US Army Corps
of Engineers

GALVESTON DISTRICT
SOUTHWESTERN DIVISION

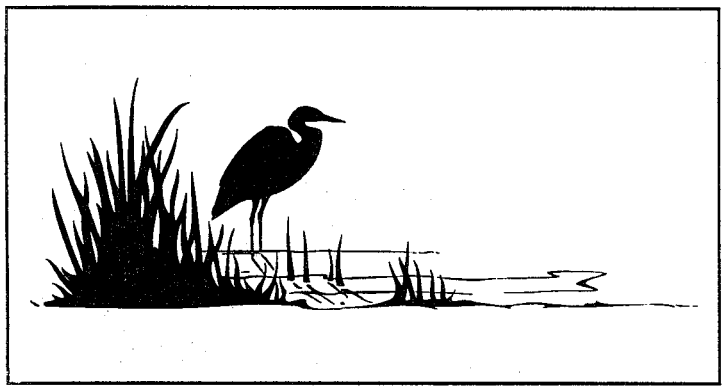
GULF INTRACOASTAL WATERWAY - ARANSAS NATIONAL WILDLIFE REFUGE, TEXAS

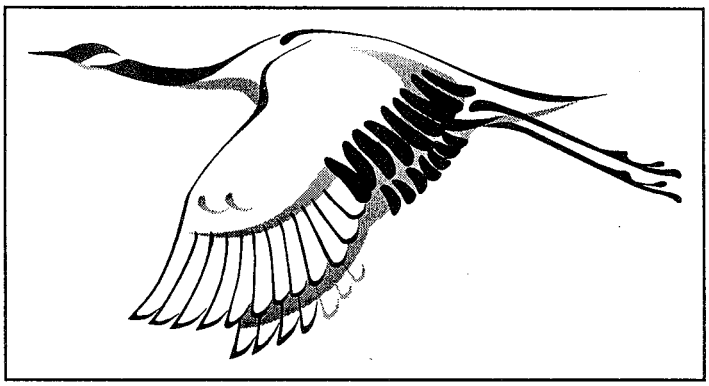
FEASIBILITY REPORT

AND

FINAL ENVIRONMENTAL IMPACT STATEMENT

VOLUME 2: APPENDICES





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SPILL CONTINGENCY AND PREVENTION PLAN

Gulf Engineers
& Consultants
Inc

June 1992

Final Report

Contract No. DACW64-91-D-0002
GEC Project No. 22302203

SPILL CONTINGENCY AND PREVENTION PLAN FOR THE GULF INTRACOASTAL WATERWAY AT THE ARANSAS NATIONAL WILDLIFE REFUGE

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EXECUTIVE SUMMARY

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This study examines the most likely and worst case spills of commodities transported in barge tows on the Gulf Intracoastal Waterway (GIWW) and potential effects on the rare and endangered whooping crane and its habitat. Other navigation-related habitat preservation matters are also considered, including bank erosion and structural and nonstructural contingency plans for protecting the Aransas National Wildlife Refuge (ANWR).

Over 82 percent of the commodities now being shipped by barge on the 31-mile portion of the GIWW in the vicinity of the ANWR are materials that if spilled in large amounts can endanger whooping cranes or their habitat. However, the physical and chemical properties of most of these commodities, the manner in which these commodities are transported (in barges), and the natural and man-made hydrographic features (such as channel width and depth in the locale) preclude the spilling of sufficient amounts of these materials to constitute a serious threat. The materials shipped that present the greatest threat to whooping cranes and habitat are floatable oils such as crude petroleum, residual (#6) oil, and lubricating oils, which constitute about 16.8 percent of all commodities shipped.

Spills of less than ten barrels of troublesome petroleum-based oils occur occasionally on the GIWW, but these fugitive spills have not as yet done any serious damage. It is larger volume spills that could do significant damage at the ANWR. Since this area is isolated from industrial and commercial activities, the only foreseeable reason for a large spill would be a collision in the GIWW between a loaded barge and another large vessel such as a barge or towboat.

Historical data indicate that a barge collision is unlikely to occur in the study area. Dimensions and other physical restraints, including barge design, indicate a worst case in which up to 1,500 barrels of troublesome floatable oils could be spilled in the unlikely event of a collision involving an oil barge.

The probability of chemical or oil spills from a navigation accident involving vessels traversing the 50-mile reach of the GIWW that crosses the critical habitat of the whooping crane was evaluated by using an approach similar to that used by the Minerals Management Service (MMS) to estimate the likelihood of oil spills in association with the production and transportation of oil on the U.S. Outer Continental Shelf. Spills resulting from docking or loading accidents were excluded from consideration because no such facilities are located in the study area. Spill data were obtained from the Texas Waterway Commission, Coast Guard,

ANWR, and the MMS. Detailed traffic data for 1989 (the most recent available) listing tonnages, origins, and destinations for commodities shipped through the study reach were obtained from the Waterborne Commerce Statistics Center (WCSC), New Orleans. The data were used to determine the most likely spill commodity (Gasoline, WCSC commodity code 2819), which was defined as the commodity with the highest level of ton-hours of shipments through the study area. The traffic data were also used in combination with information obtained from interviews with biologists from the ANWR and representatives from companies shipping hazardous materials through the study reach to determine the worst case spill of the most dangerous commodity (or combination of commodities) to the whooping crane and the whooping crane habitat.

The worst case spill scenario developed from this information is a collision between two barge tows resulting in a spill of significant quantities of crude oil, residual fuel oil, or lubricating oils. A spill of as little as 10 barrels or more of these floatable, persistent oils at a critical location on the GIWW in the study reach under adverse wind and tide conditions could damage habitat or injure birdlife and is considered "significant" for the purposes of this analysis. A spill of 100 barrels or more of other toxic but volatile (rapidly evaporating) polluting substances capable of causing damage to birds or habitat is also considered "significant". A spill of only a small portion of the contents of a single compartment of a tank barge (with capacity of up to 3,000 barrels or 126,000 gallons) typically exceeds 100 barrels.

The approach to evaluate the likelihood of spills uses a spill rate constant (λ), based on historical spill data, expressed in terms of the number of spills per billion ton-hours of commodities transported through the area from which the spill data were obtained. The probability of one or more significant spills in the entire Texas inland waterway system was considered because no significant spills were found to have occurred in the study reach in spill database queries for the period of 1986 to 1990 in the TWC, Coast Guard, or MMS databases. This probability was estimated by using the two significant spills identified (which occurred at Freeport and Port Arthur) and the five-year traffic volume for the entire Texas inland waterway system in a Poisson process and adjusting the resulting probability to the study area exposure. The five-year traffic volume of approximately 44.74573 billion ton-miles (or 8.94915 billion ton-hours) for the Texas inland waterway system was obtained from the traffic records available from the WCSC.

The estimated probability of the most likely spill (one or more significant spills over an exposure to Gasoline of 26,227,210 ton-hours in the study reach in 1989 as determined from WCSC data) is 0.00217, or 0.217 percent. Expressed as an odds ratio, this probability of the most likely spill is equivalent to a 1 in 461 chance of one or more most likely spills over an exposure to Gasoline of 26,227,210 ton-hours per year in the study reach.

The mean spill occurrence estimate ("spill frequency") for the most likely spill is obtained by multiplying λ, the spill rate constant, by the projected ton-hours (t) of Gasoline for the study reach. The mean most likely spill occurrence is therefore estimated as:

mean most likely spill occurrence $= \lambda * t = 0.22348 * 0.03242$

$=$ <u>0.00724 spills per billion ton-hours</u>

or 1 spill per 138.03549 billion ton-hours of commodities transported through the study reach. Assuming traffic volume per year through the study reach remained at 1989 levels (128,393,996 ton-hours per year), the mean most likely spill occurrence rate for the study reach is 1 spill per 1,075 years.

The probability of the worst case spill was defined for this analysis as the probability of a collision between two tows that results in a significant spill of crude petroleum (WCSC commodity code 1311), residual fuel oil (WCSC commodity code 2915), or lubricating oils (WCSC commodity code 2916) from one or more tank compartments of barges in either or both tows. The total exposure to worst case commodities traversing the study area in 1989 was 20,764,677 ton-hours or 0.02076 billion ton-hours, as determined from WCSC data. The probability of the worst case spill is estimated at 0.0000013344, or 0.00013344 percent, over an exposure in the study area to crude petroleum, residual fuel oil, or lubricating oils of 12,112,728 ton-hours. The exposure to 20,764,677 ton-hours of these commodities was reduced by 7/12 to the total of 12,112,728 ton-hours, since the whooping cranes are only in residence for 7/12 of the year. Expressed as an odds ratio, this probability of the worst case spill is equivalent to a 1 in 749,400 chance of one or more worst case spills over an exposure to worst case commodities of 12,112,677 ton-hours per year in the study reach.

The mean spill occurrence estimate ("spill frequency") for the worst case spill is obtained by multiplying λ, the spill rate constant, by the projected ton-hours (t) of crude, residual fuel oil, and lubricating oil for the study reach. The mean worst case spill occurrence rate is therefore:

mean worst case spill occurrence rate $= \lambda * t = 0.11174 * 0.01497 =$

$=$ <u>0.00167 spills per billion ton-hours</u>

or 1 spill per 597.82 billion ton-hours of crude, residual fuel oil, and lubricating oil transported through the study reach. Assuming that traffic volume per seven months of whooping crane residence at ANWR remained at 1989 levels (128,393,996 ton-hours per year or 74,896,498 ton-hours per seven months of cranes in residence at ANWR), the mean worst case spill occurrence for the study reach is 1 worst case spill per 7,982 years.

To determine how to minimize damages from a spill, an estimate of effects was made for worst case spills at four locations within the study area, which were selected in consultation with the U.S. Fish and Wildlife Service. Likely effects were estimated for the two most prominent wind and tide conditions prevailing from mid-October to late April while whooping cranes are normally resident in the area. Prevailing weather conditions are both beneficial and problematic depending on spill location, but with early response to a spill, favorable weather conditions usually can be exploited.

Bank erosion problems near the GIWW at the ANWR are caused by both vessel wakes and wind-driven waves. Field observations indicate that high-speed vessels such as commercial, sport, and fishing boats cause more wake erosion damage than slow-moving low-wake barge tows.

Nonstructural contingency measures were considered. Nonstructural measures such as vessel speed control and one-way traffic would reduce erosion damage and the probability of barge collisions in the study area. However, vessel speed limits would not eliminate erosion damage from vessel wakes and would have no effect on erosion from wind-blown waves. In addition, navigation traffic control measures cannot eliminate the possibility of accidental spillage of pollutants.

If barge navigation is restricted to one-way traffic through the study area, barge tows going in the opposite direction must be parked temporarily at the ends of the control zone until direction change occurs, and the traffic congestion would increase the danger of a collision. There would be some additional shipping costs associated with delays encountered by barge tows waiting for traffic direction changes, and regulatory expenses would also be significant.

Structural measures to reduce erosion and spill damage threat were also considered. The construction of riprap dikes and revetments along the navigation channel would control erosion damage from both navigation traffic and wind-driven waves. Riprap dikes and revetment can block spilled oils from getting into sensitive areas such as marsh and tidal flats, particularly when augmented with floating oil booms at openings in the dikes and revetments for inlet channels,

small boat access, etc. Spilled oils would be generally confined to the navigation channel on prevailing winds and could be more easily contained by portable booms for prompt cleanup by skimming and/or absorption.

The most significant advantage of a riprap dike and revetment system with floating booms at openings is that the consequences of less-than-immediate spill response with portable booms are not as severe. Habitat protection from oil spills would be in place whenever whooping cranes were in the vicinity.

Revetments placed where sensitive marsh banks come very close to the edge of the navigation channel may cause damage to empty errant barges, but should not endanger errant loaded barges that would ground in shallow waters at channel edge. Revetments, therefore, do not increase spill risks. Riprap revetments placed on marsh banks may alter or destroy some critical habitat. Riprap dikes placed in mud flats may alter existing water flow characteristics and sedimentation rates in the shallows and mud flats between the dike and existing shores. These changes may be favorable or possibly unfavorable to certain habitat regimes.

The construction of riprap dikes and revetments in the designated areas will reduce erosion damage and habitat damage in the event of an oil spill. Construction and maintenance costs for such facilities will be significant, although total costs have not been determined. The monetary value (liability) of habitat damage that would be prevented by these structures has also not been determined.

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SPILL CONTINGENCY AND PREVENTION PLAN FOR THE GULF INTRACOASTAL WATERWAY AT THE ARANSAS NATIONAL WILDLIFE REFUGE

SPILL CONTINGENCY AND PREVENTION PLAN FOR THE GULF INTRACOASTAL WATERWAY AT THE ARANSAS NATIONAL WILDLIFE REFUGE

I. INTRODUCTION

The purpose of this study was to evaluate the effects of potential spill incidents and determine whether spills can be controlled or prevented with structural measures in the 50-mile reach of the Gulf Intracoastal Waterway (GIWW) that crosses the critical habitat of the rare and endangered whooping crane, including a 13.25-mile reach of the Aransas National Wildlife Refuge (ANWR). In addition, erosion control was to be incorporated into the evaluation of spill prevention/protection structures. The elements of the analysis included identification of commodities most frequently transported along the study reach, identification of the commodities that would be most dangerous to the whooping crane and its habitat in the event of a spill, selection of locations within the study area for simulation of different types of spills, assessment of the effects of these different types of spills, analysis of current and mandated prevention and contingency plans, and development of structural and nonstructural contingency plans that would prevent spills or reduce their effects and that would also reduce the effects of erosion.

II. STUDY AREA

The study area is located about 35 miles northeast of Corpus Christi, Texas, along the GIWW between miles 475 and 525 as shown in Figure 1. All mileage locations are statute miles measured west from Harvey Locks, Louisiana. A 31-mile portion of the GIWW in the 50-mile study reach crosses the critical habitat of the rare and endangered whooping crane, including 13.25 miles of the GIWW that traverse the southern perimeter of the ANWR.

III. BACKGROUND

The critical habitat of the rare and endangered whooping crane adjacent to the GIWW is the wintering ground for the only wild breeding flock of whooping cranes. The whooping crane was nearly extinct in 1941 when the population was only 16. It has grown to over 130 whooping cranes that winter along the Texas coast. The possibility of barge traffic producing an oil or chemical spill in the study reach is of concern because whooping crane mortality could occur from a single spill. Another concern is that the critical habitat is eroding at

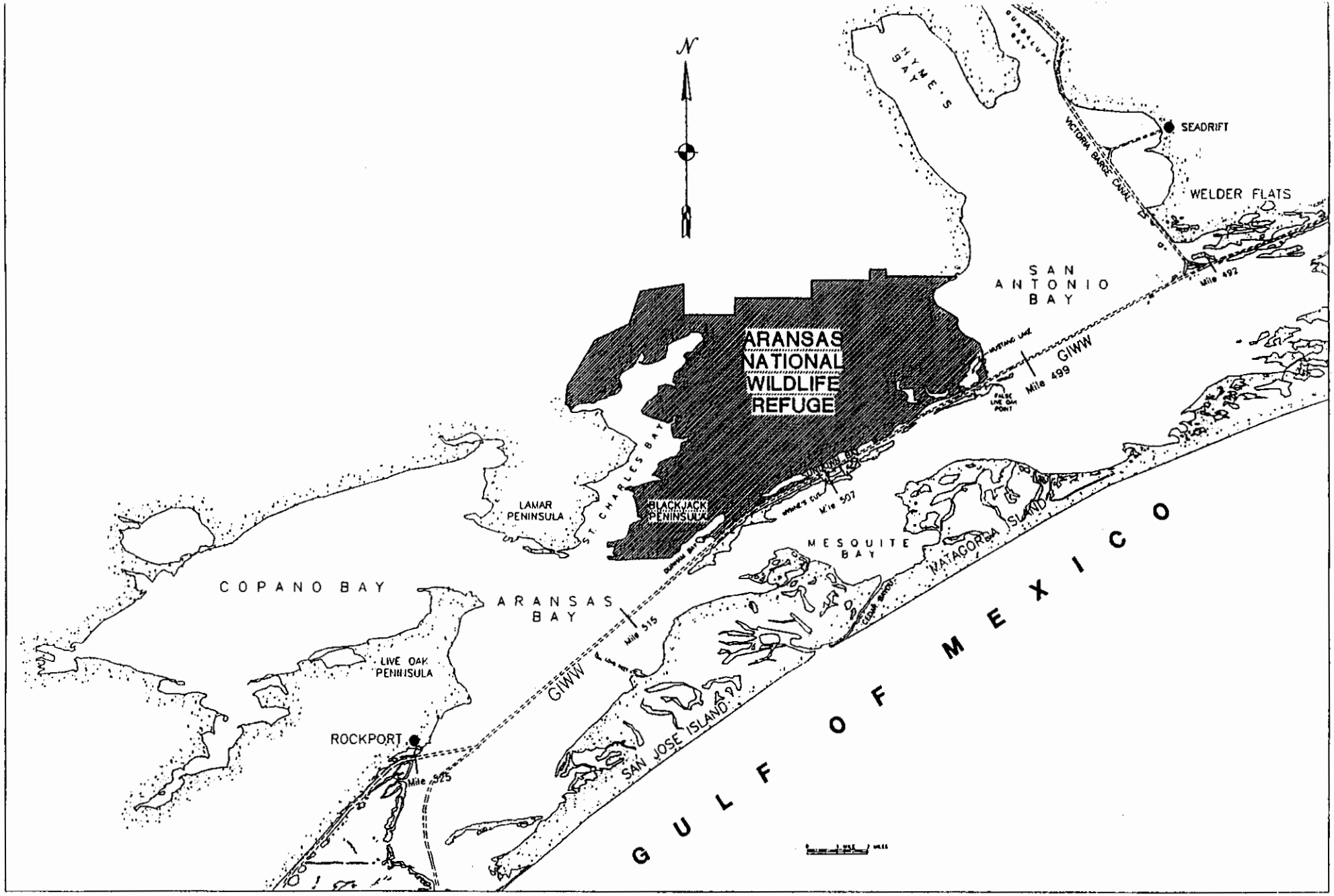


Figure 1 Study Area Map

a rate of about two acres a year from vessel traffic wakes and wind-generated waves. This study examines the commodities shipped through the study area to determine the probability of a spill of the most frequently shipped commodity (most likely spill), the worst case spill in which the commodities most hazardous to the whooping crane and its habitat are spilled, the probability of the worst case spill, the potential spill size and spill effects, existing spill contingency plans, and structural and nonstructural plans to reduce the effects of spills and prevent spills.

IV. COMMODITY TRAFFIC ANALYSIS

Barged tonnage by commodity traversing, originating, or ending within the study reach in 1989 was analyzed using commodity figures by port from the port-to-port cargo history database provided by the Waterborne Commerce Statistics Center (WCSC) in New Orleans. This database provides the most current tonnage records for commodities transported on the Nation's internal waterway system. WCSC commodity codes are listed in Appendix A. The five-digit location codes defined in the WCSC's 1989 Port and Dock Manuals were used as port and location classifications. Port Codes are summarized in Appendix B. Based on these data, the study area was defined as follows:

$$\text{ports} > 60658 \text{ and } < 60699 \text{ or } \geq 66475 \text{ and } \leq 66525$$

which includes ports between Matagorda Ship Channel (60658) and Rockport (60699) and any located along the GIWW between mile 475 (66475, the north end of the ANWR area) and mile 525 (66525, the south end of the ANWR area). Most of the shipments originating or terminating within the study area are to large industrial sites located along the Victoria Barge Canal (60690). The Victoria Barge Canal starts at approximately mile 492 of the GIWW and extends to the northwest of the GIWW, crossing eight miles of San Antonio Bay before its 27-mile inland portion, which is located between the Guadalupe River and Texas State Highway 185. A list of commodities and their respective total tonnages shipped along the study reach during 1989 was compiled from the WCSC database and is presented in Table 1.

Three database files that met different origin and destination criteria were derived from the master file. The first file contains commodity tonnages from locations west of the study reach moving through the study reach to destinations to the east and tonnages from locations east of the study reach moving through the study reach to destinations to the west. The second file contains commodity tonnages from locations within the study reach from which commodities were shipped west or which received commodities from the west. The third file contains

TABLE 1
1989 TONNAGE BY COMMODITY
TRAVELING ALONG THE GIWW STUDY AREA
FROM MILE 475 TO MILE 525

WCSC COMMODITY CODE	1989 TONNAGE BARGED	
Farm Products		
103	45,443	
106	1,534	
107	6,853	
111	11,945	
	SUBTOTAL:	65,775
Metallic Ores		
1011	9,356	
1051	24,501	
1061	5,172	
1091	4,820	
	SUBTOTAL:	43,849
Crude Petroleum		
1311	747,916	
	SUBTOTAL:	747,916
Nonmetallic Minerals		
1442	1,020,639	
1451	17,466	
1491	2,951	
1493	9,347	
1499	9,934	
3241	41,387	
3291	20,436	
	SUBTOTAL:	1,122,160
Food and Kindred Products		
2014	2,482	
2042	3,400	
2049	14,979	
2061	100,356	
2091	8,075	
	SUBTOTAL:	129,292
Industrial Chemicals		
2810	524,007	
2811	169,146	
2813	581,758	
2817	746,372	
2819	2,868,631	
2891	21,623	
	SUBTOTAL:	4,911,537

WCSC COMMODITY CODE	1989 TONNAGE BARGED	
Agricultural Chemicals		
2871	128,641	
2872	1,453	
2873	24,512	
2879	3,010	
	SUBTOTAL:	157,616
Petroleum Products		
2911	2,622,721	
2912	341,294	
2913	154,331	
2914	1,294,369	
2915	1,261,836	
2916	143,986	
2917	534,617	
2918	175,866	
2920	155,028	
2921	13,208	
2991	221,213	
	SUBTOTAL:	6,918,469
Primary Metal Products		
3311	45,296	
3314	14,122	
3315	33,074	
3316	2,782	
3317	4,126	
3318	5,511	
3324	1,434	
	SUBTOTAL:	106,345
OTHER COMMODITIES		
Marine Shells		
931	7,000	
Forest Products		
2411	1,221	
Fabricated Metal Products		
3411	4,044	
Machinery, Except Electrical		
3511	3,300	
Iron and Steel Scrap		
4011	92,175	
	SUBTOTAL:	107,740

TOTAL TONNAGE:	14,310,699

Source: Waterborne Commerce Statistics Center, 1989 Cargo History Files, New Orleans, La., 1991

commodity tonnages from locations within the study reach from which commodities were shipped east or which received commodities from the east. Tonnage was then summed by commodity for each database file. Total 1989 barged tonnage by commodity is presented in tables 2 through 4 based on these generalized origins and destinations. Table 2 shows that 77.8 percent (11,126,275 tons) of the total tonnage passed east or west through the 50-mile study reach. Table 3 shows that 19.6 percent (3,025,930 tons) of the total tonnage was shipped east or received from the east through only 17 miles of the 50-mile study reach (from mile 475 to mile 492), then through eight miles up the Victoria Barge Canal (which leaves the GIWW at mile 492) through San Antonio Bay. Table 4 shows that 2.6 percent (377,852 tons) of the total tonnage was shipped from the west or received from the west through 33 miles of the 50-mile study reach (from mile 525 to mile 492), then through the eight miles of the Victoria Barge Canal through San Antonio Bay.

The total 1989 study reach exposure to commodity shipments by barge is therefore:

2,806,572 tons x (17 miles + 8 miles) + 377,852 tons x (33 miles + 8 miles) + 11,126,275 tons x 50 miles = 641,969,982 ton-miles or 128,393,996 ton-hours

(based on a speed of five miles per hour for a loaded tow).

Commodity Most Likely to be Spilled

The commodity most likely to be spilled is defined for this analysis as the commodity associated with the most ton-hours of exposure to the study reach in 1989. The exposure is measured in ton-hours to reflect the highest degree of exposure over the entire study area. Ton-hours are calculated by dividing the commodity's ton-miles by five miles per hour (the maximum legal speed for a loaded tow). Traffic analysis shows that Gasoline (WCSC commodity code 2911) is the commodity type with the greatest number of ton-hours of shipments through the study reach in 1989. This data is presented in Table 5, which summarizes 1989 traffic volume along the study area by spill probability.

The total exposure to Gasoline in the study reach in 1989 was 2,622,721 tons or 26,227,210 ton-hours. Entries for Gasoline in tables 2, 3, and 4 reveal that 2,622,721 tons passed east or west through the 50-mile study reach. No shipments were reported shipped east or received from the east through only 17 miles of the 50-mile study reach (from mile 475 to mile 492), then through eight miles up the Victoria Barge Canal through San Antonio Bay; and no shipments were reported shipped west or received from the west through 33 miles of the 50-mile study reach (from mile 525 to mile 492), then through eight miles up the Victoria Barge Canal through San Antonio Bay. The eight miles of the Victoria Barge Canal from the GIWW through

TABLE 2
1989 TONNAGE BY COMMODITY
PASSING EAST OR WEST THROUGH THE GIWW STUDY AREA
FROM MILE 475 TO MILE 525

WCSC COMMODITY CODE	1989 TONNAGE BARGED	
Farm Products		
103	45,443	
106	1,534	
107	6,853	
111	11,945	
	SUBTOTAL:	65,775
Metallic Ores		
1011	9,356	
1051	24,501	
1061	5,172	
1091	4,820	
	SUBTOTAL:	43,849
Crude Petroleum		
1311	721,978	
	SUBTOTAL:	721,978
Nonmetallic Minerals		
1442	7,628	
1451	17,466	
1493	9,347	
1499	9,934	
3241	41,387	
	SUBTOTAL:	85,762
Food and Kindred Products		
2014	2,482	
2042	3,400	
2049	14,979	
2061	100,356	
2091	8,075	
	SUBTOTAL:	129,292
Industrial Chemicals		
2810	475,620	
2811	169,146	
2813	558,989	
2817	746,372	
2819	1,139,181	
2891	21,623	
	SUBTOTAL:	3,110,931

WCSC COMMODITY CODE	1989 TONNAGE BARGED	
Agricultural Chemicals		
2871	79,893	
2872	1,453	
2873	15,869	
2879	3,010	
	SUBTOTAL:	100,225
Petroleum Products		
2911	2,622,721	
2912	341,294	
2913	154,331	
2914	1,282,392	
2915	1,060,978	
2916	143,986	
2917	526,505	
2918	175,866	
2920	151,063	
2921	13,208	
2991	221,213	
	SUBTOTAL:	6,693,557
Primary Metal Products		
3311	45,296	
3314	14,122	
3315	33,074	
3316	2,782	
3317	4,126	
3318	5,511	
3324	1,434	
	SUBTOTAL:	106,345
OTHER COMMODITIES		
Forest Products		
2411	1,221	
Fabricated Metal Products		
3411	4,044	
Machinery, Except Electrical		
3511	3,300	
Iron and Steel Scrap		
4011	59,996	
	SUBTOTAL:	68,561

TOTAL TONNAGE: 11,126,275

Source: Waterborne Commerce Statistics Center, 1989 Cargo History Files, New Orleans, La., 1991

TABLE 3
1989 TONNAGE BY COMMODITY
SHIPPED EAST FROM THE STUDY AREA
OR
RECEIVED WITHIN THE STUDY AREA
FROM THE EAST

WCSC COMMODITY CODE	1989 TONNAGE BARGED	
Nonmetallic Minerals		
1442	803,048	
1491	2,951	
3291	20,436	
	SUBTOTAL:	826,435
Industrial Chemicals		
2810	43,117	
2813	22,769	
2819	1,679,730	
	SUBTOTAL:	1,745,616
Agricultural Chemicals		
2871	48,748	
2873	8,643	
	SUBTOTAL:	57,391

WCSC COMMODITY CODE	1989 TONNAGE BARGED	
Petroleum Products		
2914	11,977	
2915	113,897	
2917	8,112	
2920	3,965	
	SUBTOTAL:	137,951
OTHER COMMODITIES		
Marine Shells		
931	7,000	
Iron and Steel Scrap		
4011	32,179	
	SUBTOTAL:	39,179

TOTAL TONNAGE: 2,806,572

Source: Waterborne Commerce Statistics Center, 1989 Cargo History Files, New Orleans, La., 1991

TABLE 4
1989 TONNAGE BY COMMODITY
SHIPPED WEST FROM THE STUDY AREA
OR
RECEIVED WITHIN THE STUDY AREA
FROM THE WEST

WCSC COMMODITY CODE	1989 TONNAGE BARGED	
Crude Petroleum		
1311	25,938	
	SUBTOTAL:	25,938
Nonmetallic Minerals		
1442	209,963	
	SUBTOTAL:	209,963

WCSC COMMODITY CODE	1989 TONNAGE BARGED	
Industrial Chemicals		
2810	5,270	
2819	49,720	
	SUBTOTAL:	54,990
Petroleum Products		
2915	86,961	
	SUBTOTAL:	86,961

TOTAL TONNAGE: 377,852

Source: Waterborne Commerce Statistics Center, 1988 Cargo History Files, New Orleans, La., 1990

TABLE 5
POLLUTION POTENTIAL FROM NAVIGATION ACCIDENTS ALONG THE STUDY AREA BY SPILL PROBABILITY

POLLUTION POTENTIAL GROUP	WCSC CODE	COMMODITY DESCRIPTION	BARGE TYPE	1989 STUDY AREA TONNAGE	1989 STUDY AREA TON-HOURS	STUDY AREA SPILL PROBABILITY
3	2911	Gasoline	DST	2,622,721	26,227,210	0.002171404
3	2819	Basic Chemicals, NEC	DST	2,868,631	20,198,164	0.001672247
3	2914	Distillate Fuel Oil	DST	1,294,369	12,883,805	0.001066676
3+	2915	Residual Fuel Oil	SST^1	1,261,836	11,892,345	0.000984591
3	2817	Benzene & Toluene	DST	746,372	7,463,720	0.000617937
3+	1311	Crude Petroleum	SST^1	747,916	7,432,472	0.000615349
1	1442	Sand & Gravel	DK	1,020,639	5,813,217	0.000481288
3	2813	Alcohols	SST	581,758	5,703,735	0.000472224
3	2917	Naptha, etc., NEC	DST	534,617	5,305,610	0.000439262
2	2810	Caustic Soda	CAUS	524,007	5,014,999	0.000415202
3	2912	Jet Fuel	DST	341,294	3,412,940	0.000282564
3	2991	Petroleum & Coal Products	SST	221,213	2,212,130	0.000183147
2	2918	Asphalt, Tar, Pitches	ASPH	175,866	1,758,660	0.000145603
3	2811	Crude Products	DST	169,146	1,691,460	0.000140039
3	2913	Kerosene	DST	154,331	1,543,310	0.000127774
2	2920	Coke	CH	155,028	1,530,455	0.000126709
3+	2916	Lubricating Oils	SST^1	143,986	1,439,860	0.000119209
3	2871	Nitrogenous Chemical Fertilizer	DST	128,641	1,042,670	0.000086325
2	2061	Sugar	CH	100,356	1,003,560	0.000083087
1	4011	Iron & Steel Scrap	DK/OH	92,175	760,854	0.000062993
2	103	Corn	CH	45,443	454,430	0.000037623
1	3311	Pig Iron	OH	45,296	452,960	0.000037501
1	3241	Building Cement	CEM	41,387	413,870	0.000034265
1	3315	Iron & Steel Bars	OH	33,074	330,740	0.000027383
1	1051	Bauxite	OH	24,501	245,010	0.000020285
2	2891	Miscellaneous Chemical Fertilizer	SST	21,623	216,230	0.000017902
2	2873	Phosphatic Chemical Fertilizer	DST	24,512	201,905	0.000016716
1	1451	Clay & Ceramic	CH	17,466	174,660	0.000014460
2	2049	Grain Mill Products, NEC	CH	14,979	149,790	0.000012401
1	3314	Iron & Steel Products	OH	14,122	141,220	0.000011692
2	2921	Liquid Petroleum Gas	LPG	13,208	132,080	0.000010935
2	111	Soybeans	CH	11,945	119,450	0.000009890
1	3291	Misc. Nonmetallic Mineral Prod.	OH	20,436	102,180	0.000008460
1	1499	Nonmetallic Minerals, NEC	OH	9,934	99,340	0.000008225
1	1011	Iron Ore & Concentrates	CH	9,356	93,560	0.000007746
2	1493	Liquid Sulfur	LS	9,347	93,470	0.000007739
2	2091	Vegetable Oils	SST	8,075	80,750	0.000006685
2	107	Metallic Ores	CH	6,853	68,530	0.000005674
1	3318	Ferroallorys	OH	5,511	55,110	0.000004563
1	1061	Manganese	OH	5,172	51,720	0.000004282
2	1091	Nonferrous Metal Ores & Concentrates, NEC	OH	4,820	48,200	0.000003991
1	3317	Iron & Steel Pipe & Tube	OH	4,126	41,260	0.000003416
1	3411	Fabricated Metal Products	DK	4,044	40,440	0.000003348
1	931	Marine Shells	DK	7,000	35,000	0.000002898
2	2042	Animal Feeds	CH	3,400	34,000	0.000002815
1	3511	Machinery, except Electric	DK	3,300	33,000	0.000002732
2	2879	Fertilizers, NEC	SST	3,010	30,100	0.000002492
1	3316	Iron & Steel Plates & sheets	OH	2,782	27,820	0.000002303
2	2014	Tallow, Animal Fats, & Oils	SST	2,482	24,820	0.000002055
2	106	Farm Products	DK	1,534	15,340	0.000001270
2	1491	Salt	CH	2,951	14,755	0.000001222
2	2872	Potassic Chem. Fertilizers, Except Mixtures	DST	1,453	14,530	0.000001203
1	3324	Aluminum & Aluminum Alloys, Unworked	CH	1,434	14,340	0.000001187
1	2411	Logs	DK	1,221	12,210	0.000001011
			TOTALS:	14,310,699	128,393,996	0.010630000

BARGE TYPE LEGEND: ASPH=asphalt, CAUS=caustic soda, CEM=cement, CH=covered hopper, DK=deck, DST=double-skin tank, LS=liquid sulfur, LPG=LPG pressure tanks, OH=open hopper, SST=single-skin tank, SST^1=now 40% to 50% of barges are double-skin tanks, 1990 Oil Pollution Act requires 100% double-skin by year 2010.

Source for 1989 commodity tonnages: Waterborne Commerce Statistics Center, 1989 Cargo History Files, New Orleans, LA., 1991

Source for Pollution Potential Groupings and Spill Probability Estimates: Gulf Engineers & Consultants, Inc.

San Antonio Bay should be included in the analysis because there is nearby crane habitat, and there would be little chance of spill containment by booming or other means until the canal moves inland past San Antonio Bay. The 1989 exposure in the study reach in ton-hours to Gasoline is therefore:

(2,622,721 tons x 50 miles)/5 miles per hour = 26,227,210 ton-hours

In the following section, the probability of one or more spills of the most likely spill commodity (Gasoline, WCSC 2911) is considered. The existing oil spill probability forecasting methodologies were reviewed, and the approach that gave the most reasonable but pessimistic evaluation of spill risk was selected. In this case, an approach that gave a pessimistic evaluation of spill risk was selected in order to avoid understating the risk of a spill.

V. SPILL PROBABILITY ASSESSMENT METHODOLOGY

To assess the probability of spills, the "spill" event must be defined, spill data must be collected and analyzed, and a spill probability forecasting methodology must be selected. The following sections detail the assumptions and methods used in this study.

In this analysis, the event is a "significant" spill and the random trial involves having two or more different possible outcomes (barge tows in transit either result in a spill or do not), with uncertainty in advance as to which outcome prevails. A "significant spill" is defined for the purposes of this study as a spill of polluting substances incidental to a navigation accident (such as a hull rupture because of a grounding, collision, or striking a massive submerged object) and in volume sufficient to pose a threat of injury to whooping cranes or of destruction of whooping crane habitat. Crude oils, residual fuel oils, lubricating oils, and other low-volatility floating oils are the polluting substances posing the greatest threat, and a spill of as little as 10 barrels or more of these oils at a critical location on the GIWW in the ANWR under adverse wind and tide conditions could damage habitat or injure whooping cranes. A spill of 100 barrels or more of other polluting substances capable of causing damage to whooping cranes or their critical habitat is also considered "significant".

Ten barrels (420 gallons) was selected as the minimum size oil spill to be considered in this study because oil spills of less than this quantity would quickly become a thin film of such low oil concentration that it would pose very little threat to crane habitat. The vast majority of spills of oil and other substances reported by the Coast Guard, Texas Waterway Commission,

and other relevant authorities are in the range from a few gallons to five barrels, and little if any environmental damage has been attributed to spills of this magnitude.

The level of 100 barrels as the lowest "significant" spill quantity for other polluting substances was chosen after an evaluation of the chemical properties of all substances known to be shipped through the study reach. Most of the potentially troublesome substances would evaporate or dissolve quickly in smaller spill quantities, and the impacts would be negligible because of evaporation or dilution. The chemical composition and reaction with water of the commodities shipped through the study reach are discussed further in *X. WORST CASE SPILL FACTORS, Chemical Properties of Commodities Transported Through the Study Reach.*

VI. SPILL DATA SOURCES

The 50-mile reach (GIWW mile 475 to mile 525) was initially used for spill queries based on the expanding habitat of the whooping crane over the last several years. Biologists at the ANWR determined that as the size of the flock has grown, the cranes have required a larger habitat, extending well beyond the refuge. A study done during the winter of 1989-1990 by U.S. Fish and Wildlife personnel at the refuge indicates that the whooping crane's habitat during the 1989-1990 winter extended from Welder Flats at mile 482 east to Aransas Bay and San Jose Island at mile 517. Thus, database queries including this 50-mile reach of the GIWW encompass the entire winter habitat of the whooping crane, with 8-mile margins on either side of the habitat. This allows navigational hazards and past spill incidents to be documented up to 8 miles from the far margins of present whooping crane habitat.

A 50-mile reach also allows a greater sample of past collisions to be documented. This is likely to provide a more representative analysis of potential navigational hazards near the whooping crane's critical habitat.

Coast Guard regulations require reporting of all spills that leave a sheen on the water. Unfortunately, many spills, especially smaller spills, go unreported. Requirements under the Federal Clean Water Act (40 CFR, Secs. 110.2 et seq.) prohibit discharges that "cause a film or sheen upon or discoloration of the surface of the water or adjoining shorelines..." Many spills occur from routine maintenance such as oil changes, from bilge water discharges, or from routine oil transfers at port. Spills that occur while loading or unloading may go unnoticed by captains or workers dockside. Additionally, there may be disincentives to report spills because of negative publicity or fear of liability. Furthermore, tracing of parties responsible for fugitive

spills is extremely difficult. For example, it is unlikely that a spill at night of a few gallons will be traced to the responsible barge tow, crew boat, fishing vessel, etc. Data on spills in the vicinity of the Texas GIWW indicate that small fugitive spills are fairly infrequent, and a review of annual reports at the refuge indicate there is little evidence of direct harm to waterfowl from these spills.

Spills at loading facilities and ports are by far more frequent, and typically of much greater volume, than fugitive spills from vessels in transit. Because there are no loading or unloading facilities within the study reach, loading and unloading spills are not considered a significant factor for this study. A review of annual reports at the refuge and inquiries with refuge personnel also indicate that there is no history of spills related to loading that have migrated into the refuge from such terminals outside the study reach. It is highly unlikely that a spill from a loading or unloading facility would be of such magnitude as to pose a threat to the refuge. Also, such spills could be contained far from the refuge with booms and other methods.

For analysis purposes, data on the occurrence of prior spills were obtained from the Texas Waterway Commission, the U.S. Coast Guard, the ANWR, and the Minerals Management Service. The Environmental Protection Agency and the National Response Center also keep a detailed database of all oil and chemical spills that are reported through the Emergency Response Notification System (ERNS). However, ERNS data does not detail the cause of vessel related spills, and there is no indication of whether the spill occurred from loading or unloading, or from a collision, for example. Because our analysis of prior spills is restricted to spills from vessels within navigable waters of the Texas Intracoastal Waterway system, all such spills should fall within Coast Guard jurisdiction and should be recorded in their database. An analysis of ERNS data would therefore be unnecessary.

Texas Waterway Commission Spill Database

The Texas Waterway Commission is the primary source of data for spills occurring along the Texas GIWW. Spills included in this database are documented from a variety of sources, including the Coast Guard and other federal and state reporting agencies and petroleum companies. The database is comprehensive because it includes spills of any volume of oil, petrochemicals, or dry products. Spill queries were made for the for the period 1986 through 1990. The database details whether a spill occurred within the GIWW or at a loading facility. For analysis purposes, it was necessary to draw preliminary conclusions based on the location

and volume of the spill. For example, it is reasonable to assume that a barge spill of a few gallons that occurred at a dock from equipment failure did not result from a collision. A specific incident number is assigned to each spill, and copies of these Spill Reports are available from the Texas Waterway Commission. Full details from Spill Reports were obtained from all collisions or groundings within the Texas GIWW over the period from 1986 to 1990 because these spills may be similar to potentially threatening spills to the ANWR. These spills form the basis for the spill probability analysis.

Most documented spills occurring on the navigable waters of Texas are likely to be documented by both the Texas Waterway Commission and the U.S. Coast Guard. Although it is common for the Coast Guard to notify the Texas Waterway Commission of spills, there is no requirement for the Coast Guard to do so. In conferring with personnel at the Coast Guard and the Texas Waterway Commission, it was acknowledged that occasionally one agency neglects to notify the other of a spill or there are slips in documentation, resulting in reporting in only one source. Consequently, all spill data sources were reviewed independently.

Coast Guard Spill Database

From inquiries through the Freedom of Information Act (FOIA), a search was performed on the Coast Guard database, CASMAIN, which details all reported vessel casualties in U.S. waters. Pursuant to the inquiries, the Marine Safety Evaluation Branch of the Marine Investigation Division searched its database for all vessel casualties along the Texas GIWW from 1985 to present. This search yielded numerous instances of vessel casualties along the GIWW. Unfortunately, this database does not have parameters that allow a search to be specified to include only those vessel casualties that resulted in oil or hazardous chemical spills. Vessel casualties include a range of incidents from groundings to fires, but these casualties may not have caused spills. However, within GIWW miles 475-525, our interest is also to determine particular areas of navigational hazard. Another search was initiated through CASMAIN to include only those vessel casualties occurring in this 50-mile reach of the refuge. The results of this search include data from 1985 through 1989 and are useful because they detail those areas where groundings, collisions, and other casualties have occurred even though none of these particular casualties caused spills.

Another FOIA request was initiated through the Coast Guard's Marine Environmental Protection Division through a separate database at the (G-NEP-2) office. This database details

both vessel and non-vessel spills of chemicals, petroleum, and other oils from 1985 to the present. Because it is not possible within this database to limit a query within the GIWW, the query included all spills occurring in the contiguous navigational canals and the Gulf of Mexico between miles 475 to 525 specified by the following coordinates:

Latitude 28 degrees 26 minutes by
27 degrees 57 minutes

Longitude 96 degrees 25 minutes by
97 degrees 03 minutes.

Results from this query include spills from various fishing and commercial vessels and barges in various areas in the Gulf of Mexico and on other navigable and non-navigable waters. It also includes a number of relatively minor non-vessel spills from pipelines and land-based sources.

Aransas Wildlife Refuge Annual Reports

From inquiries and meetings with personnel from the U.S. Fish and Wildlife Service at the ANWR, copies were obtained of annual refuge reports that detail oil and chemical spills occurring at the refuge. Reports were examined from fiscal year 1975 to the present, and various spills from barges were documented. Although these spills are useful in giving a broader view of spill occurrence, they were not included in an analysis of spill probability because they occurred on July 10, 1974, and October 11, 1978, and may not be representative of present conditions because of changes in vessel safety. In the last few years, there has been a growing body of safety regulations and enforcement of these regulations pertaining to tank barges. Barge operators have also displayed growing concern over increasing financial liability and bad publicity resulting from oil and chemical spills. There has also been a growing movement in the marine industry toward the use of double-hulled vessels, especially for "dirty" or unrefined and residual fuel oils. Additionally, both of these spills were less than 50 barrels each and of marginal threat to the whooping cranes and their habitat.

Minerals Management Service

For the last several years, the Minerals Management Service (MMS) has been the primary federal agency responsible for assessing the probability and effect of oil spills associated with

offshore leasing. The MMS spill database includes all spills from 1974 to 1971 fulfilling the following two requirements:

(1) The source of the spill must be a vessel, generally a tanker or barge, on which a petroleum product was a cargo. This spill may be fuel for the carrier.

(2) The spill must be at least 1,000 barrels (42,000 gallons, or approximately 136 metric tons).

The applicability of this database to this study is limited in that the great majority of spills on any waterway from any source are small spills, under 1,000 barrels. Any analysis based only on the number of large spills would greatly underestimate the probability of smaller spills. No spills relevant to this study were found in the MMS database.

VII. ANALYSIS AND DOCUMENTATION OF PRIOR SPILLS

A review of the above detailed sources that document prior spills in or near the Texas GIWW indicates that there have been very few significant spills in or near the ANWR in the last five years.

Refuge Reports of Spills Prior to 1986

The 1975 ANWR report states that a spill occurred on July 10, 1974, when a large tank barge carrying over 30,000 barrels of No. 6 residual fuel oil developed a small leak and released between 25 to 50 barrels of its cargo along a seven-mile stretch of the refuge. The oil washed onto the banks of the GIWW and required an eighteen-day cleanup by the Corpus Christi Oil Spill Association, during which a barge loaded dragline, marsh buggy, and intensive hand removal were used. Oil, contaminated soil, and vegetation were removed at a cost of $30,000. There were no losses of wildlife as a result of the spill.

Another spill documented in reports from the refuge indicate that on October 11, 1978, a tank barge ran aground near Sundown Bay. Several small leaks were noticed, and approximately 10 to 30 barrels of light crude oil spilled into the Intracoastal Waterway. Booms and sorbent materials were used by the Coast Guard and the Corpus Christ Oil Spill Control Association to

control the spill. There were no losses of wildlife even though the spill occurred four days prior to the whooping cranes winter arrival.

Another spill occurred on March 19, 1983, in which a tank barge loaded with No. 6 fuel oil collided with a dredge at the junction of the Port Lavaca ship channel and the GIWW, leaking approximately 430 barrels into the GIWW. Northerly winds pushed the oil down to Pass Cavallo and out into the Gulf of Mexico. Some oil deposited on four miles of beach at Matagorda Island. Four dead, oil-soaked, pied-billed grebes and one ruddy duck were found on the island.

There have been a number of small fugitive spills in the refuge area in the past several years. Annual reports from the refuge indicate that two spills occurred in 1990. On January 24, 1990, a spill of approximately 15 gallons (approximately one-third of a barrel) of unknown material occurred from an unknown vessel into the GIWW south of Sundown Bay. A fugitive spill of light oil occurred on March 18, 1990, apparently from a barge. No evidence of permanent damage from these spills is available.

The small number of fugitive spills from vessels passing the refuge apparently have done little damage to the refuge ecology or the whooping crane. Martens (1976) concluded that low-level chronic oil exposure to five different marine environments, including marsh habitat, had no measurable effect on ecological indicators such as species diversity, organism size, growth rate, or reproduction.

Texas Waterway Commission Data

The Texas Waterway Commission database query performed for this study details 300 spills from various barges within the Texas GIWW and contiguous navigational canals and rivers occurring from 1986 through 1990. Of the 300 spills listed, only two spills occurred within the Intracoastal Waterway at locations other than piers, docks, berths, or port facilities. One of the two spills was caused by vessel casualty resulting from collision. These two spills are similar to potential spills in the ANWR since there are no docking or loading facilities in the study reach. Thus, they form the population of spills from which to base the probability analysis. One of the spills occurred near Freeport on March 25, 1990, which resulted in the release of approximately 800 barrels of light crude condensate. The other spill occurred on September 9, 1990, near Port Arthur in the Intracoastal Waterway and resulted in the release of 680 barrels of naphtha (raffinate).

The above mentioned spill of March 25, 1990, occurred from a 190-foot tank barge on the GIWW near Freeport and was reported in an article in the Houston Post on March 26, 1990. It is stated in the newspaper article that the spill was the result of the hull of one barge striking sunken debris identified as an unmarked sunken barge. This spill is also documented in a detailed Spill Report from the Texas Waterway Commission as a spill of light crude occurring at Freeport one-quarter mile west of Surfside Bridge. Details indicate that the spill resulted when a barge ran aground and punctured a cargo tank spilling crude at a rate of 1 barrel per minute. Interestingly, cause of the spill is listed as human error in the Spill Report, and there is no mention of the barge striking a sunken barge. Garner Environmental Services of Houston was called to conduct the cleanup.

The second spill occurred on September 9, 1990, at channel mile 291 of the GIWW, which is two miles west of the highway SH 87 bridge in Port Arthur. This spill occurred as a result of smoke from a nearby marsh fire causing poor visibility, which resulted in a collision between a barge carrying naphtha and a barge loaded with unleaded Gasoline. When Coast Guard personnel arrived on scene, the spilled materials had evaporated and there was no accumulation of the materials and therefore no noted environmental effect.

Coast Guard Database

A spill of 2800 gallons (approximately 66 barrels) of miscellaneous oil is noted to have occurred on July 8, 1989, from a fishing vessel in the GIWW within the 50-mile stretch between channel miles 475 and 525. Apparently, this incident occurred from a collision in which the vessel lost the bulk of its fuel when it overturned. This spill is unusual in the sense that fishing vessels do not normally carry such large amounts of fuel. Additionally, fishing vessels would use Gasoline or diesel as fuel and, if spilled, these materials would evaporate relatively quickly and therefore pose less of a threat to the environment than many other petroleum products carried on barges such as residual fuel oil. Fishing vessels would rarely carry volumes of materials that would pose a significant threat to the whooping crane or its habitat.

On June 2, 1989, a passenger vessel spilled 800 gallons (approximately 19 barrels) of miscellaneous oil into the GIWW between channel miles 475 and 525. This spill occurred as a result of a collision causing a hull rupture. Still another spill of 500 gallons (approximately 12 barrels) of miscellaneous oil occurred on June 10, 1988, from a fishing vessel. This spill resulted from a fire on the vessel.

Within this 50-mile stretch, five more spills of miscellaneous oil occurred from fishing vessels between 1987 and 1989. Each spill was less than 55 gallons (approximately 1.3 barrels).

Importantly, no casualty related spills occurred within this 50-mile stretch of the GIWW from barges or tows of any type between 1985 and 1990. This indicates that although tank barges pose a greater potential threat to the refuge in terms of quantity and types of oil shipped than fishing and passenger vessels, the probability of a spill of any type from barge tows, including fugitive spills from bilgewater or oil changes, is significantly less than spills from other types of vessels. In contrast, despite the greater probability of spills from passenger and fishing vessels, it is highly unlikely that even a worst case spill from such vessels poses any real threat to the whooping crane and its habitat based on volumes and types of oil carried. Therefore, such spills are not included in the spill population for the spill risk analysis for the study reach.

VIII. PROBABILITY CONCEPTS

The purpose of this analysis is to produce an *objective* estimate of the probability of spills of commodities transported through the study reach. In the *objective* interpretation of probability, the probability value of an event (symbolized by P(E) with $0 \leq P(E) \leq 1$ for any event E) is the relative frequency of occurrence of the event in reference to a large number of random trials under constant causal conditions. Existing oil spill probability forecasting methodologies were reviewed, and an approach similar to that used by the Minerals Management Service (MMS) to estimate the likelihood of oil spills in association with the production and transportation of oil on the U.S. Outer Continental Shelf was used to estimate the likelihood of a spill resulting from a navigation accident in the GIWW.

Constant causal conditions are assumed to apply to this situation as long as the number of spills observed depends only on the magnitude of the interval of exposure to barge tow traffic. The outcome of the random trial (spills or no spills) relates to a quantitative characteristic [number of spills observed (n) over an interval of exposure (t)] and is therefore a random variable whose numerical value is determined by the outcome of a random trial. Since this random variable (n spills observed over exposure t) takes on only distinct integer values (n = 0,1,2,... spills), it is a *discrete* random variable that follows a discrete probability distribution. A discrete random variable associates a probability $P(n = n_i)$ for each of the distinct outcomes n_i (i = 0,1,2,...).

The Poisson probability distribution applies to many types of random phenomena such as the number of typographical errors on a page or the number of winning state lottery tickets held by persons residing in a particular county. The point of these examples is that the number of occurrences of the event represented by the random variable is measured within a fixed exposure interval, such as a standard 8.5 by 11 inch sheet of typing paper in the typographical errors example or the constant geographic area of a particular county in the state lottery example.

The Poisson probability distribution is the probability distribution most often used to describe bounded phenomena with negligible probabilities of larger outcomes of the discrete random variable (larger values of n in the case of spills). Spill probability forecasts are made separately for different spill-size categories and types of spill sources such as pipelines, ocean-going tankers, inland barges, etc. However, the common assumption of the various forecast models commonly used is that spills occur as a Poisson process, with volume of oil (or other relevant commodity) transported as the exposure variable.

With a Poisson process, the probability P of observing n spills in the course of handling volume t of a commodity is given by the equation:

$$P(n) = \frac{(\lambda t)^n e^{-\lambda t}}{n!}$$

where λ is the spill occurrence rate per unit exposure.

Criteria for selection of an exposure variable are that the exposure should be simple to measure and predictable in the future. The choice of ton-hours barged as the exposure variable for this study is based on the availability of shipping data from the Waterborne Commerce Statistics Center (WCSC) in New Orleans, Louisiana, for the Texas portion of the GIWW. Also, forecasts for future GIWW barge traffic are available from the Institute for Water Resources, U.S. Army Corps of Engineers.

The true rate of spill occurrence per unit exposure (λ) is unknown. If v is the number of past spills in the fixed spill class over the course of τ ton-hours of exposure, the estimated probability that there will be n spills in the next t ton-hours of exposure converges over time to the Poisson with λ estimated using the equation shown below:

$$\lambda = \frac{v}{\tau}$$

The predicted probability distribution equation on spill occurrence for a fixed class of spills includes the predicted future exposure t, the past occurrence rate (v/τ), and the uncertainty that arises from the fact that (v/τ) is unlikely to equal the true spill occurrence rate (λ) exactly.

The Poisson assumption requires that spills occur independently of each other and that the number of spills that occur in any interval depends only on the length of the interval. The Poisson assumption could be questioned in this case if safety and inspection standards were improved as a result of a particular spill and several potentially subsequent spills might be averted. The historical record of spills indicates that a Poisson model for spill occurrence provides a reasonable approximation in the case of spills from barges travelling the GIWW.

IX. PROBABILITY OF THE MOST LIKELY SPILL

The probability of the most likely spill was defined for this analysis as the probability of a significant spill of the commodity associated with the most ton-hours of shipments per year through the study reach. The results of the traffic analysis show that Gasoline (WCSC commodity code 2911) is the commodity type with the greatest number of ton-hours of shipments per year through the study reach.

The nature of the most likely spill is a release of over 100 barrels (a "significant" spill) of Gasoline through a rupture in the hull of the barge carrying the commodity. This rupture is caused by either a collision with another barge in which the colliding barge ruptures the hull of the first barge and causes the release of some portion of the contents of at least one compartment of the first barge (carrying Gasoline) or a grounding in which a rupture occurs from the barge carrying Gasoline striking a hard side or bottom of the GIWW or submerged debris (such as wreckage of a vessel that has not been reported or removed, a submerged piling, or other debris massive enough to cause hull rupture). In the analysis of the probability of the <u>most</u> likely spill, the contents of the barge colliding with and rupturing a barge carrying Gasoline or the composition of the debris or other hard surface causing the rupture that results in a spill are not considered relevant. The event of concern in the probability evaluation for the most likely spill is merely the occurrence of the spill, regardless of the cause of the hull rupture. Poor visibility conditions and unreported navigation hazards (such as submerged debris, etc.) are the most common causes of spills related to navigation accidents of the type involved in the most likely spill scenario developed for this study.

The estimation of the probability of the most likely spill was developed in three steps. First, the probability of one or more significant spills was estimated for the Texas inland waterway system (which includes the entire 406 mile Texas reach of the GIWW from Sabine River to the Mexican border). In the second step, the probability of one or more significant spills obtained for the Texas inland waterway system was adjusted for the exposure in the study reach of the GIWW and the Victoria Barge Canal. The third step consisted of adjusting the probability of one or more significant spills in the study reach for the volume of Gasoline transported through the study reach.

The probability of one or more significant spills in the entire Texas inland waterway system was considered because no significant spills were found to have occurred in the study reach in spill database queries for the period of 1986 to 1990 in the TWC, Coast Guard, or MMS databases. This probability was estimated by using the two significant spills identified (which occurred at Freeport and Port Arthur, respectively) and the five-year traffic volume for the entire Texas inland waterway system in a Poisson process. The five-year traffic volume of approximately 44.74573 billion ton-miles or 8.94915 billion ton-hours for the Texas inland waterway system was obtained from the traffic records available from the WCSC.

The probability of an event equals the sum of the probability values of the basic outcomes that constitute the event. In this analysis, the event under consideration is the occurrence of one or more significant spills with the probability of this event occurring given by $P(n \geq 1) = P(1) + P(2) + P(3) + \ldots)$ where n is the number of significant spills. The probability value associated with the entire sample space of zero or more significant spills is $P(n \geq 0) = 1$, $(1 = P(0) + P(1) + P(2) + P(3) + \ldots)$, therefore, the probability of one or more significant spills is determined by $P(n \geq 1) = 1 - P(0)$. Alternately stated, the probability of one or more significant spills is equal to 1 minus the probability of zero significant spills.

The probability of one or more significant spills in the Texas inland waterway system is expressed mathematically as $P(n \geq 1) = P(1) + P(2) + P(3) + \ldots$ where $P(n)$, the probability of observing n significant spills over future exposure of t billion ton-hours, is given by the Poisson probability function,

$$P(n) = \frac{(\lambda t)^n e^{-\lambda t}}{n!}$$

where λ is the spill occurrence rate per unit exposure (in this case, two significant spills over an exposure of 8.94915 billion ton-hours with $\lambda = 2/8.94915 = 0.22348$ spills per billion ton-hours).

In order to determine the probability of zero significant spills ($P(0)$), an estimate for the parameter t (which represents billions of ton-hours of commodities shipped through the Texas inland waterway system over a five year period in the future) is required. The 1988 INLAND WATERWAY REVIEW (IWR Report 88-R-7, US Army Corps of Engineers, November 1988) contains forecasts of traffic levels on the GIWW for the year 2000 ranging from a 4.1 percent decline to a 23.6 percent increase in tonnage from 1986 levels. The variation is because of the high proportion of crude petroleum and petroleum products transported on the GIWW, commodities for which traffic projections can be particularly volatile. A similar mix of commodities is shipped on the rest of the Texas inland waterway system. For this analysis, the higher projection for traffic levels (a 23.6 percent increase which gives $t = 11.06114$ billion ton-hours over five years) was used to estimate the value of the parameter t in order to avoid understating the probability of one or more significant spills in the Texas inland waterway system.

Substituting the above values for λ and t, the probability of zero significant spills ($P(0)$) in the Texas inland waterway system over five years is given by:

$$P(0) = \frac{(0.22349 * 11.061)^0 e^{-0.22349 * 11.061}}{0!} = 0.08442$$

With $P(0)$ estimated at 0.08442, or an 8.442 percent probability of zero significant spills over an exposure of 11.061 billion ton-hours, the probability of one or more significant spills over an exposure of 11.061 billions ton-hours is $P(n \geq 1) = 1 - 0.08442 = 0.91558$, or 91.6 percent.

The next step in the estimation of the probability of the most likely spill was to adjust the probability of one or more significant spills in the Texas inland waterway system over an exposure of 11.06114 billion ton-miles to the exposure observed in the study reach in 1989. The probability of one or more significant spills adjusted for the study reach exposure of 128,393,996 ton-hours (or 0.12839 billion ton-hours) is:

$P(n \geq 1)$ = 0.91558 * (study reach exposure / projected Texas GIWW exposure)

$P(n \geq 1)$ = 0.91558 * (0.128394 / 11.06114) = <u>0.01063</u>

Alternately stated, the estimated probability of one or more significant spills over an exposure of 128,393,996 ton-hours of commodity shipments in the study reach is 0.01063, or 1.06 percent.

The final step in the estimation of the probability of the most likely spill was to adjust the probability of one or more significant spills in the study reach over an exposure of 128,393,996 ton-hours of commodity shipments in the study reach in 1989 for Gasoline. Inspection of entries for Gasoline (WCSC commodity code 2911) in Tables 2, 3, and 4 reveals that 2,622,721 tons passed east or west through the entire 50-mile study reach and that none were shipped east or received from the east or shipped west or received from the west. The exposure observed in the study reach in 1989 for Gasoline (WCSC commodity code 2911) is therefore:

2,622,721 tons * 50 miles = <u>131,136,050 ton-miles or 26,227,210 ton-hours</u>.

The probability of one or more significant spills adjusted for the study reach exposure to Gasoline (WCSC code 2911) is:

$P(n \geq 1)$ = 0.01063 * (study reach exposure to Gasoline / total study reach exposure)

$P(n \geq 1)$ = 0.01063 * (26,227,210 / 128,393,996) = <u>0.00217</u>

Alternately stated, the estimated probability of the most likely spill (one or more significant spills over an exposure to Gasoline of 26,227,210 ton-hours in the study reach) is 0.00217, or 0.217 percent. Expressed as an odds ratio, this probability of the most likely spill is equivalent to a 1 in 461 chance of one or more most likely spills over an exposure to Gasoline of 26,227,210 ton-hours in the study reach.

The mean spill occurrence estimate ("spill frequency") for the most likely spill is obtained by multiplying λ, the spill rate constant, by the projected ton-hours (t) of Gasoline for the study reach. As shown above, λ = 0.22348, and the projected shipment volume t of billion ton-hours of Gasoline was obtained by assuming the projected increase of 23.6 percent for GIWW traffic applies to shipments of Gasoline, giving

t = (26,227,210 / 1,000,000,000) * 1.236 = 0.03242 billion ton-hours

of traffic through the study reach for Gasoline. The mean most likely spill occurrence is therefore:

mean most likely spill occurrence = $\lambda * t$ = 0.22348 * 0.03242

= <u>0.00724 spills per billion ton-hours</u>

or 1 spill per 138.03549 billion ton-hours transported through the study reach. Assuming traffic volume per year through the study reach remained at 1989 levels (128,393,996 ton-hours per year), the mean most likely spill occurrence rate for the study reach is 1 spill per 1,075 years.

X. WORST CASE SPILL FACTORS

In ordinary worst case analysis, an effort is made to determine which combination of events and circumstances would cause the greatest harm. Unfortunately, since little is known about how whooping cranes would react to a spill event, it is difficult to devise a worst possible barge accident or commodity spill scenario. In the opinion of some experts, the loss of one whooping crane could be catastrophic. As a consequence, any situation that could cause whooping crane mortality either immediately or eventually as a result of habitat damage could be a worst case. This version of the worst case scenario is pessimistic. A spill that could cause mortality if it occurred at a critical location along the 50-mile reach in unfavorable weather conditions while the whooping cranes are in residence may cause no irreparable damage if it should occur a mile or so from the critical location. Also, wind direction and tidal flow at the time of an accidental spill could be favorable and transport the pollutants away from critical habitat. On the other hand, a spill large enough or perhaps toxic enough to kill one whooping crane may also be enough to kill several or many cranes if they should contact a wind-transported oil wave while feeding on a tidal flat near the GIWW.

For the purposes of this study, the worst case spill is defined as the event occurring in the 50-mile reach of the GIWW and/or the 8-mile reach of the Victoria Barge Canal near whooping crane habitat that has the potential for killing the greatest number of whooping cranes either by direct contact or indirectly through destruction or contamination of critical habitat. Since the whooping cranes occupy large areas in territorial family units, a worst case event would most likely involve killing several families of whooping cranes within a high use area. An example of a high use area is Wynne's Cut, near mile 507 of the GIWW, where up to 22 cranes have been observed feeding simultaneously in the vicinity. Figure 2 shows the locations of the whooping crane territories during the 1991-1992 winter.

The worst case spill scenario involves several factors: (1) the chemical properties of the commodities spilled, (2) the weather and tide conditions in the accident location, and (3) barge construction and the potential size of a spill (determined by hull configuration, depth of the channel bottom, and the location of a hull rupture in a navigation accident).

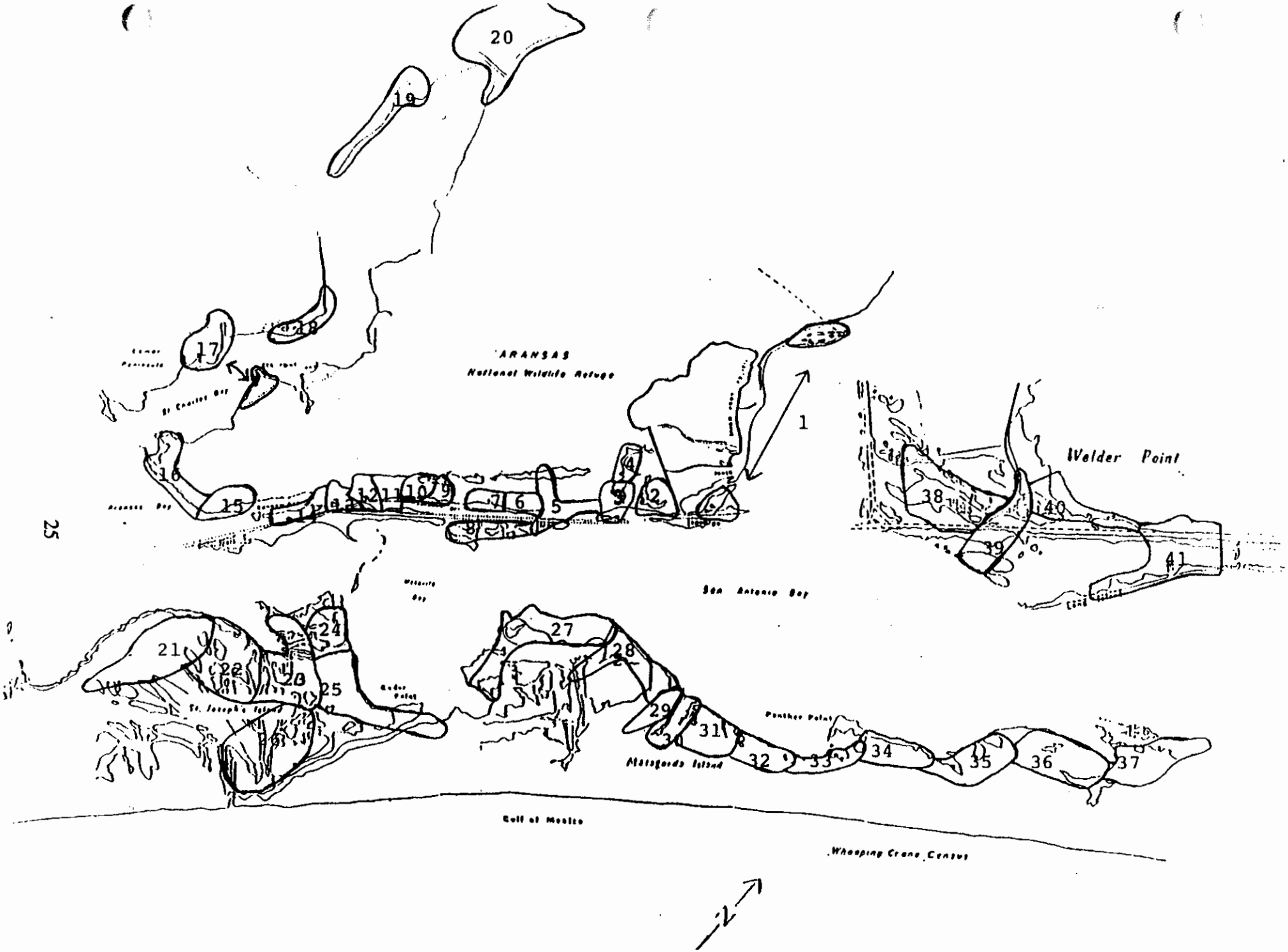


Figure 2. Locations of Whooping Crane Territories during 1991-1992 Season.

There are no manufacturing plants, product loading or transportation intermodal transfer points, or commodity storage facilities located along the 31-mile portion of the GIWW that traverses the critical habitat of the rare and endangered whooping crane. The primary spill threat to this critical habitat is presented by the commodities that are shipped through the area in barge tows on the GIWW and the Victoria Barge Canal.

Traffic analysis performed for this study indicates that over 84 percent of the commodities now being transported through the ANWR are materials that can, if spilled in "significant" amounts (over 10 barrels for oils or over 100 barrels for other volatile hazardous commodities as previously explained), endanger whooping cranes and/or damage critical habitat. However, many of these endangering materials are shipped in tanks or other containers within or upon barges designed to prevent commodity spillage (such as double hull barges). Also, physical properties of some of the materials (such as volatility) limit their damage potential.

Chemical Properties of Commodities Transported through the Study Reach

Barge cargo descriptions, shipment tonnage, and shipping distances are reported and annual statistics are published by the Waterborne Commerce Statistics Center (WCSC). Commodities shipped by barge are identified by a four-digit classification system similar to the Standard Industrial Classification (SIC) code system, with the first two digits representing the Major Industrial Group from which the commodity originates, and the last two digits representing a product description applicable to a commodity being shipped. In most cases, the WCSC code identifies a commodity specifically (e.g., 0101 - Cotton, raw), and in other cases the WCSC Code number includes a wide variety of materials (e.g., 0191 - Miscellaneous Farm Products).

Information on barge traffic on the GIWW in the study area during calendar year 1989 is shown in Table 5 of this report. The table identifies specifically a wide variety of commodities that are being shipped through the study area. The highest exposure (the most ton-hours) in the study area is to Gasoline, WCSC code 2911, because Gasoline is shipped through the entire 50-mile reach of the GIWW study area, usually originating in Corpus Christi and destined for Houston. However, the greatest tonnage of any one commodity class shipped through the study area by barge is WCSC code 2819 - Basic Chemicals and Basic Chemical Products, Not Elsewhere Classified (NEC). This broad definition does not indicate or imply any chemical or physical properties of the various "basic chemicals" included in these shipments. Because of the pollution impact of certain "basic chemicals" when spilled in marine commerce, it was necessary

to use information received from various shippers, industries, and port authorities in the vicinity of Victoria and Corpus Christi to identify the various substances being received or shipped by barge under this classification (WCSC coded 2819).

Not all of the commodities shipped by barge through the study area are dangerous or have any potential for causing whooping crane mortality or critical habitat destruction. In order to assess the environmental risk of barge shipments through the study area, the various WCSC commodity classes shown in Table 5 have been divided into three groups according to the severity of the threat to whooping cranes and their habitat associated with barge navigation. These three pollution potential groupings are shown in Table 6 and are as follows:

GROUP 1. Included in this first severity grouping are materials that are "inert" and which, when spilled in a navigation accident, pose no environmental threat except for possible obstruction of a navigation channel. Commodities in this class include mineral aggregates, ceramics, scrap iron, and steel pipe. During the 1989 reporting period, 9.52 percent of the total tonnage (or 6.96 percent of the total ton-hours of exposure) in the study area was in this grouping.

GROUP 2. Materials in this second grouping are capable of causing transient water pollution problems if spilled in a navigation accident, but which present no significant threat of whooping crane mortality or critical habitat destruction where ordinary and/or mandatory pollution response actions are in effect, such as in the GIWW. Examples of materials in this class include sugar, grain mill products, petroleum coke, and low-nitrogen-content chemical fertilizers. On a tonnage basis, 7.90 percent of the traffic in the study area during 1989 was in this category. On a ton-hours of exposure basis, 8.57 percent of the traffic in the study area during 1989 was in this category.

GROUP 3. Any class of commodity known to include or suspected of including materials that alone or in combination with other barge transported materials present a significant hazard to whooping cranes and critical habitat are included in this grouping. Materials are placed in this grouping on the basis of ignitability, chemical reactivity, and/or other physical and chemical properties that threaten whooping crane life or critical habitat. In recognition that not all materials in this grouping present the same degree of

TABLE 6
POLLUTION POTENTIAL FROM NAVIGATION ACCIDENTS ALONG THE STUDY AREA BY POLLUTION POTENTIAL GROUPINGS

POLLUTION POTENTIAL GROUP	WCSC CODE	COMMODITY DESCRIPTION	BARGE TYPE	1989 STUDY AREA TONNAGE	1989 STUDY AREA TON-HOURS	STUDY AREA SPILL PROBABILITY
1	1451	Clay & Ceramic	CH	17,466	174,660	0.000014460
1	931	Marine Shells	DK	7,000	35,000	0.000002898
1	3291	Misc. Nonmetallic Mineral Prod.	OH	20,436	102,180	0.000008460
1	3311	Pig Iron	OH	45,296	452,960	0.000037501
1	1011	Iron Ore & Concentrates	CH	9,356	93,560	0.000007746
1	3511	Machinery, except Electric	DK	3,300	33,000	0.000002732
1	1051	Bauxite	OH	24,501	245,010	0.000020285
1	4011	Iron & Steel Scrap	DK/OH	92,175	760,854	0.000062993
1	3318	Ferroalloys	OH	5,511	55,110	0.000004563
1	3316	Iron & Steel Plates & sheets	OH	2,782	27,820	0.000002303
1	3241	Building Cement	CEM	41,387	413,870	0.000034265
1	3317	Iron & Steel Pipe & Tube	OH	4,126	41,260	0.000003416
1	3324	Aluminum & Aluminum Alloys, Unworked	CH	1,434	14,340	0.000001187
1	3411	Fabricated Metal Products	DK	4,044	40,440	0.000003348
1	3314	Iron & Steel Products	OH	14,122	141,220	0.000011692
1	1442	Sand & Gravel	DK	1,020,639	5,813,217	0.000481288
1	1061	Manganese	OH	5,172	51,720	0.000004282
1	3315	Iron & Steel Bars	OH	33,074	330,740	0.000027383
1	1499	Nonmetallic Minerals, NEC	OH	9,934	99,340	0.000008225
1	2411	Logs	DK	1,221	12,210	0.000001011
		SUBTOTAL:		1,362,976	8,938,511	0.000740037
		PERCENTAGE:		9.52%	6.96%	6.96%
2	2014	Tallow, Animal Fats, & Oils	SST	2,482	24,820	0.000002055
2	1091	Nonferrous Metal Ores & Concentrates, NEC	OH	4,820	48,200	0.000003991
2	2918	Asphalt, Tar, Pitches	ASPH	175,866	1,758,660	0.000145603
2	107	Metallic Ores	CH	6,853	68,530	0.000005674
2	106	Farm Products	DK	1,534	15,340	0.000001270
2	2091	Vegetable Oils	SST	8,075	80,750	0.000006685
2	111	Soybeans	CH	11,945	119,450	0.000009890
2	2891	Miscellaneous Chemical Fertilizer	SST	21,623	216,230	0.000017902
2	2061	Sugar	CH	100,356	1,003,560	0.000083087
2	2873	Phosphatic Chemical Fertilizer	DST	24,512	201,905	0.000016716
2	103	Corn	CH	45,443	454,430	0.000037623
2	2872	Potassic Chem. Fertilizers, Except Mixtures	DST	1,453	14,530	0.000001203
2	2810	Caustic Soda	CAUS	524,007	5,014,999	0.000415282
2	2049	Grain Mill Products, NEC	CH	14,979	149,790	0.000012401
2	1491	Salt	CH	2,951	14,755	0.000001222
2	1493	Liquid Sulfur	LS	9,347	93,470	0.000007739
2	2042	Animal Feeds	CH	3,400	34,000	0.000002815
2	2879	Fertilizers, NEC	SST	3,010	30,100	0.000002492
2	2920	Coke	CH	155,028	1,530,455	0.000126709
2	2921	Liquid Petroleum Gas	LPG	13,208	132,080	0.000010935
		SUBTOTAL:		1,130,892	11,006,054	0.000911214
		PERCENTAGE:		7.90%	8.57%	8.57%
3	2913	Kerosene	DST	154,331	1,543,310	0.000127774
3	2991	Petroleum & Coal Products	SST	221,213	2,212,130	0.000183147
3	2813	Alcohols	SST	581,758	5,703,735	0.000472224
3	2914	Distillate Fuel Oil	DST	1,294,369	12,883,805	0.001066676
3	2917	Naptha, etc., NEC	DST	534,617	5,305,610	0.000439262
3	2817	Benzene & Toluene	DST	746,372	7,463,720	0.000617937
3	2811	Crude Products	DST	169,146	1,691,460	0.000140039
3	2819	Basic Chemicals, NEC	DST	2,868,631	20,198,164	0.001672247
3	2871	Nitrogenous Chemical Fertilizer	DST	128,641	1,042,670	0.000086325
3	2911	Gasoline	DST	2,622,721	26,227,210	0.002171404
3	2912	Jet Fuel	DST	341,294	3,412,940	0.000282564
		SUBTOTAL:		9,663,093	87,684,754	0.007259599
		PERCENTAGE:		67.52%	68.29%	68.29%
3+	2916	Lubricating Oils	SST^1	143,986	1,439,860	0.000119209
3+	2915	Residual Fuel Oil	SST^1	1,261,836	11,892,345	0.000984591
3+	1311	Crude Petroleum	SST^1	747,916	7,432,472	0.000615349
		SUBTOTAL:		2,153,738	20,764,677	0.001719150
		PERCENTAGE:		15.05%	16.17%	16.17%
		TOTALS:		14,310,699	128,393,996	0.010630000
		PERCENTAGE:		100.00%	100.00%	100.00%
		GROUPS 3 & 3+ TOTAL PERCENTAGE: (Hazardous Commodities)		82.57%	84.47%	84.47%

BARGE TYPE LEGEND: ASPH=asphalt, CAUS=caustic soda, CEM=cement, CH=covered hopper, DK=deck, DST=double-skin tank, LS=liquid sulfur, LPG=LPG pressure tanks, OH=open hopper, SST=single-skin tank, SST^1=now 40% to 50% of barges are double-skin tanks, 1990 Oil Pollution Act requires 100% double-skin by year 2010.

Source for 1989 commodity tonnages: Waterborne Commerce Statistics Center, 1989 Cargo History Files, New Orleans, LA., 1991

Source for Pollution Potential Groupings and Spill Probability Estimates: Gulf Engineers & Consultants, Inc.

hazard, those commodities which, when spilled in a navigation accident, present the greatest hazard to whooping cranes or critical habitat, are designated as "3+". In 1989, 67.52 percent of the total tonnage (or 68.29 percent of the total ton-hours of exposure) in the study area was in category "3", and 15.05 percent of the total tonnage (or 16.17 percent of the total ton-hours of exposure) in the study area was in category "3+".

The term "significant hazard" deserves further description in this situation. The intention is to include all materials barged through the area that under any combination of circumstances or events could injure a whooping crane or cause any immediate or long-term damage to critical habitat. Furthermore, the territorial orientation and natural tendency to disperse, and the tendency to avoid or flee from human encroachment, offers little protection because the whooping cranes have become accustomed to barge tows and other vessels travelling the GIWW (such as tour boats and crew boats) and now tend to mostly ignore these intrusions. Therefore, even otherwise harmless barged chemicals that can under unusual (and even very unlikely) circumstances explode in a barge accident, and coincidentally injure a whooping crane that may be nearby, are included in the classification "significant hazard" (Groups 3 or 3+) along with other obviously significant materials such as crude oil.

Most of the barged commodities identified in Table 5 as presenting a significant hazard to whooping cranes (Pollution Potential Group 3 and 3+) are petroleum or products derived from petroleum. There are, however, significant differences in the effect these commodities have on the environment and in the threat the individual products present to whooping cranes overwintering in the vicinity of ANWR. For instance, lighter refined products such as diesel fuel and Gasoline are more acutely toxic than crude oil, but they dissipate rapidly when spilled. Also, freshly spilled crude is more toxic than oil that has been in the water ("weathered") for a number of days because of the immediate presence of the more toxic volatile constituents of crude, such as benzene and toluene, which quickly evaporate or dissolve.

Petroleum base oils that have lost or been stripped of the more toxic volatile fractions typically present in crude oil, such as "weathered crude, residual (#6) fuel oil, and lubricants, are nevertheless a greater hazard for whooping cranes. These persistent and floatable oils, when spilled from barges, endure longer in the environment and can be transported longer distances by wind and tidal flow. Spilled oils can adhere to exposed banks, vegetation, and marine organisms (whooping crane food supply) in habitat areas and perhaps on the legs or on the head or neck of

cranes as they probe for food in oil-polluted shallow waters. Cranes subjected to oiling could lose the ability to protect themselves against the adverse characteristics of water and temperature, and preening of oiled feathers would result in oil ingestion. The tolerance, if any, that whooping cranes have for oil is unknown; but experts believe that contact with or ingestion of small amounts of petroleum base oils would probably be fatal.

A critical review of Pollution Potential Group 2 commodities listed in Table 6 may raise questions in regard to the "significance" of liquid sulfur, liquid petroleum gas, and asphalt, tar, and pitches. All of these commodities are combustible, and burning sulfur yields a very dangerous gas, sulfur dioxide, which could easily kill whooping cranes. Liquid petroleum gas is not a significant threat because these materials are carried in removable heavy steel cylinders and are very unlikely to be damaged in a navigation accident in the study area, and explosion within the tanks is not a problem if damage occurs. Sulfur, asphalt, tars, and pitches are difficult to ignite, and when spilled sink immediately to the bottom of the receiving water. These latter materials should be removed if spilled in large amounts, but even large amounts spilled in the navigation channel would not harm the whooping cranes or their critical habitat if removed within a few weeks.

Of the commodities in Pollution Potential Group 3 in Table 6, 48 percent are petroleum refining products that are increasingly shipped in double skin tank barges. These products are light weight (floatable), ignitable liquids including Gasoline, naphtha, benzene and toluene, jet fuel, kerosene, and distillate fuel oil (diesel fuel). Although spillage of these commodities usually does not cause serious water pollution problems because of rapid evaporation, spillage in large amounts at a critical time and place, such as the entire contents of a barge compartment (up to 3,000 barrels or 126,000 gallons) near a mud flat where whooping cranes are feeding, could present a "significant" hazard. Shipment of these commodities in double skin barges reduces the possibility of spilling large quantities if a navigation accident occurs, but some risk of fire and explosion incidental to barge collision remains.

Commodities classed as "WCSC code 2811 - Crude Petroleum Products" and "WCSC code 2991 - Petroleum and Crude Products" are similar in hazard to that of the petroleum products described in the previous paragraph, except that these products are now often shipped in single skin tank barges, and thus there is increased risk of the entire contents of a barge compartment (about 3,000 barrels or 126,000 gallons). Use of double skin barges for these commodities is increasing rapidly and is mandatory by 2010 under the Oil Pollution Act of 1990.

Among the commodities shipped in double skin barges is nitrogenous chemical fertilizer. Although this commodity when spilled presents only a transient water pollution control problem, it is considered a "significant" hazard because of a possibility for explosion in a barge collision and fire accident.

Alcohols (WCSC code 2813) are often shipped in single skin barges and are classed in Pollution Potential Group 3. Although the alcohols barged through the study area would tend to mix with the water column if spilled, and present a transient water pollution problem, alcohols are classed as a significant hazard because they are toxic to some degree and could present a fire and explosion hazard in a barge collision situation.

A concern mentioned previously is that the broad classification "WCSC code 2819 - Basic Chemicals, Not Elsewhere Classified" may include some barged commodities that present an extreme threat to the whooping crane and its critical habitat. Information from manufacturers, shippers, and port authorities in the vicinity (along the Victoria Barge Canal, and in or near Corpus Christi, Seadrift, Port Lavaca, Point Comfort, etc.) indicates that about a fourth of the barged commodities in this classification are liquified, combustible, and reactive gases, namely anhydrous ammonia and butadiene, which are shipped in cylindrical steel tanks within a barge similar to those used for liquified petroleum gas. A larger percent of the total consists of nitriles such as acrylonitrile and acetone cyanohydrin manufactured in the Victoria area. Because these materials are highly toxic, reactive, and ignitible, they are shipped in double-skin tank barges that have bracing in the void between the inner and outer hulls and use long forerakes (usually 25 feet), with additional bracing to provide extra protection from impact damage to the tanks containing commodities in double-skin tank barges, which reduces the risk of spillage in a navigation accident.

Another portion (about 25 percent) of the WCSC code 2819 commodities shipped through the study area is cumene and other benzene-like aromatic hydrocarbon compounds such as xylene that are manufactured in Corpus Christi. The hazard potential is the same as that for light-weight ignitable petroleum fractions shipped by double skin barges, as previously described. This broad commodity classification also includes the combustible liquid organic compounds ethylene glycol and acetone, the risk potential for which is similar to that of alcohol. The broad classification also includes some non-hazardous inorganic compounds.

The most serious threat (worst case spill commodities) to whooping cranes and critical habitat from commodities barged through the study area is presented by crude oil, residual oil,

and lubricating oil in amounts that could be spilled as a result of a navigation accident. These commodities float, persist in the environment, and are difficult to remove once contact is made with shore or vegetation. Although recent Federal legislation requires that petroleum and petroleum products all be shipped in double skin tank barges by the year 2010, a substantial quantity of oil is still being shipped in single skin tanks. Because rather large amounts of oil could be lost from the rupture of a single compartment of a tank barge (up to 3,000 barrels or 126,000 gallons) in a barge collision accident and that collision could occur at a critical location while the whooping cranes are in residence in the area, these commodities are the most hazardous to whooping crane life and critical habitat and are rated GROUP "3+" pollution potential in Table 6.

Commodities reported to be shipped through the study area do not include strong oxidants, strong acids, or other materials which might, in the event of a barge accident in which cargo commingling occurs, cause some catastrophic reaction with the products now being shipped through the study area. Caustic soda is shipped through the study area as a water solution in special barges and presents no significant reactivity threat. Also, pesticides and herbicides are not manufactured in the vicinity and are not shipped by barge through the study area.

Since there are no barge loading or unloading activities on the GIWW in the study area, there is no threat of spillage from such operations. The navigation channel in the study area is presently free of bridge piers and other structures that could cause impact damage to a barge hull that would result in cargo spillage. A cement bag erosion protection wall lines the north bank of the GIWW along the area between Mustang Lake and Sundown Bay, but this structure could only be struck by an empty barge tow because the water nearby is too shallow for a loaded barge to traverse without grounding on the soft bottom beside the channel before reaching the wall. The bottoms along the edge of the navigation channel are soft, except at the rock outcroppings (ledges) along the Rockport end of the study area (mile 525 and higher), and accidental groundings are unlikely to cause barge hull damage leading to cargo spillage. The most plausible threat is from a navigation accident involving the collision of a barge tow with another large vessel, such as another barge tow.

In consideration of the above, the worst case spill is more specifically described as any collision-type navigation accident in the study area involving a barge tow and another large vessel in which one or more barge compartments containing floatable, persistent petroleum could be ruptured.

Weather and Tide Conditions

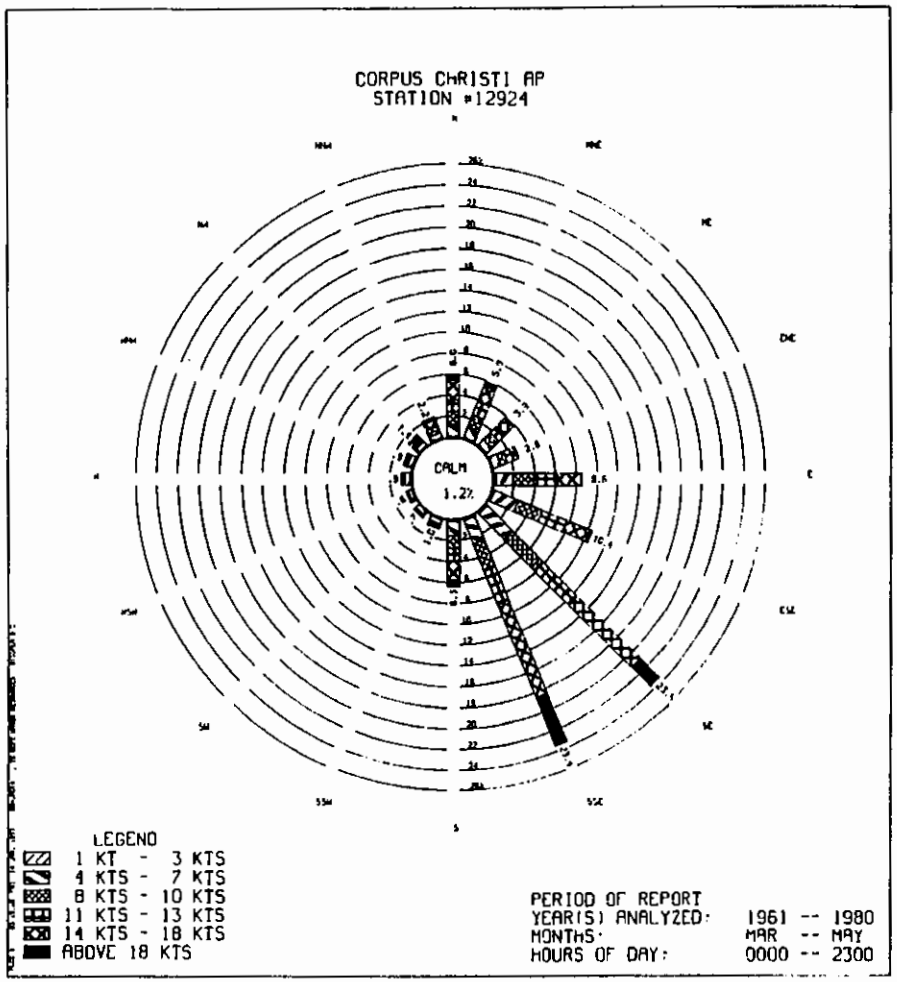
Lunar tides in the Gulf of Mexico along the coast of Texas are of the mixed type, having two unequal high waters and/or two unequal low waters each tidal day. The range between high and low each tidal day is less than two feet. Tidal flow into and from the Gulf of Mexico and embayments in the vicinity of ANWR is restricted by the narrow flow channel (Cedar Bayou) between the barrier islands of San Jose and Matagorda. The directional orientation of tidal flow in the local embayments on a falling tide is southwestwardly (parallel to the coastline, towards Cedar Bayou and Aransas Pass), but the minor fluctuation in water surface elevations from lunar tides does not cause strong currents in the GIWW and is not a major problem in pollutant spill damage control or in erosion control at the ANWR.

Tidal surges or storm tides associated with tropical cyclones (hurricanes) in the Gulf of Mexico landfalling in the vicinity of Aransas could have a profound effect on water levels, soil erosion, and the dispersion of spilled floatable pollutants into the sensitive coastal marsh environment. Hurricane landfall in the vicinity of Aransas occurs infrequently, and then usually in late summer or very early fall. The potential for hurricane landfall is minimal after arrival of cooling fall weather (about mid-October). The whooping cranes in the study area are over-wintering migratory birds. Hurricanes are not a significant threat to these whooping cranes because they do not ordinarily arrive at Aransas until after the hurricane season is past.

Ordinary and storm-related winds are the predominant weather factors influencing tidal stages, flows, and wave heights. Thus, they are the most important factors in considering the fate of any pollutants that would be spilled in a navigation accident. Mean monthly windspeeds in the Corpus Christi area during October exceed 10 mph, gradually increasing through the fall and winter to over 14 mph in April. Wind roses (Figure 3) are presented on the following pages for Corpus Christi (provided by the Texas State Climatologist) and normals, means and extremes (Figure 4) for Corpus Christi (published by the Weather Bureau) are presented below.

The available climatological data indicate that if a pollutant spill occurs on the GIWW in the vicinity of the ANWR during October through April when the whooping cranes are in residence, the most likely weather conditions will be brisk southeasterly (onshore) winds, about 10-14 mph, coming from the southeast and south-southeast. These prevailing winds would cause "high-tide" conditions, and mud flats in the vicinity of ANWR would be flooded.

