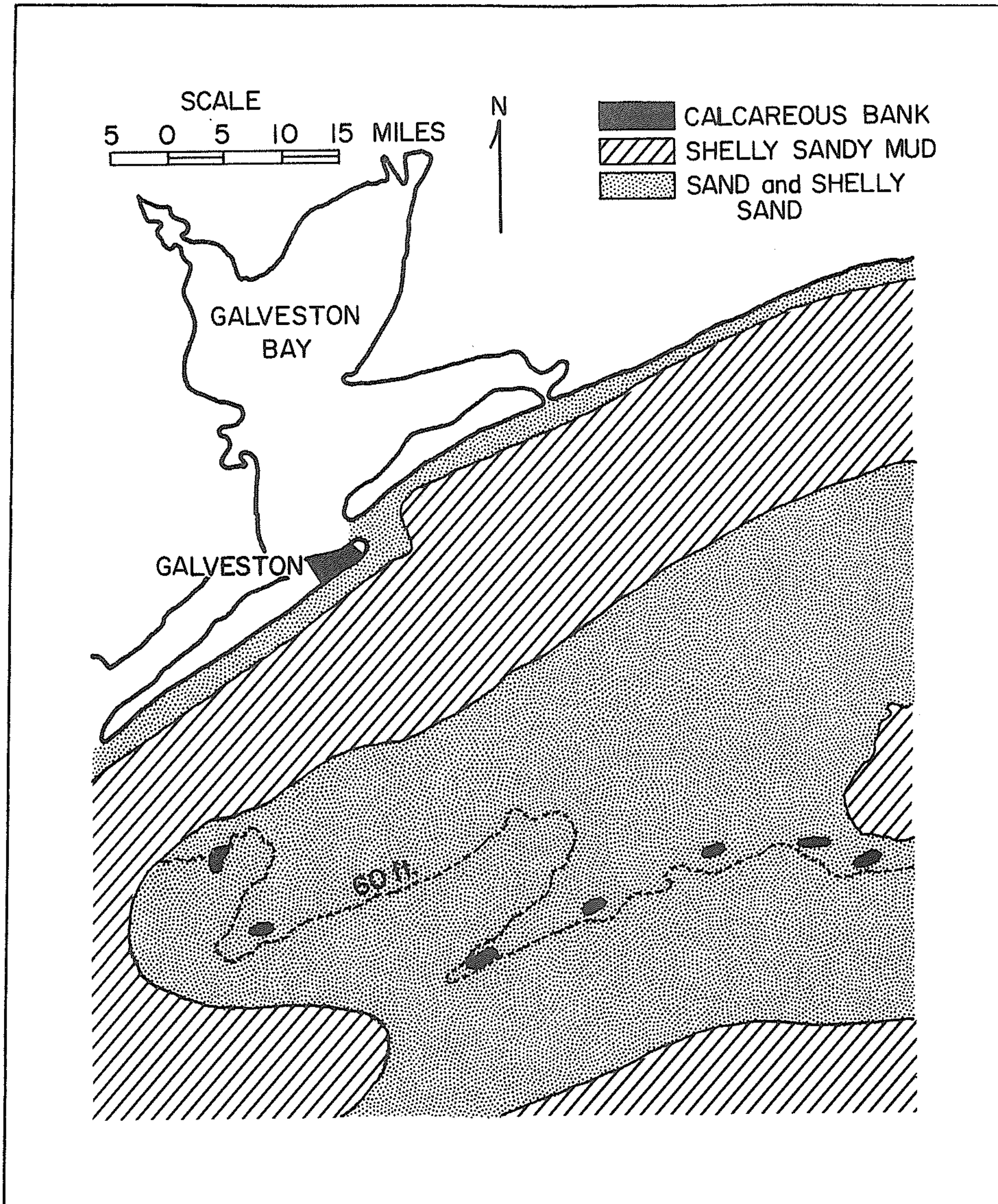

FIGURE 8

SEDIMENT CHARACTERISTICS OFFSHORE FROM GALVESTON ISLAND

CRITICAL ENVIRONMENTAL ELEMENTS

Offshore Channel: Construction and Maintenance

The construction and presence thereafter of the offshore channel will have five predominant environmental impacts:

1. It is recognized that there is general transport of sediment material along the Texas coastline from northeast to southwest. This general movement, however, is the net result of two drifts: a NE-SW movement, which prevails for much of the year, and a SW-NE movement which prevails for a lesser part of the year (3). This phenomena is depicted by the arrows in Figure 9, while Figure 10 (NASA photo) clearly shows turbidity patterns off Galveston. Of significance is the offshore sediment movement. There is current significant beach erosion both on Bolivar Peninsula and at locations on Galveston Island. A major channel, such as the one proposed for this project, could expect to intercept a significant portion of the sediment being transported along the coast. If this proves to be the case, then the danger of increased beach erosion along the Texas Coast from Galveston westward to Padre Island exists. The effect of channel modification has been particularly demonstrated at the mouth of the Brazos River where the relocation of the Brazos to its present location, and the existence of the deep draft channel and allied jetties at Freeport, have combined to cause a condition of high beach erosion between the channel and the river mouth. This could possibly be prevented by extensive disposal of dredge spoils in locations where they could be lifted and transported by normal processes, or by the continuous augmentation of beaches by pumping of sands from offshore.