The second most likely weather condition for a spill event is brisk northerly winds incoming from between True North and 22.5° N. When brisk "northers" are blowing, water is



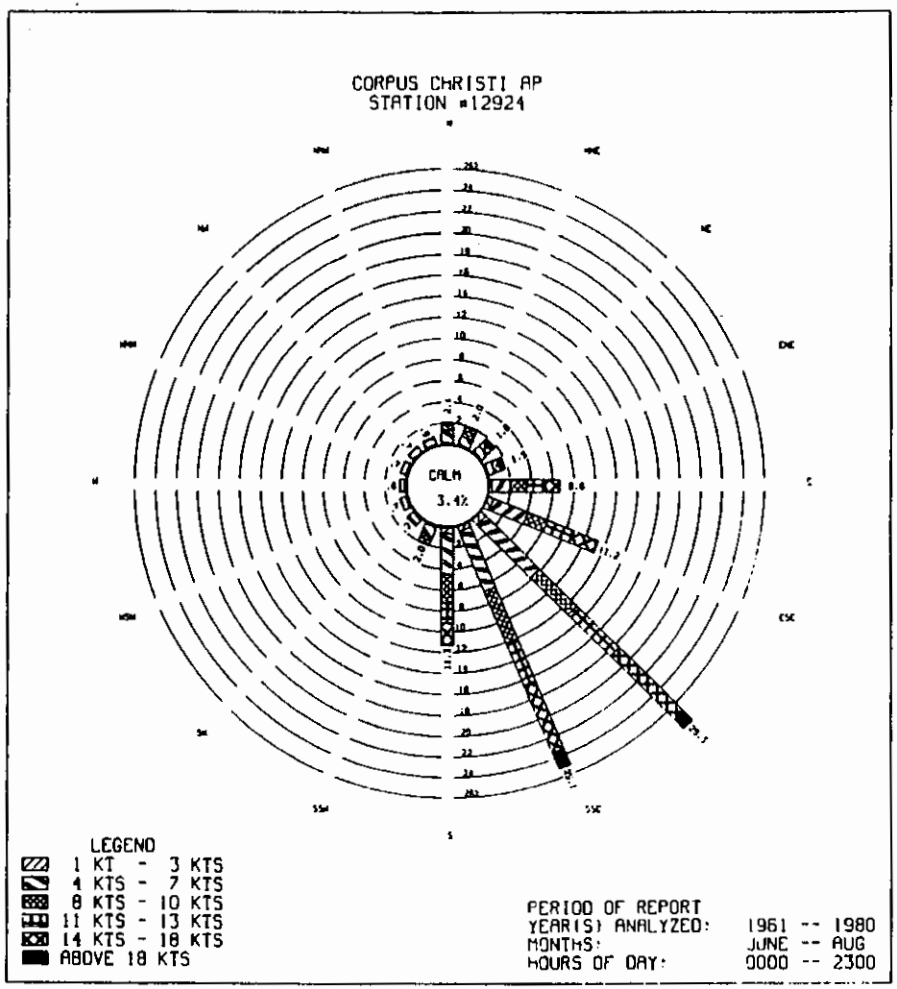
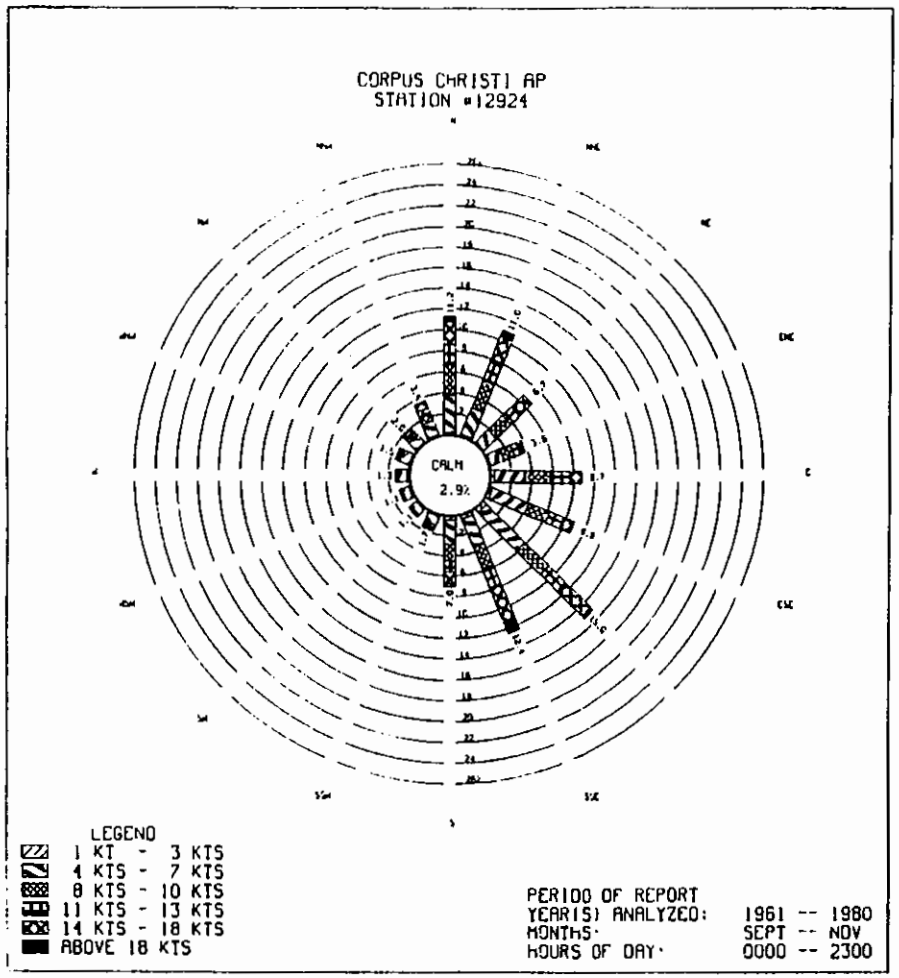


Figure 3(a). Wind Roses for Corpus Christi, Texas, March-August 1961-1980, By Office of the Texas State Climatologist



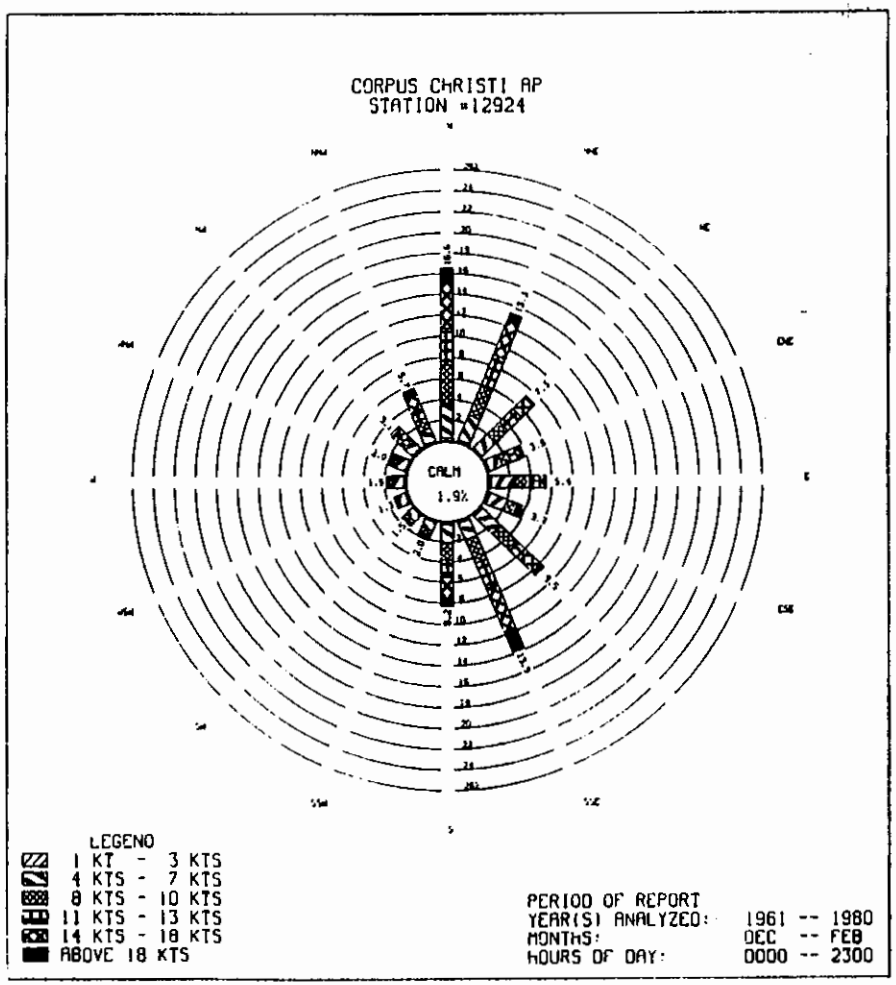


Figure 3(b). Wind Roses for Corpus Christi, Texas, September-February 1961-1980, By Office of the Texas State Climatologist

Figure 4.

NORMALS, MEANS, AND EXTREMES

CORPUS CHRISTI, TEXAS

LATITUDE: 27°46'N LONGITUDE: 97°30' W ELEVATION: FT. GRND 41 BARO 56 TIME ZONE: CENTRAL WBAN: 12924

	(a)	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEP	OCT	NOV	DEC	YEAR
TEMPERATURE °F:														
Normals														
-Daily Maximum		66.5	69.9	76.1	82.1	86.7	91.2	94.2	94.1	90.1	83.9	75.1	69.3	81.6
-Daily Minimum		46.1	48.7	55.7	63.9	69.5	74.1	75.6	75.8	72.8	64.1	54.9	48.8	62.5
-Monthly		56.3	59.3	65.9	73.0	78.1	82.7	84.9	85.0	81.5	74.0	65.0	59.1	72.1
Extremes														
-Record Highest	52	91	98	102	102	103	101	104	103	103	98	98	91	104
-Year		1971	1940	1989	1984	1984	1980	1939	1962	1977	1950	1988	1977	JUL 1939
-Record Lowest	52	14	18	24	33	47	58	64	64	50	39	29	13	13
-Year		1962	1951	1980	1987	1970	1975	1967	1967	1942	1989	1969	1989	DEC 1989
NORMAL DEGREE DAYS:														
Heating (base 65°F)		310	209	97	7	0	0	0	0	0	11	116	220	970
Cooling (base 65°F)		40	50	125	247	406	531	617	620	495	290	116	37	3574
% OF POSSIBLE SUNSHINE	48	45	50	55	56	60	73	80	77	68	68	55	45	61
MEAN SKY COVER (tenths)														
Sunrise - Sunset	48	6.8	6.4	6.6	6.7	6.4	5.2	4.9	4.9	5.2	4.7	5.7	6.5	5.8
MEAN NUMBER OF DAYS:														
Sunrise to Sunset														
-Clear	48	7.0	7.5	7.1	5.6	5.6	8.8	10.9	11.2	9.9	12.6	9.2	7.9	103.2
-Partly Cloudy	48	6.8	6.0	7.6	9.2	12.3	14.8	14.1	13.0	12.0	10.4	8.6	6.5	121.4
-Cloudy	48	17.2	14.8	16.3	15.2	13.2	6.4	6.0	6.8	8.1	8.0	12.2	16.7	140.7
Precipitation .01 inches or more	51	8.2	7.0	5.4	4.9	6.3	6.0	4.9	5.8	9.0	6.6	5.8	6.6	76.3
Snow, Ice pellets 1.0 inches or more	51	0.*	0.*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Thunderstorms	51	0.8	1.2	1.5	2.3	4.5	3.2	2.8	3.7	4.7	2.4	1.1	0.7	28.8
Heavy Fog Visibility 1/4 mile or less	48	5.9	4.8	3.9	2.6	1.1	0.2	0.2	0.2	0.3	1.1	3.5	5.3	29.0
Temperature °F														
-Maximum														
90° and above	26	0.1	0.2	0.8	1.8	5.0	19.2	27.3	26.9	17.2	5.0	0.3	0.1	104.2
32° and below	26	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.2
-Minimum														
32° and below	26	3.2	1.4	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	1.7	6.9
0° and below	26	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
AVG. STATION PRESS. (mb)	18	1018.7	1017.2	1013.1	1012.1	1010.3	1011.7	1013.5	1013.0	1012.6	1015.3	1016.0	1018.2	1014.3
RELATIVE HUMIDITY (%)														
Hour 00	26	85	84	84	87	90	89	88	86	86	85	85	83	86
Hour 06 (Local Time)	26	88	88	87	90	92	93	92	92	90	90	88	86	90
Hour 12	26	68	65	61	62	66	63	57	58	62	59	62	64	62
Hour 18	26	71	67	65	68	71	68	63	64	68	68	71	71	68
PRECIPITATION (inches):														
Water Equivalent														
-Normal		1.63	1.55	0.84	1.99	3.05	3.36	1.96	3.51	6.15	3.19	1.55	1.40	30.18
-Maximum Monthly	52	10.78	8.11	4.80	8.04	9.38	13.35	11.92	14.79	20.33	11.02	8.53	7.80	20.33
-Year		1958	1982	1974	1956	1968	1973	1976	1980	1967	1981	1947	1960	SEP 1967
-Minimum Monthly	52	0.03	T	T	T	T	0.03	0.00	0.10	0.49	0.00	T	0.01	0.00
-Year		1971	1976	1971	1984	1961	1980	1957	1952	1981	1952	1949	1950	JUL 1957
-Maximum in 24 hrs	48	6.38	4.85	2.99	7.19	4.65	5.65	4.61	8.92	8.76	7.25	3.44	3.86	8.92
-Year		1958	1982	1990	1956	1968	1978	1981	1980	1967	1960	1947	1960	AUG 1980
Snow, Ice pellets														
-Maximum Monthly	52	1.2	1.1	T	0.0	0.0	0.0	0.0	0.0	0.0	0.0	T	T	1.2
-Year		1940	1973	1990								1979	1989	JAN 1940
-Maximum in 24 hrs	52	1.1	1.1	T	0.0	0.0	0.0	0.0	0.0	0.0	0.0	T	T	1.1
-Year		1940	1973	1990								1979	1989	FEB 1973
WIND:														
Mean Speed (mph)	48	12.1	13.0	14.1	14.3	12.8	11.8	11.5	11.0	10.4	10.3	11.6	11.5	12.0
Prevailing Direction through 1963		SSE	SSE	SSE	SE	SE	SE	SSE	SSE	SE	SE	SSE	SSE	SSE
Fastest Obs. 1 Min.														
-Direction (!!!)	14	32	15	14	30	32	36	02	11	04	36	17	18	11
-Speed (MPH)	14	37	41	38	45	44	37	46	55	38	35	39	38	55
-Year		1979	1981	1983	1988	1985	1988	1980	1980	1979	1988	1983	1982	AUG 1980
Peak Gust														
-Direction (!!!)	7	N	NW	NW	NW	NW	N	S	E	E	E	NW	SE	N
-Speed (mph)	7	52	60	51	56	60	61	49	48	61	53	60	47	61
-Date		1985	1987	1986	1988	1985	1988	1986	1986	1988	1984	1987	1987	JUN 1988

(!!!) See Reference Notes on Page 68.

blown out of the embayments, and "low-tide" conditions can be expected, exposing mud flats in the vicinity of the ANWR.

Westerly winds and calms would be preferred conditions in the event of a spill, but unfortunately these conditions occur infrequently in the area. Whereas prevailing onshore winds are driven by solar heat, "northers" by arctic high pressure systems, and easterly winds by approaching weather fronts, a driving force for westerly winds is generally absent in the area. The quarterly wind roses for Corpus Christi indicate clearly that westerly winds seldom occur, and the velocity of westerly wind is quite mild (4 to 7 knots) in comparison to the strong onshore and northerly winds, which often exceed 18 knots.

Barge Construction and Potential Spill Size

Floatable petroleum-based oils are the barged commodities that have the greatest potential for harm to the whooping crane and its habitat. The spillage threat is from the possibility of an accidental collision with another barge tow or massive submerged object involving a loaded oil barge operating within the confines of the GIWW or the Victoria Barge Canal.

A search of available information found no record of a barge collision on the GIWW that resulted in spillage of a large amount of oil (1,000 barrels or more). The GIWW in the 31-mile study reach is a relatively straight run with only a few slight bends. The channel is well marked and is free of visual obstructions such as trees. However, fog is common in the study area and does represent a visual obstruction. The probability of occurrence of a barge collision accident in the area appears to be low. However, the absence of historical data does not preclude a rational estimate of how much oil would or could be lost in the event of a navigation accident involving collision with a loaded oil barge.

The presence of vessels containing large quantities of oil near whooping crane habitat is obviously not a desirable situation. The image of a large loaded ocean-going oil tanker stuck on a reef and disgorging vast quantities of crude oil at low tide through a breached hull is commonly portrayed in the news media as the typical oil spill. Fortunately, the risk situation in the GIWW and the Victoria Barge Canal near the ANWR is not the same as that in an ocean-going tanker spill situation, and the differences are not merely in magnitude. Differences in wind, weather, tide conditions, vessel architecture, and obstacles to navigation make the situation quite different. In fact, the Federal Intracoastal Waterway system was built for the purpose of protecting

waterborne shipping from the perils of navigation in the open sea, such as high winds, waves, submerged reefs, etc.

The bottom width of the GIWW navigation channel through the study area is 125 feet, and the project depth is 12 feet. The navigation channel itself contains the deepest waters in the study area, since much of the channel was cut through mud flats, low marshes, and shallow embayments. Natural waters of eight feet or more in depth are encountered only where the navigation channel extends southwestward of Long Reef (mile 517) in Aransas Bay. The channel bottom and banks throughout the study area are soft (sand and silt) and are free of oyster beds, rocky ledges, bridge abutments, and other obstructions. Because of the soft bottom, the grounding of a loaded barge has not (historically) caused a breach in the hull (and attendant oil spillage).

There are a number of shell reefs in shallow embayments alongside the GIWW navigation channel. It is possible for an empty barge to be grounded on shell reefs at high tide, but loaded barges would become grounded on soft bottoms at the edge of the channel and are thus not in jeopardy. Figure 5, which shows a loaded barge in a typical channel cross-section, illustrates the barge-confining nature of the channel in shallow waters and mud flats.

Although empty barges do not pose a significant spill threat, they are difficult to control in strong cross winds. Empty barges of all kinds, not just oil barges, ride high in the water and are vulnerable to being pushed laterally by such winds. Long tows of empty barges are especially difficult to control. When strong onshore winds (crosswise of the GIWW) are blowing, which is a frequent occurrence, tides are high and mud flats are flooded. In these conditions, accidental groundings by empty barges could occur at the edge of low marsh near the channel, causing habitat damage, accelerated marsh erosion, and possible damage to erosion control structures.

Partially loaded barges are not a consideration because of infrequent occurrence. Barges are economical for moving large quantities of cargo. Most often the shipping need is on a continuing basis, and because of the high cost and problems associated with cleaning barges, barges are dedicated for use in transporting specific commodities or compatible types of commodities. Therefore, barges are usually loaded to the draft allowable for safe navigation (about 9 feet 6 inches on the GIWW according to several tow operators interviewed) or they are empty and in transit to a shipper. Small and infrequently occurring loads are usually shipped more economically by rail or truck.

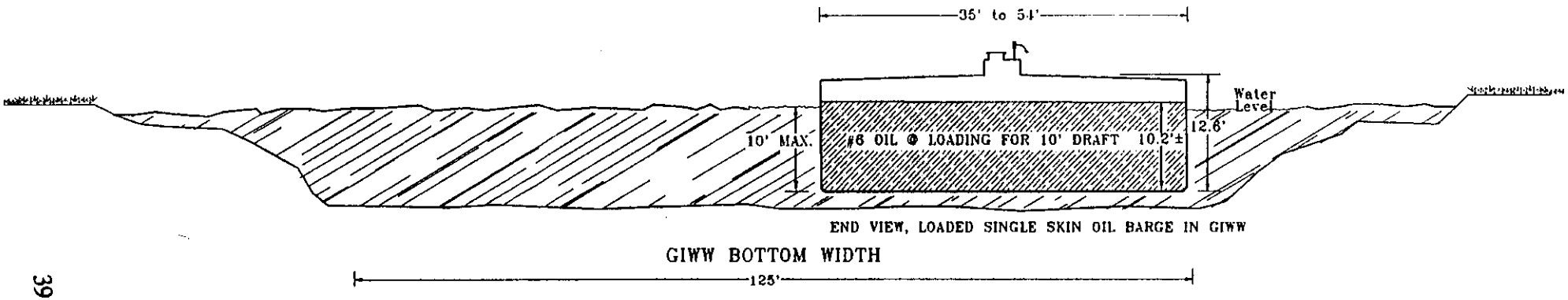


Figure 5. LOADED SINGLE SKIN BARGE IN GIWW NAVIGATION CHANNEL

Individual barges used in the area can contain as many as 20,000 barrels (840,000 gallons) of oil without drawing more than 10 feet of water in the shallow (12-foot control depth) navigation channel. However, oil barges have 3-12 individual cargo compartments, the largest of which would ordinarily contain less than the full-compartment capacity of about 3,000 barrels (126,000 gallons).

Smaller (three-compartment) oil barges are typically about 35 feet wide by 200 feet long (including a 25-foot forerake and a 6-foot stern bulkhead). Larger (as many as 10 compartments) barges have a maximum Coast Guard allowable width of 54 feet. Lengths range to over 300 feet, including fore and aft bulkheads, which help absorb collision impacts.

Some oil barges do not have a forerake, but instead have six feet of bulkhead at both ends. These barges, which are referred to as "box barges," are rarely used as lead barges in a tow because of poor navigation characteristics.

There are three ways that oil could escape accidently from the loaded cargo barges passing through the study area: (1) an undetected leak from a "single-skin" barge; (2) a barge collision causing rupture of the sides or bottom of an oil compartment; and (3) ripping open the bottom of a skin tank by grounding on rock or striking some large submerged object such as a sunken wreck. It is unlikely that a leaking oil barge would go undetected before a barge tow reaches the remote ANWR. The small amount of spillage that would be involved in such a fugitive spill (usually less than 50 gallons) is not considered in this study. The possibility of damage to the bottom of a loaded barge in this well-maintained channel with soft bottom and sides is remote. The most plausible oil spill threat in the study area is from a navigation accident involving collision of an oil barge tow with another large vessel such as another tow of loaded barges.

Because of the fact that loaded oil barges in the vicinity of ANWR cannot escape the narrow confines of the GIWW except in the open deep waters of Aransas Bay, an accident involving significant oil spillage would occur within the confines of the channel itself. Barge architecture, channel geometry, speed limits, and other navigation practices limit the amount of damage and resulting oil spillage that could occur incidental to a collision. Undamaged oil compartments cannot be completely submerged because hatches and pressure/vacuum relief valves (PRVs) are over 15 feet above barge bottoms, and oil barges are equipped with pumps which can be used to transfer cargo from a damaged compartment to undamaged compartments to reduce or eliminate spillage as shown in Figure 6.

Figure 6. Single-Skin Barge Showing Pumps (1), Pressure/Vacuum Relief Valves (2), and Cargo Compartment Hatches (3)

Loaded barges in motion are capable of causing severe structural damage during a collision. The damaging force depends upon total mass in motion and the relative speed (and thus deceleration rate) at impact. Lead barges in an oil tow are equipped with a slightly elevated forerake (see Figure 7) designed to absorb much of the collision force, which minimizes damage to the foremost oil compartment(s). Regulations of the U.S. Coast Guard limit the operating speed of loaded barge tows to five mph, which further reduces damage in the event of a collision.

Loaded oil barges drawing about 10 feet of water are comparatively easy to control on inland waterways where strong cross-currents are not a problem. Also, cross winds are not a serious problem in steering loaded barges. However, since empty barges are much more difficult to steer, especially where strong cross winds are encountered, a barge collision in the study area would most likely involve a tow of empty barges.

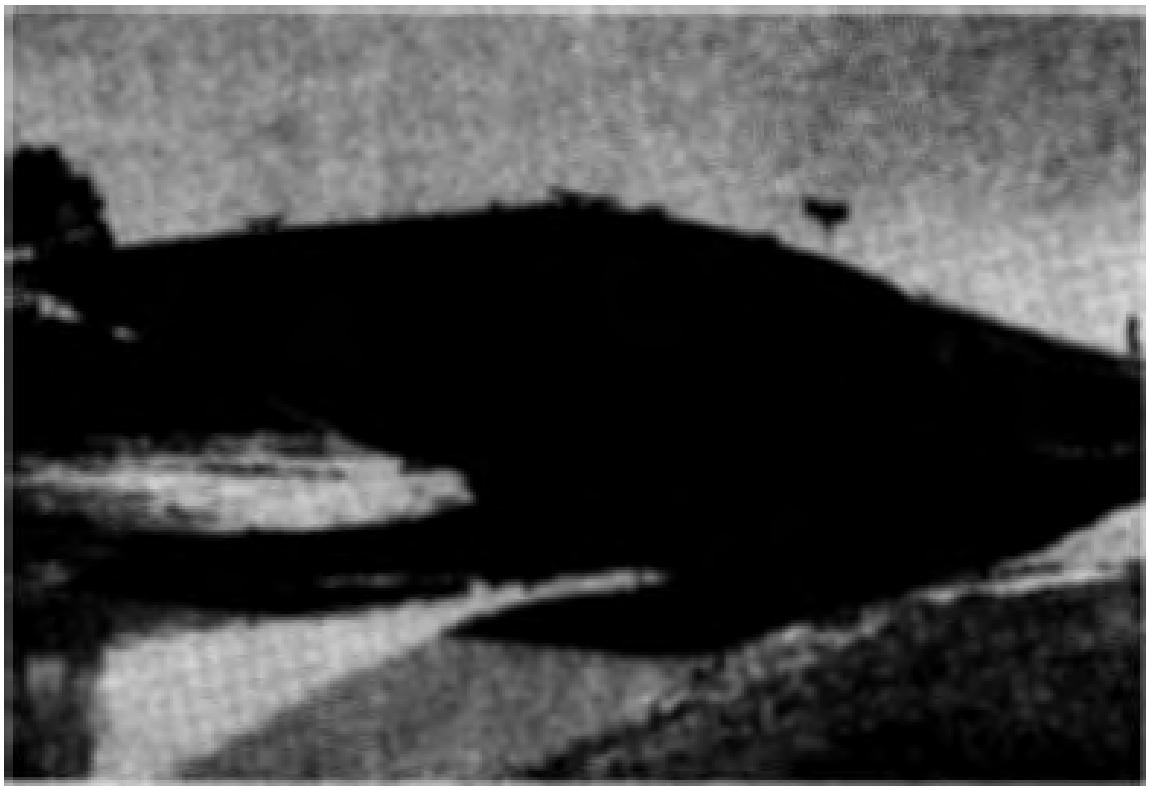
The relatively narrow channel of the GIWW tends to prevent the comparatively long tows of loaded oil barges from being sideswiped. Only through serious pilot error or the unlikely event that a loaded oil barge tow would be blown off course could a tow become grounded in a way that exposed a large sidewall to potential collision; and even under these circumstances, the exposure would be at a small acute angle. Figure 8 illustrates these factors.

The Oil Pollution Act of 1990 requires that "skin tanks" be phased out by 2010 and that oil be shipped exclusively in double-hull or "double-skin" barges. Conversions are already taking place in anticipation of this requirement. When double-skin barges for oil shipping become mandatory, the probability of damage to an oil compartment of a barge sideswiped in a collision within the channel will be negligible.

There are two specific locations in the study area where a loaded oil barge may be at risk of a side-impact collision. One location is Welder Flats, where barge tows exit the Victoria Barge Canal into the GIWW. Although there are no specific navigation traffic control systems for the area, visibility is unobstructed and radio contact and coordination is common between barge tows approaching the intersection.

Another problem area is in the open deep waters of Aransas Bay southwestward of Long Reef (mile 517). A tow of loaded oil barges could turn perpendicular to the axis of the channel without becoming grounded and perhaps be struck broadside by an oncoming barge tow. Some of the contents of two oil compartments (less than 6,000 barrels) could be spilled, but great distances (over 5 miles) and prevailing southwesterly winds would protect whooping crane habitat from damage.

Figure 7. Lead Barge With Elevated Forerake



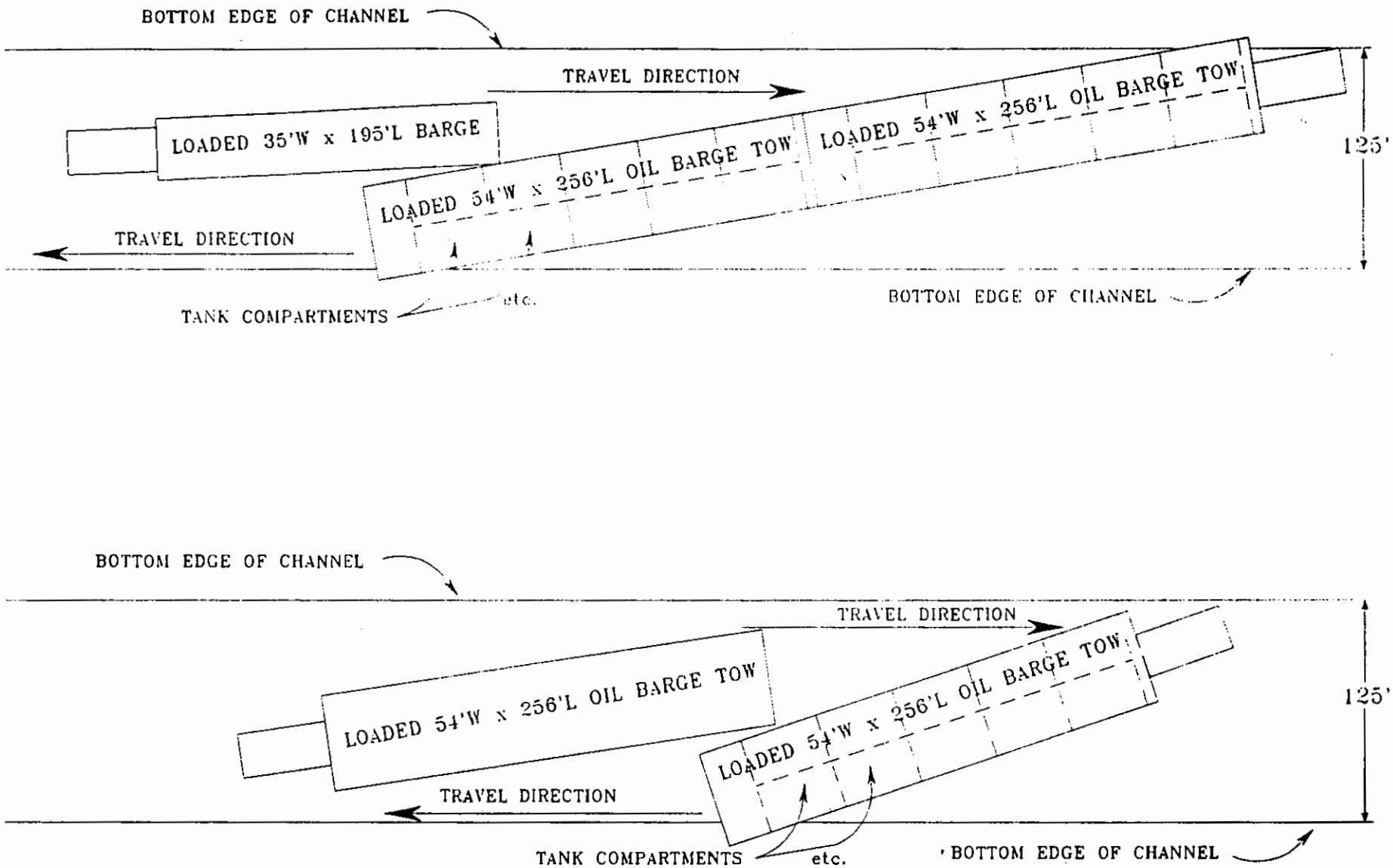


Figure 8. Theoretical "Sideswipe" Collisions Involving Loaded Barges in GIWW

From these facts, it is apparent that if a significant spill threat exists in the study area, it is associated with a frontal impact collision involving a loaded oil barge and another barge. Where collision impact energy is spread evenly across the bow, the forerake absorbs collision energy and damage to barge oil compartments is unlikely on either of the colliding front barges. If the frontal impact energy is received on only one side of the bow, damage to an oil compartment (behind the forerake) is more likely to occur. Thus, in frontal collisions involving large oil barges (54 feet wide) that have two cargo compartments side by side behind the forerake, it is unlikely that both forward compartments would be damaged.

It should also be noted that some barge tows in the area employ bow thrusters to help steering in difficult navigation situations. In the event of a frontal collision, these units would absorb shock and prevent damage to cargo compartments in the lead barge.

Most of the floatable oil commodities are being shipped through the study area in barges with "single-skin tanks." The hull plates or "outer skin" of the barge function as a containing wall for the individual oil tanks or cargo compartments.

To achieve economies of scale, the double-skin barges used for shipping crude and residual oils (comparatively low-value products) tend to be large (54 by 300 feet or more) and have a large (25 to 40-foot) forerake to help absorb the force of collisions. Many double-skin barges for oil shipment are already in service. In the event of a navigation accident involving such barges, there is significantly less risk of breaching the bottom or side walls of the oil storage compartments.

Although conversion of the shipping fleet to double-skin barges will undoubtedly reduce the possibility of oil spillage, there is a disadvantage. If the outer skin of a double-skin oil barge is breached below the water line, a loaded double-skin oil barge will most likely sink. Conversely, a single-skin barge loaded with light or medium-weight crude oil or residual oils with a specific gravity less than one will remain afloat if only one compartment is breached, because of the buoyancy of the other (unbreached) compartments and the buoyancy of the oil in the breached compartment. Because of the relatively shallow depth of the GIWW (-12 feet at mean low tide) in the study area, even a sunken oil barge would not constitute a serious spillage problem because oil compartment hatches and pressure/vacuum relief valves would be situated well above the high-water level, and oils would be retained in undamaged compartments. Figures 9 and 10 illustrate cargo compartment hatches and pressure/vacuum relief values and the situations that would be encountered with damaged single-skin and double-skin barges.

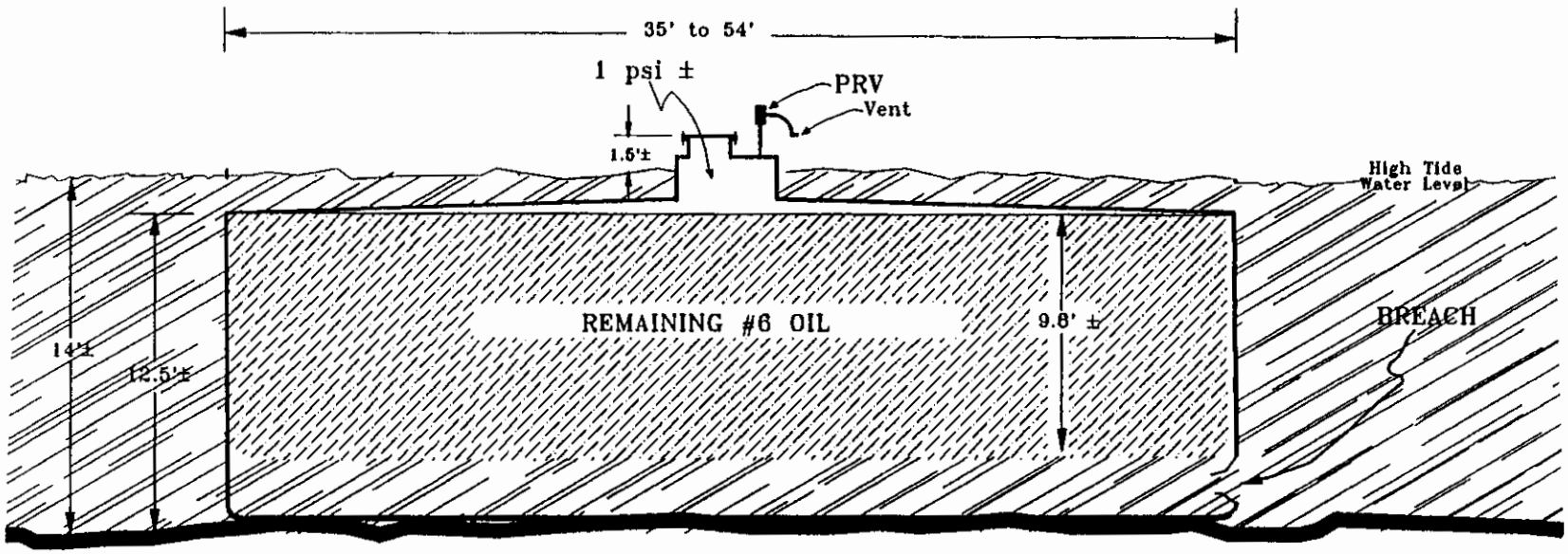
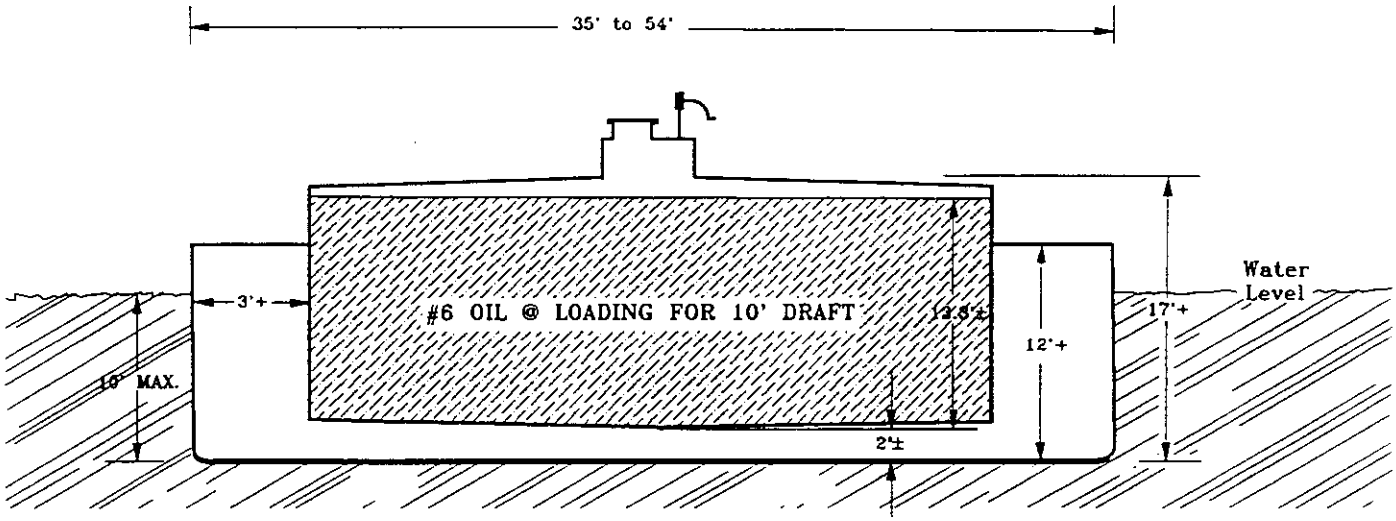
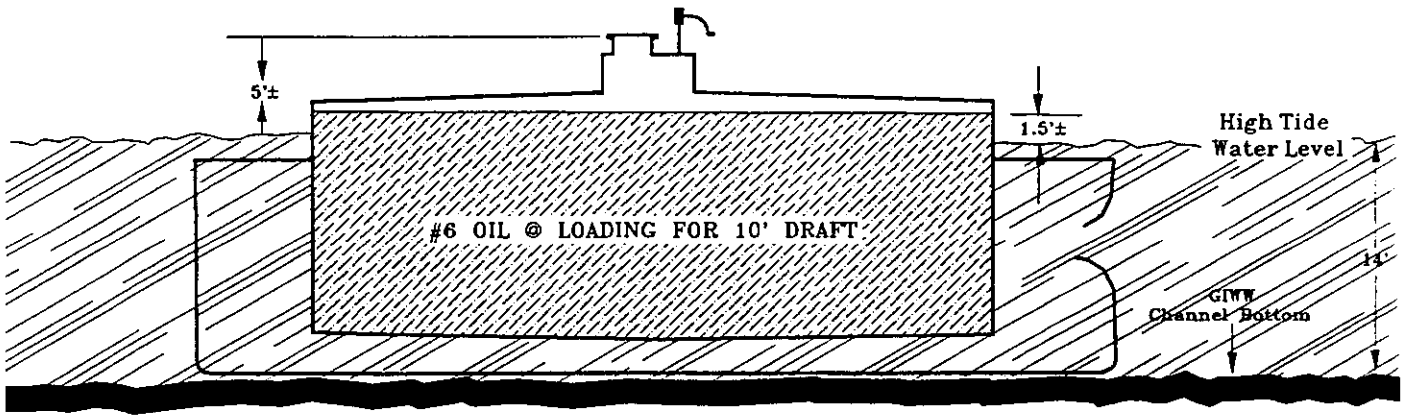


Figure 9. SINGLE SKIN OIL BARGE WITH BREACHED CARGO COMPARTMENT RESTING ON GIWW CHANNEL BOTTOM, ANWR VICINITY



TRANSVERSE SECTION

LOADED DOUBLE SKIN TANK BARGE



TRANSVERSE SECTION

LOADED DOUBLE SKIN TANK BARGE WITH BREACHED OUTER HULL

Figure 10. Double-Skin Barge Features

In the event an oil compartment was breached in a collision, the tow operator would transfer oil from the damaged compartment to undamaged compartments. The objectives would be to ballast in such a way as to eliminate or minimize oil loss through the cargo compartment breach and to transfer as much oil as possible to a safe containment tank. All oil barges have piping and a pump driven by a diesel engine to offload cargo or transfer cargo from one compartment to another. Oil barge tows also have portable compressed-air driven pumps and oil hoses that can be used to pump oil from the top of a damaged compartment to an undamaged compartment, or to a slop oil storage tank (if available). In the relatively shallow GIWW, oil cargo compartments are loaded for only 9-10 feet of draft, and plenty of extra storage space is available in undamaged compartments during an emergency.

In the very unlikely event of a head-on collision at the slow speeds in the GIWW, it is unlikely that severe damage to an oil storage compartment behind the forerake would occur. If a worst case event did occur, it is unlikely that as much as half the cargo could escape before leakage would be contained by natural or deliberate water ballasting and by cargo salvage within the injured barge. Because the largest barge compartments used on the GIWW would contain only about 3,000 barrels of oil when loaded, a worst case situation could involve less than 1,500 barrels of floatable oils spilled in a relatively short period of time (about an hour).

XI. WORST CASE SPILL PROBABILITY

The probability of the worst case spill was defined for this analysis as the probability of a collision between two tows that results in a significant spill of crude petroleum (WCSC commodity code 1311), residual fuel oil (WCSC commodity code 2915), or lubricating oils (WCSC commodity code 2916) from one or more tank compartments of barges in either or both tows. This outcome can be considered the joint outcome of two separate events: (1) a collision between two tows (event C) and (2) a significant spill of crude, residual fuel oil, or lubricating oils (event S). Therefore, the probability of the worst case spill is the joint probability of events C and S occurring, symbolized by $P(C \cap S)$. This probability is determined by multiplying the marginal probability of event S occurring irrespective of event C ($P(S)$) by the conditional probability of event C occurring, given that event S occurs ($P(C \mid S)$). This is symbolized by $P(C \cap S) = P(S) * P(C \mid S)$. The estimation of this joint probability was developed in two steps. The first step involved assessing the probability of one or more significant spills of crude, residual fuel oil, or lubricating oil using the same approach as for the most likely spill.

Secondly, the conditional probability of a collision between two tows given that a significant spill occurs was assessed by an examination of the data available concerning collisions resulting from navigation hazards (other than docking or loading related hazards) such as poor visibility conditions in the Texas inland waterway system.

The marginal probability of one or more significant spills of crude, residual fuel oil, or lubricating oil, irrespective of whether a collision occurred, is estimated by following the same procedure as for the most likely spill. The probability of one or more significant spills of any commodity in the entire Texas inland waterway system is adjusted for the ton-hours of all commodities shipped through the study reach, and then adjusted for the ton-hours of crude, residual fuel oil, and lubricating oil traversing the study reach. As shown above in the most likely spill section, the probability of one or more significant spills of any commodity in the Texas inland waterway system over an exposure of 11.06114 billion ton-hours of commodity shipments is 0.91558, or 91.6 percent.

The ton-hours of worst case commodities traversing the study area during 1989 as presented in Table 5 are: (1) 7,432,472 ton-hours of crude petroleum (WCSC code 1311), (2) 11,892,345 ton-hours of residual fuel oil (WCSC code 2915), and (3) 1,439,860 ton-hours of lubricating oils (WCSC code 2916). The total exposure to worst case commodities traversing the study area in 1989 is therefore 20,764,677 ton-hours or 0.02076 billion ton-hours.

The first step in determining the probability of one or more spills of the worst case commodities ($P(S)$) is to adjust the probability of one or more spills of any commodity in the Texas inland waterway system over an exposure of 11.06114 billion ton-hours by the overall study reach exposure of 0.12839 billion ton-hours:

overall study reach $P(S)$ = study reach $P\ (n \geq 1)$

$= 0.91558 * (0.12839 / 11.06114) = 0.01063$

This probability of one or more spills of any commodity shipped through the study reach is then adjusted for the study reach exposure to worst case commodities:

study reach worst case commodities $P(S) = 0.01063 * (0.02076 / 0.12839) =$

$= \underline{0.00172}$

The conditional probability of a collision between two tows given that a significant spill occurs was assessed by an examination of the data available for the Texas inland waterway system for the period of 1986 to 1990 concerning *collisions* unrelated to docking or loading. Only one collision meeting such criteria was found. This collision resulted in a spill of 680

barrels of naphtha (a much lighter petroleum product than any of the worst case commodities), which was caused by poor visibility conditions because of smoke from a marsh fire alongside the GIWW near Port Arthur on September 9, 1990. The assumption that collisions occur along the GIWW as a Poisson process is reasonable for this analysis, and the same approach as above for the most likely spill was used to estimate the probability of one or more collisions occurring in the Texas inland waterway system over an exposure of 11.06114 billion ton-hours.

The collision occurrence rate per unit exposure (λ) is estimated in this case by dividing the number of collisions observed in the past ($\nu = 1$) by the past exposure ($\tau = 8.949$ billion ton-hours), which gives $\lambda = 1 / 8.949 = 0.11174$. The probability of zero collisions in the Texas inland waterway system over an exposure of $t = 11.06114$ billion ton-hours is given by:

$$P(0) = \frac{(0.11174 * 11.06114)^0 e^{-0.11174 * 11.06114}}{0!} = 0.29055$$

As shown previously, the probability of one or more collisions is 1 minus the probability of zero collisions. With $P(0)$ estimated at 0.29055, or a 29.1 percent probability of zero collisions over an exposure of 11.06114 billion ton-hours, the conditional probability of one or more collisions given a significant spill over an exposure of 11.061 billion ton-hours in the Texas inland waterway system is:

$P(C \mid S) = 1 - 0.29055 = 0.70945$, or 70.9 percent.

This probability was then adjusted for the overall study reach exposure by multiplying the probability calculated above by the ratio of the study reach exposure to the entire Texas GIWW exposure:

overall study reach $P(C \mid S) = 0.70945 * (0.12839 / 11.06114) = 0.00823$

The above probability was finally adjusted for the study reach exposure to the worst case commodities by multiplying the overall study reach $P(C \mid S)$ by the ratio of the study reach exposure to worst case commodities to the overall study reach exposure:

study reach worst case commodities $P(C \mid S) = 0.00823 * (0.02076 / 0.12839) =$

$= \underline{0.00133}$

Finally, the probability of the worst case spill is estimated by

$P(C \cap S) = P(S) * P(C \mid S) = 0.00172 * 0.00133 = \underline{0.0000022876}$,

or 0.00023 percent, over an exposure to crude petroleum, residual fuel oil, or lubricating oils of 20,764,677 ton-hours in the study reach. Expressed as an odds ratio, this probability of the

worst case spill is equivalent to a 1 in 437,139 chance of one or more worst case spills over an exposure to crude oil, residual fuel oil, and lubricating oils of 20,764,677 ton-hours in the study reach.

Given the fact that the whooping cranes are in residence at the refuge from October through April (seven months of the year), the worst case spill probability must be adjusted once more by multiplying the probabilities determined above by 7/12:

$$P(C \cap S) = 0.0000022876 * 7/12 = \underline{\underline{0.0000013344}},$$

or 0.00013344 percent, over an exposure to crude petroleum, residual fuel oil, or lubricating oils of 12,112,728 ton-hours. The exposure to 20,764,677 ton-hours of these commodities is also reduced by 7/12 to the total of 12,112,728 ton-hours since the whooping cranes are only in residence for 7/12 of the year. Expressed as an odds ratio, this probability of the worst case spill is equivalent to a 1 in 749,400 chance of one or more worst case spills over an exposure to worst case commodities of 12,112,677 ton-hours in the study reach.

The mean spill occurrence estimate ("spill frequency") for the worst case spill is obtained by multiplying λ, the spill rate constant, by the projected ton-hours (t) of crude, residual fuel oil, and lubricating oil for the study reach. As shown above, $\lambda = 0.11174$, and the projected volume t of ton-hours exposure to crude, residual fuel oil, and lubricating oil was obtained by assuming the projected increase of 23.6 percent for GIWW traffic applies to shipments of crude, residual fuel oil, and lubricating oil, giving

$$t = 0.02076 * 1.236 * (7/12) = 0.01497 \text{ billion ton-hours}$$

of traffic through the study reach for crude, residual fuel oil, and lubricating oil for the seven months the whooping cranes are in residence. The mean worst case spill occurrence rate is therefore:

$$\text{mean worst case spill occurrence rate} = \lambda * t = 0.11174 * 0.01497 =$$
$$= \underline{0.00167 \text{ spills per billion ton-hours}}$$

or 1 spill per 597.82 billion ton-hours of crude, residual fuel oil, and lubricating oil transported through the study reach. Assuming traffic volume per seven months of whooping crane residence at ANWR remained at 1989 levels (128,393,996 ton-hours per year or 74,896,498 ton-hours per seven months of cranes in residence at ANWR), the mean worst case spill occurrence for the study reach is 1 worst case spill per 7,982 years.

XII. SIMULATION OF SPILL EFFECTS IN SELECTED POTENTIAL SPILL LOCATIONS

The worst case spill event in the vicinity of the ANWR is a head-on collision involving a barge loaded with crude oil, petroleum residual, or lubricating oil. Although historical navigation data and analysis of local conditions indicate that the probability of such an accident on the GIWW in the vicinity of the ANWR is quite low, it is possible that nearly 1,500 barrels of floatable oils could be spilled.

When spilled on water, floatable crude and residual oils tend to spread on the water surface. In the relatively warm ANWR climate, layers of oil on water evaporate, weather, and photo-oxidize rapidly; and wave action and rainfall help disperse oil through the water column for particle absorption and precipitation and chemical and biochemical degradation. However, intense wave action also mixes oil and water forming a floating emulsion known as "mousse". Because mousse can contain as much as 75 percent water, it complicates mechanical removal by greatly increasing the volume of material that must be removed.

After an oil slick spreads and thins, it becomes more difficult to remove by skimming. A weir skimmer has an efficiency of about 50 percent in a thick layer of oil (25 millimeters or more), but recovery efficiency drops to about 10 percent in thin layers (1 to 8 millimeters). The key to minimizing damage from an oil spill is prompt containment in the smallest possible area using natural barriers if available and artificial barriers such as floating booms. Prompt collection and removal of trapped spillage is also quite important.

A spill of about 1,500 barrels of floatable oils tends to disperse rapidly in wind-swept open waters such as San Antonio Bay. If 1,500 barrels of oil from a point source are spread evenly in a mile-long, fan-shaped plume opening at 30^0 from a spill site, the layer thickness would be less than 0.34 millimeters (assuming no evaporation or dispersion losses). Winds (in this case blowing an oil film) tend to waver in direction. Wind roses for the area (see Figure 3) indicate prevailing wind direction is from the south southeast and southeast (directions which are only 22.5^0 apart), and winter winds are from the north and north northeast (again 22.5^0 apart). A 30^0 opening was selected for the hypothetical oil plume in an attempt to illustrate the probable effect of wavering wind direction on dispersal of spilled oil in the vicinity of ANWR.

Oil films less than 1 millimeter thick are difficult to capture and recover, but would tend to weather rapidly. Whooping crane critical habitat more than a mile downwind across open water from a spill site would not be in serious jeopardy, because much of the spilled oil that is

not captured by portable oil booms would be evaporated or dispersed before travelling a greater distance from the spill site. However, small amounts of "tar balls" or oily emulsion known as "mousse" formed as a result of wave action could perhaps deposit on downwind shores if not destroyed beforehand by natural forces. Therefore, human sentinels should be deployed to haze whooping cranes away from any habitat shallows or shores in jeopardy downwind of the spill site.

Weather and tidal currents influence the speed at which spilled oils are dispersed in the environment or transported to critical habitat that is susceptible to damage by floatable oils. The prevailing winds from the southeast and south-southeast at the ANWR tend to keep tidal water levels high, so that tidal flats are usually covered with water up to the edges of low marshes. During these prevailing winds, uncontained floating pollutants such as oil would tend to be blown northwestwardly toward marsh banks or bank erosion barriers. If not trapped and/or deposited promptly, fugitive oils could be blown into unprotected openings leading to tidal ponds in the low marshes that are a favored habitat for whooping cranes.

When winds at ANWR shift to strong northerly, which is not a rare event in wintertime, they tend to push waters out of the local embayments, and tidal water levels drop. Edges of the GIWW and tidal flats incised by the channel may be exposed, and currents within the channel would tend to be southwestwardly toward Aransas Pass. Floating pollutants such as oils would be blown to the southeast side of the channel. If not trapped, deposited on adjacent mud flats, dissipated, or otherwise removed, they would migrate southwestwardly and eventually blow southward into bays through openings in the dredged material deposits on the southeast side of the GIWW.

There are many oyster beds located near the GIWW, especially near where the channel crosses San Antonio Bay. Exposed oysters could become coated with spilled floating oil, presenting a hazard to birdlife including wading birds if the oil coated oyster beds become re-submerged before cleanup. Petroleum base oils do not kill the oysters unless the oysters become smothered, but oil definitely does not improve the taste of oysters.

During prevailing southeasterly winds and associated high tides, oyster beds are not exposed and in no jeopardy from spilled floatable oils. On northerly winds with low tide, parts of some oyster beds may be exposed and subject to coating by floatable oils. In that unfortunate event, oil coated oysters would need to be cleaned by water jet or other means, using the same techniques used for coated rock jetties or natural rock deposits.

Winds from the southwest and calm (unmeasurable) winds are also experienced in the area. If winds from the southwest are experienced infrequently and for brief periods incidental to an oil spill in the GIWW, the threat to sensitive tidal ponds in the low marshes would not be as great as from the brisk prevailing winds from the southeast. Similarly, the spill damage potential on tidal flat areas south of the navigation channel could be a serious problem during low-tide conditions.

In all wind and tide situations, prompt containment by portable booms and removal by skimming and/or absorption of spilled oil is obviously an essential element in damage control. Spill control and pollution abatement procedures would be the same during "northers" as during the predominating "southeasters." However, strong northers are infrequent, and during a norther, the danger of oil blowing into tidal ponds and low marsh is minimal. Unfortunately, southeasters present the greatest risk of habitat damage, and these are the predominating winds.

Other weather conditions such as temperature and rainfall are a consideration in spill damage assessment. Freshly spilled crude oil, for example, is more acutely toxic than oil that has been in the water (weathered) for a number of days because the more toxic volatile constituents, such as benzene and toluene, quickly evaporate and dissolve. Microbes in water and soils also aid in destroying oils dispersed in the environment. Warm temperatures speed up evaporation and microbial decomposition, and rainfall may dissipate and mix floating oil constituents into the water column. Although these factors are important in long-term remediation, the major emphasis in the ANWR area should be immediate containment and removal of oils before "weathering" comes into play.

Fortunately, the worst case spill involves no more than 1,500 barrels, not all of which would be deposited on sensitive habitat. However, spillage in certain critical locations with prevailing southeasterly winds could cause oil deposits on marsh banks and emergent vegetation in flooded mud flats. The oil and heavily tainted soils and vegetation would have to be removed, and additional habitat damage would occur from the movement of workers and equipment to these difficult-to-access locations. Damage incurred on northerly winds with associated low-tide conditions would be limited to oil deposits on exposed mud flats and reefs adjacent to the navigation channel. Oil-contaminated soils should be readily accessible from the edge of the navigation channel and could be mechanically removed, if necessary, for disposal in compliance with Federal and State regulations.

Locations Within the Study Area Selected for Spill Effect Analysis

Representative potential spill locations where the most damage to the whooping crane or its habitat would occur were selected in consultation with U.S. Fish and Wildlife Service (USFWS) personnel, ANWR biologists, and Corps personnel. Criteria used in the evaluation of potential spill sites included terrain features and known or potential navigation hazards.

Four sites were selected for spill effects modelling: mile 492 of the GIWW at its intersection with the Victoria Barge Canal near Welder Flats; mile 499 of the GIWW in San Antonio Bay near Mustang Lake and False Live Oak Point; mile 507 of the GIWW in the ANWR near Wynne's Cut (across from Sundown Bay); and mile 515 of the GIWW near Long Reef in Aransas Bay.

The first site was selected because of the habitat areas in Welder Flats alongside the GIWW and the Victoria Barge Canal and the barge tow cross-traffic at the intersection of the GIWW and the Victoria Barge Canal. The second site was selected because of the open water of San Antonio Bay and the habitat areas on the shore of the Bay along the eastern side of the ANWR (near Mustang Lake, Live Oak Point, etc.). The third site was chosen because of the high density of the crane population and the commercial and private fishing boat traffic on a private channel that intersects the GIWW in the area of Wynne's Cut. The choice of the fourth site was based on the proximity of the area to habitat around Dunham Bay and the navigation hazard posed by Long Reef.

At each of the four sites selected for study, the effect of spilling up to 1,500 barrels of floatable petroleum base oil (a "worst case" spill) is modeled to aid in assessing the potential effect on whooping cranes and critical habitat. Because wind is the predominant driving force for transporting floatable oil from a spill site in the GIWW toward any critical habitat in the vicinity, the model studies illustrate the direction spilled oil would migrate when prevailing wind from the southeast are blowing, and also when the second most likely wind conditions occur ("northers"). The four locations selected do not represent the absolute instantaneous worst possible locations for spill occurrence because the whooping crane territories cover wide areas and these territories can shift location from year-to-year. However, the modeling technique can be used to illustrate spill effects at any location or weather condition selected for analysis. The analysis for the four locations does encompass the range of possible "worst case" situations from a spill in the ANWR reach of the GIWW close to a known area of consistently high whooping crane use (Wynne's Cut

site) to a spill in an open bay near a large area of critical whooping crane habitat (San Antonio Bay site).

Intersection of the GIWW and Victoria Barge Canal Near Welder Flats

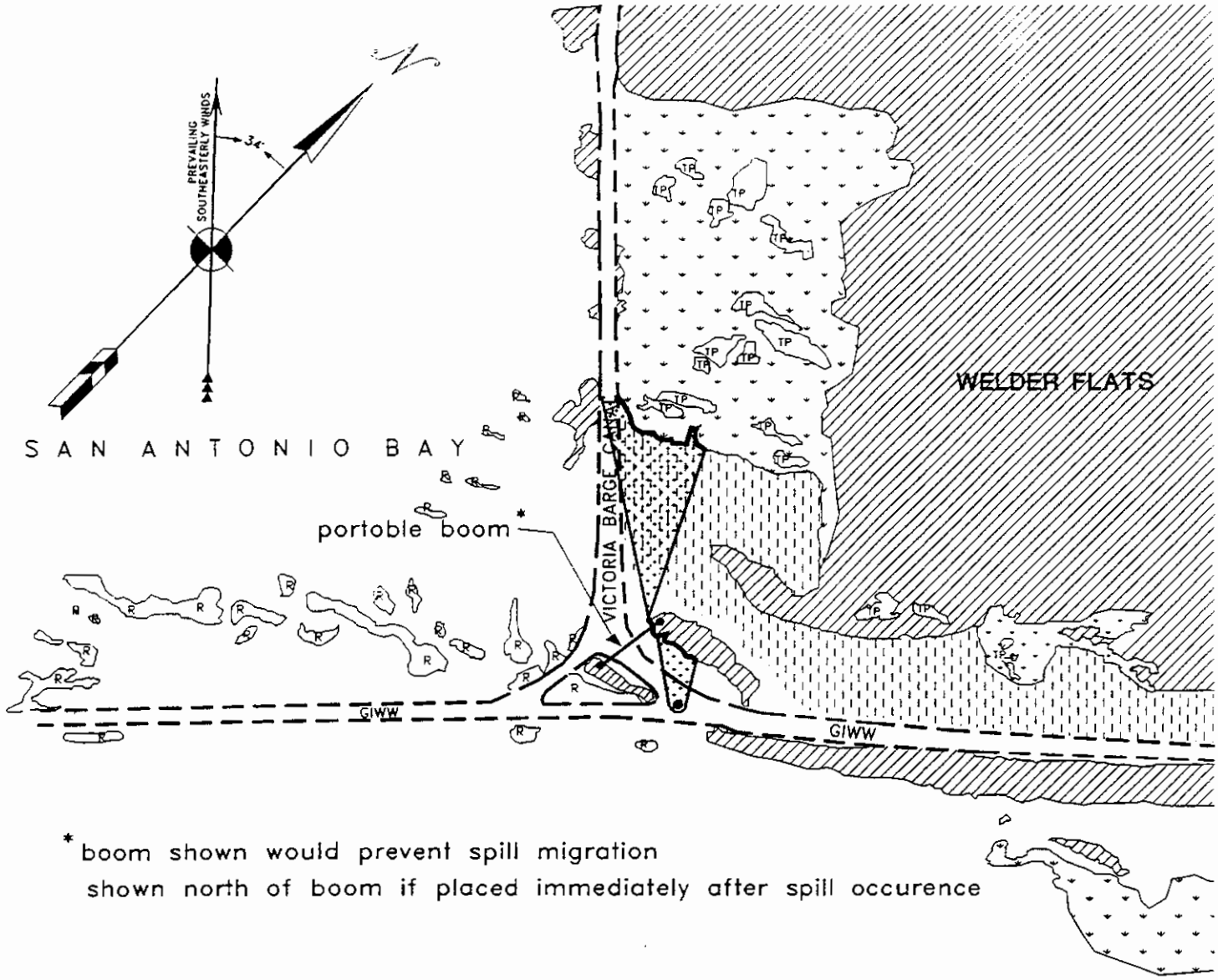
The expected downwind migration routes of floatable oils from a barge collision at Welder Flats are shown in Figures 11 and 12. During prevailing southeasterly winds, the marshy banks of a dredged materials island immediately north of the Victoria Barge Canal-GIWW intersection would almost certainly receive the brunt of the spilled oil shown in Figure 11. If booms could be set up promptly to keep oil from being blown around the western tip of the island, the spillage could be contained and very little habitat damage would result. If not contained south of the island, the oils would endanger about 23 acres of submerged vegetation and a half-mile of natural marsh banks about 2,000 feet northwest of the collision site. Further damage could be avoided by placing a portable boom across the Victoria Barge Canal to block migration. Fortunately, the potentially damaged areas are accessible from the Victoria Barge Canal.

If the worst case scenario were to occur 1,000 feet or more to the northeast, much more submerged vegetation would be in jeopardy, more marsh bank could be damaged, and access to damaged habitat for cleanup would be more difficult. If the accident occurred 1,000 feet or more to the southeast, prevailing southeast winds would blow uncontained oils into open waters, away from critical habitat.

If the worst case accident occurs during a norther, the uncontained oils would be blown into the open waters of San Antonio Bay south of the collision site as shown in Figure 12.

GIWW in San Antonio Bay Northeast of Mustang Lake

A worst case spill occurring on the GIWW in San Antonio Bay northeast of Mustang Lake would be difficult to contain because of the wave heights encountered in open waters on prevailing or northerly winds. However, the plume would spread over open waters on both prevailing and northerly winds, as indicated in Figures 13 and 14. The nearest habitat areas in jeopardy would be the marshes at Webb Point to the northeast and at Ayers Point to the south. These features are four or more miles distant from the site, and damage at these locations, if any, would be minor. However, proper spill response effort should include placing human sentinels at



* boom shown would prevent spill migration
shown north of boom if placed immediately after spill occurence

MAP

OIL DISPERSION PLUMES
GIWW AT WELDER FLATS
PREVAILING WINDS

SCALE 1:24,000
0 0.5 1 MILE

LEGEND
Uplands
Marsh
Submerged Veget
Spilled Oil
Reef
Tidal Pond

Figure 11. Oil Dispersion Plume, GIWW at Welder Flats, Prevailing Winds

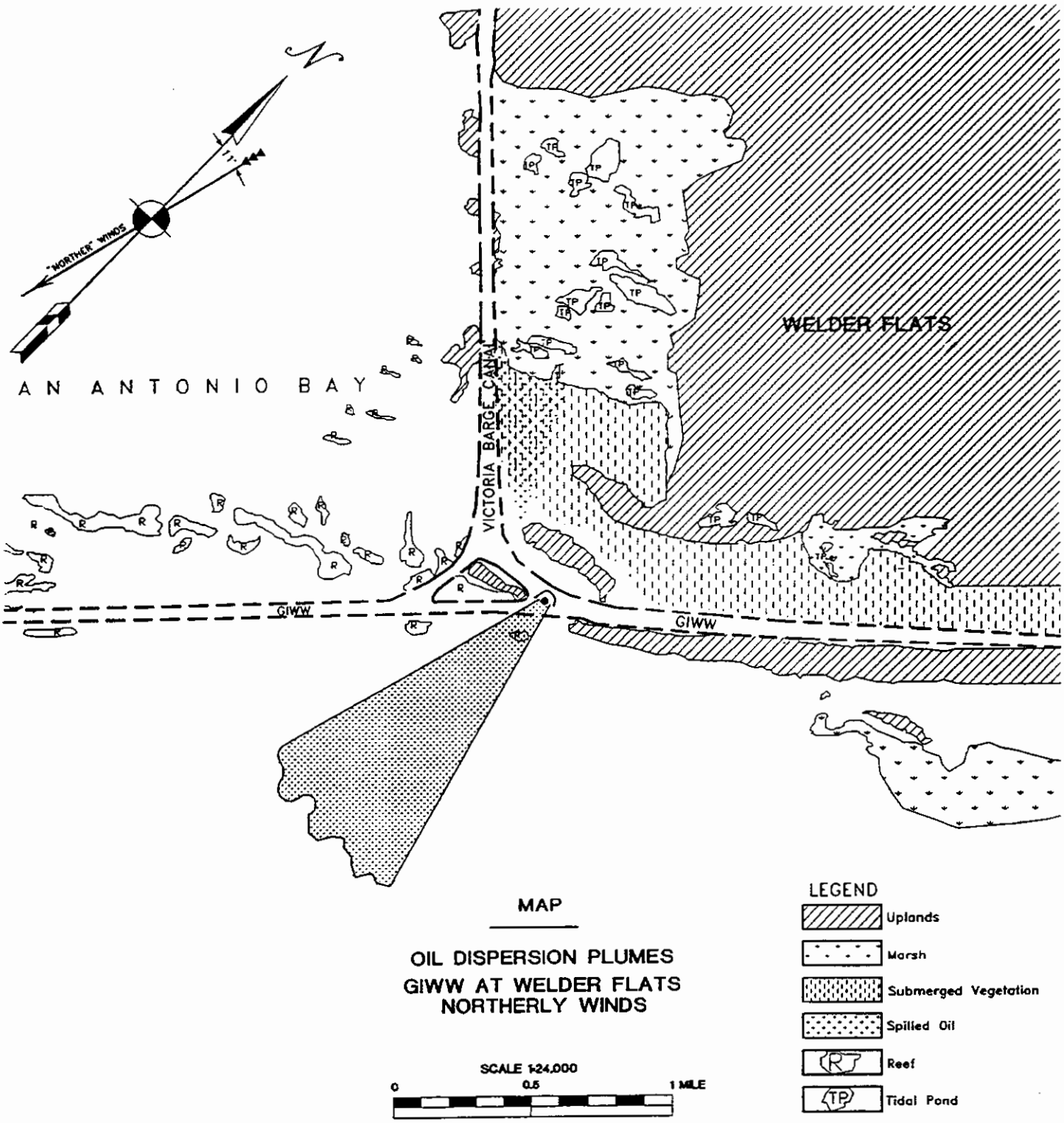
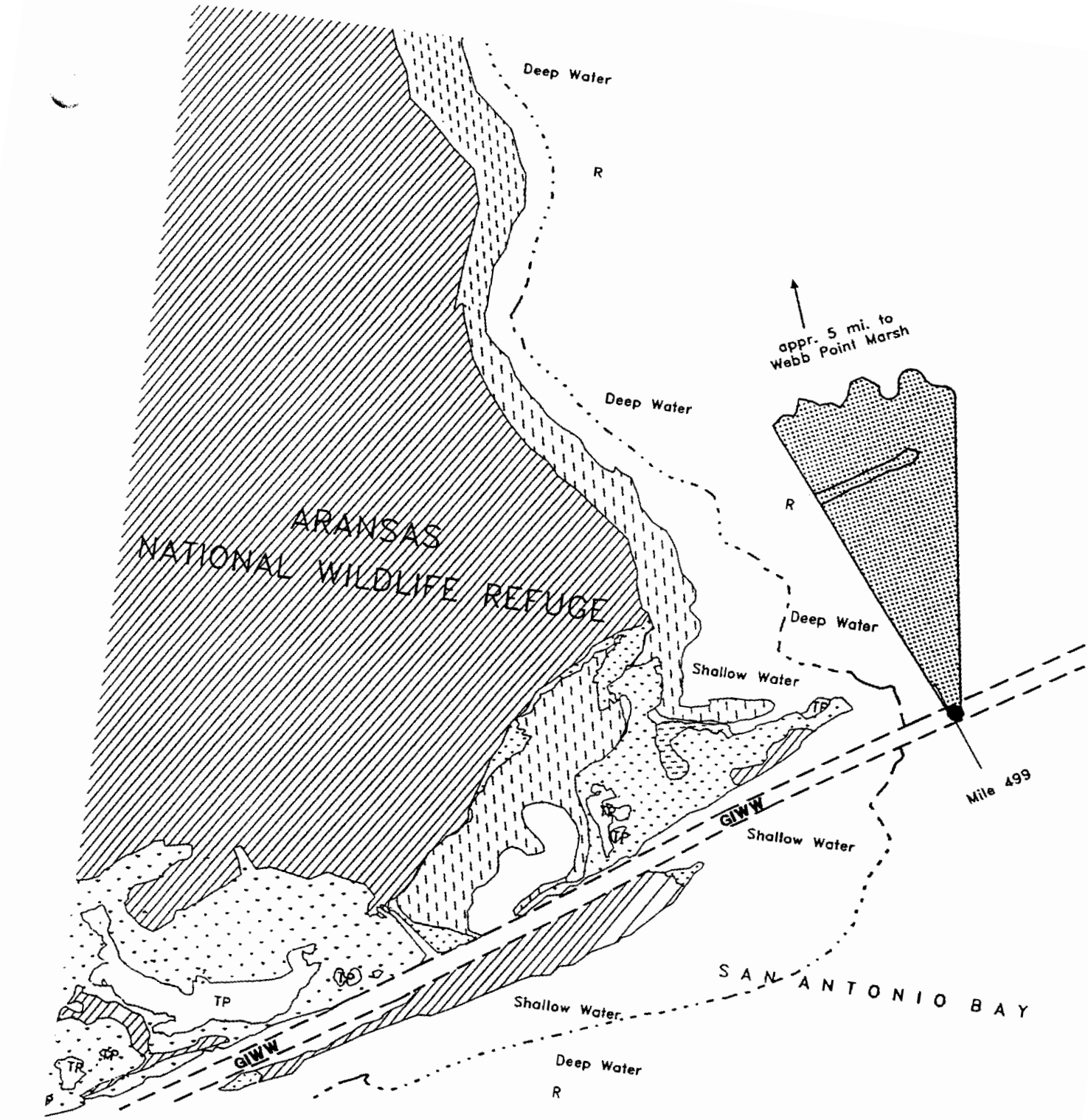


Figure 12. Oil Dispersion Plume, GIWW at Welder Flats, Northerly Winds



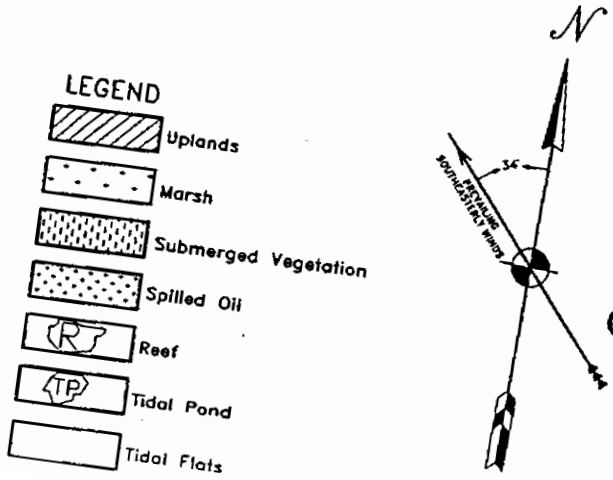


Figure 13.

MAP

OIL DISPERSION PLUMES
GIWW NORTHEAST OF MUSTANG LAKE
PREVAILING WINDS

SCALE 1:24,000
0 0.5 1 MILE

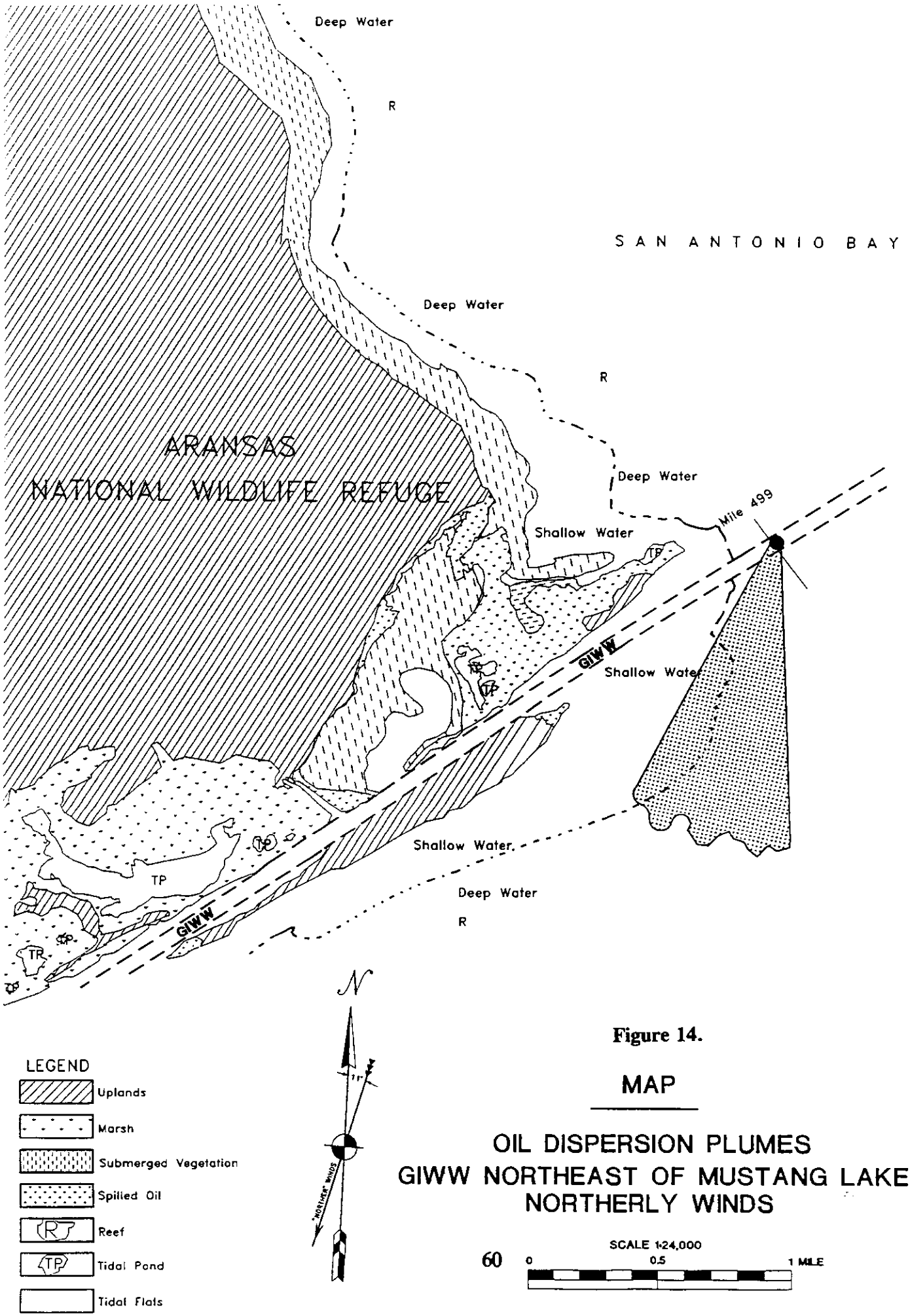


Figure 14.

MAP

OIL DISPERSION PLUMES
GIWW NORTHEAST OF MUSTANG LAKE
NORTHERLY WINDS

these locations to monitor for presence of tar balls or mousse until the threat ceases and to haze whooping cranes away from polluted or endangered shallows and shores.

If the spill were to occur more to the southwest near False Live Oak Point, some marsh immediately north of the channel could be damaged on prevailing winds, and uncontained oils would be blown around the northeast tip of a marshy peninsula and escape into open waters in the direction of Webb Point. Nevertheless, it would be easier to boom and contain a spill in more protected waters.

GIWW Near Wynne's Cut Area Across From Sundown Bay

A worst case spill occurring at Wynne's Cut on prevailing winds with high tides could result in some habitat damage even if containment booms were installed rapidly. Prevailing winds would blow oils directly toward submerged vegetation and marsh banks along the northwest shore of Sundown Bay as shown in Figure 15. Travel distance to the nearest marsh banks is less than a half-mile. Uncontained oil could then spread slowly along the shoreline of Sundown Bay, in both directions perpendicular to the winds. It would be necessary to block littoral migration by placing portable booms anchored on shore and extending perpendicular to the shore out into Sundown Bay. Jon boats may be needed for access across this shallow bay.

Although there is a cut in the marshes leading to tidal ponds about a mile northeast of the site, it is unlikely that fugitive oil would move that far before the spill could be contained by portable booms. Nevertheless, floating booms would need to be used to block oil ingress through this cut as soon as possible to prevent even more serious habitat damage. If the oil could not be contained near the spill site, booms could be placed perpendicular to the Sundown Bay shoreline to minimize the area damaged. About 10 acres of submerged vegetation and about a mile of marsh banks could be damaged, some quite severely. If whooping cranes were feeding in the area and were not deliberately and continually frightened away, they could be exposed to a fatal oil coating.

The consequences of a spill on strong northerly winds would not be as severe as shown in Figure 16. Uncontained oil could coat easily accessible banks along the bay side of the navigation channel and the west side of Wynne's Cut. Spilled oil could be easily contained by booming perpendicular to the channel bayside banks and across Wynne's Cut. If oil escapes before booms can be placed, most of the fugitive oil would be pushed out of Wynne's Cut and into open waters by the northerly winds and falling tide currents.

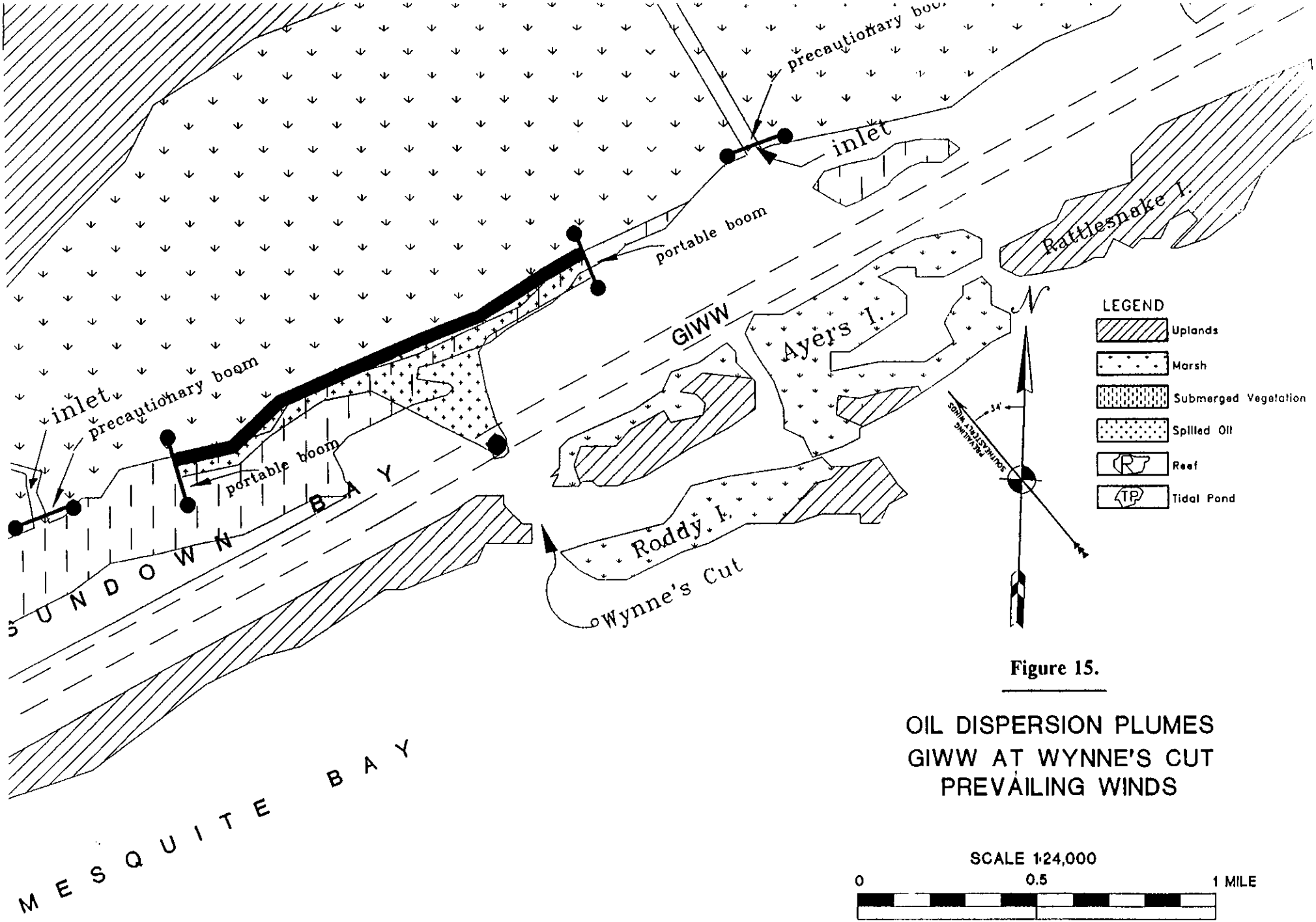


Figure 15.

OIL DISPERSION PLUMES
GIWW AT WYNNE'S CUT
PREVAILING WINDS

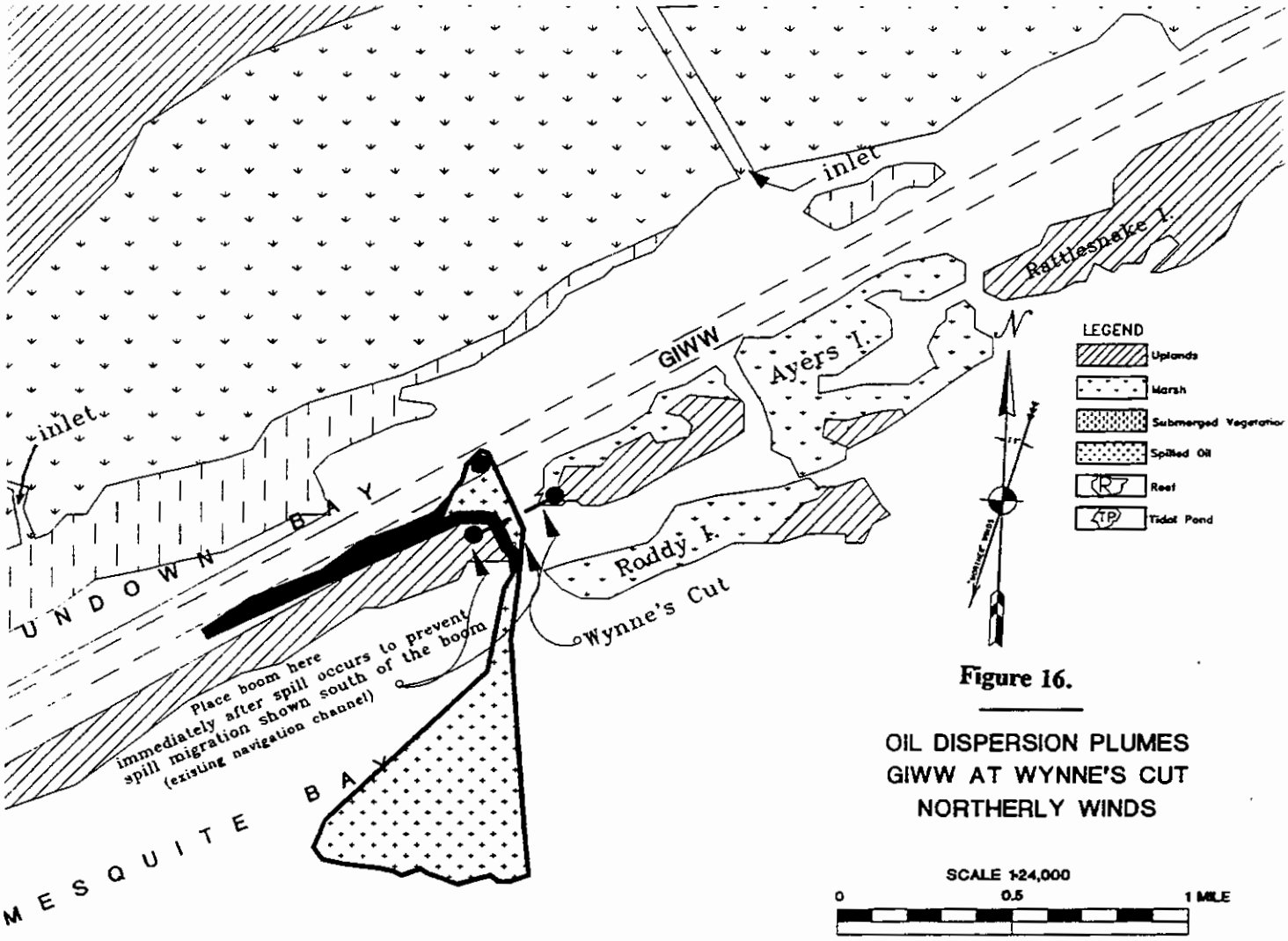


Figure 16.

OIL DISPERSION PLUMES
GIWW AT WYNNE'S CUT
NORTHERLY WINDS

GIWW in Aransas Bay Near Mile 515

A worst case spill in Aransas Bay near mile 515 would be difficult to contain because of high waves normally encountered with prevailing winds from the southeast. These winds would blow spilled oil into open waters toward Goose Island (over three miles away), and the marsh and tidal flats at Blackjack Point (2.4 miles downwind) would be in jeopardy (tar balls, mousse, etc.). The situation is illustrated in Figure 17.

In this situation, crane habitat would not be seriously damaged. If the spill occurred closer to Blackjack Peninsula, more of the marsh banks and tidal flats would be damaged, and the damage would be greater because the shoreline would be closer to the spill site. If the accident happens further to the southeast beyond Long Reef, crane habitat would not be endangered.

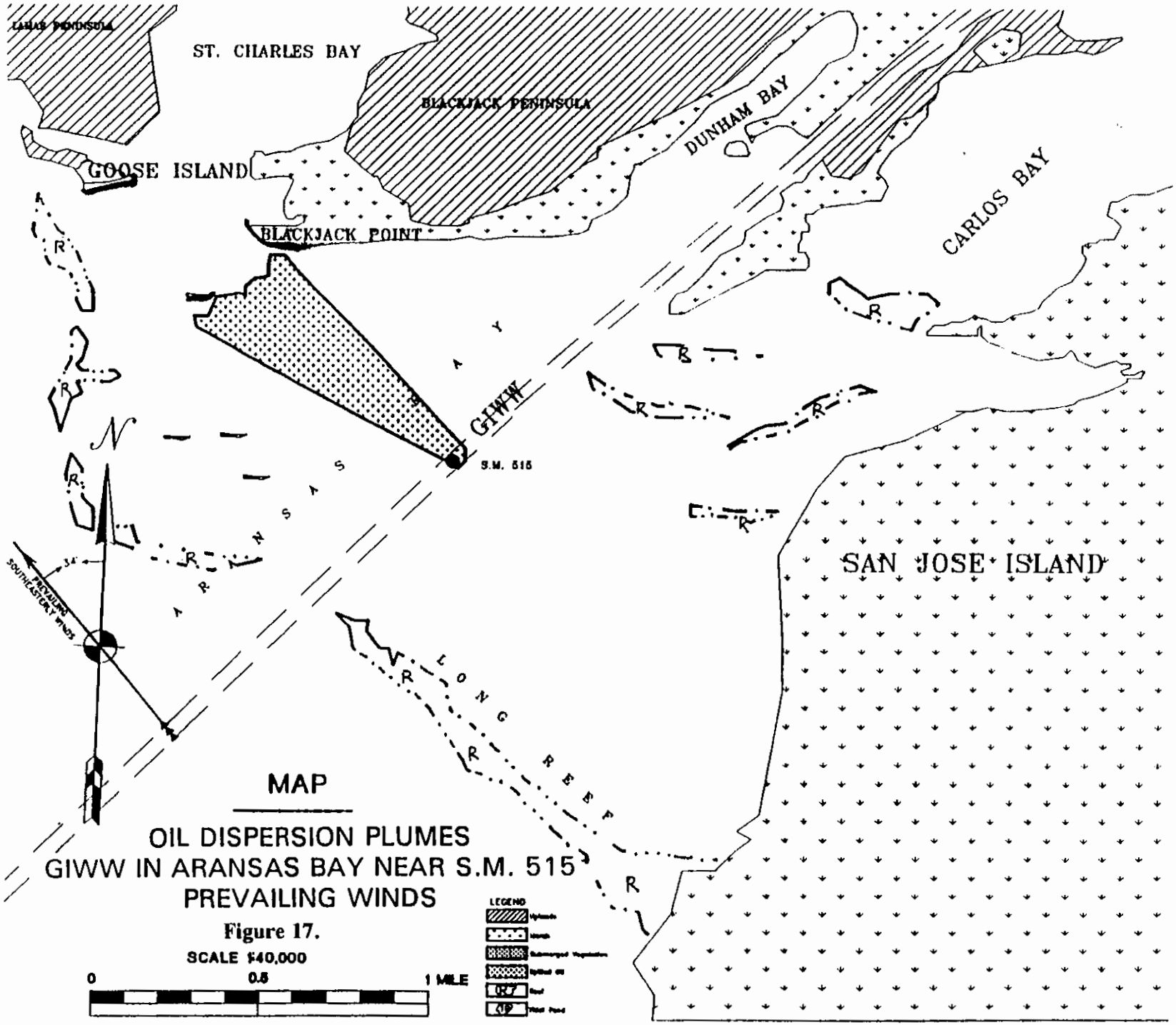
A spill occurring at mile 515 on a norther would probably cause problems at Long Reef, about two miles south of mile marker 515. Tide levels are ordinarily low during a norther, and the reef would act as a trap for undispersed oils. The reef banks downwind of the spill could be fouled. Although the area is accessible and would be easy to clean, some damage to crane habitat could occur. This situation is shown in Figure 18.

XIII. EROSION AND SPILL EFFECTS MITIGATION PLANS

The GIWW channel through the ANWR is bounded by marshland, tidal flats, and other valuable whooping crane habitat. The marshland is subject to erosion from wind and wave action generated by natural prevailing winds and navigation traffic in the GIWW.

Concern has been expressed about several aspects of GIWW usage. One concern is the erosion and subsequent loss of valuable habitat. Another concern is the potential spillage of persistent, floatable petroleum-based oils that could occur through a navigation accident on the GIWW, possibly endangering cranes in the event of direct contact or habitat contamination.

Prevention of habitat damage from spillage and control of erosion along the GIWW from San Antonio Bay to Aransas Bay would require construction of an unbroken structural barrier along the landward side of the GIWW. The bayside or gulfside shores beside the GIWW would require intermittent protection at areas of vital habitat, particularly those defined by the USFWS. However, these structural measures could cause other undetermined effects on habitat. The areas with the highest erosion rate were identified by USFWS personnel and are shown in Figure 19.

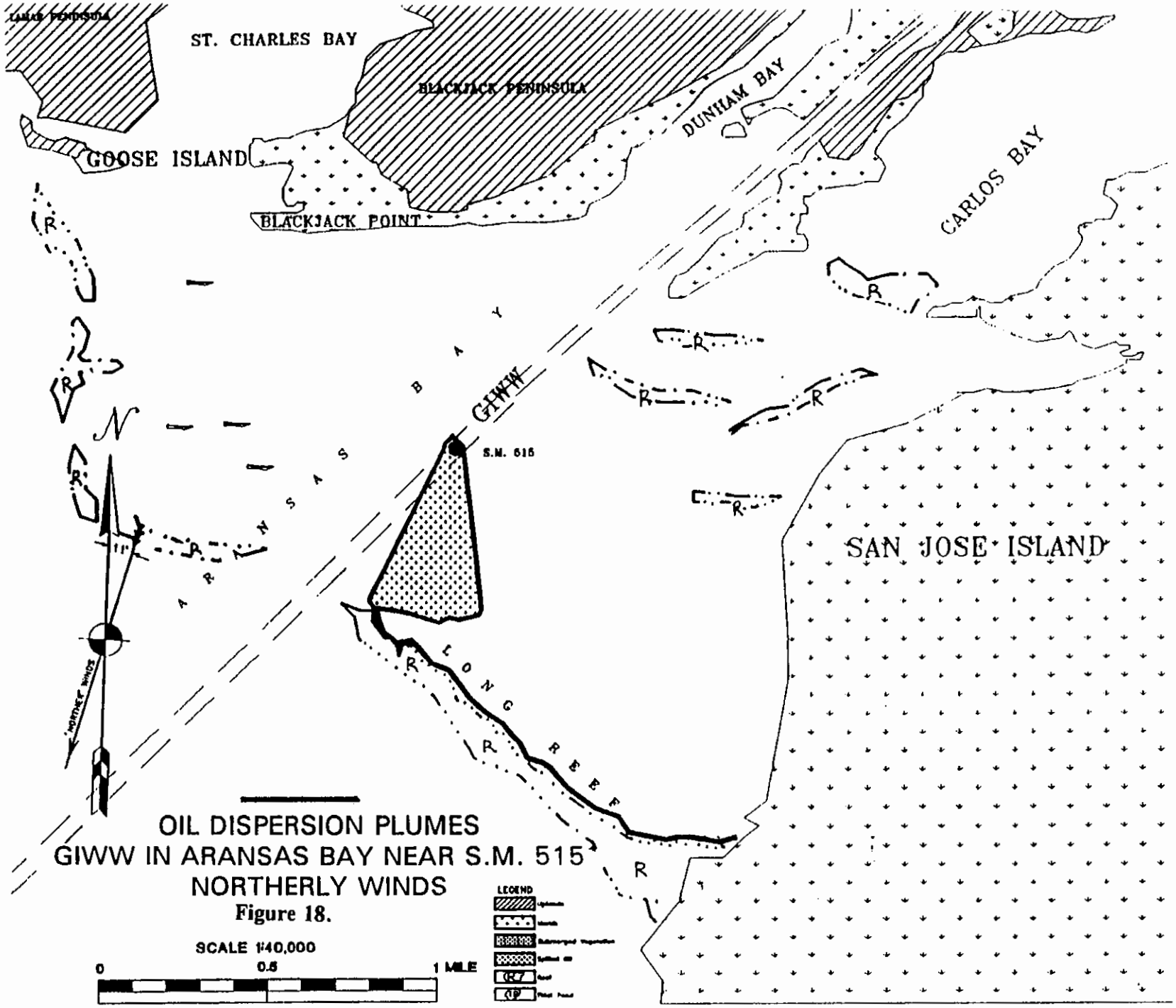


MAP

OIL DISPERSION PLUMES
GIWW IN ARANSAS BAY NEAR S.M. 515
PREVAILING WINDS

Figure 17.

SCALE 1:40,000



OIL DISPERSION PLUMES
GIWW IN ARANSAS BAY NEAR S.M. 515
NORTHERLY WINDS
Figure 18.

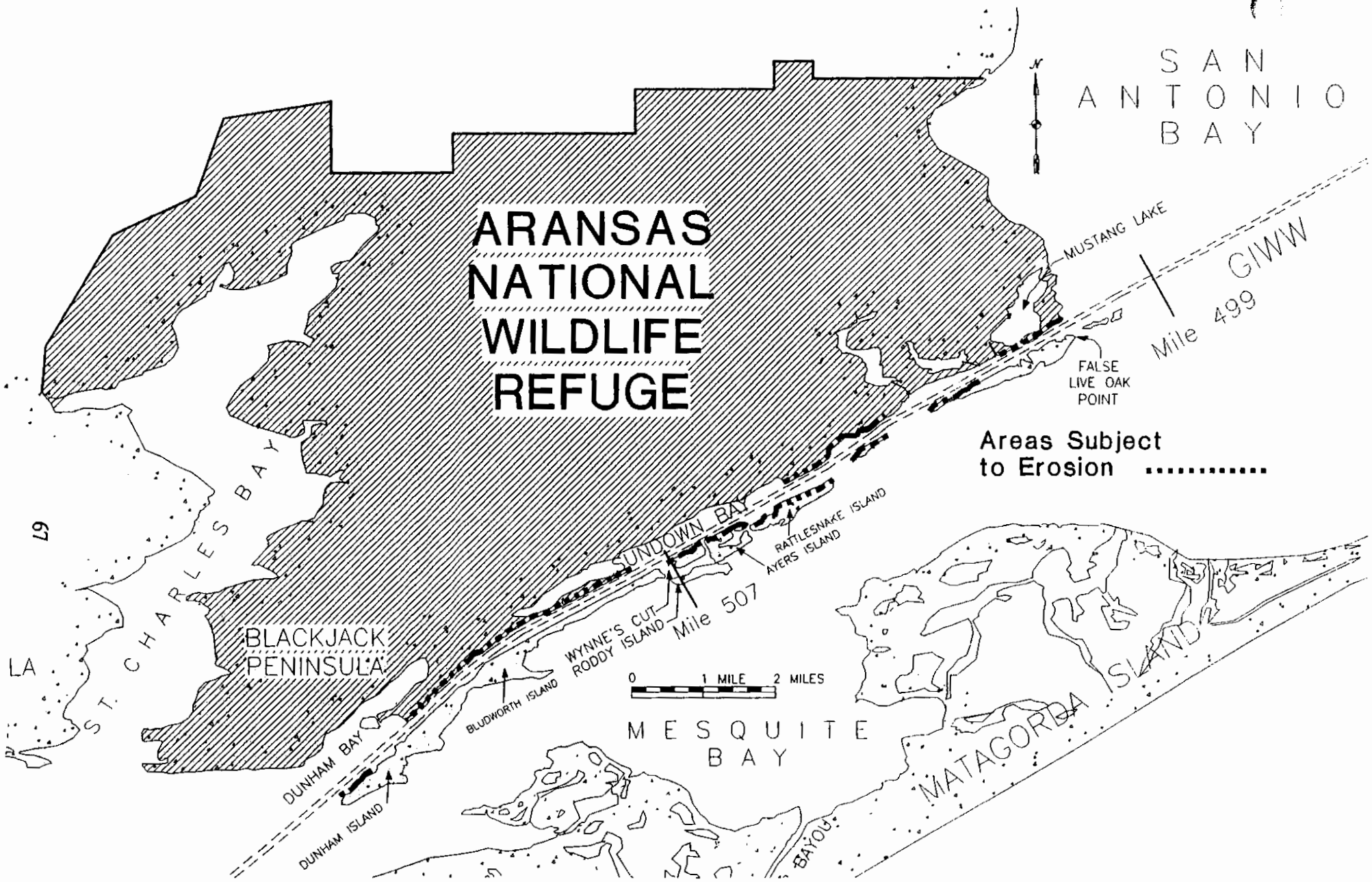


Figure 19. Main Erosion Areas, as Identified by USFWS Personnel

Nonstructural measures to reduce the risk of spills and erosion damage have the capacity to reduce the risk of spills but not to eliminate damages. Observations at the site indicate that the slow-moving barge tows in the GIWW produce very little wake. The faster commercial fishing and private motorcraft produce larger wakes and could be a significant factor in the erosion problem.

Existing Contingency Plans

The Oil Pollution Act of 1990 (enacted by Public Law 101-380, August 18, 1990) mandates that companies shipping and receiving oil in U.S. waters must have a U.S. Coast Guard-approved oil spill response plan by February 18, 1993. Oil shippers will not be allowed to operate through U.S. coastal waters to U.S. terminals without such plans. The response plan must identify private resources for responding to a catastrophic oil spill. The roles of the various public agencies and private entities are changing as the national, state, and regional response plans are being reshaped after OPA '90.

A partnership of Federal government, states, local government, and industry comprises a network of individual contingency plans that describe the roles, responsibilities, requirements, and capabilities of different levels of government and industry. The National Contingency Plan [a Federal regulation administered by the Environmental Protection Agency (EPA) under 40 CFR Part 300] requires development of local contingency plans by Coast Guard districts in which On-Scene Coordinators (OSCs) are designated for specific maritime port areas and are located in those areas. EPA's inland OSCs are designated by region and are generally stationed at EPA regional offices. Predesignated OSCs make the initial determination of the need for Federal spill oversight and response. EPA OSCs often make this evaluation by telephoning the local or state officials at the scene. Coast Guard OSCs make some level of response to virtually every spill reported, and the EPA OSCs provide technical assistance in the development of contingency plans. State oil spill contingency plans are developed under individual state authority and are not required by the NCP (National Contingency Plan). Appendix C contains a directory of contacts at various agencies and response organizations.

The Texas Water Commission (TWC) was designated by the Governor of Texas, in accordance with the provisions of the National Oil and Hazardous Substances Pollution Contingency Plan, as the agency to supervise state-authorized pollution removal operations. TWC was designated the state governmental agency to request reimbursement for pollution

cleanup expenses for the reasonable costs incurred from the 311(k) revolving fund administered by the U.S. Coast Guard pursuant to 33 CFR Part 153. In all cases, Texas requires that reports of discharges or spills be made to the Texas Emergency Response Center, or through the TWC. The TWC is required to inform its District Offices and other concerned state and Federal agencies as appropriate for minor spills and will make immediate telephone contact with the EPA, Region VI, and/or the appropriate U.S. Coast Guard Captain of the Port for all spills or releases within the U.S. Coast Guard's pre-designated OSC's area of responsibility.

Subsequent to the enactment of the 1990 Oil Pollution Act, the Legislature of Texas amended Subtitle C, Title II, Natural Resources Code by adding Chapter 40, the "Oil Spill Prevention and Response Act of 1991". This Act designated the Texas General Land Office (GLO) as the lead state agency for the prevention of and response to actual or threatened unauthorized discharges of oil. The GLO was authorized to contract with any public agency or private entity to enforce and administer the Act. The Act also created the Coastal Protection Fund, which is financed through a fee on crude oil transferred at marine terminals. The fund is used for administrative costs, acquiring state response equipment, operating regional response centers, and paying response costs and third-party and natural resource damages. The GLO will work in cooperation with the TWC, and nothing in the Act precludes the TWC from assuming response and cleanup duties in situations involving predominantly a hazardous substance discharge, pursuant to Subchapter G, Chapter 26, of the Water Code, and the state coastal discharge contingency plan.

The GLO is directed under the Act to promulgate a state coastal discharge contingency plan of response for actual or threatened unauthorized discharges of oil and cleanup of pollution from such discharges. The TWC will develop provisions of the plan relating to unauthorized discharges of hazardous substances, and the Texas Parks and Wildlife Department (TPWD) will develop provisions of the plan relating to rescue and rehabilitation of aquatic life and wildlife and the habitats on which they depend.

Contributions from the oil and maritime transport industries (in addition to tax revenues provided by the Texas OSPRA '91) have been procured through the efforts of the GLO and are being used to purchase spill response equipment. Budget allocation decisions are still being considered, and placement of on-site spill response equipment is being coordinated with other public and private agencies. The statewide response plan being developed by the GLO is currently in the initial development phase and will not be available until early 1993. The

function of the GLO in terms of spill response in the short run is to fill the gaps in Texas' spill response left by the Coast Guard and the Marine Spill Response Corporation and to analyze and develop new response procedures. Another function of the GLO is to evaluate private spill response firms and issue permits to and certify qualified spill responders.

TPWD's role in oil spill response and recovery is as the state natural resource trustee under state and Federal laws. The department investigates any pollution and can bring charges against any responsible party for damages to state biological resources. TPWD is in the process of updating its response notification plan. It has started purchasing spill response equipment (booms, etc.) and has begun arrangements with landowners around Welder Flats to pre-position storage containers with pre-measured booms and to locate numbered posts as part of the Welder Flats Spill Contingency Plan. Another initiative under the Welder Flats plan is to develop a local response team comprised of local contacts from industry personnel from plants located along the Victoria Barge Canal. These companies represent a source of experts and personnel trained in spill response and safety that could be quickly recruited during an emergency situation. The Environmental Contaminants Branch staff has received spill response training, and Law Enforcement (Wardens) have personal protection and the safety training to evaluate safety hazards of a spill situation. Additional staff and more specific training are anticipated as response capabilities are achieved.

The Corpus Christi Marine Safety Office of the U.S. Coast Guard developed the Texas Oil and Hazardous Substance Local Contingency Plan in compliance with the Federal Water Pollution Control Act (FWPCA) of 1972, as amended by the Clean Water Act (CWA) of 1977 (33 U.S.C. 1321), the Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA) (46 U.S.C. 4605), and the National Contingency Plan (40 CFR 300), which provides for the development, revision, and implementation, as necessary, of plans for areas over which the U.S. Coast Guard has the responsibility to furnish or provide the On Scene Coordinator during oil or hazardous substance spill emergencies. Discussions with the Coast Guard MSO revealed that the Local Contingency Plan will be replaced by the Port Area Committee report in early 1993. Changes to the plan are promulgated as amendments on a yearly basis following annual review, and the 1991 amendments to the existing plan (dated March 15, 1990) have been completed. These amendments consist of updated phone numbers and addresses for plan participants.

The USFWS is also developing a spill contingency plan focusing specifically on the ANWR area and the threat to the whooping crane. ANWR personnel have recorded the size and location of the small cuts between the bays and marsh areas on the refuge and the habitat areas on Matagorda Island in order to prepare for booming in the event of a spill in the GIWW (see Appendix D). Whooping crane behavior is also being analyzed to determine the best techniques for keeping the cranes away from spill sites. USFWS and TPWD personnel trained in the handling of these birds are the only people allowed by law to conduct hazing activities or to handle sick, injured, or contaminated whooping cranes. A Key Contact person (Dr. James Lewis, Whooping Crane Coordinator, (505) 766-2914 or FTS 474-2914) has been designated to advise authorized Federal and state personnel in the handling of whooping cranes. Before hazing is attempted, it is important to have an uncontaminated area the whooping cranes can be directed to. Also, whooping cranes are very fragile and have been observed to die from stress during handling. The Key Contact can provide advice in these matters. Shallow-draft boats should be used to patrol shorelines to keep the cranes away from spilled contaminants instead of airboats, because airboats would tend to flush cranes from the interior salt marsh back toward the contaminated habitat.

The Corpus Christi Area Oil Spill Control Association (CCAOSCA) is a participant in several current spill contingency plans. It is an industry-local government nonprofit cooperative that provides oil spill cleanup services primarily for the tidal waters of Aransas, Nueces, and San Patricio Counties behind the barrier islands; but its equipment and expertise are available elsewhere to its members, governmental agencies, or others who need oil spill cleanup services. When larger spills occur, equipment contractors, marine contractors, labor contractors, and others with whom the organization has working agreements are utilized to augment its own staff when the need arises. In all of the aforementioned situations, CCAOSCA provides direction of all oil spill cleanup work. CCAOSCA's office warehouse and maintenance shop are strategically located on the north side of the Corpus Christi Inner Harbor in the port area. Equipment includes a 28-foot twin inboard boat, 21-foot airboat, several outboard powered boats, a 40-foot lowboy semi-trailer, a 75-barrel vacuum truck, two pickup trucks, pumps, light plants, hoses, a 24-foot skimmer barge, and several other types of skimmers. CCAOSCA has approximately 7500 feet of containment boom, with two trailer-mounted boom reels containing 600 feet, ready for instant response when needed. CCAOSCA also maintains a large stock of manufactured sorbents. The Coast Guard's contingency plan (from the Corpus Christi Marine Safety Office)

presently incorporates CCAOSCA's services; but after the 1991 Texas OSPRA law, the membership (over 40 private companies are members of the CCAOSCA and provide funding for its activities) is revising the Association's charter and will decide on the new coverage area in order to apply for a permit to the GLO by June 15, 1992. The Association had a storage site in Rockport on land donated by the City of Rockport, but the City dedicated the land to other uses recently and the Association decided to close the Rockport facility. Currently, CCAOSCA serves the areas of Aransas, Nueces, and San Patricio counties, but has travelled as far away as the Colorado River. Response time to the ANWR area for CCAOSCA is currently (after closure of the Rockport facility) about two hours during weekdays, 8 a.m. to 5 p.m., and up to four hours otherwise.

Garner Environmental Services is another major factor in the spill cleanup business. Garner has offices in Houston, Texas City, and Port Arthur. It generally responds to spills in the area along the GIWW and its branches from the Colorado River to the Sabine River. Garner provides comprehensive control and cleanup of spills, with full supervision of the process and fast response. Garner's response time to the refuge would be approximately the same as CCAOSCA. Garner has an extensive stock of spill response equipment and could handle the situation at the refuge; but until the situation with CCAOSCA is resolved this summer, it is uncertain which company would respond to a spill in the refuge area.

The Marine Spill Response Corporation (MSRC) was created in August 1990 to succeed the Petroleum Industry Response Organization (PIRO). It will operate out of five regional response centers, the closest of which is in Lake Charles, Louisiana. Each of the centers will be supported by several strategically placed equipment sites. The Marine Preservation Association, an organization including oil companies and shippers and receivers of oil, will fund MSRC, but will have no control over operations. Each region will have four to six prestaging areas where equipment and sometimes vessels and personnel will be located. MSRC is intended to provide a best-effort response to major spills of persistent oil in U.S. coastal and tidal waters that are beyond the capacity of local response organizations. MSRC is in the initial stages of acquiring equipment and staffing the Lake Charles office and is planning on reaching fully operational status within 30 months of enactment of the comprehensive Oil Pollution Act of 1990. MSRC is not intended to replace existing oil spill cooperatives and independent response contractors such as CCAOSCA and Garner. MSRC will respond when this infrastructure does not have sufficient

resources to respond to a large spill. Some joint training of MSRC subcontractors will be paid for by MSRC.

Nonstructural Spill Contingency Plans

In addition to the proposed riprap dikes and revetments, several nonstructural plans for reducing the likelihood of spills and erosion were evaluated. These plans would require coordination between authorities because some aspects are outside the jurisdiction of the Corps of Engineers.

Slower operating speeds have been proposed to help reduce habitat erosion and the chances for navigation accidents and their severity. The Coast Guard has jurisdiction over navigation practices on the GIWW. Coast Guard regulations limit barge tow speeds to five mph when loaded and seven mph empty. Barge tows traversing the study area at these speeds were observed to produce a very small wake that does not appear to be a significant factor in habitat erosion. Crew boats, fishing boats, and private craft have been observed travelling through the study reach at speeds much faster than barge tows, producing wakes several times as high. To control vessel operating speeds in the study area, new Coast Guard speed limits would be needed, involving a rule-making procedure as well as additional funding for the increased Coast Guard personnel and equipment that would be needed for effective enforcement.

Another measure for reducing the risk of navigation accidents would be one-way traffic restrictions. This measure, which would also fall under the authority of the Coast Guard for implementation, would reduce the chances for collisions between vessels travelling in opposite directions. Risk reductions would occur in areas that are navigation hazards because of channel conditions (such as shoaling or sharp bends) or visual obstructions resulting from weather conditions, vegetation, or smoke from channel-side fires. Tow captains operating in the GIWW and Victoria Barge Canal have indicated that they maintain radio contact and receive advice from approaching operators about wind and weather conditions ahead. If the weather is unsafe or another tow would be crossing San Antonio Bay simultaneously from the opposite direction, tow captains usually moor on the side of the GIWW in places such as the dredged material disposal area (Barge Mooring Area) near the intersection of the Victoria Barge Canal and the GIWW.

Hazards that most concern operators regularly navigating the study area were identified through interviews with twelve tow captains and port captains from companies of various sizes in Houston, New Orleans, and Baton Rouge. Most of those interviewed had navigated the GIWW

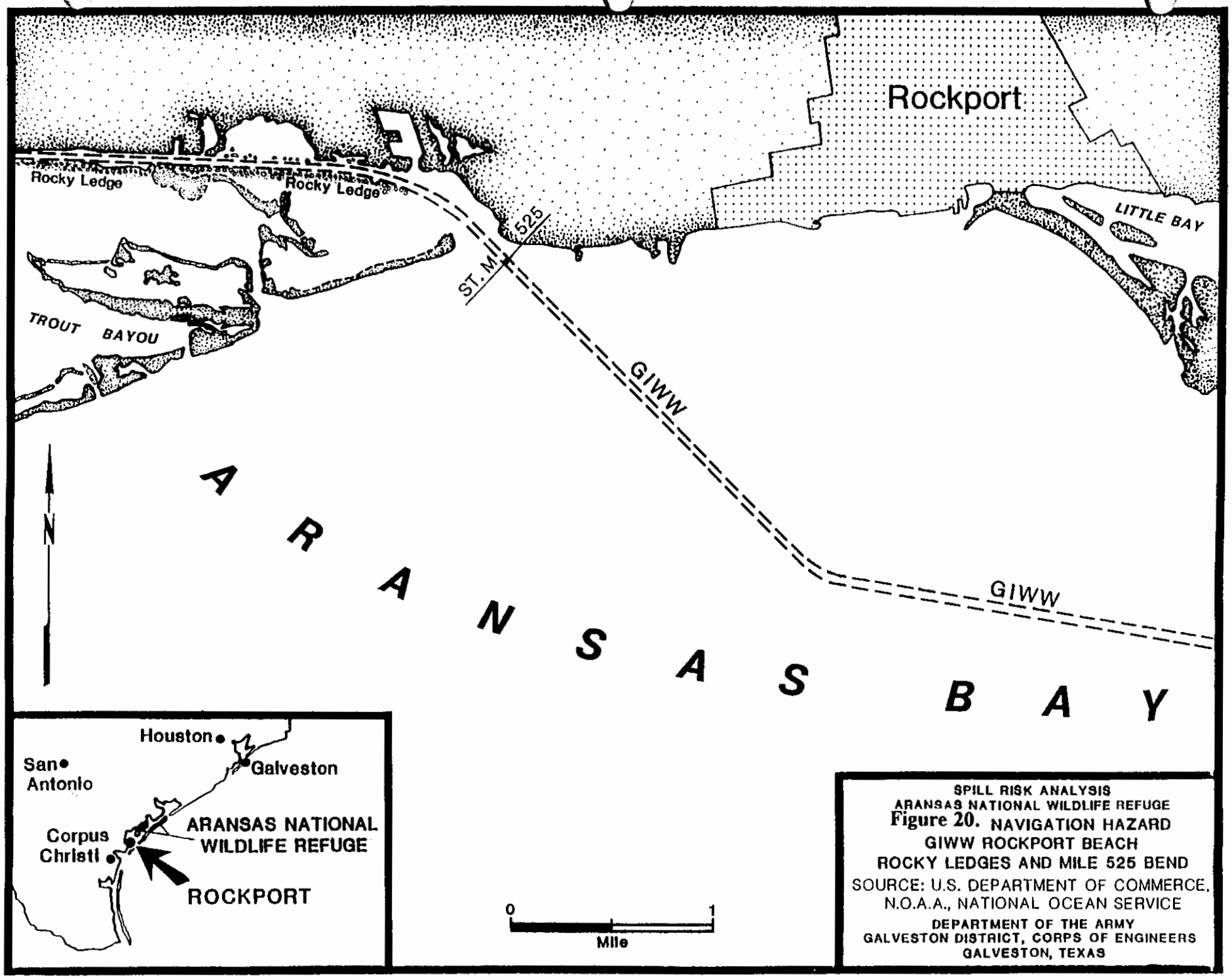
through Aransas Bay within the past three months. Interviewed tow captains and port captains agree that the study reach is safe for navigation. Unlike certain areas of the GIWW in Louisiana or on the eastern Texas coast, the study reach is free of visual obstructions. In daylight, tow operators can see oncoming traffic clearly because of the lack of trees. Another navigational advantage is the straight run of the study reach, which contains few bends or turns. In general, there is an adequate number of properly maintained navigational aids such as green and red dayboard markers and radar buoys for navigation after dark or in poor visibility.

Another factor adding to the safety of the study reach is its muddy and sandy bottom, which is free of oyster beds, reefs, rocky ledges, or other obstructions. With such a soft bottom, a grounding is very unlikely to cause a spill. The only exception is in the GIWW near Rockport (see Figure 20), which a port captain mentioned as a hazard because of the abundant rock ledges lining the canal. His concern was that grounding on a rock ledge could split a number of compartments in a single-skin tank barge and cause a significant spill. The portion of the GIWW near Rockport is just outside of the study reach, and prevailing winds would push spilled oil away from the refuge.

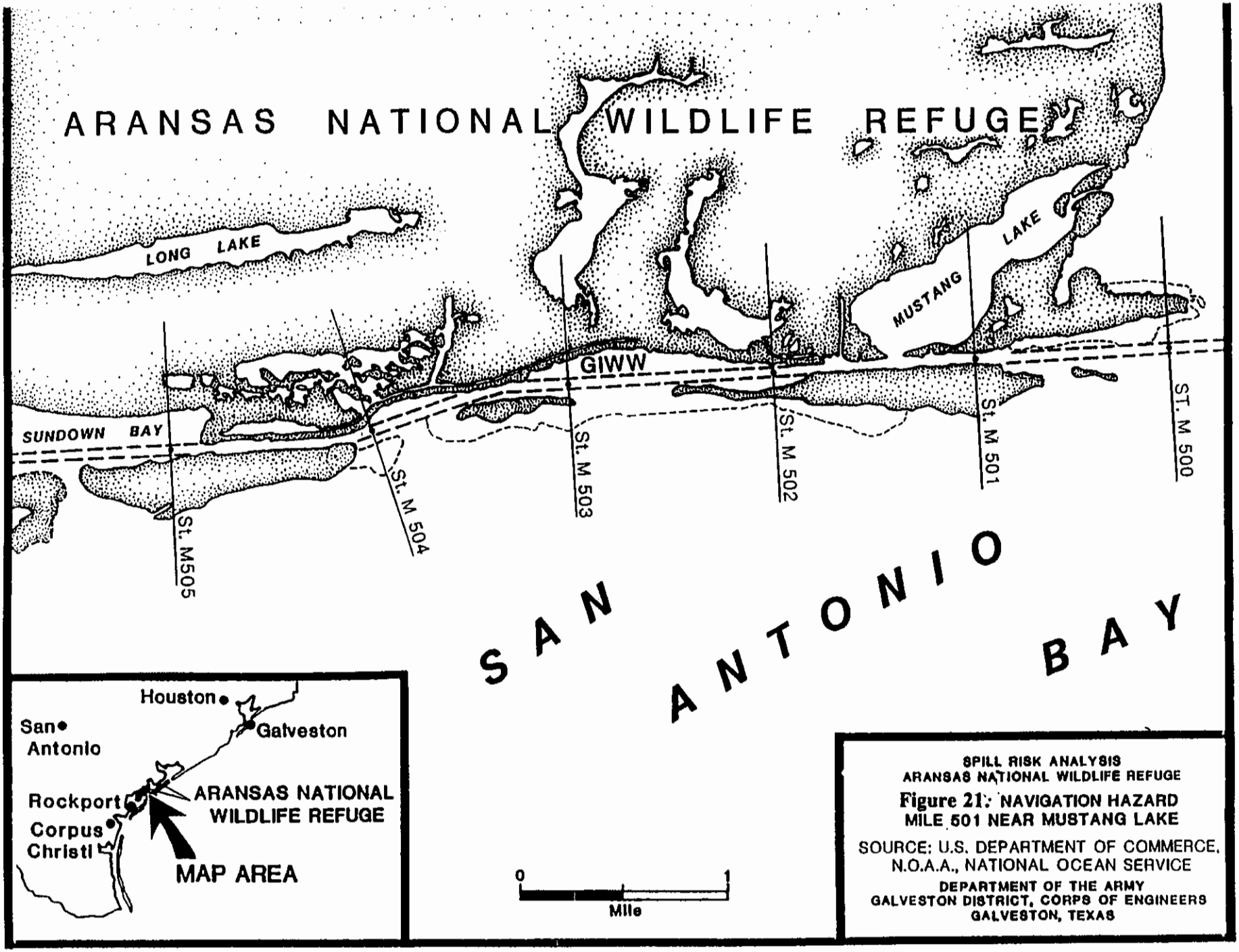
Another area of navigational concern lies directly across from the entrance to Mustang Lake approximately at mile 501 (Figure 21). This is a high shoaling area of the GIWW, and barge groundings have been reported (see Table 7). Nearby, approximately at mile 503, there is a bend in the channel that could be improved through better markings with additional dayboards.

One common concern is pushing empty barges (empties) when there is a strong wind, especially when the empties are in line (strung out) instead of side-by-side (doubled up). Because empty barges sit high in the water, they have a large area for the wind to catch. It is not uncommon when pushing at least two barges strung out in a 25-mph wind to use a steering compensation of 12 degrees or more to maintain a straight course. To avoid entering open bays, tow captains typically "hold up in the wind" by mooring in areas where the channel is protected by dredged material banks or barrier islands. If there is a strong wind over a number of hours, numerous vessels may be moored along the canal in the "Barge Mooring Area" at approximately mile 491.5, as shown in Figure 22. This is an area of concern to captains because the moored vessels may present a collision hazard to oncoming barge traffic.

Another area of concern is that navigational buoys may become off-station and lose their original placement. Wayward barges may run over red and green markers, resulting in their becoming off-station, particularly when empty barges face high winds and are blown slightly



SPILL RISK ANALYSIS
ARANSAS NATIONAL WILDLIFE REFUGE
Figure 20. NAVIGATION HAZARD
GIWW ROCKPORT BEACH
ROCKY LEDGES AND MILE 525 BEND
SOURCE: U.S. DEPARTMENT OF COMMERCE, N.O.A.A., NATIONAL OCEAN SERVICE
DEPARTMENT OF THE ARMY
GALVESTON DISTRICT, CORPS OF ENGINEERS
GALVESTON, TEXAS



SPILL RISK ANALYSIS
ARANSAS NATIONAL WILDLIFE REFUGE

Figure 21: NAVIGATION HAZARD MILE 501 NEAR MUSTANG LAKE

SOURCE: U.S. DEPARTMENT OF COMMERCE, N.O.A.A., NATIONAL OCEAN SERVICE

DEPARTMENT OF THE ARMY
GALVESTON DISTRICT, CORPS OF ENGINEERS
GALVESTON, TEXAS

Table 7. Non-Spill Vessel Casualties Within the GIWW Channel Miles 475 to 525 (1985 through 1988)

Year/Date	Channel Mile	Description
1985		
2/18/85	525	Accidental grounding of barge and towboat due to pilot error; $5,000 damage to barge
5/10/85	525	Barge and towboat collision with a pier or dock due to pilot error; no documented monetary damage
1986		
1/27/86	475	Crossing collision between an OSV and a tank barge in tow due to pilot error; no documented monetary damage
5/19/86	523	Meeting collision between a fishing vessel and a tank barge and its towboat due to pilot error; $60,000 damage to fishing vessel
7/08/86	503	Accidental grounding of a tank barge in tow due to error in judgement; $38,000 damage to tank barge
1987		
2/27/87	525	Collision with a pier of a tank barge in tow due to error in judgement; no noted monetary damage
7/15/87	492	Accidental grounding of a freight barge in tow due to error in judgement; $500.00 damage to freight barge
12/3/87	506.9	Accidental grounding of two tank barges in tow due to error in judgement; no documented monetary damage
12/25/87	525	Accidental grounding of a tank barge in tow due to error in judgement; $2,200 damage to tow
1988		
6/14/91	515	Accidental grounding of a tow due to unknown cause; $5,000 damage to tow
11/14/88	487	Accidental grounding of a tow due to pilot error; $1,500 damage to tow
1988		
4/15/89	487	Accidental grounding of a tow due to pilot error; $23,000 damage to tow
9/16/89	525	Accidental grounding of a tow due to shoaling; no documented monetary damage

Source: U.S. Coast Guard CASMAIN Data Base (1991), Washington, D.C.

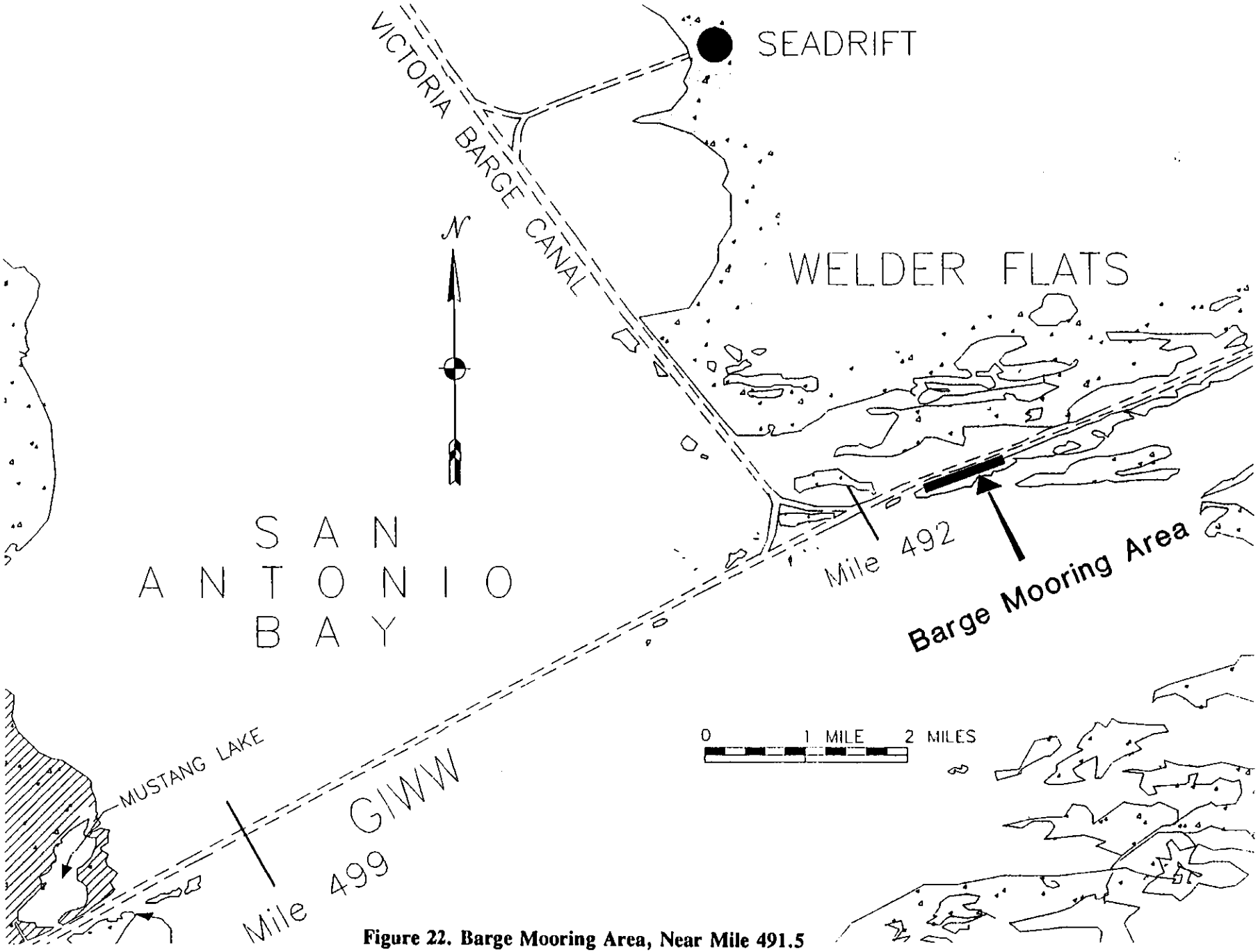


Figure 22. Barge Mooring Area, Near Mile 491.5

off-course. Storms and high winds may also result in marker displacement. The Coast Guard is responsible for replacement and maintenance of these navigational aids and does so on a regular basis. The prevailing opinion is that the markers are well maintained. However, it is not uncommon for buoys to become off-station for a few days. Although the prudent mariner does not rely solely on navigational aids, tow captains occasionally ground barges because they relied on an off-station buoy.

The majority of tow operators interviewed were from larger companies. The larger companies commonly stated that in comparison to many other areas of the GIWW in Texas and other states, the study reach is a relatively safe navigational area. Captains from smaller companies have some reservations about the safety of the study reach. This difference seems to be related to the horsepower that accompanies the barge tow and whether the company typically uses bow thrusters in its tow configurations. It appears that smaller companies may be more likely to have underpowered towboats and lack bow thrusters.

Bow thrusters have been suggested as one possible remedy to the situation of underpowered tows and their associated problems with steering and control. A bow thruster is a self-propelled, steerable, wedged section that is attached to the bow of the leading barge in a tow. It provides additional steering and control and is especially helpful in high winds or when operated with an underpowered towboat. In addition to providing steerage, about one-half of the bow thrusters assist the towboat by providing backward thrust.

Data from the U.S. Coast Guard's CASMAIN database details various vessel casualties for mile 475-525 from 1985 through 1988 (see Table 7). Although this database does not identify vessel casualties that resulted in spills, it does indicate areas along the waterway that may pose navigational hazards as evidenced by past collisions, groundings, or shoaling.

From 1985 through 1988, there were 13 separate tow vessel casualties in the 50-mile study reach. Five of these casualties occurred on mile 525 (see Figure 15). The most common casualty was accidental grounding, which occurred in nine of the 13 cases. There were three accidental groundings and two collisions of barges with piers and docks in separate years at mile 525. These data indicate that mile 525 in Aransas Bay is a recurrent navigational hazard for collisions with docks and piers, for accidental groundings, and for shoaling. There is a fairly sharp bend at mile 525, and eastbound or westbound tows that are steered too wide before the bend may become grounded in the seven- to eight-foot depths adjacent to the channel.

The area of next greatest concern is mile 487, in which two vessel casualties occurred, both of which were groundings through pilot error. That pilot error is the most common cause of vessel casualty was confirmed by the interviews with experienced tow captains, who agreed that vessel operator experience and care are the most important factors in vessel safety and far exceed factors such as vessel horsepower, double-hulled tanks, and bow thrusters.

These data are significant only for determining areas of navigational hazard and do not necessarily indicate that these areas of the channel are more prone to vessel spills. Accidental grounding is by far the most common cause of vessel casualty. However, an accidental grounding is unlikely to cause a spill within the study area because of the soft bottom composed of mud and sand.

In summary, the implementation of one-way traffic would only provide a small decrease in the likelihood of a collision because one-way traffic is already a common practice on the portions of the study area that pose a navigation hazard. Safety records also indicate the extreme rarity of collisions of barge tows in the GIWW. Reports for the entire Texas inland waterway system (which includes the GIWW and all intersecting rivers and channels) from the Texas Water Commission for the years 1986 through 1990 indicate that only one out of 300 spills resulted from a collision between barge tows at a site other than those with piers, docks, berths, or port facilities. This collision resulted from poor visibility caused by a nearby marsh fire.

One-way traffic enforcement would require installation of a Coast Guard traffic control station within the study area, along with appropriate communications equipment and personnel. Traffic control centers are usually only located in major cross-traffic areas near industrial or metropolitan centers such as Houston or Texas City. Some facilities have been closed because of cutbacks in Coast Guard funding.

The only barge tow cross-traffic location within the study area is at the intersection of the GIWW and the Victoria Barge Canal. Southbound traffic on the Victoria Barge Canal has the right-of-way over traffic on the GIWW according to Coast Guard regulations, but tows on the Victoria Barge Canal generally yield to tows on the GIWW according to experienced tow captains.

An alternative to a traffic control facility would be use of mandatory turning notices on marine radio. Creation and enforcement of a regulation requiring this type of broadcast notice would fall under the authority of the Coast Guard. Such messages are broadcast over channels 13 (GIWW information channel) and 16 (emergency messages) when tows are turning at

an intersection of the GIWW and a busy tributary such as the ship channels in Mississippi at Bayou Cassat, Pascagoula, and Gulfport. The message used in Mississippi consists of the phrase "Security, Security, Security, this is <vessel name> travelling <direction> on <GIWW or intersecting channel> turning onto <direction and path>." The study area is remote enough so that little if any interference from typical sources (such as police radios) would be encountered.

Structural Measures

A protection system capable of withstanding the effects of both wind-driven waves and navigation wakes is needed to prevent marshland erosion and to provide the desired level of protection for crane habitat along the study reach of the GIWW. The protection system should also facilitate cleanup and serve as a barrier to prevent spilled commodities from leaving the GIWW and contaminating critical habitat.

Several erosion control methods and protective devices that have proven effective in similar environments were reviewed for consideration at this site. Protection devices considered for use at this location included riprap dikes, sand bags, sand pillows, Longard tubes rubber tire dikes, brush dikes and gobi-block revetment. These types of devices and systems were used by the Corps of Engineers in the Shoreline Erosion Control Demonstration Program authorized by Section 54 of Public Law 93-251 of the Water Resources Development Act of 1974. This program was accomplished by 16 Corps of Engineers Districts including the Galveston District.

The devices were evaluated at the specific sites in the program. However, each device was not evaluated under all environments and conditions. Also, the devices were not ranked since each was used at an individual site. Each structure or device was monitored to determine its general effectiveness and capacity to withstand the wave climate to which it was subjected.

Primary considerations in the evaluation of any protection system are construction costs, minimizing damage to habitat during construction, minimizing long-term maintenance costs, and maintaining accessibility to the structure(s) utilized at the protection system location. These considerations must be balanced with the desire to provide the highest level of erosion prevention and spillage containment. To the extent possible, the protection system should also provide for circulation of tidal flow to prevent stagnation and promote entrapment of sediment in off-channel areas too deep to be useful as habitat.

Since permeability is an important factor in providing for tidal exchange and drainage, riprap dike should be constructed using the smallest rock size consistent with the wave climate.

Since this is a relatively protected area not subject to wave action from the Gulf of Mexico, it will be possible to use a moderate size stone. Also, because permeability is necessary for circulation of tidal flow, a core of impervious material (such as clay) should not be used in the riprap revetments or dikes. The rock configuration will be such as to minimize or prevent non-soluble commodities spilled in the GIWW from passing through the dike. Although the riprap may become coated with spilled material, its effectiveness will not be diminished and the rock in the revetments or dikes can be cleaned by waterjet or other means during the spill response and remediation process.

Through evaluation of the various erosion control devices discussed above, it was determined that the protection system that would best accomplish the project objectives is a riprap dike located immediately adjacent and parallel to the GIWW. The location of the riprap revetments and dikes is shown in Figures 23 and 24. The placement of the riprap dike on the natural bottom outside the dredged channel provides several benefits. The shallow natural bottom between the top-of-cut of the GIWW and the channel-side toe of the riprap dike would reduce or prevent damage from barge or boat traffic and reduce the chance for dike undermining from channel-side erosion. Most importantly, the dike would reduce wave action. Permeability of the dike would be low enough to prohibit the passage of oils and high enough to allow sufficient flow-through for interior drainage and tidal flow exchange with the adjacent bays and tidal ponds. Openings would be required only at major channel entrances or at access points required for habitat management.

Locating the riprap dike alongside the channel would facilitate construction and maintenance. The disadvantage of a rock dike in the vicinity of the channel is that there is a danger that an empty barge tow could be blown off course by strong onshore winds, damaging the dike and/or empty barges.

Riprap for dike construction can be placed from barge loads of rock with boom-type equipment. Barge-based construction along the channel would result in little or no damage to the mud flats, although the areas covered by riprap would obviously be destroyed. Other types of construction along the existing shoreline would require land-based or marsh-buggy equipment, which would damage marshland and tidal pond water bottoms, thereby producing habitat losses.

In areas where the edge of the channel comes close to the marsh and there is insufficient berm on which to place a dike, rock can be placed from a barge-mounted crane bucket, and

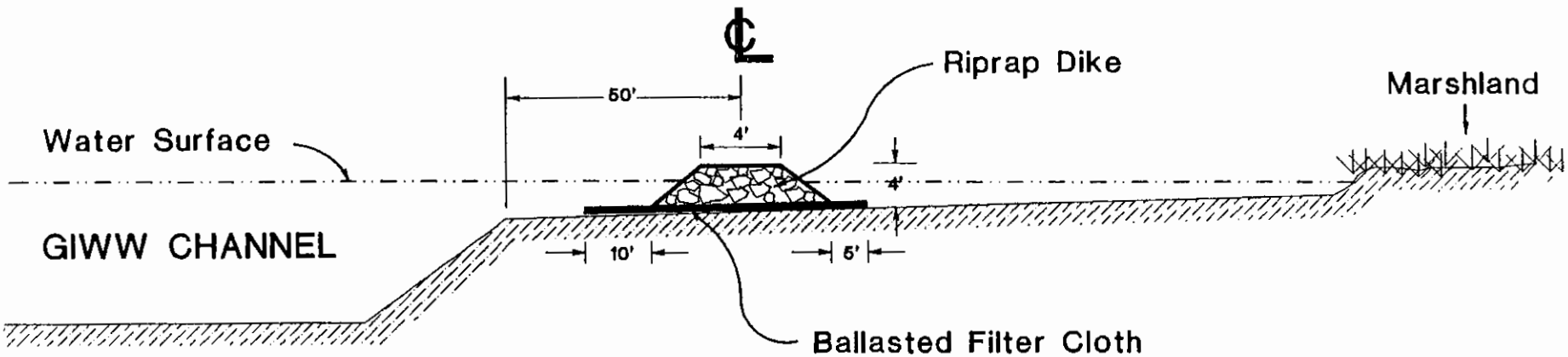


Figure 23.

TYPICAL SECTION
RIPRAP DIKE - OPEN BANKLINE

NTS

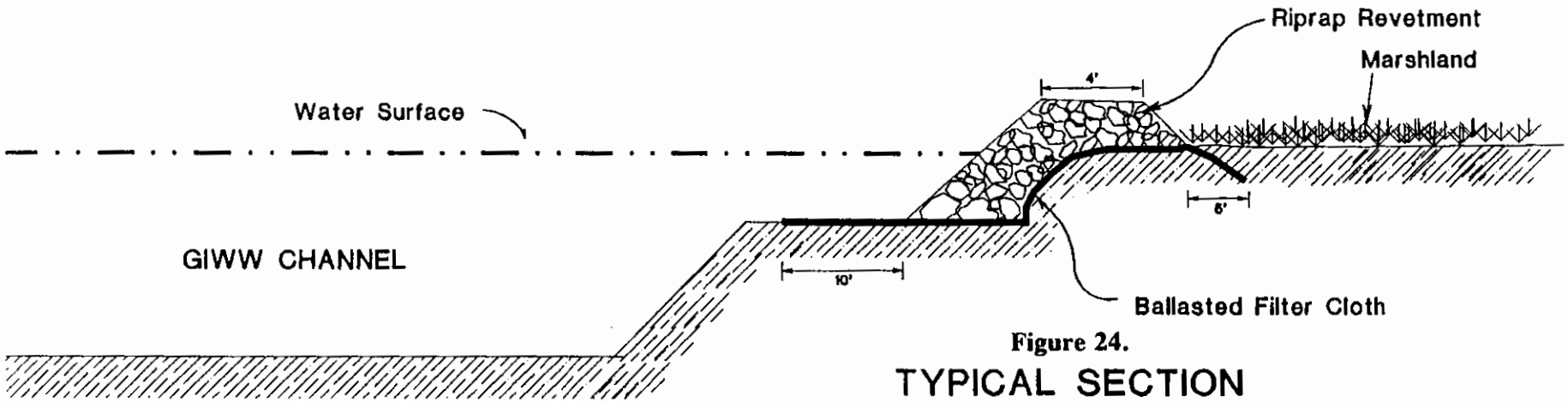


Figure 24.

TYPICAL SECTION
RIPRAP REVETMENT - OPEN BANKLINE

NTS

riprap revetments can be placed along the edge of the channel adjacent to the marshland as shown in Figure 24.

In consultation with U.S. Fish and Wildlife (USFWS) representatives, areas along the GIWW with erosion problems and nearby critical habitat of the whooping crane were identified. These areas are shown on Figure 19. USFWS agents have indicated a need for erosion protection along the entire shoreline on the Blackjack Peninsula side of the GIWW and on certain parts of the Bay side of the GIWW and the islands immediately south of the GIWW. The locations recommended for placement of the rock dikes protect these areas and provide a structural barrier to block pollutants spilled in the GIWW, especially floatable oils, from entering critical habitat areas and to facilitate spill cleanup.

The locations recommended for the riprap dikes are shown in Figures 25 (ANWR) and 26 (Welder Flats). It should be noted that the recommendations also include placement of riprap dikes near Welder Flats (Figure 26) from the island (just north of the Victoria Barge Canal/GIWW intersection) northward beside the GIWW. These dikes would help protect critical habitat in the vicinity of the increased navigation hazard associated with cross traffic near the intersection of the two canals.

All the erosion and habitat areas of concern could be protected with dikes constructed from barge-based equipment, with the exception of the San Antonio Bay side of the small, unnamed island between False Live Oak Island and Rattlesnake Island. The GIWW side of this island could be protected with a riprap revetment constructed with barge-based equipment, but the shallow waters on the San Antonio Bay side of the island would preclude the use of barge-based procedures.

The dike system should be constructed to the lowest elevation consistent with the average wave climate and tidal conditions. This would usually be about one and one-half feet above normal high tide. It is not practical or necessary to construct the dikes to an elevation to withstand hurricane tides. In the event of hurricane tides, the dikes would be inundated at an early stage in the approaching storm tides and would not suffer severe damage as a result of being completely covered. The base of the dike should be on filter cloth ballasted to secure placement and prevent displacement of the outboard edges. The typical sections shown in figures 12 and 13 provide a view of the recommended construction.

The dike should be intermittently pierced with timber piles at approximately one-half mile intervals. The timber piles should be suitably marked with reflective markers or other approved

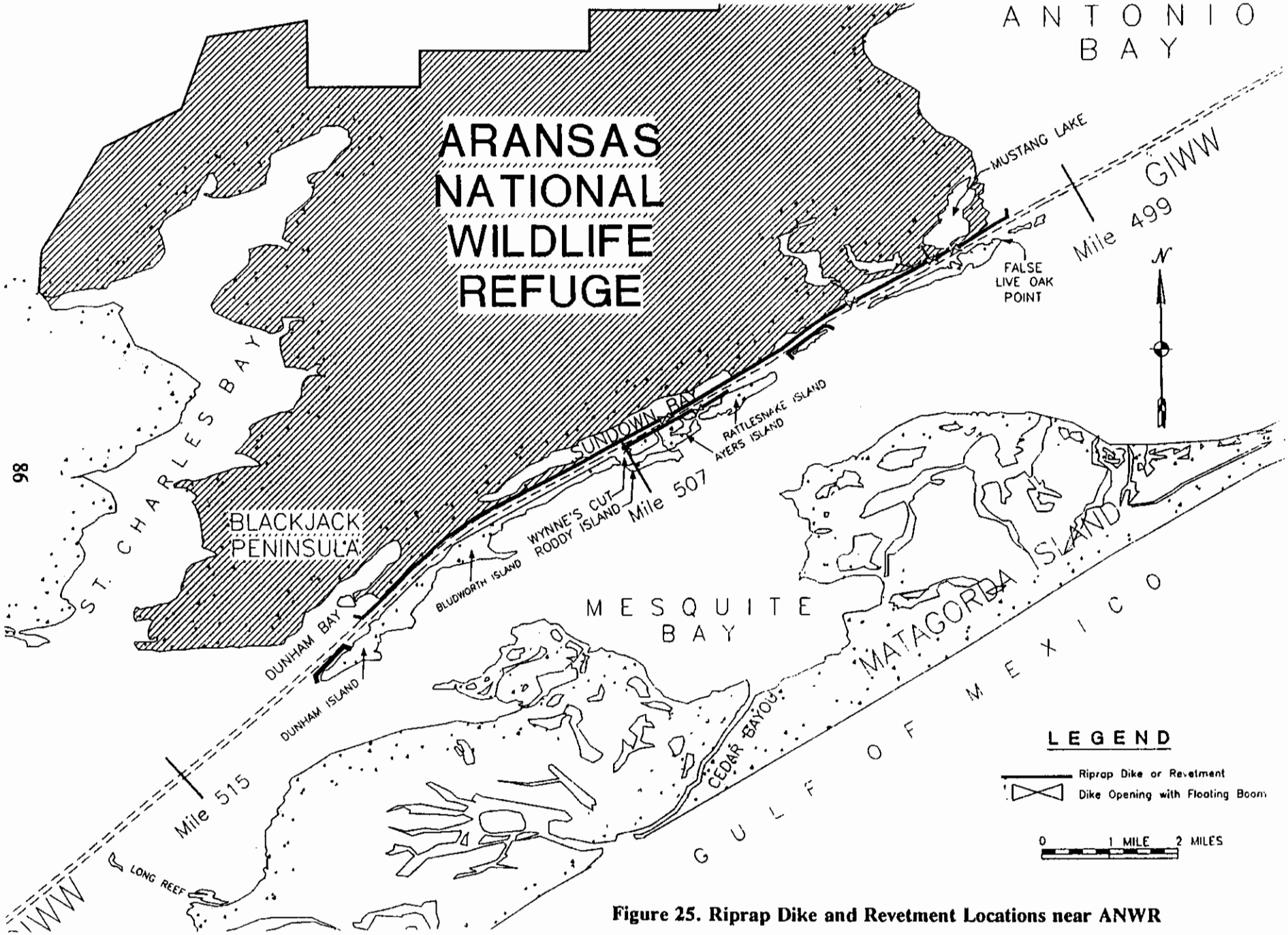


Figure 25. Riprap Dike and Revetment Locations near ANWR

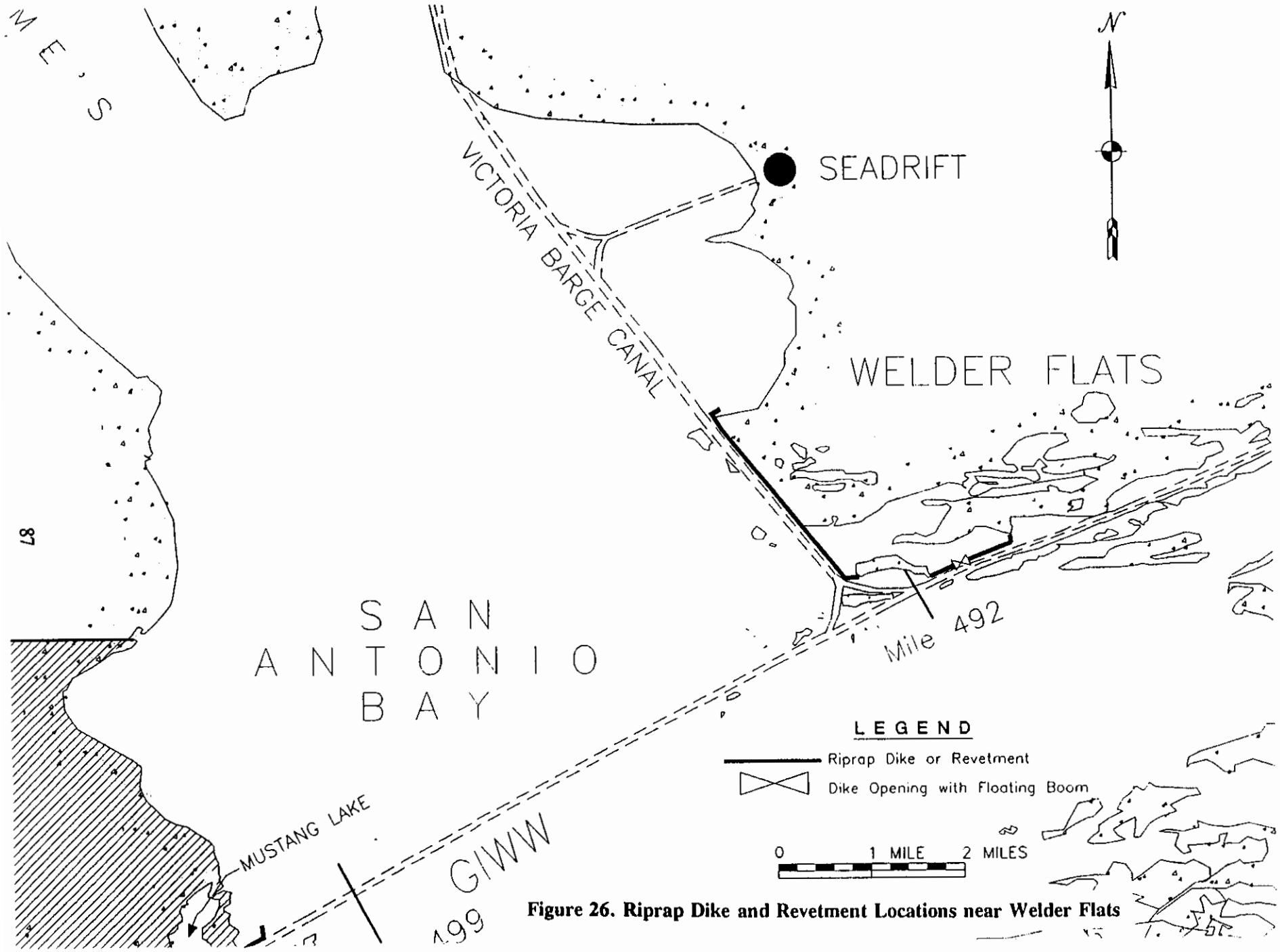


Figure 26. Riprap Dike and Revetment Locations near Welder Flats

devices to advise marine traffic of the dike locations and access openings. The openings should be about 50 feet wide with piling on each terminus as shown in Figure 27 to serve as markers and to facilitate attachment of a floating boom during seasonal occupation by the whooping cranes and to provide protection for off-channel areas during spill occurrences and when cleanup activities are underway.

Evaluation of Proposed Contingency Plans

Nonstructural measures such as vessel speed control and one-way traffic would reduce erosion damage and the probability of barge collisions in the study area. However, vessel speed limits would not eliminate erosion damage from vessel wakes and would have no affect on erosion from wind-blown waves. In addition, navigation traffic control measures cannot eliminate the possibility of accidental spillage of pollutants.

If barge navigation is restricted to one-way traffic through the study area, barge tows going in the opposite direction must be parked temporarily at the ends of the control zone until direction change occurs, which increases the danger of a collision. There would obviously be some additional shipping costs associated with delays encountered by barge tows waiting for traffic direction changes, and regulatory expenses would also be significant.

The construction of riprap dikes and revetments along the navigation channel would control erosion damage from both navigation traffic and wind-driven waves. Riprap dikes and revetment can block spilled oils from getting into sensitive areas such as marsh and tidal flats, particularly when augmented with floating oil booms at openings in the dikes and revetments for inlet channels, small boat access, etc. Spilled oils would be generally confined to the navigation channel on prevailing winds. On northerly winds, oils not trapped within the dike and revetments could be blown through openings between the dredge material islands and into open waters southward of the navigation channel. Although soluble pollutants can flow easily through riprap dikes, the soluble pollutants such as sugar and alcohol that are shipped through the study area do not present a serious threat to whooping cranes or their habitat.

The most significant advantage of a riprap dike and revetment system with floating booms at openings is that the consequences of less-than-immediate spill response with portable booms are not as severe. Habitat protection from oil spills would be in place whenever whooping cranes were in the vicinity.

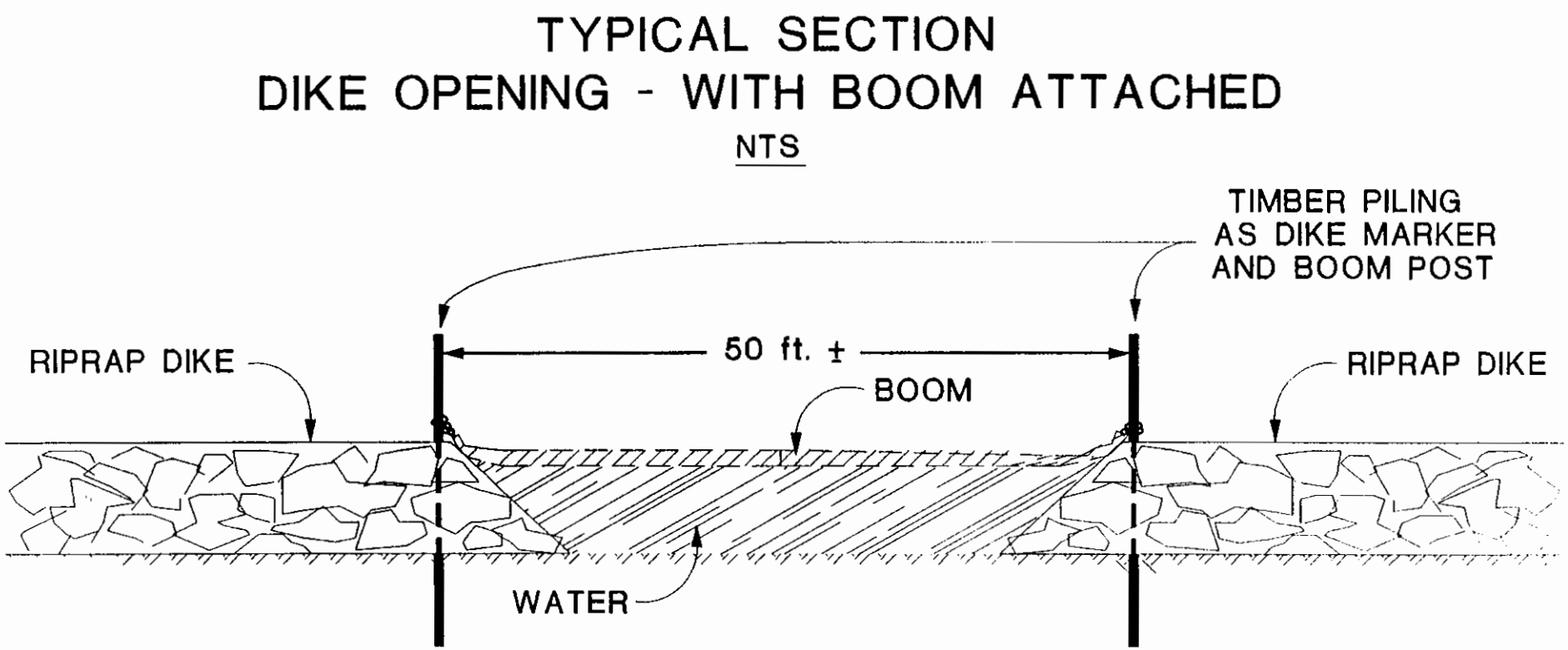


Figure 27. Typical Section, Dike Opening - With Boom Attached

Oil-polluted riprap is not easy to clean, but dikes and revetments would be easily accessible from the navigation channel. Oil-contaminated riprap needs to be cleaned sufficiently by pressure hoses or other means so that a sheen does not form on the water surface after wave lap. Black coating or caking that does not leave a sheen when splashed should not present a hazard to whooping crane life and should eventually biodegrade.

Floating oil booms in place from October to April in order to protect openings in riprap dikes and revetments can be removed in late spring for repair and storage and replaced when whooping cranes arrive in the fall. The booms require maintenance while in place, and additional portable booms should be available in the vicinity for rapid deployment to prevent an oil spill from spreading, coating riprap, and increasing cleanup area and costs. Presumably, the capability for these tasks, or at least supervisory control, would be given to the ANWR.

Revetments placed where sensitive marsh banks come very close to the edge of the navigation channel may cause damage to empty errant barges, but should not endanger loaded barges and therefore do not increase spill risks. Riprap revetments placed on marsh banks may alter or destroy some whooping crane habitat. Riprap dikes placed in mud flats may alter existing water flow characteristics and sedimentation rates in the shallows and mud flats between the dike and existing shores. These changes may be favorable or possibly unfavorable to certain habitat regimes.

The construction of riprap dikes and revetments in the designated areas will reduce erosion damage and habitat damage in the event of an oil spill. Construction and maintenance costs for such facilities will be significant, although total costs have not been determined. The monetary value (liability) of habitat damage that would be prevented by these structures has also not been determined.

The U.S. Coast Guard *Local Contingency Plan* for the Corpus Christi Marine Safety Zone takes special recognition of critical habitat areas at and near ANWR requiring immediate notification of any spill. Unfortunately, the critical area is a long distance from Coast Guard installations and/or the resources such as portable booms, skimmers, and absorbants. The key to minimizing damage is containment of spilled oil at the spill site, and the sooner portable oil booms are deployed to contain the oil spilled, the less likelihood there is of habitat damage and more costly cleanup measures. With prompt response to a spill, less boom footage is required for containment than after a delay of several hours for marshalling and transport.

Although federal and state laws place responsibility for initial containment measures on the vessel operator (at least until the arrival of the Coast Guard On-Scene Coordinator), Vessel operators have not always been able to handle the situation following a spill. In view of the critical situation at ANWR, it is recommended that the capability to respond immediately with sufficient boom to contain a "worst case" spill should be available at or near ANWR to minimize response time.

If the passive protection system of riprap dikes and seasonally placed floating booms is installed, the capability to install, maintain, repair and store oil booms and similar equipment will be needed at ANWR. This capability could also be expanded to include spill response with portable booms, absorbants, and other equipment.

XIV. REFERENCES

Cairns, J. and D. Orvos. 1990. "Developing an Ecological Risk Assessment for the Chesapeake Bay" 1990 in *Perspective on the Chesapeake Bay, 1990.* Advances in Estuarine Studies. M. Haire and E. C. Krome, eds. Chesapeake Bay Consortium, Gloucester Point, Va. 83-98.

Cairns, J. and A. Buikema, Jr. 1984. *Restoration of Habitats Impacted by Oil Spills* (Boston: Butterworth).

Findings of Fact: M/M RACHEL B *Collision With the* M/V GAYOLYN ANN GRIFFIN, November 27, 1989. Issued by the Marine Safety Office of the U.S. Coast Guard, Galena Park, Tx.

Lanfear, K., A. Nakassis, W. Samuels, and C. Schoen. 1979. *An Oil Spill Risk Analysis for the the Northern Gulf of Alaska (Proposed Sale 55) Outer Continental Shelf Lease Area,* U.S. Geological Survey Open-Fire Report 79-1284.

Lanfear, K., and D. Amstutz. 1983. *A Reexamination of Occurrence Rates for Accidental Oil Spills on the U. S. Outer Continental Shelf:* Presented at the Eighth Conference on the Prevention, Behavior, Control, and Cleanup of Oil Spills, San Antonio, Texas, Feb.28, 1983.

Martens, E. W. "The Impact of Oil on Marine Life: A Summary of Field Studies," in *Symposium on Sources, Effects, and Sinks of Hydrocarbons in the Aquatic Environment* (Washington, DC: American Institute of Biological Sciences, 1976), pp. 507-514.

McMahon, S. and Robert LaBelle "Estimated Occurrence Rates for Analysis of Accidental Oil Spills on the US Outer Continental Shelf" in 6 *Oil and Chemical Pollution* 1990: 21-35.

National Research Council (NRC). 1989. *Using Oil Dispersants on the Sea.* Washington, DC: National Academy Press. 355 pp.

National Oil Spill Contingency Plan: A Report to the President. October 1990. Prepared by The National Response Team from The Department of Transportation and The Environmental Protection Agency.

Neter, J., W. Wasserman, and G. A. Whitmore. 1988. *Applied Statistics,* Boston: Allyn and Bacon, Inc.

Personal Communication with representatives from the Port of Corpus Christi, Port of Houston; Chemical Companies' representatives in Victoria, Corpus Christi, Houston, Port Lavaca, Point Comfort, and Bay City, Texas; Towing Companies' representatives in Houston and Corpus Christi, Texas, Baton Rouge, Harahan, and New Orleans, Louisiana.

Personal Communication with Bennett H. Farrier, P.E., Chemical Engineer, Louisiana Department of Environmental Quality.

Personal Communication with Tom Stehn, Crane Biologist, Arkansas National Wildlife Refuge.

Rainey, G. 1991. *The Risk of Oil Spills From The Transport of Petroleum in the Gulf of Mexico.* Proceedings of the eleventh annual Gulf of Mexico information transfer meeting, November 1990. U.S. Dept. of the Interior, Minerals Management Service. MMS Contract No. 14-35-0001-30499

Samuels, W. and K. Lanfear. 1984. *An Oil Spill Risk Analysis for the Navarian Basin Lease Offering.* U.S. Department of the Interior Minerals Management Service. U.S. Geological Survey Open File Report 83-120.

Smith, R.A., Slack, J.R. Wyant, T & Lanfear, K.J. (1982). *The Oil Spill Risk Analysis Model of the US Geological Survey.* USGS Professional Paper 1227, USGS, Reston, VA.

Texas Parks and Wildlife Department, *Welder Flats Coastal Preserve, Baseline Studies Report, Submitted to US Environmental Protection Agency, Cooperative Agreement Number X-006299-01.* December 1990

U. S. Congress, Office of Technology Assessment, "Oil Transportation by Tankers: An Analysis of Marine Pollution and Safety Measures," U. S. Govt. Printing Office, Washington D.C. (1990).

U. S. Department of the Interior, Minerals Management Service, Environmental Policy and Programs Division, Washington, D.C. (USDOI/MMS, Wash. DC). 1990. Unpublished database on oil spills May 1991.

U. S. Department of the Interior, Mineral Management Service, *1990 Gulf of Mexico Sales 139 and 141 (Central and Western Planning Areas)* OCS EIS/EA MMS 91-0018.

U. S. Fish and Wildlife Service, *Whooping Crane Contingency Plan for the IXTOC I Oil Spill,* November 1979, received from ANWR personnel.

Appendix A

WATERBORNE COMMERCE STATISTICS CENTER, COMMODITY CODES

Appendix A

WATERBORNE COMMERCE STATISTICS CENTER COMMODITY CODES

WCSC CODE	COMMODITY NAME
101	COTTON, RAW
102	BARLEY AND RYE
103	CORN
104	OATS
105	RICE
106	SORGHUM GRAINS
107	WHEAT
111	SOYBEANS
112	FLAXSEED
119	OILSEEDS, NOT ELSEWHERE CLASSIFIED
121	TOBACCO, LEAF
122	HAY AND FODDER
129	FIELD CROPS, AND ELSEWHERE CLASSIFIED
131	FRESH FRUITS
132	BANANAS AND PLANTAINS
133	COFFEE, GREEN AND ROASTED (INCLUDING INSTANT)
134	COCOA BEANS
141	FRESH AND FROZEN VEGETABLES
151	LIVE ANIMALS (LIVESTOCK) EXCEPT ZOO ANIMALS, CATS, DOGS, ETC.
161	ANIMALS AND ANIMAL PRODUCTS, NOT ELSEWHERE CLASSIFIED
191	MISC. FARM PROD
841	CRUDE RUBBER & ALLIED GUMS
861	FOREST PRODUCTS, NOT ELSEWHERE CLASSIFIED
911	FRESH FISH, EXCEPT SHELLFISH
912	SHELLFISH, EXCEPT PREPARED OR PREPARED
913	MENHADEN
931	MARINE SHELLS
1011	IRON ORE AND CONCENTRATES
1021	COPPER ORE AND CONCENTRATES
1051	BAUXITE AND OTHER ALUMINUM ORES & CONCENTRATES
1061	MANGANESE ORES AND CONCENTRATES
1091	NONFERROUS METAL ORES & CONCENTRATES, NOT ELSEWHERE CLASSIFIED
1121	COAL & LIGNITE
1311	CRUDE PETROLEUM
1411	LIMESTONE FLUX & CALCAREOUS STONE
1412	BUILDING STONE, UNWORKED
1442	SAND, GRAVEL AND CRUSHED ROCK
1451	CLAY, CERAMIC AND REFRACTORY MATERIALS
1471	PHOSPHATE ROCK
1479	NATURAL FERTILIZER MATERIALS, NOT ELSEWHERE CLASSIFIED

Appendix A

WATERBORNE COMMERCE STATISTICS CENTER COMMODITY CODES

WCSC CODE	COMMODITY NAME
1491	SALT
1492	SULPHUR, DRY
1493	SULPHUR, LIQUID
1494	GYPSUM, CRUDE AND PLANTERS
1499	NONMETALLIC MINERALS, EXCEPT FUELS, NOT ELSEWHERE CLASSIFIED
1911	ORDNANCE & ACCESSORIES
2011	MEAT, FRESH, CHILLED, FROZEN
2012	MEAT & MEAT PRODUCTS PREPARED OR PRESERVED, INCLUDING CANNED MEAT PRODUCTS
2014	TALLOW, ANIMAL FATS AND OILS
2015	ANIMAL BY-PRODUCTS, NOT ELSEWHERE CLASSIFIED
2021	DAIRY PRODUCTS, EXCEPT DRIED MILK & CREAM
2022	DRIED MILK & CREAM
2031	FISH & FISH PRODUCTS, INCLUDING SHELLFISH, PREPARED OR PRESERVED
2034	VEGETABLES & PREPARATIONS, CANNED & OTHERWISE PREPARED & PRESERVED
2039	FRUITS, AND FRUIT & VEGETABLE JUICES, CANNED & OTHERWISE PREPARED & PRESERVED
2041	WHEAT FLOUR AND SEMOLINA
2042	ANIMAL FEEDS
2049	GRAIN MILL PRODUCTS, NOT ELSEWHERE CLASSIFIED
2061	SUGAR
2062	MOLASSES
2081	ALCOHOLIC BEVERAGES
2091	VEGETABLE OILS, ALL GRADES, MARGARINE & SHORTENING
2092	ANIMAL OILS AND FATS, NOT ELSEWHERE CLASSIFIED, INCLUDING MARINE
2094	GROCERIES
2095	ICE
2099	MISC FOOD PROD
2111	TOBACCO MANUFACTURES
2211	BASIC TEXTILE PRODUCTS, EXCEPT TEXTILE FIBERS
2212	TEXTILE FIBERS NOT ELSEWHERE CLASSIFIED
2311	APPAREL AND OTHER FINISHED TEXTILE PRODUCTS
2411	LOGS
2412	RAFTED LOGS
2413	FUEL WOOD, CHARCOAL, AND WASTES
2414	TIMBER, POSTS, POLES, PILING, AND OTHER WOOD IN THE ROUGH
2415	PULPWOOD, LOG
2416	WOOD CHIPS, STAVES, MOLDINGS
2421	LUMBER
2431	VENEER, PLYWOOD AND OTHER WORKED WOOD
2491	WOOD MANUFACTURES, NOT ELSEWHERE CLASSIFIED
2511	FURNITURE & FIXTURES
2611	PULP

Appendix A

WATERBORNE COMMERCE STATISTICS CENTER COMMODITY CODES

WCSC CODE	COMMODITY NAME
2621	STANDARD NEWSPRINT PAPER
2631	PAPER AND PAPERBOARD
2691	PULP, PAPER NOT OTHERWISE CLASSIFIED
2711	PRINTED MATTER
2810	SODIUM HYDROXIDE (CAUSTIC SODA)
2811	CRUDE PRODUCTS FROM COAL TAR, PETROLEUM & NATURAL GAS, EXCEPT BENZENE & TOLUENE
2812	DYES, ORGANIC PIGMENT, DYEING & TANNING MATERIALS
2813	ALCOHOLS
2816	RADIOACTIVE & ASSOCIATED MATERIALS, INCLUDING WASTES
2817	BENZENE AND TOLUENE, CRUDE & COMMERCIALLY PURE
2818	SULFURIC ACID
2819	BASIC CHEMICALS AND PRODUCTS, NOT ELSEWHERE CLASSIFIED
2821	PLASTIC MATERIALS, REGENERATED CELLULOSE & OTHER SYNTHETIC RESINS, INCLUDING FILM, SHEETING, & LAMINATES
2822	SYNTHETIC RUBBER
2823	SYNTHETIC (MAN-MADE) FIBER
2831	DRUGS (BIOLOGICAL PRODUCTS, MEDICINAL CHEMICALS, BOTANICAL PRODUCTS & PHARMACEUTICAL PREPARATION
2841	SOAP, DETERGENTS, & CLEANING PREPARATIONS; PERFUMES, COSMETICS, & OTHER TOILET PREPARATIONS
2851	PAINTS, VARNISHES, LACQUERS, ENAMELS, AND ALLIED PRODUCTS
2861	GUM AND WOOD CHEMICALS
2871	NITROGENOUS CHEM FERTILIZERS, EXCEPT MIXTURES
2872	POTASSIC CHEM FERTILIZERS,EXCEPT MIXTURES
2873	PHOSPHATIC CHEM FERTILIZERS, EXCEPT MIXTURES
2876	INSECTICIDES, FUNGICIDES, PESTICIDES, & DISINFECTANTS
2879	FERTILIZERS AND FERTILIZERS MATERIALS
2891	MISC CHEM PROD
2911	GASOLINE, INCLUDING NATURAL GASOLINE
2912	JET FUEL
2913	KEROSENE
2914	DISTILLATE FUEL OIL
2915	RESIDUAL FUEL OIL
2916	LUBRICATING OILS & GREASES
2917	NAPTHA, MINERAL SPIRITS, SOLVENTS, NOT ELSEWHERE CLASSIFIED
2918	ASPHALT, TAR, AND PITCHES
2920	COKE, INCLUDING PETROLEUM COKE
2921	LIQUEFIED PETROLEUM GASES, COAL GASES, NATURAL GAS, & NATURAL GAS LIQUIDS
2951	ASPHALT BUILDING MATERIALS
2991	PETROLEUM AND COAL PRODUCTS, NOT ELSEWHERE CLASSIFIED
3011	RUBBER AND MISC PLASTIC PROD
3111	LEATHER AND LEATHER PRODUCTS
3211	GLASS AND GLASS PRODUCTS
3241	BUILDING CEMENT

Appendix A

WATERBORNE COMMERCE STATISTICS CENTER COMMODITY CODES

WCSC CODE	COMMODITY NAME
3251	STRUCTURAL CLAY PRODUCTS, INCLUDING REFRACTORIES
3271	LIME
3281	CUT STONE & STONE PRODUCTS
3291	MISC NONMETALLIC MINERAL PROD
3311	PIG IRON
3312	SLAG
3313	COKE (COAL & PETROLEUM), PETROLEUM PITCHES & ASPHALTS, & NAPTHA & SOLVENTS
3314	IRON & STEEL INGOTS, & OTHER PRIMARY FORMS, INCLUDING BLANKS FOR TUBE & PIPE, & SPONGE IRON
3315	IRON & STEEL BARS, RODS, ANGLES, SHAPES & SECTIONS, INCLUDING SHEET PILINGS
3316	IRON AND STEEL PLATES, SHEETS
3317	IRON AND STEEL PIPE AND TUBE
3318	FERROALLOYS
3319	PRIMARY IRON & STEEL PRODUCTS, NOT ELSEWHERE CLASSIFIED INCLUDING CASTINGS IN THE ROUGH
3321	NONFERROUS METALS PRIMARY SMELTER PRODUCT, BASIC SHAPES, WIRE CASTINGS & FORGINGS, EXCEPT COPPER, LEAD, ZINC & ALUM
3322	COPPER AND COPPER ALLOYS, WHETHER OR NOT REFINED, UNWORKED
3323	LEAD AND ZINC INCLUDING ALLOYS, UNWORKED
3324	ALUMINUM AND ALUMINUM ALLOYS, UNWORKED
3411	FABRICATED METAL PRODUCTS,EXCEPT ORDNANCE, MACHINERY, & TRANSPORTATION EQUIPMENT
3511	MACHINERY, EXCEPT ELECTRICAL
3611	ELECTRICAL MACHINERY EQUIPMENT & SUPPLIES
3711	MOTOR VEHICLES, PARTS AND EQUIPMENT
3721	AIRCRAFT AND PARTS
3731	SHIPS AND BOATS
3791	MISC TRANS EQUIPMENT
3811	INSTR, TIME, PHOTO, OPTICAL GOODS, WATCHES AND CLOCKS
3911	MISC MANUF PRODUCTS
4011	IRON AND STEEL SCRAP
4012	NONFERROUS METAL SCRAP
4022	TEXTILE WASTE, SCRAP, AND SWEEPINGS
4024	PAPER WASTE AND SCRAP
4029	WASTE AND SCRAP, NOT ELSEWHERE CLASSIFIED
4111	WATER
4112	COMMODITIES, NOT ELSEWHERE CLASSIFIED
4113	MISCELLANEOUS SHIPMENTS NOT IDENTIFIABLE BY COMMODITY
4116	MATERIALS USED IN WATERWAY IMPROVEMENT, GOVERNMENT MATERIALS
4119	EMPTY CONTAINERS
9999	DEPARTMENT OF DEFENSE CONTROLLED CARGO & SPECIAL CATEGORY ITEMS

Appendix B

WATERBORNE COMMERCE STATISTICS CENTER, PORT AND DOCK CODES

Appendix B

WATERBORNE COMMERCE STATISTICS CENTER
PORT AND DOCK CODES

DISTRICT/REGION	BEGIN	END	AREA
NEW ENGLAND DIVISION	1	1999	ATLANTIC AREA
NEW YORK DISTRICT	2000	3999	ATLANTIC AREA
PHILADELPHIA DISTRICT	4000	4999	ATLANTIC AREA
BALTIMORE DISTRICT	5000	6549	ATLANTIC AREA
NORFOLK DISTRICT	6550	10999	ATLANTIC AREA
WILMINGTON DISTRICT	11000	11999	ATLANTIC AREA
CHARLESTON DISTRICT	12000	12999	ATLANTIC AREA
SAVANNAH DISTRICT	13000	13999	ATLANTIC AREA
JACKSONVILLE DISTRICT (CONT AT 16158)	14000	14999	MV-GC
MOBILE DISTRICT	15000	15699	MV-GC
JACKSONVILLE DISTRICT (CONT FROM 14999)	16158	17999	MV-GC
NEW ORLEANS DISTRICT (CONT FROM 15999 & CONT AT 65000)	20000	20999	MV-GC
VICKSBURG DISTRICT	21313	21999	MV-GC
MEMPHIS DISTRICT	22000	22954	MV-GC
ST LOUIS DISTRICT	30000	30999	MV-GC
ROCK ISLAND DISTRICT	31300	31999	MV-GC
ST PAUL DISTRICT	32615	32999	MV-GC
LOUISVILLE DISTRICT	40000	41543	MV-GC
HUNTINGTON DISTRICT	41544	42999	MV-GC
PITTSBURGH DISTRICT	43000	43981	MV-GC
NASHVILLE DISTRICT (CONT AT 45003)	44000	44999	MV-GC
LOUISVILLE DISTRICT (CONT FROM 41543)	45000	45002	MV-GC
NASHVILLE DISTRICT	45003	47999	MV-GC
KANSAS CITY DISTRICT	50900	50999	MV-GC
OMAHA DISTRICT	51499	52999	MV-GC
GALVESTON DISTRICT (SEE INDIVIDUAL PORT CODES BELOW)	60001	60999	MV-GC
TULSA DISTRICT (CONTINUED AT 64308)	61000	61699	MV-GC
LITTLE ROCK DISTRICT	62000	64307	MV-GC
TULSA DISTRICT (CONTINUED FROM 61699)	64308	64999	MV-GC
NEW ORLEANS (CONT FROM 20436/CONT AT 66000)	65000	65034	MV-GC
MOBILE DISTRICT	65035	65450	MV-GC
NEW ORLEANS (CONT FROM 65033/CONT AT 67000)	66000	66265	MV-GC
GALVESTON DISTRICT/GIWW (SEE INDIVIDUAL CODES BELOW)	66266	66700	MV-GC
NEW ORLEANS DISTRICT (CONT FROM 66265)	67000	67020	MV-GC
ALASKAN TRANS-SHIP PT AT PANAMA	69999		MV-GC
ST. LAWRENCE RIVER, NY	70001	70499	GREAT LAKES
ST. LAWRENCE RIVER, ONTARIO	70500	70799	GREAT LAKES
LAKE ONTARIO	71000	71999	GREAT LAKES
LAKE ERIE	72000	72999	GREAT LAKES
DETROIT RIVER	73000	73999	GREAT LAKES
LAKE ST CLAIR	74000	74999	GREAT LAKES
ST CLAIR	75000	75999	GREAT LAKES
LAKE HURON	76000	76999	GREAT LAKES
ILLINOIS RIVER	77000	77291	GREAT LAKES
LAKE MICHIGAN	77410	77999	GREAT LAKES
ST MARY'S RIVER	78000	78999	GREAT LAKES
LAKE SUPERIOR	79000	79999	GREAT LAKES
LOS ANGELES DISTRICT	80000	80999	PACIFIC AREA
SAN FRANCISCO DISTRICT	81000	82899	PACIFIC AREA
PACIFIC OCEAN DIVISION	84000	89999	PACIFIC AREA
PORTLAND DISTRICT	90000	90999	PACIFIC AREA
SEATTLE DISTRICT	91000	91599	PACIFIC AREA
WALLA WALLA DISTRICT	92000	92899	PACIFIC AREA
ALASKA DISTRICT	93000	99998	PACIFIC AREA

Appendix B

WATERBORNE COMMERCE STATISTICS CENTER
PORT AND DOCK CODES

GALVESTON DISTRICT	BEGIN	END	AREA
JOHNSON BAYOU, LA	60002		MV-GC
GULF VIA SABINE PASS	60019		MV-GC
SABINE PASS HARBOR	60020		MV-GC
SABINE LAKE LOWER AREA	60021		MV-GC
SABINE LAKE UPPER AREA	60049		MV-GC
ORANGE, TX	60050		MV-GC
BEAUMONT, TX	60056		MV-GC
FERRY LANDING PORT BOLIVAR	60200		MV-GC
PORT BOLIVAR, TX	60206		MV-GC
JCT HSC AND TEXAS CITY CHANNEL	60205		MV-GC
TRINITY BAY OFF DOUBLE BAYOU	60300		MV-GC
DOUBLE BAYOU	60302		MV-GC
GALVESTON BAY OFF ANAHUAC CHANNEL	60314		MV-GC
ANAHUAC CHANNEL, TX	60315		MV-GC
TRINITY RIVER CHANNEL	60318		MV-GC
MATAGORDA BAY (THIS IS OUT OF ORDER / SEE 60658)	60350		MV-GC
CEDAR BAYOU	60352		MV-GC
GOOSE CREEK	60365		MV-GC
GULF AT HOUSTON, TEXAS CITY, GALVESTON	60369		MV-GC
HOUSTON SHIP CHANNEL	60370		MV-GC
GALVESTON BAY VIA CLEAR CREEK	60391		MV-GC
CLEAR CREEK	60392		MV-GC
GALVESTON BAY VIA DICKINSON BAYOU	60404		MV-GC
DICKINSON BAYOU	60405		MV-GC
TEXAS CITY, TX	60414		MV-GC
CHOCOLATE BAYOU	60480		MV-GC
BASTROP BAYOU	60494		MV-GC
SAN BERNARD RIVER	60517		MV-GC
FREEPORT	60518		MV-GC
GULF AT FREEPORT	60519		MV-GC
COLORADO RIVER	60523		MV-GC
OPEN WATER VIA CHANNEL TO PALACIOS	60529		MV-GC
CHANNEL TO PALACIOS	60530		MV-GC
OPEN WATER VIA PORT LAVACA	60657		MV-GC
MATAGORDA SHIP CHANNEL	60658		MV-GC
OPEN WATER VIA GUADALUPE RIVER	60689		MV-GC
GUADALUPE RIVER TO VICTORIA	60690		MV-GC
OPEN WATER VIA ROCKPORT CHANNEL	60698		MV-GC
ROCKPORT	60699		MV-GC
GULF AT PORT ARANSAS	60749		MV-GC
CHANNEL TO ARANSAS PASS	60750		MV-GC
CORPUS CHRISTI	60770		MV-GC
TRANS-SHIPMENT PT GULF OF MEXICO	60779		MV-GC
OPEN WATER AT PT MANSFIELD	60929		MV-GC
OPEN WATER VIA ARROYO COLORADO	60939		MV-GC
ARROYO COLORADO	60940		MV-GC
GIWW SABINE TO GALVESTON	66266	-66350	MV-GC
GALVESTON BAY TO GALVESTON CHANNEL	66350	-66355	MV-GC
GALVESTON CAUSEWAY	66357		MV-GC
NORTH END SARGENT BEACH	66410		MV-GC
SOUTH END SARGENT BEACH	66422		MV-GC
NORTH END ARANSAS WILDLIFE REFUGE (AWR)	66475		MV-GC
SOUTH END ARANSAS WILDLIFE REFUGE	66525		MV-GC
SOUTH END AWR TO BROWNSVILLE (MILE 690)	66525	-66690	MV-GC

SOURCE: Port and Dock Manuals, Calendar Year 1988, 4 Vols., Waterborne Commerce Statistics Center, New Orleans, La. 1988.

Appendix C

RESPONSE DIRECTORY

RESPONSE ASSISTANCE DIRECTORY

2500 FEDERAL AGENCIES

U. S. COAST GUARD

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Mr. Russel F. Rhoades Environmental Services Division	Duty Hours COM: (214) 655-2210 FTS: 255-2210 Non-Duty Hours FTS: 255-2222 COM: (214) 655-2222 Telecopy FTS: 255-2142 COM: (214) 655-2142
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National Oceanic and Atmospheric Administration

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Mr. Jim Walters National Park Service Sante Fe, NM	FTS: 476-6371 COM: (505) 988-6371 Non-Duty Hours (505) 471-8392
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Mr. Don Briggs (Alternate)	COM: (409) 766-3960

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Mr. Charles Webster (Brownsville)	COM: (512) 968-3165
Ms. Mary Track or Mr. Don Fawn (Austin)	COM: (512) 463-7761 COM: (512) 463-8175

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Corpus Christi Satellite Office	COM: (512) 546-5135

Texas Department of Highways and Public Transportation

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Mr. Amadeo Saenz Pharr	Duty Hours COM: (512) 787-2773 Non-Duty Hours COM: (512) 686-6617

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Mr. Robert J. Guzman Director Harlingen	Duty Hours COM: (512) 425-6010 Non-Duty Hours COM: (512) 423-0163

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Mr. Charles B. Marshall, Jr. Public Health Regional Director Harlingen Office	COM: (512) 423-0130
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Mr. Fermin Munoz, Jr. District 4 District Director	COM: (512) 242-3113 COM: (512) 242-3117

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University of Texas Marine Lab at Port Aransas

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Dr. Pat Parker	COM: (512) 749-6756

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Marine Services P. O. Box 416 Port Isabel, TX 78578	COM: (512) 943-2648
Peterson-Riedel Maritime Services 1110 Howard Drive Deer Park, TX 77536	COM: (713) 479-5295 1-800-334-0004
Marine Pollution Control Inc. 21 21st St South Texas City, TX 77590	COM: (713) 488-3463
Clean Gulf Association 101 Holt Rd Victoria, TX 77901	COM: (512) 575-1443
Garner Environmental Service 314 Allen Genoa Rd Houston, TX 77017	COM: (713) 920-1300
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Cleanup Contractors (cont'd)

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Nueces Vacuum Services	COM: (512) 884-9642
Parkem Industrial Services	COM: (512) 289-0832
Pronto Vacuum Service	COM: (512) 449-1541
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Union Carbide Corporation	COM: (512) 552-9711
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Coastal Refining and Marketing	COM: (512) 887-4100
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The Humane Society of the U.S. 2100 L Street NW Washington, D.C.	COM: (202) 452-1100
National Audubon Society Corpus Christi, TX	COM: (512) 854-6070

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Petroleum Helicopters N Highway 35, Rockport	COM: (512) 289-5057

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SDC Service, Inc. P. O. Box 7142 Corpus Christi, TX 78415	COM: (512) 855-4551
Texas Ecologists, Inc. P. O. Box 307 Robstown, TX 78380	COM: 1-800-242-3209
Safety-Kleen Corporation 4 Mile N. of Jackson Rd McAllen, TX 78501	COM: (512) 697-8460

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Padre Island Dive Shop 7336 SPID, C. C.	COM:	(512) 851-9238
Bill Wolf Diving Brownsville	COM:	(512) 943-2980
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Portable Marine Services Inc. Pasadena, TX	COM:	(713) 472-7716
The Salvage Association Houston, TX	COM:	(713) 961-0591
Robertson Marine Sales	COM:	(512) 749-5820
Redfish Bay Terminal	COM:	(512) 758-1323
Billy Cannon	COM:	(512) 233-4833 (512) 942-2648
Homer Robertson	COM: Mobil:	(512) 749-5820 850-0499
Jed Brundrett	COM:	(512) 749-5532
Gulf King	COM:	(512) 758-5379

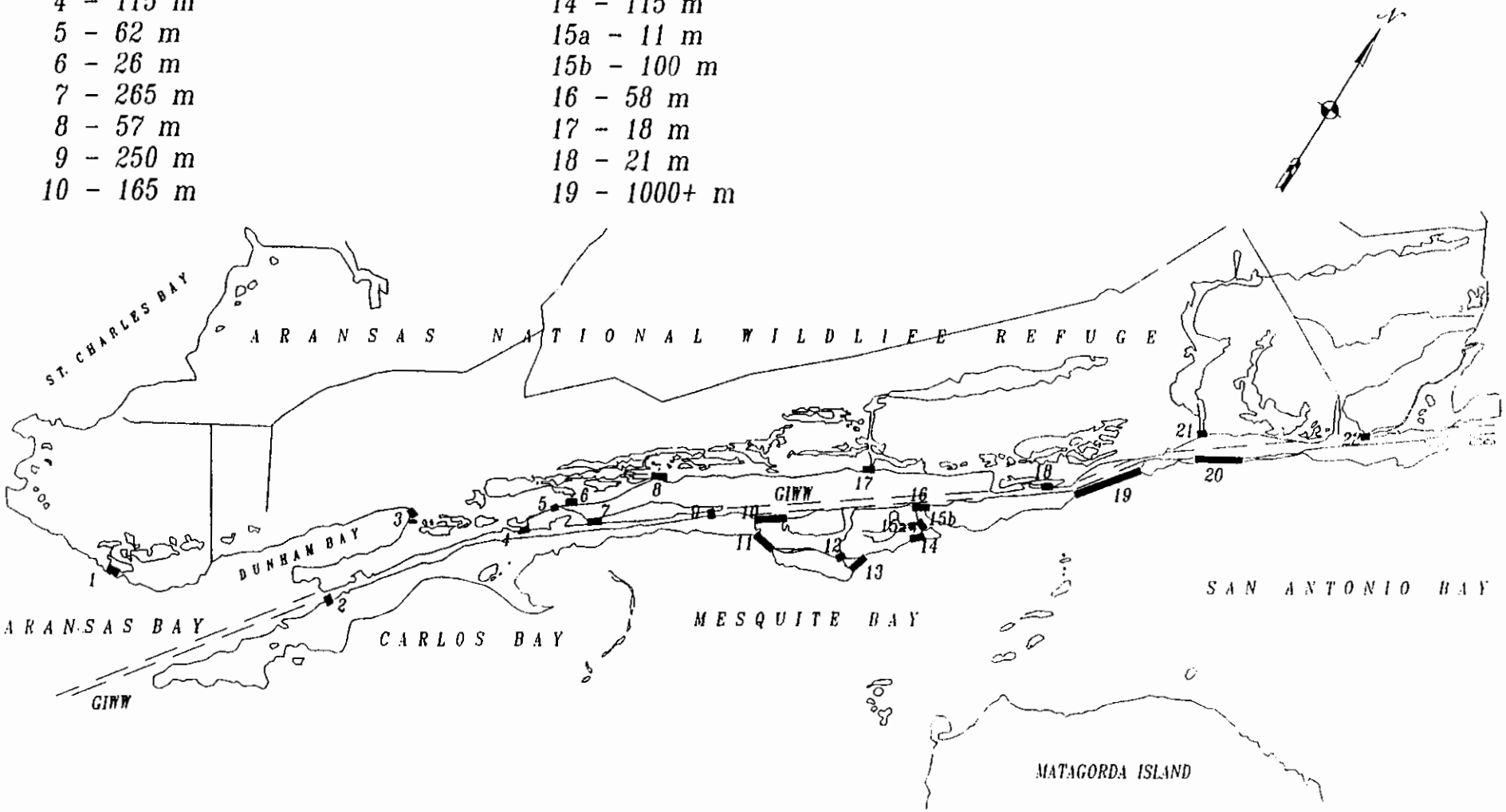
Appendix D

SIZE AND LOCATION OF CUTS BETWEEN BAYS AND MARSH AREAS IN WHOOPING CRANE CRITICIAL HABITAT

MARSH OPENINGS - OIL SPILL RESPONSE PLANNING

Boom Length/Marsh Opening (Cut) Length:
(cuts not drawn to scale)

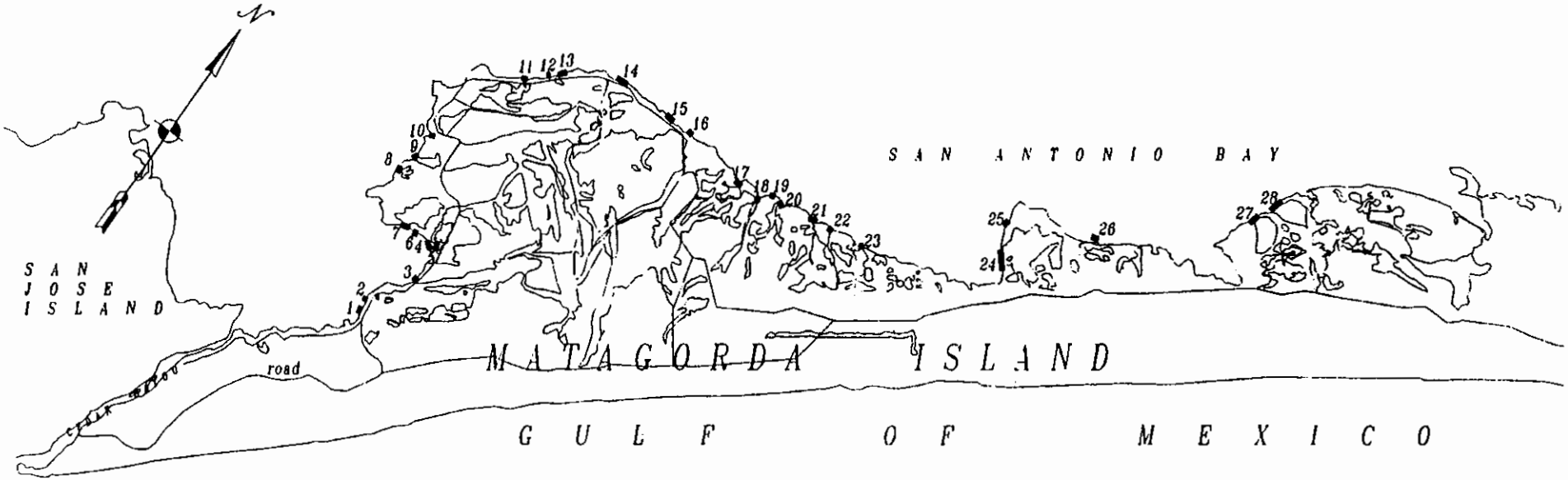
1 - 20 m
2 - 240 m
3 - two cuts, ~ 20 m each
4 - 115 m
5 - 62 m
6 - 26 m
7 - 265 m
8 - 57 m
9 - 250 m
10 - 165 m
11 - 248 m
12 - 50 m
13 - 160 m
14 - 115 m
15a - 11 m
15b - 100 m
16 - 58 m
17 - 18 m
18 - 21 m
19 - 1000+ m
20 - 1000+ m
21 - 7 m
22 - 320 m



MARSH OPENINGS - OIL SPILL RESPONSE PLANNING

Boom Length/Marsh Opening (Cut) Length:
(cuts not drawn to scale)

1 - 30 m
2 - 17 m (low spot, high tide will breach)
3 - 10 m (low spot)
4 - 30 m
5 - 35 m
6 - 22 m
7 - 45 m
8 - 145 m
9 - 52 m
10 - 20 m
11 - 25 m
12 - 19 m
13 - 45 m
14 - 5 m
15 - 60 m
16 - 40 m
17 - 30 m (side creek off cove)
18 - 110 m at mouth, 40 m at sandbar inside
19 - 110 m
20 - double cut, two openings measuring 35 m & 15 m, respectively
21 - 25 m (needed only at high tide)
22 - 143 m (3 cuts, use one continuous boom)
23 - 85 m
24 - 180 m
25 - 15 m (only needed at high tide - oyster ridge low spot)
26 - 30 m
27 - 220 m
28 - 250 m



APPENDIX A - SECTION 2

QUALITATIVE CONTAMINANT SPILL ANALYSIS

FINAL REPORT, MAY 1994

ARANSAS NATIONAL WILDLIFE REFUGE QUALITATIVE CONTAMINANT SPILL ANALYSIS FOR THE EXISTING GIWW ALIGNMENT AND AN OPEN BAY ALTERNATIVE ALIGNMENT

Prepared for

U.S. Army Corps of Engineers
Galveston District
Galveston, Texas

GULF ENGINEERS & CONSULTANTS, INC.

Engineering ■ Economics ■ Transportation Technology ■ Social Analysis ■ Environmental Planning

Gulf Engineers
& Consultants
Inc

May 1994

Final Report

Contract No. DACW64-93-D-0004
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GEC Project No. 22302303

ARANSAS NATIONAL WILDLIFE REFUGE QUALITATIVE CONTAMINANT SPILL ANALYSIS FOR THE EXISTING GIWW ALIGNMENT AND AN OPEN BAY ALTERNATIVE ALIGNMENT

Submitted to

U.S. Army Corps of Engineers
Galveston District
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Galveston, Texas

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EXECUTIVE SUMMARY

EXECUTIVE SUMMARY

This study principally reports on the outcome of discussions held by a Delphi panel brought together to compare a proposed open water channel with the existing land-locked channel of the GIWW in the vicinity of the Aransas National Wildlife Refuge, the wintering ground for the threatened and endangered whooping cranes. One outcome of the meeting was to look at an additional open bay alternative. The additional alternative is considered in this report as well as the originally proposed alternative.

Most of the panel judged the existing channel to be safer for navigation than either open bay alternative. The alternative consisting of two straight legs with a turn in Mesquite Bay was judged to have five to six times greater spill potential due to collision than the existing channel. The proposed alternative which followed the historic channel and made use of existing cuts through the reefs was judged to have a potential risk factor nine to 10 times greater than the existing channel.

The panel members felt that small spills of less than 20-30 gallons of diesel fuel or bilge pumpage were the most likely spills with small spills of several hundred gallons of fuel from a sunken shrimp boat or pleasure boat as the next most likely. The worst case spill was judged by most of the panel members to be a significant quantity of crude oil, residual oil or lubricating oil.