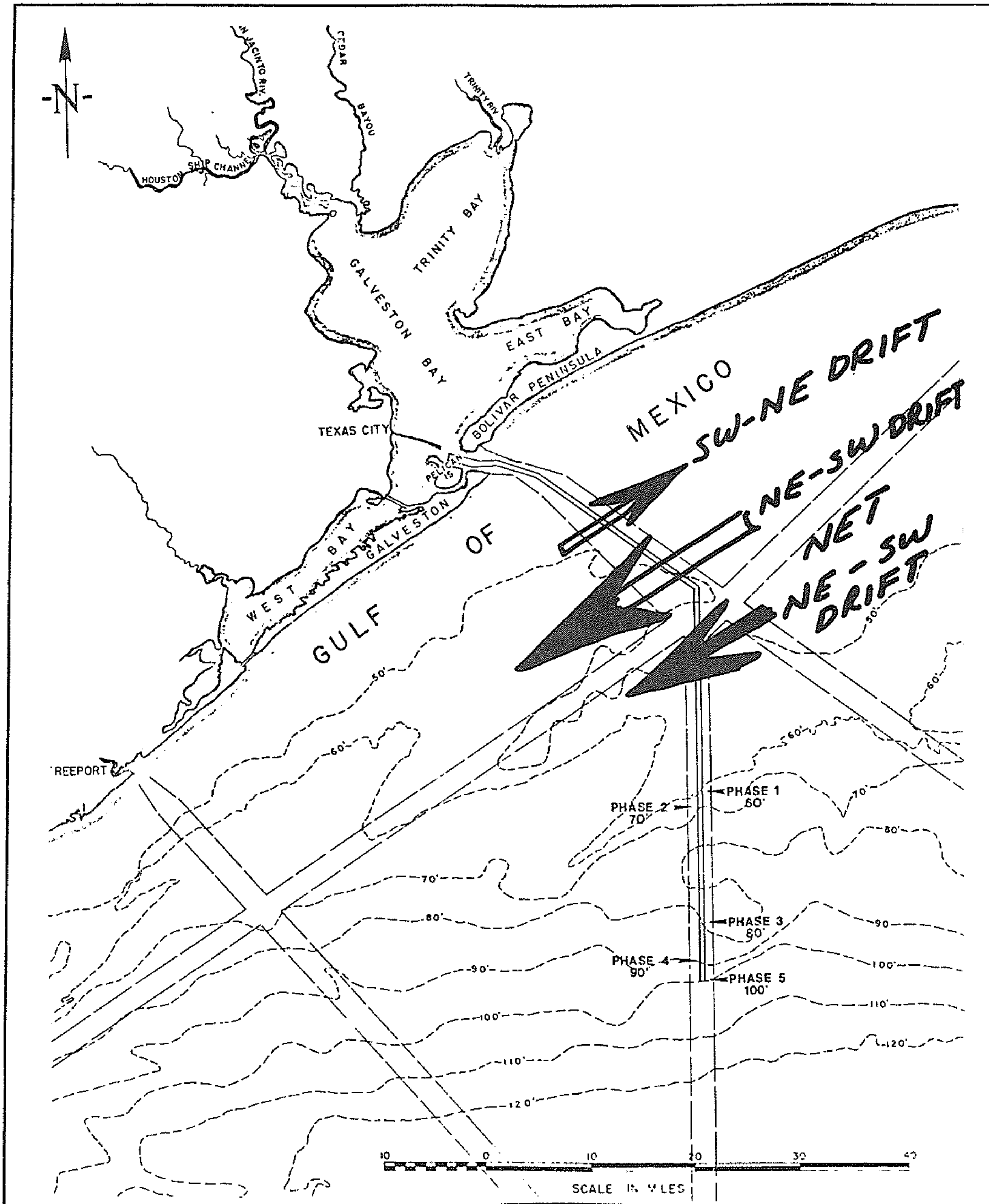

FIGURE 9

SEDIMENT MOVEMENT OFFSHORE NEAR GALVESTON

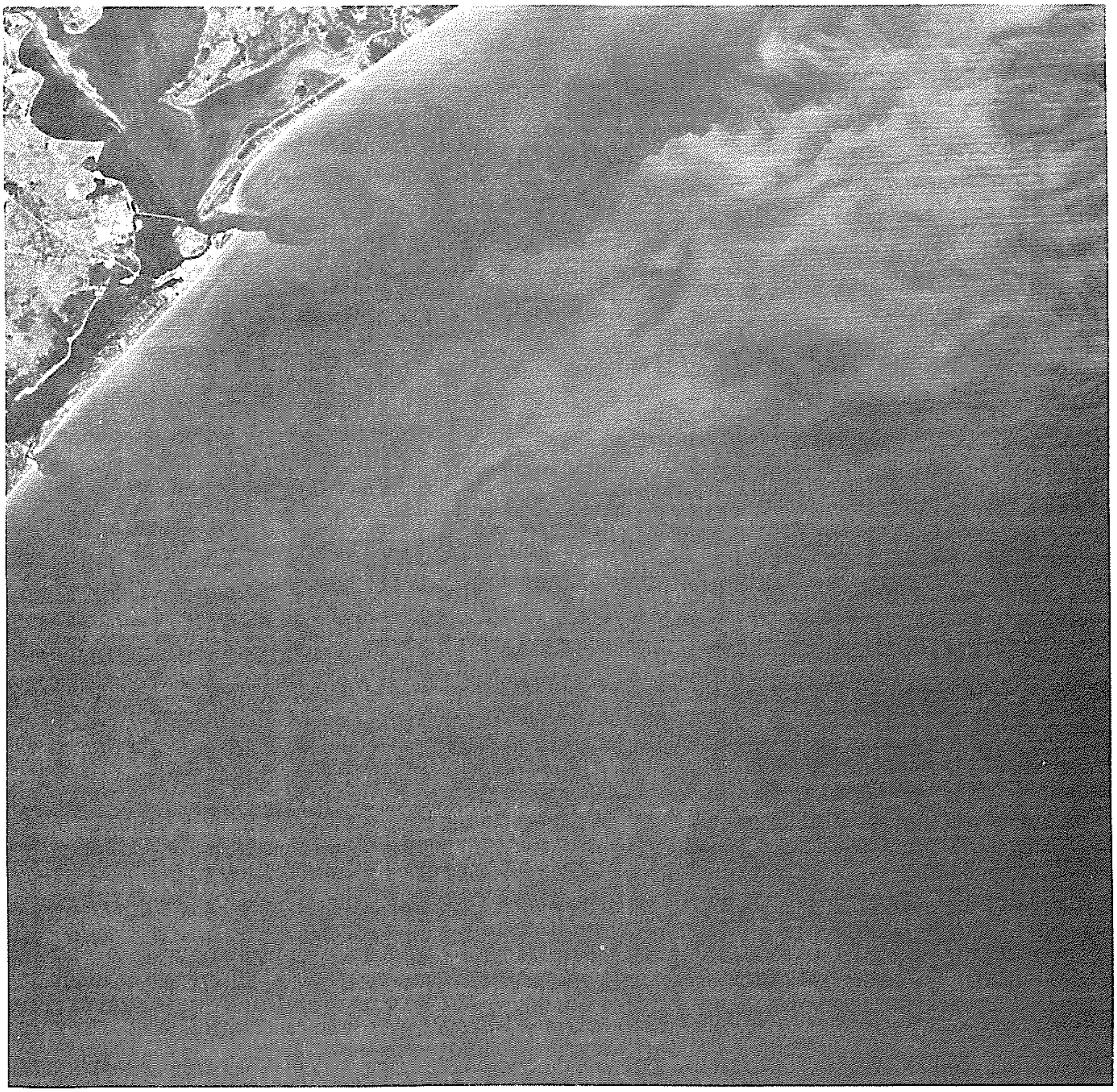

FIGURE 10

NASA PHOTO OF PROJECT AREA SHOWING SEDIMENTS IN WATER

Figure 11 shows the shoreline changes along the Texas coast as determined from maps drawn periodically between 1850 and 1966 (1). In Galveston, the shoreline is advancing in the area of the jetties, but retreating both east and west of the entrance. The delicate balance that exists between the Gulf, the barrier islands and the bays behind the islands make it imperative that the impact of the entrapment of sediment be carefully evaluated to minimize impact of this project.

2. The removal of the existing bottom along the continental shelf will be a direct environmental cost of the project. This could become particularly acute because any reestablished bottom community would be removed by the deeper dredging of succeeding phases of the channel construction or by later maintenance dredging. Based on an average top of channel width of approximately 1,300 feet, some 15 square miles of productive continental shelf bottom would be reduced in population and productivity by the proposed project.

Recovery of the disturbed bottom could be expected to be quite different and likely slower in offshore areas, than in the bays and estuaries. This is because bottom currents and turbulence, which move seed organisms and nutrients, would be less than in the shallow bays. The deeper system is not accustomed to disruption and the deeper water of a channel would be a different ecosystem, i.e., in terms of light, salinity, etc., than surrounding areas.

Study of established channels, such as at Sabine, Galveston and Corpus Christi, to evaluate habitat conditions and the state of the benthic communities in the dredged bottom areas, in relation to undisturbed areas nearby, should provide a considerable insight into what to expect with the proposed project.

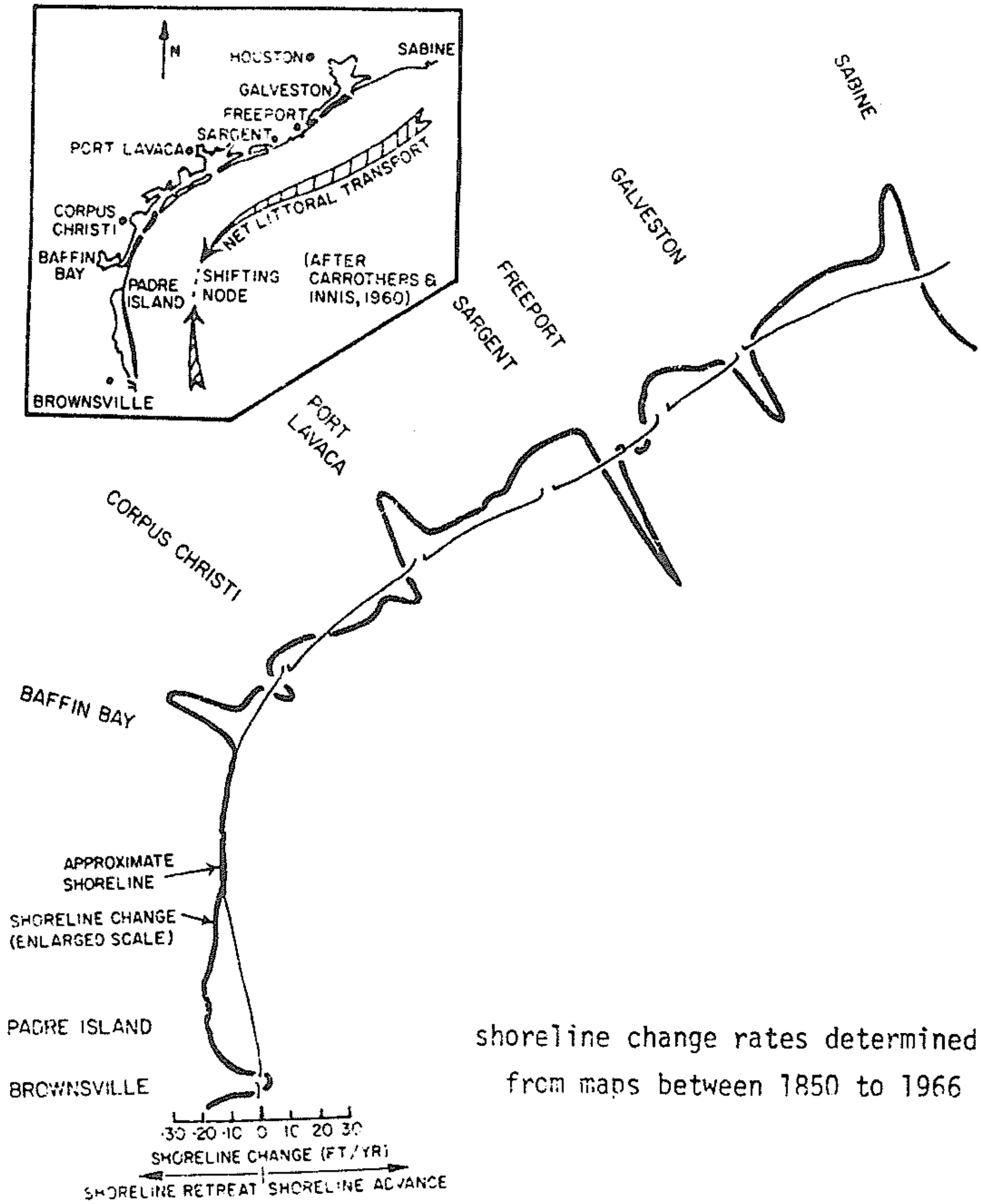

FIGURE 11

TEXAS SHORELINE CHANGE

3. The deposition of the dredged material from the channel construction can be of great importance to the marine environment, depending upon the method and location of disposal. For example, if an average dredged depth of 50 feet is assumed and the material is deposited in a layer one foot deep, then some 750 square miles of bottom would be blanketed. The surface area covered by other depths is shown in Figure 12. If, as is likely, the density of the settled spoil is less than that of the dredged material, the figures could be larger. The economics of disposing of this material under open sea dredging conditions could restrict the distance that it is carried before discharge and, if such is the case, it could end up in a zone parallel to the channel. Deposits of significant height above the surrounding bottom could influence local currents.