Environmental impacts of spills on the different alternatives were discussed without a decision on which alternative would suffer the most impact. The point was made that the whooping cranes are irreplaceable while other resources were duplicated in other areas.

It was agreed that cleanup would be more difficult in the open bay than in the existing channel with the exception that if contamination got into the shallow Sundown Bay the impacts would be quite severe.

An estimate of effects of spills was made for worst case spills at a number of sites on the two alternatives. Likely effects were estimated for the two most prominent wind/tide regimes prevailing from mid-October to late April while whooping cranes are normally resident in the area. Biotic communities affected by each spill scenario were identified and probable biological effects discussed.

Most of the panel members felt the existing alignment to be the better alternative. Their agreement was highly conditional on the ability to insure against negative impacts in the event of a spill. Several of the panel members declined to express a position on this question.

General concerns and points of comparison among the alternatives, both explicit and implicit, were evident during the panel discussion and during meetings by GEC staff with individual resource agency personnel and other informed parties. These and other factors were taken into account in Gulf Engineers & Consultants' (GEC) evaluation of the existing and alternative routes. As a result of its own deliberations GEC felt that the best course of action would be to continue to use the existing channel while seeking increased protection for whooping cranes and their habitat; particularly in the vicinity of Sundown Bay.

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ARANSAS NATIONAL WILDLIFE REFUGE, QUALITATIVE CONTAMINANT SPILL ANALYSIS

Final Report

ARANSAS NATIONAL WILDLIFE REFUGE QUALITATIVE CONTAMINANT SPILL ANALYSIS FOR THE EXISTING GIWW ALIGNMENT AND AN OPEN BAY ALTERNATIVE ALIGNMENT

I. INTRODUCTION

In June of 1992, Gulf Engineers & Consultants, Inc. (GEC) produced a report titled *Spill Contingency and Prevention Plan for the Gulf Intracoastal Waterway at the Aransas National Wildlife Refuge* for the Galveston District, U.S. Army Corps of Engineers. That study examined the most likely and worst case spill scenarios of commodities transported in barge tows on the Gulf Intracoastal Waterway (GIWW) and potential effects on the rare and endangered whooping crane and its habitat. The project area covered in that report consisted of a 31-mile portion of the existing channel of the GIWW that crosses the critical habitat of the rare and endangered whooping crane, including a 13.25-mile reach of the Aransas National Wildlife Refuge (ANWR). The southern end of the project area is located about 35 miles northeast of Corpus Christi, Texas. The 1992 report used an analysis of the types and amounts of the commodities shipped over this portion of the GIWW, a spill probability estimation procedure developed by the Minerals Management Service, and historical spill data on the GIWW to define a worst case spill and calculate the probability of a worst case spill occurring in the study region. The worst case spill was defined as the release of 10 or more barrels of crude petroleum, residual fuel oil, or lubricating oil.

The present study is a follow-on to the 1992 study cited above and draws heavily on it. The purpose of the present study is to evaluate the relative probability and effect of a contaminant spill in the existing channel alignment and in two possible alternate open bay alignments southeast of the existing channel. Because there are no previous large spills along the GIWW in the project area or along the Texas coast (except at docks) to provide a basis for statistical comparisons of land-locked and open bay navigation incidents that could cause a contaminant spill, it was decided to use a qualitative approach (the Delphi Technique) to compare the existing route and alternative open bay routes. A panel made up of knowledgeable experts from state and federal natural resource agencies, navigation and shipping interests, regulatory agencies, spill response agencies, and the Corps of Engineers was convened and charged with judgmentally determining the relative probability, probable locations, and most likely and worst case scenarios for a spill occurring along the three routes.

Drawing on the 1992 study, input from the Delphi panel, and other sources, a qualitative impact analysis of the most probable and worst case spill events for the various alignments was carried out. The analysis includes a study of spill direction of movement, biological impacts on the ecosystem, and practicality and impacts of recovery and cleanup. Comparison of alternatives is restricted to the geographic areas that fall within the points of divergence of the alternate routings. To provide for both comparison and continuity, maps and discussion concerning the projected dispersion plumes and effects of wind and tide conditions for spill locations on the existing channel are included from the 1992 GEC Report. The same methodology and assumptions used in that report to project oil spill plumes and impacts are used in this effort. Finally, the routing alternatives are

evaluated in terms of their overall positive and negative qualities, particularly with respect to their probable effect on whooping cranes.

II. ROUTING ALTERNATIVES

The routing alternatives that serve as the basis for this evaluation are the existing channel alignment and two open bay alternatives (Figure 1). The first open bay alternative was designed by the Corps of Engineers. The second open bay alternative was designed by GEC on the basis of comments made during the panel meeting to consider the effects of a straighter channel.

Existing Channel

The existing channel of the GIWW is a fairly straight land-locked route that passes through the area of the ANWR where the residual flock of less than 20 whooping cranes were concentrated in the 1940s. This is still the area in which they are most heavily concentrated.

Open Bay Alignment 1

Open Bay Alignment 1 follows as much as possible a route that was in use before the present land-locked alignment was dredged. It makes use of a number of natural previously dredged cuts or passages through existing oyster reefs that trend approximately north-south across Carlos Bay, Mesquite Bay, and Ayres Bay. Traversing from one pass or cut through a reef to one in the next reef requires a number of direction changes that typically are made near the easterly or westerly sides of the reefs. The Delphi panel judged this alternative to be very difficult to navigate safely. Consequently, a second alternative was explored that removed the hazards of multiple turns.

Open Bay Alignment 2

Open Bay Alignment 2 consists of two straight legs with a turn in the middle of Mesquite Bay. New passages through the oyster reefs would need to be dredged under this alignment alternative.

III. DELPHI PANEL

Panel Inputs

Persons participating in the Delphi panel were sent a packet of background materials in preparation for the meeting. The background material for the Delphi panel included the following: a copy of the 1992 GEC report; a copy of the letter informing them of the questions/concerns to be addressed in the meeting; a study area map showing several likely spill sites on the proposed alternative (Open Bay Alignment 1) open bay route; commodity tonnages shipped through the study area; a classification of commodities by the impact potential; wind roses showing prevailing and frontal passage wind directions; and a preliminary spill analysis for the likely spill sites on Open Bay Alignment 1. The purposes of these materials were to both focus and inform the discussion while still leaving the panel members free to explore any questions they thought pertinent. A copy of the information packet contents is included as Attachment 1 to this report.

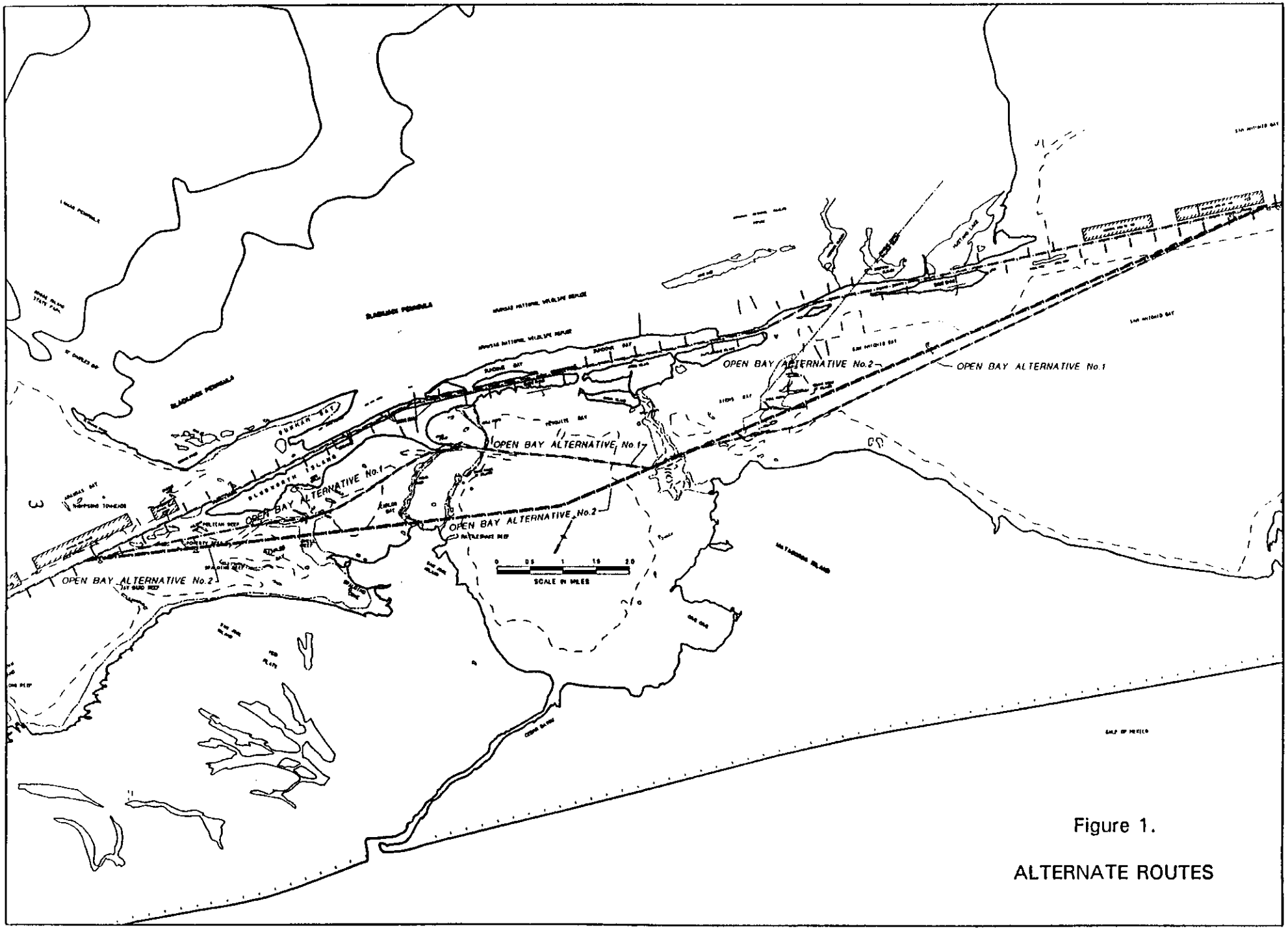


Figure 1.

ALTERNATE ROUTES

Seven questions were posed to panel members in advance letters and in the information packet:

1. In what places are spills most likely to occur in the existing alignment and in the open bay alignment?

2. What is the relative probability of a spill occurring in the existing channel alignment versus the open bay alignment?

3. Is one alignment more dangerous than another in terms of the quantity of any particular commodity that could be spilled?

4. What is the most likely spill in the two alignments?

5. What is the worst case spill in the two alignments?

6. What would be the environmental effects of the worst case spills for the two alignments?

7. What are the potentials for containment and cleanup of the worst case spills in the two alignments?

The Delphi panel identified the average most likely spill as being a spill of 20-30 gallons of diesel fuel or bilge pumpage from a shrimp boat, crew boat, or pleasure yacht. Spills making up this average could range from a few gallons to several hundred gallons of fuel (in the unlikely event that a shrimp boat or pleasure boat sank in the area). Spills of this nature were discussed in the 1992 GEC report, and literature was cited (Martens, 1976) that indicated little environmental damage was likely from small spills such as these. After discussion of a number of possibilities, it was agreed by a number of the panel members that the most likely worst case spill would be one involving crude oil, residual fuel oil or lubricating oil from a barge collision. This is the same worst case identified in the 1992 GEC report. Accordingly, the same model has been applied to likely spill locations in the two open bay alternatives in order to describe the actions of such a spill under the same wind/tide conditions used in the 1992 study. Using the outcomes of this analysis, qualitative descriptions were prepared of likely environmental effects on the different biotic communities impacted under the various scenarios. The descriptions of likely spills is presented in Section IV. *Worst Case Spill Scenarios*. Descriptions of the biotic communities in the area subject to impact by worst case spills and the effects on these various communities of a worst case oil spill are described in Section V. *Environmental Impact*.

Meeting Summary

A meeting was held at the Marriott Hotel in Corpus Christi, Texas, on December 7, 1993, to discuss the relative risk of barge spills on the existing GIWW alignment in the vicinity of the Aransas National Wildlife Refuge versus an alternate open bay alignment south of the existing channel. A panel of experts was assembled to make this determination because of an absence of historic data on spills in open bay situations along the GIWW. Other issues that were to be

addressed by the panel included probable spill site, spill quantities, most likely and worst case spills, environmental effects, and potentials for containment and cleanup.

The panel members in attendance were as follows:

Captain Jay Reining -- U.S. Coast Guard

James Randall -- Texas Department of Transportation

Duke Mroz -- Texas General Land Office

Terry Roberts -- Galveston District Corps of Engineers

Billy Harper -- Hollywood Marine

Brent Giezentanner -- Aransas National Wildlife Refuge

Roy Perez -- U.S. Fish and Wildlife Service

Tom Stehn -- Aransas National Wildlife Refuge

Neil McLellan -- Galveston District Corps of Engineers

Johnny French -- U.S. Fish and Wildlife Service

Leo Braun -- Dixie Carriers

Ken Rice -- Texas Parks and Wildlife Department

Others in attendance were:

Bill Kasparek -- U.S. Coast Guard

Kelly Roberts -- U.S. Coast Guard

Jacques Bagur -- Gulf Engineers & Consultants, Inc.

Jim Hoover -- Gulf Engineers & Consultants, Inc.

Mike Loden -- Gulf Engineers & Consultants, Inc.

The first question that was addressed in the discussion concerned the most likely places for spills on the existing GIWW channel and the alternative open bay alignment within the confines of the points where the channels diverged. There was general agreement that the existing channel did not have any particular places that posed unusual difficulties, but that if a collision were to occur anywhere, it would probably be at the entrances to the land-locked portion of the channel. For the open bay alignment, there was general agreement that the greatest potential for collisions and spills would be at turns in the channel where there were reefs, that the potentials would exist on either side of the reefs under either of the two prevailing wind conditions, and that a spill would probably involve a collision between a loaded barge and an empty, wind-driven barge.

Throughout this discussion, the resource agency panel members usually deferred to the panel members who were knowledgeable about barge transport and safety. However, an objection was raised to the numerous turns in the open bay alignment design, since these produced the most likely circumstances for collisions. It was explained that the alternate alignment was designed to minimize environmental damage by making maximum use of existing passes through the reefs. The panel

requested that GEC provide a supplementary analysis involving a broad open bay channel alignment that would minimize turns. This supplementary analysis is included in the present report.

With respect to the relative potential for a collision in the existing channel versus the open bay alignment, there was general agreement that the existing channel is safer because it is fairly straight and offers protection from the wind. The open bay alignment would be more dangerous because of winds, the long unprotected distances involved, the inability of empty barge tows to get off-channel to avoid loaded tows or oncoming empty tows in difficult circumstances (because the open bay is shallow and contains mud and reefs), currents, shoaling that would be exacerbated by the inability to maintain constant dredging because of the presence of birds, difficulties in maintaining aids to navigation (which are easily knocked off position by empties in windy circumstances), and the need to maintain greater speed for control under windy conditions, which would increase the severity of accidents.

Panel members were asked to give a number rating for the spill potentials on the existing channel, the original open bay alternative (Open Bay Alignment 1), and the modified open bay alternative (Open Bay Alignment 2) involving straightening the design. Some of the resource agency panel members were reluctant to pose numbers, pointing out that the unpredictable often happens and that it is alright to increase the potential for a spill if the potential for damage from a spill was decreased. There was general agreement that straightening the open bay alignment would reduce the chance of a spill, particularly if a very wide channel were to be constructed, but that because of the wind factor (primarily), it would still be more dangerous than the existing channel. According to the panel members who responded to this question, which included most of them, the relative chance of a spill would be 9-10 times greater in the open bay alignment as originally proposed than in the existing channel and five to six times greater in the modified open bay alignment than in the existing channel.

The third question addressed was whether there could be any differences in the quantities that would be spilled in an open bay collision versus the existing channel. There was little comment on this question, but a general consensus emerged that there would be little or no difference as far as barges were concerned. The point was made that the concrete mats on the edge of the GIWW in the Aransas Refuge do not present a hazard because they generally cannot be reached by loaded barges, and even if they could be reached by empty barges, the mats would simply be pushed down into the mud.

The discussion during this period centered on the potential for explosions and the problem of chronic, small spills from shrimp boats and pleasure boats. Questions with respect to the potential for explosions and attendant damage were generally answered in terms of the unlikelihood of such an occurrence given present transport storage technology and the strong likelihood that any blast effects would be directed upward with little horizontal impact.

ANWR panel members objected to the concentration on barge spills in GEC's original report and suggested that smaller spills from collisions or simply improper practices on the part of small vessel operators could have a significant impact on the resources under their jurisdiction. Although there was general agreement that small vessel operators pose greater hazards, discussions with respect to the relative risks of small spills in enclosed channels versus open bay channels were inconclusive.

The next question concerned the most likely spill commodity, which appears to be determined by the commodity most commonly carried. Again, however, the discussion quickly shifted to small spills and the relative likelihood of their occurrence in different areas. Although there was some agreement that small spills would most likely involve diesel fuel rather than gasoline, the problem of relative risks was unresolvable because of the lack of data on small vessel discharges and on spills involving small vessel collisions in closed channels versus open bay channels.

The fourth issue addressed by the panel concerned the most probable worst case and worst conceivable worst case. There was considerable discussion about the meaning of terms and the appropriateness of such categories. Although it would be inappropriate to say that there was a consensus in this area, three primary points emerged. If probability of occurrences alone is taken into consideration, the worst case would be the sinking of a shrimp boat with a possible fuel spill of several hundred gallons. Some panel members, particularly the navigational interests, stated that oil would be the worst case spill. Resource agency panel members were much more concerned with any commodity that might be persistent or have long-term effects on the habitat or food chain. Benzene and toluene were suggested as possibme,but objections were raised with respect to the technical possibility of spillage. The point was also made that if a chemical entered the food chain through an open bay spill, it would have the same impact as a similar spill in the existing channel.

The discussion on the fifth issue, environmental impact and cleanup, was conducted in general terms with respect to different geographic areas. There was widespread agreement that the whole area is filled with valuable resources; but the point was made that all resources other than the whooping cranes were replaceable. The ANWR panel members emphasized the critical concentration of cranes in the area immediately north of the existing GIWW channel and were particularly concerned about a spill that would get into Sundown Bay.

There was general agreement that cleanup in the open bay would be more difficult than in the existing channel; but again, differential impact was emphasized. The point was then made that under certain conditions the critical habitat of the whooping cranes could be affected adversely by a spill in the open bay because of the amount of time that would be needed to get men and equipment to the spill site and the difficulty of operating in very shallow water. It was also suggested that technological measures are available for protecting the critical habitat that are much less costly than building a new channel.

One panel member then asked the other panel members if they would be willing to summarize their opinions about the existing channel versus the alternatives. There was an objection to any formal voting, and the point was made that there are many issues other than spill potential that would need to be taken into consideration in reaching a decision. For those willing to take a position there was a consensus in favor of the existing channel, but with the introduction of additional safety measures.

IV. MOST PROBABLE WORST CASE SPILL SCENARIOS

As noted earlier the present report draws on the methods and findings of the 1992 report. The discussion of the effects of likely weather and tide conditions on oil spill plume dispersion is excerpted from that study and reprised below.

Weather and Tide Conditions

Lunar tides in the Gulf of Mexico along the coast of Texas are of the mixed type, having two unequal high waters and/or two unequal low waters each tidal day. The range between high and low each tidal day is less than two feet. Tidal flow into and from the Gulf of Mexico and embayments in the vicinity of ANWR is restricted by the narrow flow channel (Cedar Bayou) between the barrier islands of San Jose and Matagorda. The directional orientation of tidal flow in the local embayments on a falling tide is southwestwardly (parallel to the coastline, towards Cedar Bayou and Aransas Pass), but the minor fluctuation in water surface elevations from lunar tides does not cause strong currents in the GIWW and is not a major problem in pollutant spill damage control or in erosion control at the ANWR.

Tidal surges or storm tides associated with tropical cyclones (hurricanes) in the Gulf of Mexico landfalling in the vicinity of Aransas could have a profound effect on water levels, soil erosion, and the dispersion of spilled floatable pollutants into the sensitive coastal marsh environment. Hurricane landfall in the vicinity of Aransas occurs infrequently, and then usually in late summer or very early fall. The potential for hurricane landfall is minimal after arrival of cooling fall weather (about mid-October). The whooping cranes in the study area are over-wintering migratory birds. Hurricanes are not a significant threat to these whooping cranes because they do not ordinarily arrive at Aransas until after the hurricane season is past.

Ordinary and storm-related winds are the predominant weather factors influencing tidal stages, flows, and wave heights. Thus, they are the most important factors in considering the fate of any pollutants that would be spilled in a navigation accident. Mean monthly windspeeds in the Corpus Christi area during October exceed 10 mph, gradually increasing through the fall and winter to over 14 mph in April. (Wind roses are presented in the information sent to panel members, see Attachment 1).

The available climatological data indicate that if a pollutant spill occurs on the GIWW in the vicinity of the ANWR during October through April when the whooping cranes are in residence, the most likely weather conditions will be brisk southeasterly (onshore) winds, about 10-14 mph, coming from the southeast and south-southeast. These prevailing winds would cause "high-tide" conditions, and mud flats in the vicinity of ANWR would be flooded.

The second most likely weather condition for a spill event is brisk northerly winds incoming from between True North and 22.5^0 N. When brisk "northers" are blowing, water is blown out of the embayments, and "low-tide" conditions can be expected, exposing mud flats in the vicinity of the ANWR.

Westerly winds and calms would be preferred conditions in the event of a spill, but unfortunately these conditions occur infrequently in the area. Whereas prevailing onshore winds are driven by solar heat, "northers" by arctic high pressure systems, and easterly winds by approaching weather fronts, a driving force for westerly winds is generally absent in the area. The quarterly wind roses for Corpus Christi indicate clearly that westerly winds seldom occur, and the velocity of westerly wind is quite mild (3 to 6 mph) in comparison to the strong onshore and northerly winds, which often exceed 16 mph.

Existing Channel

Site No. 1 (San Antonio Bay Northeast of Mustang Lake--Figures 2 and 3)

Scenario A: Wind from Northeast

A worst case spill occurring on the GIWW in San Antonio Bay northeast of Mustang Lake would be difficult to contain because of the wave heights encountered in open waters on either prevailing or northerly winds. However, with northerly winds the plume would spread over open waters as indicated in Figure 2. The nearest habitat areas in jeopardy to the south would be at Ayres Point. These features are four or more miles distant from the site, and damage at this location, if any, would be minor and likely limited to the presence of some tar balls or mousse.

Scenario B: Wind from Southeast

The same difficulty in containing spills due to wave heights in open water would be encountered in this scenario as that above. The nearest habitat areas in jeopardy to the northwest would be the marshes at Webb Point, four or more miles away. As in the case of northerly winds at this location, the minor damages expected would be limited to the presence of tar balls and mousse (see Figure 3).

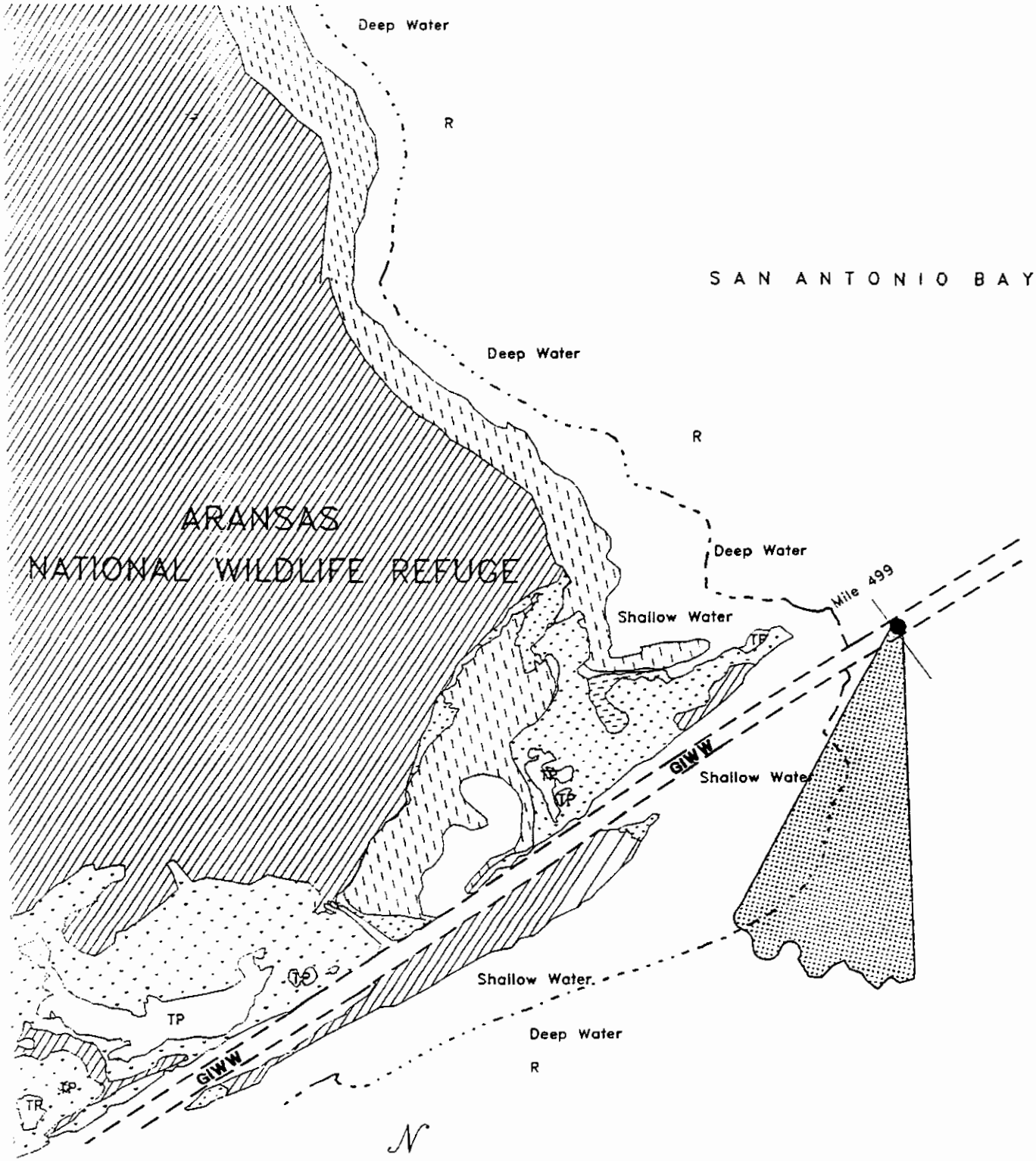
Site No. 2 (Near Wynne's Cut Area Across From Sundown Bay--Figures 4 and 5)

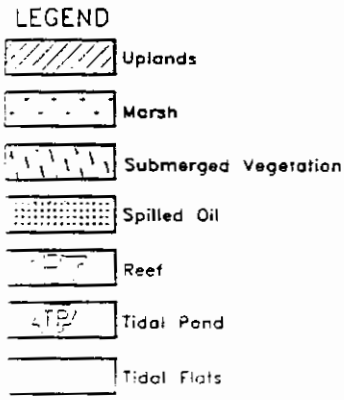
Scenario A: Wind from Northeast

The consequences of a spill on strong northerly winds are shown in Figure 4. Uncontained oil could coat easily accessible banks along the bay side of the existing navigation channel and the west side of Wynne's Cut. If oil escapes before booms can be placed, most of the fugitive oil would be pushed out of Wynne's Cut and into open waters by the northerly winds and falling tide currents.

Scenario B: Wind from Southeast

A worst case spill occurring at Wynne's Cut on prevailing winds with high tides could result in some habitat damage even if containment booms were installed rapidly. Prevailing winds would blow oils directly toward submerged vegetation and marsh banks along the northwest shore of Sundown Bay as shown in Figure 5. Travel distance to the nearest marsh banks is less than a half-mile. Uncontained oil could then spread slowly along the shoreline of Sundown Bay, in both directions perpendicular to the winds. It would be necessary to block littoral migration by placing portable booms anchored on shore and extending perpendicular to the shore out into Sundown Bay. Jon boats may be needed for access across this shallow bay.





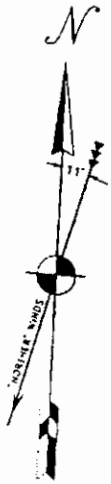
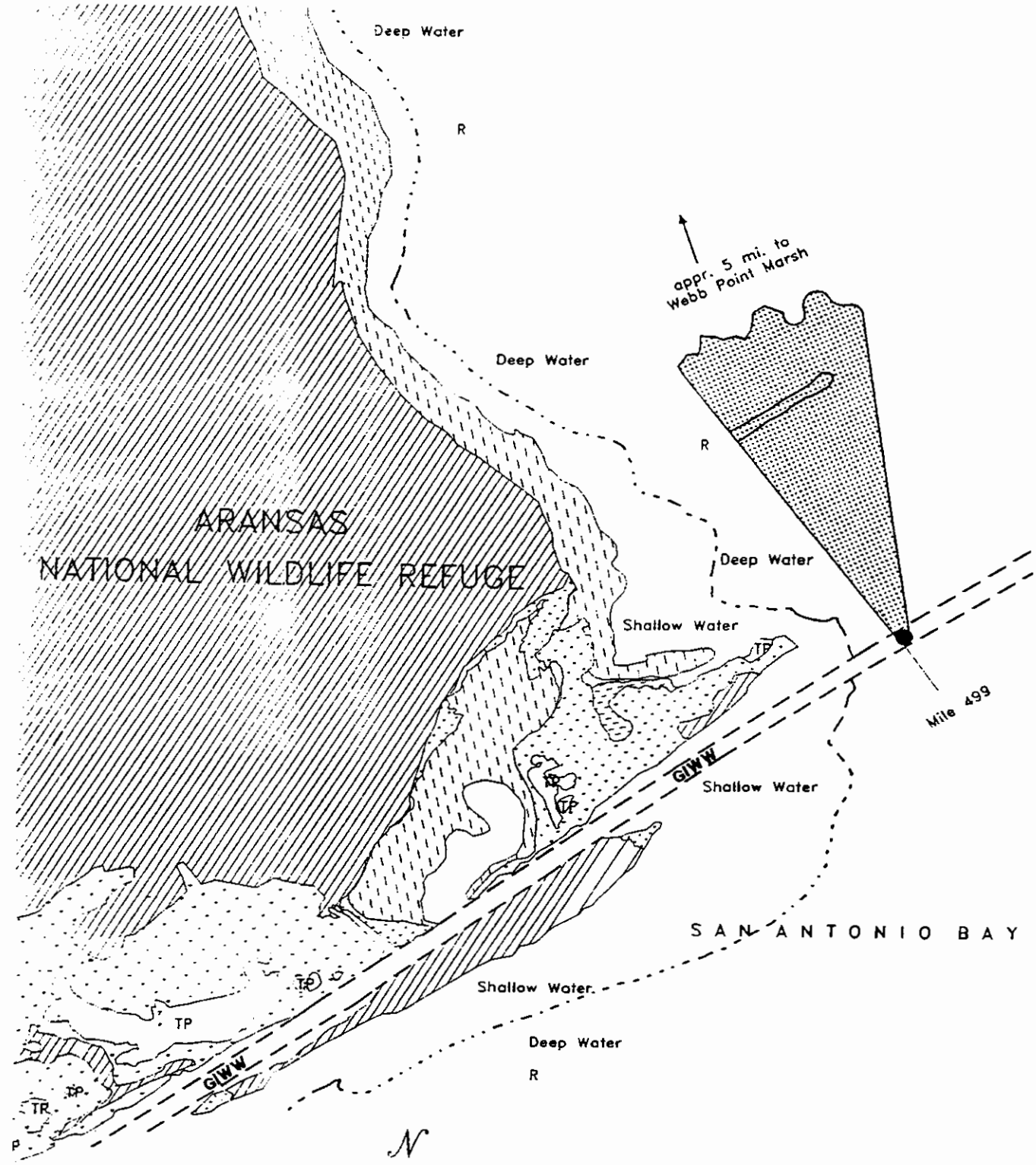


Figure 2

MAP

OIL DISPERSION PLUMES
GIWW NORTHEAST OF MUSTANG LAKE
NORTHERLY WINDS

SCALE 1:24,000
0 0.5 1 MILE



LEGEND

- Uplands
- Marsh
- Submerged Vegetation
- Spilled Oil
- Reef
- Tidal Pond
- Tidal Flats

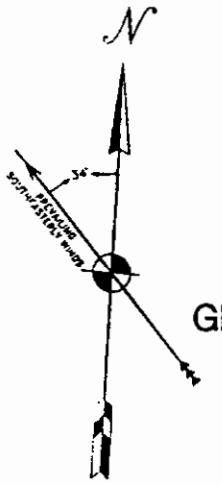


Figure 3

MAP

OIL DISPERSION PLUMES
GIWW NORTHEAST OF MUSTANG LAKE
PREVAILING WINDS

SCALE 1:24,000

0 0.5 1 MILE

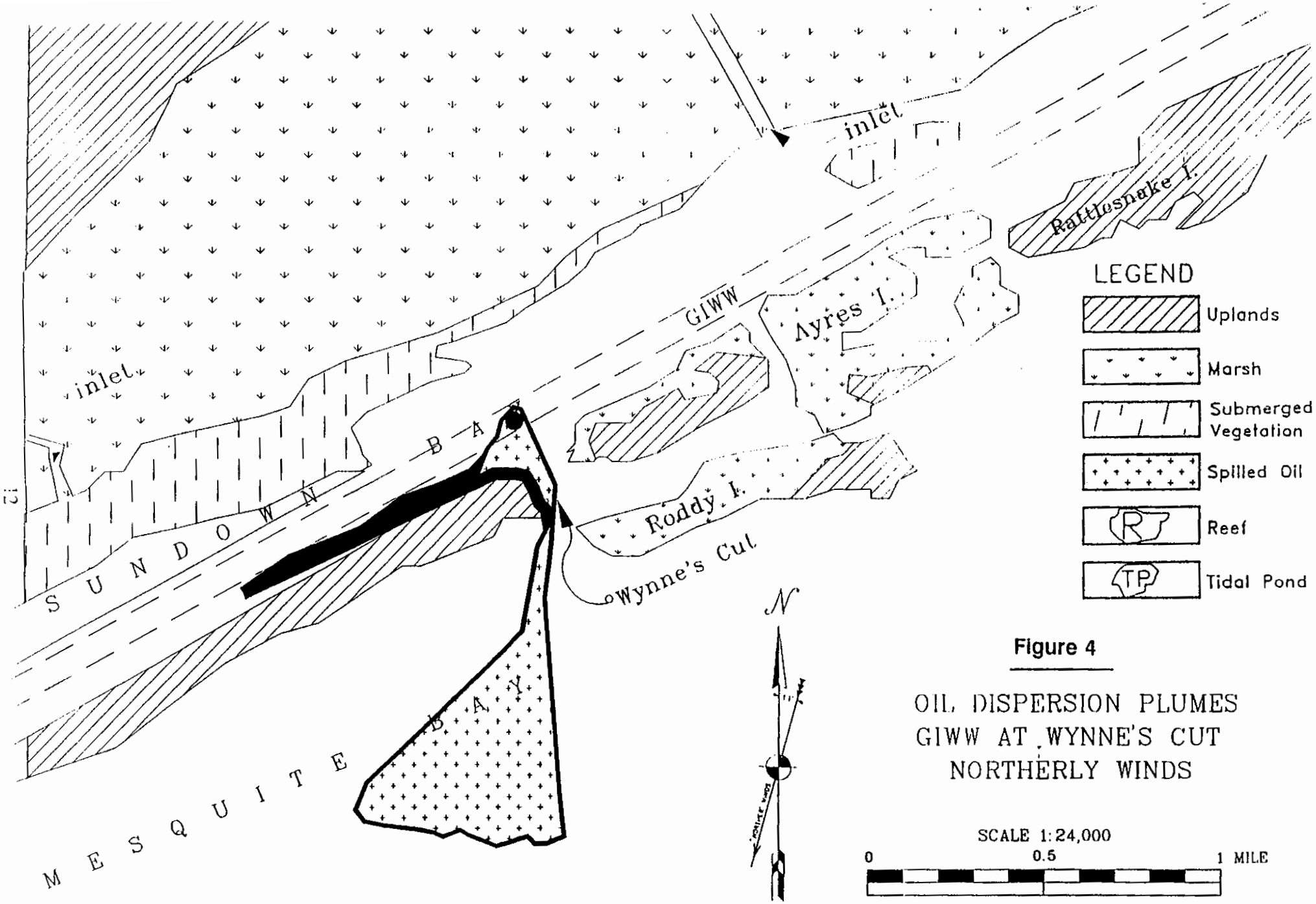


Figure 4

OIL DISPERSION PLUMES
GIWW AT WYNNE'S CUT
NORTHERLY WINDS

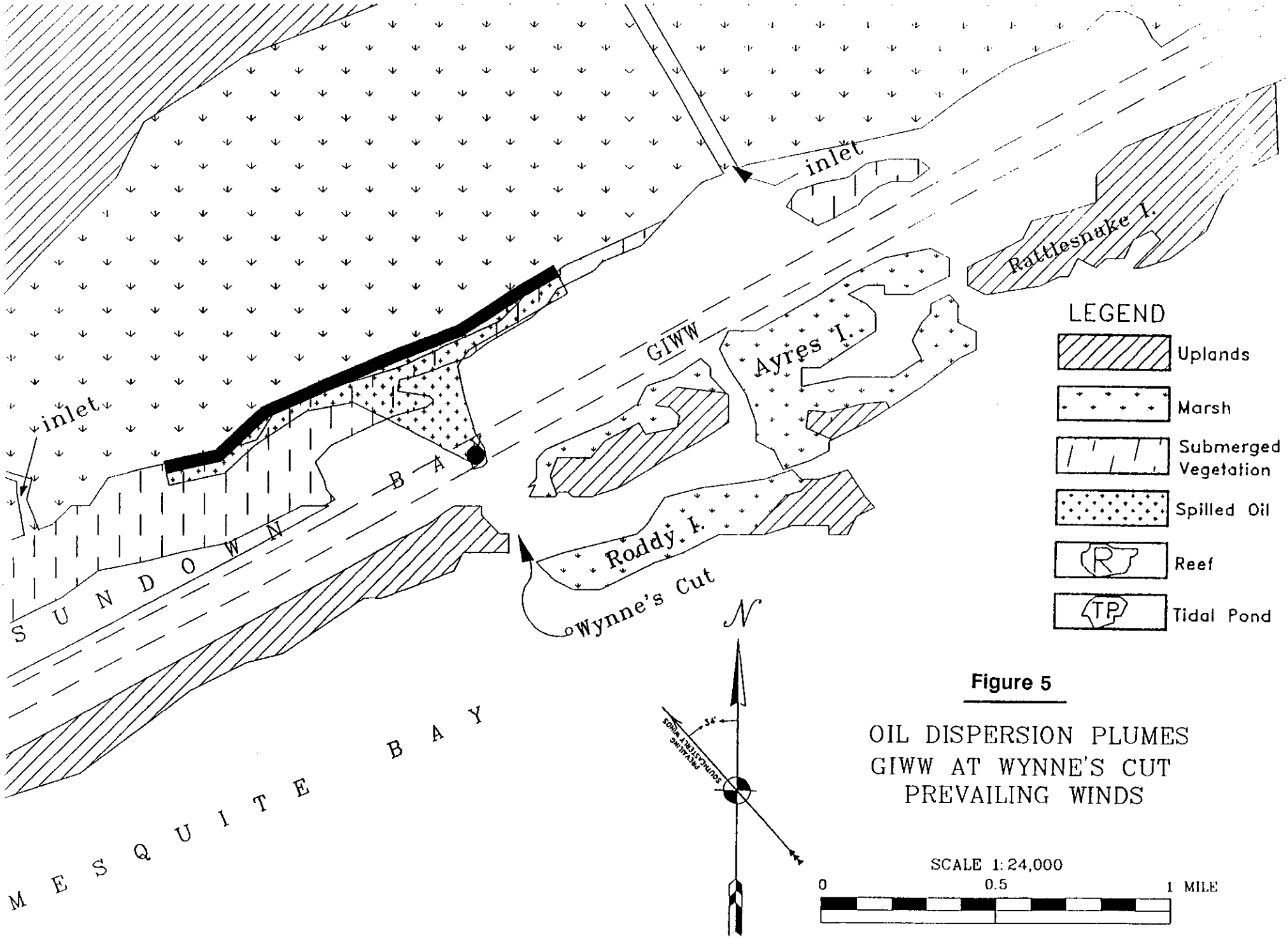


Figure 5

OIL DISPERSION PLUMES
GIWW AT WYNNE'S CUT
PREVAILING WINDS

Although there is a cut in the marshes leading to tidal ponds about a mile northeast of the site, it is unlikely that fugitive oil would move that far before the spill could be contained by portable booms. Nevertheless, floating booms would need to be used to block oil ingress through this cut as soon as possible to prevent even more serious habitat damage. If the oil could not be contained near the spill site, booms could be placed perpendicular to the Sundown Bay shoreline to minimize the area damaged. About 10 acres of submerged vegetation and about a mile of marsh banks could be damaged, some quite severely. If whooping cranes were feeding in the area and were not deliberately and continually frightened away, they could be exposed to a fatal oil coating.

Site No. 3 (Aransas Bay Near Mile 515--Figures 6 and 7)

Scenario A: Wind from Northeast

A spill occurring at mile 515 on a norther would probably cause problems at Long Reef, about two miles south of mile marker 515. Tide levels are ordinarily low during a norther, and the reef would act as a trap for undispersed oils. The reef banks downwind of the spill could be fouled. Although the area is accessible and would be easy to clean, some damage to crane habitat could occur. This situation is shown in Figure 6.

Scenario B: Wind from Southeast

A worst case spill in Aransas Bay near mile 515 would be difficult to contain because of high waves normally encountered with prevailing winds from the southeast. These winds would blow spilled oil into open waters toward Goose Island (over three miles away), and the marsh and tidal flats at Blackjack Point (2.4 miles downwind) would be in jeopardy (tar balls, mousse, etc.). The situation is illustrated in Figure 7.

In this situation, crane habitat would not be seriously damaged. If the spill occurred closer to Blackjack Peninsula, more of the marsh banks and tidal flats would be damaged, and the damage would be greater because the shoreline would be closer to the spill site. If the accident happens further to the southeast beyond Long Reef, crane habitat would not be endangered.

Open Bay Alignment 1

Site No. 1 (Second Chain of Islands--Figure 8)

Scenario A: Wind from Northeast

Tides under this situation are typically very low. The natural area at this site has a depth of three feet (plus or minus). Thus, loaded barges would be confined to the channel. An oil spill would probably involve one compartment, since reef sheer or crushing should not be a problem. Under

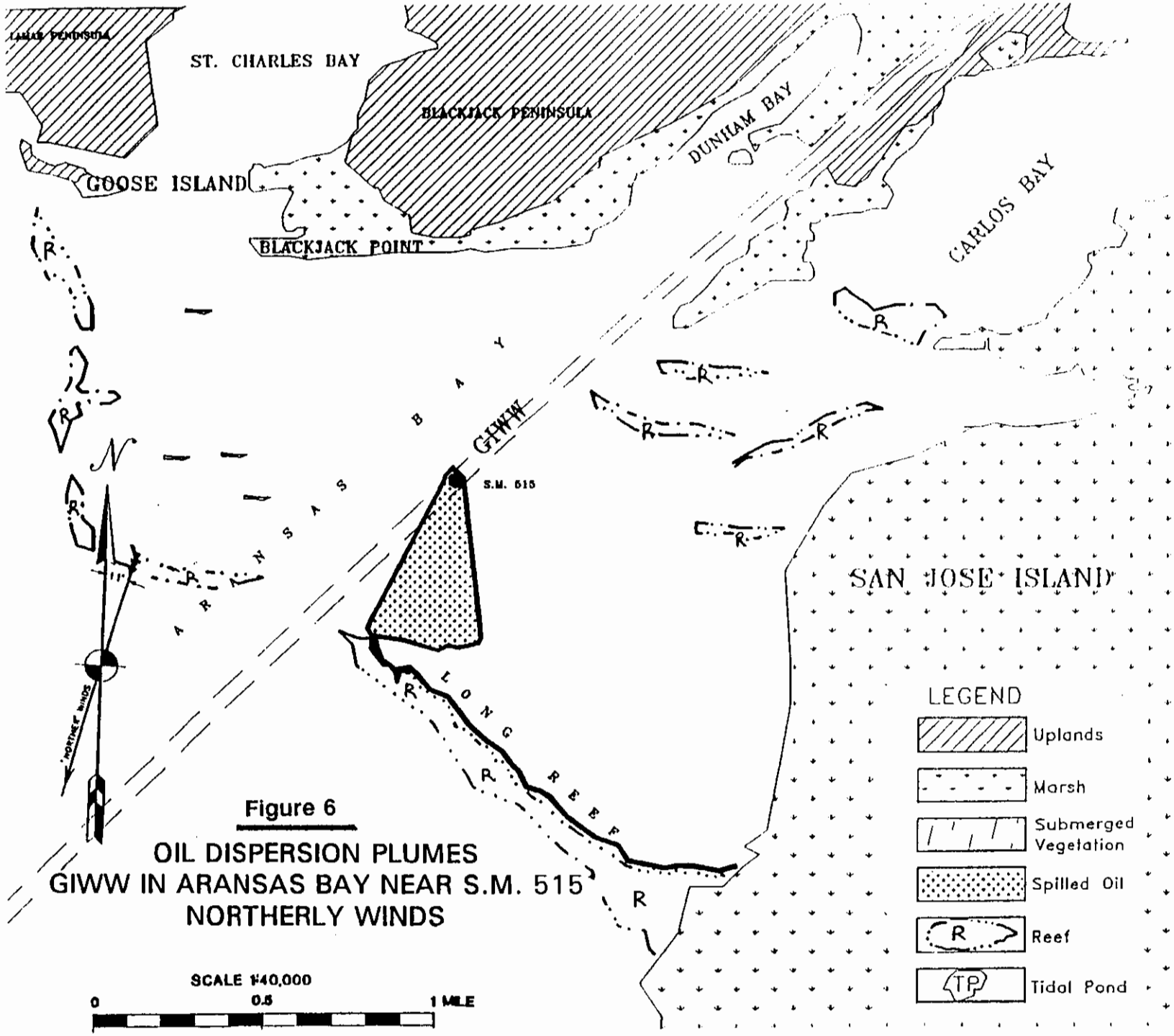
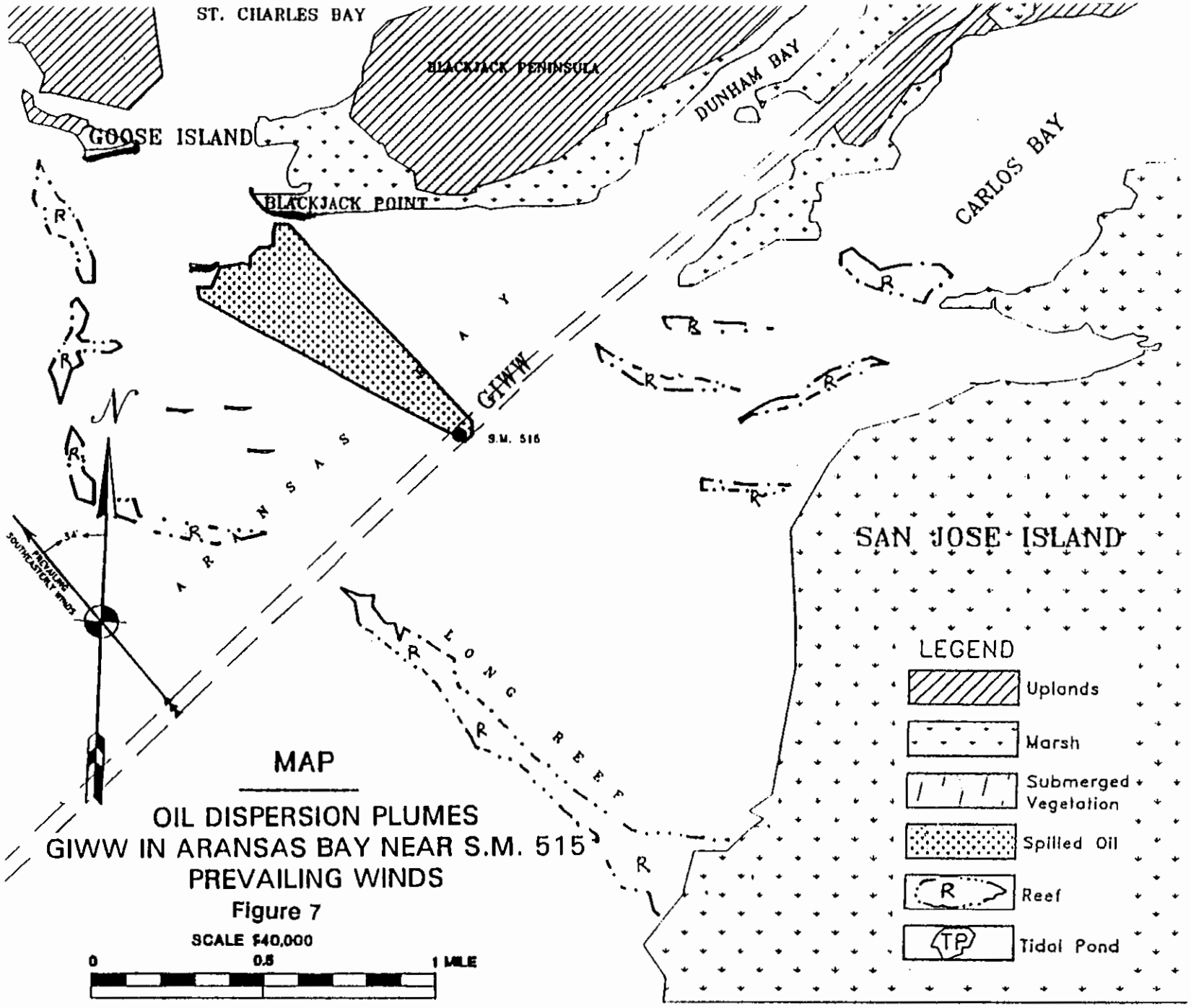


Figure 6

OIL DISPERSION PLUMES
GIWW IN ARANSAS BAY NEAR S.M. 515
NORTHERLY WINDS



MAP

OIL DISPERSION PLUMES
GIWW IN ARANSAS BAY NEAR S.M. 515
PREVAILING WINDS

Figure 7

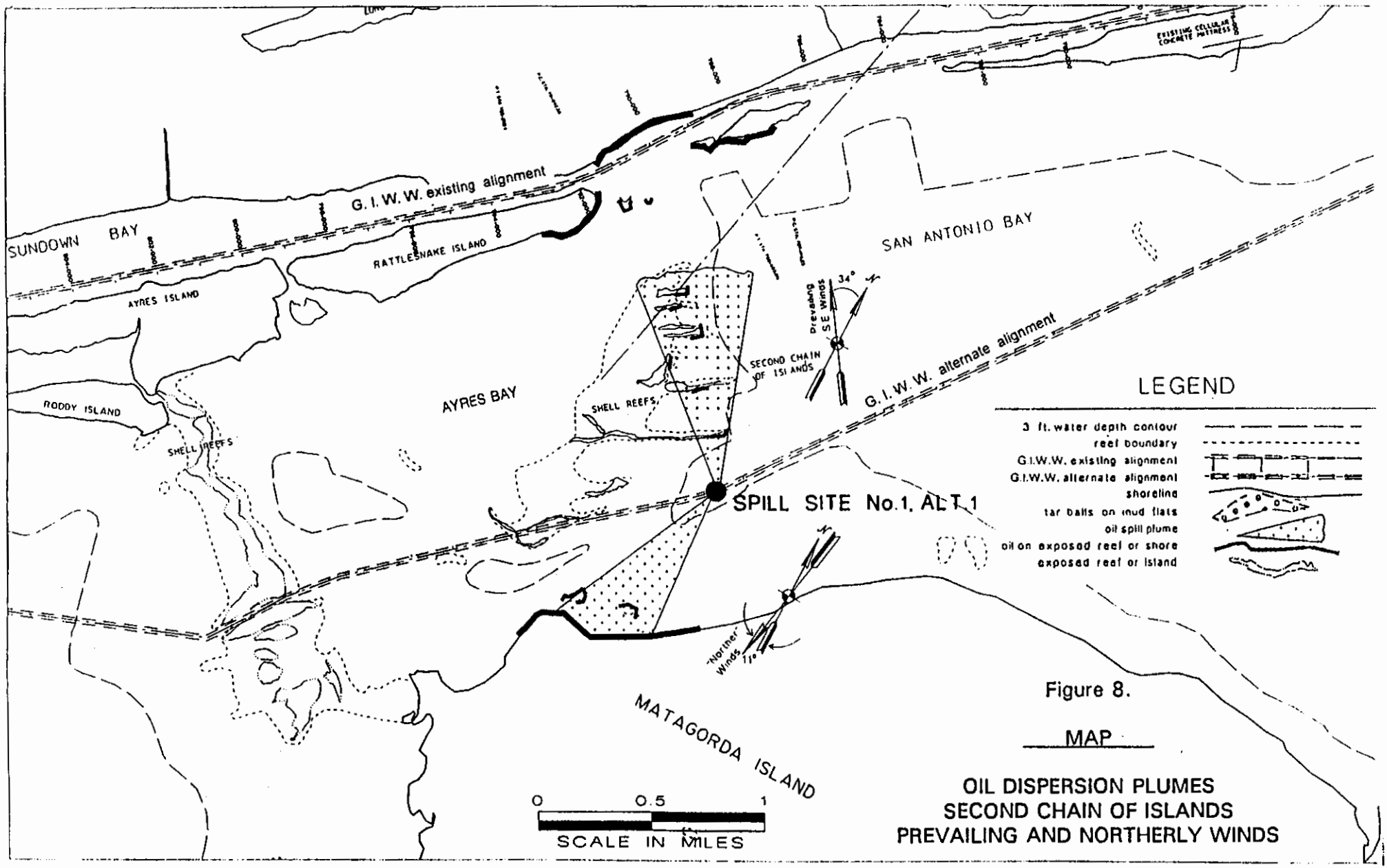


Figure 8.

MAP

OIL DISPERSION PLUMES
SECOND CHAIN OF ISLANDS
PREVAILING AND NORTHERLY WINDS

these circumstances, shallow water to the south would be comparatively unobstructed for about one-half mile, and then shallow bands of exposed reef would be encountered. Oils would stick to a wide band of exposed bank, and the rest would be blown southwestward toward the lower end of Ayres Reef, which is exposed at low tide, where the rest of the oil would be trapped.

Scenario B: Wind from Southeast

This is typically a higher tide situation. Only small parts of the shell reefs of the Second Chain of Islands would be exposed, but the exposed parts could become oil coated. Winds would tend to blow the oil toward the pass about 1.2 miles away at the northeast end of Rattlesnake Island. The oil slick should be well broken up by landfall, but tar balls and oil would deposit at the high tide level on the southeast shore of Rattlesnake Island and the spoil area northeast of Rattlesnake Island. Some tar balls could be carried on high tide through the pass and into the marshes beyond the existing GIWW channel, unless an oil boom was placed promptly to block floating oil at the pass.

Site No. 2 (Southeast Edge of Ayres Dugout--Figure 9)

Scenario A: Wind from Northeast

Under this low tide condition, the oil plume would tend to disperse in the open water of Mesquite Bay toward Cedar Bayou. Some tar balls would be deposited on mud flats near Cedar Bayou that would be exposed at low tide.

Scenario B: Wind from Southeast

Under this high tide situation, there may be a danger of greater spill volume, since reef at the edge of the channel could cause shearing or cracking of a barge hull. Some oil may coat the exposed parts of Ayres Reef, but the water would be high enough to prevent much reef coating. With less than a mile of open water to the southeast shore of Roddy Island, the high tide shore should be significantly affected. Some oil would probably also deposit on Ayres Island, but it is not likely that much would go through the pass between Roddy Island and Ayres Island, even if it were not boomed.

Site No. 3 (Southwest End of Cedar Dugout--Figure 10)

Scenario A: Wind from Northeast

The left flank of the oil plume would be blown against the west side of Cedar Reef, which is well exposed on low tide. The exposed edge of the reef would be heavily coated with oil. Most of the plume would be blown out into Carlos Bay. Although the plume would probably be broken up and dispersed, tar balls and some oil would probably coat the exposed shallow bottoms and the shell reef at the northwest side of San Jose Island.

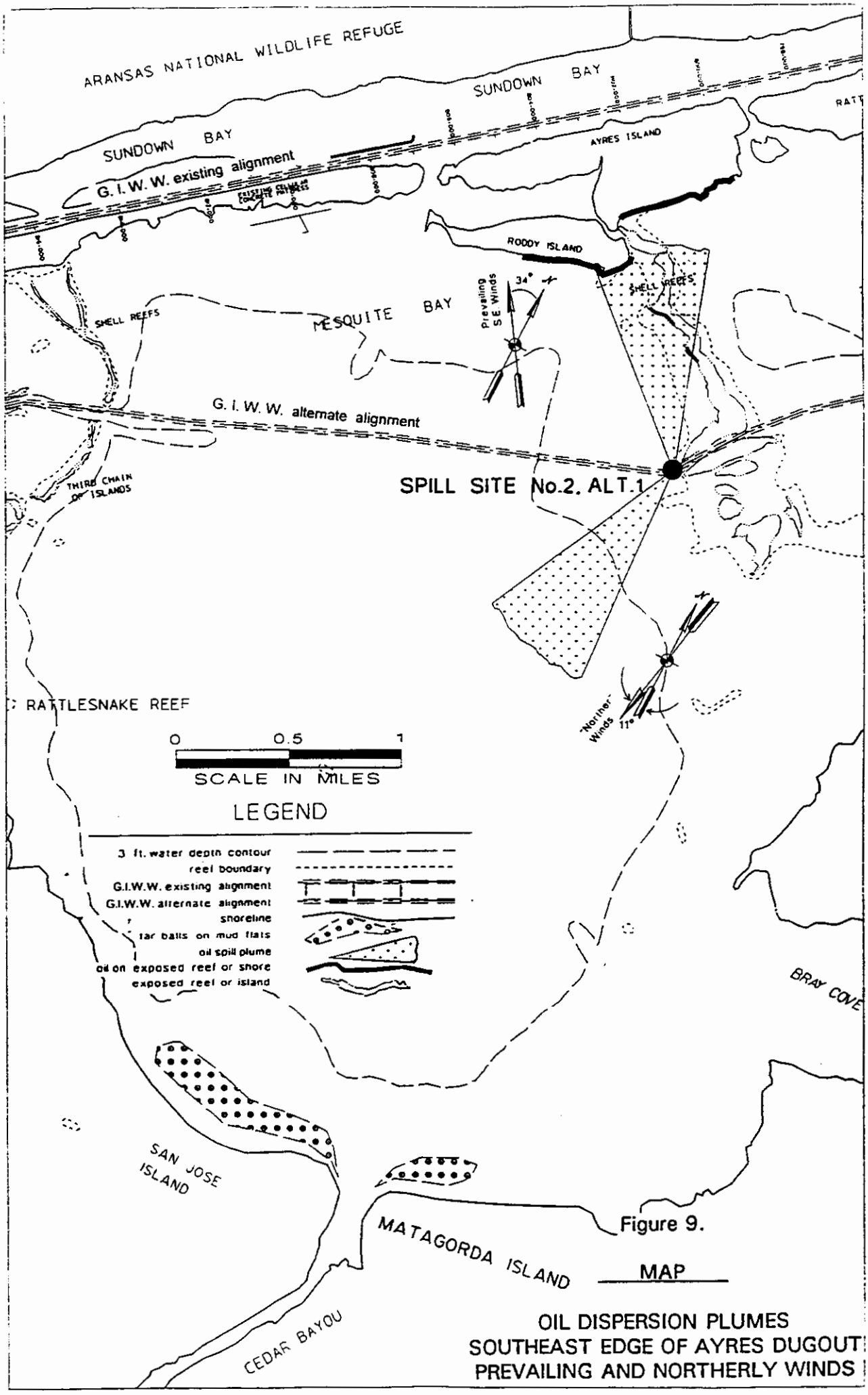


Figure 9.

MAP

OIL DISPERSION PLUMES
SOUTHEAST EDGE OF AYRES DUGOUT
PREVAILING AND NORTHERLY WINDS

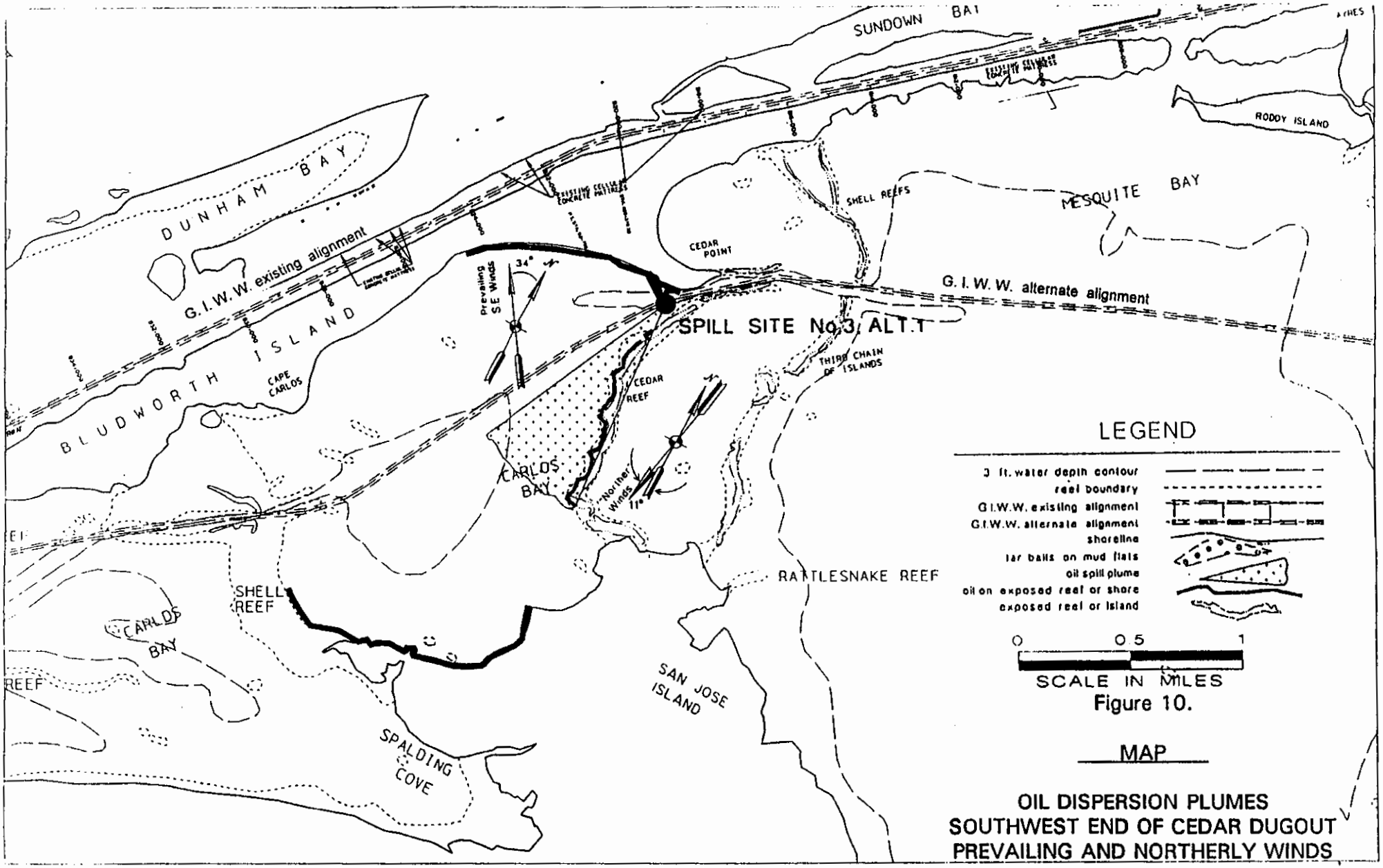


Figure 10.

MAP

OIL DISPERSION PLUMES
SOUTHWEST END OF CEDAR DUGOUT
PREVAILING AND NORTHERLY WINDS

Scenario B: Wind from Southeast

Winds would cause spilled oil to be blown promptly to and deposit on the high tide shore at Cedar Point and thence westerly along the north, high water shoreline of Carlos Bay. The spill could be easily contained near Cedar Point by rapidly installing a floating boom from the shoreline a few hundred feet west of Cedar Point extending a few hundred feet southward into Carlos Bay. However, the exposed high water shore could be heavily coated with oil.

Site No. 4 (Southwest End of Cape Carlos Dugout--Figure 11)

Scenario A: Wind from Northeast

Oil spilled at this point would be blown out into Spalding Bight toward Spalding Reef, about 0.7 mile downwind. Because of low tides associated with strong northers, Spalding Reef should be exposed sufficiently so that most, if not all, of the oil still floating would heavily coat the north side of Spalding Reef or be trapped against the reef. If any slipped by the sides or over the top of the reef, some slight tar balling could occur in the shallow flats near the shoreline northeast of Jay Bird Point. However, if booms are placed promptly at the flanks of Spalding Reef, the spill should be contained.

Scenario B: Wind from Southeast

Aerial photographs indicate most of the reef north of the spill site should be submerged on high tide, so spilled oil would tend to be blown promptly against the high tide shoreline of Bludworth Island. The shoreline would probably be heavily coated, but the maps and photographs indicate spilled oils would tend to be contained by the onshore winds in the concave shoreline southwest of Cape Carlos.

Open Bay Alignment 2

Site No. 1 (Second Chain of Islands--Figure 12)

Scenario A: Wind from Northeast

Under ordinary conditions, most of the reef at the Second Chain of Islands is submerged, although surrounding waters are less than three feet deep. With strong wind from the north/northeast, tides would be very low and much of the shell reef exposed, including banks where the channel would incise the reef from the northeast side to the southwest. In this vicinity, barges would tend to be confined to the navigation channel itself, minimizing the danger of reef sheer in the event of a barge accident, or of crashing on reef rock. In the event of an oil spill at the northeast side of the reef, probably only one barge compartment of oil would be involved; but depending on where an accident occurs, some or most of any spilled oil

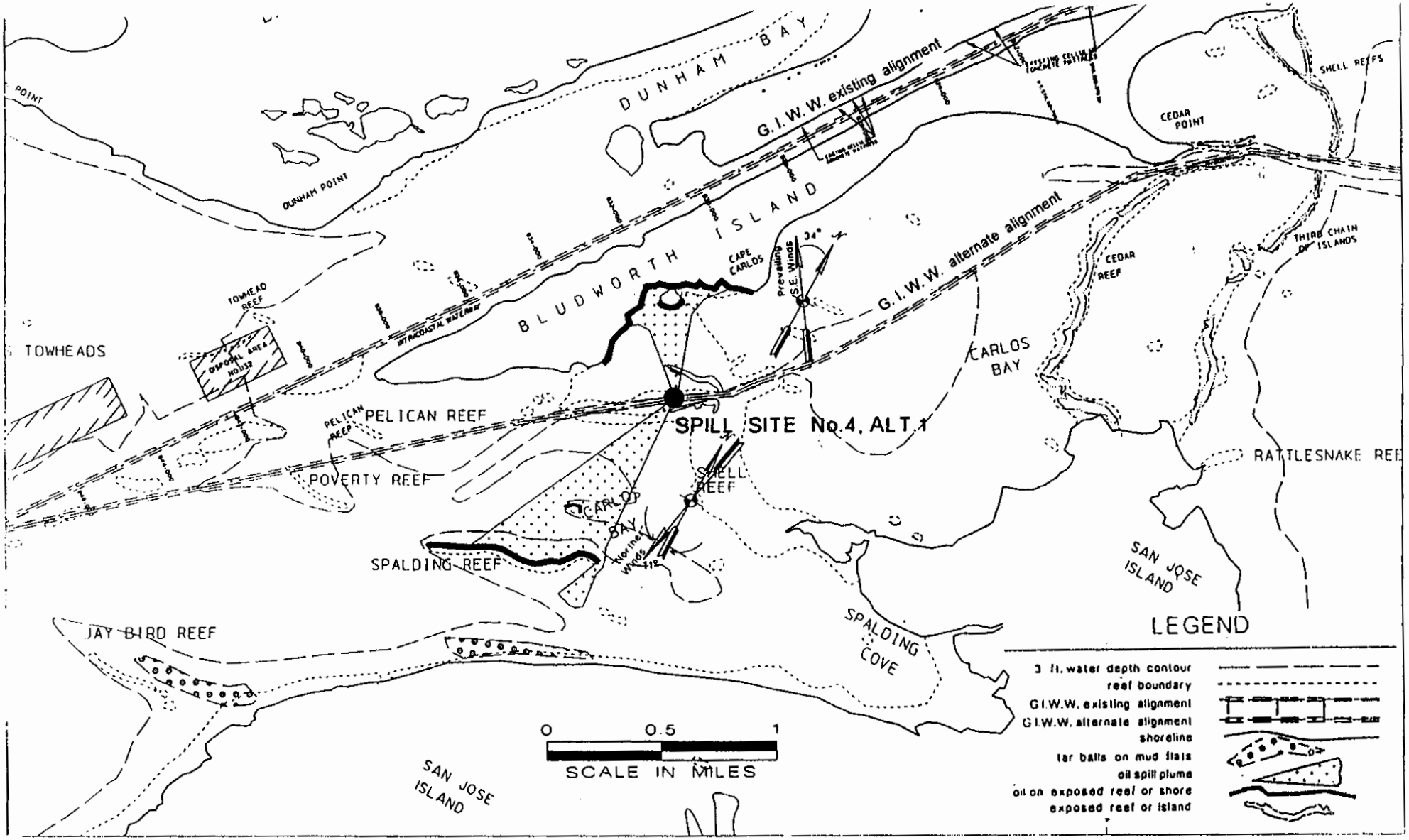


Figure 11.

MAP

OIL DISPERSION PLUMES
SOUTHWEST END OF CAPE CARLOS DUGOUT
PREVAILING AND NORTHERLY WINDS

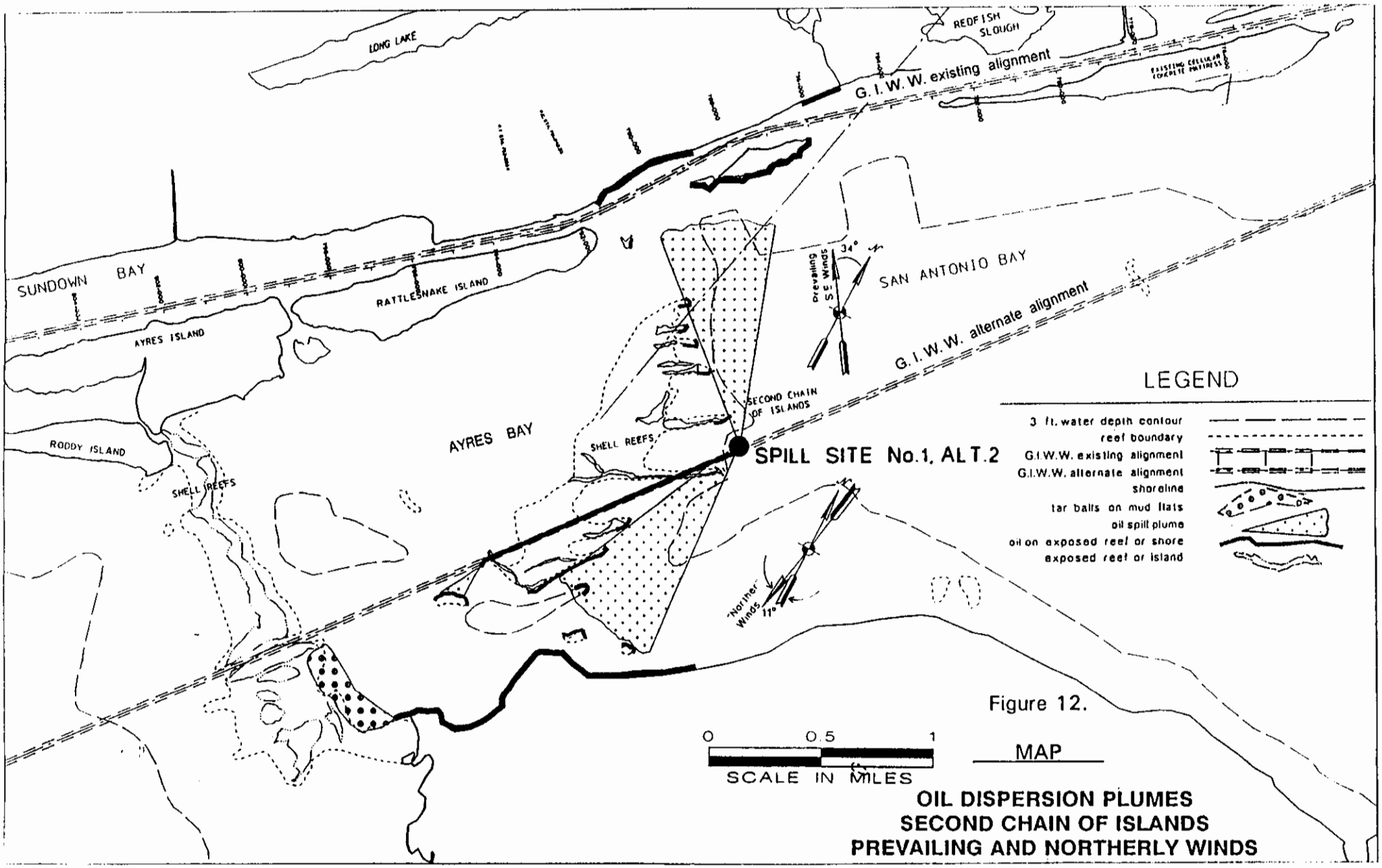


Figure 12.

MAP

OIL DISPERSION PLUMES
SECOND CHAIN OF ISLANDS
PREVAILING AND NORTHERLY WINDS

would be funnelled (blown) promptly down the narrow channel through the reef and escape into the lower end of Ayres Bay. Other oils escaping at the spill site would tend to heavily coat exposed reef bands on the southeast side of the Second Chain of Islands, and the rest blown south/southwestwardly with a trap formed by the exposed shallow bottoms at and eastward of Ayres Reef.

Scenario B: Wind From Southeast

This is typically a higher tide situation. Only small parts of the shell reefs of the Second Chain of Islands would be exposed, but the exposed parts could become oil coated. Winds would tend to blow the oil toward the pass about one mile away at the northeast end of Rattlesnake Island. The oil slick should be well broken up by landfall, but tar balls and oil would deposit at the high tide level on the spoil area northeast of Rattlesnake Island. Some tar balls could be carried on high tide through the pass and into the marshes beyond the existing GIWW channel, unless an oil boom was placed promptly to block floating oil at the pass.

Site No. 2 (Southeast Edge of Ayres Dugout--Figure 13)

Scenario A: Wind From Northeast

Under this low tide condition, the oil plume would tend to disperse in the open water of Mesquite Bay toward Cedar Bayou. Some tar balls would be deposited on mud flats near Cedar Bayou that would be exposed at low tide.

Scenario B: Wind From Southeast

Under this high tide situation, there may be a danger of greater spill volume, since reef at the edge of the channel could cause shearing or cracking of a barge hull. Some oil may coat the exposed parts of Ayres Reef, but the water would be high enough to prevent much reef coating. With less than a mile of open water to the southeast shore of Roddy Island, the high tide shore should be significantly affected. Some oil would probably also deposit on Ayres Island, but it is not likely that much would go through the pass between Roddy Island and Ayres Island, even if it were not boomed.

Site No. 3 (Turn In Mesquite Bay--Figure 14)

Scenario A: Wind From Northeast

Under ordinary conditions, the waters in Mesquite Bay are only about four feet deep. A loaded oil barge would be confined to the channel, and the threat of reef damage to barges by shear or crushing is absent at this location. Winds would spread oil southwestwardly over open waters toward San Jose Island about two miles downwind. The plume should be well dispersed in open waters; but the shallow flats within the vicinity, which are well exposed due to low tide conditions, could be heavily tar balled.

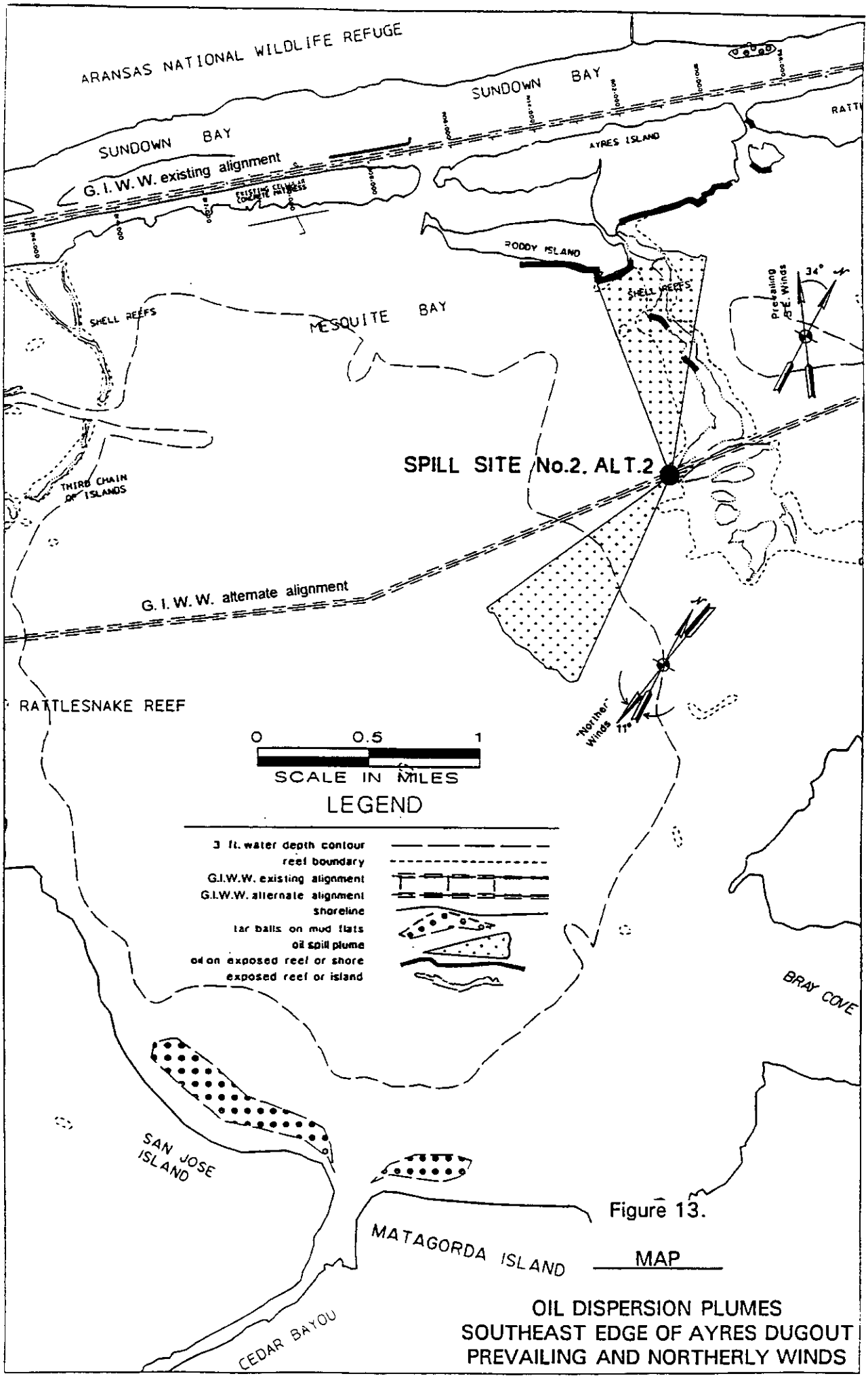


Figure 13.

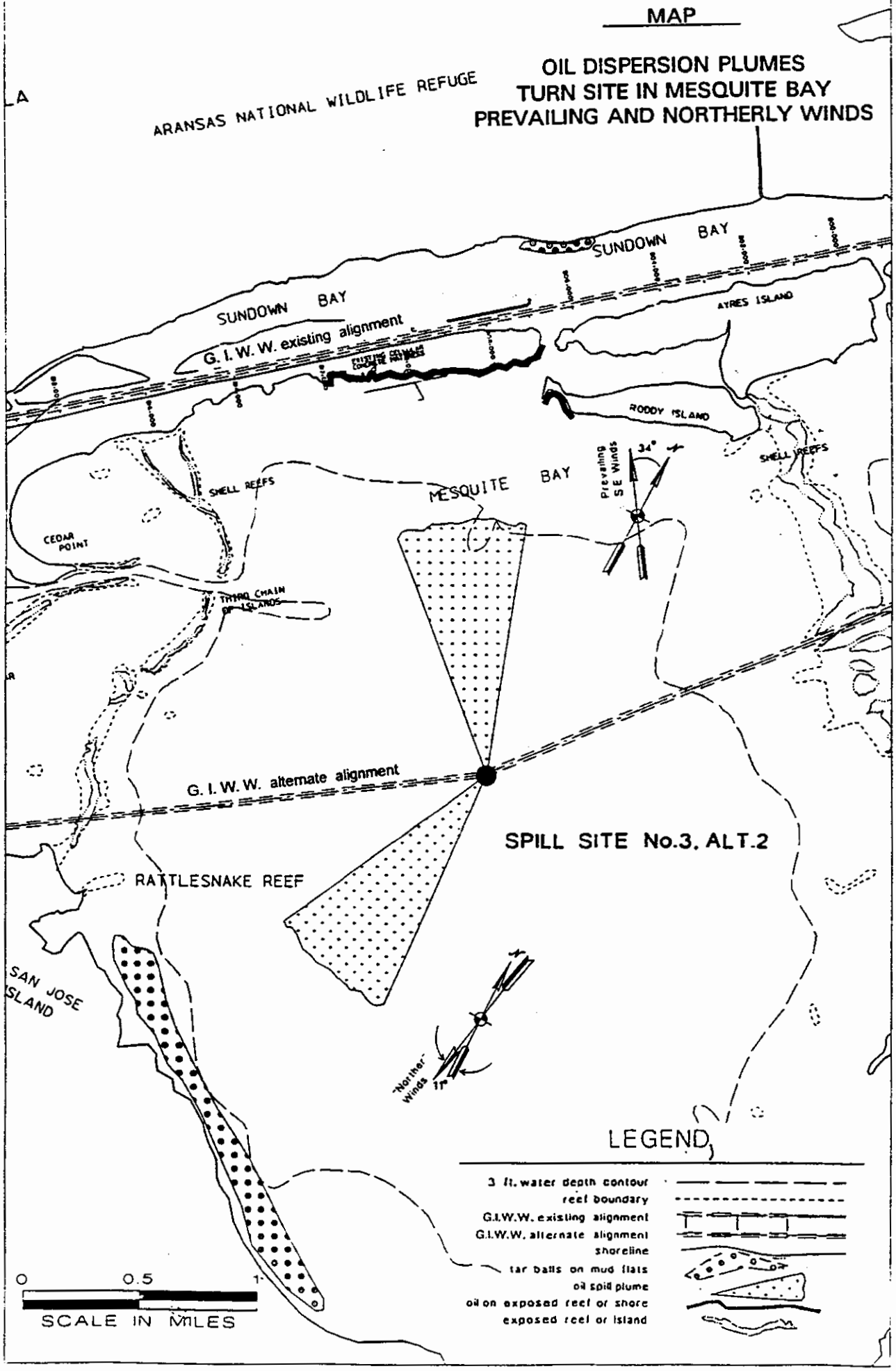
MAP

OIL DISPERSION PLUMES
SOUTHEAST EDGE OF AYRES DUGOUT
PREVAILING AND NORTHERLY WINDS

Figure 14.

MAP

OIL DISPERSION PLUMES
TURN SITE IN MESQUITE BAY
PREVAILING AND NORTHERLY WINDS



Scenario B: Wind From Southeast

Spilled oil would be blown northwesterly over open waters toward Bludworth Island, about two miles downwind. The plume should be well dispersed before landfall; but under the associated high tide condition, the high water shoreline of Bludworth Island and the southwest end of Roddy Island would be heavily coated with oil. Some oil would be blown through the pass between Bludworth and Ayres islands, and tar balls would be blown across and deposited on the banks of Sundown Bay.

Site No. 4 (East Edge of Cedar Reef--Figure 15)

Scenario A: Wind From Northeast

Oils spilled at this location would be blown promptly toward and heavily coat the banks along the northwest shore of San Jose Island and shallow bottoms northward of Spalding Cove, which would be exposed on the low tide conditions.

Scenario B: Wind From Southwest

Aerial photographs indicate most of Cedar Reef should be submerged under the high tide conditions associated with strong southeasterlies; however, any exposed parts of the reef northward of the spill site would be heavily coated as the plume spreads toward Bludworth Island. Although the plume would be well dispersed before landfall, the high water shoreline of Bludworth Island between Cedar Point and Cape Carlos would be heavily coated with oil.

Site No. 5 (Southwest Edge of Reef South of Cape Carlos--Figure 16)

Scenario A: Wind From Northeast

Oil spilled at the point would be blown into Spalding Cove toward Spalding Reef about 0.5 miles downwind. Because of low tides associated with strong northers, Spalding Reef should be well exposed and be heavily coated with oil. Much of the oil would slip by the reef and heavily coat and tar ball the shallow flats exposed by low tides, along the shoreline of San Jose Island to Jay Bird Reef.

Scenario B: Wind From Southeast

Aerial photographs indicate most of the reef north of the spill site should be submerged on high tide, so spilled oil would tend to be blown promptly against the high tide shoreline of Bludworth Island. The shoreline would probably be heavily coated, but the maps and photographs indicate spilled oils would tend to be contained by the onshore winds in the concave shoreline southwest of Cape Carlos.

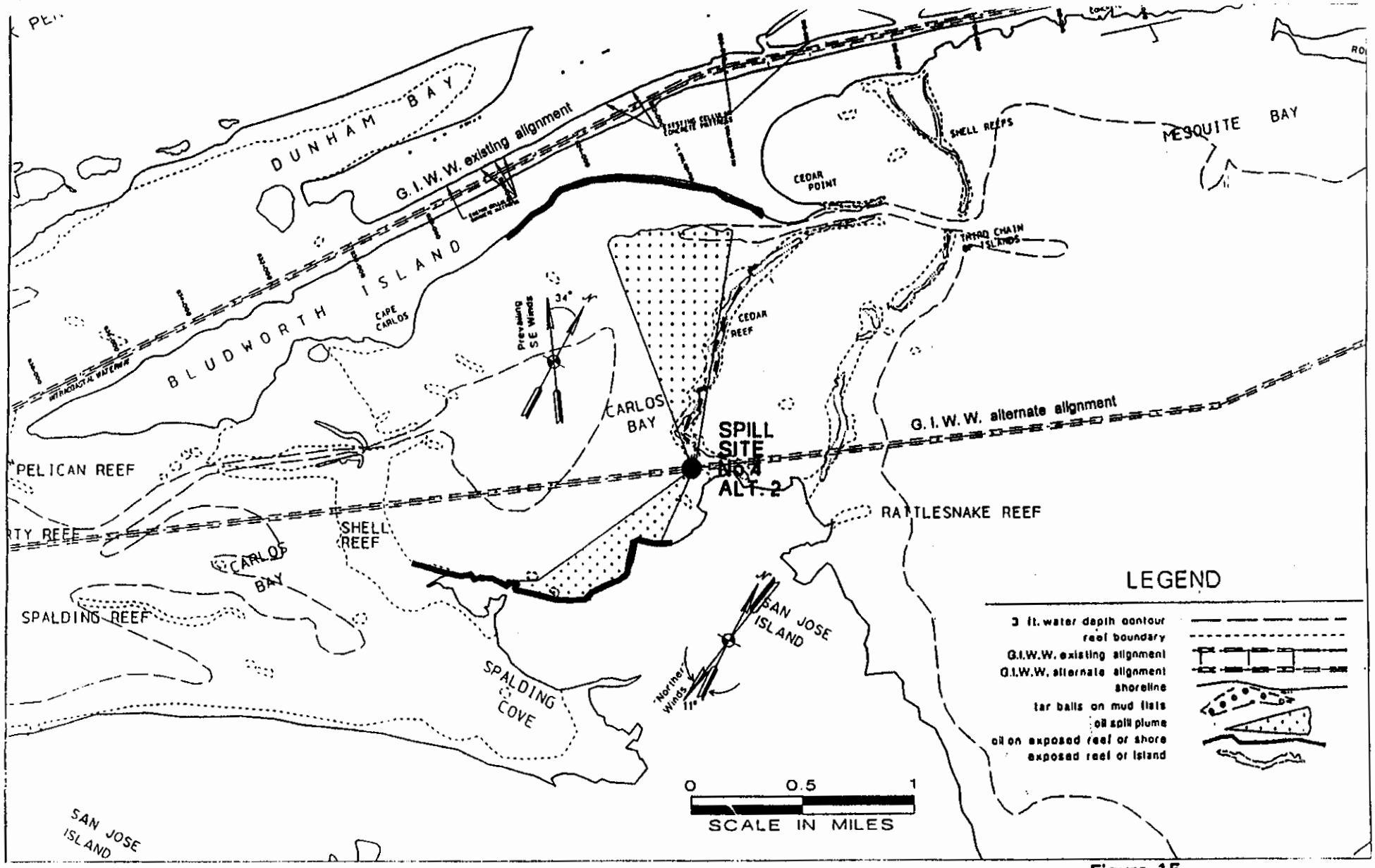


Figure 15.

MAP

OIL DISPERSION PLUMES
EAST EDGE OF CEDAR REEF
PREVAILING AND NORTHERLY WINDS

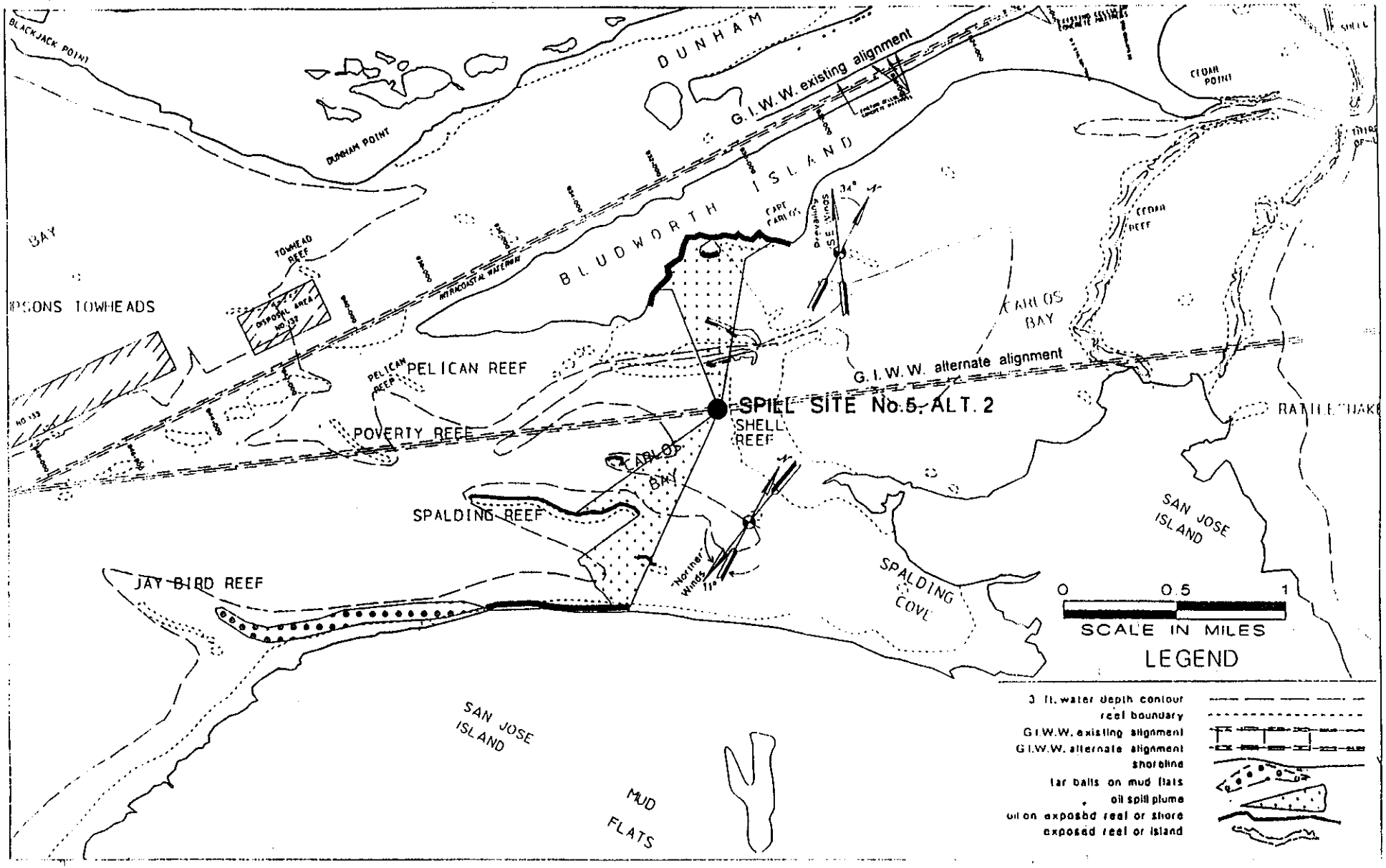


Figure 16.

MAP

OIL DISPERSION PLUMES
SOUTHWEST EDGE OF REEF
SOUTH OF CAPE CARLOS
PREVAILING AND NORTHERLY WINDS

V. ENVIRONMENTAL IMPACT

Biotic Communities

In the event of a petroleum spill in the GIWW there is a potential for adverse impacts on biotic communities. To determine which communities might be impacted, the locations of oil plumes and coastal contamination, as determined in figures 2 through 16 were compared with habitats identified by Espey, Huston & Associates (1987). Tables 1 through 3 list the types of communities likely impacted for each spill site under each alternative route.

There are eight community types (EHA, 1987) that could be affected by spills that may occur within the two alternate routes:

1. Shell Reef Community
2. Shallow Water Community
3. Shell Ridge Community
4. Tidal Flat Community
5. Seagrass Community
6. Low Marsh Community
7. High Marsh Community
8. Tidal Pond Community

Each of these communities is an integral part of the bay ecosystem. Each community has its own unique species and assemblages of species. Protected species may tend to be concentrated in a particular community. Green sea turtles are more likely found in seagrass beds; piping plovers utilize tidal flats for foraging; and brown pelicans are most often observed feeding in shallow estuarine waters.

Some animals utilize a variety of resources from several community types to provide food, defense, and cover. Whooping cranes, as well as other wading birds, are likely to forage in most of the communities potentially impacted by spills.

Shell Reef Community

Reefs within the area consist of live oysters and clams and accumulations of dead oyster or clam shells that are oriented perpendicular to the prevailing currents and often exposed at high tide. They are centers of secondary productivity where suspended organic particulate matter is concentrated and made available to other consumers (EPA, 1992). Shell reefs, by virtue of the hard substrate and crevices, provide cover for a variety of worms, crustaceans, and mollusks that typically are different and more diverse than those found in the soft substrates elsewhere in the bay.

Table 1. Biotic Communities Potentially Impacted by Spills Occurring in the Existing Channel

Spill Site	Wind Direction	Communities Impacted
GIWW Northeast of Mustang Lake	Northeast	Shallow water
	Southeast	Reef Shallow water
GIWW at Wynne's Cut	Northeast	Shallow water Low marsh
	Southeast	Shallow water Low marsh High marsh Tidal pond Seagrass
GIWW in Aransas Bay near S.M. 515	Northeast	Reef Shallow water
	Southeast	Reef Shallow water Low marsh

Source: Gulf Engineers & Consultants, Inc.