Other studies have found that the benthal community is concentrated in the top 10 centimeters of the marine sediments. Some benthal organisms are motile and could move away from or through sediments deposited on the seabed. However, many benthal organisms would be expected to be smothered by a deposition of even a few millimeters over a short time span.

Research is needed on this phenomenon to better evaluate the effect of dredge spoil on offshore benthal organisms.

4. When dredge spoil is deposited into the water the material will sink to the bottom under the influence of the specific gravity and particle size of the discharged material and the currents and turbulent diffusion characteristics of the receiving waters. This process is usually accompanied by a turbid cloud of the finer materials in the spoil.

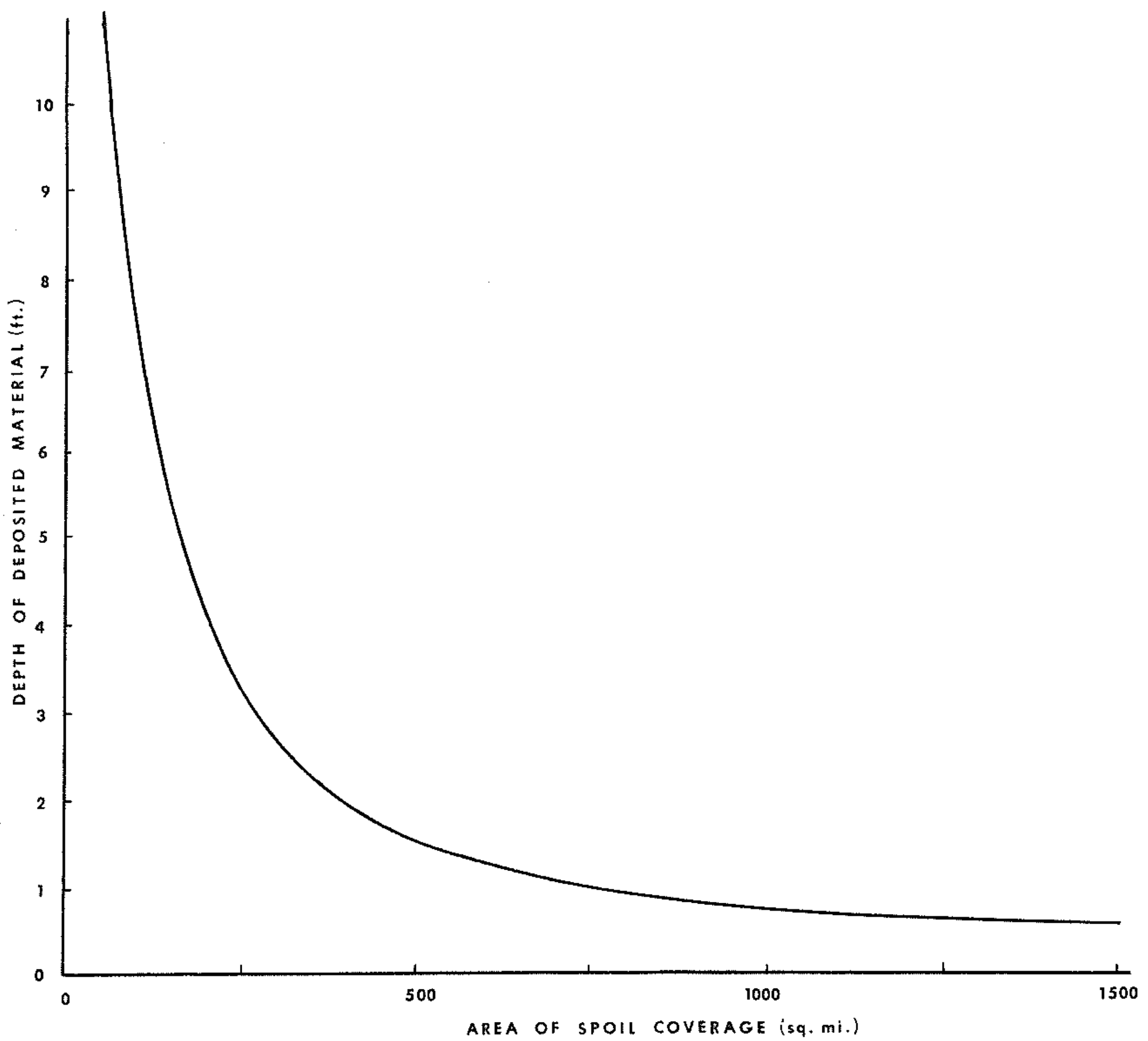

FIGURE 12

SPOIL DEPTH - AREA COVER RELATIONSHIP

This fine material may cause harm to aquatic organisms both on the bottom and in the water column which are not motile enough to escape it. It is likely that some environmental harm will result from the turbidity clouds generated by the extensive dredging operation (i.e., approximately 10 dredges for 5 years) required by this project.

Analysis of particle size, settling characteristics and chemical quality of deep cores collected throughout the proposed channel zone, drilled to the 100' depth contour, is needed to evaluate both settling characteristics and expected turbidity cloud impacts.

5. The deepened channel could possibly intercept the natural flow of groundwater and modify the fresh water/saline water balance of coastal aquifers. Specialized studies are needed to determine if this could be a significant problem.

Offshore Channel: Operation

The primary concern over the operation of the offshore channel is the potential of massive oil spills from transportation accidents. It is a fact that no waterway is built with the intention of having accidents, just as no highway is built to have auto accidents, yet accidents do occur. An ultra-large bulk ship, traversing 50 miles of relatively narrow dredged channel in open water, subjected to currents and winds, could have a high potential for grounding. For this reason, measures must be taken to prepare for oil spills, and research must be done in order to be able to predict spills and to pinpoint their most likely behavior.

Analytical models have been developed which predict the movement of spilled oil from offshore accident sites inward to shore along the Texas Gulf Coast. As a part of the Supertanker Port Study by

Texas A&M for the Council on Environmental Quality, it was determined that approximately 60 percent of the time a spill 30 miles offshore would spread to the Texas coastline. The models calculate the spread and movement of oil based upon oil properties, turbulent diffusion, wind direction and velocity, and current direction and velocity.

A deep draft channel to an onshore terminal creates a larger hazard to the Texas shoreline than would an offshore terminal in the case of an accidental massive spill (as opposed to loading and unloading accidents). This is because 1) the ships are traveling in a narrow channel with shallow water on each side 2) the ships are exposed to higher traffic density as they near shore 3) the chance of an oil spill reaching the most important beaches in Texas increases as the vessel nears the shore and 4) a spill occurring nearer to shore would reach the beach with a shorter travel time, therefore, some of the toxic volatile fractions would not have a chance to evaporate into the atmosphere or to dissolve into the water column before the oil mass arrived.

The final environmental study should include evaluation of the above parameters using available models and assuming the occurrence of a spill at several points along the channel alignment. Use of the models can also help determine the most probable points of spill impact where clean-up equipment should be stationed.

Entrance Channel: Construction and Maintenance

The entrance channel will pose the same problems regarding the removal of sediments and disposal of the dredge spoil as the offshore channel. There is perhaps, however, less concern over the bottom resource in the zone between the jetties because of the traditional role of this area as a transportation thoroughfare.

There is cause for concern, however, about the widening and deepening of the waterway, inasmuch as this could possibly be an environmental modification of great consequence with regard to the present salinity and current regimes in Galveston Bay. Figure 13 shows a plan view of the entrance channel area with three cross sections marked thereon. Figure 14 shows cross section areas of the present channel at the three points and the cross section areas which would exist after construction of the deep draft channel.

Required dredging would increase the cross section area at Section A-A by 44 percent, at B-B by 36 percent and C-C by 65 percent. As a result, tidal velocities would be decreased and/or the time period of high tidal velocities would be decreased at these cross sections. Figure 15 shows present current profiles at the Galveston Bay entrance and shows how this would be altered for a present 2.0 knot current at Section C-C. A Corps of Engineers' report (2) covering studies of this area cautions against construction operations which increase present cross sections and reduce current velocity.

The presence of the deep draft channel would undoubtedly bring more dense saline bottom water into the channel and thence into the Bay system. It should be remembered that this increase in sea water salinity is coupled with decreasing fresh water inflow to the Bay because of water resource development on the San Jacinto, Trinity, and other watersheds which drain into the Bay. Movement of the saline water into the Bay should, however, improve the flushing of the lower Bay.