Table 2. Biotic Communities Potentially Impacted by Spills Occurring in Open Bay Alignment 1

Spill Site	Wind Direction	Communities Impacted
No. 1	Northeast	Reef Shallow Water Shell Ridge Tidal Flat
	Southeast	Reef Shallow Water Seagrass Tidal Flat Low Marsh
No. 2	Northeast	Reef Shallow Water Seagrass Tidal Flat[1]
	Southeast	Reef Shallow Water Low Marsh High Marsh Tidal Flat Seagrass
No. 3	Northeast	Reef Shallow Water Tidal Flat Seagrass
	Southeast	Shallow Water Low Marsh High Marsh
No. 4	Northeast	Reef Shallow Water Seagrass Tidal Flat[1]
	Southeast	Reef Shallow Water Low Marsh High Marsh Tidal Pond

[1]The community would likely be impacted by the presence of tar balls resulting from the spill.

Source: Gulf Engineers & Consultants, Inc.

Table 3. Biotic Communities Potentially Impacted by Spills Occurring in Open Bay Alignment 2

Spill Site	Wind Direction	Communities Impacted
No. 1	Northeast	Reef Shallow Water Tidal Flat[1]
	Southeast	Reef Shallow Water Seagrass Tidal Flat Low Marsh
No. 2	Northeast	Shallow Water Seagrass Tidal Flat
	Southeast	Reef Shallow Water Low Marsh High Marsh Tidal Flat Seagrass
No. 3	Northeast	Shallow Water Low Marsh[1] Tidal Flat[1] Seagrass[1]
	Southeast	Reef Shallow Water Low Marsh Tidal Flat Seagrass
No. 4	Northeast	Reef Shallow Water Tidal Flat Seagrass
	Southeast	Shallow Water Low Marsh High Marsh Tidal Flat
No. 5	Northeast	Reef Shallow Water Tidal Flat Seagrass
	Southeast	Shallow Water Low Marsh High Marsh Tidal Flat

[1]The community would likely be impacted by the presence of tar balls resulting from the spill.

Source: Gulf Engineers & Consultants, Inc.

Shallow Water Community

Shallow water habitats are defined as areas of open water between mean sea level and three feet deep. Substrates are soft to moderately firm, consisting of sand and silt (EHA, 1988). Large populations of burrowing polychaete worms, crabs, shrimps, and bivalves are found in this community. Many of these benthicinvertebrates, but particularly polychaetes, are fed upon by other burrowing species and by bottom-feeding fishes (EPA, 1992). Important shellfish include brown, white, and pink shrimps. Commercial finfish include menhaden, seatrout, red and black drum, croaker, mullet, spot, flounder, and anchovy. Piscivorous diving birds include pelicans, cormorants, and ospreys.

Shell Ridge Community

The shell ridge community develops on accumulations of dead oyster shells on the bay shore. The community is considered to be among the more diverse in the area because of gradients in ground moisture, soil salinity, soil compaction, wind exposure, and surface isolation (McAlister, 1988). Within the shell ridge habitat there is a transition from dense live oaks to brushy-scrubby vegetation to halophytic grasses. Animals include semi-terrestrial crustaceans, insects, rodents, and reptiles. Numerous birds utilize the shell ridge habitats for feeding and roosting (McAlister and McAlister, 1993).

Tidal Flats Community

Tidal flats are flat, barren washover areas influenced by tidal regimes and wind (EHA, 1988). They range from mean sea level to two to three feet in elevation. Because of tidal inundation and drying, tidal flats are characterized by hypersaline soil that supports relatively few patches of vascular vegetation, with cover less than 25 percent (EHA, 1988). Algal mats, which can form a dense layer, occur in the lower areas of the tidal flats. Bacteria, however, are the major biomass producers. Invertebrates include polychaete worms, some bivalves and snails, and others tolerant of substrates with high salinity, low oxygen, and high temperatures during low tides. At high tide, mobile invertebrates, such as crabs and shrimp, and fishes are present. Terrestrial vertebrates feeding in tidal flats include a variety of wading birds, gulls, terns, and black skimmers (McAlister and McAlister, 1993).

Seagrass Community

Seagrass beds within the area consist of mixtures primarily of widgeongrass and shoal grass that occur in shallow-water areas usually between one and three feet deep. Seagrasses are generally limited in distribution by depth, turbidity, and temperature (EPA, 1992). Seagrass beds serve as nursery sites, feeding locations, and cover for a variety of crustaceans and fishes of commercial and recreational importance.

Low Marsh Community

Low marshes are found adjacent to open water and generally receive frequent inundation by tides. In the Aransas area two types of low marshes have been observed: those dominated by smooth cordgrass and those dominated by a mixture of maritime saltwort and sea oxeye daisy (EHA, 1988). Burrowing invertebrates include polychaete worms, clams, and small

crustaceans. Snails are abundant on the plants. Crabs, shrimps, and small fishes are found in the shallow water during high tides. A number of vertebrates take advantage of the food resources of this community.

High Marsh Community

High marsh tends to be inundated less frequently than low marsh, but may occasionally be flooded by rainfall or unusually high tides. The most abundant plants include the sea oxeye daisy, marsh elder, shoregrass, and saltgrass (EHA, 1988). Semi-terrestrial crustaceans and insects are the most abundant invertebrates. Reptiles and foraging birds are the most common vertebrates.

Tidal Pond Community

Tidal ponds are located within low marsh areas and differ from landlocked ponds by having a tidal connection. Vegetation surrounding the ponds is that typical of the low marsh community. Animals include a variety of small crustaceans, worms, and snails and bivalves. Crabs, shrimps, and fishes provide food for the many species of birds that forage in these ponds.

Biological Impacts

General

It has been determined that the most likely location for any open bay spill is at a turn at or near a shell reef. Under the scenario developed for such a spill, it would occur during adverse weather conditions with winds blowing either from the north-northeast or from the southeast. Plumes would be roughly triangular in shape extending from the point of the spill and spread by wind either toward the south-southwest or toward the northwest.

The distance of the shoreline (or exposed reef) from the point of the spill and the rate at which spilled petroleum is advanced by wind will, to a great extent, determine the amount of damage to shoreline communities. The longer the petroleum is exposed to the elements and the more dispersed the substance, the less severe will be the impacts on shoreline communities.

Petroleum products such as crude oil and heavier fuels consist of a mixture of volatile lighter fractions, such as shorter-chained aliphatic compounds and aromatic compounds, and non-volatile heavy fractions consisting of large molecular weight substances. As the lighter fractions are lost from the mixture, the spilled petroleum loses many of its adhesive characteristics, or "stickiness," and asphalt-like "tar balls" are formed from the heavy fractions. Temperature and wind velocity would influence the rate at which the volatile fractions would be lost. Higher temperatures would increase the rate at which volatile compounds would be lost to the atmosphere. Higher winds would increase turbulence, promoting emulsification of the oil and the retention of the volatile fractions in the oil mass.

Physical impacts of a petroleum spill on an organism are due, in large part, to the product coating the body of the organism, thereby suffocating it or interfering with the function of external protective structures (e.g., bird feathers). Semi-solid tar balls generally cause fewer adverse physical impacts on organisms than fresher, stickier oil.

Systemic impacts on estuarine organisms result from the ingestion or absorption of compounds that make up the volatile fraction of the oil. Many of the aliphatic and aromatic (including polyaromatic) compounds are toxic and/or carcinogenic. Organisms that come into direct contact with freshly spilled oil can absorb toxic compounds directly through the integument. Others may ingest the oil. The acute adverse impacts of oil spills are typically of short duration (EPA, 1992) because of the volatility of the lighter fractions of petroleum products.

There is, however, a potential for chronic adverse effects of the lighter fractions. Although many of these materials are only slightly soluble, they are able to enter the water column through petroleum spills (Wang and Hoffman, 1991).

The effects of exposure of polyaromatic hydrocarbons (PAHs), which constitute a portion of the volatile fraction, are both acute and chronic. PAHs are toxic and are "among the most potent carcinogens known to exist" (Eisler, 1987, as related by Gamble *et al.*, 1989). Petroleum spills are the primary source of PAHs in aquatic systems (Gamble *et al.*, 1989). Once in the water, these materials tend to become associated with organic matter and become incorporated into animal tissue through ingestion by detritivores. Some filter feeding invertebrates, particularly mollusks, tend to concentrate PAHs, while fishes and crustaceans tend to metabolize them (Gamble *et al.*, 1989; Gilmore, 1991).

Shell Reef Community

Physical impacts of an oil spill on a shell reef would include the coating of exposed oyster shells and crevices. Exposed invertebrates would be killed. Birds that feed or rest on oily reefs could become coated with oil and killed outright or mortally incapacitated.

Chronic effects include the incorporation of toxic substances into the tissues of invertebrates thereby potentially affecting predators such as fishes, crustaceans, and birds.

Shallow Water Community

Adverse impacts of an oil spill on shallow water organisms would primarily be restricted to those that would come directly into contact with the surface of the water. Turtles and marine mammals that must surface for air could inhale or ingest oil. Swimming and diving birds that alight on the surface of the oil and water could become coated with oil.

Shell Ridge Community

Wind-driven tides would wash oil onto the shell ridge. Plants, insects, crustaceans, and other organisms that would be coated with oil would die. Burrows and crevices would trap oil, thereby eliminating potential habitat. Reptiles, birds, and mammals that feed at shell ridges or inhabit them could suffer acute or chronic injury.

Tidal Flat Community

Tidal flats have a potential to suffer severely from oil contamination. A coating of oil on the exposed substrate could virtually eliminate not only burrowing and surface-dwelling invertebrates found in these communities, but also the bacterial and algal production on which the

community depends. An extended period of decreased primary and secondary productivity would likely result.

Seagrass Community

Seagrasses are unlikely to be exposed directly to floating oil. There is, however, a likelihood of sea turtles ingesting or inhaling oil when they surface for air. Chronic effects on the seagrass community could result in decreased productivity until such time as volatile compounds become reduced in concentration and isolated from the community.

Low Marsh Community

As with the tidal flat community, the low marsh community could receive significant adverse impacts from an oil spill. Marsh plants would be killed, invertebrates would be destroyed, and predators could become coated with oil. Chronic effects could include a migration of toxic substances into the substrate, thereby inhibiting primary and secondary production for an extended period of time.

High Marsh Community

Effects of an oil spill on the high marsh community would be influenced by tides. A spill during times of especially high tides would create conditions similar to those of the low marsh. At relatively low tides, oil contamination may not extend far into the high marsh community. Community

In the tidal pond community, the periphery of the pond, which is predominantly low marsh habitat, would be coated with oil. Birds and reptiles on the surface of the water could be physically impacted by the oil. Chronic effects could be more significant in this habitat than in others because restricted flushing would tend to retain toxic substances in the ponds. Long-term damage would involve lowered primary and secondary productivity, thereby reducing food availability. Contaminated food items may adversely affect such predators as birds, reptiles, fishes, and small mammals.

VI. EVALUATION OF ALTERNATIVES

The preceding analysis provides an overview of the generalized environmental impacts that would be sustained by various communities under an oil spill scenario for the existing Gulf Intracoastal Waterway (GIWW) channel and two alternate Open Bay Alignments. A higher level of analysis would require site-specific information and a much greater refinement of the impact scenario than is appropriate at this stage of planning.

GEC's analysis of environmental impact is based on oil and not on small spills or persistent chemicals for the following reasons:

1. Oil is the most likely commodity to be involved in a spill that would produce significant environmental damage.

2. The chance of a spill involving a persistent chemical that would affect the food chain is negligible because of the way in which such chemicals are carried on barges. In any case, an open bay spill affecting the food chain would afford the same dangers as an existing channel spill affecting the food chain. As a consequence, this appears to be a moot issue in the comparison of alternative courses of action.

3. As the panel noted, a small spill involving collision of a barge and a shrimp boat is much more likely than a large spill involving a collision between two barges. However, the environmental damage from such a spill and even the accumulation of such spills would be small. The 1992 GEC Report noted that the small number of fugitive spills from vessels passing the refuge apparently have done little damage to the refuge ecology or to the whooping crane. A research report cited (Martens, 1976) concluded that for five different marine environments, including marsh habitat, low level chronic oil exposure had no measurable effect on ecological indicators such as species diversity, organism size, growth rate, or reproduction. This is not to suggest that this is not an important issue for agencies or that a single crane that might be killed under such circumstances is of no importance to the survival of the flock. Nevertheless, the chance of a small spill is at least as great in the open bay scenarios as it is for the existing channel.

As a consequence, the following analysis is restricted to a comparison of alternatives in the context of differential impacts related to the potential for a significant oil spill.

Existing Channel

1. Since this is the no-action alternative, it would not entail the environmental damage that would accompany construction of Open Bay Alignments 1 and 2.

2. Environmental problems in conjunction with the existing channel are minor and are not expected to increase significantly.

3. The existing channel is very safe for navigation because it is mostly protected from wind and currents and is fairly straight with good visibility, and has soft banks. Its degree of safety is demonstrated by the fact that it has been used for many decades by a high volume of traffic without mishap.

4. The major concern with the existing channel is that it is near the highest concentration of whooping cranes.

5. An oil spill at Sundown Bay would have the potential to produce whooping crane mortality unless mechanical containment devices were installed to keep oil from entering Sundown Bay.

6. A spill within the existing channel would be comparatively easier to contain and clean up, especially if it occurred in the confined portions of the channel.

Open Bay Alignment 1

1. The construction of Open Bay Alignment 1 would cause significant environmental damage, but not as much damage as Open Bay Alignment 2.

2. Open Bay Alignment 1 does not appear to offer as great a risk of changing existing bay ecology because it utilizes existing cuts. Some (if not all) of these cuts were dredged at the turn of the century and almost certainly were made through areas of natural flow at that time.

3. Rapid containment of a spill would not be feasible as a practical matter in the open bay. As a consequence, some spills would have the potential to affect the whooping cranes presently concentrated on the north side of the existing channel. The only way that Open Bay Alignment 1 could secure the desired protection for the cranes would be if the passes from the bay into the existing GIWW channel were closed off, either by filling the passes with something like dredge spoil or by installing mechanical protective devices.

4. Open Bay Alignment 1 would increase the risk of whooping crane mortality on the north shores of San Jose and Matagorda Islands and on the south shores of the islands paralleling the existing GIWW channel. The problem will probably be more acute by the time construction is completed because of the high probability of increased concentrations of cranes in the these areas.

5. Open Bay Alignment 1 would increase the risk of a spill by 9-10 times as compared to the existing channel, based on the judgment of some of the panel members.

6. Containment would be difficult if not impossible under the circumstances in which spills are most likely to occur (e.g., high winds, strong tides).

7. A spill would be difficult to clean up because of problems of equipment deployment and access to impacted areas due to shallow water, reefs, etc.

Open Bay Alignment 2

1. Open Bay Alignment 2 provides increased safety for waterborne transport, reducing the risk of a spill due to collisions between barges to 5-6 times as compared to the existing channel, based on the judgment of some of the panel members.

2. The construction of Open Bay Alignment 2 would involve large-scale environmental damage.

3. Construction of Open Bay Alignment 2 would perhaps be more likely than Open Bay Alignment 1 to change the ecology of the bay in a way that would significantly alter the natural resources in the area.

4. Open Bay Alignment 2 would not resolve the critical deficiency of Open Bay Alignment 1, which is its inability to insure that a spill would not invade the area in which whooping cranes are presently concentrated.

5. It would move the channel closer to the north shores of San Jose and Matagorda Islands. These areas provide whooping crane habitat at present and will probably have greater concentrations of whooping cranes in the future.

6. Containment would be difficult if not impossible under most circumstances.

7. A spill would be difficult to clean up because of problems of equipment deployment and access to impacted areas due to shallow water, reefs, etc.

8. If Open Bay Alignment 2 is pursued, the channel should be made much larger than presently envisioned. The major problem with the open bay alternatives using a narrow channel is the inability of barges, particularly of a tow of empties, to maneuver sufficiently in high winds and strong tide situations to avoid collisions. Since the level of environmental damage would be high for Open Bay Alignment 2 under any circumstances, the level of environmental damage might as well be increased to secure a much higher level of safety.

VII. SUMMARY AND CONCLUSIONS

Panel members, calling on their varied experience and expertise, were requested to consider seven specific questions relative to the existing channel and a proposed open bay alignment. Discussion was not limited to the seven questions posed in advance of the panel meeting. At the request of the panel members a second open bay alternative route was also considered.

The seven questions posed to panel members in advance of the meeting were:

1. In what places are spills most likely to occur in the existing alignment and in the open bay alignment?

2. What is the relative probability of a spill occurring in the existing channel alignment versus the open bay alignment?

3. Is one alignment more dangerous than another in terms of the quantity of any particular commodity that could be spilled?

4. What is the most likely spill in the two alignments?

5. What is the worst case spill in the two alignments?

6. What would be the environmental effects of the worst case spills for the two alignments?

7. What are the potentials for containment and cleanup of the worst case spills in the two alignments?

The panel felt that spills on the existing channel would be most likely at the entrances on each end of the land-locked portions. Spills/collisions were most likely at turns or reef passages on the open alternatives.

The panel felt that the existing channel was a very safe route for navigation since it is straight, land-locked, has good visibility, and is not subject to wind and current effects. In contrast, collisions/spills on the two open bay alternatives were judged to be five times more likely for Open Bay Alignment 2 and 9-10 times more likely for Open Bay Alignment 1 than the existing channel.

The panel members had little comment on the question of differences in quantities that would be spilled in an open bay collision versus the existing channel. A general consensus emerged that there would be little or no difference as far as barges are concerned.

The most likely spill was identified as a relatively small spill of diesel fuel or bilge pumpage resulting from improper practices by shrimp boats, pleasure craft or crew boats, or from the possible sinking of one of these types of vessels.

The panel agreed that the worst case spill, based on probability and environmental impact, would be one involving crude oil, residual fuel oil or lubricating oil from a barge collision.

Environmental impacts were discussed in general terms concerning different geographical areas. As stated earlier, the point was made that the whooping cranes are irreplaceable despite wide agreement that the whole area is filled with valuable biologic resources. Of particular concern was a spill that might get into Sundown Bay from a collision in the existing channel.

There was general agreement that cleanup of any spill would be more difficult in the open bays than in the confines of the existing channel.

Most of the panel members indicated that the existing channel was the preferred navigation route but with a strong emphasis on introducing additional safety measures that would protect critical habitat in the event of a spill.

LITERATURE CITED

LITERATURE CITED

Eisler, R. 1987. Polycyclic aromatic hydrocarbon hazards to fish, wildlife, and invertebrates: a synoptic review. U.S. Fish Wildl. Serv. Biol. Rep. 85: (1.11). 81 pp.

Espey, Huston & Associates (ESA). 1987. Analysis of Habitat Changes from 1930 to 1986 along the Gulf Intracoastal Waterway at Aransas National Wildlife Refuge and San Antonio Bay, Texas. Prepared for U.S. Army Corps of Engineers, Galveston District. Contract No. DACW64-87-D-0002. 15 pp. + figs.

Gamble, L.R., G. Jackson, and T.C. Maurer. 1989. Contaminants investigation of the Aransas Bay Complex, Texas, 1985-1986. U.S. Fish Wild. Ser., Ecol. Serv., Corpus Christi, TX. 38pp.

Gilmore, R.G. and M.D. Hanisak. 1991. Environmental Survey Relative to the Expansion and Development of the Port of Fort Pierce. Harbor Branch Oceanogr. Inst. Report Submitted to St. Lucie County Port And Airport Authority. 187 pp.

Gulf Engineers & Consultants, Inc. 1992. Spill Contingency and Prevention Plan for the Gulf Intracoastal Waterway at the Aransas National Wildlife Refuge. Report submitted to the Galveston District, U.S. Army Corps of Engineers. 93 pp+ app.

Martens, E.W., "The Impact of Oil on Marine Life: A Summary of Field Studies", in *Symposium on Sources, Effects, and Sinks of Hydrocarbons in the Aquatic Environment*. (Washington, DC: American Institute of Biological Science, 1976). pp. 507-514.

McAlister, W.H. 1988. An Annotated List of the Plants of the Aransas National Wildlife Refuge. Unpublished mss. 66 pp.

McAlister, W.H. and M.K. McAlister. 1993. A Naturalist's Guide: Matagorda Island. Univ. of Texas Press. Austin. 354 pp.

U.S. Environmental Protection Agency (EPA). 1992. Draft Environmental Impact Statement: Formosa Plastics Corporation, Texas Facilities Expansion, Port Comfort, Texas. EPA 906/07-92-001. 251 pp. + app.

Wang, T.C. and M.E. Hoffman. 1991. Sediment Contaminant Studies. Pp 17-39. In: Gilmore, R.G. and M.D. Hanisak. 1991. Environmental Survey Relative to the Expansion and Development of the Port of Fort Pierce. Harbor Branch Oceanogr. Inst. Report Submitted to St. Lucie County Port And Airport Authority.

Attachment 1

BACKGROUND MATERIALS

Gulf Engineers
& Consultants
Inc

Jerol Adam, PE, PLS
President

November 30, 1993

Dear _____:

Enclosed is a packet of background materials for the meeting that will be held on December 7, 1993, in Corpus Christi to discuss the relative risk of barge spills on the existing GIWW alignment in the vicinity of the Aransas National Wildlife Refuge versus an alternative open bay alignment south of the existing channel.

There are seven questions that we hope to have answered before the meeting is concluded:

1. In what places are spills most likely to occur in the existing alignment and in the alternate open bay alignment?

   These places should be limited to points between where the alignments diverge, since we are interested in comparing one alignment to the other. Some of the factors that should be taken into consideration in answering this question are turns, visibility, and obstructions. (See enclosed study area map.)

2. What is the relative probability of a spill occurring in the existing channel alignment versus the open bay alignment?

   Given the absence of historic data on spills in open bay situations along the GIWW, this question will need to be answered by the panel's best judgment. Factors that should be taken into consideration in estimating the relative probability of spills on the two alignments include channel straightness, obstructions, visibility, wind, waves, currents, and channel length. (See enclosed study area map.)

3. Is one alignment more dangerous than another in terms of the quantity of any particular commodity that could be spilled?

   In GEC's Spill Contingency and Prevention Plan for the GIWW, a one-compartment spill was used for analysis. Is this a reasonable assumption for the existing alignment, and are there factors about the open bay alignment that would make a two-compartment spill possible? (See enclosed study area map.)

4. What is the most likely spill in the two alignments?

   Most likely spills are generally determined by the highest-volume commodity moving through an area that has the capacity to be spilled. We have enclosed Waterborne Commerce statistics for your consideration. Are there any factors on the horizon that would cause this commodity mix to change?

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5. What is the worst case spill for the two alignments?

We would like this discussion to consider two possibilities: (a) a most probable worst case spill; and (b) a worst conceivable worst case spill. The latter will allow free rein for the imagination, but must be based on technically real spill potentials. Factors that should be taken into consideration in answering this question include commodity movements through the area, ability to be spilled (storage factors), volume that could be spilled, and general potential for environmental damage. The information contained in Chapter 10 of GEC's Spill Contingency and Prevention Plan for the GIWW should be helpful in answering this question. In that report and in the most probable worst case spill scenarios presented in the enclosed packet, oil was considered to be the worst case spill commodity. The panel may decide on a different commodity for the most probable worst case spill and almost certainly will decide on a different commodity for the worst conceivable worst case spill.

6. What would be the environmental effects of the worst case spills for the two alignments?

Obviously, potential effects on whooping cranes will be a subject of discussion. However, the discussion should consider all aspects of the environment. We will need to talk concretely about the probable effects of specific spills at specific points and under different wind conditions, as in the most probable worst case spill scenarios for oil presented in the enclosed writeup and illustrated in the study area map. Please remember that we will not be discussing the overall effects of construction of the open bay alignment. These are important issues; but our conversation will be restricted to the effects of spills.

7. What are the potentials for containment and cleanup of the worst case spills in the two alignments?

(See enclosed study area map.)

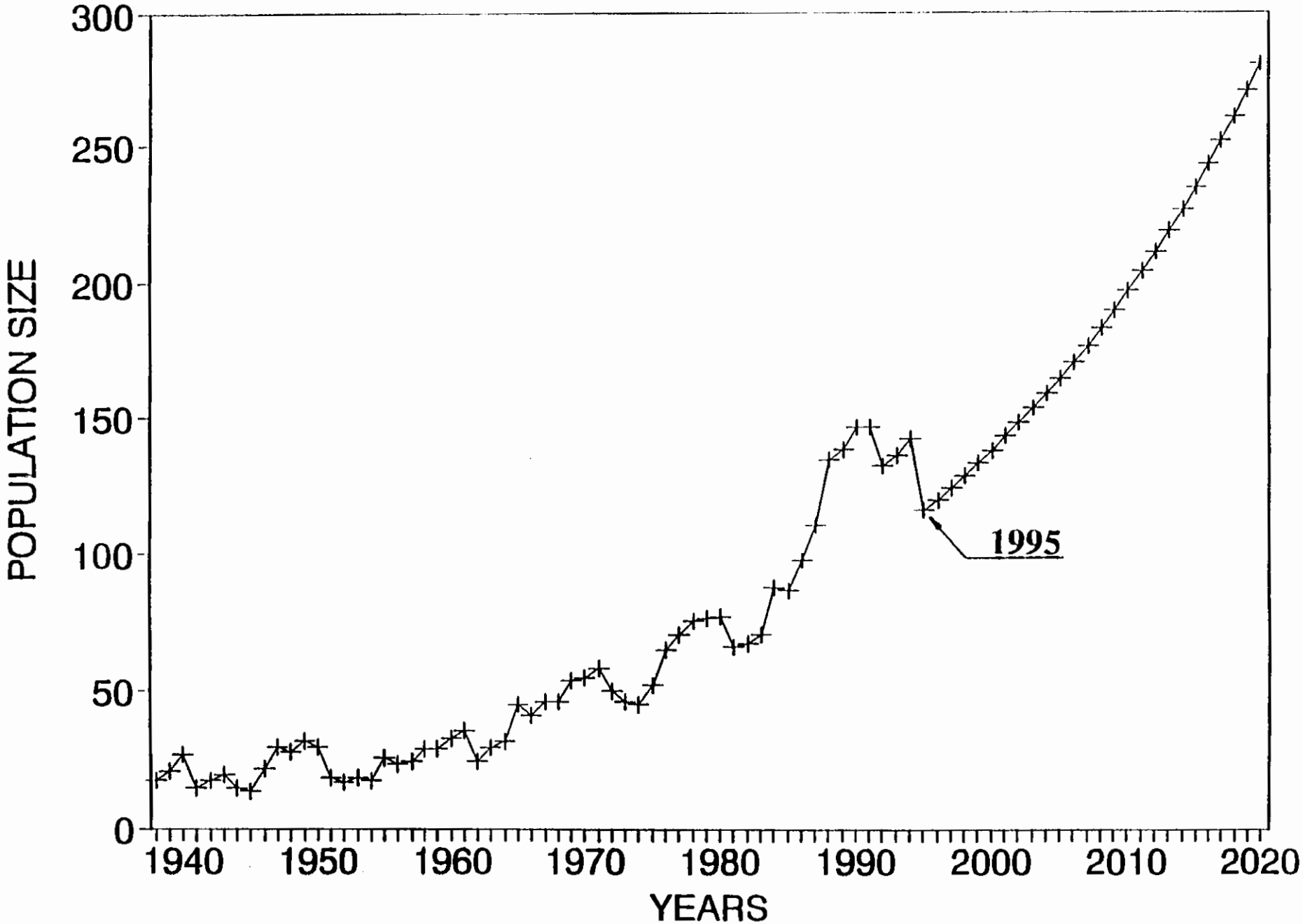
We hope to be able to achieve a consensus among the panel members in providing answers to these seven questions, which will be quite a challenge for all of us even in an all-day meeting.

We look forward to seeing you at 8:30 a.m. on Tuesday at the Marriott in Corpus Christi.

Sincerely,

James Hoover

ARANSAS WHOOPING CRANE POPULATION
HISTORIC AND PROJECTED



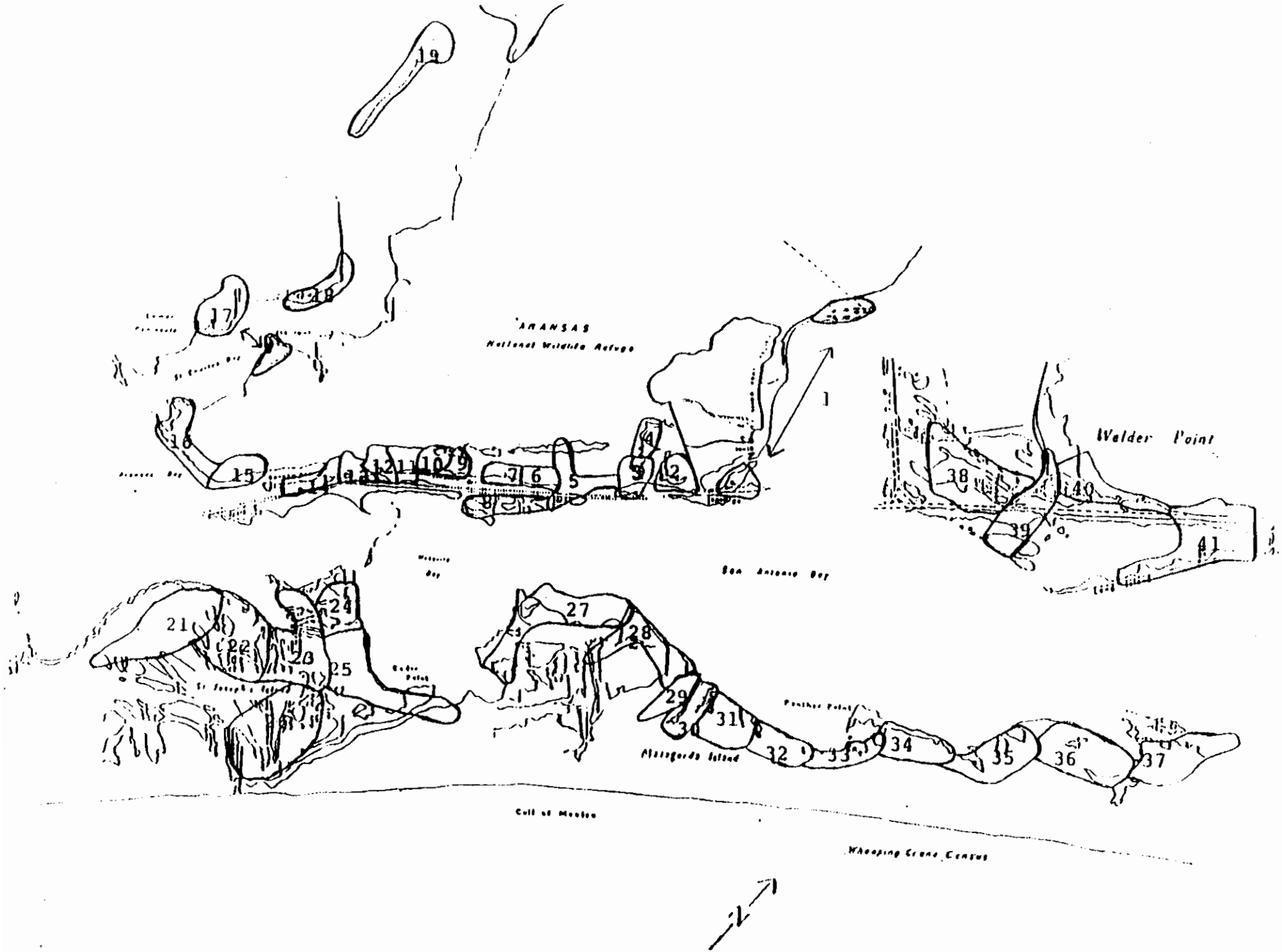


Figure 2. Locations of Whooping Crane Territories during 1991-1992 Season.

TABLE 1
1989 TONNAGE BY COMMODITY
TRAVELING ALONG THE GIWW STUDY AREA
FROM MILE 475 TO MILE 525

WCSC COMMODITY CODE	1989 TONNAGE BARGED	
Farm Products		
103	45,443	
106	1,534	
107	6,853	
111	11,945	
	SUBTOTAL:	65,775
Metallic Ores		
1011	9,356	
1051	24,501	
1061	5,172	
1091	4,820	
	SUBTOTAL:	43,849
Crude Petroleum		
1311	747,916	
	SUBTOTAL:	747,916
Nonmetallic Minerals		
1442	1,020,639	
1451	17,466	
1491	2,951	
1493	9,347	
1499	9,934	
3241	41,387	
3291	20,436	
	SUBTOTAL:	1,122,160
Food and Kindred Products		
2014	2,482	
2042	3,400	
2049	14,979	
2061	100,356	
2091	8,075	
	SUBTOTAL:	129,292
Industrial Chemicals		
2810	524,007	
2811	169,146	
2813	581,758	
2817	746,372	
2819	2,868,631	
2891	21,623	
	SUBTOTAL:	4,911,537

WCSC COMMODITY CODE	1989 TONNAGE BARGED	
Agricultural Chemicals		
2871	128,641	
2872	1,453	
2873	24,512	
2879	3,010	
	SUBTOTAL:	157,616
Petroleum Products		
2911	2,622,721	
2912	341,294	
2913	154,331	
2914	1,294,369	
2915	1,261,836	
2916	143,986	
2917	534,617	
2918	175,866	
2920	155,028	
2921	13,208	
2991	221,213	
	SUBTOTAL:	6,918,469
Primary Metal Products		
3311	45,296	
3314	14,122	
3315	33,074	
3316	2,782	
3317	4,126	
3318	5,511	
3324	1,434	
	SUBTOTAL:	106,345
OTHER COMMODITIES		
Marine Shells		
931	7,000	
Forest Products		
2411	1,221	
Fabricated Metal Products		
3411	4,044	
Machinery, Except Electrical		
3511	3,300	
Iron and Steel Scrap		
4011	92,175	
	SUBTOTAL:	107,740

TOTAL TONNAGE: 14,310,699

Source: Waterborne Commerce Statistics Center, 1989 Cargo History Files, New Orleans, La., 1991

TABLE 6
POLLUTION POTENTIAL FROM NAVIGATION ACCIDENTS
ALONG THE STUDY AREA
BY POLLUTION POTENTIAL GROUPINGS

POLLUTION POTENTIAL GROUP	WCSC CODE	COMMODITY DESCRIPTION	BARGE TYPE	1989 STUDY AREA TONNAGE	1989 STUDY AREA TON-HOURS	STUDY AREA SPILL PROBABILITY
1	1451	Clay & Ceramic	CH	17,466	174,660	0.000014460
1	931	Marine Shells	DK	7,000	35,000	0.000002898
1	3291	Misc. Nonmetallic Minerals Prod.	OH	20,436	102,180	0.000008460
1	3311	Pig Iron	OH	45,296	452,960	0.000037501
1	1011	Iron Ore & Concentrates	CH	9,356	93,560	0.000007746
1	3511	Machinery, except Electric	DK	3,300	33,000	0.000002732
1	1051	Bauxite	OH	24,501	245,010	0.000020285
1	4011	Iron & Steel Scrap	DK/OH	92,175	760,854	0.000062993
1	3318	Ferroalloys	OH	5,511	55,110	0.000004563
1	3316	Iron & Steel Plates & sheets	OH	2,782	27,820	0.000002303
1	3241	Building Cement	CEM	41,387	413,870	0.000034265
1	3317	Iron & Steel Pipe & Tube	OH	4,126	41,260	0.000003416
1	3324	Aluminum & Aluminum Allows, Unworked	CH	1,434	14,340	0.000001187
1	3411	Fabricated Metal Products	DK	4,044	40,440	0.000003348
1	3314	Iron & Steel Products	OH	14,122	141,220	0.000011692
1	1442	Sand & Gravel	DK	1,020,639	5,813,217	0.000481288
1	1061	Manganese	OH	5,172	51,720	0.000004282
1	3315	Iron & Steel Bars	OH	33,074	330,740	0.000027383
1	1499	Nonmetallic Minerals, NEC	OH	9,934	99,340	0.000008225
1	2411	Logs	DK	1,221	12,210	0.000001011
		SUBTOTAL:		1,362,976	3,938,511	0.000740037
		PERCENTAGE:		9.52%	6.96%	6.96%
2	2014	Tallow, Animal Fats, & Oils	SST	2,482	24,820	0.000002055
2	1091	Nonferrous Metal Ores & Concentrates, NEC	OH	4,820	48,200	0.000003991
2	2918	Asphalt, Tar, Pitches	ASPH	175,866	1,758,660	0.000145603
2	107	Metallic Ores	CH	6,853	68,530	0.000005674
2	106	Farm Products	DK	1,534	15,340	0.000001270
2	2091	Vegetable Oils	SST	8,075	80,750	0.000006685
2	111	Soybeans	CH	11,945	119,450	0.000009890
2	2391	Miscellaneous Chemical Fertilizer	SST	21,623	216,230	0.000017902
2	2061	Sugar	CH	100,356	1,003,560	0.000083087
2	2873	Phosphatic Chemical Fertilizer	DST	24,512	201,905	0.000016716
2	103	Corn	CH	45,443	454,430	0.000037623
2	2372	Potassic Chem. Fertilizers, Except Mixtures	DST	1,453	14,530	0.000001203
2	2310	Caustic Soda	CAUS	524,007	5,014,999	0.000415202
2	2049	Grain Mill Products, NEC	CH	14,979	149,790	0.000012401
2	1491	Salt	CH	2,951	14,755	0.000001222
2	1493	Liquid Sulfur	LS	9,347	93,470	0.000007739
2	2042	Animal Feeds	CH	3,400	34,000	0.000002815
2	2879	Fertilizers, NEC	SST	3,010	30,100	0.000002492
2	2920	Coke	CH	155,028	1,530,455	0.000126709
2	2921	Liquid Petroleum Gas	LPG	13,208	132,080	0.000010935
		SUBTOTAL:		1,130,892	11,006,054	0.000911214
		PERCENTAGE:		7.90%	8.57%	8.57%
3	2913	Kerosene	DST	154,331	1,543,310	0.000127774
3	2991	Petroleum & Coal Products	SST	221,213	2,212,130	0.000183147
3	2513	Alcohols	SST	581,758	5,703,735	0.000472224
3	2914	Distillate Fuel Oil	DST	1,294,369	12,883,805	0.001066676
3	2917	Naphtha, etc., NEC	DST	534,617	5,305,610	0.000439262
3	2817	Benzene & Toluene	DST	746,372	7,463,720	0.000617937
3	2811	Crude Products	DST	169,146	1,691,460	0.000140039
3	2319	Basic Chemicals, NEC	DST	2,868,631	20,198,164	0.001672247
3	2571	Nitrogenous Chemical Fertilizer	DST	128,641	1,042,670	0.000086325
3	2911	Gasoline	DST	2,622,721	26,227,210	0.002171404
3	2912	Jet Fuel	DST	341,294	3,412,940	0.000282564
		SUBTOTAL:		9,663,093	87,684,754	0.007259599
		PERCENTAGE:		67.52%	68.29%	68.29%
3+	2916	Lubricating Oils	SST^1	143,986	1,439,860	0.000119209
3+	2915	Residual Fuel Oil	SST^1	1,261,836	11,892,345	0.000984591
3+	1311	Crude Petroleum	SST^1	747,916	7,432,472	0.000615349
		SUBTOTAL:		2,153,738	20,764,677	0.001719150
		PERCENTAGE:		15.05%	16.17%	16.17%
		TOTALS:		14,310,699	128,393,996	0.010630000
		PERCENTAGE:		100.00%	100.00%	100.00%
		GROUPS 3 & 3+ TOTAL PERCENTAGE: (Hazardous Commodities)		82.57%	84.47%	84.47%

BARGE TYPE LEGEND: ASPH=asphalt, CAUS=caustic soda, CEM=cement, CH=covered hopper, DK=deck, DST=double-skin tank, LS=liquid sulfur, LPG=LPG pressure tanks, OH=open hopper, SST=single-skin tank, SST^1=now 40% to 50% of barges are double-skin tanks, 1990 Oil Pollution Act requires 100% double-skin by year 2010.

Source for 1989 commodity tonnages: Waterborne Commerce Statistics Center, 1989 Cargo History Files, New Orleans, LA., 1991

Source for Pollution Potential Groupings and Spill Probability Estimates: Gulf Engineers & Consultants, Inc.

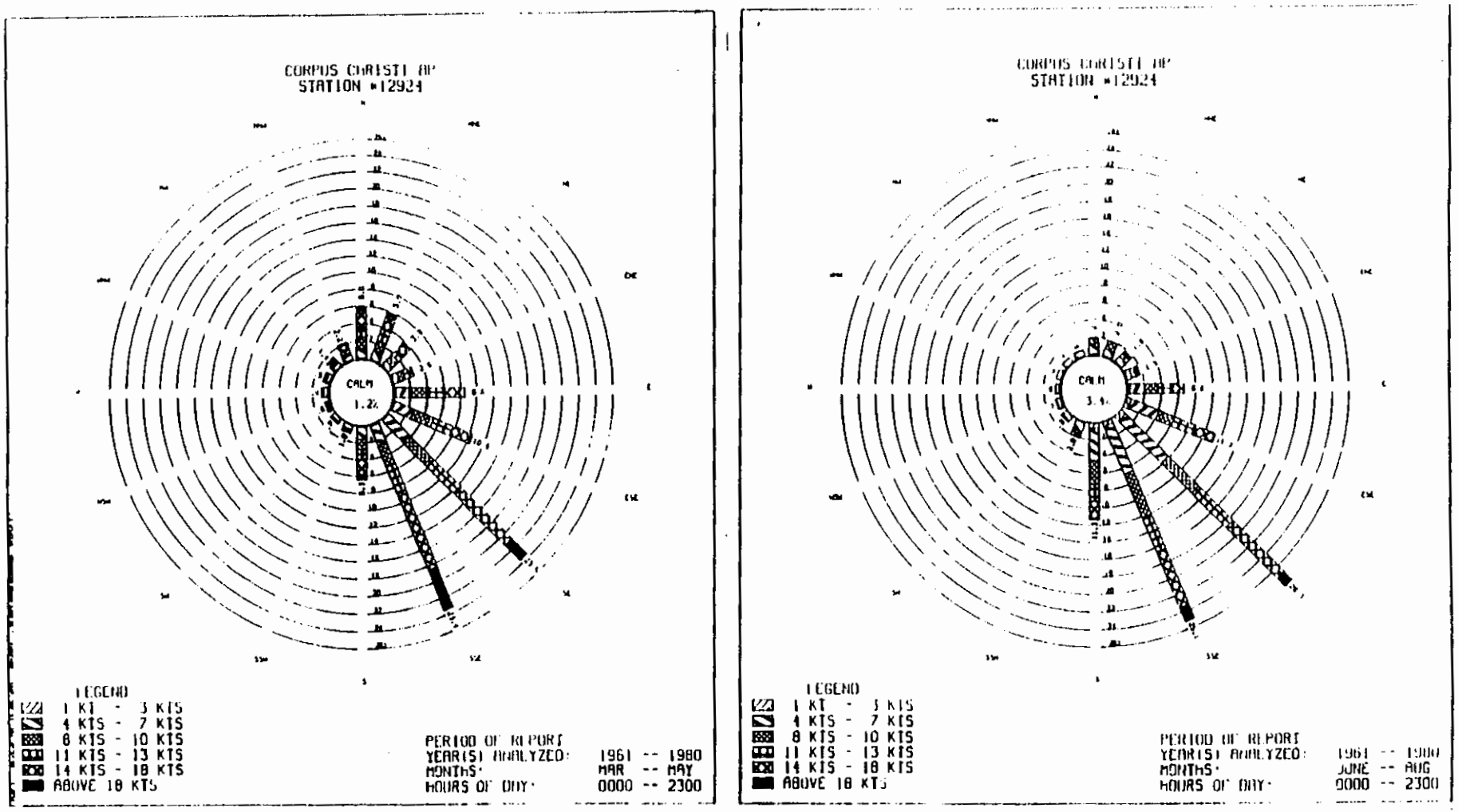


Figure 3(a). Wind Roses for Corpus Christi, Texas, March-August 1961-1980, By Office of the Texas State Climatologist

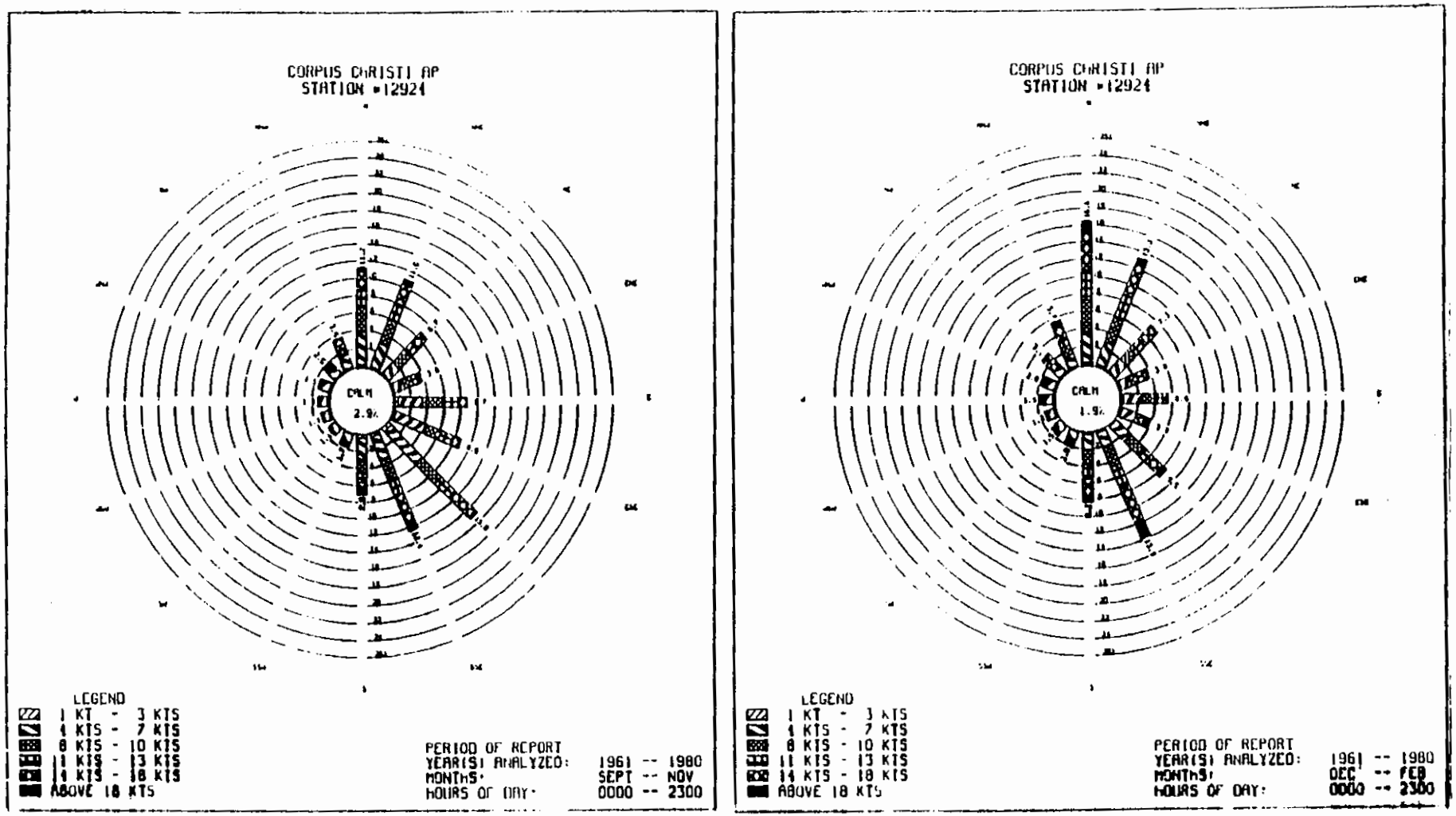


Figure 3(b). Wind Roses for Corpus Christi, Texas, September-February 1961-1980, By Office of the Texas State Climatologist

MOST PROBABLE WORST CASE SPILL SCENARIOS
OPEN BAY ALIGNMENT

SITE NO. 1 (SECOND CHAIN OF ISLANDS)

Scenario A: Wind from Northeast

Tides under this siltation are typically very low. The natural area at this site has a depth of three feet (plus or minus). Thus, loaded barges would be confined to the channel. An oil spill would probably involve one compartment, since reef sheer or crushing should not be a problem. Under these circumstances, shallow water to the south would be comparatively unobstructed for about one-half mile, and then shallow bands of exposed reef would be encountered. Oils would stick to a wide band of exposed bank, and the rest would be blown southwestward toward the lower end of Ayres Reef, which is exposed at low tide, where the rest of the oil would be trapped.

Scenario B: Wind from Southeast

This is typically a higher tide situation. Only small parts of the shell reefs of the Second Chain of Islands would be exposed, but the exposed parts could become oil coated. Winds would tend to blow the oil toward the pass about 1.2 miles away at the northeast end of Rattlesnake Island. The oil slick should be well broken up by landfall, but tar balls and oil would deposit at the high tide level on the southeast shore of Rattlesnake Island and the spoil area northeast of Rattlesnake Island. Some tar balls could be carried on high tide through the pass and into the marshes beyond the existing GIWW channel, unless an oil boom was placed promptly to block floating oil at the pass.

SITE NO. 2 (SOUTHEAST EDGE OF AYRES DUGOUT)

Scenario A: Wind from Northeast

Under this low tide condition, the oil plume would tend to disperse in the open water of Mesquite Bay toward Cedar Bayou. Some tar balls would be deposited on mud flats near Cedar Bayou that would be exposed at low tide.

Scenario B: Wind from Southeast

Under this high tide situation, there may be a danger of greater spill volume, since reef at the edge of the channel could cause shearing or cracking of a barge hull. Some oil may coat the exposed parts of Ayres Reef, but the water would be high enough to prevent much reef coating. With less than a mile of open water to the southeast shore of Roddy Island, the high tide shore should be significantly affected. Some oil would probably also deposit on Ayres Island, but it is not likely that much would go through the pass between Roddy Island and Ayres Island, even if it were not boomed.

SITE NO. 3 (SOUTHWEST END OF CEDAR DUGOUT)

Scenario A: Wind from Northeast

The left flank of the oil plume would be blown against the west side of Cedar Reef, which is well exposed on low tide. The exposed edge of the reef would be heavily coated with oil. Most of the plume would be blown out into Carlos Bay. Although the plume would probably be broken up and dispersed, tar balls and some oil would probably coat the exposed shallow bottoms and the shell reef at the northwest side of Ballou Island.

Scenario B: Wind from Southeast

Winds would cause spilled oil to be blown promptly to and deposit on the high tide shore at Cedar Point and thence westerly along the north, high water shoreline of Carlos Bay. The spill could be easily contained near Cedar Point by rapidly installing a floating boom from the shoreline a few hundred feet west of Cedar Point extending a few hundred feet southward into Carlos Bay. However, the exposed high water shore could be heavily coated with oil.

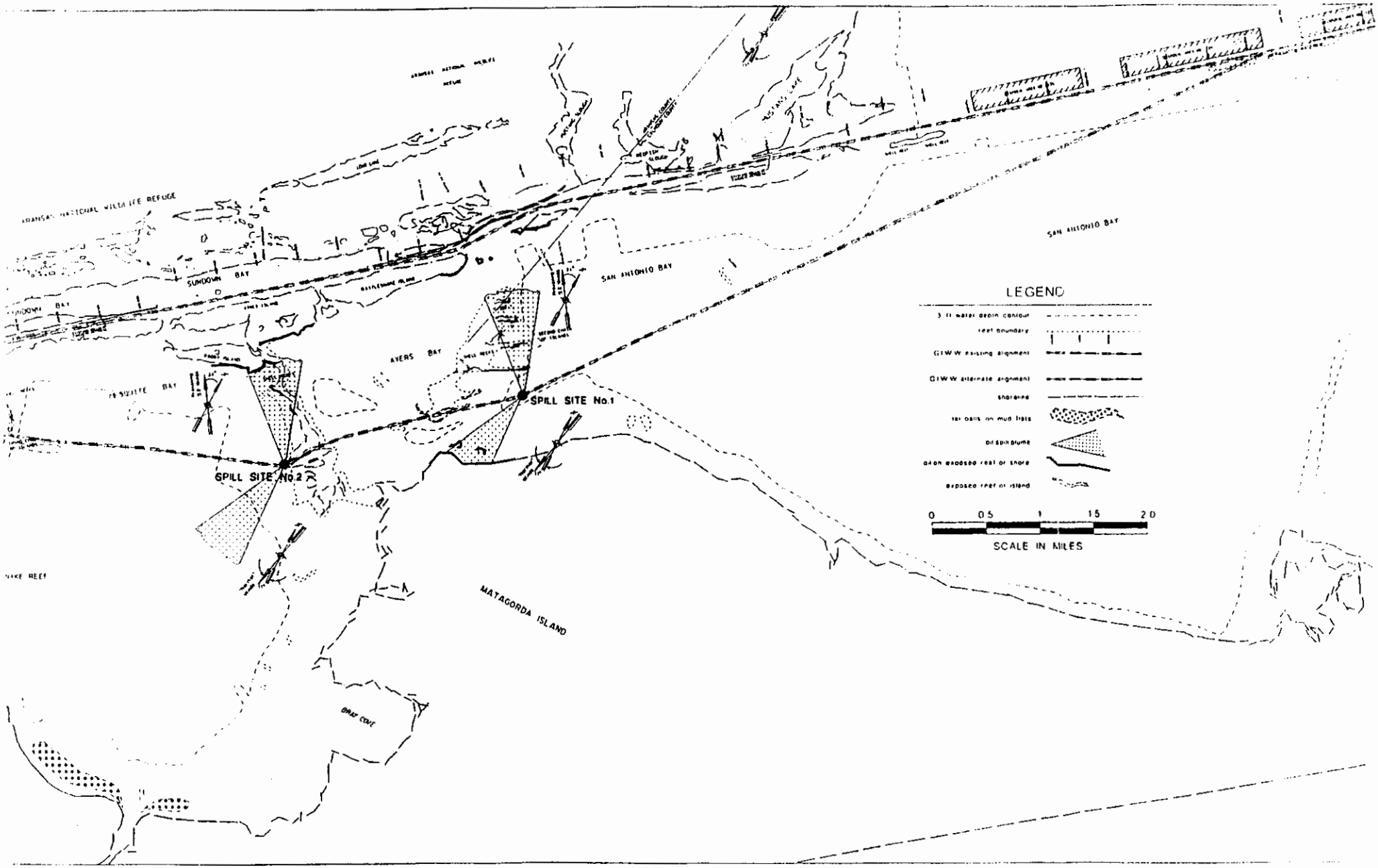
SITE NO. 4 (SOUTHWEST END OF CAPE CARLOS DUGOUT)

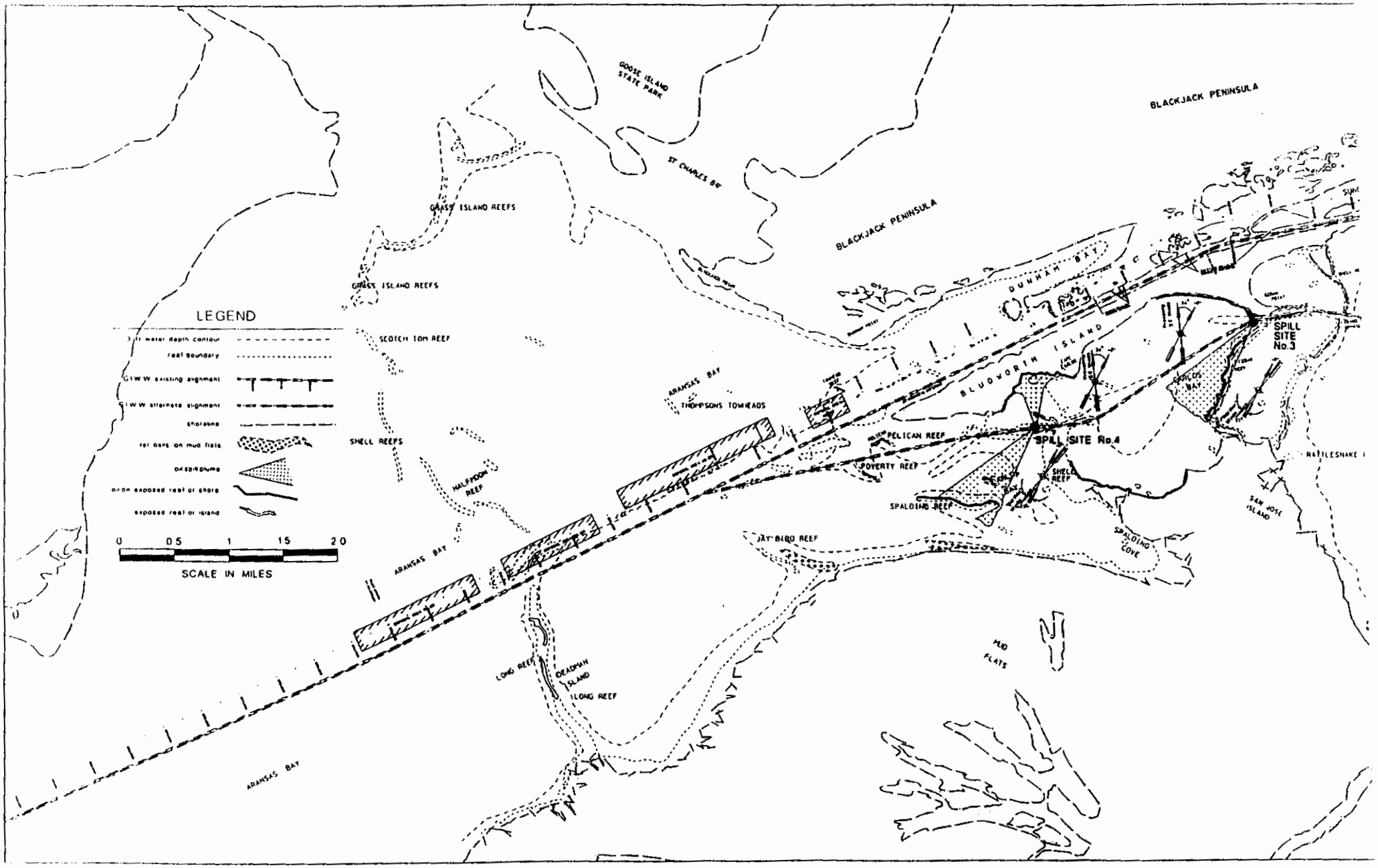
Scenario A: Wind from Northeast

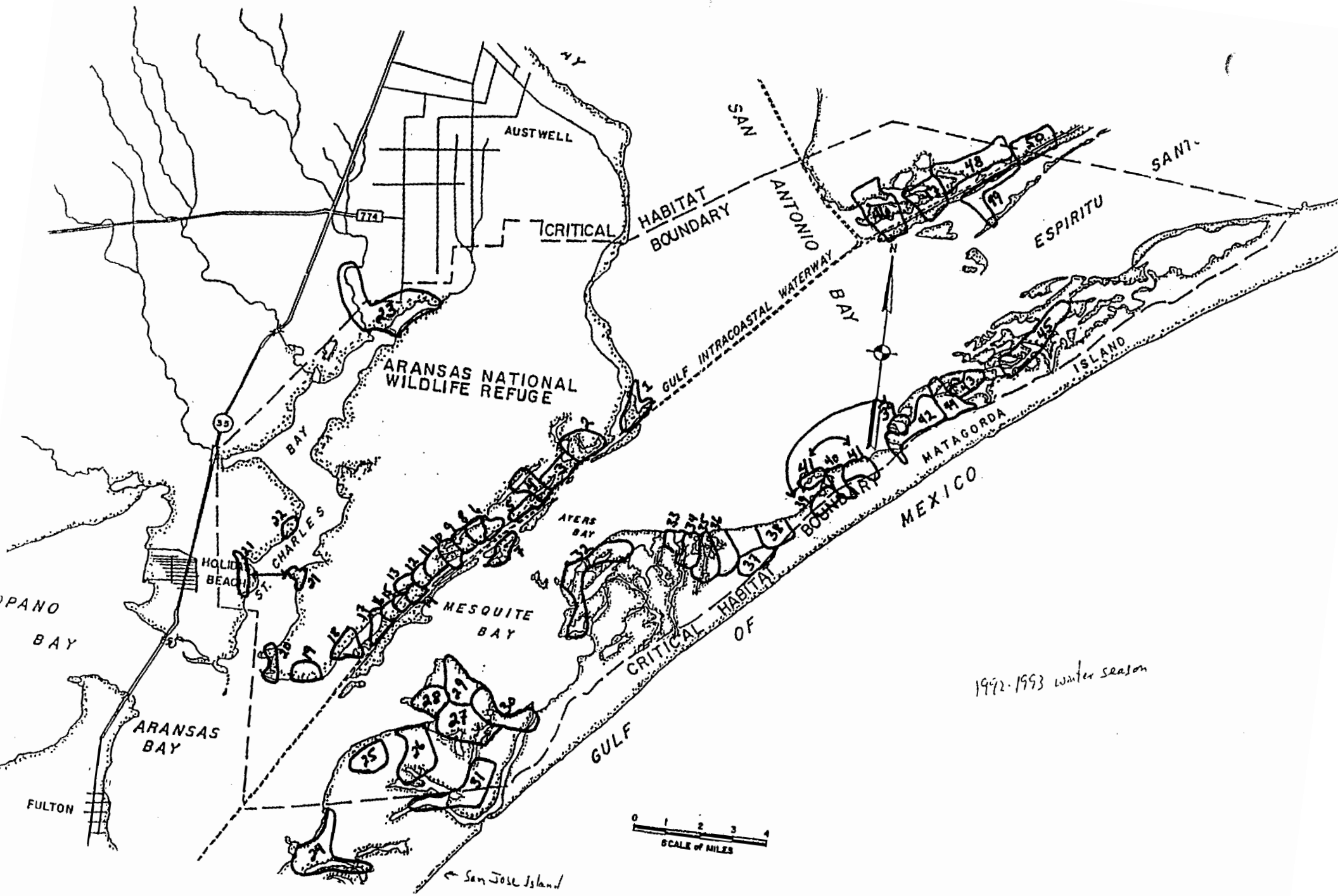
Oil spilled at this point would be blown out into Spalding Bight toward Spalding Reef, about 0.7 mile downwind. Because of low tides associated with strong northers, Spalding Reef should be exposed sufficiently so that most, if not all, of the oil still floating would heavily coat the north side of Spalding Reef or be trapped against the reef. If any slipped by the sides or over the top of the reef, some slight tar balling could occur in the shallow flats near the shoreline northeast of Jay Bird Point. However, if booms are placed promptly at the flanks of Spalding Reef, the spill should be contained.

Scenario B: Wind from Southeast

Aerial photographs indicate most of the reef north of the spill site should be submerged on high tide, so spilled oil would tend to be blown promptly against the high tide shoreline of Bludworth Island. The shoreline would probably be heavily coated, but the maps and photographs indicate spilled oils would tend to be contained by the onshore winds in the concave shoreline southwest of Cape Carlos.


SUNDOWN BAY
SAN ANTONIO BAY
AYERS BAY
SPILL SITE No.1
SPILL SITE No.2
MATAGORDA ISLAND
LEGEND
3 ft water depth contour
reef boundary
GIWW existing alignment
GIWW alternate alignment
shoreline
oil spill on mud flats
oil spill plume
oil on exposed reef or shore
exposed reef or island
0 0.5 1 1.5 2.0
SCALE IN MILES


LEGEND
water depth contour
reef boundary
GIWW existing alignment
GIWW alternate alignment
shoreline
oil on mud flats
oil spill plume
oil on exposed reef or shore
exposed reef or island
0 0.5 1 1.5 2.0
SCALE IN MILES
GOOSE ISLAND STATE PARK
ST CHARLES BAY
BLACKJACK PENINSULA
BLACKJACK PENINSULA
GRASS ISLAND REEFS
GRASS ISLAND REEFS
SCOTCH TOM REEF
SHELL REEFS
HALFMOON REEF
ARANSAS BAY
ARANSAS BAY
ARANSAS BAY
THOMPSONS TOWHEADS
DUNHAM BAY
BLUDWORTH ISLAND
PELICAN REEF
POVERTY REEF
SPALDING REEF
SHELL REEF
SPILL SITE No.4
SPILL SITE No.3
CARLOS BAY
SPALDING COVE
SAN JOSE ISLAND
RATTLESNAKE
JAY BIRD REEF
MUD FLATS
LONG REEF
DEADMAN ISLAND
LONG REEF


AUSTWELL
774
CRITICAL HABITAT BOUNDARY
SAN ANTONIO BAY
GULF INTRACOASTAL WATERWAY
ESPIRITU
SANT-
ARANSAS NATIONAL WILDLIFE REFUGE
BAY
CHARLES
HOLIDAY BEACH
ST.
MESQUITE BAY
AYERS BAY
CRITICAL HABITAT BOUNDARY OF GULF MEXICO
MATAGORDA ISLAND
ARANSAS BAY
FULTON
SCALE of MILES
San Jose Island
1992-1993 winter season

APPENDIX A - SECTION 3

OIL SPILL CONTINGENCY PLAN FOR ARANSAS NATIONAL WILDLIFE REFUGE, TEXAS

OIL SPILL CONTINGENCY PLAN

FOR

ARANSAS NATIONAL WILDLIFE REFUGE,TEXAS

Prepared by

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Tom Stehn[2]
John Magera[2]

Reviewed By

Thomas Schultz[1]
and
Brian Cain[3]
Environmental Contaminants Specialists

April 1993

1 U.S. Fish and Wildlife Service
Fish and Wildlife Enhancement
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Campus Box 338, 6300 Ocean Drive
Corpus Christi, Texas 78412

2 U.S. Fish and Wildlife Service
Division of Refuges
Aransas National Wildlife Refuge
Post Office Box 68
Austwell, Texas 77950

3 U.S. Fish and Wildlife Service
Fish and Wildlife Enhancement
Clear Lake Field Office
17629 El Camino Real, Ste. 211
Houston, Texas 77058

Oil Spill Contingency Plan

for

Aransas National Wildlife Refuge

Purpose

This plan is intended to serve as a step by step guide to emergency oil spill response in the event that such a spill threatens refuge lands and wildlife.

Because it may take several hours before professional oil spill responders and cleanup crews arrive, the emergency efforts of refuge personnel may play a key role in reducing impacts to refuge lands and wildlife resources. The primary goal in this emergency response is to minimize the impacts on the trust resources of the U.S. Fish and Wildlife Service (Service). Appendix B lists the priorities for Service response, as outlined in the Service's Response Plan for Discharges of Oil and Releases of Hazardous Substances (Service Contingency Plan - SCP). For specifics regarding legal authorities and responsibilities, refer to the Service Contingency Plan.

This plan pertains to spills of petroleum products only. Because of the threat to human health involved in responding to hazardous substances spills, evacuation may be the appropriate response. There are few Service personnel who are trained for hazardous spill response. The Service policy states that Service personnel will not enter hazardous waste sites without specific Regional clearance. Additionally, the likelihood of a petroleum spill in the vicinity of Aransas National Wildlife Refuge (ANWR) is greater than that of a hazardous substance spill, since most barges carrying hazardous cargo are double-hulled versus the single-hulled barges used for petroleum products. Of particular concern at this refuge are potential impacts to endangered whooping cranes and their critical habitat (see appendix A).

Following is a numbered, step by step response sequence that should be followed in the event an oil spill is discovered or reported to the refuge. Three likely spill scenarios are covered in the response sequence. These three scenarios are:

(A) A pipeline leak or rupture on land.

(B) A barge collision or spill in the Gulf Intracoastal Waterway (GIWW), a submerged pipeline leak or break, or a leak from sinking vessel fuel tanks.

(C) An offshore oil spill in the Gulf of Mexico moving onshore.

After completing steps one through six proceed to 7A (landlocked pipeline leak or rupture), 7B (spill in the GIWW), or 7C (spill offshore) according to the spill scenario. Actions which should be taken in order to prepare for a spill are presented in Appendix D. Equipment needs are presented in Appendix E. Secondary responses are listed in Appendix F. Appendix G provides telephone numbers of those who may need to be contacted. Wildlife rehabilitation, in particular oiled bird cleaning, is addressed in Appendix H.

This is a dynamic document and is intended to be updated as appropriate. Although it is recognized that it is impossible to foresee, prepare for, and control all potential oil spill scenarios, it is hoped that this document will help guide personnel reacting in the critical initial stages.

Priority Response Sequence

1. Cease all non-critical work. If more than one staff member is available, assign one to make the telephone contacts while other personnel proceed immediately to field response (step 7). If only one staff member is available, begin with the phone calls in the order listed.

2. If they have not already been notified, call the following:
Corpus Christi Marine Safety Office 512/888-3162.
Pipeline Company (in the event of a pipeline spill only.
See Appendices C for locations and D for phone numbers)
Refuge Manager Brent Geizentanner Home (512) 552-5282
Office (512) 286-3559/3533
National Response Center (800) 424-8802 or **(202) 267-2675.**
Texas Emergency Response Center (TERC) (512) 463-7727
Texas General Land Office 1-800-832-8224
Texas Water Commission (512) 968-3165
USFWS Texas Coast Spill Coordinator - Brian Cain
Office (713) 286 8282
Home (713) 480 7418
Mobile phone (713) 542 1861

Tell them:

i. Your name and callback number.
ii. Exact location and nature of the incident.
iii. Extent of personal injuries, fire and damage.
iv. Wind speed and direction (if possible).
v. If identifiable, the type of material involved and the extent of the spill. If possible, give them the barge or ship name and number. ONLY trained personnel should ever approach a fire or spill.

3. Call the Environmental Contaminants Specialist at the Corpus Christi ES Office.
Contaminants Specialists - Tom Schultz or Steve Robertson
Office (512) 994-9005
After Hours (512) 855-8744 or (512) 991-4659

4. Call the designated pilot and arrange for an overflight survey for the refuge manager immediately, or at first light if spill occurs at night.
Contact pilot for low-level flight:
Air Exec (Victoria) (512) 578-3506
Pilot, Gerry Shore (Home) (512) 782-6407

Other federally approved aircraft:
Victoria Aviation (Victoria) (512) 578-1221

Helicopters:
Crescent Airways (Corpus Christi) (305) 987-1900

5. Check wind speed and direction. Call Weather information at the National Weather Service:

Corpus Christi (512) 289-1861
Victoria (512) 575-1782

6. If possible, designate one person as the media contact. This should be someone who can provide specific information about the resources at risk. If the spill is large enough to catch the media's attention, the refuge will be besieged by the press! Make sure the media is informed that they must stay above the 2000 foot airspace above the refuge to avoid harassment (constituting take under the Endangered Species Act) of the whooping cranes when they are present.

A. <u>Rupture of pipeline on Refuge property.</u>

7A. Contact the pipeline company (if you have not already done so) and ensure they have shut down the line and are responding to the spill. Refer to Appendix C for identification of pipeline operators and Appendix G for pipeline phone numbers.

8A. **Contain the oil.** Immediately go to the vicinity with bulldozers, other heavy equipment and hand tools (shovels, picks etc.) and begin erecting a containment berm all around the blowout area. The pond required may be of significant size, depending on the flow of oil. Some uplands will be destroyed but it will be far better to contain the spill. Prevent the spill from getting into any waterways, where it would spread very quickly. Erect (bulldoze) earthen dikes across affected ditches if there is little water flow in them. If there is significant water flow in the affected waterways, setup barrier and absorbent booms to help contain the flow of oil.

9A. If oil threatens to get into the GIWW, proceed with steps 7B and 8B. It may be necessary to contain the oil within a marsh area by closing off an inlet area.

10A. Remain in the area and haze birds away from the oiled sections, and, if vehicle access is possible, to direct vacuum trucks to the boom locations.

11A. Coordinate with the USFWS spill coordinator to determine if oiled birds will be cleaned. Follow oiled wildlife rehabilitation protocol (see appendix H).

B. <u>One or more barges run aground or collide in the GIWW</u>, breaking their hulls and thus releasing their cargo. Note: this also applies to submerged pipeline breaks.

7B. Immediately go to the vicinity with boom materials and extend these across the inlets and openings at prior designated stations (Appendix B, various figures), securing the booms to the fixed anchor points. Continue fixing booms along openings both above and below the spill, especially downwind or downstream: however, boom deployment must occur throughout the area because shifting winds, tides and currents could spread oil virtually everywhere. **Important: Make sure of the identity of the material before approaching. Do not approach the spill area if the material spilled is unknown. Hazardous chemical spills present a severe danger, and evacuation of the area may be necessary.** During winter months, (October-April) whooping cranes and waterfowl will be at high risk. In spring and summer, (March-July) nesting colonies of birds on the rookery islands will be at high risk. Concentrations of shore birds will be at risk from August through May.

8B. Mobilize boats to the spill area. Contact TP&W (appendix G) and request their assistance. Patrol and haze waterfowl and/or shorebirds from the area about to be oiled, as directed from aerial survey, and later from the oiled areas. During the period of March to July herons, egrets, terns, and gulls will be nesting on islands on spoil and natural islands, in particular the Second Chain of Islands. Hazing these birds in the vicinity of these islands would be counterproductive and is not recommended. An absorbent barrier, even if only of hay bales, in the intertidal area of the rookeries should be deployed to help minimize impacts.

9B. Remain in the area and haze birds away from the oiled sections, and, if vehicle access is possible, to direct vacuum trucks to the boom locations.

10B. Coordinate with the USFWS Spill Coordinator to determine if oiled birds will be cleaned. Follow oiled wildlife rehabilitation protocol (see appendix H).

C. <u>Offshore Spill coming onshore</u>.

In this scenario, there should be a little more time to organize a response. The Coast Guard may coordinate booming of passes to the Gulf, use of dispersants, etc., to reduce impacts on shore

and bays.

7C. Booming of small inlet areas (see 9A & 10A) may be appropriate, but the decision to do so will be made by the USFWS Spill Coordinator on a case by case basis.

8C. The more severe impact will likely be to the beaches on Matagorda Island. Human activities on the beach, such as pre-assessment and cleanup crews will help to deter bird presence. Additional hazing crews and deployment of scare guns will be necessary to keep birds away from oiled areas, with particular attention on piping plovers and brown pelicans.

9C. Coordinate with the USFWS Spill Coordinator to determine if oiled birds will be cleaned. Follow oiled wildlife rehabilitation protocol (see appendix H).

APPENDICES

Version 4/1/93

APPENDIX A

Limitations of Plan in Reference to Threat to Whooping Cranes

An insurmountable problem that many feel is the greatest threat faced by the whooping cranes is the location of the GIWW. Hazardous chemicals are hauled within 100 yards of wintering whoopers. More than 60% of the whooper territories adjoin the GIWW. Spilled materials could contact whooping cranes even as a boat captain was reporting the incident to the Coast Guard.

This plan is inadequate in providing full protection for the whooping cranes. Such a plan is not possible since chemicals are transported right through the center of the whooping crane winter range. Spills of hazardous materials may threaten human health so that approach could only be done by personnel wearing special protective suits and breathing apparatus. Spills of gaseous materials could directly kill all whoopers downwind of the disaster. Response time at best is 1-2 hours by the refuge staff, and 3-4 hours by spill control specialists. An event occurring at night or during bad weather (the most probable times), would slow response time further. In addition, the response of the whooping cranes to spilled materials and humans trying to haze the whoopers away from a spill is currently unknown.

What this plan does attempt to do is organize the refuge staff so that what little can be done to lessen impacts to wildlife will be done professionally.

Plan limitations-Whooping Crane Biology

1. It is likely that because chemicals are carried so close to the cranes, some whooping cranes and some habitat will be impacted by a spill incident.

   a. There is no known safe technology to capture whooping cranes and keep them in captivity until their habitat is no longer contaminated. Whooping cranes are fragile and can die from shock during capture and/or handling. If whooping cranes become oiled, they can probably only be captured when they are too weak to fly. By this time the stress of capture and handling may kill them. In addition, ingested oils, and/or chemical exposure will probably lead to permanent physical damage and could affect the reproductive process. The decision to attempt to capture a whooping crane must be made by the refuge manager, and should be done only if knowledgeable avian health experts are present.

   b. Whooping crane adults are strongly territorial. This means that hazing whooping cranes away from a spill area using a helicopter, airboat, or human on foot, may not be effective. Adult whoopers on their territory normally will respond to disturbance by walking or flying to a different part of the territory. If a large section of habitat is impacted by a spill, the problem becomes very difficult. Even if the whoopers leave a territory temporarily during the day, they are likely to try to return to the territory at night to roost. Although the whoopers decades ago responded to the placement of

agricultural grains on the edges of the salt marsh, the whoopers alive today have never been exposed to this. At best, response to baiting would take days. Even after feeding on bait, the whoopers would then return to their territories in the salt marsh, just as whoopers that feed on acorns in upland areas return to the marsh regularly. Similarly, burning refuge uplands to provide feeding areas for whoopers would not be effective.

c. Once saltmarsh habitat has been impacted by oil and/or chemicals, cleanup will be at best incomplete and recovery could take many years. Burning oil residues in the marsh may lessen impacts somewhat. To clean saltmarsh, all contaminated soil and vegetation would have to be removed, and then the marsh re-built. This has never been accomplished on a large scale.

2. If it is necessary to haze whooping cranes away from a small area impacted by a spill, the following methods are suggested;

a. Whooping cranes definitely flush upon approach by an airboat or a human on foot. Approach in a small boat or vehicle will also flush cranes. Since airboats cause the most disturbance, they should only be used in a spill response after approval by the refuge manager, who hopefully will be in consultation with the Services' Whooping Crane Coordinator (Jim Lewis (505) 766-2914) in Albuquerque. Human presence in the spill area either in an outboard or on foot will keep cranes away from the immediate area.

b. A major problem in keeping cranes out of a spill area is that territorial cranes will tend to remain in their territory when flushed, and will at a minimum try to roost at night in their territory. Thus, humans would have to patrol the spill area 24 hours a day. If a spill is located along a refuge shoreline, such as along the banks of the GIWW or the edge of Sundown Bay, these areas will need to be patrolled in a small outboard or on foot on a 24-hour basis. Scare guns alone would not be effective.

c. Helicopters should not be used to flush whooping cranes unless a whooping crane expert is present. No one should attempt to "herd" a group of whoopers once they are flushed. In addition, much helicopter traffic normally connected with the spill event will have to be prohibited, closely limited or controlled to prevent disturbance to the whoopers in nearby areas not impacted by the spill. Helicopter flights by the media should not be allowed. All helicopters should maintain the 2,000-foot minimum altitude over a national wildlife refuge as required by the FAA unless a specific waiver is received from the refuge manager. It is likely that a single Coast Guard helicopter will be used to locate the spill and will need to approach the spill site at a low level. After that, all helicopter operations should be prohibited during the 6-month time frame when the cranes are present (October 15 to April 15) unless authorized in advance by the refuge manager. Aerial operations should be conducted in fixed-wing aircraft that are much less disturbing to the whoopers.

Version 4/1/93

Appendix B

Priorities for Service Response

Each of the actions listed below should be provided for during advance planning and carried out where applicable in the event of a spill. The actions are listed in order of priority, should lack of manpower or other limiting factors constrain the level of response to a spill.

1. Protect threatened and endangered species and their habitats including, where advisable, rescue and rehabilitation of individual animals.

2. Minimize the direct and immediate impacts to fish and wildlife populations (such as dispersal of birds and other wildlife) and advise the On Scene Coordinator (OSC) of actions needed to minimize impacts to or prevent destruction of fish and wildlife and their habitats.

3. Assist State agencies or the OSC with collection of oiled birds and other wildlife and advise/assist groups wishing to rehabilitate oiled wildlife. The Texas Wildlife Rehabilitation Coalition out of Houston will likely be involved. Refer to appendix H "Oiled Wildlife Rehabilitation Protocol".

4. Provide the media and public with information on Service response activities only through the On Scene Coordinator. Avoid talking directly to the press "off the cuff".

5. Perform other activities to minimize indirect impacts to fish and wildlife resources, as warranted. Identify priorities and mark nesting islands that could easily be boomed or 'hay banded' to help keep oil off the beach.

Version 4/1/93

Appendix C

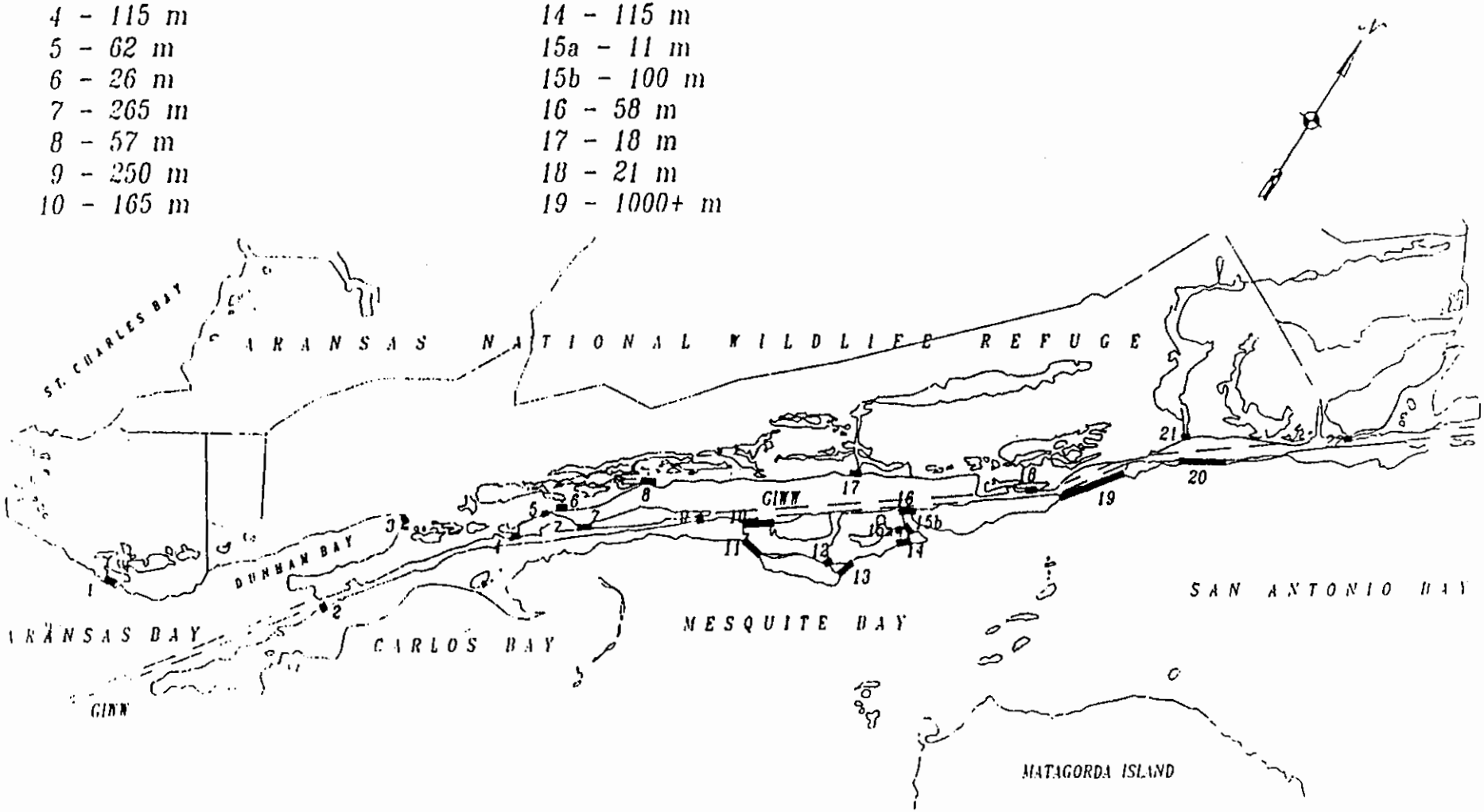
Maps and Figures

C1 Marsh Inlets for Booms on Aransas NWR
C2 Marsh Inlets for Booms on Matagorda Island
C3 Pipelines on Aransas NWR
C4 Pipelines on Matagorda Island
C5 Description of active pipelines
C6 Roads, trails and gates on Aransas NWR
C7 Roads, trails and gates on Matagorda Island

MARSH OPENINGS - OIL SPILL RESPONSE PLANNING

Boom Length/Marsh Opening (Cut) Length:
(cuts not drawn to scale)

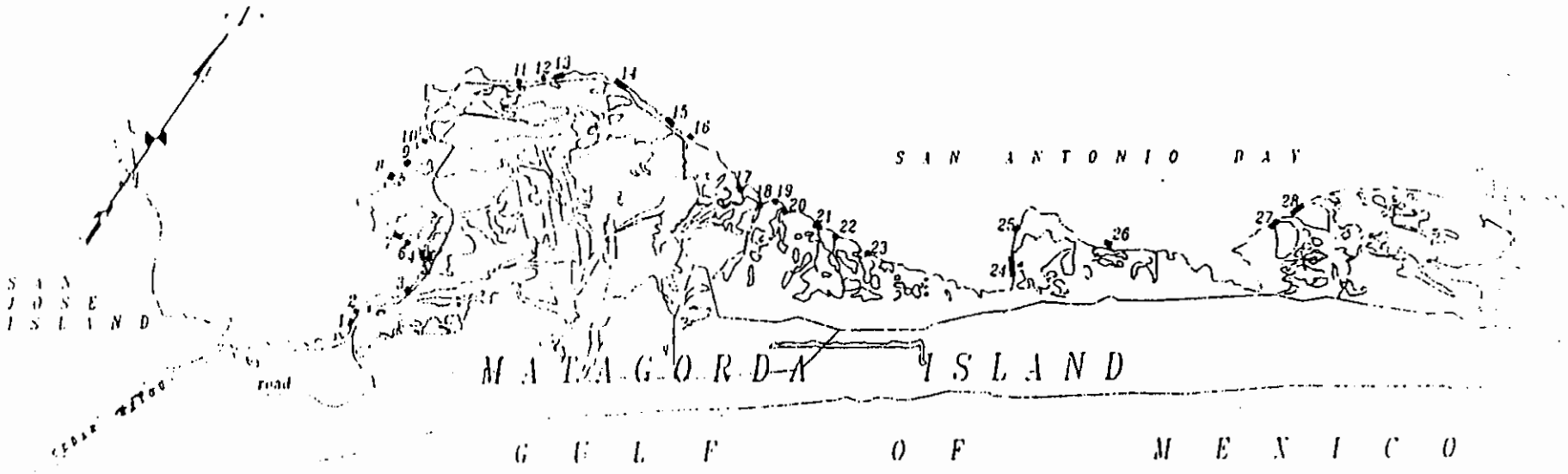
1 - 20 m
2 - 240 m
3 - two cuts, ~ 20 m each
4 - 115 m
5 - 62 m
6 - 26 m
7 - 265 m
8 - 57 m
9 - 250 m
10 - 165 m
11 - 248 m
12 - 50 m
13 - 160 m
14 - 115 m
15a - 11 m
15b - 100 m
16 - 58 m
17 - 18 m
18 - 21 m
19 - 1000+ m
20 - 1000+ m
21 - 7 m
22 - 320 m



MARSH OPENINGS - OIL SPILL RESPONSE PLANNING

Boom Length/Marsh Opening (Cut) Length:
(cuts not drawn to scale)

1 - 30 m
2 - 17 m (low spot, high tide will breach)
3 - 10 m (low spot)
4 - 30 m
5 - 35 m
6 - 22 m
7 - 45 m
8 - 145 m
9 - 52 m
10 - 20 m
11 - 25 m
12 - 19 m
13 - 45 m
14 - 5 m
15 - 60 m
16 - 40 m
17 - 30 m (side creek off cove)
18 - 110 m at mouth, 40 m at sandbar inside
19 - 110 m
20 - double cut, two openings measuring 35 m & 15 m, respectively
21 - 25 m (needed only at high tide)
22 - 143 m (3 cuts, use one continuous boom)
23 - 85 m
24 - 180 m
25 - 15 m (only needed at high tide - oyster ridge low spot)
26 - 30 m
27 - 220 m
28 - 250 m



C2

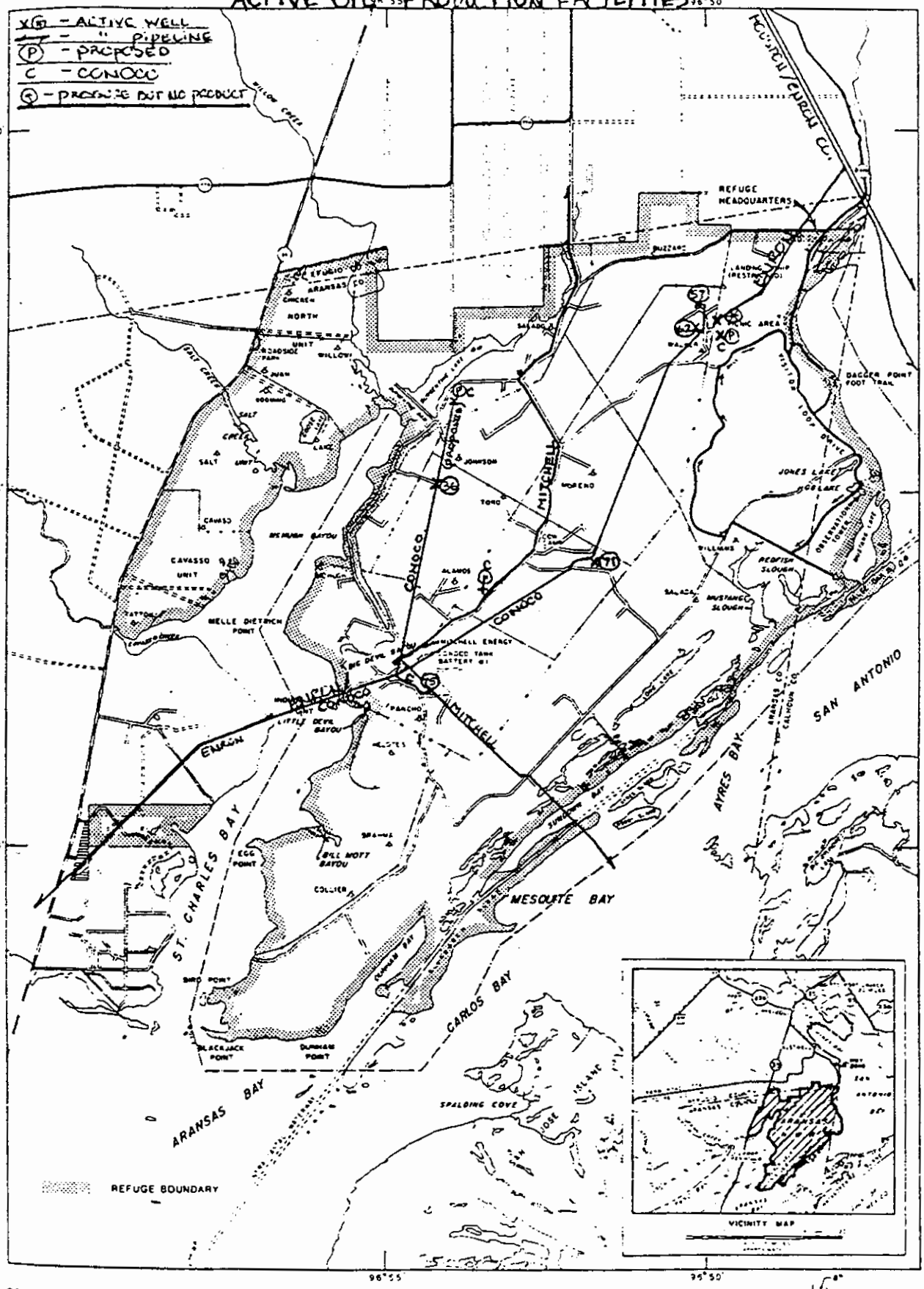
ARANSAS NATIONAL WILDLIFE REFUGE

UNITED STATES
DEPARTMENT OF THE INTERIOR

ARANSAS, CALHOUN AND REFUGIO COUNTIES, TEXAS

UNITED STATES
FISH AND WILDLIFE SERVICE

ACTIVE OIL PRODUCTION FACILITIES



COMPILED IN REALTY
FROM U.S.G.S. QUADRANGLES,
U.S.F.W.S. SURVEYS, AND OTHER
OFFICIAL RECORDS

ALBUQUERQUE NEW MEXICO NOVEMBER 1984

MEAN DECLINATION 1965

C3

2R TX. 212.3

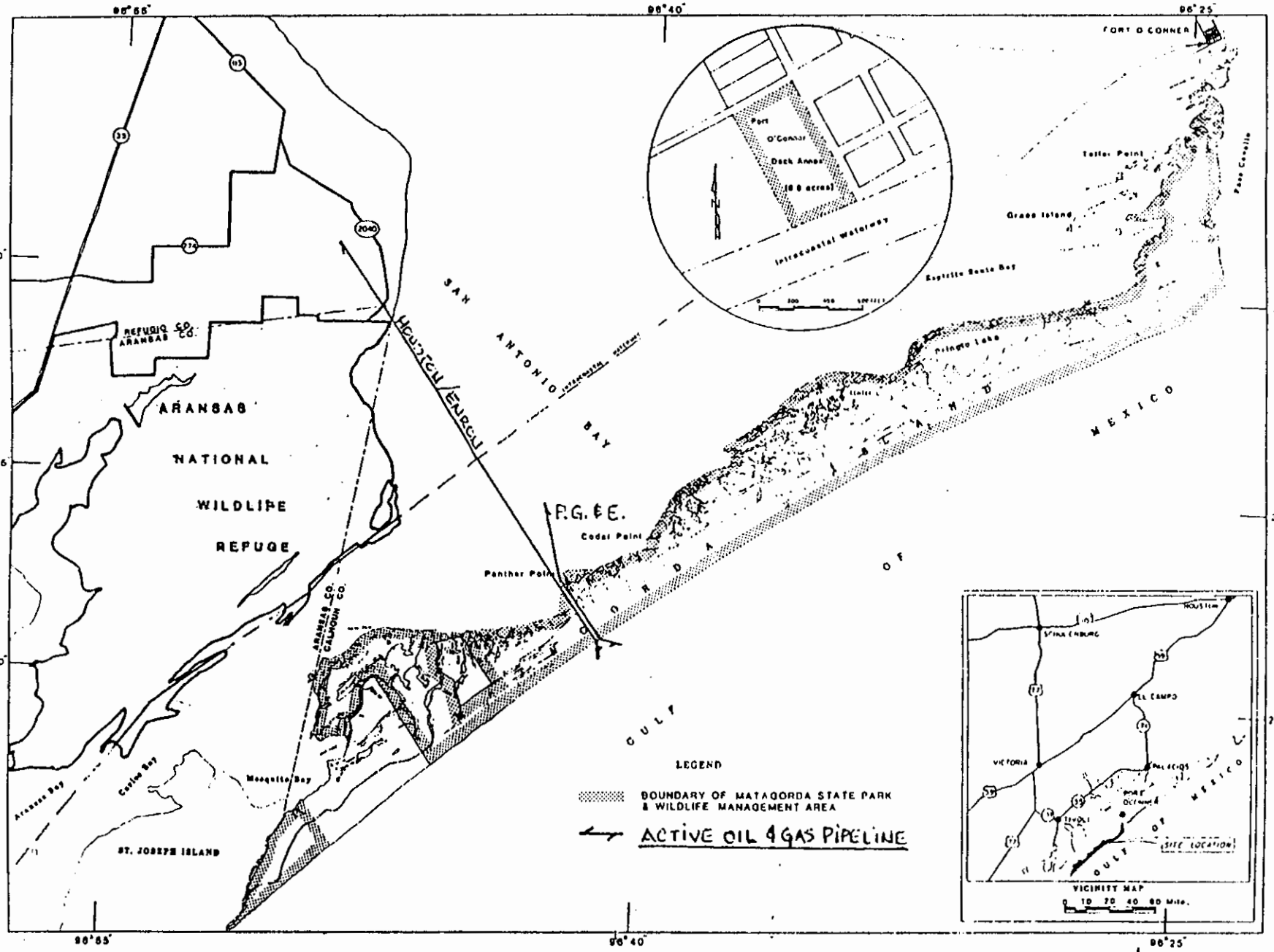
MATAGORDA STATE PARK & WILDLIFE MANAGEMENT AREA.