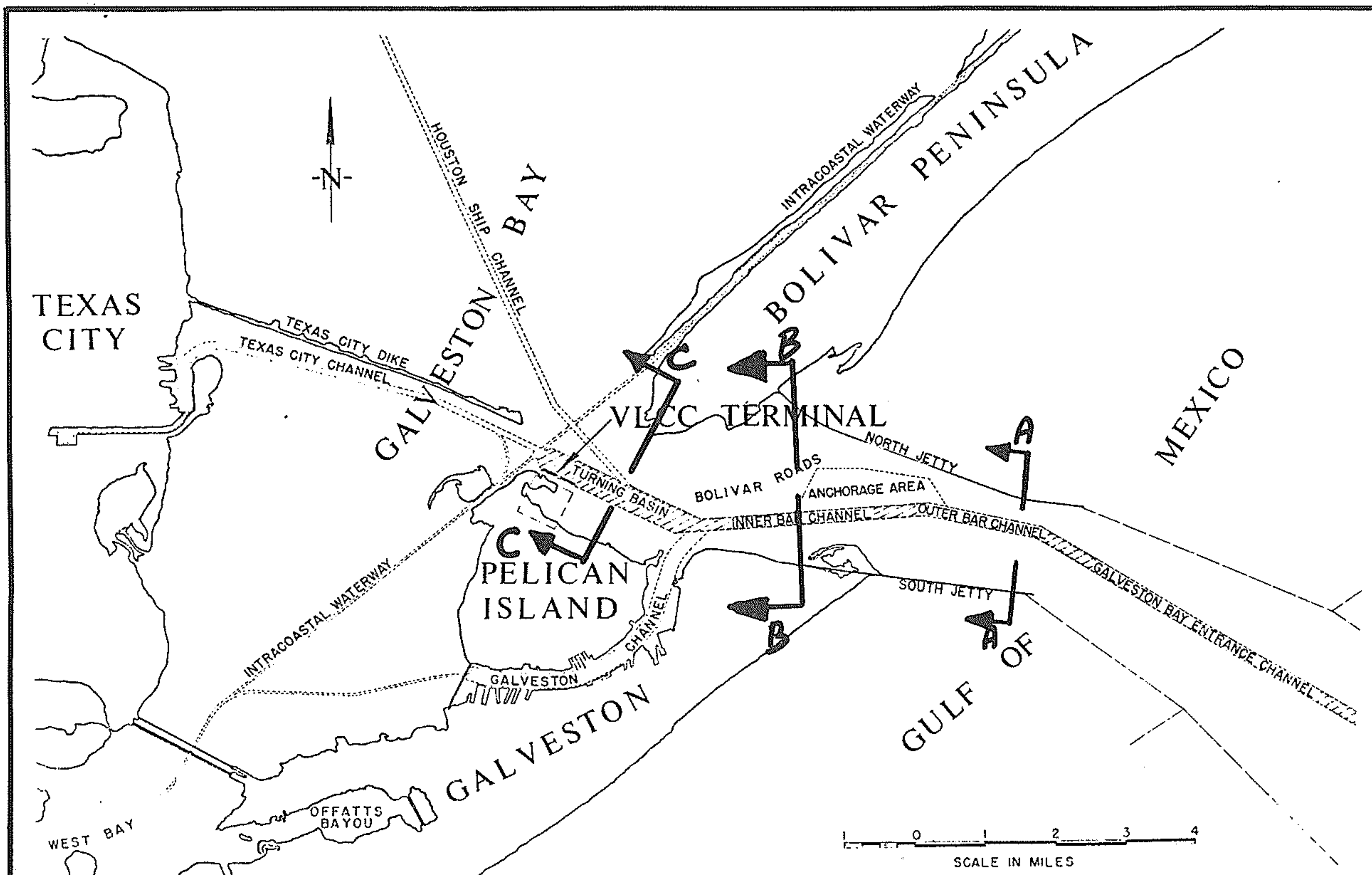

FIGURE 13

ENTRANCE CHANNEL CROSS SECTION LOCATIONS

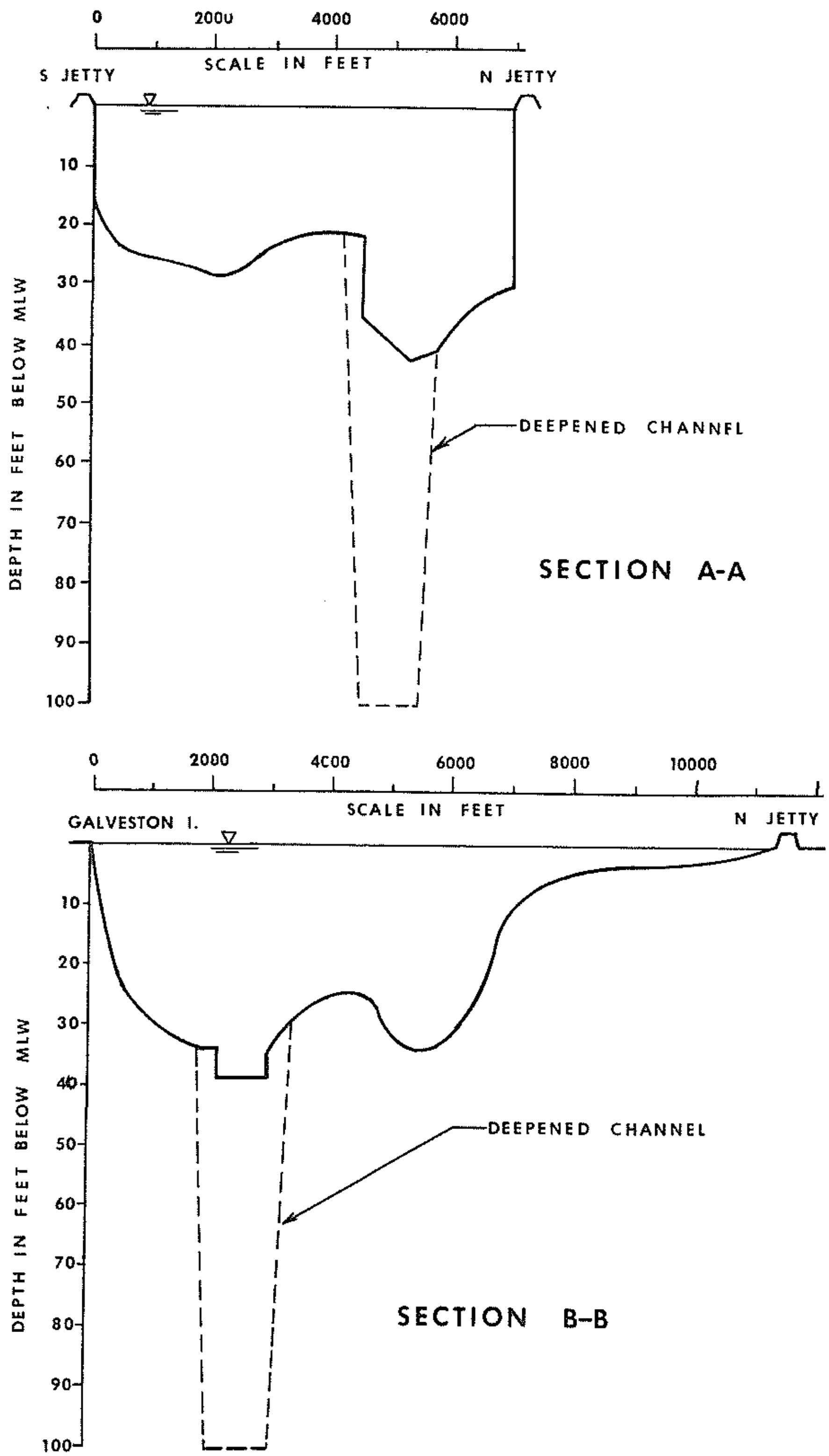

FIGURE 14

ENTRANCE CHANNEL CROSS SECTIONS

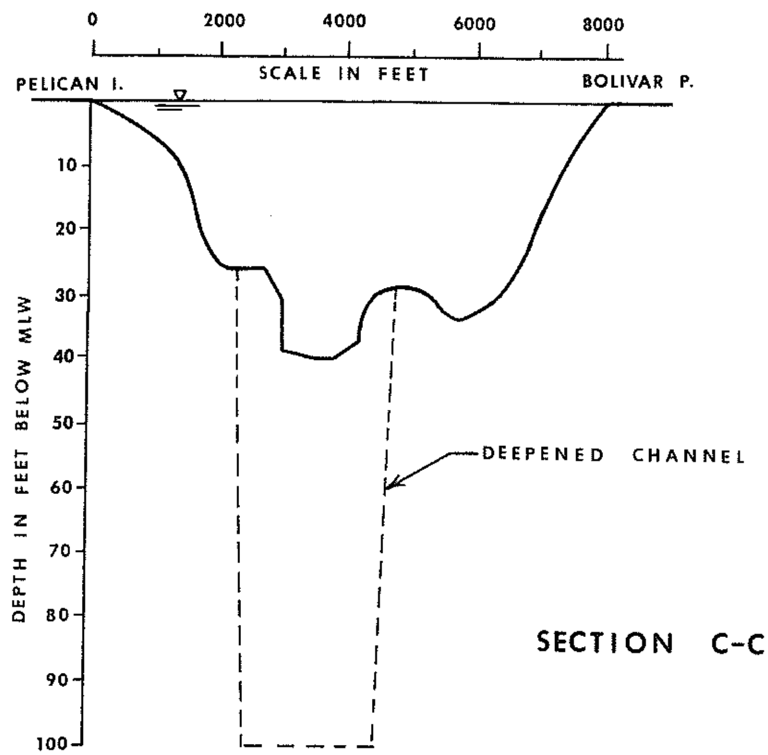

FIGURE 14 (continued)