A UNIT OF THE NATIONAL WILDLIFE REFUGE SYSTEM

CALHOUN COUNTY, TEXAS

UNITED STATES
DEPARTMENT OF THE INTERIOR

UNITED STATES
FISH AND WILDLIFE SERVICE



COMPILED IN REALTY
FROM U.S.G.S. QUADRANGLES
U.S.F.W.S. SURVEYS, AND OTHER
OFFICIAL RECORDS.

ALBUQUERQUE, NEW MEXICO MAY 1984
5/88

C4

2R 212 405

ACTIVE OIL AND GAS FACILITIES, ARANSAS AND MATAGORDA IS.

1. Conoco operates a pipeline and right-of-way (R.O.W.) originating at wells 57 and 62 north of Walker Mill, crossing Walker Mill road, running to well 71 on Lime Ash road, crossing Lime Ash road and running to their battery on the Middle road.

2. Conoco operates a pipeline (R.O.W.) originating at well 36 (Which will soon be plugged), and running to their battery on the middle road. An addition to this will be made once their well on the east side of Burgentine Lake begins producing.

3. Conoco is currently operating 5 active wells on Aransas Refuge. These are #36, 71, 75, 62, and 57. Well #36 is Scheduled to be plugged. Two new wells are scheduled to be drilled in 1993, one on the east side of Burgentine lake and another northwest of the middle road between lime ash and Mitchell headquarters. Conoco is also planning to rework a well in the Walker Mill area.

4. Enron's Houston Pipeline Co. Division has a right-of-way for a 12 inch pipeline that originates at the Conoco battery, crosses St. Charles bay and the Lamar tract, and carries Conoco production to off-refuge facilities.

5. Enron operates a pipeline (R.O.W.) from an inactive well near Walker mill that joins thier lines north of the refuge entrance. This pipeline currently has no product in it, but is under pressure.

6. Enron operates a pipeline (R.O.W.) that originates from facilities in the Gulf, crosses Matagorda Island South of Panther Point, and returns ashore north of the refuge entrance.

7. Mitchell Energy operates a pipeline (R.O.W.) that originates from production facilities in Mesquite Bay, runs across the G.I.W.W., Sundown Bay and East Shore Road to their headquarters on the Middle road.

8. Mitchell Energy operates a pipeline (R.O.W.) for a 4 inch line from its on-refuge processing plant, along the west side of Middle road and the back gate road to loading docks outside the refuge.

9. P.G. and E. Resources Offshore operates a pipeline (R.O.W.) originating in the Gulf that crosses Matagorda Island south of Panther point (but is north of and parallel to the Enron line).

Active Oil and Gas Production Facilities (Cont.)

Addresses:

CONOCO Inc.
4444 Corona Dr.
P.O. Box 2226
Corpus Christi, TX 78403
(512) 850-7400 (Corpus off.)
286-3640 (Refuge off.)

ENRON/HOUSTON PIPELINE
Hwy 35
Tivoli, TX 77099
(512) 286-3567 (Tivoli off.)
(713) 225-7444 (Houston off.)

MITCHELL ENERGY
2001 Timberloch Place
P.O. Box 4000
The Woodlands,TX 77387-4000
(713) 377-5500

P.G. AND E. RESOURCES OFFSH.
545 Upper Broadway, Suite 706
Corpus Christi, TX 78476
(512) 884-3399 (C.C. office)
(214) 750-3800 (Dallas off.)

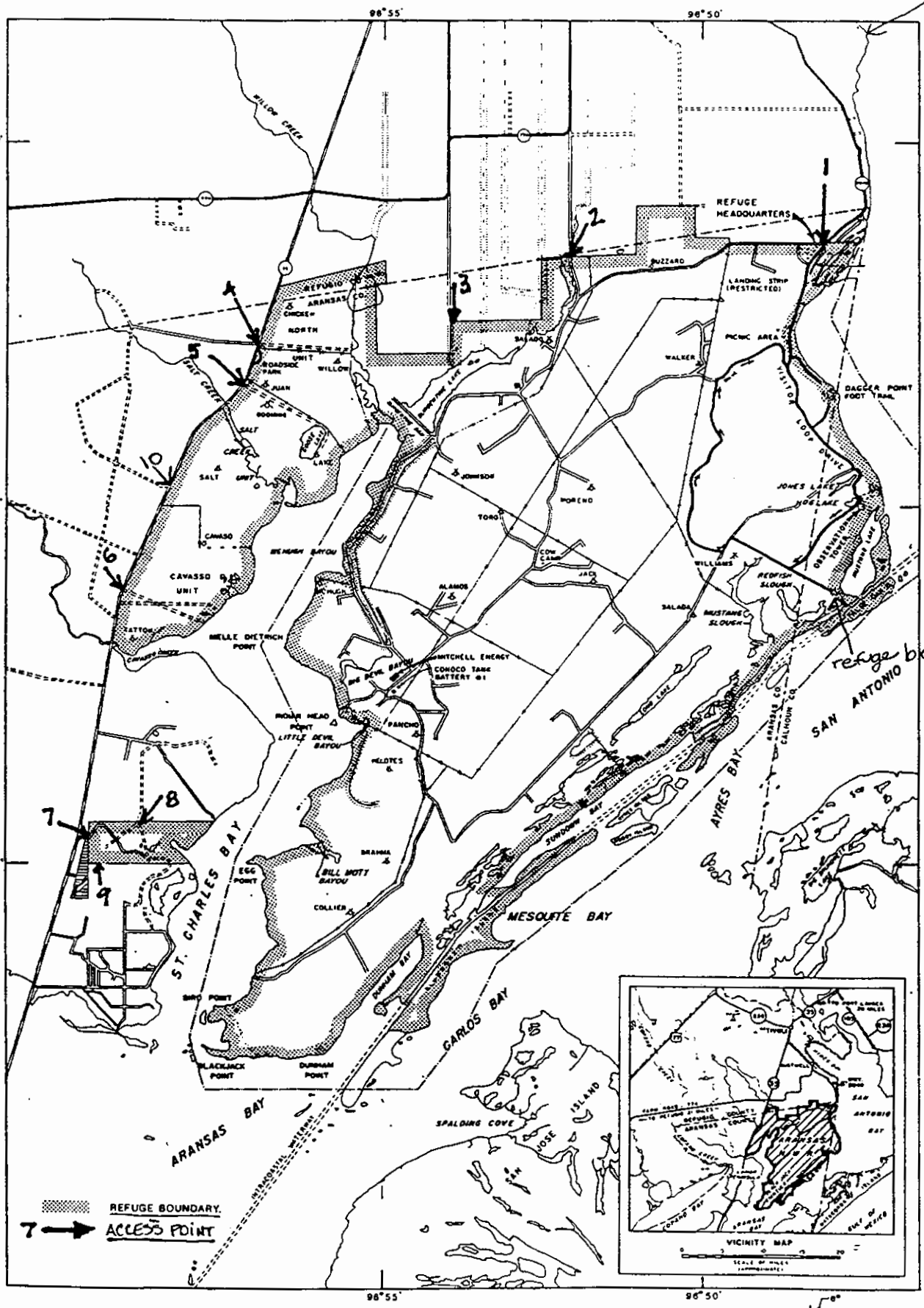
ARANSAS NATIONAL WILDLIFE REFUGE

UNITED STATES
DEPARTMENT OF THE INTERIOR

ARANSAS, CALHOUN AND REFUGIO COUNTIES, TEXAS

UNITED STATES
FISH AND WILDLIFE SERVICE

Hopper's L
boat r



COMPILED IN REALTY
FROM U.S.G.S. QUADRANGLES,
U.S.F.W.S. SURVEYS, AND OTHER
OFFICIAL RECORDS.

ALBUQUERQUE, NEW MEXICO NOVEMBER 1964
REVISION: 11/90

0 6000 7000 8000 9000 FEET
1 2 3 4 5 KILOMETERS

C6

True North
Magnetic N.
8°
MEAN DECLINATION 1965

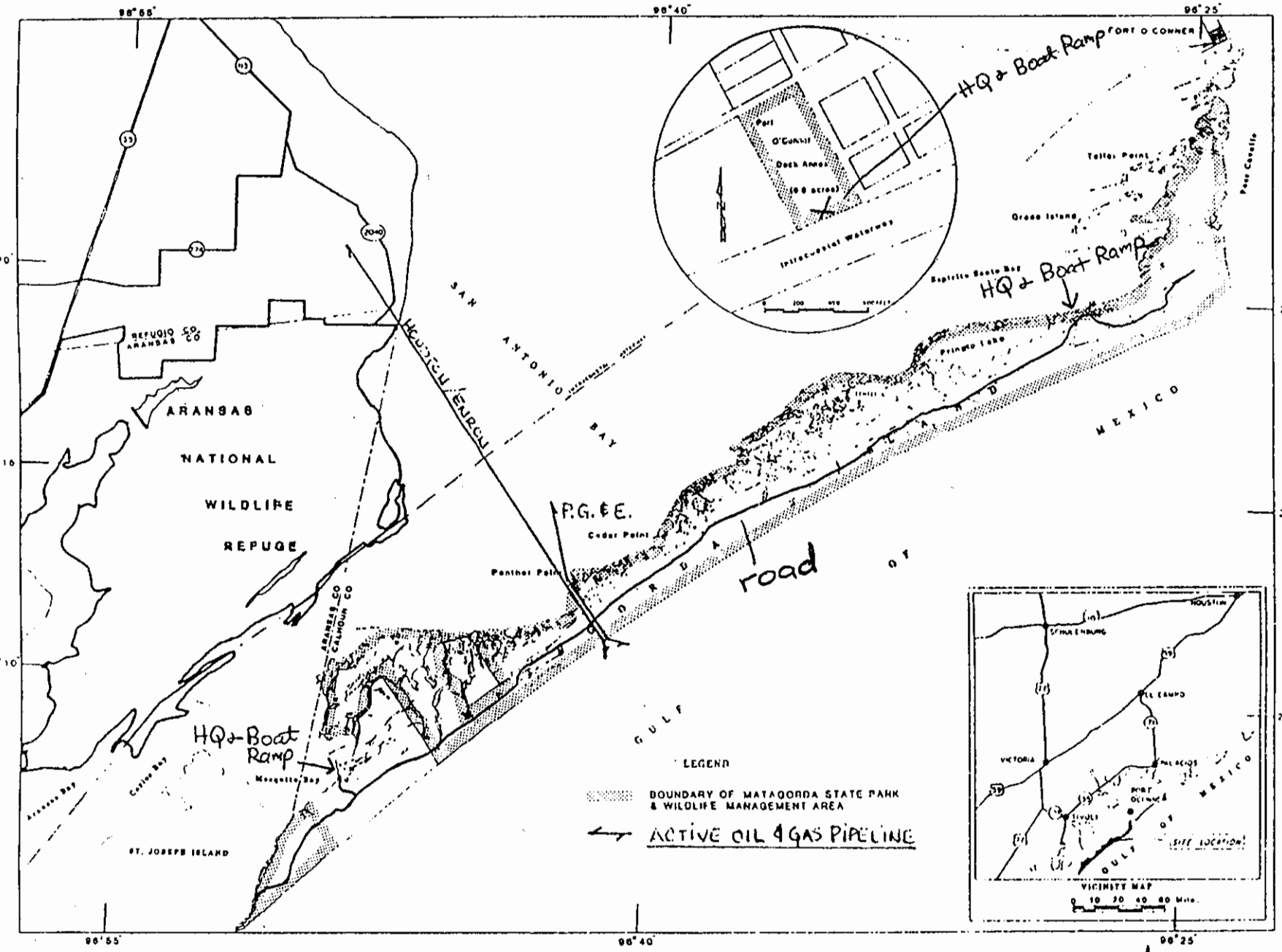
2R TX. 242 404

A UNIT OF THE NATIONAL WILDLIFE REFUGE SYSTEM

CALHOUN COUNTY, TEXAS

UNITED STATES
DEPARTMENT OF THE INTERIOR

UNITED STATES
FISH AND WILDLIFE SERVICE



COMPILED IN REALTY
FROM U.S.G.S. QUADRANGLES
U.S.F.W.S. SURVEYS, AND OTHER
OFFICIAL RECORDS

ALBUQUERQUE NEW MEXICO MAY 1984

0 1 2 3 4 5 6 MILES
0 1 2 3 4 5 6 KILOMETERS

MEAN DECLINATION 1984

C7

Version 4/1/93

Appendix D

Preparations Prior to a Spill

1. Locate pilot with proper certifications for overflight survey. Clarify needs, billing, availability etc. so no time is lost when a situation arises.

2. Arrange for training of personnel.

   i. Oil Spill Control School. Corpus Christi. Personnel involved in oil spill response work should have OSHA safety training.

   ii. Oiled Bird Cleaning. Annual workshops.

3. Ensure that all staff who may be capturing oiled birds are listed on state and federal collecting permits.

4. Measure distances to be covered by fixed-position booms, taking into account sags and angular deflection arrangements. Acquire sufficient boom material. Install on site storage sheds or obtain trailer for storing/transporting booms and other spill control material. Ensure availability of a boat adequate for boom deployment along minor inlet areas.

5. Locate positions for boom anchors and set. Refuge personnel must develop a boom strategy, locating and marking exact locations where booms should be placed for maximum efficiency for all three of the likely scenarios. Determine where permanent anchors should be installed.

6. Check to see if booms can be extended without wading/swimming.. ie. using throwlines.

7. Carry out drills as required to familiarize staff with equipment, procedures, etc.

Version 4/1/93

Appendix E

Equipment On Site

Quantity	Item
200 feet in 10' sections	Acme oil containment boom
200 feet in 10' sections	5" sorbent 5 boom
0	Ropes, throw lines for setting up booms
?? scare guns	Bird hazing equipment (air canons, etc)
25 lb scale 55 gallon drum soap 1 Edemco 100-Jr blow dryer 1 Sears dental aqua jet	Bird cleaning supplies and designated work area
1 Wells Cargo Express Wagon mobilization to site	Trailer loaded with boom material for
0	Sorbent pads and materials
0	Portable anchors for variable-position booms

Need:

Plastic mesh screen (100 ft), 1X2" stakes, 30-36" high (30), and electricians plastic cable ties (150 6-8" size) for tern chick corrals if this is deemed a viable option.

Absorbent pads and boom material- identify potential source, sufficient for thousands of linear feet of coverage for shoreline barriers.

Appendix F

Secondary Responses

1. Search for, cleanup, and tabulate oiled birds. Prepare data sheets on bird numbers and species. See appendix H. As part of oiled wildlife rehabilitation efforts, considerable volumes of oily, soapy water will be produced. A tank for storage of this effluent will be necessary, along with a regular removal, by vacuum truck, to the PRP's (potentially responsible party) designated waste handler.

2. Maintain documentation of staff time and expenditures for equipment during the response since these will be reimbursed either from the responsible party or the Oil Spill Liability Trust Fund administered by the US Coast Guard. Accurate documentation will also be needed for NRDA (Natural Resource Damage Assessment) compensation claims.

Version 4/1/93

Appendix G

Other Important Contacts and Phone Numbers

Refuge radio frequency Band # 34.830 mhz

Matagorda Island Office 813-2156

Pilot: Gerry Shore (512) 578-3506 Home
(512) 782-6407 Office

Refuge personnel

Brent Giezentanner	552-5282
Ken Schwindt	576-9481
John Magera	286-3532
Tom Stehn	758-2354
Chris Pease	286-3860
Andy Andes	790-9824
Louise Frasier	286-3594
Susie Perez	286-3826 (unlisted)
Smokey Cranfill	286-3308
Jenny Plympton	286-3728
Frank Cortez	286-3693
Mickey Harris	552-9316
Norman Von Heuvel	729-6051
Gary Coppock	364-4321
Gary Murphy	729-9836
Beverly Fletcher	286-3848
Diana Villarreal	286-3742 (unlisted)

FIRE DEPARTMENTS Tivoli 286-3211
Austwell 286-3763

ADJACENT LANDOWNERS

Alan Reilly (512) 286-3314
FM 2040
Austwell, TX 77950

John Tatton (512) 526-2932
Salt Creek Ranch, FM 774
Refugio, TX 78377

Version 4/1/93

Matagorda Island State Park & Wildlife Management Area

Port O'Connor	983-2215
Matagorda Is. Cellular	319-1622

TEXAS GAME WARDENS

Carl Wilson	Tivoli	286-3676
	Mobile	319-4019

TP&W Regional Law Enforcement Office in Rockport, Tx 729-2315

Port Lavaca Wardens Office	553-4683
R.G. Martinez	987-2913

Texas Nature Conservancy	Matagorda	877-7024
	Rockport	790-9440

Texas Wildlife Rehabilitation Coalition Inc. (713) 941-8902

USFWS LAW ENFORCEMENT Tom Mason Office (512) 888 3167
Corpus Christi

Tom Healy Office (512) 575-8608
Victoria

Regional Whooping Crane Coordinator Jim Lewis Office (505) 766-3792
Home (505) 821-3823

Pipeline companies

CONOCO Inc. Refuge Office (512) 850-7400
Corpus Office (512) 286-3640

Enron/Houston Tivoli Office (512) 286-3567
Houston Office (713) 225-7444

Mitchell Energy (713) 377-5500

P.G. & E. Resources Corpus Office (512) 884-3399
Dallas Office (214) 750-3800

County Law Enforcement/Emergency Medical Services

Aransas County Sheriff 729-2222

Version 4/1/93

Refugio County Sheriff 526-2351
Tivoli Deputy Sheriff 286-3737
Austwell Deputy Sheriff 286-3263

Version 4/1/93

Appendix H

Oiled Wildlife Rehabilitation Strategy

During an oil spill event, the US Fish and Wildlife Service (USFWS) and Texas Parks and Wildlife Department (TP&W) will jointly assume the responsibility for the cleanup and rehabilitation of oiled wildlife. The decision as to IF, WHERE and WHEN will be made on a case by case basis. The procedures to be used will be those employed in the Oiled Bird Cleaning Workshops jointly sponsored by USFWS, TP&W and the Texas Wildlife Rehabilitation Coalition (TWRC) and/or other permitted wildlife rehabilitation individuals. Only rehabilitators with current state and federal permits will operate cleanup centers, with non permitted volunteers working under their guidance in the case of a spill having a major impact on wildlife.

NOTE: Oiled wildlife can be quite dangerous, especially herons and their kin. Do not attempt their "rescue" unless you are properly prepared with protective eye wear, nets, gloves etc. Be aware of possible infectious disease risks from handling weakened and sick wildlife.

APPENDIX B

ENVIRONMENTAL DOCUMENTATION

APPENDIX B - SECTION 1

FISH AND WILDLIFE COORDINATION

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Ecological Services
c/o TAMU-CC, Campus Box 338
6300 Ocean Drive
Corpus Christi, Texas 78412

October 13, 1995

James M. Kieslich
Chief, Planning Division
Attn: Terry Roberts
U.S. Army Corps of Engineers
P.O. Box 1229
Galveston, Texas 77553-1229

Dear Mr. Kieslich:

Enclosed are copies dated October 12, 1995 of a final biological opinion and a final Supplemental Fish and Wildlife Coordination Act Report based upon the activities proposed in the Galveston District's May 1995 Draft Gulf Intracoastal Waterway - Aransas National Wildlife Refuge (Section 216) Feasibility Study and the Draft Environmental Impact Statement, Gulf Intracoastal Waterway (Section 216 Study), Aransas National Wildlife Refuge. Also enclosed is a copy of a Draft Fish and Wildlife Coordination Act Report dated September 20, 1994 which compared the environmental impacts of alternative routes for this reach of the GIWW. Both coordination act reports were submitted for review to the District, the Fish and Wildlife Service's Regional Office, the National Marine Fisheries Service, and the Texas Parks and Wildlife Department. Few comments were generated by the September 20, 1994 report; accordingly, it is adopted verbatim as a Final FWCA Report. Verbal comments were received from the District and the Service's Regional Office; the District's are reflected in small but substantive changes in the text of the Supplemental FWCA Report, while the Regional Office only noted its approval of those documents. Brief comments were received from the NMFS in a letter dated August 4, 1995, while more lengthy comments were provided by TPWD in a draft letter dated October 4, 1995. Copies of these letters are enclosed. Changes were made to the Supplemental FWCA Report as appropriate. A copy of any final letter of comment from TPWD will be forwarded upon its receipt.

Comments were also solicited and received on the biological opinion from the District and the Regional Office. The final opinion reflects substantive inputs from both sources.

If there are any questions about any of these documents, please contact Johnny French at (512) 994-9005.

Sincerely,

Floyd A. Nudi

Floyd A. Nudi
Acting Field Supervisor

DRAFT FISH AND WILDLIFE

COORDINATION ACT REPORT

ALTERNATIVE ROUTES THROUGH

ARANSAS REACH OF THE

GULF INTRACOASTAL WATERWAY

September 20, 1994

(Adopted as Final FWCA Report October 12, 1995)

Executive Summary

DRAFT

This report is provided as a supplement for the reconnaissance study of the proposed dredging maintenance and/or realignment plan of the Gulf Intercoastal Waterway (GIWW) Section 216 Study. This report addresses 43.3 miles of the Texas section of the Gulf Intercoastal Waterway (GIWW), extending from the Espiritu Santo Bay near Matagorda Island (Calhoun County) to Aransas Bay near Rockport, Texas (Aransas County).

This Draft Fish and Wildlife Coordination Act Report (DFWCAR) involves evaluating the GIWW's proposed four alternatives (Fig.1). The alternatives consisted of the following: Alternative # 1 - shoreline protection of existing GIWW channel, Alternative #2 - realignment to north of the Aransas National Wildlife Refuge (NWR), Alternative # 3 - realignment to old channel through bay, and Alternative # 4 - realignment through barrier island. The objective(s) of the selected route would entail the following points: 1) avoiding the whooping crane critical habitat boundary located on Aransas National Wildlife Refuge (NWR); 2) averting impacts to other listed species and critical habitat(s); and 3) maximizing the economic benefits of the proposed realignment.

As a result of various discussions and meetings, listed below, that have occurred concerning these alternatives, the preferred alternative has been Alternative #1 (shoreline protection of the existing channel). Problems associated with poor containment structures and improper spoil disposal methods have resulted in repeated levee failures at various spoil disposal sites along this waterway. In addition to affecting the wintering habitats of the endangered whooping crane, this problem could result in increased turbidity and contaminant levels within the bays, affecting seagrass beds, seabird rookeries, Federally listed sea turtles, fisheries, and oyster reefs. The general shoreline areas that would require protection along the existing alignment between channel miles 485 and 525

were considered to be every exposed bank within approximately 600 feet of the waterway. The possible bank hardening methods include riprap, interlocking concrete mats, articulated concrete mats, and bulkheads.

General authority for this study is provided in the Endangered Species Act, Fish and Wildlife Coordination Act, Coastal Zone Management Act, Estuary Protection Act, Migratory Bird Treaty Act, and the National Environmental Policy Act. The information and project assessment contained in this DFWCAR are based on data obtained during Fish and Wildlife Service (Service) field investigations, Texas Colonial Waterbird Colonies Census Summaries, materials generated by the Port Area Committee for the South Texas Coastal Zone and correspondence with Mr. Terry Roberts of the U.S. Army Corps of Engineers (Corps), Galveston District.

This DFWCAR was prepared under the specific authority of and in accordance with the provisions of the U.S. Fish and Wildlife Coordination Act (48 Stat; 401, as amended; 16 U.S.C. 661 et seq.). The Fish and Wildlife Coordination Act indicates that fish and wildlife conservation measures should consist of "means and measures that should be adopted to prevent the loss of or damage to such wildlife resources, as well as to provide concurrently for the development and improvement of such resources". In addition, the Endangered Species Act requires that "each Federal agency shall, in consultation with and with the assistance of the Service, insure that any action authorized, funded, or carried out by such agency is not likely to jeopardize the continued existence of any endangered or threatened species...". Section 7 of the Endangered Species Act requires each Federal agency to formally consult with the Service if their project "may effect" an endangered or threatened species and/or adversely modify its critical habitat. This report will constitute the official report of the Secretary of Interior on the project within the meaning of Section 2(b) of the Act. We have worked with the Texas Parks and Wildlife Department (TPWD) and the National Marine Fisheries Service (NMFS), and their comments will be included in the Final FWCAR.

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Relevant Prior Studies/Reports

The Corps provided previous views on the project in a November 1989 report entitled, "Gulf Intercoastal Waterway, Texas, Section 216 Reconnaissance Report". Other relevant documents include both a report dated July 1991 concerning a draft biological opinion on erosion of whooping crane habitat along the GIWW and reports associated with the Second Agency Scoping Meeting for the GIWW located at Aransas NWR on May 1993. Panel members at that scoping meeting included personnel from the following agencies: U.S. Fish and Wildlife Service (Service), TPWD, NMFS, U.S. Coast Guard, Texas Department of Transportation, and the Corps. Following the Second Agency Scoping Meeting, another meeting was held in December 1993 to discuss a comparison of spill risks on two preferred alternatives, the shore protection of existing GIWW channel (Alternative #1) and the realignment to the old channel through Mesquite and Ayers bays (Alternative #3). This meeting utilized the Delphi techniques to qualitatively discuss the issues and arrive at a consensus. The members at this meeting included agency personnel from the previous Second Agency Scoping meeting plus personnel from the Texas General Land Office, Hollywood Marine, Dixie Carriers, and Gulf Engineers & Consultants, Inc.

Description of Study Area

The study area consists of 43.3 miles of the Texas section of the Gulf Intercoastal Waterway (GIWW) and extends from the Espiritu Santo Bay near Matagorda Island (Calhoun County) to Aransas Bay near Rockport, Texas (Aransas County). The proposed project area contains bays and estuaries, wetlands, and upland wildlife habitats.

Explanation of Fish and Wildlife Resource Concerns and Planning Objectives

Concerning the feasibility of the proposed alternatives, there are several factors which influence their selection, such as: 1) impacts to listed species and critical habitat(s), 2) alterations to hydrology, and 3) economic issues. Favorable objectives of the selected route would be to avoid the whooping crane critical habitat boundary located near the Aransas NWR; to minimize the environmental effects to the critical habitat; and to maximize the economic benefits of the proposed realignment.

Description of Fish and Wildlife Resources

Existing: The proposed project area contains wetland and upland wildlife habitats. The wetland areas, including tidal marshes and estuaries, provide habitat for various waterfowl, shorebirds, wading birds, gulls, terns, rails, cranes, reptiles, and amphibians. During migration, waterfowl use the wetland areas and adjacent croplands for resting and feeding. Snow geese, white-fronted geese, Canadian geese, pintail widgeon, gadwall, green-winged teal, mallards, sandhill cranes, and whooping cranes use these areas. A species catalog of the Federally listed and candidate species per county is provided below.

The upland habitat provides habitat for numerous species of openland and rangeland wildlife. Mammals inhabiting these areas include white-tailed deer, javelina, raccoon, opossum, cottontail rabbit, jack rabbit, skunk, armadillo, bobcat, wild hogs, bats, squirrel, and coyote. Birds that inhabit these areas include the Rio Grande turkey, bobwhite quail, mourning dove, sandhill crane, Attwater's prairie chicken, vermillion flycatcher, and western kingbird. Numerous species of hawks, owls, woodpeckers, flycatchers, swallows, thrashers, thrushes, warblers, buntings, and sparrows also inhabit the area.

Fish, reptiles, and amphibians utilize the wet habitats also. The Mission, San Antonio, Guadalupe, and Aransas Rivers contain fresh and saltwater fish including catfish, black bass, carp, sunfish, gar, redfish, and other drum species. The bays and estuaries are also important areas for shrimp, crab, seatrout, redfish, flounder, Atlantic croaker, dolphin, sea turtles and other salt water species.

The following list provides information on Federally listed threatened and endangered species from the proposed project area. The list has been expanded to include candidate species as well. Candidate species have no protection under the Endangered Species Act; however, the Service has substantial information on Category 1 species to support their listing as threatened or endangered. The development and publication of proposed rules for Category 1 species is anticipated. Category 2 species are those for which available information indicates that proposing to list as endangered or threatened is possibly appropriate, but substantial data on biological vulnerability and threats are not currently known to support the immediate preparation of rules. However, actions that might contribute to the listing of candidate species should be avoided. A letter designation follows the species name that represents the current Federal status of the species. Within the following list, the letters E, PE, T, PT, C1, and C2 represent the status of Endangered, Proposed Endangered, Threatened, Proposed Threatened, Category 1, and Category 2, respectively. Our data indicates that the following species may occur in the area:

Aransas County:

American peregrine falcon (*Falco peregrinus anatum*) - E
Attwater's prairie chicken (*Tympanuchus cupido attwateri*) - E
brown pelican (*Pelecanus occidentalis*) - E
hawksbill sea turtle (*Eretmochelys imbricata*) - E
jaguarundi (*Felis yagouaroundi*) - E
Kemp's ridley sea turtle (*Lepidochelys kempi*) - E
leatherback sea turtle (*Dermochelys coriacea*) - E
ocelot (*Felis pardalis*) - E
whooping crane (*Grus americana*) - E
bald eagle (*Haliaeetus leucocephalus*) - PT
Arctic peregrine falcon (*Falco peregrinus tundrius*) - T
green sea turtle (*Chelonia mydas*) - T
loggerhead sea turtle (*Caretta caretta*) - T
piping plover (*Charadrius melodus*) - T

Gulf Coast hog-nosed skunk (Conepatus leuconotus texensis) - C1
mountain plover (Charadrius montanus) - C1
Gulf salt marsh snake (Nerodia clarki) - C2
Aransas short-tailed shrew (Blarina hylophaga plumbea) - C2
Audubon's oriole (Icterus graduacauda audubonii) - C2
black-spotted newt (Notophthalmus meridionalis) - C2
ferruginous hawk (Buteo regalis) - C2
long-billed curlew (Numenius americanus) - C2
loggerhead shrike (Lanius ludovicianus) - C2
rough-seed sea purslane (Sesuvium trianthemoides) - C2
reddish egret (Egretta rufescens) - C2
Texas Botteri's sparrow (Aimophila botterii texana) - C2
Texas diamondback terrapin (Malaclemys terrapin littoralis) - C2
Texas horned lizard (Phrynosoma cornutum) - C2
Texas olive sparrow (Arremonops rufivirgatus rufivirgatus) - C2
western snowy plover (Charadrius alexandrinus nivosus) - C2
white-faced ibis (Plegadis chihi) - C2

Refugio County:

Attwater's prairie chicken (Tympanuchus cupido attwateri) - E
black lace cactus (Echinocereus reichenbachii var. albertii) -E
hawksbill sea turtle (Eretmochelys imbricata) - E
Kemp's ridley sea turtle (Lepidochelys kempi) - E
leatherback sea turtle (Dermochelys coriacea) - E
ocelot (Felis pardalis) - E
whooping crane (Grus americana) - E
green sea turtle (Chelonia mydas) - T
loggerhead sea turtle (Caretta caretta) - T
bald eagle (Haliaeetus leucocephalus) - PT
piping plover (Charadrius melodus) - T
Gulf Coast hog-nosed skunk (Conepatus leuconotus texensis) - C1
mountain plover (Charadrius montanus) - C1
black-spotted newt (Notophthalmus meridionalis) - C2
Cagle's map turtle (Graptemys caglei) - C1
ferruginous hawk (Buteo regalis) - C2
long-billed curlew (Numenius americanus) - C2
loggerhead shrike (Lanius ludovicianus) - C2
northern gray hawk (Buteo nitidus) - C2
reddish egret (Egretta rufescens) - C2
Rio Grande lesser siren (Siren intermedia texana) - C2
Texas diamondback terrapin (Malaclemys terrapin littoralis) - C2
Texas horned lizard (Phrynosoma cornutum) - C2
Texas olive sparrow (Arremonops rufivirgatus rufivirgatus) - C2
Texas windmill grass (Chloris texensis) - C2
Welder spine aster (Machaeranthera heterocarpa) - C2
syn.=(Psilactis heterocarpa)
western snowy plover (Charadrius alexandrinus nivosus) - C2
white-faced ibis (Plegadis chihi) - C2

Calhoun County:

American peregrine falcon (Falco peregrinus anatum) - E
brown pelican (Pelecanus occidentalis) - E
hawksbill sea turtle (Eretmochelys imbricata) - E
Kemp's ridley sea turtle (Lepidochelys kempi) - E
leatherback sea turtle (Dermochelys coriacea) - E
whooping crane (Grus americana) - E
bald eagle (Haliaeetus leucocephalus) - PT
Arctic peregrine falcon (Falco peregrinus tundrius) - T

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green sea turtle (Chelonia mydas) - T
loggerhead sea turtle (Caretta caretta) - T
piping plover (Charadrius melodus) - T
Gulf Coast hog-nosed skunk (Conepatus leuconotus texensis) - C1
ferruginous hawk (Buteo regalis) - C2
Gulf salt marsh snake (Nerodia clarki) - C2
long-billed curlew (Numenius americanus) - C2
loggerhead shrike (Lanius ludovicianus) - C2
reddish egret (Egretta rufescens) - C2
Texas diamondback terrapin (Malaclemys terrapin littoralis) - C2
Texas horned lizard (Phrynosoma cornutum) - C2
western snowy plover (Charadrius alexandrinus nivosus) - C2
white-faced ibis (Plegadis chihi) - C2

Future Without: The future without the project would involve continuation of this section of the GIWW without utilization of the proposed shoreline protection alternative. A continued gradual loss of shoreline habitats due to erosion and of bay habitats due to the expansion of existing disposal areas would be expected.

Summary of Plan Selection Process and Identification of Evaluated Alternatives

Based on information obtained on a FAX from Mr. Terry Roberts of the U.S. Army Corps of Engineers on June 7, 1994, previous literature on the project, and notes from the Second Agency Scoping Meeting held in May 1994, there exist three other realignment alternatives in addition to the modification of the existing channel for this reach of the GIWW. These four alternatives are the following:

#1) shore protection of existing GIWW channel

#2) realignment to north of the Aransas NWR

#3) realignment to old channel through Mesquite and Ayers Bays

#4) realignment through Barrier Island.

Description of Selected Plan and Evaluated Alternatives

By the time the Second Agency Scoping Meeting took place (May 1994), the list of

four potential alternatives was reduced to two. These were Alternative # 1 (shore protection of existing GIWW channel) and Alternative #3 (realignment to old channel through Mesquite and Ayers Bays). Although a consensus was not achieved by the end of the latter December 1993 meeting, most members of the Delphi panel agreed that shore protection of the existing GIWW channel (Alternative # 1) was the preferred selected plan. The primary reasons for this selection are as follows. The open-bay alignment (# 3) was much riskier for cargo spills than the existing, present channel since the tows would not be protected from winds and currents as in the land-locked existing reach. Also, navigational aids (buoys) would be more likely to be moved accidently out of position, creating additional navigational hazards. The panel also agreed that a spill in the open bay would be more hazardous to the environment because it could not be contained and had the potential to destroy many more acres of marsh than a similar spill in the present alignment.

Description of Impacts

Concerning assorted impacts of the proposed selected plan and the three alternative plans, the following considerations are addressed. Regarding impact to listed species and critical habitat(s), the shore protection of the existing channel or alternative #1 would leave the GIWW within the whooping crane critical habitat boundary and the Aransas NWR. Problems associated with faulty containment structures and improper spoil disposal methods have resulted in repeated levee failures at various spoil disposal sites along this waterway. In addition to affecting the wintering habitats of the endangered whooping crane, this problem could result in increased levels of turbidity and contaminants within the bays, affecting seagrass beds, seabird rookeries, listed sea turtles, fisheries, and oyster reefs.

The proposed terrestrial route (Alternative # 2) would affect a variety of habitats, many of which are important to listed species. The predominant species of concern for this route would be the Attwater's prairie chicken, whooping crane, bald eagle, American peregrine falcon, brown pelican, Kemp's ridley sea turtle, green sea turtle, loggerhead sea turtle, piping plover, ocelot, and jaguarundi.

In addition to impacting these species, the utilization of this alternative could increase bay water turbidity, thus affecting the oyster beds, seagrass communities, seabirds, and fisheries; and it would significantly alter the overall hydrology of Aransas NWR, which would be isolated on an island by this alternative.

The potential impacts associated with Alternative # 3, the open bay route, were listed above. Specifically, this involved the following: 1) greater risks for cargo spills due to the lack of wind and current protection; 2) increased navigational hazards due to the curves present in the route; and 3) the potential for spills to be more hazardous and environmentally damaging since they could not be contained as readily as when in a land-locked channel.

Finally, the potential impacts connected with Alternative # 4, realignment through the barrier islands, Matagorda Island and San Jose Island, would include impacts to habitats proximal to the whooping crane critical habitat boundary, which also harbor populations of the threatened piping plover and other shorebirds. A canal through the islands would also severely impact the hydrology of the islands.

In addition to the potentially impacted species listed in this section, the following listed and candidate plant species may be present if appropriate habitat exists. In Aransas county, the C2 plant rough-seed sea purslane (Sesuvium trianthemoides) may be present along saline, sandy dunes and bay flats

areas. Two C2 and one endangered plant may exist in Refugio county if appropriate habitat exists. The Federally endangered black lace cactus (Echinocereus reichenbachii var. albertii) occurs in natural open areas in mesquite brush in loamy to sandy loam soils that are somewhat saline and sometimes inundated. The black lace cactus is a small, deep green cylinder shaped cactus with dark-tipped spines and pink to purple flowers. Also, the C2 plants Texas windmill grass (Chloris texensis) and Welder spine aster (Machaeranthera heterocarpa) may be present in Refugio county. The Texas windmill grass exists in native prairie communities, while and the Welder spine aster prefers weedy, clayey soils, and road-side habitats. Surveys for these species may be required prior to initiating any land clearing development.

Description of Selected Plan and Evaluated Alternatives

The selected plan (Alternative #1) would eliminate or greatly reduce the erosion impacts from navigation traffic in the existing channel by hardening or armoring the banks via several means. These possible bank hardening methods include riprap, interlocking concrete mats, articulated concrete mats, and bulkheads. The general shoreline areas that would require protection along the existing alignment occurs between channel miles 485 and 525 were considered to be any exposed banks within approximately 600 feet of the waterway. It is proposed that no protection is required for the GIWW reach across San Antonio Bay from mile 492 to approximately mile 501 and in Aransas Bay from mile 512.5 to the end of the project at mile 525. Therefore, the total distance of shoreline protection, including both sides of the waterway where required, is 29.7 miles. The wind tidal flats directly adjacent to the waterway are largely barren mud and sand surfaces that are periodically covered with blue-green algal mats and scattered marsh plants. These environments along the waterway grade into a brackish to freshwater marsh with big cordgrass, marshy cordgrass, bullrush, cattail, rushes, mammals, snakes, and waterfowl. Beneficial uses with this alternative for dredge

material include the possible creation of intertidal marshes along with the enlargement and nourishment of selected islands. These actions were suggested as part of the proposed 50-year disposal plan for this alternative.

Alternative #2 would involve realignment of the channel to the north of the Aransas NWR. This alignment would occur completely outside of the whooping crane critical habitat area. The dimensions of the proposed realignment would be consistent with the existing GIWW at 12 feet deep and 125 feet wide. This proposed alignment is divided into three landlocked reaches and two bay reaches. The start of the proposed alternative #2 realignment exits the existing GIWW at channel mile marker 485.5 (near Fulghum Camp) and travels in a westerly direction across the prairie until it enters San Antonio Bay just north of Mosquito Point. Afterwards, the alignment turns slightly southwest and crosses the water to a location just north of Webb Point on the west side of San Antonio Bay. At this point, the proposed route continues across the farmland just north of Aransas NWR until it meets Texas State Highway 35 northwest of Burgentine Lake. The channel parallels the highway to the east until it crosses Cavasso Creek. At this location, the channel route turns slightly southeast and enters Aransas Bay between Holiday Beach and Goose Island State Park. Once at Aransas Bay, the channel alignment turns almost due south and passes near Fulton and Rockport to again intersect the existing GIWW near statute mile marker 521.3 across from Key Allegro. The environments this route would traverse consist of cultivated areas, prairie grasslands vegetated with bluestem and indiangrass, flat to gently rolling uplands covered with chaparral (sparse mesquite, huisache, hackberry and cactus), and a mixed oak-pothole complex of ancient dunes and wind-formed depressions. The latter habitat type is heavily populated with whitetail deer and aquatic birds, especially waterfowl in season. Cattle grazing is the chief land use; many terrestrial birds and small mammals also live along this route (e.g., meadowlarks flycatchers, souther harrier hawks, racoons, bobcats, and skunks). The waterway sections include reef communities with patches of dense oysters, mollusks, algae, and bryozoans. The length of the new proposed

realignment would be 43.4 miles.

Alternative #3 involves realignment of the GIWW to follow an old channel through Mesquite and Ayers Bays. Heading northeasterly, the departure from the existing channel would occur at approximately mile 515 and reunite with the existing channel at mile 494. Some of the work materials dredged between San Antonio and Aransas Bays would be deposited in the bays to create bird islands. Additional work material would be stockpiled in existing leveed disposal areas and later forced into the existing channel for marsh creation. Maintenance material from landlocked reaches would be disposed of using a combination of beneficial uses, channel filling, or placed along the Gulf shoreline of Matagorda Island. This route would intersect areas with reef communities, dense oyster beds, brackish to freshwater marsh, muddy sand, saltmarsh, cordgrass, bullrush, cattails, rushes, and assorted waterfowl.

The final Alternative #4 involves realignment through the barrier islands. Traveling northeasterly, the departure from the existing channel would take place at approximately mile 522.5 near Rockport and reunite with the existing channel at mile 478. All new work and maintenance material would be placed along the Gulf of Mexico shoreline of Matagorda Island. Once the new channel was completed, material from the existing leveed disposal areas would be pushed into the existing channel to fill it as much as possible for marsh creation. The environments involved in this alternative consist of reef communities, brackish to freshwater marsh, berms along bay-lagoon margin, salt-tolerant grasses, vegetated barrier flat, and blue-green algal flats.

Discussion and Justification of Fish and Wildlife Conservation Measures

The primary fish and wildlife conservation measure for the proposed existing route (Alternative #1) has been the halting of the extensive erosion of whooping

crane critical habitat that has occurred due to the effects of barge traffic vessel wakes, river discharge, and wind generated wave exposure.

List of Recommendations

The Service recommends instituting effective methods to stop erosion and preventing levee failure. These actions are essential to the continued use of the GIWW waterway within the whooping crane critical habitat. Concerning beneficial uses of dredged material, the proposal to utilize dredged material to create intertidal marshes requires more research to determine its effect on the aquatic community. It is apparent that the use of this technique as a beneficial use of dredged material will result in an overall loss of shallow, unvegetated subtidal bay bottom. This type of habitat is also in short supply. Continued studies should be performed to determine the significance of the proposed exchange of habitat types on aquatic species. It is also essential that the beneficial program uses plans be carried out under exacting supervision to achieve the benefits desired. Unless this kind of supervision is provided, the Service will not support the program.

Summary of Findings and Service Position

A Service position on the preferred alternative(s) for the operation of the 43.3 miles of the Texas section of the Gulf Intercoastal Waterway (GIWW) has not been determined at this time. The Service will await the responses of the other resource agencies to this draft document and to the upcoming meetings to be held by the Corps on the specific details of the beneficial use actions and levee failure prevention techniques, and will incorporate the coordinated findings in the final FWCAR.

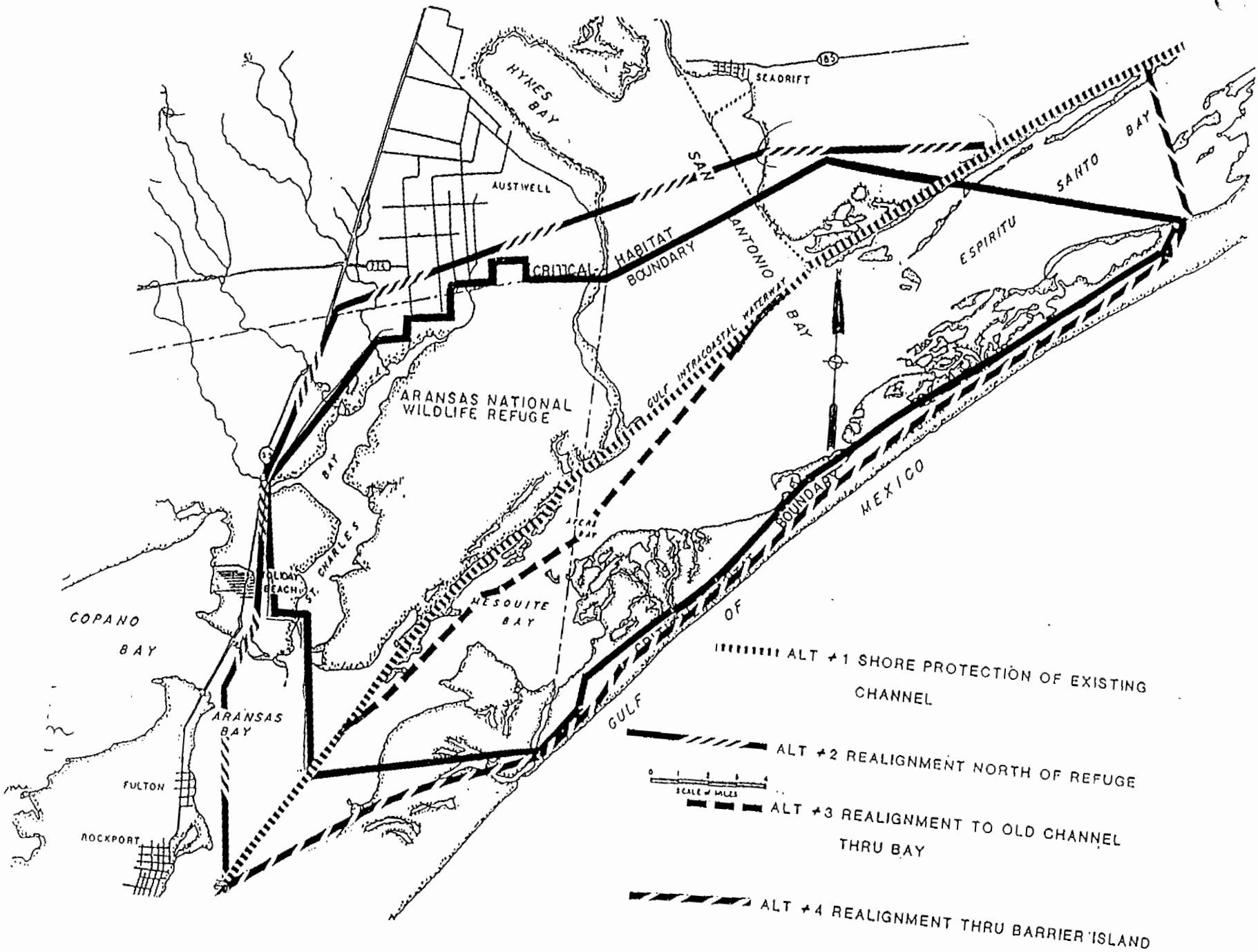
HYNES BAY
SEADRIFT
185
AUSTWELL
SAN
ANTONIO
BAY
SANTO
BAY
ESPIRITU
CRITICAL HABITAT BOUNDARY
GULF INTRACOASTAL WATERWAY
ARANSAS NATIONAL WILDLIFE REFUGE
CHARLES BAY
HOLIDAY BEACH
MESQUITE BAY
BOUNDARY
MEXICO
OF
GULF
COPANO BAY
ARANSAS BAY
FULTON
ROCKPORT
ALT #1 SHORE PROTECTION OF EXISTING CHANNEL
ALT #2 REALIGNMENT NORTH OF REFUGE
SCALE OF MILES
ALT #3 REALIGNMENT TO OLD CHANNEL THRU BAY
ALT #4 REALIGNMENT THRU BARRIER ISLAND

Figure 1

SUPPLEMENTAL FISH AND WILDLIFE

COORDINATION ACT REPORT

GULF INTRACOASTAL WATERWAY - ARANSAS

NATIONAL WILDLIFE REFUGE

(SECTION 216) FEASIBILITY STUDY

October 12, 1995

U.S. Fish and Wildlife Service
Corpus Christi, Texas

Supplemental Fish and Wildlife Coordination Act Report
Gulf Intracoastal Waterway - Aransas National Wildlife Refuge
(Section 216) Feasibility Study

Executive Summary

On September 20, 1994 the Fish and Wildlife Service provided a Draft Fish and Wildlife Coordination Act Report to the Galveston District, U.S. Army Corps of Engineers, to assist in the comparison of four alternative routes for the Gulf Intracoastal Waterway (GIWW) within the vicinities of the critical habitat of the whooping crane and the Aransas National Wildlife Refuge in Aransas and Calhoun Counties, Texas. Since that date, the District has completed additional planning regarding that Aransas reach of the GIWW, as described in two documents provided to the Service on June 2, 1995: The Draft Gulf Intracoastal Waterway - Aransas National Wildlife Refuge Section 216) Feasibility Study and the Draft Environmental Impact Statement, Gulf Intracoastal Waterway (Section 216 Study, Aransas National Wildlife Refuge. These documents provide additional information not only on the four alternative routes, but also details on proposed shoreline erosion control and spill containment facilities and on a proposed 50-year disposal plan for the project's maintenance dredging. This Supplemental Fish and Wildlife Coordination Act Report addresses this new information, discusses some of the issues of potential conflict, and expresses the Service's position of conditional endorsement of the proposed actions.

This Supplemental FWCA Report was prepared under the specific authority of and in accordance with the provisions of the U.S. Fish and Wildlife Coordination Act (48 Stat; 401, as amended; 16 U.S.C. 661 et seq.). The Fish and Wildlife Coordination Act indicates that fish and wildlife conservation measures should consist of "means and measures that should be adopted to prevent the loss of or damage to such wildlife resources, as well as to provide concurrently for the development and improvement of such resources." In addition, the Endangered Species Act requires that "each Federal agency shall, in consultation with and with the assistance of the Service, insure that any action authorized, funded, or carried out by such agency is not likely to jeopardize the continued existence

of any endangered or threatened species or result in the destruction or adverse modification of [the critical] habitat of such species". Section 7 of the Endangered Species Act requires each Federal agency to formally consult with the Service if their project "may effect" an endangered or threatened species and/or adversely modify its critical habitat. This report will constitute the official report of the Secretary of the Interior on the project within the meaning of Section 2(b) of the Act. We have worked with the Texas Parks and Wildlife Department (TPWD) and the National Marine Fisheries Service (NMFS), and their comments on the Draft FWCA Report and the Supplemental Draft FWCA Report are enclosed.

Description of New Selected Plans

The following information is excerpted from the DEIS:

> Bank Erosion Protection Plan.
>
> - - - [E]rosion is still occurring along the GIWW and is reducing the amount of feeding habitat for the endangered whooping crane. In an effort to stop this loss, erosion control using a temporary barrier of concrete bags held in place with steel reinforcing rods was first initiated in 1989 through the cooperative efforts of the COE; USFWS; several navigation, oil supply, and oil companies; local whooping crane tour guides; and several hundred citizen volunteers. Approximately 6,900 feet of shoreline in Aransas NWR was protected by these volunteers between 1989 and 1992. In 1992, the USFWS experimented with a more permanent method of shore stabilization using 8-foot wide cellular concrete mattress to protect 400 feet of shoreline. This method was acceptable to the USFWS, so it was added to the list of methods for evaluation. - - - The concrete mattress plan was determined the "best" armoring method and would

meet the requirements of the agreement with the USFWS reached during a section 7 consultation for maintaining the GIWW in designated critical habitat - - -.

The COE has placed about 16,000 feet of concrete mattress varying from 16 to 20 feet wide along the north bank of the GIWW in the Aransas NWR in the summers of 1992, 1993, and 1994. Approximately 2,000 feet or more of shoreline will be added each year thereafter, until the Section 216 study is completed and the project is authorized for construction. Authorization is currently expected in FY 1996, with construction to begin in FY 1998. At that time, the remainder of the shoreline identified by the USFWS as requiring protection will be armored for a total length of about 84,000 feet (Figure 6). Additional protection consisting of geotextile tubes filled with dredged material and/or grout will be used to protect the open stretch of Sundown Bay. The tubes will run in approximately 1,000-foot lengths with 100 foot openings between each section for a total length of about 13,500 feet. The final length of each section of tubes and number and width of openings will be determine during the PED phase after circulation studies in Sundown Bay are completed. The circulation studies will determine the number and size of openings needed to maintain adequate circulation in Sundown Bay. These tubes will simulate oyster reefs running parallel to the GIWW with the top protruding slightly above the water at low tide. Oysters are expected to colonize the surface of the tubes and form a series of reefs to protect the back marshes of Sundown Bay. Seagrass coverage and density also should increase in Sundown Bay as a result of the wave protection afforded by the tubes.

The concrete mats and the grout tubes will require periodic

maintenance throughout the 50-year project life. Periodic inspection of all of the project components is necessary to make timely repairs, as required. The specific responsibilities of the various agencies in regards to operation and maintenance of the erosion control and the spill containment features are continuing to be developed. The responsibilities related to the maintenance of the erosion control components would consist of mat repairs and grout tube replacement/repairs, as necessary. These activities would result from normal deterioration, vandals, boat or barge damage and storms. The Refuge staff frequently monitors the entire reach of waterway through the critical habitat and would, therefore, be aware of the needs for maintenance and best be able to determine what could and should be done in the best interests of the endangered species and its habitat that they are entrusted to protect. This rationale has led to a request by the COE for the USFWS to assume this responsibility. There are other factors that will also weigh heavily on the final decision which will be resolved as coordination continues. [Note: Rick Medina confirmed via telephone on October 2, 1995 that the COE had determined to assume this maintenance responsibility.] Regardless of which agency assumes this responsibility, maintenance of the erosion control features will be accomplished entirely at Federal expense. These costs are estimated to average $15,000 per year.

- - -

Spill Contingencies and Analysis - - -

The concrete mattress and grout tube erosion protection in the critical habitat will help prevent contaminants from reaching the marsh, except on very high tides or under storm conditions. The COE

will also place timber pilings on each side of all openings to the marsh or cuts leading to the surrounding bays for attaching booms to contain oil or other floating contaminants. For large areas requiring protection that are wider than the normal 100-foot length of spill containment booms, such as Dunham Bay and most of Welder Flats, pilings will be placed parallel to and near the GIWW at about 300 foot intervals. The booms will be stored at the Refuge in a location to be designated later by the Refuge Manager.

The COE is coordinating with the USFWS, refuge personnel. TGLO, and U.S. coast Guard on the roles and responsibilities of each agency for spill response, deployment, clean-up, equipment storage, normal maintenance, and replacement of the spill equipment. The question of who should be responsible for the estimated $34,000 annual costs for the operation, maintenance, repair, and replacement of the spill control components is more complex than for erosion control features. The Texas General Land Office and the U.S. Coast Guard have responsibilities for spill response, as well as the USFWS as it relates to protection of the habitat of the Refuge. All agencies have agreed that responsibility for spill response, deployment, clean-up, and storage of the spill equipment resides with the USFWS, TGLO, and Coast Guard. However, the issue of responsibility for normal maintenance and replacing equipment (booms, storage trailers, and attachment pilings) that is no longer operable has not been resolved. [Note: Rick Medina confirmed via telephone on October 2, 1995, that the COE was assuming this maintenance responsibility.] Coordination between the various agencies concerning a specific delineation of roles and responsibilities is continuing. The decisions will be documented in the Final Feasibility Report for consideration for Congressional authorization.

- - -

50-Year Disposal Plan

Net losses of whooping crane critical habitat since the original GIWW was completed through Welder Flats and Blackjack Peninsula in 1940 (and including a short stretch of the Channel to Victoria) have amounted to about 2,078 acres. This includes direct losses from construction of the channel and disposal of dredged material, indirect losses from wind and vessel waves, sea-level rise and land subsidence, and any gains in crane habitat in the area during the period 1940 to 1986 (the period of analysis for the above reference). Recent annual losses have been calculated at 2.5-4 acres per year, mostly on the northern (mainland) side of the channel.

The 50-year disposal plan will offset most of these habitat losses by beneficially using most of the dredged maintenance material to create approximately 1,614 acres of marsh at several selected sites within the critical habitat. The rest of the dredged material will be placed in existing upland disposal areas and one new upland disposal area (upland site 1) located just outside the critical habitat east of Welder Flats. The new disposal area will replace DA 120 and 120A.

Maintenance dredging through the land-locked areas of the critical habitat generally occurs on a 4 to 7-year cycle, depending on the reach of channel. Under the new disposal plan, the smaller beneficial use marsh sites (less than 50 acres) will be filled in one cycle, generally during the first to third dredging cycles for the closest section of channel. The larger beneficial use sites

will be subdivided into cells sized to contain most, if not all, of the material to be dredged during its designated cycle in the closest section of channel. The exact size of the cell will be determined prior to dredging after surveys are conducted to determine the amount of material to be removed from the channel and the bottom topography and depth of the beneficial use sites to be filled. Confining levees for the cells (probably geotextile tubes) will be constructed at the time of filling. The beneficial use sites will be used during alternating dredging cycles to give the newly created marsh a chance to establish before depositing new material in adjacent cells and then creating connecting channels between cells and the surrounding bay. The connecting channels will allow circulation within and between the cells and bays to enhance their use by estuarine organisms and increase their value as crane feeding habitat.

On an alternating basis, the next dredging cycle will use upland leveed disposal areas and then the beneficial use sites - - -. To prevent levee failures, the leveed upland sites will have a minimum of 2 feet of freeboard (one more foot than previously used) above ponded water level with more frequent inspections to prevent ponded water from overtopping the levees. By alternating between beneficial use sites and upland leveed sites between cycles, an extra drying time of at least 4 years is established in the disposal schedule which will allow the material to compact more and extend the life of the upland disposal site. The extra capacity may be needed if some unforeseen event should occur, such as a severe storm creating extra shoaling problems or some shoaled material may become contaminated during a particular dredging cycle which must be contained in a leveed site. At the end of the 50-year disposal period, the levees for the upland disposal sites (except upland site

1 east of Welder Flats) are expected to reach final heights of 18-36 feet. These heights are based on past dredging history and may change depending on actual dredging volumes encountered in the future.

Upland site 1 which replaces DA 120 and 120A is located about 500 feet northeast of the road going to Fulghum's Fish Camp (outside the Critical Habitat) and 3,000 feet northwest of the centerline of the GIWW. The proposed site is at least 1,500 feet northeast of the closest whooping crane territory and whooping cranes have not been observed feeding in the proposed area. The site covers an area of 100 acres (3,630 x 1,200 feet) plus another 53 acres of right-of-way for access to perimeter levees and pipeline influent and effluent routes. A final levee height for this disposal site after 50 years use is expected to be about 12 feet. The site was chosen to be as near the GIWW as possible to minimize pumping distance and environmental impacts using aerial photographs as a guide. The site avoids the salt flats next to the GIWW (except for the pipeline corridors), all ponds that show up on the photograph, and will remove only a few small live oak thickets in the area. The major benefit of the new disposal site is the elimination of the long, narrow DA 120 which has a history of levee failure. The disposal site is too narrow for efficient levee maintenance and dredging needs and, as a consequence, material has spilled into Shoalwater Bay covering valuable emergent marsh and seagrass beds used by whooping cranes. DA 121 is expected to reach its capacity by the time the 50-year disposal plan is implemented and will not be part of the new disposal plan.

Whooping cranes are very cautious about approaching high obstructions because of the potential for predators hiding nearby.

Therefore, in order to enhance the marshes and aquatic habitat near DA 120 and 121 for whooping crane use and to prevent erosion of levees and their contents which could adversely affect these habitats, the sites will be modified by pushing the levees into the interior of the disposal sites. Upland vegetation will quickly invade the sites to help prevent erosion and provide a diversity of habitat for wildlife in the area.

- - -

About 77% of the previously lost whooping crane feeding habitat will be replaced and newly created marsh in the beneficial use sites and an inefficient upland disposal site (DA 120) will be replaced, preventing the possibility of future levee failure and burial of valuable crane feeding habitat in Shoalwater Bay. Also, the remaining upland leveed disposal sites will have at least 2 feet of levee freeboard above water ponding levels and more frequent levee inspections to prevent overtopping and levee failure to protect surrounding crane feeding habitat. Maintenance material destined for DA 121, which will soon reach its capacity, will be placed in beneficial use Site A and open-bay DA 122. Although the new upland disposal site will remove some potential upland feeding area that could be used by whooping cranes (small live oak thickets), its major benefit is the elimination of any future levee failures on DA 120 which could destroy much more valuable marsh and seagrass feeding habitat. Several studies and site redesigns will alleviate concerns of State and Federal resource agencies about the disposal and beneficial uses plan and an Interagency Coordination Team will be formed to follow the progress of the beneficial use sites and make recommendations to correct any deficiencies that may occur. The NMFS will monitor the sites to determine their success in

> becoming functionally equivalent to natural marshes and make recommendations to correct any problems that may be found. [Citations and references deleted]

Description of Impacts

The proposed bank erosion protection plan is expected to reduce GIWW-related erosion to a negligible level. In fact, according to the Draft Feasibility Study, the plan would prevent the loss of approximately 1139 acres of critical habitat during the period of 1996 through 2051. Since the construction proposed would take place while the whooping cranes are absent, the erosion controls structures' installation would not disturb these birds. Observations of whooping cranes feeding in areas already armored against erosion have shown them to be indifferent to the presence of the shoreline protection. Some of these birds still feed in ponds which would have been destroyed by now if that protection had not been afforded. Installation of the remaining concrete mattress structures would call for the removal or displacement of 9 to 10 acres of salt marsh and/or submerged aquatic vegetation, but some of this loss would be offset as marsh plants grow in between the mattress blocks, and the same amount of acreage would have been lost in as little as 2-3 years had it not been installed. Other erosion control mechanisms may be used where feasible instead of concrete mattresses to reduce impacts in specific areas.

The DEIS paints a very different picture of the situation if the erosion control plan is not carried out:

> Although approximately 16,000 feet of the most critically eroded shoreline will be protected by late 1994, if no action is taken at the end of the feasibility study to protect the critical habitat from further erosion, maintenance operations will cease and erosion from continued navigation use and natural causes up to about 2003

> will occur at about 2 acres per year. After 2003 and up to the end of the study period of analysis (2051), it is estimated that natural erosion (navigation-induced erosion will have ceased) will occur at about (or somewhat less than) one acre per year. The direct loss of marsh due to erosion is estimated at about 64 acres for the period 1 996-2051. However, there is an indirect loss of habitat when erosion exposes marsh ponds and lakes. This allows waves and currents to enter and scour the soft bottom and deepen the pond until it is not useable by feeding cranes. This loss is estimated to be about 1,075 acres over the period of analysis, most of which will occur in McMullen Lake and Sundown Bay. This loss may not jeopardize the survival of the whooping crane as a species, but it will limit the ability of the population which has already established territories along the GIWW to survive, particularly during periods of low food availability. During these times of stress, the cranes need larger areas to forage in order to survive. [Reference deleted.]

The Service points out if enough critical habitat is lost, it <u>may</u> jeopardize the species. A similar, though less immediate, picture can be predicted if the erosion control structures are completed as planned, but not maintained. Little by little, erosion would begin again to destroy the marshes and ponds of the critical habitat, and, through that loss, eventually threaten the continued existence of the whooping cranes.

As regards the plans to control oil spills in the critical habitat, there are actually three methods proposed. The first of these is the GIWW's alignment. The Draft Feasibility Report concludes that of the alternative routes assessed through the habitat, the current alignment had navigational safety advantages, as well as a nearly land-locked configuration, which would tend to minimize the frequency of spills and aid in their confinement. The second method is the use

of the proposed shoreline erosion control structures, which would almost double as booms, limiting the spread of spills. The third method involves the actual installation of anchor piling in the erosion controls at gaps, and the provision for booms to be stored at the Aransas National Wildlife Refuge to facilitate their rapid deployment. Installation of the timber piling would take place when the whooping cranes were not present, and would not present a significant deterrent to their use of the critical habitat when present. Failure to provide and maintain in the anchors and booms as proposed would significantly delay spill control efforts, allowing spilled material to penetrate deeply into marshes, ponds, and tidal flats where cleanup would be difficult, if not impossible to accomplish without lasting adverse impact to the critical habitat.

The impacts of the proposed 50-year disposal plan are designed to be beneficial, making it difficult to find potential adverse effects. One of the latter might be the construction of a new upland disposal site which would remove some small live oak thickets that might have provided foraging areas for the whooping crane. However, this disposal site has not historically been used by the cranes, and it would lie outside the critical habitat. Use of this site would also allow abandonment of an existing disposal site with inadequate capacity and a history of levee failure. This and another site soon to reach full capacity would be altered by pushing their old bayshore levees down into the center of the sites, making the adjacent shorelines less intimidating to feeding cranes. Future levee failures would be avoided by increasing freeboards and inspecting the levee failures more frequently, thus protecting the critical habitat, and the District would coordinate with the Service and other resource agencies in the formation of an Interagency Coordination Team to address similar levee problems should they recur. The Interagency Coordination Team would also evaluate the methods used for construction, planting and monitoring the 1600 acres of marsh that would be produced by the 50-year plan. The National Marine Fisheries Service will play a vital role in monitoring the success of the marshes, and has already established a baseline for comparing the productivity of unvegetated bay bottoms

which would be the sites of the proposed beneficial uses disposal areas. Finally, some of the dredged material is to be placed to add to the beneficial effects of the erosion control structures.

The locations of the disposal areas are as yet not precisely settled, and years of planning and last-minute changes will make it impossible to predict how large each will be and which designs will be incorporated. One issue yet to be addressed is how to meet the suspended sediment standard for the effluents from the relatively small beneficial uses disposal area cell sites. Another is whether discharging these effluents into the bays, rather than back into the GIWW, would have a significant effect on the water quality of each bay. These are issues potentially affecting the critical habitat which cannot be addressed easily at this time, but it is expected that the Interagency Coordination Team will consider them and offer solutions. It is anticipated that as the solutions are proposed, they will be subject to further consultation, at least informally.

Discussion and Justification of Fish and Wildlife Conservation Measures

In addition to the primary fish and wildlife conservation measure originally proposed, that of halting the extensive erosion of whooping crane critical habitat, the proposed alternative now includes the measures of installing spill control features and utilizing a 50-year dredged material disposal plan which would create 1600 acres of new marsh. Thus, while preventing the loss due to erosion of another 1139 acres of critical habitat during the period from 1996 through 2051, the project would help defend the deterioration of that same habitat from the infiltration of spilled liquid cargoes, and at the same time restore an acreage of marsh equivalent to approximately 77 percent of loss of whooping crane habitat previously attributable to the existence of the GIWW.

List of Recommendations

On October 2, 1995, Rick Medina notified the Service telephonically that the District had determined to assume the responsibility for maintaining the erosion and spill control structures proposed after they are installed. The Service views the maintenance of the structures in the same light it views their construction: both construction and maintenance are necessary to insure the continued presence of the GIWW does not indirectly cause the destruction or adverse modification of the whooping crane's critical habitat, and, over time, cause so much harm as to become likely to jeopardize the continued existence of that species. The District's assumption of this maintenance responsibility thereby responds affirmatively to the major recommendation of the Supplemental Draft FWCA Report.

The placement of the concrete mattress erosion control devices would involve the loss of 9 to 10 acres of aquatic vegetation if installed at all proposed sites. Consequently, where feasible, alternative control measures should be considered and constructed to minimize this loss.

There are details of the proposed 50-year disposal plan which have yet to be worked out. These include additional actions to be taken to prevent levee failures from affecting critical habitat, selection of specific sizes and locations for the beneficial uses sites, monitoring and retrofitting the beneficial use sites to improve their productivity, and issues relating to the quality, location, and impacts of effluents from those sites. The District proposes, and the Service recommends, the formation of an Interagency Coordination Team to address these areas of concern and to formulate proposed responses to them.

Summary of Findings and Service Position

The Service believes Interagency Coordination Team supervision of the whole beneficial uses program is essential to achieving the benefits desired and to

avoiding or minimizing possible adverse impacts. The Service conditions its approval of the 50-year dredged material disposal plan on the formation and oversight of the plan by the Interagency Coordination Team. The Service considers the proposed alternative channel location, shoreline protection facilities, and spill containment facilities necessary and appropriate responses to the requirements of the Fish and Wildlife Coordination Act and the Endangered Species Act. Maintenance of each of the latter by the District is considered equally necessary and appropriate.

Enclosures

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Southeast Regional Office
9721 Executive Center Drive N.
St. Petersburg, Florida 33702

August 8, 1995

Rogelio Perez, Field Supervisor
U.S. Fish and Wildlife Service
Ecological Services
c/o TAMU-CC, Campus Box 358
6300 Ocean Drive
Corpus Christi, Texas 78412

AUG 10 1995

Dear Mr. Perez:

The National Marine Fisheries Service has received the Draft Fish and Wildlife Coordination Report and the Supplement to that report dated June 30, 1995. These documents were prepared by the U.S. Fish and Wildlife Service to assist the Galveston District Corps of Engineers in the planning for the Section 216 Report for the Gulf Intracoastal Waterway (GIWW) Aransas Wildlife Refuge Reach.

We have reviewed the subject document and concur with the "List of Recommendations" provided on page 13 of the Executive Summary. We have determined that of the four proposed alternatives investigated, Alternative 1, which calls for shoreline protection of the existing GIWW alignment, would have the least adverse impact to living marine resources. We also believe that the proposed 50 year disposal plan to create 1600 acres of intertidal marsh would be beneficial to living marine resources, if properly constructed and maintained.

If we can be of further assistance, please contact Rusty Swafford of our Galveston Field Branch at (409) 766-3699.

Sincerely yours,

Rusty Swafford

Andreas Mager, Jr.
Assistant Regional Director
Habitat Conservation Division

Printed on Recycled Paper

DRAFT **DRAFT**

TEXAS
PARKS AND WILDLIFE DEPARTMENT
4200 Smith School Road • Austin, Texas 78744 • 512-389-4800

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Executive Director

October 4, 1995

U. S. Fish and Wildlife Service
Ecological Services
c/o TAMU-CC, Campus Box 338
6300 Ocean Dr.
Corpus Christi, Texas 78412

Attention: Mr. Johnny French

RE: Draft Coordination Report on the U. S. Army Corps of Engineers Study of Alternative Routes for the Gulf Intracoastal Waterway, Vicinity of the Aransas National Wildlife Refuge, Aransas and Calhoun Counties, Texas and a Supplement to this Draft Report

Dear Mr. French:

After a review of the subject report and its supplement this Department wishes to provide the following comments:

We are in general agreement with the September 20, 1994 Draft Report. This document, while meaningful, is very general and indicates that upon being provided with more specific information, more definitive comments can be provided. The paramount item in this document is that Alternative No. 1 is the preferred choice. We concur.

While again, this Department generally agrees with the July 5, 1995 Supplement, which is more specific and detailed than the earlier document, there are some areas for which we would like to offer important, specific recommendations. On Page 2, Last paragraph and Page 3, first paragraph: While the cellular concrete mattress has proven to be acceptable in many applications, there are some cases where other methods of erosion control such as the geotextile tube or rock rubble breakwater are more appropriate. The ability to maintain sufficient flexibility to employ all of these different methods when needed will be important in achieving the least damaging, efficient erosion control geared toward habitat enhancement/creation.

Page 3, bottom of page: This Department is not aware of extensive oyster colonizations occurring on existing

DRAFT DRAFT

geotextiles (tubes in use for two years in this area). Department staff has visited these sites on several occasions and has yet to see a significant oyster population.

Page 5, second paragraph: The Federal agencies should be aware that this Department is the State Agency, assisted by the Texas General Land Office, responsible for the management of the Welder Flats Coastal Preserve. The State has a Management Plan developed, including a Spill Contingency Plan for this area. Coordination/cooperation between the Federal and State agencies should result in a more effective spill response effort should the need arise.

In addition to the above comments, we are providing a copy of our letter of July 13, 1995 to the Corps of Engineers regarding their Draft Feasibility Study on the 216 Study of the Aransas National Wildlife Refuge, Gulf Intracoastal Waterway. Please give these comments consideration where appropriate.

Sincerely,

_____

Robert W. (Bob) Spain
Chief, Habitat Assessment Branch

RWS:RAH:JRM:fmd

APPENDIX B - SECTION 2

ENDANGERED SPECIES ACT CORRESPONDENCE

DEPARTMENT OF THE ARMY
GALVESTON DISTRICT, CORPS OF ENGINEERS
P.O. BOX 1229
GALVESTON, TEXAS 77553-1229

REPLY TO
ATTENTION OF:

October 1, 1992

Environmental
Resources Branch

Mr. Rogelio Perez
Field Supervisor
U.S. Fish and Wildlife Service
c/o CCSU, Campus Box 338
Corpus Christi, Texas 78412

Dear Mr. Perez:

The Galveston District, Corps of Engineers, is studying the feasibility of protecting about 18 miles of eroding shoreline along the Gulf Intracoastal Waterway (GIWW) where it passes through designated Critical Habitat for the endangered whooping crane (see enclosed map). The study is authorized by Section 216 of Public Law 91-611 (1970 Flood Control Act) which permits the Corps of Engineers to review the operation of completed Corps projects that may have changed because of physical or economic reasons.

Shore erosion along the study segment, located between Port O'Connor and Port Aransas, is caused by a combination of wind-generated waves and vessel traffic in the GIWW. Erosion is removing marsh habitat in the Aransas National Wildlife Refuge (ANWR) and nearby Welder Flats area that is critical to the survival of the whooping crane. If no action is taken to stop the erosion, the established territories of each pair of cranes will be gradually reduced until the area can no longer support them, leading to a possible decline in the population.

The feasibility study is considering three realignment alternatives for the GIWW (two going around the critical habitat and one following the original route through the middle of the bay system), one armoring plan to prevent erosion along the present alignment, and a "No Action" plan (see enclosed map). Beneficial uses of dredged material will also be explored.

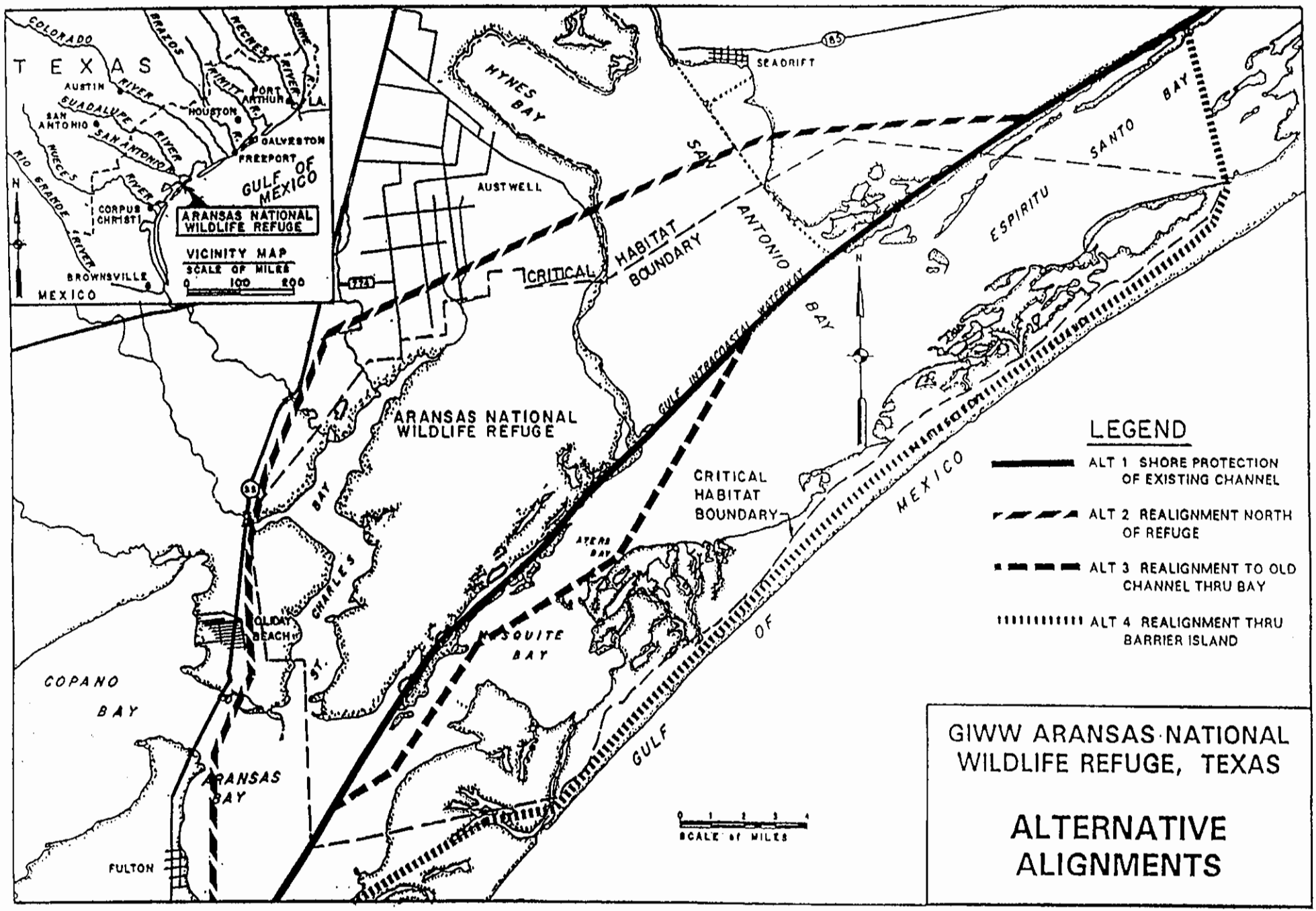
I request that you provide a list of any threatened or endangered species and their critical habitats that may occur in the study area. I appreciate your cooperation in assisting us to

fulfill our responsibilities regarding Section 7 of the Endangered Species Act. If you have any questions, please contact Dr. Terry Roberts at 409/766-3035.

Sincerely,

Sidney H. Tanner
Acting Chief, Planning Division

Enclosure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NUECES
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CRITICAL HABITAT BOUNDARY
GULF INTRACOASTAL WATERWAY
ARANSAS NATIONAL WILDLIFE REFUGE
CRITICAL HABITAT BOUNDARY
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OF
GULF
ATHENS BAY
MOUITE BAY
ST. CHARLES BAY
OLIVER BEACH
COPANO BAY
ARANSAS BAY
FULTON
SCALE OF MILES
LEGEND
ALT 1 SHORE PROTECTION OF EXISTING CHANNEL
ALT 2 REALIGNMENT NORTH OF REFUGE
ALT 3 REALIGNMENT TO OLD CHANNEL THRU BAY
ALT 4 REALIGNMENT THRU BARRIER ISLAND
GIWW ARANSAS NATIONAL WILDLIFE REFUGE, TEXAS
ALTERNATIVE ALIGNMENTS

DEPARTMENT OF THE ARMY
GALVESTON DISTRICT, CORPS OF ENGINEERS
P.O. BOX 1229
GALVESTON, TEXAS 77553-1229

REPLY TO
ATTENTION OF:

October 1, 1992

Environmental
Resources Branch

Dr. Charles Oravetz
Chief, Protected Species Management Branch
National Marine Fisheries Service
9450 Koger Boulevard
St. Petersburg, Florida 33702

Dear Dr. Oravetz:

The Galveston District, Corps of Engineers, is studying the feasibility of protecting about 18 miles of eroding shoreline along the Gulf Intracoastal Waterway (GIWW) where it passes through designated Critical Habitat for the endangered whooping crane (see enclosed map). The study is authorized by Section 216 of Public Law 91-611 (1970 Flood Control Act) which permits the Corps of Engineers to review the operation of completed Corps projects that may have changed because of physical or economic reasons.

Shore erosion along the study segment, located between Port O'Connor and Port Aransas, is caused by a combination of wind-generated waves and vessel traffic in the GIWW. Erosion is removing marsh habitat in the Aransas National Wildlife Refuge (ANWR) and nearby Welder Flats area that is critical to the survival of the whooping crane. If no action is taken to stop the erosion, the established territories of each pair of cranes will be gradually reduced until the area can no longer support them, leading to a possible decline in the population.

The feasibility study is considering three realignment alternatives for the GIWW (two going around the critical habitat and one following the original route through the middle of the bay system), one armoring plan to prevent erosion along the present alignment, and a "No Action" plan (see enclosed map). Beneficial uses of dredged material will also be explored.

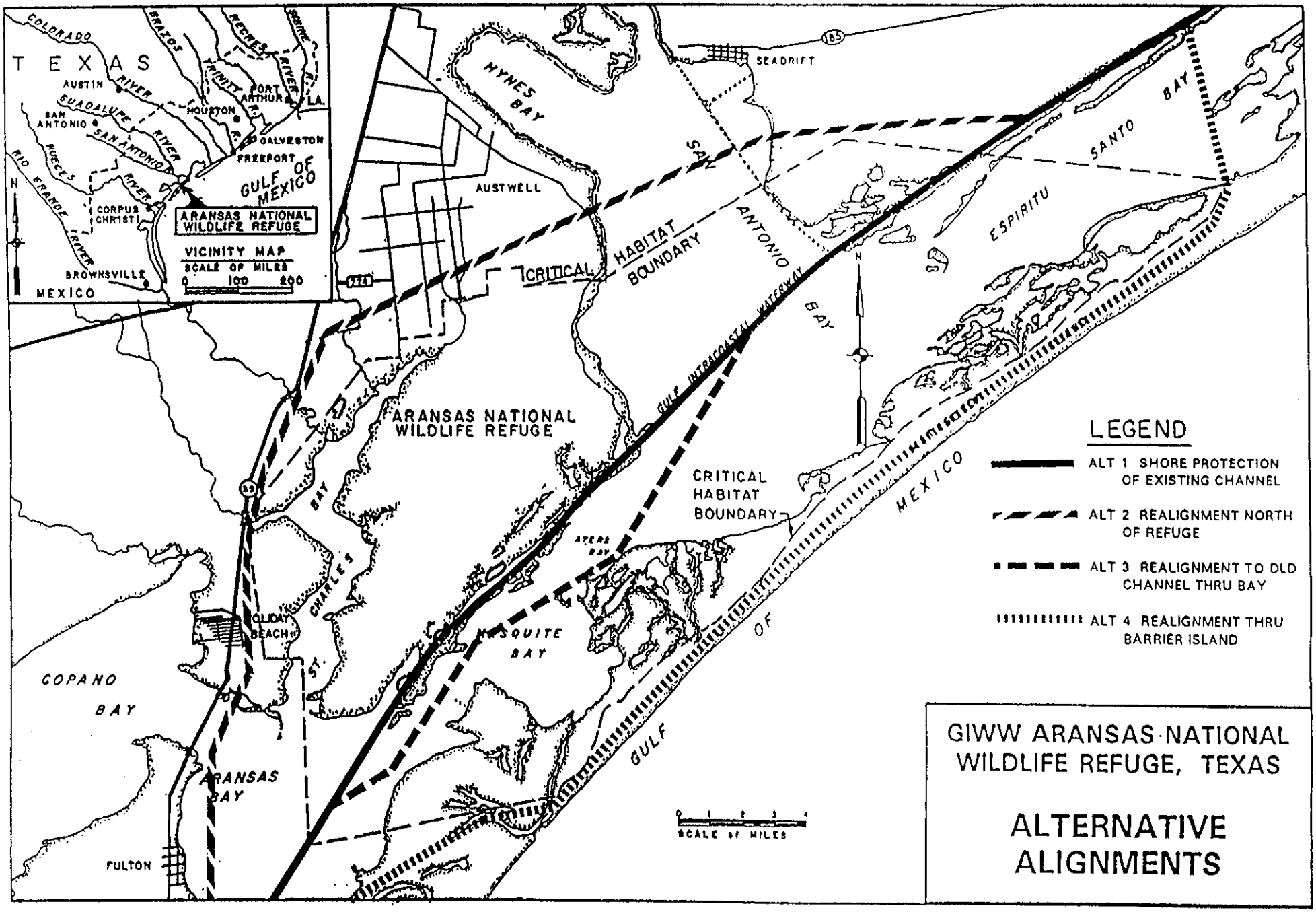
I request that you provide a list of any threatened or endangered species and their critical habitats that may occur in the study area. I appreciate your cooperation in assisting us to

fulfill our responsibilities regarding Section 7 of the Endangered Species Act. If you have any questions, please contact Dr. Terry Roberts at 409/766-3035.

Sincerely,

Sidney H. Tanner
Acting Chief, Planning Division

Enclosure



GIWW ARANSAS NATIONAL WILDLIFE REFUGE, TEXAS

ALTERNATIVE ALIGNMENTS

DEPARTMENT OF THE ARMY
GALVESTON DISTRICT, CORPS OF ENGINEERS
P.O. BOX 1229
GALVESTON, TEXAS 77553-1229

REPLY TO
ATTENTION OF:

October 30, 1992

Environmental
Resources Branch

Mr. Gary Graham
Endangered Resources Branch
Texas Parks and Wildlife Department
3000 I-Highway 35 South, Suite 100
Austin, Texas 78704

Dear Mr. Graham:

The Galveston District, Corps of Engineers, is studying the feasibility of protecting about 18 miles of eroding shoreline along the Gulf Intracoastal Waterway (GIWW) where it passes through designated Critical Habitat for the endangered whooping crane (see enclosed map). The study is authorized by Section 216 of Public Law 91-611 (1970 Flood Control Act) which permits the Corps of Engineers to review the operation of completed Corps projects that may have changed because of physical or economic reasons.

Shore erosion along the study segment, located between Port O'Connor and Port Aransas, is caused by a combination of wind-generated waves and vessel traffic in the GIWW. Erosion is removing marsh habitat in the Aransas National Wildlife Refuge (ANWR) and nearby Welder Flats area that is critical to the survival of the whooping crane. If no action is taken to stop the erosion, the established territories of each pair of cranes will be gradually reduced until the area can no longer support them, leading to a possible decline in the population.

The feasibility study is considering three realignment alternatives for the GIWW (two going around the critical habitat and one following the original route through the middle of the bay system), one armoring plan to prevent erosion along the present alignment, and a "No Action" plan (see enclosed map). Beneficial uses of dredged material will also be explored.

It would help the Corps to prepare an Environmental Impact Statement and Biological Assessment of project impacts to rare and endangered species if you would provide a list of these species recognized by the State of Texas that might occur in the area of the project. Please include any information you may have on known locations for these species as well as any federally

listed threatened or endangered species in the area. I appreciate your cooperation in assisting us in preparing these documents. If you have any questions, please contact Dr. Terry Roberts at 409/766-3035.

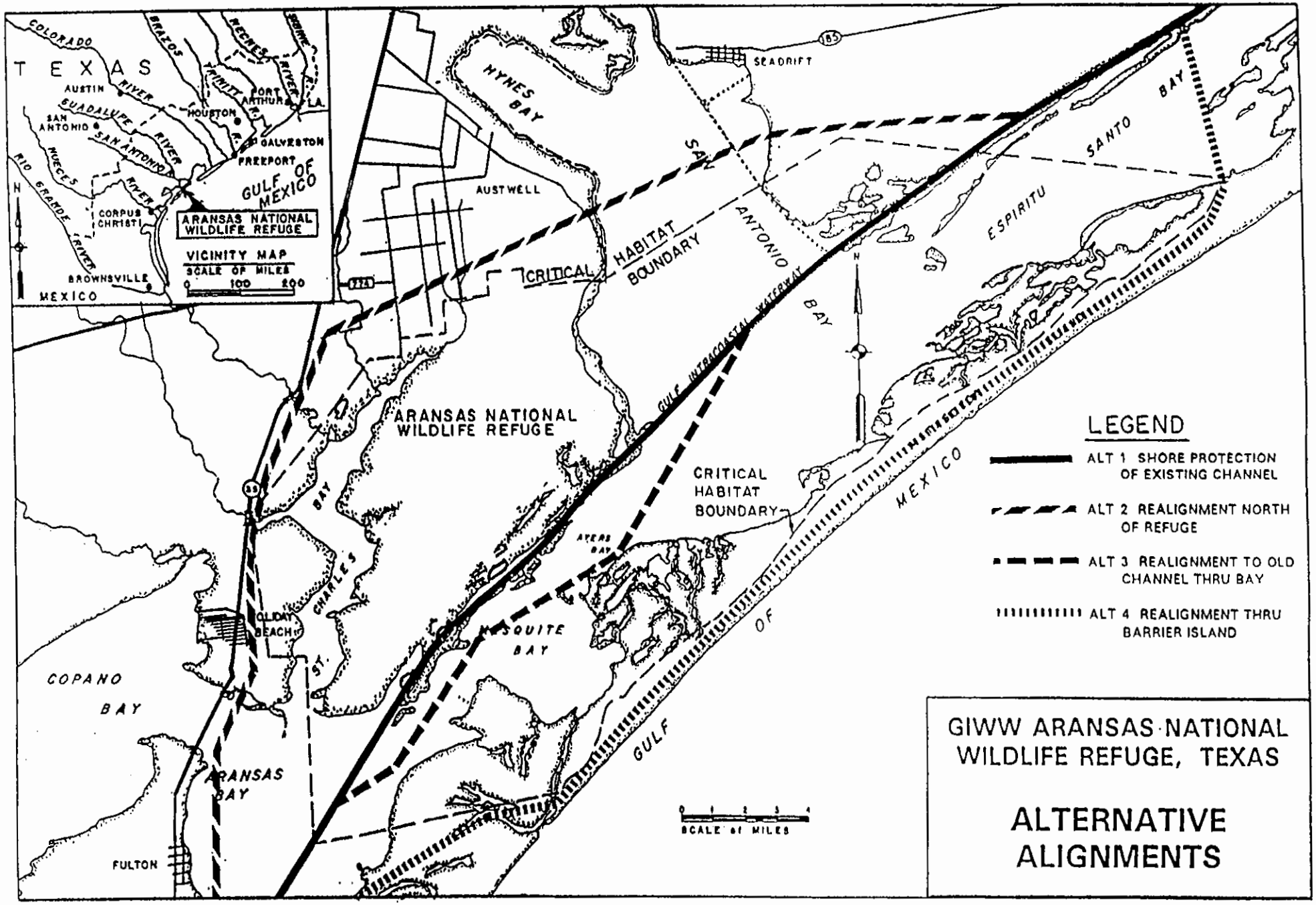
Sincerely,

Sidney H. Tanner
Acting Chief, Planning Division

Enclosure

Copy Furnished with Enclosure:

Mr. Dick Harrington
Resource Protection Division
Texas Parks and Wildlife Department
Campus Box 317
Corpus Christi State University
6300 Ocean Drive
Corpus Christi, Texas 78412



GIWW ARANSAS NATIONAL WILDLIFE REFUGE, TEXAS

ALTERNATIVE ALIGNMENTS

February 25, 1994

Environmental
Resources Branch

Mr. Rogelio Perez
Field Supervisor
U.S. Fish and Wildlife Service
c/o CCSU, Campus Box 338
Corpus Christi, Texas 78412

Dear Mr. Perez:

The Galveston District sent a letter to you dated October 1, 1992, requesting a list of threatened and endangered species and their critical habitats that may occur in the area of the Aransas National Wildlife Refuge. A copy of this letter and map is enclosed for quick reference. In your reply dated February 10, 1993, you provided a list of species for the District to consider under the guidelines of the Endangered Species Act (ESA).

Because it has taken longer than expected to obtain the necessary information on the project alternatives and any impacts on the protected species in the area, a Biological Assessment for your review has been delayed beyond the 180 day time limit provided in the ESA. Therefore, I request an update on the species list you previously provided. This list is also enclosed for quick reference.

Thank you for your cooperation in helping us to fulfill our responsibilities under Section 7 of the ESA. If you have any questions, please contact Dr. Terry Roberts at 409/766-3035.

Sincerely,

James M. Kieslich
Chief, Planning Division

Enclosures

February 25, 1994

Environmental Resources Branch

Dr. Charles Oravetz
Chief, Protected Species
Management Branch
National Marine Fisheries Service
9450 Koger Boulevard
St. Petersburg, Florida 33702

Dear Dr. Oravetz:

The Galveston District sent a letter to you dated October 1, 1992 requesting a list of threatened and endangered species and their critical habitats that may occur in the area of the Aransas National Wildlife Refuge. A copy of this letter and map is enclosed for quick reference. In your reply dated October 9, 1992, you provided a list of species for the District to consider under the guidelines of the Endangered Species Act (ESA).

Because it has taken longer than expected to obtain the necessary information on the project alternatives and any impacts on the protected species in the area, a Biological Assessment for your review has been delayed beyond the 180 day time limit provided in the ESA. Therefore, I request an update on the species list you previously provided. This list is also enclosed for quick reference.

Thank you for your cooperation in helping us to fulfill our responsibilities under Section 7 of the ESA. If you have any questions, please contact Dr. Terry Roberts at 409/766-3035.

Sincerely,

James M. Kieslich
Chief, Planning Division

Enclosures

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Ecological Services
c/o CCSU, Campus Box 338
6300 Ocean Drive
Corpus Christi, Texas 78412

TAKE PRIDE IN AMERICA

February 10, 1993

Colonel John P. Basilotto
District Engineer
Attn: Sidney H. Tanner
U.S. Army Corps of Engineers
P.O. Box 1229
Galveston, TX 77553

Consultation No. 2-11-93-I-082

Dear Colonel Basilotto:

This responds to your facsimile transmission dated January 4, 1993, requesting information on species Federally listed or proposed for listing as threatened or endangered occurring in Aransas, Calhoun and Refugio counties. In addition, you requested information on designated critical habitat in your action area. It is our understanding that the information will be used to assess potential impacts associated with the proposed realignment alternatives for the Gulf Intracoastal Waterway.

The following list provides information on Federally listed species from the area mentioned in your request. The list has been expanded to include candidate species as well. Candidate species have no protection under the Endangered Species Act; however, the U. S. Fish and Wildlife Service (Service) has substantial information on Category 1 species to support their listing as threatened or endangered. The development and publication of proposed rules for Category 1 species is anticipated. Category 2 species are those for which available information indicates that proposing to list as endangered or threatened is possibly appropriate, but substantial data on biological vulnerability and threats are not currently known to support the immediate preparation of rules. However, actions that might contribute to the listing of candidate species should be avoided. A letter designation follows the species name that represents the current Federal status of the species. Within the following list, the letters E, T, C1, and C2 represent the statuses of Endangered, Threatened, Category 1, and Category 2 respectively. Our data indicates that the following species may occur in the area:

Aransas

American peregrine falcon (Falco peregrinus anatum) - E
Attwater's prairie chicken (Tympanuchus cupido attwateri) - E
bald eagle (Haliaeetus leucocephalus) - E
brown pelican (Pelecanus occidentalis) - E
hawksbill sea turtle (Eretmochelys imbricata) - E
jaguarundi (Felis yagouaroundi) - E
Kemp's ridley sea turtle (Lepidochelys kempi) - E
leatherback sea turtle (Dermochelys coriacea) - E
ocelot (Felis pardalis) - E
whooping crane (Grus americana) - E

Arctic peregrine falcon (Falco peregrinus tundrius) - T
green sea turtle (Chelonia mydas) - T
loggerhead sea turtle (Caretta caretta) - T
piping plover (Charadrius melodus) - T
Gulf Coast hog-nosed skunk (Conepatus leuconotus texensis) - C1
Gulf salt marsh snake (Nerodia clarki) - C2
Aransas short-tailed shrew (Blarina hylophaga plumbea) - C2
Audubon's oriole (Icterus graduacauda audubonii) - C2
black-spotted newt (Notophthalmus meridionalis) - C2
ferruginous hawk (Buteo regalis) - C2
long-billed curlew (Numenius americanus) - C2
loggerhead shrike (Lanius ludovicianus) - C2
mountain plover (Charadrius montanus) - C2
rough-seed sea purslane (Sesuvium trianthemoides) - C2
reddish egret (Egretta rufescens) - C2
Texas Botteri's sparrow (Aimophila botterii texana) - C2
Texas diamondback terrapin (Malaclemys terrapin littoralis) - C2
Texas horned lizard (Phrynosoma cornutum) - C2
Texas olive sparrow (Arremonops rufivirgatus rufivirgatus) - C2
western snowy plover (Charadrius alexandrinus nivosus) - C2
white-faced ibis (Plegadis chihi) - C2

Calhoun

American peregrine falcon (Falco peregrinus anatum) - E
bald eagle (Haliaeetus leucocephalus) - E
brown pelican (Pelecanus occidentalis) - E
hawksbill sea turtle (Eretmochelys imbricata) - E
Kemp's ridley sea turtle (Lepidochelys kempi) - E
leatherback sea turtle (Dermochelys coriacea) - E
whooping crane (Grus americana) - E
Arctic peregrine falcon (Falco peregrinus tundrius) - T
green sea turtle (Chelonia mydas) - T
loggerhead sea turtle (Caretta caretta) - T
piping plover (Charadrius melodus) - T
Gulf Coast hog-nosed skunk (Conepatus leuconotus texensis) - C1
ferruginous hawk (Buteo regalis) - C2
Gulf salt marsh snake (Nerodia clarki) - C2
long-billed curlew (Numenius americanus) - C2
loggerhead shrike (Lanius ludovicianus) - C2
reddish egret (Egretta rufescens) - C2
Texas diamondback terrapin (Malaclemys terrapin littoralis) - C2
Texas horned lizard (Phrynosoma cornutum) - C2
western snowy plover (Charadrius alexandrinus nivosus) - C2
white-faced ibis (Plegadis chihi) - C2

Refugio

Attwater's prairie chicken (Tympanuchus cupido attwateri) - E
bald eagle (Haliaeetus leucocephalus) - E
black lace cactus (Echinocereus reichenbachii var. albertii) -E
hawksbill sea turtle (Eretmochelys imbricata) - E
Kemp's ridley sea turtle (Lepidochelys kempi) - E
leatherback sea turtle (Dermochelys coriacea) - E
ocelot (Felis pardalis) - E
whooping crane (Grus americana) - E
green sea turtle (Chelonia mydas) - T
loggerhead sea turtle (Caretta caretta) - T
piping plover (Charadrius melodus) - T

Gulf Coast hog-nosed skunk (Conepatus leuconotus texensis) - C1
black-spotted newt (Notophthalmus meridionalis) - C2
Cagle's map turtle (Graptemys caglei) - C2
ferruginous hawk (Buteo regalis) - C2
long-billed curlew (Numenius americanus) - C2
loggerhead shrike (Lanius ludovicianus) - C2
mountain plover (Charadrius montanus) - C2
northern gray hawk (Buteo nitidus) - C2
reddish egret (Egretta rufescens) - C2
Rio Grande lesser siren (Siren intermedia texana) - C2
Texas diamondback terrapin (Malaclemys terrapin littoralis) - C2
Texas horned lizard (Phrynosoma cornutum) - C2
Texas olive sparrow (Arremonops rufivirgatus rufivirgatus) - C2
Texas windmill grass (Chloris texensis) - C2
Welder spine aster (Machaeranthera heterocarpa) - C2
western snowy plover (Charadrius alexandrinus nivosus) - C2
white-faced ibis (Plegadis chihi) - C2

Whooping cranes winter at the Aransas National Wildlife Refuge and on Matagorda Island, and critical habitat has been designated in Aransas, Calhoun and Refugio counties. The endangered whooping crane occurs as a migrant throughout central Texas. The crane's preferred roosting habitat consists of relatively isolated wetlands (marshes, shallow stream channels and playa lakes) often within two miles of grain fields.

Section 7 of the Endangered Species Act requires that all Federal agencies consult with the U.S. Fish and Wildlife Service to ensure that actions authorized, funded or carried out by such agencies do not jeopardize the continued existence of any listed threatened or endangered species or adversely modify or destroy critical habitat of such species. It is the responsibility of the Federal action agency to determine if the proposed project may affect threatened or endangered species. If a "may affect" determination is made, the Federal agency shall initiate the formal Section 7 consultation process by writing to: Field Supervisor; U.S. Fish and Wildlife Service; c/o CCSU - Campus Box 338; 6300 Ocean Drive; Corpus Christi, Texas 78412. If no effect is evident, no further consultation is needed; however, we would appreciate the opportunity to review the criteria used to arrive at that determination.

If we can be of further assistance, please contact Tim Cooper of our office at (512) 888-3346.

Sincerely,

ROGELIO PEREZ
Field Supervisor

cc:
Area Engineer, U.S. Army Corps of Engineers, Corpus Christi, TX
Executive Director, Texas Parks & Wildlife Department, Austin, TX
Supv., Resource Protection Br., Texas Parks & Wildlife Dept., Austin, TX
R. A. Harrington, Texas Parks & Wildlife Dept., Corpus Christi, TX
Director, Land Management Policy Section, General Land Office, Austin, TX
Field Representative, General Land Office, Aransas Pass, TX
Commissioner, Texas Water Commission, ATTN: Charles Eanes, Austin, TX
Southwest Regional Office, National Audubon Society, Austin, TX
Texas Sanctuary Coordinator, Nat'l Audubon Society, Corpus Christi, TX
Executive Director, The Texas Shrimp Association, Austin, TX
Regional Administrator, Environmental Protection Agency, Dallas, TX
Regional Director, Nat'l Marine Fisheries Service, St. Petersburg, FL
Area Supervisor, Habitat Conservation Division, NMFS, Galveston, TX
Regional Director, National Park Service, USDI, Santa Fe, NM

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Southeast Regional Office
9450 Koger Boulevard
St. Petersburg, FL 33702

October 9, 1992 F/SE013:TLD

Mr. Sidney H. Tanner
Acting Chief, Planning Division
U.S. Dept. of the Army
Galveston District, COE
Post Office Box 1229
Galveston, Texas 77553-1229

Dear Mr. Tanner:

This responds to your letter of October 1, 1992, requesting information on endangered and threatened species under the jurisdiction of the National Marine Fisheries Service (NMFS) which might occur in the vicinity of Gulf Intracoastal Waterway's shoreline between Port O'Connor and Port Aransas, Texas. The enclosed list contains species under NMFS purview that may occur in the marine environment off Texas coast. No critical habitat for species under NMFS jurisdiction has been designated in that area, nor has critical habitat been proposed.

If you have any questions, please contact Terry Henwood, Fishery Biologist, at 813/893-3366.

Sincerely yours,

Terry Henwood

for Charles A. Oravetz, Chief
Protected Species Management
Branch

Enclosure

Endangered and Threatened Species and Critical Habitats
under NMFS Jurisdiction

Texas

Listed species	Scientific Name	Status	Date Listed
fin whale	*Balaenoptera physalus*	E	12/02/70
humpback whale	*Megaptera novaeangliae*	E	12/02/70
right whale	*Eubaleana glacialis*	E	12/02/70
sei whale	*Balaenoptera borealis*	E	12/02/70
sperm whale	*Physeter catodon*	E	12/02/70
green sea turtle	*Chelonia mydas*	TH	07/28/78
hawksbill sea turtle	*Eretmochelys imbricata*	E	06/02/70
Kemp's (Atlantic) ridley sea turtle	*Lepidochelys kempi*	E	12/02/70
leatherback sea turtle	*Dermochelys coriacea*	E	06/02/70
loggerhead sea turtle	*Caretta caretta*	TH	07/28/78

SPECIES PROPOSED FOR LISTING
None

CRITICAL HABITAT
None

CRITICAL HABITAT PROPOSED FOR LISTING
None

COMMISSIONERS
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TEXAS
PARKS AND WILDLIFE DEPARTMENT
4200 Smith School Road • Austin, Texas 78744 • 512-389-4800

ANDREW SANSOM
Executive Director

January 12, 1993

Mr. Terry Roberts
Department of the Army
Galveston District, Corps of Engineers
P.O. Box 1229
Galveston, Texas 77553-1229

Dear Mr. Roberts:

I am writing to provide information relative to the endangered resource concerns of alternatives suggested in a study authorized by Section 216 of Public Law 91-611. The study in question addresses the feasibility of protecting eroding shoreline along the Gulf Intracoastal Waterway (GIWW) where it passes through designated critical habitat of the endangered whooping crane. The following is a list of the species identified by the Natural Heritage Program as being of special concern and occurring in the area of the four alternative routes. The species name, common name and state and federal listing status are presented.

Species	Common name	Federal	State
Grus americana	Whooping Crane	E	E
Lepidochelys kempi	Kemp's Ridley Sea Turtle	E	E
Pelecanus occidentalis	Brown Pelican	E	E
Tympanuchus cupido attwateri	Attwater's Prairie Chicken	E	E
Charadrius melodus	Piping Plover	T	T
Egretta rufescens	Reddish Egret	C2	T
Malaclemys terrapin littoralis	Texas Diamondback Terrapin	C2	
Nerodia clarkii	Gulf Saltmarsh Snake	C2	
Thurovia triflora *	Threeflower Broomweed		

** Unlisted species tracked by the Texas Natural Heritage Program.*

For purposes of our evaluation, we have identified the four alternatives as follows:

Alternative I : Existing alignment.
Alternative II : Realignment north of the refuge.
Alternative III : Realignment through the old channel through the bay.
Alternative IV : Realignment through the barrier island.

Whooping Crane
We have several concerns relative to the whooping crane. These include the reduction of quality habitat for the wintering birds due to erosion along the GIWW. In the cases of Alternatives I and III, some measures, possibly armoring areas adjacent to the waterway and/or restricting the speed of traffic within critical habitat, must be taken to reduce the risk of such erosion. Such measures would be equally necessary in the vicinity of Welder Flats, an area also within the boundaries of critical habitat for the crane. In addition, restoration of marsh habitat already lost to erosion should be pursued, regardless of the alignment finally agreed upon. Options for future dredge disposal should be outlined and presented. These options might include, but should not be limited to, beneficial uses such as restoration of degraded or destroyed marsh.

The other major consideration for those alternatives remaining within critical habitat is the potential for toxic spills by cargo traffic through the GIWW. It appears to us that Alternative I may provide a better alternative relative to this concern. Alternative I offers a straighter course for movement of traffic and also provides some areas where spill containment is simplified by the presence of high ground adjacent and parallel to the existing channel. On the other hand, a spill along the existing waterway would immediately impact high quality, heavily used critical habitat. It should be kept in mind, however, that spills along Alternative III have the potential of impacting a broader expanse of critical habitat due to the decreased opportunity of spill containment offered by the open bay conditions. The possibility of toxic spills within the existing alignment might be minimized if traffic control measures (i.e. one-way traffic) are initiated for barge traffic traversing critical habitat. Deployment of spill control equipment along the waterway in the area of critical habitat might also be considered.

To reiterate, erosion control measures and restoration of already degraded or lost marsh should be addressed regardless of the alternative. Alternative II and IV, of course, offer better solutions to problems associated with the whooping cranes as these realignments completely avoid critical habitat.

Piping Plover
Piping plovers are present in the coastal areas of Texas during migration and winter. The species is federally listed as threatened in Texas and uses areas of sand, mud, and algal flats as well as beaches. Alternatives III and IV have the greatest potential for negative impacts on these habitats. Alternative III passes near several areas along the west sides of Matagorda and San Jose Islands where piping plovers are known to forage. These areas, located on flats along Ayers Reef and north and west of Big Brundrett Lake, represent known locations used by piping plovers. Other nearby localities may also be important to the species. The possibility of cumulative impacts to these foraging areas should be addressed in any analysis of preferred routes. The negative impact associated with Alternative IV arises from the potential degradation or destruction of areas used by piping plovers on the Gulf side (beach habitats) of Matagorda Island. The effects of erosion, toxic contamination, and increased traffic on the viability of these wintering populations should be considered. It may be

possible to address some of the concerns associated with Alternative III by adjusting the route such that it passes further away from Matagorda and San Jose Islands (along a more direct route through the bay). This sort of realignment would have associated negative impacts as it would require the dredging of previously undredged bay bottom. Also, this realignment might more directly impact the Second and Third Chains of Islands. Erosion control should be considered in the development of plans for Alternative III since problems of erosion associated with this route could have negative consequences for piping plover foraging habitat, waterbird nesting islands, and whooping crane critical habitat.

Waterbird Colonies

The brown pelican, a federally endangered species, historically nested on Long Reef, Second Chain of Islands, and Third Chain of Islands. The route proposed in Alternative III would pass closer to Second and Third Chains than the present route does and therefore may cause increased erosion of these islands as well as subjecting them to increased risk of contamination by toxic or oil spills. These islands may become important in the future as the USFWS and TPWD attempt to initiate brown pelican colonies in presently unoccupied areas of the Texas Gulf Coast, as is recommended in the Recovery Plan for the species. Reddish egrets, a species under consideration for listing, recently nested on Long Reef, Second Chain of Islands, and Third Chain of Islands and uses nearby marsh areas for foraging. Impacts associated with degradation of foraging habitat for reddish egrets appear to be less in Alternative III than in Alternative I. Other species nest on the forementioned islands as well as Turnstake Spoil. Erosion control should be addressed when considering alternative routes which pass near these islands. The following is a list of colonies impacted by the various alternatives. Colonies highlighted in bold are those that were known to be active during the 1990 census:

		Alternatives			
Colony Name	Colony No.	I	II	III	IV
Long Reef *	609-501	X		X	
Second Chain *	609-422			X	
Third Chain *	609-424	X		X	
Turnstake	609-320	X		X	
Big Bird Island	609-321	X		X	
Aransas Spoil	609-421	X			
Aransas Mainland	609-380		X		
San Antonio Spoil	609-322		X		
Cape Carlos Dugout	609-540			X	
Ballou Island	609-500			X	
Matagorda Spit	609-423			X	
Matagorda Island NAS	609-360				X
Cedar Bayou	609-520				X

* Historical nesting sites for the Brown Pelican.

Attwater's Prairie Chicken
The route suggested in Alternative II lies within essential habitat of Attwater's prairie chicken and therefore is a cause for concern. Construction of a canal within this area would inevitably lead to loss of habitat for this species. This route is the only route that could impact many of the terrestrial species of the area.

Category 2 Reptile Species
Two species of reptiles which are being considered for listing by the USFWS are found in the vicinity of the critical habitat of whooping cranes. These species are the Gulf saltmarsh snake (*Nerodia clarkii*) and the Texas diamondback terrapin (*Malaclemys terrapin littoralis*). With respect to impacts on the viability of populations of these two species, Alternative III would be preferable to Alternative I. Both species use brackish to salt water marshes and flats and Alternative I presently has the greatest negative impact on these habitats. Solutions to erosion and spill risk problems associated with Alternative I would also provide protection for these species. Alternative II passes through the upper portions of San Antonio and St. Charles Bays and would also have negative consequences for these species.

Kemp's Ridley Sea Turtle
It is difficult to determine the relative impacts of the various alternatives on this species. It seems likely, however, that routes traversing longer sections of open water (i.e. Alternatives I and III) have the potential for greater impacts. This is particularly true with respect to risk of toxic contamination. Measures taken to alleviate the threat of spills would be beneficial for this species, as well as other sea turtles and marine mammals.

Additional Concerns
Overall disturbance to ecosystems should be heavily weighted in any analysis of the effects on threatened or endangered species of an area. In this context, it appears that Alternatives II and IV have the greatest potential for damage to existing ecosystems. Both of these options would require digging new canals through terrestrial systems. If damage due to erosion can be controlled and reversed along the present route, continued use of this route would prevent further disturbance that would inevitably be associated with re-dredging the old waterway route (Alternative III). Hydrologic disturbances associated with each alternative should also be addressed.

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

Sincerely,

Lee F. Elliott

Lee F. Elliott
Conservation Scientist

cc:
Lee Ann Linam, TPWD

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Ecological Services
c/o CCSU, Campus Box 338
6300 Ocean Drive
Corpus Christi, Texas 78412

TAKE PRIDE IN AMERICA

April 15, 1994

James M. Kieslich,
Chief, Planning Division
U.S. Army Corps of Engineers
P. O. Box 1229
Galveston, TX 77553-1229
attn: Dr. Terry Roberts

Consultation No. 2-11-93-I-082A

Dear Mr. Kieslich:

This responds to your letter dated February 25, 1994, regarding your request for an update on the Federally listed threatened, endangered and candidate species for the counties included in the area of the Aransas National Wildlife Refuge. It is our understanding that the information will be used in the preparation of a biological assessment of the Gulf Intracoastal Waterway through the refuge.

The following list provides information on the Federally listed species from the area mentioned in your request. The list has been expanded to include candidate species as well. Candidate species have no legal protection under the Endangered Species Act; however, the Service has substantial information on Category 1 species to support their listing as threatened or endangered. The development and publication of proposed rules for these species is anticipated. Category 2 species are those for which available information indicates that proposing to list as endangered or threatened is possibly appropriate, but substantial data on biological vulnerability and threats are not currently known to support the immediate preparation of rules. Actions that might contribute to the listing of the candidate species should be avoided. Our data indicates that the following candidate species may occur in the area:

Aransas

American peregrine falcon (Falco peregrinus anatum) - E
Attwater's prairie chicken (Tympanuchus cupido attwateri) - E
bald eagle (Haliaeetus leucocephalus) - E
brown pelican (Pelecanus occidentalis) - E
hawksbill sea turtle (Eretmochelys imbricata) - E
jaguarundi (Felis yagouaroundi) - E
Kemp's ridley sea turtle (Lepidochelys kempi) - E
leatherback sea turtle (Dermochelys coriacea) - E
ocelot (Felis pardalis) - E

whooping crane (Grus americana) - E
Arctic peregrine falcon (Falco peregrinus tundrius) - T
green sea turtle (Chelonia mydas) - T
loggerhead sea turtle (Caretta caretta) - T
piping plover (Charadrius melodus) - T
Gulf Coast hog-nosed skunk (Conepatus leuconotus texensis) - C1
mountain plover (Charadrius montanus) - C1

Gulf salt marsh snake (Nerodia clarki) - C2
Aransas short-tailed shrew (Blarina hylophaga plumbea) - C2
Audubon's oriole (Icterus graduacauda audubonii) - C2
black-spotted newt (Notophthalmus meridionalis) - C2
ferruginous hawk (Buteo regalis) - C2
loggerhead shrike (Lanius ludovicianus) - C2
rough-seed sea purslane (Sesuvium trianthemoides) - C2
reddish egret (Egretta rufescens) - C2
Texas Botteri's sparrow (Aimophila botterii texana) - C2
Texas diamondback terrapin (Malaclemys terrapin littoralis) - C2
Texas horned lizard (Phrynosoma cornutum) - C2
Texas olive sparrow (Arremonops rufivirgatus rufivirgatus) - C2
western snowy plover (Charadrius alexandrinus nivosus) - C2
white-faced ibis (Plegadis chihi) - C2

Calhoun

American peregrine falcon (Falco peregrinus anatum) - E
bald eagle (Haliaeetus leucocephalus) - E
brown pelican (Pelecanus occidentalis) - E
hawksbill sea turtle (Eretmochelys imbricata) - E
Kemp's ridley sea turtle (Lepidochelys kempi) - E
leatherback sea turtle (Dermochelys coriacea) - E
whooping crane (Grus americana) - E
Arctic peregrine falcon (Falco peregrinus tundrius) - T
green sea turtle (Chelonia mydas) - T
loggerhead sea turtle (Caretta caretta) - T
piping plover (Charadrius melodus) - T
Gulf Coast hog-nosed skunk (Conepatus leuconotus texensis) - C1
ferruginous hawk (Buteo regalis) - C2
Gulf salt marsh snake (Nerodia clarki) - C2
loggerhead shrike (Lanius ludovicianus) - C2
reddish egret (Egretta rufescens) - C2
Texas diamondback terrapin (Malaclemys terrapin littoralis) - C2
Texas horned lizard (Phrynosoma cornutum) - C2
western snowy plover (Charadrius alexandrinus nivosus) - C2
white-faced ibis (Plegadis chihi) - C2

Refugio

Attwater's prairie chicken (Tympanuchus cupido attwateri) - E
bald eagle (Haliaeetus leucocephalus) - E
black lace cactus (Echinocereus reichenbachii var. albertii) -E
hawksbill sea turtle (Eretmochelys imbricata) - E
Kemp's ridley sea turtle (Lepidochelys kempi) - E
leatherback sea turtle (Dermochelys coriacea) - E
ocelot (Felis pardalis) - E
whooping crane (Grus americana) - E
green sea turtle (Chelonia mydas) - T
loggerhead sea turtle (Caretta caretta) - T
piping plover (Charadrius melodus) - T
Cagle's map turtle (Graptemys caglei) - C1
Gulf Coast hog-nosed skunk (Conepatus leuconotus texensis) - C1
mountain plover (Charadrius montanus) - C1
black-spotted newt (Notophthalmus meridionalis) - C2
ferruginous hawk (Buteo regalis) - C2
loggerhead shrike (Lanius ludovicianus) - C2
northern gray hawk (Buteo nitidus) - C2
reddish egret (Egretta rufescens) - C2
Rio Grande lesser siren (Siren intermedia texana) - C2
Texas diamondback terrapin (Malaclemys terrapin littoralis) - C2
Texas horned lizard (Phrynosoma cornutum) - C2

Texas olive sparrow (Arremonops rufivirgatus rufivirgatus) - C2
Texas windmill grass (Chloris texensis) - C2
Welder spine aster (Machaeranthera heterocarpa) - C2
syn.=(Psilactis heterocarpa)
western snowy plover (Charadrius alexandrinus nivosus) - C2
white-faced ibis (Plegadis chihi) - C2

Please note that since our letter to you, dated February 10, 1993, there has changes in the status of two candidate species. The mountain plover (Charadrius montanus) has been changed from a candidate category 2 to a category 1 species. The long-billed curlew (Numenius americanus) has been removed from an candidate ~~category 2~~ designation. The status of all other threatened, endangered and candidate species is unchanged, and there are no additional species for Aransas, Cameron and Refugio counties.

We appreciate the opportunity to assist you in fulfilling your responsibilities under Section 7 of the ESA. If you have any further questions, please contact Pat Bacak-Clements of our office at (512) 994-9005.

Sincerely,

Thomas E. Grahl

THOMAS E. GRAHL
Acting Field Supervisor

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Ecological Services
c/o TAMU-CC, Campus Box 338
6300 Ocean Drive
Corpus Christi, Texas 78412

October 13, 1995

James M. Kieslich
Chief, Planning Division
Attn: Terry Roberts
U.S. Army Corps of Engineers
P.O. Box 1229
Galveston, Texas 77553-1229

Dear Mr. Kieslich:

Enclosed are copies dated October 12, 1995 of a final biological opinion and a final Supplemental Fish and Wildlife Coordination Act Report based upon the activities proposed in the Galveston District's May 1995 Draft Gulf Intracoastal Waterway - Aransas National Wildlife Refuge (Section 216) Feasibility Study and the Draft Environmental Impact Statement, Gulf Intracoastal Waterway (Section 216 Study), Aransas National Wildlife Refuge. Also enclosed is a copy of a Draft Fish and Wildlife Coordination Act Report dated September 20, 1994 which compared the environmental impacts of alternative routes for this reach of the GIWW. Both coordination act reports were submitted for review to the District, the Fish and Wildlife Service's Regional Office, the National Marine Fisheries Service, and the Texas Parks and Wildlife Department. Few comments were generated by the September 20, 1994 report; accordingly, it is adopted verbatim as a Final FWCA Report. Verbal comments were received from the District and the Service's Regional Office; the District's are reflected in small but substantive changes in the text of the Supplemental FWCA Report, while the Regional Office only noted its approval of those documents. Brief comments were received from the NMFS in a letter dated August 4, 1995, while more lengthy comments were provided by TPWD in a draft letter dated October 4, 1995. Copies of these letters are enclosed. Changes were made to the Supplemental FWCA Report as appropriate. A copy of any final letter of comment from TPWD will be forwarded upon its receipt.

Comments were also solicited and received on the biological opinion from the District and the Regional Office. The final opinion reflects substantive inputs from both sources.

If there are any questions about any of these documents, please contact Johnny French at (512) 994-9005.

Sincerely,

Floyd A. Nudi

Floyd A. Nudi
Acting Field Supervisor

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Ecological Services
c/o TAMU-CC, Campus Box 338
6300 Ocean Drive
Corpus Christi, Texas 78412

October 12, 1995

Colonel Robert B. Gatlin
District Engineer
U.S. Army Corps of Engineers
P.O. Box 1229
Galveston, Texas 77553-1229

Consultation No. 2-11-89-F-77B

Dear Colonel Gatlin:

This responds to a request by Galveston District representatives Rick Medina, Sid Tanner, and Terry Roberts at a meeting in this office on April 28, 1995, that the Fish and Wildlife Service formally consult with the District pursuant to Section 7 of the Endangered Species Act of 1973, as amended, on the effects of activities under way and proposed by the District along the Gulf Intracoastal Waterway within the critical habitat of the endangered whooping crane. This consultation was initiated, or, more properly, reinitiated, upon receipt of draft documents, including a biological assessment, from the District on May 11, 1995.

CONSULTATION HISTORY

The District and the Service last consulted formally over the effects of the GIWW's presence within the critical habitat between May of 1989 and May of 1993. By that consultation's conclusion, actions had already been taken to combat temporarily erosion-related losses of the critical habitat, and studies were underway under the authority of Section 216 of the 1970 Flood Control Act to permanently control that erosion and also to control spills of fuels or cargoes from vessels transitting the critical habitat, mainly within the boundaries of the Aransas National Wildlife Refuge. The May 25, 1993 biological opinion reached these findings:

> It is my biological opinion that erosion indirectly associated with the presence of the Gulf Intracoastal Waterway within the critical habitat of the whooping crane has resulted in the destruction and adverse modification of that critical habitat, and that toxic spills on that reach of the GIWW likewise threaten its destruction and adverse modification. However, it is also my biological opinion that temporary and long-term features presently incorporated into the Corps' programs, especially those associated with the Section 216 study, will avoid significant destruction and adverse modification of the critical habitat from erosion and spills, and as a consequence avoid erosion- and spill-related jeopardy to the whooping crane's continued existence.

Since the date of that opinion, the District has continued to study and experiment with shoreline protection and spill control measures as anticipated, and has also analyzed alternative routes to see if the erosion and spill problems could be avoided in that fashion. At the same time, the District has also been seeking solutions to its long-term dredged material disposal needs in the

critical habitat reach. The control measures and routes and a proposed 50-year disposal plan have been discussed in the District's Draft Gulf Intracoastal Waterway - Aransas National Wildlife Refuge (Section 216) Feasibility Study, and Draft Environmental Impact Statement, Gulf Intracoastal Waterway (Section 216 Study), Aransas National Wildlife Refuge, released on June 2, 1995. The DEIS contains extensive discussions of the potential effects of the erosion control, spill control, and 50-year disposal plans upon Federally-listed threatened, and endangered, and candidate species, and is intended to serve as a biological assessment in the context of this formal consultation.

On June 30, 1995, the Service provided the District with a draft biological opinion which improperly constituted a "conditional jeopardy;" i.e., it determined that jeopardy would occur unless the District committed itself to carry out the construction and maintenance of the erosion and spill control structures. When Rick Medina confirmed this commitment by telephone on October 2, 1995, the biological opinion was corrected and finalized accordingly.

This biological opinion is based upon the information provided by the District in previous biological assessments, the Draft Feasibility Study, the DEIS, consultation with experts, and available literature and data in Service files, including the May 25, 1993 biological opinion.

BIOLOGICAL OPINION

It is my biological opinion that the construction and maintenance of the existing and proposed erosion and spill control structures will insure that the continued presence of the GIWW, a waterway which exists because the District is the sole entity authorized to maintain it, within the critical habitat of the whooping crane, does not indirectly cause the habitat's destruction or adverse modification, and thereby also eventually jeopardize the continued existence of the endangered species. It is also my opinion that the specific erosion and spill control structures and the general 50-year maintenance plan proposed are in their net effects likely to be beneficial to the critical habitat and to the whooping crane, although assurances regarding the last are likely to require further informal consultations as the maintenance plan is refined. I concur with the findings in the DEIS/biological assessment that all other listed or candidate species in the project area are not likely to be adversely affected to a measurable degree, and that most should benefit from the proposed actions.

BACKGROUND INFORMATION

The following information is excerpted from the District's May 1995 DEIS.

Project Description

Bank Erosion Protection Plan.

> - - - [E]rosion is still occurring along the GIWW and is reducing the amount of feeding habitat for the endangered whooping crane. In an effort to stop this loss, erosion control using a temporary barrier of concrete bags held in place with steel reinforcing rods was first initiated in 1989 through the cooperative efforts of the COE; USFWS; several navigation, oil supply, and oil companies; local whooping crane tour guides; and several hundred citizen volunteers. Approximately 6,900 feet of shoreline in Aransas NWR was protected by these volunteers between 1989 and 1992. In 1992, the USFWS experimented with a more permanent method of shore stabilization using 8-foot wide cellular concrete mattress to protect 400 feet of shoreline. This method was acceptable to the USFWS, so it was added to the list of methods for evaluation. - - - The concrete mattress plan was determined the "best" armoring method and would

meet the requirements of the agreement with the USFWS reached during a Section 7 consultation for maintaining the GIWW in designated critical habitat - - -.

The COE has placed about 16,000 feet of concrete mattress varying from 16 to 20 feet wide along the north bank of the GIWW in the Aransas NWR in the summers of 1992, 1993, and 1994. Approximately 2,000 feet or more of shoreline will be added each year thereafter, until the Section 216 study is completed and the project is authorized for construction. Authorization is currently expected in FY 1996, with construction to begin in FY 1998. At that time, the remainder of the shoreline identified by the USFWS as requiring protection will be armored for a total length of about 84,000 feet. Additional protection consisting of geotextile tubes filled with dredged material and/or grout will be used to protect the open stretch of Sundown Bay. The tubes will run in approximately 1,000-foot lengths with 100 foot openings between each section for a total length of about 13,500 feet. The final length of each section of tubes and number and width of openings will be determined during the PED phase after circulation studies in Sundown Bay are completed. The circulation studies will determine the number and size of openings needed to maintain adequate circulation in Sundown Bay. These tubes will simulate oyster reefs running parallel to the GIWW with the top protruding slightly above the water at low tide. Oysters are expected to colonize the surface of the tubes and form a series of reefs to protect the back marshes of Sundown Bay. Seagrass coverage and density also should increase in Sundown Bay as a result of the wave protection afforded by the tubes.

The concrete mats and the grout tubes will require periodic maintenance throughout the 50-year project life. Periodic inspection of all of the project components is necessary to make timely repairs, as required. The specific responsibilities of the various agencies in regards to operation and maintenance of the erosion control and the spill containment features are continuing to be developed. The responsibilities related to the maintenance of the erosion control components would consist of mat repairs and grout tube replacement/repairs, as necessary. These activities would result from normal deterioration, vandals, boat or barge damage and storms. The Refuge staff frequently monitors the entire reach of waterway through the critical habitat and would, therefore, be aware of the needs for maintenance and best be able to determine what could and should be done in the best interests of the endangered species and its habitat that they are entrusted to protect. This rationale has led to a request by the COE for the USFWS to assume this responsibility. There are other factors that will also weigh heavily on the final decision which will be resolved as coordination continues. [Note: Rick Medina confirmed via telephone on October 2, 1995 that the COE had determined to assume this maintenance responsibility.] Regardless of which agency assumes this responsibility, maintenance of the erosion control features will be accomplished entirely at Federal expense. These costs are estimated to average $15,000 per year.

- - -

Spill Contingencies and Analysis - - -

The concrete mattress and grout tube erosion protection in the critical habitat will help prevent contaminants from reaching the marsh, except on very high tides or under storm conditions. The COE will also place timber pilings on each side of all openings to the marsh or cuts leading to the surrounding bays for attaching booms to

contain oil or other floating contaminants. For large areas requiring protection that are wider than the normal 100-foot length of spill containment booms, such as Dunham Bay and most of Welder Flats, pilings will be placed parallel to and near the GIWW at about 300 foot intervals. The booms will be stored at the Refuge in a location to be designated later by the Refuge Manager.

The COE is coordinating with the USFWS, refuge personnel, TGLO, and U.S. coast Guard on the roles and responsibilities of each agency for spill response, deployment, clean-up, equipment storage, normal maintenance, and replacement of the spill equipment. The question of who should be responsible for the estimated $34,000 annual costs for the operation, maintenance, repair, and replacement of the spill control components is more complex than for erosion control features. The Texas General Land Office and the U.S. Coast Guard have responsibilities for spill response, as well as the USFWS as it relates to protection of the habitat of the Refuge. All agencies have agreed that responsibility for spill response, deployment, clean-up, and storage of the spill equipment resides with the USFWS, TGLO, and Coast Guard. However, the issue of responsibility for normal maintenance and replacing equipment (booms, storage trailers, and attachment pilings) that is no longer operable has not been resolved. [Note: Rick Medina confirmed via telephone on October 2, 1995, that the COE was assuming this maintenance responsibility.] Coordination between the various agencies concerning a specific delineation of roles and responsibilities is continuing. The decisions will be documented in the Final Feasibility Report for consideration for Congressional authorization.

- - -

50-Year Disposal Plan

Net losses of whooping crane critical habitat since the original GIWW was completed through Welder Flats and Blackjack Peninsula in 1940 (and including a short stretch of the Channel to Victoria) have amounted to about 2,078 acres. This includes direct losses from construction of the channel and disposal of dredged material indirect losses from wind and vessel waves, sea-level rise and land subsidence, and any gains in crane habitat in the area during the period 1940 to 1986 (the period of analysis for the above reference). Recent annual losses have been calculated at 2.5-4 acres per year, mostly on the northern (mainland) side of the channel.

The 50-year disposal plan will offset most of these habitat losses by beneficially using most of the dredged maintenance material to create approximately 1,614 acres of marsh at several selected sites within the critical habitat. The rest of the dredged material will be placed in existing upland disposal areas and one new upland disposal area (upland site 1) located just outside the critical habitat east of Welder Flats. The new disposal area will replace DA 120 and 120A.

Maintenance dredging through the land-locked areas of the critical habitat generally occurs on a 4- to 7-year cycle, depending on the reach of channel. Under the new disposal plan, the smaller beneficial use marsh sites (less than 50 acres) will be filled in one cycle, generally during the first to third dredging cycles for the closest section of channel. The larger beneficial use sites will be subdivided into cells sized to contain most, if not all, of the material to be dredged during its designated cycle in the closest section of channel. The exact size of the cell will be determined prior to dredging after surveys are conducted to

determine the amount of material to be removed from the channel and the bottom topography and depth of the beneficial use sites to be filled. Confining levees for the cells (probably geotextile tubes) will be constructed at the time of filling. The beneficial use sites will be used during alternating dredging cycles to give the newly created marsh a chance to establish before depositing new material in adjacent cells and then creating connecting channels between cells and the surrounding bay. The connecting channels will allow circulation within and between the cells and bays to enhance their use by estuarine organisms and increase their value as crane feeding habitat.

On an alternating basis, the next dredging cycle will use upland leveed disposal areas and then the beneficial use sites. To prevent levee failures, the leveed upland sites will have a minimum of two feet of freeboard (one more foot than previously used) above ponded water level with more frequent inspections to prevent ponded water from overtopping the levees. By alternating between beneficial use sites and upland leveed sites between cycles, an extra drying time of at least four (4) years is established in the disposal schedule which will allow the material to compact more and extend the life of the upland disposal site. The extra capacity may be needed if some unforeseen event should occur, such as a severe storm creating extra shoaling problems or some shoaled material may become contaminated during a particular dredging cycle which must be contained in a leveed site. At the end of the 50-year disposal period, the levees for the upland disposal sites (except upland site 1 east of Welder Flats) are expected to reach final heights of 18-36 feet. These heights are based on past dredging history and may change depending on actual dredging volumes encountered in the future.

Upland site 1 which replaces DA 120 and 120A is located about 500 feet northeast of the road going to Fulghum's Fish Camp (outside the Critical Habitat) and 3,000 feet northwest of the centerline of the GIWW. The proposed site is at least 1,500 feet northeast of the closest whooping crane territory and whooping cranes have not been observed feeding in the proposed area. The site covers an area of 100 acres (3,630 x 1,200 feet) plus another 53 acres of right-of-way for access to perimeter levees and pipeline influent and effluent routes. A final levee height for this disposal site after 50 years use is expected to be about 12 feet. The site was chosen to be as near the GIWW as possible to minimize pumping distance and environmental impacts using aerial photographs as a guide. The site avoids the salt flats next to the GIWW (except for the pipeline corridors), all ponds that show up on the photograph, and will remove only a few small live oak thickets in the area. The major benefit of the new disposal site is the elimination of the long, narrow DA 120 which has a history of levee failure. The disposal site is too narrow for efficient levee maintenance and dredging needs and, as a consequence, material has spilled into Shoalwater Bay covering valuable emergent marsh and seagrass beds used by whooping cranes. DA 121 is expected to reach its capacity by the time the 50-year disposal plan is implemented and will not be part of the new disposal plan.

Whooping cranes are very cautious about approaching high obstructions because of the potential for predators hiding nearby. Therefore, in order to enhance the marshes and aquatic habitat near DA 120 and 121 for whooping crane use and to prevent erosion of levees and their contents which could adversely affect these habitats, the sites will be modified by pushing the levees into the interior of the disposal sites. Upland vegetation will quickly

invade the sites to help prevent erosion and provide a diversity of habitat for wildlife in the area.

- - -

About 77% of the previously lost whooping crane feeding habitat will be replaced with newly created marsh in the beneficial use sites and an inefficient upland disposal site (DA 120) will be replaced, preventing the possibility of future levee failure and burial of valuable crane feeding habitat in Shoalwater Bay. Also, the remaining upland leveed disposal sites will have at least 2 feet of levee freeboard above water ponding levels and more frequent levee inspections to prevent overtopping and levee failure to protect surrounding crane feeding habitat. Maintenance material destined for DA 121, which will soon reach its capacity, will be placed in beneficial use Site A and open-bay DA 122. Although the new upland disposal site will remove some potential upland feeding area that could be used by whooping cranes (small live oak thickets), its major benefit is the elimination of any future levee failures on DA 120 which could destroy much more valuable marsh and seagrass feeding habitat. Several studies and site redesigns will alleviate concerns of State and Federal resource agencies about the disposal and beneficial uses plan and an ICT will be formed to follow the progress of the beneficial use sites and make recommendations to correct any deficiencies that may occur. The NMFS will monitor the sites to determine their success in becoming functionally equivalent to natural marshes and make recommendations to correct any problems that may be found.
[Citations and references deleted]

WHOOPING CRANE

Habitat Requirements, Distribution and Population, Reasons for Decline, and Vulnerability to Extinction - The discussions of these subjects are incorporated by reference to pages 20 through 27 of the May 25, 1993 biological opinion.

Project Impacts

The proposed bank erosion protection plan is expected to reduce GIWW-related erosion to a negligible level. In fact, according to the Draft Feasibility Study, the plan would prevent the loss of approximately 1139 acres of critical habitat during the period of 1996 through 2051. Since the construction proposed would take place while the whooping cranes are absent, the erosion control structures' installation would not disturb these birds. Observations of whooping cranes feeding in areas already armored against erosion have shown them to be indifferent to the presence of the shoreline protection, and some birds still feed in ponds which would have been destroyed by now if that protection had not been afforded. Installation of the remaining concrete mattress structures would call for the removal or displacement of 9 to 10 acres of salt marsh and/or submerged aquatic vegetation, but some of this loss would be offset as marsh plants grow in between the mattress blocks, and the same acreage would have been lost in as little as 2-3 years had it not been installed. Minor adjustments in the location and type of erosion control structure will be made where feasible to reduce or even offset these losses with additional vegetation.

The DEIS paints a very different picture of the situation if the erosion control plan is not carried out:

Although approximately 16,000 feet of the most critically eroded shoreline will be protected by late 1994, if no action is taken at

> the end of the feasibility study to protect the critical habitat from further erosion, maintenance operations will cease and erosion from continued navigation use and natural causes up to about 2003 will occur at about 2 acres per year. After 2003 and up to the end of the study period of analysis (2051), it is estimated that natural erosion (navigation-induced erosion will have ceased) will occur at about (or somewhat less than) one acre per year. The direct loss of marsh due to erosion is estimated at about 64 acres for the period 1996-2051. However, there is an indirect loss of habitat when erosion exposes marsh ponds and lakes. This allows waves and currents to enter and scour the soft bottom and deepen the pond until it is not useable by feeding cranes. This loss is estimated to be about 1,075 acres over the period of analysis, most of which will occur in McMullen Lake and Sundown Bay. This loss may not jeopardize the survival of the whooping crane as a species, but it will limit the ability of the population which has already established territories along the GIWW to survive, particularly during periods of low food availability. During these times of stress, the cranes need larger areas to forage in order to survive. [Reference deleted.]

The Service points out if enough critical habitat is lost, it <u>may</u> jeopardize the species. A similar, though less immediate, picture can be predicted if the erosion control structures are completed as planned, but not maintained. Little by little, erosion would begin again to destroy the marshes and ponds of the critical habitat, and through that loss, eventually threaten the continued existence of the whooping cranes.

As regards the plans to control oil spills in the critical habitat, there are actually three mechanisms proposed. The first of these is the GIWW's alignment. The Draft Feasibility Report concludes that of the alternative routes assessed through the habitat, the current alignment had navigational safety advantages, as well as a nearly land-locked configuration, which would tend to minimize the frequency of spills and aid in their confinement. The second mechanism is intrinsic to the proposed shoreline erosion control structures, which would almost double as booms, limiting the spread of spills. The third mechanism is the actual installation of anchor piling at gaps in the erosion controls and the provision for booms to be stored at the Aransas National Wildlife Refuge to facilitate their rapid deployment. Installation of the timber piling would take place when the whooping cranes were not present, and would not present a significant deterrent to their use of the critical habitat when present. Failure to provide and maintain the anchors and booms as proposed would significantly delay spill control efforts, allowing spilled material to penetrate deeply into marshes, ponds, and tidal flats where cleanup would be difficult, if not impossible to accomplish, without lasting adverse impact to the critical habitat.

The impacts of the proposed 50-year disposal plan are designed to be beneficial, making it difficult to find potential adverse effects. One of the latter might be the construction of a new upland disposal site which would remove some small live oak thickets that might have provided foraging areas for the whooping crane. However, this disposal site has not historically been used by the cranes, and it would lie outside the critical habitat. Use of this site would also allow abandonment of an existing disposal site with inadequate capacity and a history of levee failure. This and another site soon to reach full capacity would be altered by pushing their old bayshore levees down into the center of the sites, making the adjacent shorelines less intimidating to feeding cranes. Future levee failures would be avoided by increasing freeboards and inspecting the levees failures more frequently, thus protecting the critical habitat, and the District would coordinate with the Service and other resource agencies in the formation of an Interagency Coordination Team (ICT) to address similar levee problems should they recur. The ICT would also evaluate the methods used for constructing, planting and monitoring the 1600 acres of marsh that would be

produced by the 50-year plan. The National Marine Fisheries Service will play a vital role in monitoring the success of the marshes, and has already established a baseline for comparing the productivity of unvegetated bay bottoms which would be the sites of the proposed beneficial uses disposal areas. Finally, some of the dredged material is to be placed to add to the beneficial effects of the erosion control structures.

The locations of the disposal areas are as yet not precisely settled, and years of planning and last-minute changes will make it impossible to predict how large each will be and which designs will be incorporated. One issue yet to be addressed is how to meet the suspended sediment standard for the effluents from the relatively small beneficial uses disposal area cell sites. Another is whether discharging these effluents into the bays, rather than back into the GIWW, would have a significant effect on the water quality of each bay. These are issues potentially affecting the critical habitat which cannot be addressed easily at this time, but it is expected that the ICT will consider them and offer solutions. It is anticipated that as the solutions are proposed, they will be subject to further consultation, at least informally.

Conclusions

The proposed actions are generally beneficial to the critical habitat and the whooping crane. As far as the Service is concerned, the District would uphold the intent of Section 7 of the ESA by constructing and maintaining the proposed or similar shoreline erosion and spill control structures.

Avoidance of future levee failures, tailoring the exact size and locations of the beneficial uses sites, and the quality of the sites' return flows are all issues still under review by the agencies. Further consultation must address these issues when their solutions are proposed.

OTHER SPECIES

The DEIS assessed, in addition to the whooping crane, 42 other species on the Federal endangered, threatened, or candidate lists and found that they would either be benefited by the creation of marsh, have their habitat protected, and/or be unaffected by the proposed actions. The Service concurs with this biological assessment; hence, further consultation is not necessary for these other species unless the plans or information assessed change.

Incidental Take

Section 9 of the Act, as amended, prohibits any taking (harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or attempt to engage in any such conduct) of listed species without special exemption. Under the terms of Section 7 (b)(4) and Section 7 (O)(2), taking that is incidental to and not intended as part of the agency action is not considered taking within the bounds of the Act, provided that such taking is in compliance with the incidental take statement. Furthermore, "Harm", in the definition of "take" in the Act means an act which actually kills or injures wildlife. Such an act may include significant habitat modification or degradation where it actually kills or injures wildlife by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering.

The unavoidable loss of 9 to 10 acres of marsh within the critical habitat during installation of the erosion control structures is considered too small to have a detectable effect on the whooping crane or its recovery. Most other activities within the critical habitat, provided they take place in the manner planned, should either avoid impacting areas currently used by the whooping cranes, or

create more useable habitat for them. Therefore, no incidental take of individual whooping cranes is anticipated.

Conservation Recommendations

Section 7 (a)(1) of the Endangered Species Act directs Federal agencies to utilize their authorities to further the purposes of the Act by carrying out conservation programs for the benefit of endangered and threatened species. The term "conservation recommendations" has been defined as suggestions of the Service regarding discretionary measures to minimize or avoid adverse effects of a proposed action on listed species or critical habitat or regarding the development of information.

The Service made two conservation recommendations in its May 25, 1993 biological opinion. The first of these, to seek to apply the beneficial uses of dredged material techniques to erosion control and the restoration of marsh in the Aransas reach, has been followed and would be implemented as a part of the present maintenance program. The second, regarding reduction of navigation hazards and additional spill control features, has not received as much response, and should remain on the record as worthy of further consideration.

In order for the Service to be kept informed of actions that either minimize or avoid adverse effects or benefit listed species or their habitat, the Service is requesting notification of the implementation of any conservation recommendations.

Conclusion

This concludes formal consultation on the indirect effects of erosion and spills associated with the existence of the GIWW, the effects of plans to control these impacts, and on the effects of a 50-year maintenance plan. As required by 50 CFR 402.16, reinitiation of formal consultation is required if: (1) new information reveals effects of the agency action that may impact listed species or critical habitat in a manner or to an extent not considered in this biological opinion; (2) the agency action is subsequently modified in a manner that causes an effect to the listed species or critical habitat that was not considered in this biological opinion; (3) a new species is listed or critical habitat designated that may be affected by the action; or (4) the anticipated incidental take amount or extent is exceeded.

The Service appreciates the cooperation the Corps provided in this consultation. If you have any question about this biological opinion, please contact me at (512) 994-9005.

Sincerely,

Floyd A. Nudi

Floyd A. Nudi
Acting Field Supervisor

cc:
Director, U.S. Fish & Wildlife Service, Washington, D.C.
Regional Director, U.S. Fish & Wildlife Service, Albuquerque, NM
Division Engineer, Southwest Division, 1114 Commerce, Dallas, TX
Executive Directory, Texas Parks & Wildlife Department, Austin, TX
Refuge Manager, Aransas National Wildlife Refuge, Austwell, TX
Regional Director, National Marine Fisheries Service, St. Petersburg, FL

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Southeast Regional Office
9721 Executive Center Drive N.
St. Petersburg, FL 33702

OCT 20 1995 F/SEO13:JEB

James M. Kieslich
Chief, Planning Division
Galveston District
U.S. Army Corps of Engineers
P. O. Box 1229
Galveston, TX 77553-1229

Dear Mr. Kieslich:

This responds to your request for consultation on measures to protect whooping crane critical habitat in the Aransas National Wildlife Refuge, Texas. The project involves: 1) erosion control along 84,000 feet of shoreline adjacent to the Gulf Intracoastal Waterway using concrete mattress; 2) placing 10 sections of geotextile tubes filled with dredged material and/or grout to protect the open stretch of Sundown Bay; 3) placement of pilings for attaching spill containment booms; and 4) a 50-year disposal plan which will create additional wetland areas. A biological assessment (BA), in the form of the Environmental Impact Statement, was submitted pursuant to Section 7 of the Endangered Species Act of 1993 (ESA).

We have reviewed the BA and concur with your determination that populations of threatened or endangered species under our purview would not be adversely affected by the proposed action. Because of the creation of seagrass habitat, Kemp's ridley, green, and loggerhead turtles are likely to benefit from this project.

This concludes consultation responsibilities under Section 7 of the ESA. However, consultation should be reinitiated if new information reveals impacts of the identified activity that may affect listed species or their critical habitat, a new species is listed, the identified activity is subsequently modified, or critical habitat is determined that may be affected by the proposed activity. Please be reminded that this project should also be coordinated with our Habitat Conservation Division. You may contact Donald Moore at the Galveston Field Branch, 4700 Avenue U, Galveston, TX 77551-5997 or call (409) 766-3699.

If you have any questions please contact Jeffrey Brown, Fishery Biologist, at (813) 570-5312.

Sincerely,

Andrew J. Kemmerer
Regional Director

cc: F/PR8
F/SEO2

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APPENDIX B - SECTION 3

SECTION 404 (b) (1) EVALUATION

GULF INTRACOASTAL WATERWAY
ARANSAS NATIONAL WILDLIFE REFUGE
(SECTION 216 STUDY)

SECTION 404 (b) (1) EVALUATION

I. Project Description

a. Location. The Aransas National Wildlife Refuge (NWR) reach of the GIWW is located in Aransas and Calhoun Counties between Aransas and Matagorda Bays about 40 miles northeast of Corpus Christi. The Aransas NWR study area encompasses a 42-mile section of the GIWW between channel mile 478.5 and 521.1 measured from the Harvey Locks, Louisiana.

b. General Description.

(1) Bank Protection Plan - Structures for a bank protection and spill containment plan will be located between Aransas and Shoalwater Bays along the GIWW. The bank protection plan consists of a geotextile filter fabric placed on the smoothed banks of the existing marsh with 17 to 19-foot lengths of articulated concrete mattress on top. Slopes will be 1 vertical (V) on 3 horizontal (H) with the bottom of the mattress at an elevation of about 2.0 feet below Mean Low Tide (MLT). The top at the existing marsh is at an elevation of about 2.5 feet above MLT. The concrete mattress will be anchored at the top and exposed sides at the ends of protection by cable and flexible anchors. The top and toe of the mattress will be buried with the excavated material. A barrier consisting of up to 1000-foot sections of grout tubes with 100-foot openings between sections will be used to protect Sundown Bay from wave scour. The grout tube sections will be placed along the edge of the GIWW and will be barely emergent at Mean Low Tide (MLT) to mimic oyster reefs.

(2) Spill Containment Plan - The spill containment plan consists of piles placed on each side of marsh/pond openings and passes leading to the bays. For wider areas, such as Dunham Bay and Welder Flats, the piles for attaching the booms will be placed 300 feet apart paralleling, but away from the edge of the GIWW. Spill containment booms will be stored at the Aransas NWR headquarters for safety and ease of maintenance until needed.

(3) Beneficial Use Sites - A 50-year disposal plan is not part of the recommended plan to protect critical habitat for the endangered whooping crane. However, long-term plans for disposal of dredged maintenance material is considered a necessary part of the overall solution to the loss of critical habitat. The 50-year disposal plan will be constructed under O&M authority and consists of, among other things, beneficial uses of dredged material

that will create additional marsh habitat for the whooping cranes to feed in. The 11 beneficial use sites vary in size from approximately 10 to 407 acres and, except for the smaller sites (generally less than 40 acres), will be composed of smaller cells that will be filled with dredged maintenance material over a period of about 50 years. The cell levees consist of geotextile tubes, except along the inside margin nearest the shoreline which will be an earthfill levee. The outside beneficial use site perimeter in the bays will consist of geotubes filled with sand or similar material and breakwater riprap at the most erosive sites to protect the sites from wave erosion. The smaller beneficial use sites will be used to fill in some deeper areas of scoured lakes to restore their usefulness as crane-feeding habitat and to narrow the openings in some marsh ponds that have been eroding wider. Disposal Areas 127, 129, 130A, 130B, and 131 still have capacity and will be used on alternating dredging cycles with the beneficial use sites. Disposal Areas 120A, 120, and 121 will not be used since they will have reached their capacity by the time the 50-year disposal plan is implemented. A new disposal site will be created inland from Fulghum's Fish Camp northeast of the critical habitat. It is about 3,000 feet inland from the centerline of the GIWW.

c. Authority and Purpose. This study is being conducted under authority of Section 216 of the 1970 River and Harbor and Flood Control Act (Public Law 91-611).

d. General Description of Dredged or Fill Material.

(1) General Characteristics of Material.

(a) Bank Protection Plan - Fill material will consist of new-work material (generally stiff clay) that will be removed and stored nearby during bank shaping for the concrete mattress. After the mattress is laid on the prepared bank, the top and toe of the mattress will be buried by placing the previously removed fill material on the ends at the top and toe. The grout tubes consist of 9-foot long geotextile tubes filled with a grout mixture consisting of 15% concrete aggregate and 85% sand.

(b) Spill Containment Plan - Piles approximately 30-feet long will be driven into the mud at preselected locations to serve as attachment points for oil spill booms. The top of the pile will be between 1.5 and 3.0 feet above MLT.

(c) Beneficial Use Sites - These sites have a combination of earthen, geotextile tube, and breakwater levees. The inside levee nearest the shoreline (about 300 feet away from and paralleling the shore) will consist of sand-clay material removed from the interior of the beneficial use site with a back-hoe or similar device. The levee will have a 10-foot crown, 1V:3H side slopes, and will be designed to provide a minimum of 1-foot of freeboard. The 500-foot long geotextile tubes will be filled with coarse-grained material (sand). The breakwater around parts of some of the beneficial use sites will consist of riprap (5-80 lb. stones) with a 6-foot crown, 1.5V:1H side slopes, with a top elevation of

about 3.6 feet above MLT. The upland disposal sites have earthen levees with a 10-foot crown and 1V:3H side slopes. Material for the levees will be taken from the interior of the sites. Dredged maintenance material from the GIWW will be placed into the upland disposal sites and beneficial use sites.

(2) Quantity of Material - Required materials include:

(a) Bank Protection Plan - 1,239,700 square feet (sf) of cellular concrete mattress and 153,600 square yards (sy) of filter fabric are required. Grout tube revetments require 29,140 sy of filter fabric, 20,175 cubic yards (cy) of grout, and 8,965 geotextile tubes.

(b) Piles - 772 piles will be used.

(c) Beneficial Use Sites - These sites will be constructed over a 50-year period and the larger sites will be subdivided into cells sized to be filled during one dredging cycle. Quantities of materials and fill used in these sites will consist of 29,118 feet of cast levees requiring 233,000 cy of fill; 787,000 sy of filter fabric under the geotextile tubes and breakwater with about 122,000 cy of fill to bury the edges of the cloth; approximately 154,000 feet of 500-foot long geotextile tubes of various sizes and configurations (1-3 tubes in a cross-section) for a total of 570 tubes requiring about 858,000 cy of fill; 1,100 feet of 9-foot long grout tubes for a total of 122 tubes; and 30,800 feet of breakwater requiring about 39,000 tons of 5-80 lb. rock. Approximately 20,873,000 cy of dredged maintenance material will be used to fill these sites over the 50-year period. The levees on the upland disposal sites will be raised as needed and will require varying amounts of earth fill.

(3) Source of Material - Fill material for the geotextile tubes and the earthen levees will come from suitable sources inside the beneficial use sites or a nearby area if suitable materials cannot be found inside the sites. Aggregate for the grout will come from commercial sources near Columbus, Texas. Geotextile tubes and filter fabric are available from commercial sources in Houston, Texas. Rock for the breakwater will come from quarries in central Texas.

e. Description of the Proposed Discharge - Construction Sites.

(1) Location - Figure 1 shows the proposed sites for bank protection, spill containment, and beneficial use sites.

(2) Size - The bank armoring will consist of laying about 62,000 feet of 17 to 19-foot wide concrete mattress which will cover about 35 acres of marsh bank. The beneficial use sites will cover a total of about 1,614 acres of shallow, nonvegetated bay bottom. The upland disposal sites, including the new site, cover about 600 acres.

(3) Type of Site and Habitat - Habitat affected by the bank protection plan includes marsh edge, mud/shell bank, and shallow nonvegetated water adjacent to the GIWW. The spill containment booms will be driven into the mud next to inlets, sloughs, and in shallow, nonvegetated water next to the GIWW. The beneficial use sites will be located in shallow, nonvegetated bay bottom or inlets to ponds/lakes. These sites will be confined with low levees. The presently-designated upland sites are built on old unconfined disposal mounds built up over the years, and the new site is on coastal prairie.

(4) Timing and Duration of Discharge - Construction of the bank protection and spill containment plans will occur during the summers of 1998-2000. The beneficial use sites and the new upland disposal site will be constructed during the maintenance dredging cycles over a 50-year period. Dredging is limited to the 6-month period when whooping cranes are absent from the Aransas NWR.

f. Description of Disposal Method.

The bank protection plan will use barges to haul equipment and material to the sites. Back-hoes or similar devices will shape the bank and the concrete mattress will be placed on the bank with a crane. A pile-driver will be used to drive the piles into position. Construction equipment and materials will be barged to the beneficial use sites where back-hoes, draglines, bulldozers, pumps, and hydraulic dredges will be used to build the breakwaters, levees, and fill the grout and geotextile tubes. Maintenance material will be pumped to the cells in the sites by hydraulic pipeline dredge during a dredging cycle and marsh vegetation planted after the sediments have compacted. Levees at the upland sites will be raised or built using draglines and bulldozers. Maintenance material will be pumped inside with a hydraulic pipeline dredge.

II. Factual Determinations

a. Physical Substrate Determinations.

(1) Substrate Elevation and Slope - The concrete mattress for the bank protection plan will be placed at heights between about 2.0 feet below MLT and 3.5 feet above MLT and will have a slope of about 1V:3H. The grout tubes across Sundown Bay are designed to be barely emergent at MLT. The 30-foot piles in the spill containment plan will be driven into the mud until the top is at a height of about 1.5 to 3 feet above MLT. Some beneficial use sites will have earthen levees with 10-foot crowns, 1V:3H side slopes, and have a height of about 7 feet above MLT. The geotextile tubes are designed to provide about 1 foot of freeboard, except for the outer perimeter tubes which will have a height of at least 3.6 feet above MLT. The stone breakwater will have a height of 3.6 feet above MLT. The earth levees for the upland disposal sites will have a 10-foot crown and 1V:3H side slopes. The final estimated levee heights at the end of the 50-year disposal period range from 17 to 36 feet.

(2) Sediment Type - The concrete mattress in the bank protection plan will be placed on a layer of filter fabric which is on top of the shaped bank. The stiff mud removed during bank shaping will be placed over the top and toe ends of the mattress and filter fabric to help anchor them. Grout tubes across Sundown Bay will be placed on a layer of filter fabric which is on top of the soft bay sediments. Piles for the spill containment plan will be driven into the native mud substrate in preselected locations. Earthen levees in the beneficial use sites will be constructed with stiff clay from inside the sites. The geotextile tubes will be filled with coarse sediments from within the sites or from a nearby area if none can be found inside the site. Stone for the breakwater range in size from 5 to 80 lbs.

(3) Dredged/Fill Material Movement - Material excavated during bank shaping for the bank protection plan will be stored nearby and returned to the site to bury the top and toe ends of the mattress and filter fabric. Grout tubes will be placed directly on top of the filter fabric and sediments along Sundown Bay. Some of the softer muds will be gradually moved aside as the heavy grout tubes settle. The earthen levees at the beneficial use sites are expected to erode slightly until vegetation covers and protects them. They are not expected to experience wave erosion since they are located on the back (protected) side of the sites near land. The geotextile tubes and rock breakwater are not expected to move laterally once in place. Some softer mud under these barriers may be displaced as the tubes and rock settle. Most of the dredged maintenance material pumped into the cells will be held in place by the levees. Design modifications will be evaluated before construction to minimize sediment escape in the effluent. The upland disposal sites have a firm base and the levees and contained sediments are not expected to move.

(4) Physical Effects on Benthos - Those nonmobile organisms occurring in the sediments at the bank protection and beneficial use sites will be buried or removed during construction (bank shaping and mattress placement) and disposal operations. The concrete mattress is designed with voids to allow some recolonization after construction. The beneficial use sites are designed to create new marsh with interconnecting channels and ponds which will create more diverse habitat for recolonization than existed before the sites were constructed. There are no effects expected on benthos due to disposal in the upland sites.

(5) Other Effects - None known.

(6) Actions Taken to Minimize Impacts - Each of the plans were fully coordinated with State and Federal resource agencies. Their recommendations were fully considered during redesign of the plans to minimize adverse impacts. An Interagency Coordination Team made up of members from appropriate State and Federal resource agencies will oversee design, construction, and monitoring efforts for the beneficial use sites to ensure functional marshes are created.

b. Water Circulation, Fluctuation, and Salinity Determinations.

(1) Water - The bank protection plan, beneficial use sites, and upland disposal areas are expected to have only short-term impacts on water quality in the area.

(a) Salinity - Salinity will not be altered.

(b) Water Chemistry - No impacts are expected.

(c) Clarity - There will be some temporary increase in local turbidity during construction and disposal operations. Water clarity is expected to return to normal background levels shortly after operations are completed.

(d) Color - Water immediately surrounding the construction sites will become discolored temporarily due to disturbance of the sediment.

(e) Odor - There may be a short period when foul odors are emitted by the dredged material contained in the beneficial use sites and upland disposal areas. This is caused by decomposition of organic materials exposed in the freshly-deposited sediments. There is no human habitation close to this area that may be affected by the odors.

(f) Taste - No detectable impacts. This is a marine environment.

(g) Dissolved Gas Levels - Dissolved oxygen may be lowered temporarily inside the beneficial use sites as freshly exposed organic material decomposes.

(h) Nutrients - Nutrient levels may be temporarily elevated near the beneficial use sites as sediments release their organic compounds.

(i) Eutrophication - Nutrients are not expected to reach levels high enough for periods long enough to lead to eutrophication of the surrounding waters.

(j) Others as Appropriate - None known.

(2) Current Patterns and Circulation - The District will evaluate the impacts of two large disposal sites (A and B) on circulation in the lower part of San Antonio Bay at the request of the resource agencies. Circulation affects in Sundown Bay caused by the grout tube protection plan will also be evaluated. The other beneficial use sites, upland disposal sites, and bank protection plan are not expected to adversely affect currents or circulation patterns.

(a) Current Patterns and Flow - The effects of two beneficial use sites and the grout tubes at Sundown Bay will be evaluated and redesigned, if necessary.

(b) Velocity - No adverse impacts expected.

(c) Stratification - None expected. This is a shallow-water environment.

(d) Hydrologic Regime - No adverse impacts expected. The 300-foot band of water between most of the beneficial use sites and the shoreline will be protected from wave action, allowing seagrass to invade the area.

(3) Normal Water Level Fluctuations - No adverse impacts expected.

(4) Salinity Gradients - No changes expected.

(5) Actions That Will Be Taken to Minimize Impacts - The effects of two beneficial use sites and the grout tube protection for Sundown Bay will be evaluated. The plans will be redesigned, if necessary, to minimize any adverse impacts.

e. Suspended Particulate/Turbidity Determination.

(1) Expected Changes in Suspended Particulates and Turbidity Levels in Vicinity of Disposal Site - An increase in suspended particulates and turbidity levels is expected during construction and disposal operations. These are temporary and localized events. Construction of the beneficial use sites will be re-evaluated and coordinated with the resource agencies to further minimize any escape of suspended particulates.

(2) Effects on Chemical and Physical Properties of the Water Column.

(a) Light Penetration - Turbidity levels will be temporarily increased near the construction and disposal sites. However, water clarity will benefit in the areas behind the beneficial use sites where luxuriant seagrass beds are expected to grow due to the calm conditions. This has already been demonstrated in the area where Mitchell Energy constructed two similar beneficial use sites as mitigation for their operations.

(b) Dissolved Oxygen - Dissolved oxygen is not expected to be adversely impacted, except temporarily inside the beneficial use sites during disposal operations.

(c) Toxic Metals and Organics - None have been identified at any of the construction sites or in the GIWW during dredging operations, except for some aberrant high oil and grease values in 1984-1985. These high values have not been found since that time.

(d) Pathogens - None expected or found.

(e) Aesthetics - The bank protection and beneficial use sites have been designed and coordinated with the resource agencies to minimize environmental impacts and adverse aesthetic qualities. All facilities are designed to have the lowest profile possible while protecting the critical habitat and newly created marsh from erosion.

(f) Others as Appropriate - None known.

(3) Effects on Biota - About 9-10 acres of marsh will be removed during construction of the bank protection plan. However, this marsh would have been lost to erosion without the bank protection plan. About 1,614 acres of new marsh will be created with the beneficial use sites which will benefit approximately 95% of the estuarine species. These species depend on salt marshes at sometime in their life cycle for protection, food, and as a nursery site. Only the new upland disposal site will have a new impact since the others already exist and will not be enlarged. About 100 acres of coastal prairie will be covered by the new site and another 53 acres of prairie and nonvegetated salt flats will be used as right-of-way and for pipeline corridors. No other impacts are expected on photosynthesis, suspension/filter feeders, and sight feeders, except for temporary impacts from disposal operations which will temporarily increase the local turbidity levels.

(4) Actions Taken to Minimize Impacts - Construction and disposal will be closely coordinated with the resource agencies to assure minimal impacts.

d. Contaminant Determinations - No increase in contaminant levels is expected during construction and disposal operations. Sediment and elutriate samples from the channel have indicated compliance with all EPA standards for heavy metals and organic compounds where they exist.

e. Aquatic Ecosystem and Organism Determinations.

(1) Effects on Plankton - Construction and disposal operations are expected to have only minor temporary, local impacts on plankton due to increased turbidity levels.

(2) Effects on Benthos - Construction and disposal operations of the bank protection plan and beneficial use sites will bury some benthos, but marsh creation will ultimately benefit a greater diversity of benthic species than before.

(3) Effects on Nekton - The same effects are expected on nekton as listed for benthos. Marsh creation will ultimately provide greater benefits for estuarine species than existed in the nonvegetated bay habitat.

(4) Effects on Aquatic Food Web - The estuarine food web will benefit from greater productivity associated with creation of an additional 1,614 acres of marsh and protection of existing marsh/pond habitat by bank protection.

(5) Effects on Special Aquatic Sites - The project has been extensively coordinated with the resource agencies to protect the wetlands (marsh/pond), mudflats, and shallow vegetated (seagrass) habitats inside the designated critical habitat for the endangered whooping cranes. Other threatened and endangered species will benefit as well (see EIS). There are no coral reefs or riffle and pool complexes in the project area. The EIS also describes benefits to other wildlife in the area.

f. Proposed Disposal Site Determinations.

(1) Mixing Zone Determination - There is adequate area in the GIWW where upland disposal sites and some beneficial use sites (one-time use only) discharge their effluent and in the bays where most of the beneficial use sites will discharge effluent over the 50-year disposal period to establish a mixing zone sufficient for diluting suspended particulates and preventing concentrations of pollutants above EPA standards from occurring.

(2) Determination of Compliance With Applicable Water Quality Standards - Sediment and elutriate samples from the GIWW and bioassay tests indicate all values for heavy metals and organic compounds are within EPA standards, except for 1984-1985. There were some aberrant and temporary high values for oil and grease at some sites in the GIWW in those years. The high values have not been recorded since. The State of Texas has issued a water quality certificate for current maintenance dredging in the project area, indicating the District is meeting water quality standards.

(3) Potential Effects on Human Use Characteristic.

(a) Municipal and Private Water Supply - The project is in a remote, marine environment where there are no freshwater supplies. The project will not impact any municipal or private water supplies.

(b) Recreational and Commercial Fisheries - Recreational and commercial fishing in the bays in the project area may increase as a result of the additional marsh created in the beneficial use sites. The desirable sports and commercial species use marsh habitat during development and depend on marsh productivity to enhance the marine food web.

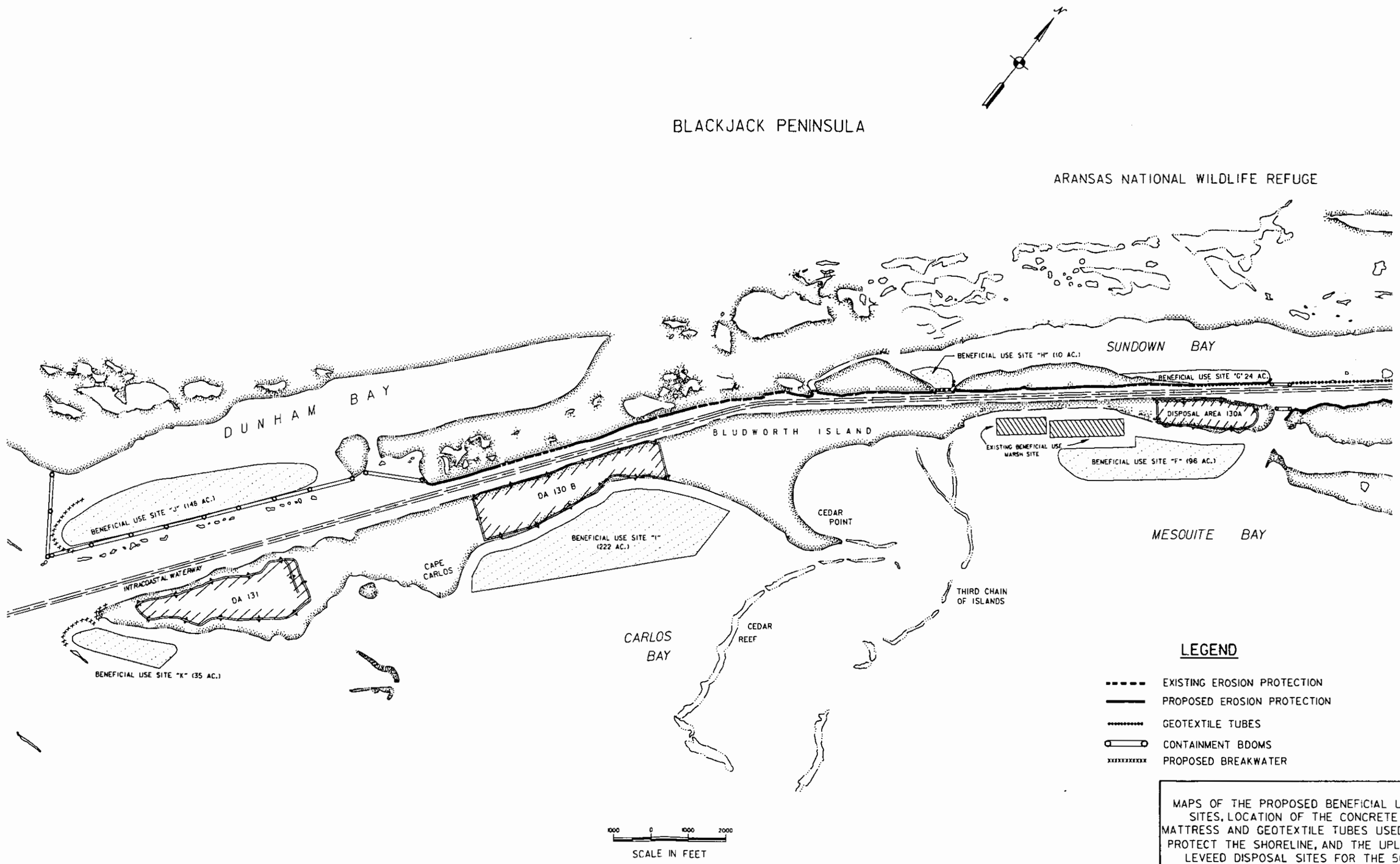
(c) Water Related Recreation - The project will not affect recreation directly, but may enhance sports fishing indirectly by increasing the population of desirable sports species.

(d) Aesthetics - The project is designed to minimize any adverse impacts to the environment and aesthetic qualities in the area in order to benefit an endangered species and its critical habitat.

(e) Parks, National and Historic Monuments, National Seashores, Wilderness Areas, Research Sites, and Similar Preserves - Only the Aransas NWR is located in the project area. The project is designed specifically to protect wetland habitat in the Refuge and create additional wetlands during a 50-year period with beneficial uses of dredged maintenance material.

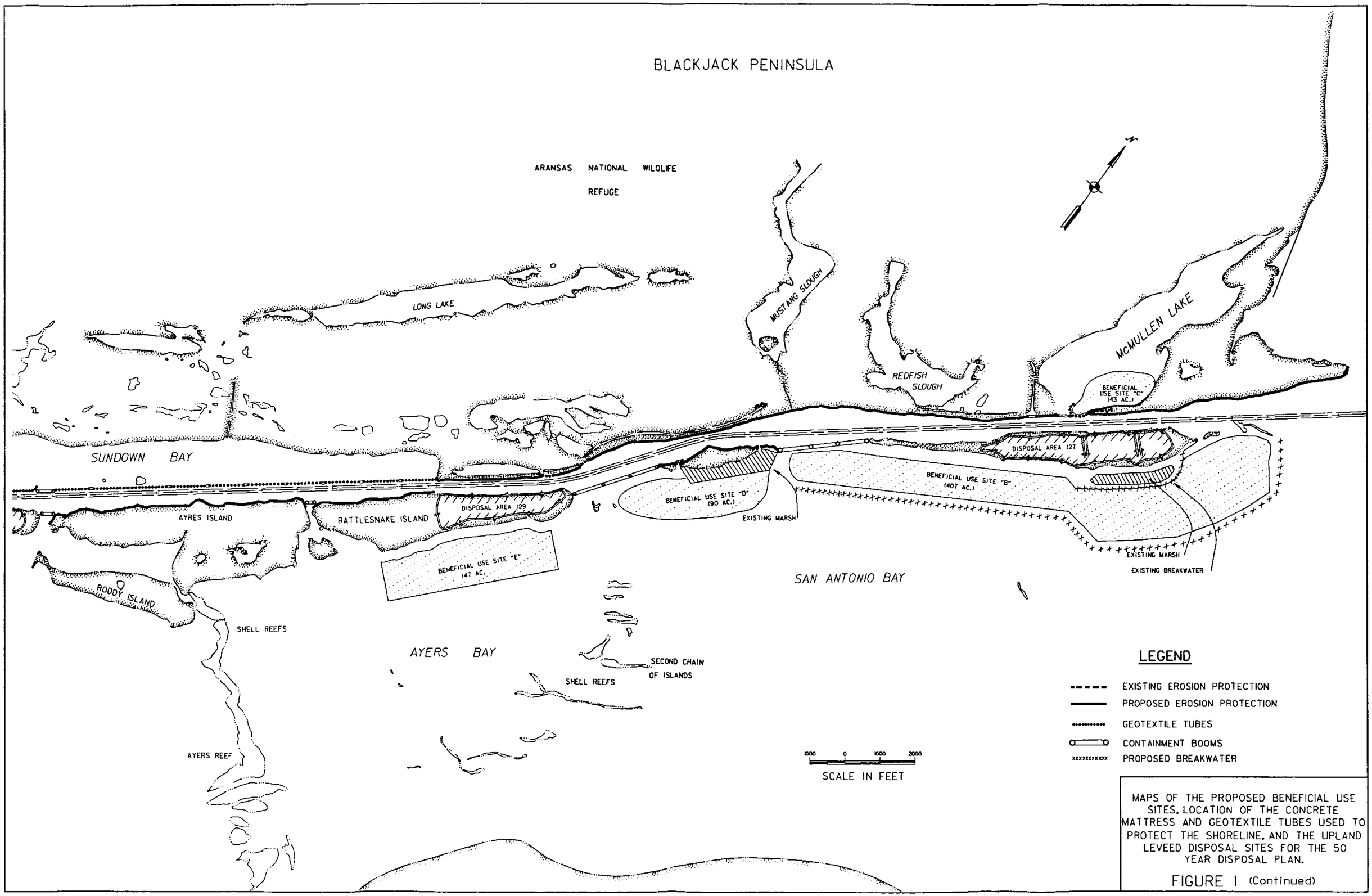
g. Determination of Cumulative Effects on the Aquatic Ecosystem - The project construction and disposal plans are designed to eliminate any adverse affects on the aquatic ecosystem. The plans are expected to result in net benefits to the environment without adding to negative cumulative impacts in the aquatic ecosystem.

h. Determination of Secondary Effects on the Aquatic Ecosystem - No significant secondary effects on the aquatic ecosystem should occur as a result of the recommended project.



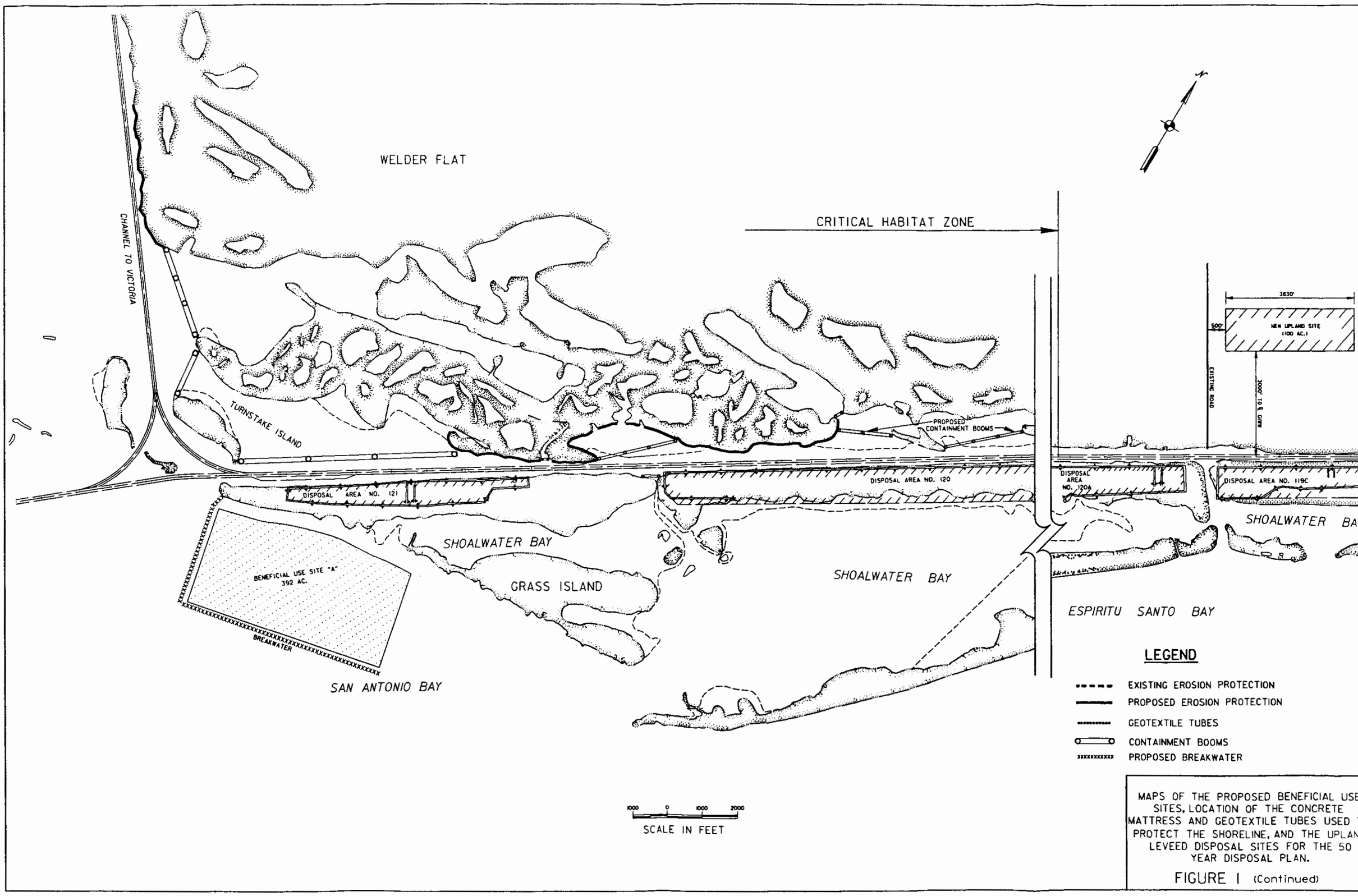
MAPS OF THE PROPOSED BENEFICIAL USE SITES, LOCATION OF THE CONCRETE MATTRESS AND GEOTEXTILE TUBES USED TO PROTECT THE SHORELINE, AND THE UPLAND LEVEED DISPOSAL SITES FOR THE 50 YEAR DISPOSAL PLAN.

FIGURE 1



MAPS OF THE PROPOSED BENEFICIAL USE SITES, LOCATION OF THE CONCRETE MATTRESS AND GEOTEXTILE TUBES USED TO PROTECT THE SHORELINE, AND THE UPLAND LEVEED DISPOSAL SITES FOR THE 50 YEAR DISPOSAL PLAN.

FIGURE 1 (Continued)



MAPS OF THE PROPOSED BENEFICIAL USE SITES, LOCATION OF THE CONCRETE MATTRESS AND GEOTEXTILE TUBES USED TO PROTECT THE SHORELINE, AND THE UPLAND LEVEED DISPOSAL SITES FOR THE 50 YEAR DISPOSAL PLAN.

FIGURE 1 (Continued)

FINDINGS OF COMPLIANCE WITH
SECTION 404 (b) (1) GUIDELINES

FOR

GULF INTRACOASTAL WATERWAY
ARANSAS NATIONAL WILDLIFE REFUGE
(SECTION 216)

1. No significant adaptations of the Guidelines were made relative to the evaluation for this project.

2. Four alternatives and two variations of two of the alternatives to the GIWW in the study area were evaluated for this project (Section 2.0, EIS). All plans, including a No Action plan, were considered to the same level of detail for evaluation in a two-step process to arrive at a plan for recommendation for construction. The three alternative realignment plans (Figure 9, EIS) were not selected because of significant environmental damages that would occur (Table 1, EIS) and higher costs. Alternative 2 - Existing Alignment was the recommended plan because it protected designated critical habitat, minimized environmental damage, and was the least-costly alternative.

3. The recommended project will not violate any applicable State or Federal water quality criteria or toxic effluent standards of Section 307 of the Clean Water Act. Dredging and construction is limited to the six months of the year when whooping cranes (an endangered species) are absent from the project area.

4. The recommended project will not adversely affect any State or Federally-listed threatened or endangered species or their critical habitat or violate any protective measures for any sanctuary. The project is specifically designed to protect critical habitat designated under the Endangered Species Act for the whooping crane.

5. The recommended bank protection, and spill containment plans, as well as the ancillary beneficial use plan, will not result in adverse effects on human health and welfare, including municipal and private water supplies, recreation and commercial fishing, plankton, fish, shellfish, wildlife, and special aquatic sites. The new marshes in the beneficial use sites will provide additional habitat for various life stages of estuarine species and other wildlife. There are no significant adverse impacts expected for the estuarine ecosystem diversity, productivity and stability, and recreational, aesthetic, and economic values.

6. Appropriate steps to minimize potential adverse impacts of beneficial use site effluent on the estuarine system include close coordination with State and Federal resource agencies during final design prior to construction to incorporate all valid suggestions.

7. Based on the guidelines, the recommended construction of the bank protection, spill containment, and beneficial use sites and upland disposal areas for a 50-year disposal plan and subsequent disposal operations are specified as complying with requirements of Section 404(b)(1) guidelines.

Date: James M. Kieslich 10/5/95

James M. Kieslich
Chief, Planning and
Environmental Division

APPENDIX B - SECTION 4

CULTURAL RESOURCES COORDINATION

DEPARTMENT OF THE ARMY
GALVESTON DISTRICT, CORPS OF ENGINEERS
P.O. BOX 1229
GALVESTON, TEXAS 77553-1229

REPLY TO
ATTENTION OF:

August 23, 1991

Environmental
Resources Branch

James E. Bruseth, Ph.D.
Deputy State Historic
Preservation Officer
Texas Historical Commission
P.O. Box 12276
Austin, Texas 78711

Dear Dr. Bruseth:

The Galveston District, Corps of Engineers is studying erosion control alternatives along a segment of the Gulf Intracoastal Waterway (GIWW) in Calhoun and Aransas Counties, Texas. Several alternatives have been proposed, with structural protection of the existing channel banks appearing to be the most feasible. A cultural resource survey with a locational map and brief project description is enclosed for your review. The survey covers the existing channel banks of the GIWW and does not include possible alternative alignments, disposal areas, or underwater resources.

We request your review of this report and concurrence in our finding that no cultural resource sites will be impacted by possible erosion control measures constructed immediately adjacent to the existing GIWW channel in this project area. Please direct any questions to Ms. Carolyn Good at 409/766-3038.

Sincerely,

William Fickel, Jr.
Chief, Planning Division

Enclosure

THE STATE OF TEXAS

CURTIS TUNNELL
EXECUTIVE DIRECTOR

TEXAS HISTORICAL COMMISSION

P.O. BOX 12276 AUSTIN, TEXAS 78711 (512)463-6100

September 10, 1991

Mr. George Rochen
Chief, Construction-Operations
Division
Department of the Army
Galveston District, Corps of Engineers
P.O. Box 1229
Galveston, TX 77553

Re: Gulf Intercoastal Waterway
erosion control alternatives in Calhoun/ Aransas Co.
(COE-VD, A4, A5, A6, D1d)

Dear Mr. Rochen:

We are in receipt of an archeological report concerning the above referenced undertaking. After reviewing the report we conclude that, as described, the proposal should not affect sites on the National Register of Historic Places, nor any site determined eligible for the National Register. Please be advised that any artifacts collected during the cultural resources survey should be curated at an adequate repository as defined in the Secretary of Interior's regulations entitled "Curation of Federally-Owned and Administered Archeological Collections" (36CFR79).

The project may continue without further consultation with this office. However, it is possible that buried archeological deposits may be present in the project area. If artifacts are encountered during construction, work should cease in the immediate area; work can continue in the project area where no archeological deposits are present. The Advisory Council on Historic Preservation should be contacted in accordance with 36CFR800.11.b.2. Please also notify the State Historic Preservation Officer (512/463-6096).

Sincerely,

James E. Bruseth

James E. Bruseth, Ph.D.
Deputy State Historic Preservation Officer

SS/JEB

May 9, 1994

Environmental
Resources Branch

James E. Bruseth, Ph.D.
Deputy State Historic
Preservation Officer
Texas Historical Commission
P.O. Box 12276
Austin, Texas 78711

Dear Dr. Bruseth:

Reference is made to the Gulf Intracoastal Waterway (GIWW), Aransas National Wildlife Refuge Project, Calhoun and Aransas Counties, Texas. A shoreline cultural resource survey was previously coordinated with your office on August 23, 1991. At this time we would like to coordinate a Scope of Work for Archival Research with you. The primary emphasis of this work will be the investigation of historic shipwrecks and navigational features that may be affected by our project, as well as other historic sites that may be present. The proposed archival research will be conducted by Steven Hoyt of Espey, Huston and Associates, Inc. We would appreciate your review of this Scope of Work. Please direct any questions or comments to Ms. Carolyn Murphy at 409/766-3038.

Sincerely,

James M. Kieslich
Chief, Planning Division

Enclosure

CURTIS TUNNELL
EXECUTIVE DIRECTOR

TEXAS HISTORICAL COMMISSION

P.O. BOX 12276 AUSTIN, TEXAS 78711-2276 (TELEPHONE) 512-463-6096 (FAX) 512-463-6095 (RELAY TX) 1-800-735-2989 (TDD)

DEPARTMENT OF ANTIQUITIES PROTECTION

May 20, 1994

James M. Kieslich
Department of t he Army
Galveston District, Corps of Engineers
P.O. Box 1229
Galveston, Texas 77553-1229

5/25

Re: GIWW Aransas National Wildlife Refuge
(CL, AS, F2, F11)

Dear Mr. Kieslich:

Thank you for sending for review the Scope of Work for the above referenced archival research project. The concur with the work planned. We are glad to see this little known stretch of the coast receive study.

We look forward to working with you n this project.

Yours truly,

James E. Bruseth, Ph.D.
State Histoc Preservation Officer

J. Barto Arnold III
State Marine Archeologist

JEB/JBA/jg

APPENDIX B - SECTION 5

ESTUARINE HABITAT STUDY

Comparison of Estuarine Habitat Utilization by Nekton at Aransas National Wildlife Refuge

Lawrence P. Rozas
Thomas J. Minello
Raymond Burditt
Shannon Whaley
John Boyd
Marie Pattillo
Mark Pattillo
Timothy Baumer

National Marine Fisheries Service
Southeast Fisheries Science Center
Galveston Laboratory

9 September 1994

A Final Report to the
Galveston District U.S. Army Corps of Engineers

Introduction

Erosion along the shores of the Gulf Intracoastal Waterway (GIWW) at the southern boundary of the Aransas National Wildlife Refuge (ANWR) is causing a net loss of the salt marsh in the vicinity of the refuge (Ray and Wilber 1991, Hershberger et al. 1993). Salt marsh provides valuable fishery habitat, supporting the young of many species (Zimmerman and Minello 1984, Rozas 1993). In addition, the animals inhabiting these marshes provide food for Whooping Cranes *Grus americana*, which overwinter at ANWR. Primary foraging areas for the cranes are in the brackish bays, marshes, and salt flats between the mainland and barrier islands in and around the refuge (U.S. Fish and Wildlife Service 1993). In the fall when high tides flood tidal marshes, the birds feed primarily on blue crabs *Callinectes sapidus*; in winter when water levels are low, cranes forage in shallow subtidal areas where they prey on clams as well as blue crabs (Hunt and Slack 1989, U.S. Fish and Wildlife Service 1993).

Natural marsh formation through delta-building processes can offset marsh losses; however, this is not occurring in the vicinity of the refuge. Natural marsh formation along the Gulf coast is currently occurring at a significant rate only at the Atchafalaya River delta in Louisiana. In the vicinity of ANWR, as along most of the northwestern Gulf, where wetland loss rates are high and losses are not compensated by natural marsh formation, the use of dredged material to create intertidal marshes is one of the few options available for offsetting wetland losses (Shreffler et al. 1992).

A proposed project to use dredged material produced from routine maintenance of the GIWW to create intertidal marshes along the channel would increase the area of salt marsh habitat in the vicinity of ANWR. In addition, placing dredged material islands away from the present shoreline as planned will provide protected shallow areas behind created marshes and may increase the coverage of submerged aquatic vegetation (SAV) in the area. However, use of dredged material to create these habitats alongside the GIWW would result in an overall loss of shallow unvegetated subtidal habitat. The impact of this tradeoff on fishery species and whooping crane prey is unknown. Although previous studies have quantified benthic infaunal populations, nekton assemblages of aquatic habitats in the area have not been quantitatively sampled (Harper 1976, Espey, Huston & Associates, Inc. 1986a, b, Ray and Wilber 1991).

The objectives of our study were to (1) describe the nekton assemblages of shallow subtidal and intertidal habitats of the Aransas National Wildlife Refuge, (2) compare nekton densities among

three major habitats (unvegetated bottom, submerged grass bed, and salt marsh), and (3) predict what the tradeoff will be in replacing shallow subtidal areas with salt marsh and possibly SAV.

Approach

Our approach was to document preferred habitats of nekton using the ANWR during the fall just prior to the arrival of Whooping Cranes at the refuge and again in the spring after the cranes had departed for their breeding grounds. Preferred habitats were identified by sampling all habitats over a short period of time when they were all inundated, and therefore equally accessible to aquatic organisms, and comparing densities of animals among habitats. The results on habitat utilization can then be used to predict the impact of replacing marsh with subtidal habitat.

Methods

The study area was located in south Texas along the southeast border of ANWR and encompassed all proposed dredged material disposal sites along the GIWW between Aransas Bay and San Antonio Bay (Fig. 1). We sampled three major habitats (shallow unvegetated bottom, seagrass, and salt marsh) at 12 different locations to determine animal use patterns (Fig. 1); the habitat types sampled at each location are listed in Table 1. During each sampling period (September 20-23, 1993 and May 9-12, 1994), we collected a total of 100 macrofaunal samples from 20 sites; these included six *Spartina alterniflora* marsh sites, seven seagrass sites dominated by a mixture of *Ruppia maritima* and *Halodule wrightii*, and seven shallow unvegetated subtidal sites. Within each site, we randomly selected replicate sample locations (five replicate samples/site) using a random number generator and a grid placed over the potential sample areas. We collected samples during the day when all habitats were inundated and available to aquatic organisms.

Macrofauna (fishes, crustaceans, and molluscs) were collected with a drop sampler using the procedure described by Zimmerman et al. (1984). We employed a 1.14 m diameter cylinder that was dropped from a boom on a boat and entrapped organisms within a 1.0 m^2 area. Two persons positioned the cylinder over the sample area by slowly pushing from the boat's stern. When released from the boom, the cylinder fell rapidly onto the sample area. Disturbance to the sample area prior to releasing the cylinder was minimized using this procedure. The distances from the bow and stern of the boat to the edge of the sample area were 3.5 and 8.3 m, respectively.

After the cylinder enclosed a sample, we measured water temperature and dissolved oxygen in the sampler with a YSI Model 51B meter. We determined salinity with an American Optical temperature-compensated refractometer. Turbidity was ascertained in the laboratory from a water

sample collected in the cylinder. We estimated water depth at the sample site by averaging the maximum and minimum depths measured within the sampler. At vegetated sites, we clipped plant stems at ground level, counted them (dead and alive combined), and removed them from the cylinder. At each seagrass site, we determined SAV biomass (above- and below-ground) from three 5-cm diameter cores collected at random locations inside the drop sampler; vegetation was washed, dried to a constant weight, and weighed to the nearest 0.1 g.

We captured natant macrofauna trapped in the drop sampler using dip nets and by pumping the water out of the enclosure and through a 1-mm mesh net. When the sampler was completely drained, any animals remaining on the bottom were removed by hand. Samples were preserved in formalin with Rose Bengal stain and returned to the laboratory for processing. In the laboratory the samples were sorted, and macrofauna were identified to species or lowest feasible taxon. Crustaceans were measured to the nearest 1 mm in total length or carapace width, and fishes were measured and assigned to 5 mm size categories.

Data Analyses

Fall 1993 and Spring 1994 data were analyzed separately. We examined differences among habitats by using 1-way ANOVAs to test whether physical characteristics (mean dissolved oxygen, salinity, water temperature, turbidity, and water depth) and densities of numerically dominant fishes and decapod crustaceans were equal among all sampling sites. We then used *a priori* contrasts to compare unvegetated bottom, seagrass, and salt marsh sites. Densities of fishes and crustaceans were positively related to the standard deviation; therefore, we performed a log + 1 transformation of the original density values prior to analyses. Other variables were not transformed. All tabular and graphical data presented in this report are untransformed means. All analyses were conducted with SuperANOVA software (Abacus Concepts 1989) using a significance level of 0.05.