ENTRANCE CHANNEL CROSS SECTIONS

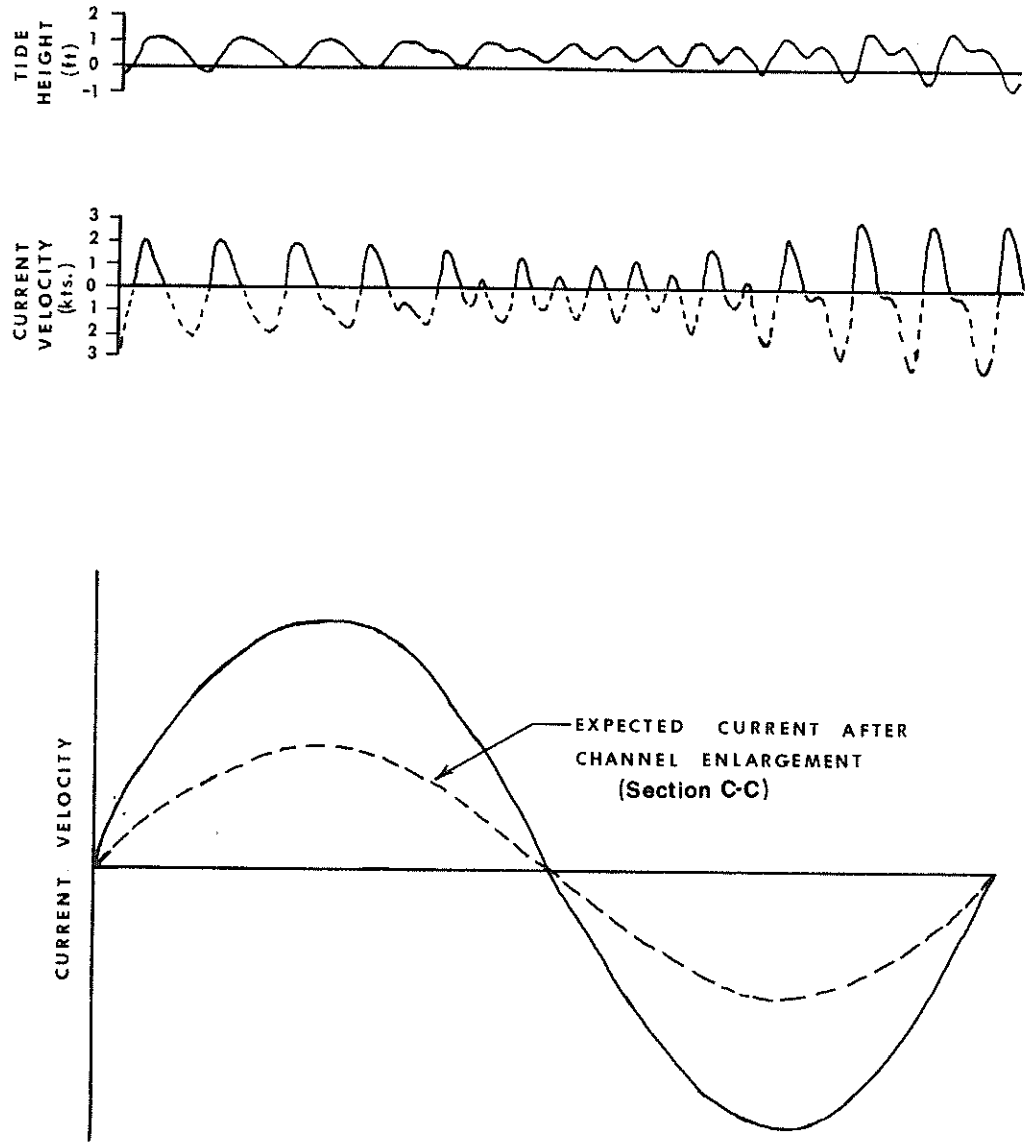

FIGURE 15

ENTRANCE CHANNEL TIDE CHARACTERISTICS

It is difficult to predict what the magnitude of the velocity or salinity changes will be, or the impact on such biological factors as prey-predator relationships, etc. Insight into the salinity and velocity questions could most likely be provided by hydraulic model studies at the Vicksburg Waterways Experiment Station of the Corps of Engineers. Also, the wider and deeper channel could be expected to trap more sediment coming from Galveston Bay than is now trapped and the magnitude of this process could be predicted with a hydraulic model. It was estimated (1) that deepening the present channel to 46 and 48 feet would increase maintenance dredging by 100,000 cubic yards per year. This would be an increase of between 5 and 10 percent over present maintenance dredging quantities.

Entrance Channel: Operation

The major environmental hazard within the entrance channel would again be the danger of oil spill from transportation accidents. A significant improvement could result, however, because of the change in the currents in the entrance channel area as shown in Figure 15. The present ebb and flood current of two knots is at the upper limit of the effectiveness of oil booms, thus a widening of the channel, with a subsequent reduction in current velocity, could make oil spill containment equipment more effective.

An added consideration with regard to entrance channel modification is the potential Bay-Gulf interaction during a hurricane. Would the existence of a larger opening create greater flooding in and around Galveston Bay? The answer to this question could also be predicted by hydraulic model studies.

Terminal and Turning Basin: Construction and Maintenance

The terminal area and turning basin construction will most likely consist of the dredged basin, platforms or piers, elevated or submerged pipelines, an onshore storage terminal, and assorted undefined secondary construction activities relating to transportation facilities such as transshipping piers, pipelines and railroads; refinery and other petrochemical installations; and supporting industries.

Each of these activities should have its environmental impact evaluated but the impact from the primary components should be modest in scope and local in nature.

The secondary impact of increased petrochemical and refining activities around West Bay and Galveston Bay could be significant with regard to water pollution in the Bays, air pollution, and impact on terrestrial species and waterfowl displaced by the construction. These are questions, however, which must await further project definition and more intensive study.

Terminal and Turning Basin: Operation

There is little doubt that a properly designed and operated terminal can minimize or eliminate the likelihood of the escape of oil during transfer operations. However, the exposed position of the terminal area to entrance channel tidal currents and wind fetch makes special care necessary. For example, considering tidal currents, will spill booms be effective when utilized to surround and enclose the supertankers at the proposed anchorage? While this question may seem to be more operational than environmental in nature, there is a possibility of real environmental danger if the unforeseen develops or if design shortcomings should materialize.

CONCLUSIONS AND RECOMMENDATIONS

TAMU

CONCLUSIONS

The development of a deep draft port for the Galveston area is a project of major consequences. An attempt has been made here to establish a framework for a comprehensive environmental study which should be undertaken in the early stages of planning for the proposed port. Also, those environmental factors deemed to be of greatest significance have been flagged in order to emphasize their importance as a part of future project planning.

Evaluation of the environmental aspects of a deep draft channel must include a comparison with alternative methods of achieving the project objectives. The no-action alternative is probably the most environmentally desirable solution but it ignores economics. The adverse, as well as the beneficial, environmental effects of the various alternatives must be considered along with economic and social impacts. Alternatives should include methods for minimizing any adverse environmental effects.

A deep draft channel will enlarge the entrance cross section to Galveston Bay and should improve the flushing characteristics of the Bay. The impact of the offshore deepwater channel on coastal erosion is a major environmental concern. Dredging operations and dredge spoil disposal must be planned to minimize the adverse effects on the barrier islands and coastal beaches. A beach nourishment plan might be included in the project to reduce the coastal erosion presently occurring along much of the Texas coast. Detailed studies will be required to conceive and assess various dredging and spoil disposal plans.

A massive oil spill could cause severe environmental damage. Oil spill control and containment should be included in planning, design, and operation phases of this project.

RECOMMENDATIONS

In the area of environmental concern, a wide variety of studies, some of the "before and after" type, should be undertaken to ensure a complete understanding of the potential problem areas. Some of these studies were suggested in the earlier environmental discussion and these, along with several others, are summarized as follows:

1. Analysis of sediment transport along upper Texas coast. Evaluation of shoreline erosion and nourishment processes, including sources of sand deposited on beaches.

2. Estimation of recovery processes and rates for deeper bottom areas inside channel.

3. Evaluation of the effects of dredge spoil on benthal organisms.

4. Census of biota population in dredged and spoil areas before, during, and after construction.

5. Analysis of settling characteristics of bottom materials, down to 100 feet below the water surface, and application of this data, in conjunction with known turbidity sensitivity levels of resident biota types, to evaluate impact of construction turbidity.

6. Evaluation of possible impact of project on fresh-water aquifers in the area.

7. Development of analytical models for predicting the behavior of close-in oil spills. Develop predictions for oil-spill potential, and establish procedures for the control and clean-up of spills. Also, estimate the impact of spills that reach shore under varying conditions of size, time in water, etc.

8. Evaluate impact on water interchange processes between rivers, the Bay and the Gulf. Estimate changes that will occur in the saline-fresh water balances in the Bay.

9. Model studies of hydrology and tidal velocity changes likely to occur.

10. Study of possible changes in hurricane-induced flooding around the Bay.

11. Estimation of air and water pollution, development of wetlands and other impacts of secondary development.

12. Monitoring program to watch operation of facility for a number of years to ensure that environmental normalcy is maintained.

REFERENCES

REFERENCES

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