Results

There were differences among habitats in most physical parameters that were measured (Tables 2-4). Fall water temperatures were higher than those measured in the spring. Average water temperatures in marsh and seagrass beds were significantly higher than in unvegetated subtidal areas in both fall and spring; temperatures in marsh and seagrass beds were similar in fall, but slightly higher in the grass beds than marsh in spring. Dissolved oxygen concentrations were similar at SAV sites during both sampling periods, but higher in spring in the other two habitats (Table 2). Average concentrations were highest in seagrass beds and marsh in the fall and spring,

respectively; average dissolved oxygen levels were greater in the vegetated habitats than unvegetated areas during both sampling periods. Turbidity levels, which were higher in spring than fall, were always lower at unvegetated than vegetated sites (Tables 2-4). In fall, average turbidity was greatest at SAV sites, but in spring marsh sites had the highest values. Although we collected all our samples in shallow water (<1m deep), the deepest water occurred over unvegetated bottom, and marsh habitat contained the shallowest water. Water levels were generally higher during the fall than spring sampling period (Table 2). Salinities were higher in spring than fall (21.9-22.1$^{o}/_{oo}$ vs 14.5-14.8$^{o}/_{oo}$). Average salinities at marsh and SAV sites were similar during both sampling periods, and in fall all three habitats had similar salinities. Although salinities at unvegetated sites were lower than vegetated sites in the spring, the difference was less than the accuracy of the instrument we used to measure this parameter (Tables 2 and 4). The density of stems in the *Spartina* marsh was higher in fall than in spring, but SAV biomass was greater in spring than fall (Table 2).

We collected a total of 25 species of fishes, 12 species of crustaceans, and 8 species of molluscs in fall and 29 species of fishes, 13 species of crustaceans, and 12 species of molluscs in spring (Tables 5 and 6). Macrofaunal densities (all taxa combined) were significantly higher in marshes than the other two habitats, and densities in seagrass beds were greater than in unvegetated habitat (Tables 5-8). Although marsh and seagrass beds had significantly higher densities of fishes than unvegetated bottom, densities in marsh and seagrass habitats were not significantly different (Fig. 2 and 3, Tables 5-8). Significant differences in overall macrofaunal densities among habitats were due mostly to crustaceans, which were much more numerous than fishes or molluscs in the study area (Figs. 2-7, Tables 5-8).

In fall, naked goby *Gobiosoma bosc*, rainwater killifish *Lucania parva*, bay anchovy *Anchoa mitchilli*, and spotted seatrout *Cynoscion nebulosus* numerically dominated the fish assemblages and accounted for 79% of the fishes we collected (Table 5). The distribution of these species (except bay anchovy) differed among habitats (Fig. 8). Naked goby, rainwater killifish, and spotted seatrout were all significantly more abundant in marsh and seagrass beds than unvegetated bottom (Tables 5 and 7). Naked goby and spotted seatrout densities in marsh and seagrass were similar, but rainwater killifish were significantly more abundant in marsh (Tables 5 and 7).

In spring, naked goby and bay anchovy also numerically dominated the fishes, as did pinfish *Lagodon rhomboides* and gulf pipefish *Syngnathus scovelli*; these species accounted for 75% of the fishes collected (Table 6). Pinfish, naked goby, and gulf pipefish were significantly more abundant in marsh and SAV than unvegetated habitat; pinfish densities were greater in marsh than SAV, but naked goby and gulf pipefish were similarly distributed between the two vegetated

habitats (Fig. 9, Tables 6 and 8). Bay anchovy were significantly more abundant in unvegetated habitat than SAV and were absent from marsh habitat (Fig. 9, Tables 6 and 8).

Numerically dominant crustaceans in the fall included daggerblade grass shrimp *Palaemonetes pugio*, blue crab, brown shrimp *Penaeus aztecus*, and white shrimp *P. setiferus*, which represented 97% of the crustaceans in our samples (Table 5). Greatest densities of dominant crustaceans (except white shrimp) occurred in marsh (Fig. 10), and abundances in seagrass were significantly greater than on unvegetated bottom (Tables 5 and 7). Densities of white shrimp were also lowest in unvegetated habitat, but densities in marsh and seagrass were not significantly different (Fig. 10, Tables 5 and 7).

In spring, daggerblade grass shrimp, blue crab, brown shrimp, and brackish grass shrimp *Palaemonetes intermedius* were numerically dominant, accounting for 98% of the crustacean catch (Table 6). Densities of these species (except brown shrimp) were greatest in marsh, and greater in SAV than unvegetated habitat (Fig. 11, Tables 6 and 8). Brown shrimp densities were also greater in marsh and SAV than unvegetated areas, but highest densities were found in SAV (Fig. 11, Tables 6 and 8).

Our sampling method can quantitatively sample large epifaunal molluscs (e.g., marsh periwinkle *Littorina irrorata*), but it is not designed to quantitatively sample benthic infauna and small epifauna. Most molluscs were taken when the intake hose came into contact with the substrate as we pumped the water out of the sampler. Therefore, densities reported here for most species are much lower than what occurs naturally in the study area. However, these data do give an indication of the relative abundance of molluscs among habitats. We collected most molluscs on unvegetated bottom and in seagrass beds (Tables 5 and 6). Atlantic rangia *Rangia cuneata* accounted for >80% of all molluscs taken in fall (Table 5), whereas brown rangia *Rangia flexuosa* and minor jackknife *Enis minor* represented >65% of molluscs collected in spring (Table 6). Atlantic rangia (in fall) and minor jackknife (in spring) were most abundant in unvegetated bottom and they were absent in marsh habitat (Tables 5-8). In the spring, the abundance of brown rangia in unvegetated and SAV habitats was similar, but this species was significantly less abundant in marsh (Tables 6 and 8).

Discussion

The salt marsh and seagrass habitats of our study area supported much higher densities of fishes and decapod crustaceans than nearby unvegetated subtidal areas (Table 9). Bay anchovy was the only numerically dominant species that was collected in unvegetated areas at densities that were similar to (fall) or greater than (spring) the vegetated habitats. Our results are supported by studies conducted in other estuaries that also document less direct use of unvegetated subtidal habitat in

comparison with salt marshes and submerged grass beds (Heck and Thoman 1984, Zimmerman and Minello 1984, Lubbers et al. 1990, Thomas et al. 1990, Fredette et al. 1991).

Dissolved oxygen concentrations and water temperatures were significantly lower in unvegetated than vegetated habitats, but it is unlikely that these differences could explain the low densities of nekton on unvegetated bottom. Dissolved oxygen concentrations in the unvegetated habitat were always adequate to sustain estuarine species, and it is unlikely that the lower water temperature we observed in the deeper unvegetated habitat was biologically significant. Turbid water may alter predator-prey relationships, affecting the value of estuarine habitats for some species (Cyrus and Blaber 1987, Minello et al. 1987), and we did observe a statistically significant lower average turbidity level in unvegetated habitats. The low turbidity levels observed in unvegetated habitat may have contributed to the low densities of nekton we found there. However, the higher turbidity observed in the shallow vegetated habitats may be a sampling artifact. Dropping the sampler into shallow water may cause resuspension of bottom sediments and a rise in turbidity levels throughout the water column. The sampler may have also resuspended bottom sediments in the deeper unvegetated habitat; however, turbidity levels at the surface where the water sample was taken may not have been affected as it was in shallow water.

In addition to the presence of vegetative structure, vegetated and unvegetated habitats differed substantially in water depth. These factors combined may have been most important in influencing nekton habitat selection because the risk of predation in deep, unvegetated areas is high (Baltz et al. 1993, Minello 1993, Ruiz et al. 1993). Unvegetated areas may have harbored large aquatic predators that were constrained by the shallow water and structure of vegetated habitats. In a study of a subestuary of Chesapeake Bay, Ruiz et al. (1993) found that known predators of small fishes and decapods (e.g., large spot *Leiostomus xanthurus*, Atlantic croaker *Micropogonias undulatus*, and blue crabs) were often most abundant in waters >70 cm deep, and the mortality rates of tethered daggerblade grass shrimp, killifish, and small blue crabs significantly increased with depth. Animals using marsh or seagrass beds are also afforded protection from predators by hiding in the vegetation (Heck and Thoman 1981, Minello and Zimmerman 1983, Wilson et al. 1987, 1990, Rozas and Odum 1988, Minello et al. 1989).

Because our marsh samples were confined to low marsh adjacent to shallow subtidal areas, our results should not be applied to high marsh or marsh remote from subtidal areas. Marsh elevation and the proximity of a marsh to subtidal habitat may influence habitat selection within salt marshes (Minello et al. 1991, Rozas 1993). For example, Rozas and Reed (1993) found that gulf killifish and diamond killifish preferred high (*Distichlis spicata*) marsh over low *S. alterniflora* marsh, but brown shrimp and white shrimp were most abundant in low *S. alterniflora* marsh. Minello et al.

1994 reported densities of daggerblade grass shrimp and brown shrimp 1.2 to 4.3 times higher on low than high S. *alterniflora* marsh, but found no effect of elevation on the abundance of white shrimp. A difference in average water depth between fall and spring in our study area may have caused the switch in habitat preference we observed for brown shrimp. In the fall, brown shrimp were most abundant in salt marsh when the water depth in this habitat averaged 37 cm. However, in the spring when the average flooding depth in marsh habitat was only 19 cm, brown shrimp densities were greatest in SAV.

Habitat at the marsh-water interface (marsh edge habitat) has been shown to contain greater densities of most nekton species, especially those of commercial value. Peterson and Turner (1994) found that although resident marsh species (mostly grass shrimp and killifishes) used interior *Spartina* marsh, most nekton was concentrated in marsh within 3 m of the waters edge. Because many fishery species prefer marsh edge, increasing this habitat in solid stands of *Spartina alterniflora* marsh may enhance its habitat value and cause a substantial increase in its use by these species. For example, constructing channels in a transplanted *Spartina* marsh increased densities of brown shrimp and white shrimp near the channels by a factor of 4.6 to 13 (Minello et al. 1994). Adding channels also significantly raised the densities of polychaete worms and daggerblade grass shrimp in the marsh edge. These animals are an important food of nekton predators such as small fishes, blue crabs, and brown shrimp (Gleason and Wellington 1988, Minello et al. 1989, Thomas 1989, McTigue and Zimmerman 1991).

In summary, salt marsh and seagrass habitats supported significantly greater densities of most species. Therefore, replacing some open bay bottom in the study area with marsh and seagrass habitats should have a positive effect on most species that were dominant in our study. Even though some open bay habitat will be lost by creating new marsh, the area replaced by marsh will be small relative to the total area of open bay habitat in the vicinity, and species that use shallow unvegetated bottom will likely find suitable habitat near constructed marshes. Therefore, if marshes that are functionally equivalent to natural marshes can be constructed, the increased benefit of enlarging the habitat area for fishery and forage species that use marsh systems should outweigh the loss of open bay habitat. To enhance fishery habitat, we recommend expanding both salt marsh and seagrass habitat in the study area. Low marsh edge habitat should be maximized by creating large areas of *S. alterniflora* marsh interspersed with a dense network of shallow channels and interconnected ponds. Expansion of seagrass habitat should be promoted by leaving shallow protected subtidal areas between existing disposal areas and the constructed marshes. Such areas, as well as marsh ponds, will likely provide suitable conditions for the establishment of seagrasses.

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Literature Cited

Abacus Concepts. 1989. SuperANOVA. Abacus Concepts, Inc. Berkeley, CA. 322 p.

Baltz, D. M., C. Rakocinski, and J. W. Fleeger. 1993. Microhabitat use by marsh-edge fishes in a Louisiana estuary. Environmental Biology of Fishes 36:109-126.

Cyrus, D. P., and S. J. M. Blaber. 1987. The influence of turbidity on juvenile marine fishes in estuaries. Part 1. Field studies at Lake St. Lucia on the southeastern coast of Africa. Journal of Experimental Marine Biology and Ecology 109:53-70.

Espey, Huston & Associates, Inc. 1986a. Baseline study in Ayres Bay near Rattlesnake Island. Document No. 860795. EH&A Job No. 7535. Prepared for U.S. Army Engineer District, Galveston, Texas. Espey, Huston & Associates, Inc., Austin, Texas. 43 p. + appendices.

Espey, Huston & Associates, Inc. 1986b. Second baseline study in Ayres Bay near Rattlesnake Island: Ayres Bay II survey. Document No. 861058. EH&A Job No. 7535-12. Prepared for U.S. Army Engineer District, Galveston, Texas. Espey, Huston & Associates, Inc., Austin, Texas. 44 p. + appendices.

Fredette, T. J., R. J. Diaz, J. van Montfrans, and R. J. Orth. 1991. Secondary production within a seagrass bed (*Zostera marina* and *Ruppia maritima*) in lower Chesapeake Bay. Estuaries 13:431-440.

Gleason, D. F., and G. M. Wellington. 1988. Food resources of postlarval brown shrimp (*Penaeus aztecus*) in a Texas salt marsh. Marine Biology 97:329-337.

Harper, D. E. 1976. The effects of shell dredging on the biota of the Aransas National Wildlife Refuge. Pages 221-232 in A. H. Bouma (ed.) Shell Dredging and Its Influence on Gulf Coast Environments, Gulf Publishing Company, Houston, Texas.

Heck, K. L., Jr., and T. A. Thoman. 1981. Experiments on predator-prey interactions in vegetated aquatic habitats. Journal of Experimental Marine Biology and Ecology 53:125-134.

Heck, K. L., Jr., and T. A. Thoman. 1984. The nursery role of seagrass meadows in the upper and lower reaches of the Chesapeake Bay. Estuaries 7:70-92.

Hershberger, D., C. A. Spell, N. Sultan, F. Ting, and J. Zhang. 1993. Bank erosion at the Aransas National Wildlife Refuge. Pages 133-143 in S. Laska and A. Puffer (eds.) Coastlines of the Gulf of Mexico. Am. Soc. Civil Eng., New York, NY.

Hunt, H. E. and R. D. Slack. 1989. Winter diets of whooping and sandhill cranes in south Texas. Journal of Wildlife Management 53:1150-1154.

Lubbers, L., W. R. Boynton, and W. M. Kemp. 1990. Variations in structure of estuarine fish communities in relation to abundance of submersed vascular plants. Marine Ecology Progress Series 65:1-14.

McTigue, T. A., and R. J. Zimmerman. 1991. Carnivory versus herbivory in juvenile *Penaeus setiferus* (Linnaeus) and *Penaeus aztecus* (Ives). Journal of Experimental Marine Biology and Ecology 151:1-16.

Minello, T. J. 1993. Chronographic tethering: a technique for measuring prey survival time and testing predation pressure in aquatic habitats. Marine Ecology Progress Series 101:99-104.

Minello, T. J., and R. J. Zimmerman. 1983. Fish predation on juvenile brown shrimp, *Penaeus aztecus* Ives: the effect of simulated *Spartina* structure on predation rates. Journal of Experimental Marine Biology and Ecology 72:211-231.

Minello, T. J., R. J. Zimmerman, and E. X. Martinez. 1987. Fish predation on juvenile brown shrimp, *Penaeus aztecus* Ives: effects of turbidity and substratum on predation rates. Fishery Bulletin 85:59-70.

Minello, T. J., R. J. Zimmerman, and E. X. Martinez. 1989. Mortality of young brown shrimp *Penaeus aztecus* in estuarine nurseries. Transactions of the American Fisheries Society 118:693-708.

Minello, T. J., R. J. Zimmerman, and R. Medina. 1994. The importance of edge for natant macrofauna in a created salt marsh. Wetlands (in press).

Minello, T. J., J. W. Webb, Jr., R. J. Zimmerman, R. B. Wooten, J. L. Martinez, T. J. Baumer, and M. C. Pattillo. 1991. Habitat availability and utilization by benthos and nekton in Hall's Lake and West Galveston Bay. NOAA Technical Memorandum NMFS-SEFC-275. 37 p.

Peterson, G. W., and R. E. Turner. 1994. The value of salt marsh edge vs interior as a habitat for fish and decapod crustaceans in a Louisiana tidal marsh. Estuaries 17: 235-262.

Ray, G. L. and T. P. Wilber. 1991. Beneficially using dredged material at Aransas National Wildlife Refuge, Austwell, Texas, results of benthic and seine sampling. Final Report prepared for U.S. Army Engineer District, Galveston, Texas. 101 p.

Rozas, L. P.. 1993. Nekton use of salt marshes of the southeast region of the United States. Pages 528-537 in O. T. Magoon, W. S. Wilson, H. Converse, and L. T. Tobin (eds.) Proceedings of the Eighth Symposium on Coastal and Ocean Management. Coastal Zone '93 Conference. Am. Soc. Civil Eng., New Orleans, LA.

Rozas, L. P., and D. J. Reed. 1993. Nekton use of marsh-surface habitats in Louisiana (USA) deltaic salt marshes undergoing submergence. Marine Ecology Progress Series 96:147-157.

Rozas, L. P., and W. E. Odum. 1988. Occupation of submerged aquatic vegetation by fishes: testing the roles of food and refuge. Oecologia 77:101-106.

Ruiz, G. M., A. H. Hines, and M. H. Posey. 1993. Shallow water as a refuge habitat for fish and crustaceans in non-vegetated estuaries: an example from Chesapeake Bay. Marine Ecology Progress Series 99:1-16.

Shreffler, D. K., C. A. Simenstad, and R. M. Thom. 1992. Foraging by juvenile salmon in a restored estuarine wetland. Estuaries 15:204-213.

Thomas, J. L. 1989. A comparative evaluation of *Halodule wrightii* Aschers, *Spartina alterniflora* Loisel and bare sand as nursery habitats for juvenile *Callinectes sapidus* (Rathbun). M.S. Thesis, Texas A & M University, College Station. 119 p.

Thomas, J. L., R. J. Zimmerman and T. J. Minello 1990. Abundance patterns of juvenile blue crabs (*Callinectes sapidus*) in nursery habitats of two Texas bays. Bulletin of Marine Science 46:115-125.

U.S. Fish and Wildlife Service. 1993. Whooping crane recovery plan. Albuquerque, New Mexico. 76 p.

Wilson, K. A., K. L. Heck, and K. W. Able. 1987. Juvenile blue crab, *Callinectes sapidus*, survival: an evaluation of eelgrass, *Zostera marina*, as refuge. Fishery Bulletin 85:53-58.

Wilson, K. A., K. W. Able, and K. L. Heck. 1990. Habitat use by juvenile blue crabs: a comparison among habitats in southern New Jersey. Bulletin of Marine Science 46:105-114.

Zimmerman, R. J., and T. J. Minello. 1984. Densities of *Penaeus aztecus*, *Penaeus setiferus*, and other natant macrofauna in a Texas salt marsh. Estuaries 7:421-433.

Zimmerman, R. J., T. J. Minello and G. Zamora 1984. Selection of vegetated habitat by brown shrimp, *Penaeus aztecus*, in a Galveston Bay salt marsh. Fishery Bulletin 82:325-336.

Table 1. Habitat types sampled at each location September 20-23, 1993 (F=fall) and May 9-12, 1994 (S=spring). Numbers (1-12) refer to sample locations in the study area shown in Figure 1.

LOCATION NUMBER	MARSH	SEAGRASS	UNVEGETATED BOTTOM
1			F, S
2			F, S
3	F, S	F, S	F, S
4	F, S	F	
5		S	F, S
6	F, S	F, S	
7		F, S	F, S
8	F, S	F, S	F, S
9			F, S
10	F, S	F, S	
11	F, S	F	
12		S	

Table 2. Environmental characteristics of habitats. Mean and (one standard error) are given for six parameters measured in September 1993 and May 1994. Vegetation was characterized for Spartina marsh as stem density (stems/square m) and for Seagrass beds as biomass, dry weight (g/58.9 square cm). Sample number: marsh=30, seagrass=35, and unvegetated bottom=35 (except one missing value for dissolved oxygen concentration during spring 1994 period).

	Oxygen (ppm)		Salinity (o/oo)		Temperature (oC)		Turbidity (FTU)		Water Depth (cm)		Vegetation	
HABITAT	**MEAN**	**S. E.**	**MEAN**	**S. E.**	**MEAN**	**S. E.**	**MEAN**	**S. E.**	**MEAN**	**S. E.**	**MEAN**	**S. E.**
FALL 1993												
Spartina marsh	**7.0**	(0.26)	**14.5**	(0.33)	**31.3**	(0.24)	**37.6**	(4.33)	**37**	(1.4)	**117**	(12)
Seagrass beds	**8.1**	(0.27)	**14.6**	(0.34)	**31.1**	(0.26)	**51.6**	(9.89)	**48**	(1.7)	**0.33**	(0.06)
Unvegetated bottom	**5.8**	(0.11)	**14.8**	(0.32)	**29.4**	(0.16)	**16.4**	(1.84)	**78**	(1.1)	**0**	(0)
SPRING 1994												
Spartina marsh	**8.7**	(0.41)	**22.1**	(0.05)	**27.3**	(0.22)	**76.1**	(9.79)	**19**	(1.3)	**83**	(8)
Seagrass beds	**8.1**	(0.14)	**22.1**	(0.04)	**27.7**	(0.28)	**63.9**	(5.10)	**30**	(1.7)	**0.48**	(0.12)
Unvegetated bottom	**6.6**	(0.16)	**21.9**	(0.14)	**26.4**	(0.13)	**51.3**	(6.30)	**66**	(2.2)	**0**	(0)

Table 3. Results of the ANOVA a priori Contrasts of differences in environmental parameters among habitats for the September 1993 sampling period. M = marsh, SG = seagrass, and UB = unvegetated bottom.

Parameter	Contrast	d.f.	F	p
Water Temperature	M vs SG	1,80	3.242	0.0756
	M vs UB	1,80	317.324	0.0001
	SG vs UB	1,80	277.789	0.0001
Salinity	M vs SG	1,80	0.192	0.6627
	M vs UB	1,80	2.768	0.1001
	SG vs UB	1,80	1.628	0.2057
Dissolved Oxygen	M vs SG	1,80	19.629	0.0001
	M vs UB	1,80	22.582	0.0001
	SG vs UB	1,80	91.346	0.0001
Turbidity	M vs SG	1,80	6.496	0.0127
	M vs UB	1,80	14.738	0.0002
	SG vs UB	1,80	44.203	0.0001
Water Depth	M vs SG	1,80	50.038	0.0001
	M vs UB	1,80	689.195	0.0001
	SG vs UB	1,80	411.874	0.0001

Table 4. Results of the ANOVA a priori Contrasts of differences in environmental parameters among habitats for the May 1994 sampling period. M = marsh, SG = seagrass, and UB = unvegetated bottom.

Parameter	Contrast	d.f.	F	p
Water Temperature	M vs SG	1,80	10.051	0.0022
	M vs UB	1,80	63.827	0.0001
	SG vs UB	1,80	134.913	0.0001
Salinity	M vs SG	1,80	0.042	0.8384
	M vs UB	1,80	20.262	0.0001
	SG vs UB	1,80	20.000	0.0001
Dissolved Oxygen	M vs SG	1,79	11.483	0.0011
	M vs UB	1,79	125.258	0.0001
	SG vs UB	1,79	64.346	0.0001
Turbidity	M vs SG	1,80	3.413	0.0684
	M vs UB	1,80	14.160	0.0003
	SG vs UB	1,80	3.975	0.0496
Water Depth	M vs SG	1,80	38.908	0.0001
	M vs UB	1,80	746.436	0.0001
	SG vs UB	1,80	481.550	0.0001

Table 5. Density of animals in habitats sampled September 20-23, 1993. Mean, number of animals/sample, and (S. E.), one standard error, are given for each habitat. Sample number: marsh=30, seagrass=35, and unvegetated bottom=35. Total number of animals collected in all habitats combined is given for each taxa. Relative abundance (RA) of species within major categories (fishes, crustaceans, and molluscs) for all habitats combined are given only when equal to a least 1%.

	Spartina marsh		Seagrass beds		Unvegetated bottom		Total	
SPECIES	**MEAN**	**S. E.**	**MEAN**	**S. E.**	**MEAN**	**S. E.**	Catch	RA(%)
FISHES								
Naked Goby Gobiosoma bosci	4.3	(0.80)	6.4	(1.25)	0.4	(0.21)	367	54.0
Rainwater Killifish Lucania parva	1.5	(0.55)	0.9	(0.44)	0.0	(0.00)	77	11.3
Bay Anchovy Anchoa mitchilli	0.3	(0.19)	0.5	(0.28)	0.8	(0.31)	55	8.1
Spotted Seatrout Cynoscion nebulosus	0.5	(0.13)	0.5	(0.12)	0.1	(0.05)	36	5.3
Unidentified Larval Fish	0.3	(0.10)	0.2	(0.10)	0.2	(0.10)	23	3.4
Sheepshead Minnow Cyprinodon variegatus	0.3	(0.22)	0.2	(0.14)	0.0	(0.00)	16	2.4
Gulf Killifish Fundulus grandis	0.5	(0.16)	0.0	(0.00)	0.0	(0.00)	15	2.2
Pinfish Lagodon rhomboides	0.2	(0.07)	0.3	(0.13)	0.0	(0.00)	15	2.2
Unknown fish species	0.2	(0.20)	0.1	(0.06)	0.1	(0.05)	11	1.6
Gulf Pipefish Syngnathus scovelli	0.2	(0.10)	0.1	(0.05)	0.0	(0.00)	10	1.5
Flagfin Mojarra Eucinostomus melanopterus	0.0	(0.03)	0.3	(0.26)	0.0	(0.00)	10	1.5
Blackcheek Tonguefish Symphurus plagiusa	0.0	(0.00)	0.2	(0.13)	0.0	(0.03)	7	1.0
Inland Silverside Menidia beryllina	0.0	(0.00)	0.2	(0.17)	0.0	(0.00)	6	
Mojarra Eucinostomus spp.	0.0	(0.00)	0.1	(0.06)	0.1	(0.09)	6	
Striped Mullet Mugil cephalus	0.1	(0.05)	0.1	(0.04)	0.0	(0.03)	5	
Darter goby Gobionellus boleosoma	0.0	(0.00)	0.1	(0.05)	0.0	(0.00)	4	
Gulf Toadfish Opsanus beta	0.0	(0.03)	0.0	(0.00)	0.1	(0.06)	3	
Lined Sole Achirus lineatus	0.0	(0.03)	0.0	(0.00)	0.0	(0.03)	2	
Unidetified Goby	0.0	(0.03)	0.0	(0.03)	0.0	(0.00)	2	
Red Drum Scianops ocellatus	0.0	(0.03)	0.0	(0.00)	0.0	(0.00)	1	
Sailfin Molly Poecilia latipinna	0.0	(0.03)	0.0	(0.00)	0.0	(0.00)	1	
Spotfin Mojarra Eucinostomus argenteus	0.0	(0.03)	0.0	(0.00)	0.0	(0.00)	1	
Gulf Menhaden Brevoortia patronus	0.0	(0.00)	0.0	(0.03)	0.0	(0.00)	1	
Green Goby Microgobius thalassinus	0.0	(0.00)	0.0	(0.03)	0.0	(0.00)	1	
Speckled Worm eel Myrophis puctatus	0.0	(0.00)	0.0	(0.00)	0.0	(0.03)	1	
Inshore Lizardfish Synodus foetens	0.0	(0.00)	0.0	(0.03)	0.0	(0.00)	1	
Chain Pipefish Syngnathus lousianae	0.0	(0.00)	0.0	(0.03)	0.0	(0.00)	1	
Gizzard Shad Dorosoma cepedianum	0.0	(0.00)	0.0	(0.03)	0.0	(0.00)	1	

Table 5. (Continued).

SPECIES	Spartina marsh MEAN	Spartina marsh S. E.	Seagrass beds MEAN	Seagrass beds S. E.	Unvegetated bottom MEAN	Unvegetated bottom S. E.	Total Catch	RA(%)
Gafftopsail Catfish Bagre marinus	0.0	(0.00)	0.0	(0.00)	0.0	(0.03)	1	
TOTAL FISHES	8.7	(0.99)	10.1	(1.46)	1.9	(0.50)	680	
CRUSTACEANS								
Daggerblade Grass Shrimp Palaemonetes pugio	106.0	(14.48)	4.4	(1.37)	0.0	(0.00)	3333	68.9
Blue Crab Callinectes sapidus	11.1	(0.93)	7.5	(1.42)	0.4	(0.22)	610	12.6
Brown Shrimp Penaeus aztecus	6.0	(0.94)	5.3	(1.49)	0.2	(0.08)	371	7.7
White Shrimp Penaeus setiferus	5.8	(0.94)	5.1	(1.02)	0.0	(0.03)	355	7.3
Brackish Grass Shrimp Palaemonetes intermedius	1.9	(1.06)	0.5	(0.28)	0.0	(0.00)	74	1.5
Harris Mud Crab Rhithropanopeus harissi	0.5	(0.20)	0.6	(0.28)	0.1	(0.05)	39	
Estuarine Ghost Shrimp Callianassa jamaicensis	0.0	(0.00)	0.1	(0.04)	0.8	(0.33)	29	
Ghost Shrimp Callianassa spp.	0.0	(0.00)	0.0	(0.00)	0.2	(0.12)	7	
Unknown Xanthidae	0.0	(0.33)	0.1	(0.07)	0.0	(0.03)	6	
Estuarine longeye shrimp Oygrides limicola	0.0	(0.00)	0.1	(0.09)	0.0	(0.00)	4	
Palaemonetes spp.	0.0	(0.00)	0.0	(0.03)	0.0	(0.03)	4	
Thinstripe Hermit Crab Clibanarius vittatus	0.1	(0.07)	0.0	(0.03)	0.0	(0.00)	3	
Mud Crab Neopanope texana	0.1	(0.13)	0.0	(0.00)	0.0	(0.00)	2	
Marsh Grass Shrimp Palaemonetes vulgaris	0.0	(0.03)	0.0	(0.00)	0.0	(0.00)	1	
Carolinian Ghost Shrimp Callianassa major	0.0	(0.00)	0.0	(0.00)	0.0	(0.03)	1	
Unknown Crustacean	0.0	(0.00)	0.0	(0.00)	0.0	(0.03)	1	
TOTAL CRUSTACEANS	131.5	(15.20)	23.7	(3.79)	1.8	(0.42)	4840	
MOLLUSCS								
Atlantic Rangia Rangia cuneata	0.0	(0.00)	0.8	(0.25)	2.5	(1.14)	114	80.9
Brown Rangia Rangia flexuosa	0.0	(0.00)	0.1	(0.08)	0.1	(0.09)	10	7.1
Virgin Nerite Neritina virginea	0.2	(0.08)	0.1	(0.04)	0.0	(0.00)	7	5.0
Minor Jackknife Ensis minor	0.0	(0.00)	0.1	(0.09)	0.0	(0.00)	3	2.1
Olive Nerite Neritina reclivata	0.1	(0.05)	0.0	(0.00)	0.0	(0.00)	2	1.4
Bantum Hydrobe Littoridinops palustrus	0.0	(0.03)	0.0	(0.00)	0.0	(0.00)	1	
Hooked Mussel Ischadium recurvum	0.0	(0.03)	0.0	(0.00)	0.0	(0.00)	1	
Tellin Tellina spp.	0.0	(0.00)	0.0	(0.03)	0.0	(0.00)	1	
Atlantic Papermussel Amygdalum papyrium	0.0	(0.00)	0.0	(0.03)	0.0	(0.00)	1	
Macoma Macoma spp.	0.0	(0.00)	0.0	(0.03)	0.0	(0.00)	1	
TOTAL MOLLUSCS	0.3	(0.10)	1.2	(0.29)	2.6	(1.14)	141	
GRAND TOTAL	140.5	(15.33)	35.0	(4.88)	6.3	(1.48)	5661	

Table 6. Density of animals in habitats sampled May 9-12, 1994. Mean, number of animals/sample, and (S. E.), one standard error, are given for each habitat. Sample number: marsh=30, seagrass=35, and unvegetated bottom=35. Total number of animals collected in all habitats combined is given for each taxa. Relative abundance (RA) of species within major categories (fishes, crustaceans, and molluscs) for all habitats combined are given only when at least 1%.

	Spartina marsh		Seagrass beds		Unvegetated bottom		Total catch	RA(%)
SPECIES	**MEAN**	**S.E.**	**MEAN**	**S.E.**	**MEAN**	**S.E.**		
FISHES								
Pinfish Lagodon rhomboides	4.6	(1.08)	2.1	(0.43)	0.0	(0.00)	214	29.6
Naked goby Gobiosoma bosc	2.1	(0.58)	3.8	(1.03)	0.3	(0.17)	208	28.8
Gulf pipefish Syngnathus scovelli	1.2	(0.36)	0.9	(0.20)	0.0	(0.00)	69	9.5
Bay anchovy Anchoa mitchilli	0.0	(0.00)	0.3	(0.14)	1.1	(0.25)	52	7.2
Inland silverside Menidia beryllina	0.6	(0.30)	0.2	(0.17)	0.0	(0.03)	27	3.7
Silver perch Bairdiella chrysoura	0.9	(0.90)	0.0	(0.00)	0.0	(0.00)	27	3.7
Sheepshead Archosargus probatocephalus	0.3	(0.11)	0.2	(0.10)	0.0	(0.00)	17	
Sheepshead minnow Cyprinodon variegatus	0.2	(0.14)	0.3	(0.22)	0.0	(0.00)	16	
White mullet Mugil curema	0.3	(0.24)	0.0	(0.00)	0.0	(0.00)	9	
Striped anchovy Anchoa hepsetus	0.0	(0.00)	0.0	(0.00)	0.2	(0.16)	8	
Unidentified goby	0.0	(0.03)	0.2	(0.12)	0.0	(0.03)	8	
Spot Leiostomus xanthurus	0.0	(0.00)	0.2	(0.08)	0.0	(0.00)	7	
Gulf killifish Fundulus grandis	0.2	(0.09)	0.0	(0.00)	0.0	(0.00)	7	
Skilletfish Gobiesox strumosus	0.2	(0.10)	0.0	(0.00)	0.0	(0.00)	6	
Gulf menhaden Brevoortia patronus	0.1	(0.07)	0.1	(0.09)	0.0	(0.00)	5	
Red drum Sciaenops ocellatus	0.1	(0.06)	0.0	(0.03)	0.0	(0.00)	5	
Rough silverside Membras martinica	0.0	(0.00)	0.0	(0.03)	0.1	(0.11)	5	
Striped mullet Mugil cephalus	0.1	(0.05)	0.1	(0.04)	0.0	(0.00)	4	
Rainwater killifish Lucania parva	0.1	(0.07)	0.1	(0.04)	0.0	(0.00)	4	
Unidentified larval fish	0.0	(0.00)	0.0	(0.03)	0.1	(0.09)	4	
Atlantic croaker Micropogonias undulatus	0.0	(0.00)	0.0	(0.00)	0.1	(0.05)	3	
Darter goby Gobionellus boleosoma	0.0	(0.00)	0.1	(0.09)	0.0	(0.00)	3	
Chain pipefish Syngnathus louisianae	0.0	(0.03)	0.1	(0.04)	0.0	(0.00)	3	
Southern flounder Paralichthys lethostigma	0.0	(0.03)	0.0	(0.03)	0.0	(0.00)	2	
Spotted seatrout Cynoscion nebulosus	0.0	(0.00)	0.1	(0.06)	0.0	(0.00)	2	
Hardhead catfish Arius felis	0.0	(0.00)	0.0	(0.00)	0.1	(0.06)	2	
Atlantic needlefish Strongylura marina	0.0	(0.00)	0.1	(0.06)	0.0	(0.00)	2	
Speckled worm eel Myrophis punctatus	0.0	(0.00)	0.0	(0.03)	0.0	(0.00)	1	
Bay whiff Citharichthys spilopterus	0.0	(0.00)	0.0	(0.03)	0.0	(0.00)	1	
Pigfish Orthopristis chrysoptera	0.0	(0.00)	0.0	(0.03)	0.0	(0.00)	1	
Gulf toadfish Opsanus beta	0.0	(0.03)	0.0	(0.00)	0.0	(0.00)	1	
TOTAL FISHES	11.2	(1.91)	9.0	(1.44)	2.1	(0.34)	723	

Table 6. (Continued).

SPECIES	Spartina marsh MEAN	Spartina marsh S. E.	Seagrass beds MEAN	Seagrass beds S. E.	Unvegetated bottom MEAN	Unvegetated bottom S. E.	Total Catch	RA(%)
CRUSTACEANS								
Daggerblade grass shrimp Palaemonetes pugio	233.3	(26.37)	28.7	(12.23)	0.0	(0.00)	8003	81.3
Brackish grass shrimp Palaemonetes intermedius	21.2	(6.73)	2.3	(0.92)	0.0	(0.00)	717	7.3
Brown shrimp Penaeus aztecus	4.5	(0.88)	11.3	(1.25)	0.7	(0.16)	557	5.7
Blue crab Callinectes sapidus	10.3	(0.96)	2.5	(0.32)	0.1	(0.06)	401	4.1
Harris mud crab Rhithropanopeus harrissi	0.6	(0.18)	1.7	(0.29)	0.1	(0.07)	83	
Big claw snapping shrimp Alpheus heterochaelis	0.6	(0.28)	0.0	(0.00)	0.0	(0.00)	18	
Grass shrimp Palaemonetes spp.(pl)	0.0	(0.03)	0.4	(0.23)	0.1	(0.04)	16	
Thinstripe hermit Clibanarius vittatus	0.2	(0.14)	0.2	(0.08)	0.1	(0.05)	15	
White shrimp Penaeus setiferus	0.1	(0.07)	0.2	(0.08)	0.0	(0.00)	8	
Zostera shrimp Hippolyte zostericola	0.0	(0.00)	0.2	(0.15)	0.0	(0.00)	8	
Esturine ghost shrimp Callianassa jamaicensis	0.0	(0.00)	0.0	(0.03)	0.1	(0.08)	6	
Lesser blue crab Callinectes similis	0.0	(0.00)	0.1	(0.04)	0.0	(0.03)	3	
Arrow shrimp Tozeuma carolinense	0.0	(0.00)	0.1	(0.06)	0.0	(0.00)	2	
Glass shrimp Leptochela spp.	0.0	(0.00)	0.0	(0.00)	0.0	(0.03)	1	
Marsh grass shrimp Palaemonetes vulgaris	0.0	(0.00)	0.0	(0.03)	0.0	(0.00)	1	
Grass shrimp Palaemonetes spp.	0.0	(0.00)	0.0	(0.00)	0.0	(0.03)	1	
TOTAL CRUSTACEANS	270.8	(30.78)	47.7	(13.30)	1.3	(0.24)	9840	
MOLLUSCS								
Brown rangia Rangia flexuosa	0.3	(0.14)	1.8	(0.37)	3.8	(1.85)	207	41.6
Minor Jackknife Ensis minor	0.0	(0.00)	0.2	(0.12)	3.2	(0.92)	118	23.7
Sayella spp.	0.1	(0.07)	1.8	(0.63)	0.1	(0.04)	69	13.9
Plicate hornsnail Cerithidea pliculosa	0.4	(0.37)	1.0	(0.59)	0.0	(0.00)	47	9.4
Dwarf surfclam Mulinia lateralis	0.1	(0.07)	0.6	(0.37)	0.0	(0.00)	24	4.8
Tellin Tellina spp.	0.0	(0.00)	0.1	(0.09)	0.3	(0.16)	14	
Atlantic papermussel Amygdalum papyrium	0.0	(0.03)	0.1	(0.09)	0.0	(0.00)	6	
Atlantic rangia Rangia cuneata	0.0	(0.03)	0.0	(0.03)	0.1	(0.06)	4	
Virgin nerite Neritina virginea	0.0	(0.03)	0.1	(0.04)	0.0	(0.00)	3	
Say tellin Tellina texana	0.0	(0.00)	0.0	(0.00)	0.0	(0.03)	1	
Amber glassy-bubble Haminoea succinea	0.0	(0.00)	0.0	(0.03)	0.0	(0.00)	1	
Tampa tellin Tellina tampaensis	0.0	(0.00)	0.0	(0.00)	0.0	(0.03)	1	
Ribbed mussel Geukensia demissa	0.0	(0.00)	0.0	(0.00)	0.0	(0.03)	1	
Tagelus spp.	0.0	(0.03)	0.0	(0.00)	0.0	(0.00)	1	
Pitted baby-bubble Rictaxis punctostriatus	0.0	(0.00)	0.0	(0.03)	0.0	(0.00)	1	
TOTAL MOLLUSCS	1.1	(0.46)	5.8	(1.13)	7.5	(2.02)	498	
GRAND TOTAL	283.1	(31.41)	62.4	(14.46)	11.0	(2.02)	11061	

Table 7. Results of the ANOVA a priori Contrasts of differences in mean catch among habitats for the September 1993 sampling period. M = marsh, SG = seagrass, and UB = unvegetated bottom.

Taxa	Contrast	d.f.	F	p
Total Macrofauna	M vs SG	1,80	73.703	0.0001
	M vs UB	1,80	305.821	0.0001
	SG vs UB	1,80	85.864	0.0001
Total Fishes	M vs SG	1,80	0.021	0.8842
	M vs UB	1,80	49.328	0.0001
	SG vs UB	1,80	51.238	0.0001
Naked Goby	M vs SG	1,80	0.844	0.3609
	M vs UB	1,80	32.663	0.0001
	SG vs UB	1,80	47.679	0.0001
Rainwater Killifish	M vs SG	1,80	6.024	0.0163
	M vs UB	1,80	30.758	0.0001
	SG vs UB	1,80	10.354	0.0019
Bay Anchovy	M vs SG	1,80	0.073	0.7884
	M vs UB	1,80	2.385	0.1264
	SG vs UB	1,80	1.762	0.1882
Spotted Seatrout	M vs SG	1,80	0.102	0.7498
	M vs UB	1,80	9.987	0.0022
	SG vs UB	1,80	8.740	0.0041
Total Crustaceans	M vs SG	1,80	87.072	0.0001
	M vs UB	1,80	340.259	0.0001
	SG vs UB	1,80	90.004	0.0001
Daggerblade Grass Shrimp	M vs SG	1,80	182.978	0.0001
	M vs UB	1,80	489.509	0.0001
	SG vs UB	1,80	27.576	0.0001
Blue Crab	M vs SG	1,80	20.765	0.0001
	M vs UB	1,80	162.879	0.0001
	SG vs UB	1,80	72.943	0.0001
Brown Shrimp	M vs SG	1,80	4.155	0.0448
	M vs UB	1,80	77.523	0.0001
	SG vs UB	1,80	49.599	0.0001

Table 7. (Continued).

Taxa	Contrast	d.f.	F	p
White Shrimp	M vs SG	1,80	1.168	0.2831
	M vs UB	1,80	75.264	0.0001
	SG vs UB	1,80	62.488	0.0001
Total Molluscs	M vs SG	1,80	6.603	0.0120
	M vs UB	1,80	17.943	0.0001
	SG vs UB	1,80	3.008	0.0867
Atlantic Rangia	M vs SG	1,80	9.396	0.0030
	M vs UB	1,80	30.544	0.0001
	SG vs UB	1,80	6.564	0.0123

Table 8. Results of the ANOVA a priori Contrasts of differences in mean catch among habitats for the May 1994 sampling period. M = marsh, SG = seagrass, and UB = unvegetated bottom.

Taxa	Contrast	d.f.	F	p
Total Macrofauna	M vs SG	1,80	123.758	0.0001
	M vs UB	1,80	384.941	0.0001
	SG vs UB	1,80	78.183	0.0001
Total Fishes	M vs SG	1,80	1.307	0.2563
	M vs UB	1,80	55.158	0.0001
	SG vs UB	1,80	42.774	0.0001
Pinfish	M vs SG	1,80	9.371	0.003
	M vs UB	1,80	92.668	0.0001
	SG vs UB	1,80	46.693	0.0001
Naked Goby	M vs SG	1,80	1.681	0.1986
	M vs UB	1,80	14.139	0.0003
	SG vs UB	1,80	27.700	0.0001
Gulf Pipefish	M vs SG	1,80	0.140	0.7091
	M vs UB	1,80	29.763	0.0001
	SG vs UB	1,80	27.969	0.0001
Bay Anchovy	M vs SG	1,80	3.240	0.0756
	M vs UB	1,80	29.463	0.0001
	SG vs UB	1,80	14.258	0.0003
Total Crustaceans	M vs SG	1,80	186.778	0.0001
	M vs UB	1,80	856.979	0.0001
	SG vs UB	1,80	263.895	0.0001
Daggerblade Grass Shrimp	M vs SG	1,80	331.847	0.0001
	M vs UB	1,80	829.924	0.0001
	SG vs UB	1,80	121.533	0.0001
Brackish Grass Shrimp	M vs SG	1,80	106.765	0.0001
	M vs UB	1,80	192.070	0.0001
	SG vs UB	1,80	13.470	0.0004

Table 8. (Continued).

Taxa	Contrast	d.f.	F	p
Brown Shrimp	M vs SG	1,80	30.751	0.0001
	M vs UB	1,80	40.152	0.0001
	SG vs UB	1,80	152.944	0.0001
Blue Crab	M vs SG	1,80	111.305	0.0001
	M vs UB	1,80	360.686	0.0001
	SG vs UB	1,80	77.199	0.0001
Total Molluscs	M vs SG	1,80	27.641	0.0001
	M vs UB	1,80	30.520	0.0001
	SG vs UB	1,80	0.077	0.7818
Brown Rangia	M vs SG	1,80	9.799	0.0024
	M vs UB	1,80	15.937	0.0001
	SG vs UB	1,80	0.804	0.3724
Minor Jackknife	M vs SG	1,80	0.744	0.3909
	M vs UB	1,80	78.241	0.0001
	SG vs UB	1,80	69.032	0.0001

Table 9. Summary of habitat preferences in two study periods for major taxonomic groups and numerically dominant species. M = marsh, SG = seagrass, and UB = unvegetated bottom. > - significantly greater than (i.e., habitat to left of symbol contained significantly more animals than habitat to right of symbol) and = - no significant difference in animal density between habitats. Missing habitat contained no individuals of the taxon.

	Preferred Habitat	
Taxa	Fall 1993	Spring 1994
Total Macrofauna	M > SG > UB	M > SG > UB
Total Fishes	M = SG > UB	M = SG > UB
Naked Goby	M = SG > UB	M = SG > UB
Bay Anchovy	M = SG = UB	UB > SG
Rainwater Killifish	M > SG	
Spotted Seatrout	M = SG > UB	
Pinfish		M > SG
Gulf Pipefish		M = SG
Total Crustaceans	M > SG > UB	M > SG > UB
Daggerblade Grass Shrimp	M > SG	M > SG
Brown Shrimp	M > SG > UB	SG > M > UB
Blue Crab	M > SG > UB	M > SG > UB
White Shrimp	M = SG > UB	
Brackish Grass Shrimp		M > SG
Total Molluscs	UB = SG > M	UB > SG > M
Atlantic Rangia	UB > SG	
Brown Rangia		UB = SG > M
Minor Jackknife		UB > SG

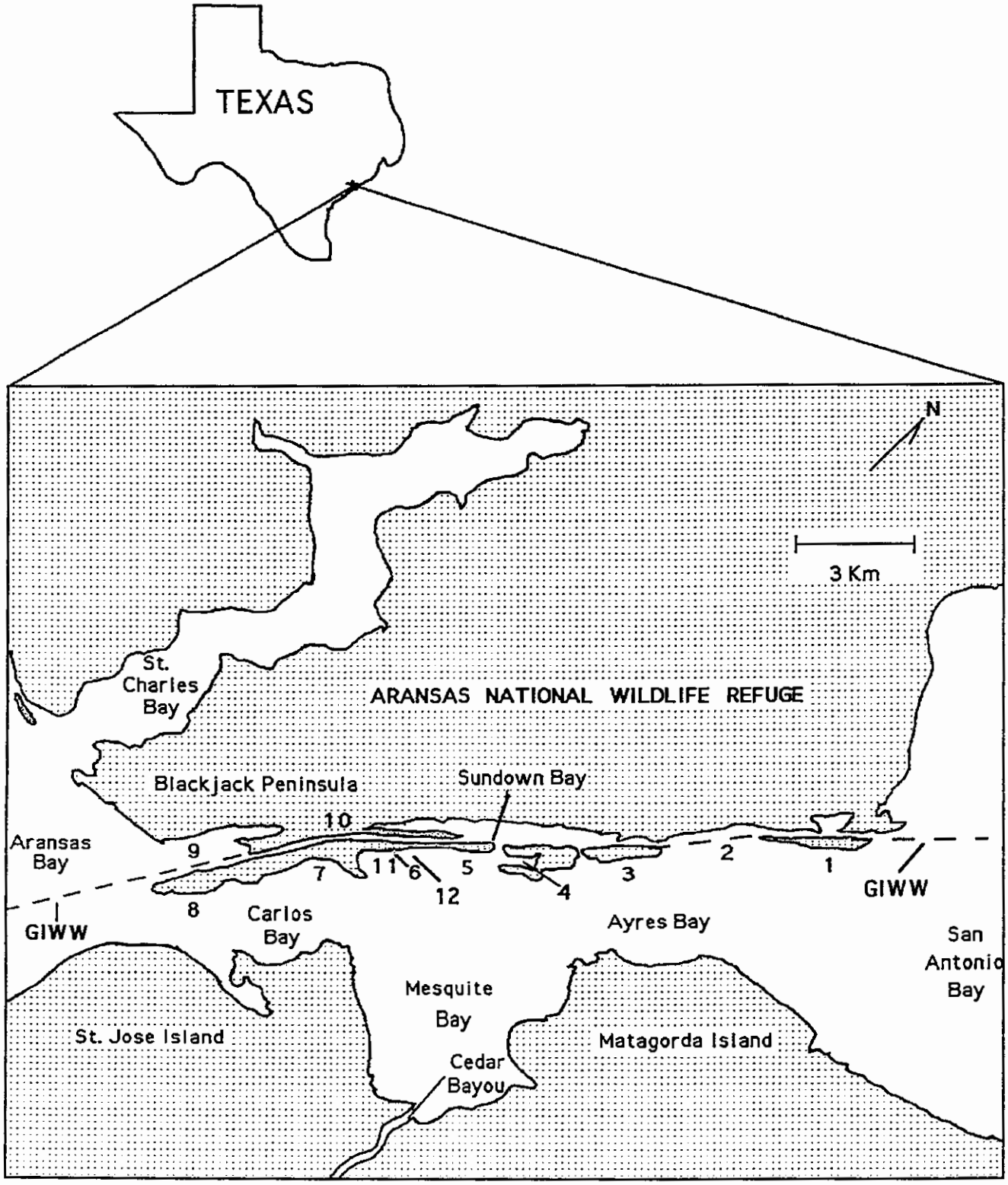

Figure 1. Map of the study area showing its location along the south Texas coast. We sampled salt marsh, seagrass, and unvegetated habitats at 20 sites in twelve locations (1-12) between San Antonio Bay and Aransas Bay. See Table 1 for habitats sampled at each location.

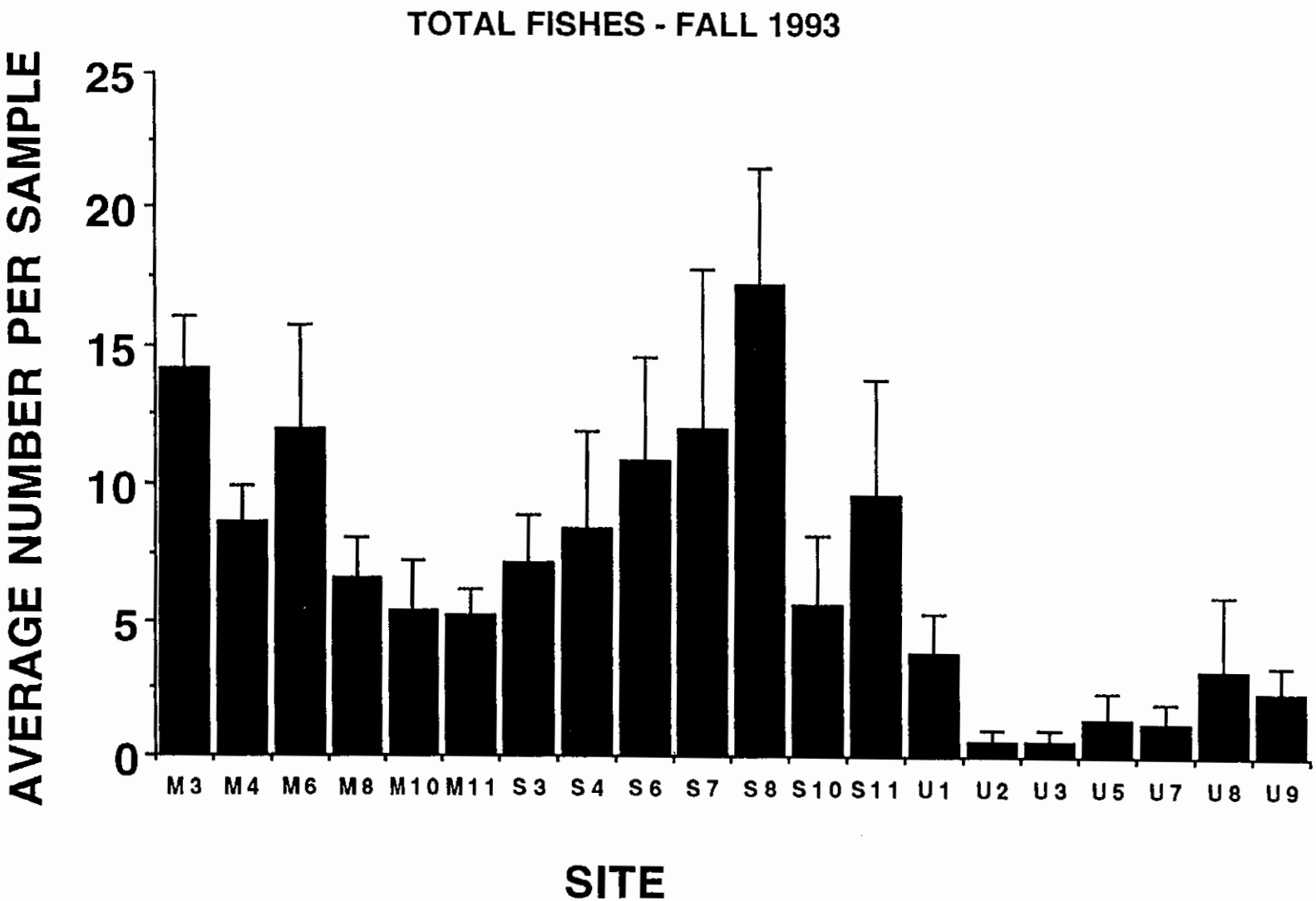

Figure 2. Average number of fishes (individuals/m^2) collected in September 1993 from each marsh (M), seagrass (S), and unvegetated (U) site. Error bars = one standard error (S. E.). Means and S. E.'s were calculated from five samples taken at each site.

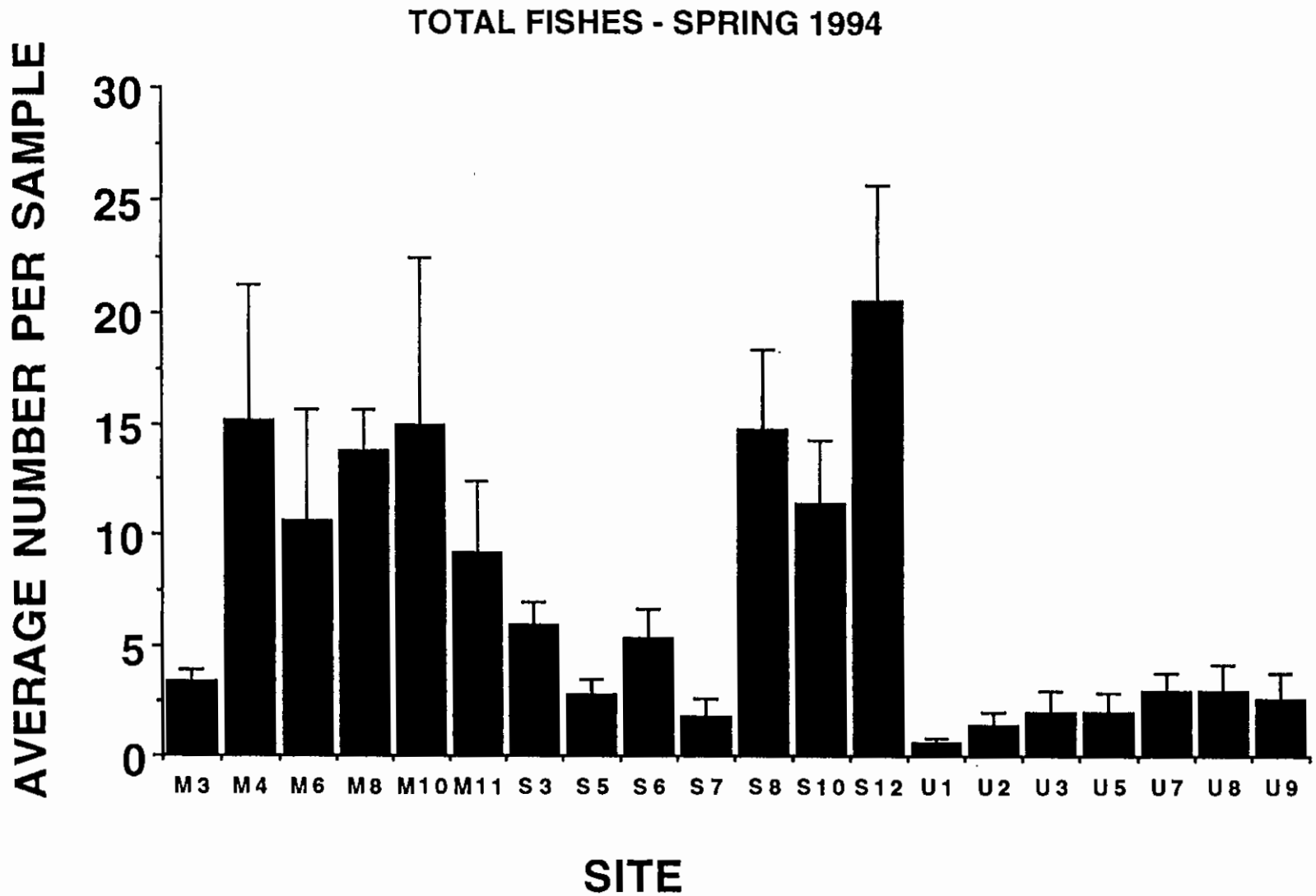

Figure 3. Average number of fishes (individuals/m^2) collected in May 1994 from each marsh (M), seagrass (S), and unvegetated (U) site. Error bars = one standard error (S. E.). Means and S. E.'s were calculated from five samples taken at each site.

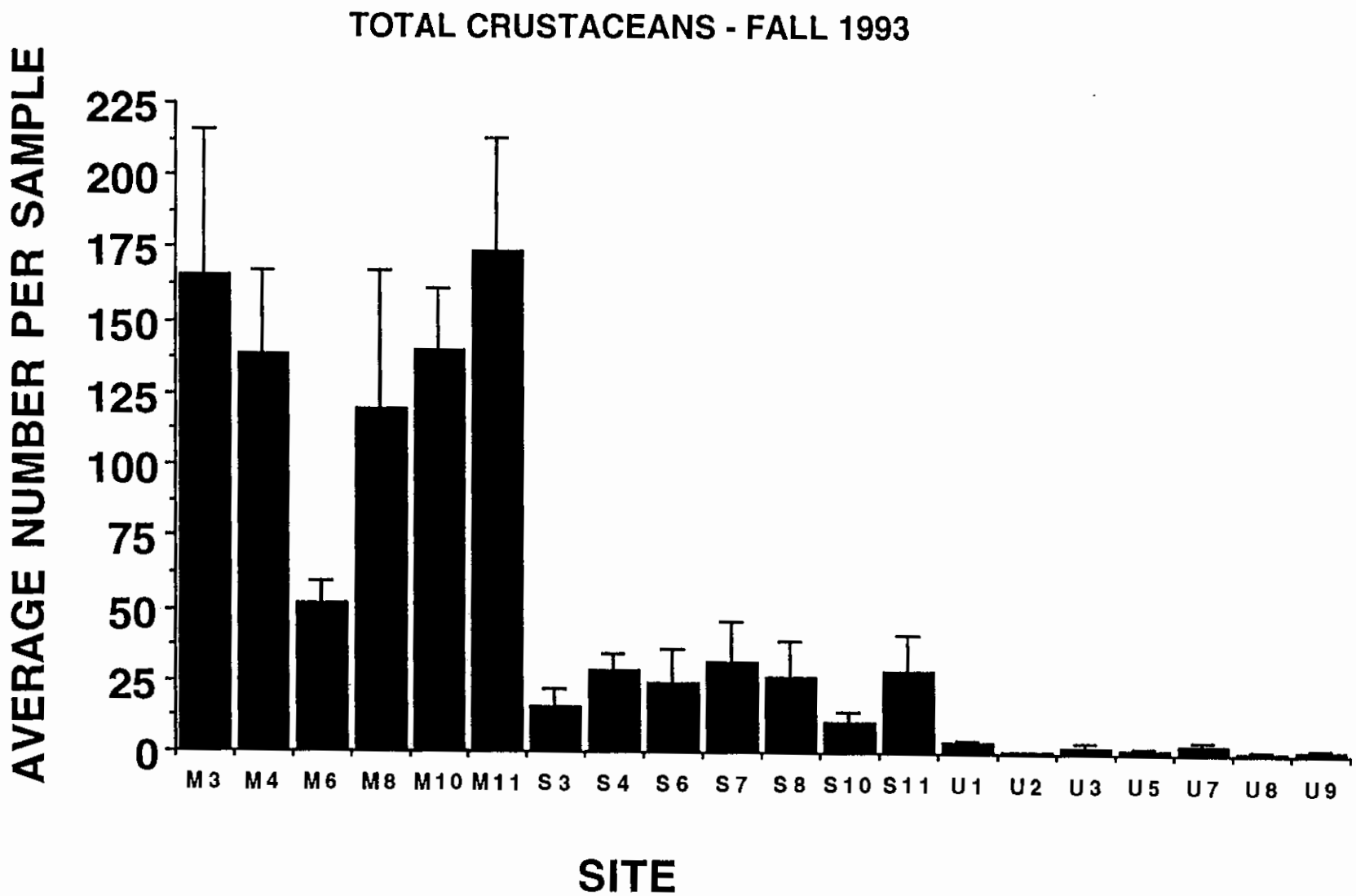

Figure 4. Average number of crustaceans (individuals/m^2) collected in September 1993 from each marsh (M), seagrass (S), and unvegetated (U) site. Error bars = one standard error (S. E.). Means and S. E.'s were calculated from five samples taken at each site.

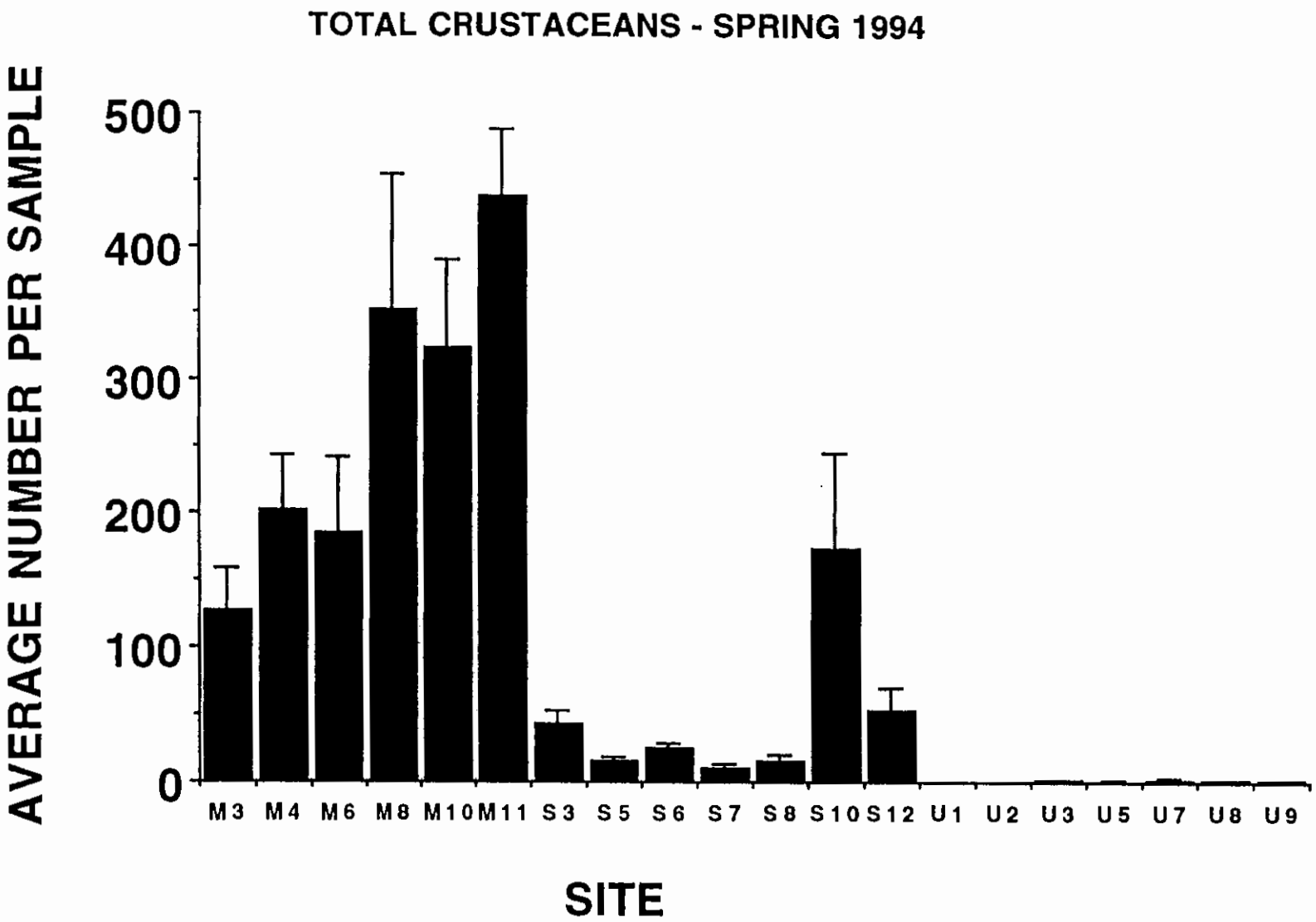

Figure 5. Average number of crustaceans (individuals/m^2) collected in May 1994 from each marsh (M), seagrass (S), and unvegetated (U) site. Error bars = one standard error (S. E.). Means and S. E.'s were calculated from five samples taken at each site.

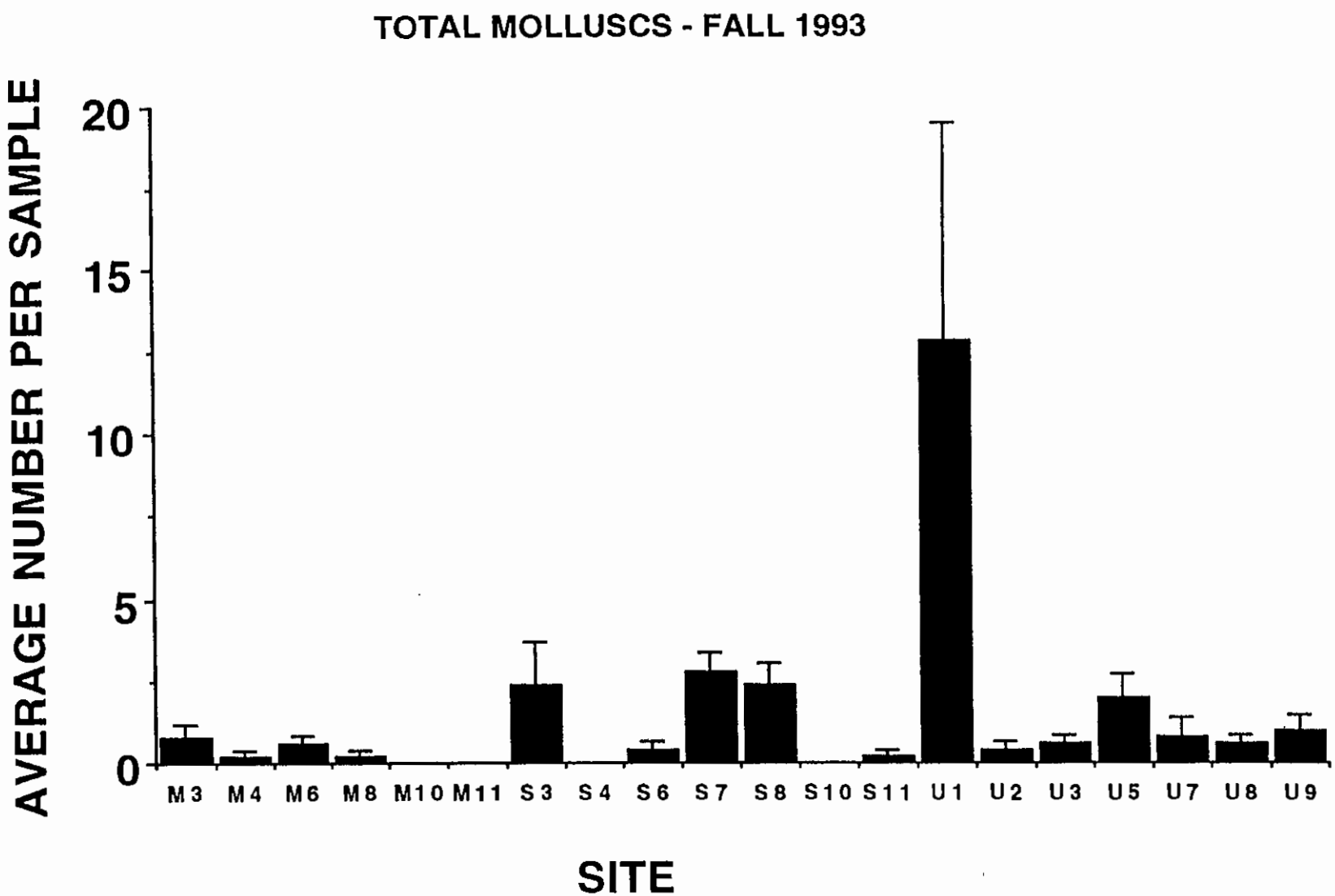

Figure 6. Average number of molluscs (individuals/m^2) collected in September 1993 from each marsh (M), seagrass (S), and unvegetated (U) site. Error bars = one standard error (S. E.). Means and S. E.'s were calculated from five samples taken at each site.

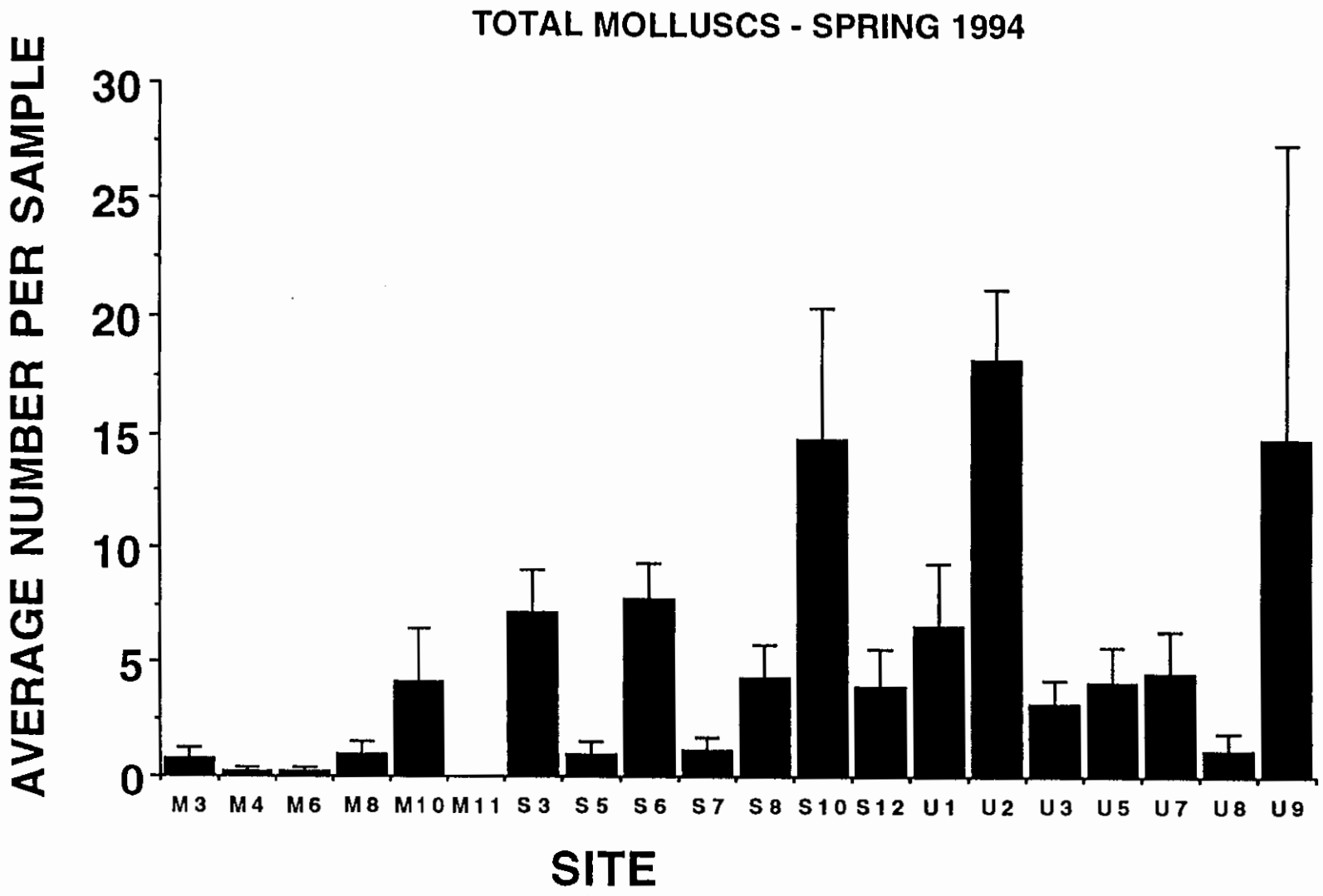

Figure 7. Average number of molluscs (individuals/m^2) collected in May 1994 from each marsh (M), seagrass (S), and unvegetated (U) site. Error bars = one standard error (S. E.). Means and S. E.'s were calculated from five samples taken at each site.

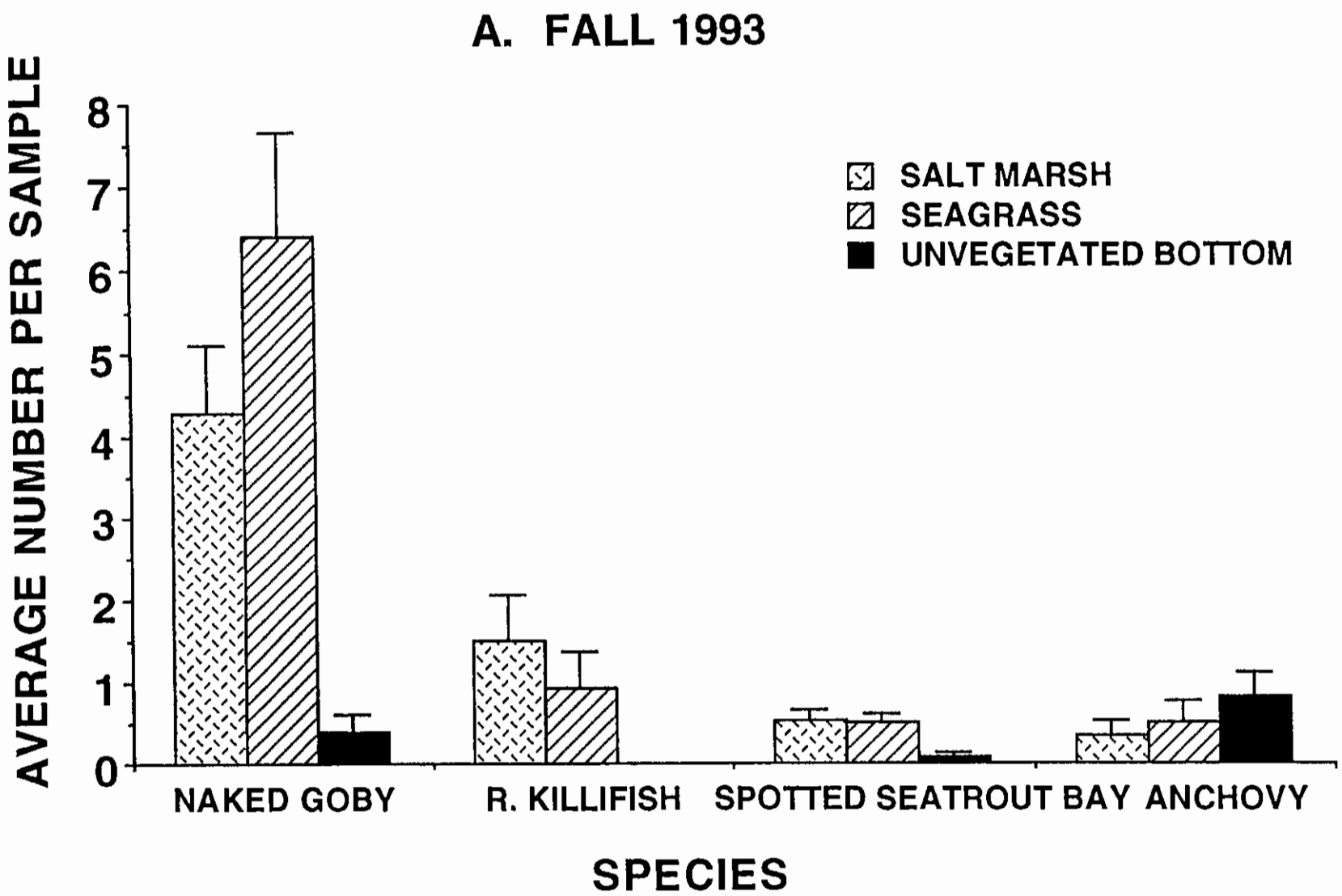

Figure 8. Average number (individuals/m^2) of numerically dominant fish species collected in September 1993 from marsh, seagrass, and unvegetated habitats. R. Killifish = Rainwater Killifish. Error bars = one standard error (S. E.). Means and S. E.'s were calculated from 30 marsh, 35 seagrass, and 35 unvegetated samples.

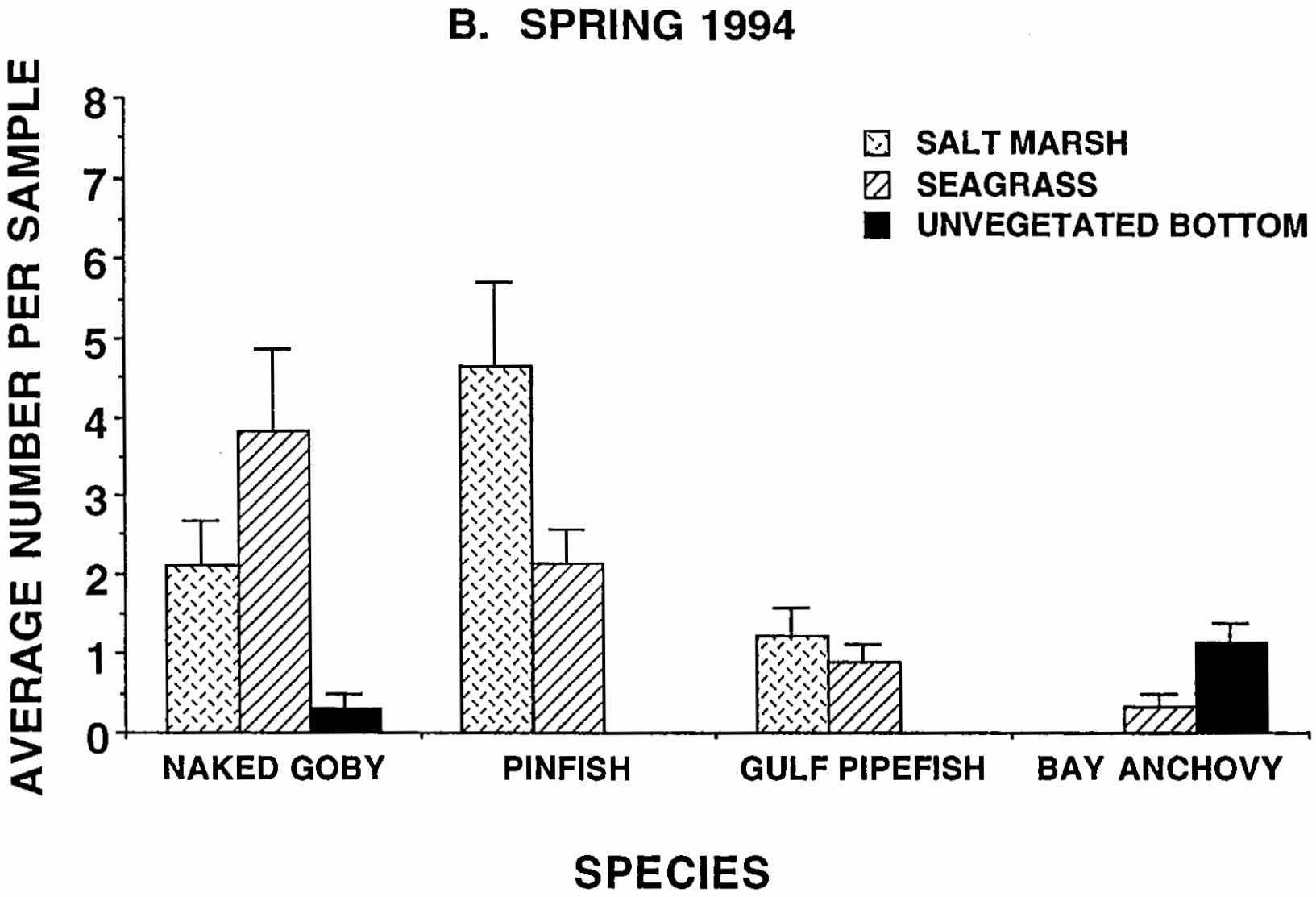

Figure 9. Average number (individuals/m^2) of numerically dominant fish species collected in May 1994 from marsh, seagrass, and unvegetated habitats. Error bars = one standard error (S. E.). Means and S. E.'s were calculated from 30 marsh, 35 seagrass, and 35 unvegetated samples.

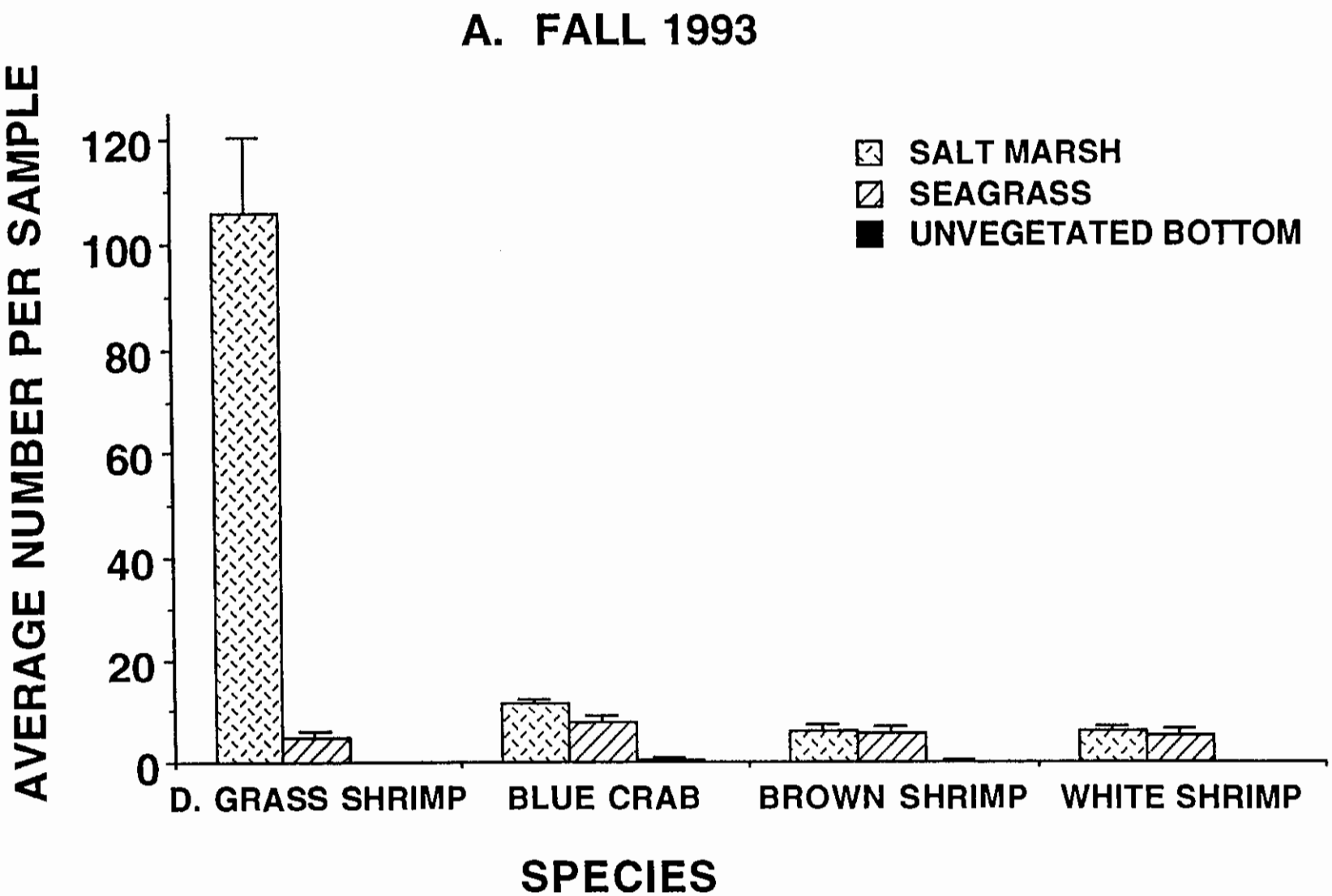

Figure 10. Average number (individuals/m^2) of numerically dominant crustacean species collected in September 1993 from marsh, seagrass, and unvegetated habitats. D. Grass Shrimp = Daggerblade Grass Shrimp. Error bars = one standard error (S. E.). Means and S. E.'s were calculated from 30 marsh, 35 seagrass, and 35 unvegetated samples.

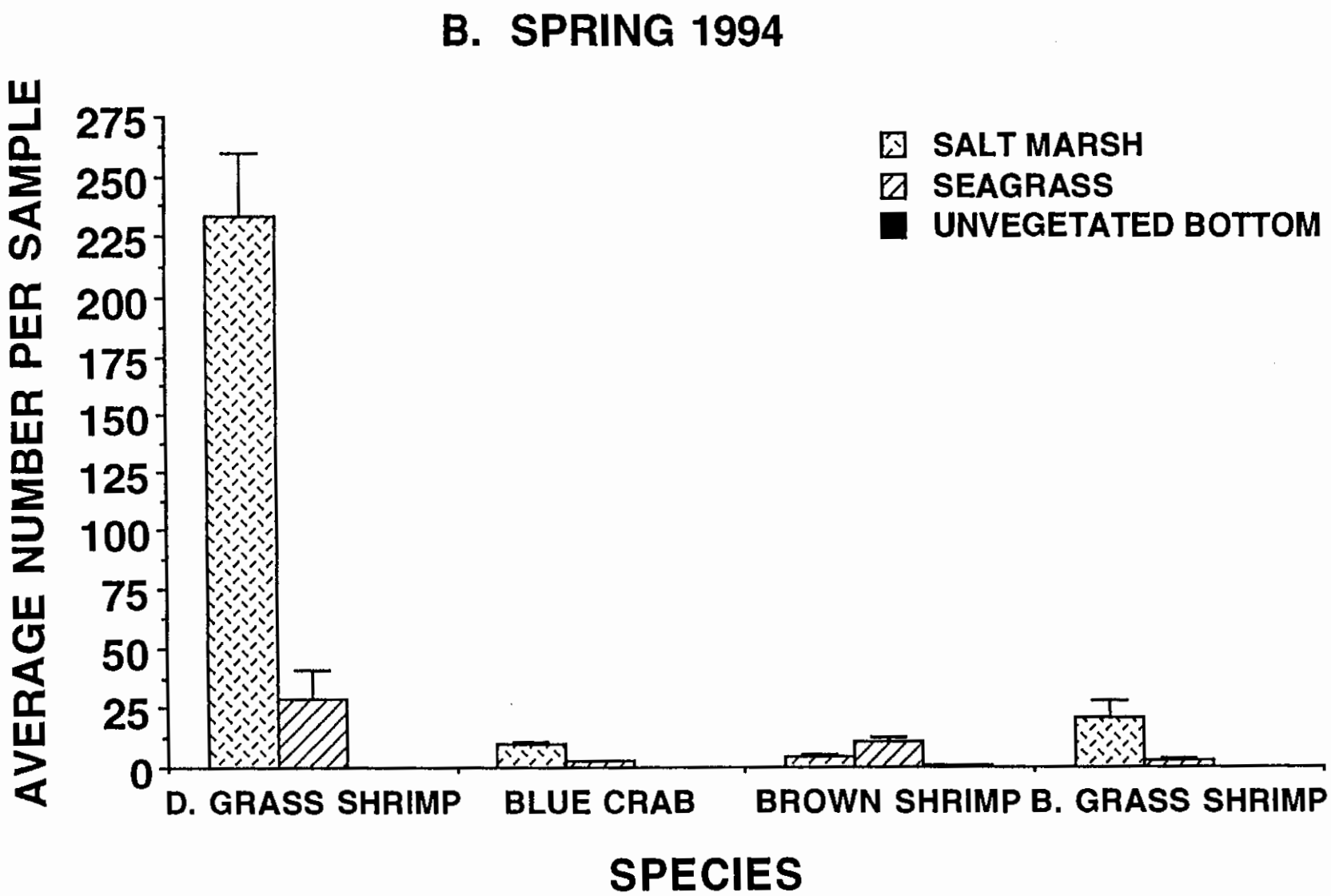

Figure 11. Average number (individuals/m^2) of numerically dominant crustacean species collected in May 1994 from marsh, seagrass, and unvegetated habitats. D. Grass Shrimp = Daggerblade Grass Shrimp. B. Grass Shrimp = Brackish Grass Shrimp. Error bars = one standard error (S. E.). Means and S. E.'s were calculated from 30 marsh, 35 seagrass, and 35 unvegetated samples.

APPENDIX B - SECTION 6

1989 USCE BIOLOGICAL ASSESSMENT AND 1993 USFWS BIOLOGICAL OPINION

BIOLOGICAL ASSESSMENT FOR

IMPACTS TO ENDANGERED AND THREATENED SPECIES

MAINTENANCE DREDGING

GULF INTRACOASTAL WATERWAY, TEXAS (STATIONS 698+000 - 860+000)

AND

CHANNEL TO VICTORIA, TEXAS (STATIONS 0+00 - 180+00)

U. S. ARMY ENGINEER DISTRICT, GALVESTON

GALVESTON, TEXAS

MAY 1989

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BIOLOGICAL ASSESSMENT FOR

IMPACTS TO ENDANGERED AND THREATENED SPECIES

MAINTENANCE DREDGING

GULF INTRACOASTAL WATERWAY, TEXAS (STATIONS 698+000 - 860+000) AND CHANNEL TO VICTORIA, TEXAS (STATIONS 0+00 - 180+00)

1.0 INTRODUCTION AND PURPOSE

This assessment is being prepared for the purpose of fulfilling the Galveston District's requirements as outlined under Section 7(c) of the Endangered Species Act. The Federal activity is the maintenance dredging of the Gulf Intracoastal Waterway, Texas (GIWW) between U. S. Army Corps of Engineers (COE) Stations 698+000 and 860+000 and maintenance dredging of the Channel to Victoria, Texas (CV) between COE Stations 0+00 and 180+00. These channel segments are within the critical habitat of the Whooping Crane.

This biological assessment is being prepared to address the use of disposal areas not previously assessed, assess impacts to species not previously listed, provide updated water and sediment quality data, and assess the effects of erosion as related to the Federal navigation projects within the critical habitat. Portions of these channels, adjacent channels, the corresponding disposal areas, and the associated impacts to listed species have been addressed in previous biological assessments (BA) and formal consultation within and adjacent to the critical habitat. The documents listed below have been previously furnished to the U. S. Fish and Wildlife Service (USFWS) and National Marine Fisheries Service (NMFS) and are incorporated by reference.

- Biological Assessment, GIWW - San Antonio Bay to Aransas Bay, June 1984 (COE, 1984).

- Biological Opinion from U. S. Fish and Wildlife Service, GIWW - San Antonio Bay to Aransas Bay, April 1985 (USFWS, 1985).

- Biological Assessment, GIWW - Matagorda Bay to Shoalwater Bay, February 1986 (COE, 1986a).

- Biological Assessment, GIWW - Channel to Victoria and Channel to Seadrift, February 1986 (COE, 1986b).

- Biological Assessment, GIWW - Across San Antonio Bay, April 1986 (COE, 1986c).

- Biological Assessment, GIWW - Across Aransas Bay (Stations 860+000 - 890+000), October 1986 (COE, 1986d).

- Biological Assessment, GIWW - Across Aransas Bay (Stations 830+000 - 860+000), April 1988 (COE, 1988a).

In addition, an August 1988 Draft report by Espey, Huston and Associates, Inc. (EH&A) entitled "Disposal Plan for Maintenance Dredging of the Gulf Intracoastal Waterway through the Critical Habitat of the Whooping Crane" is also incorporated by reference. The report provides detailed information on the project area, proposed disposal areas, habitat changes and water and sediment quality data. The draft report has been previously furnished to the USFWS and NMFS.

2.0 LISTED SPECIES AND CRITICAL HABITAT

The USFWS by letter dated March 31, 1989 and the NMFS by letter dated March 29, 1989 (Appendix A) provided a listing of the endangered and threatened species that may occur in the vicinity of the projects. These species are listed in Table 1. Of the listed species, only the whooping crane has designated critical habitat in the vicinity of the projects. The critical habitat was designated by Federal Register, Vol. 43, No. 94, Monday, May 15, 1978. The channels and the critical habitat boundary are shown on Figure 1.

3.0 DREDGING AND DISPOSAL METHODS

Dredging is performed by a hydraulic pipeline dredge. The dredging utilizes a variety of upland and open water disposal areas. The project area includes the dredging and disposal that occurs within the critical habitat on the GIWW between COE stations 698+000 and 860+000 and on the CV between stations 0+00 and 180+00. These channels have been segmented into reaches based on the historical frequency of dredging (Figures 2-5). The average frequency of maintenance dredging and average annual shoaling rate for each reach is shown below:

REACH	COE STATIONS	DREDGING FREQ.(YRS)	AVG. ANNUAL SHOALING (CY)
I	698+000 to 724+000	9.0	46,000
II	724+000 to 775+000	2.5	713,000
III	775+000 to 830+000	4.0	171,000
IV	830+000 to 860+000	3.0	279,000
CV	0+00 to 180+00	2.5	52,000

4.0 DESCRIPTION OF DISPOSAL AREAS

The disposal areas to be used for each reach are depicted in Figures 1-5 also. A complete description of all disposal areas to be utilized can be found in the corresponding referenced BA and/or in the EH&A report. Only those disposal areas not addressed in previous assessments will be included here.

TABLE 1

LIST OF ENDANGERED AND THREATENED SPECIES

LISTED SPECIES	SCIENTIFIC NAME	STATUS
Fin Whale	*Balaenoptera physalus*	E
Sei Whale	*Balaenoptera borealis*	E
Humpback Whale	*Megaptera novaeangliae*	E
Right Whale	*Balaena glacialis*	E
Sperm Whale	*Physeter catodon*	E
Leatherback Sea Turtle	*Dermochelys coriacea*	E
Hawksbill Sea Turtle	*Eretmochelys imbricata*	E
Loggerhead Sea Turtle	*Caretta caretta*	TH
Green Sea Turtle	*Chelonia mydas*	TH
Kemp's Ridley Sea Turtle	*Lepidochelys kempii*	E
Ocelot	*Felis pardalis*	E
Jaguarundi	*Felis yagouaroundi*	E
American Alligator	*Alligator mississippiensis*	TH
Attwater's Prairie Chicken	*Tympanuchus cupido attwateri*	E
Interior Least Tern	*Sterna antillarum*	E
Aplomado Falcon	*Falco femoralis septentrionalis*	E
Arctic Peregrine Falcon	*Falco peregrinus tundrius*	TH
Bald Eagle	*Haliaeetus leucocephalus*	E
Piping Plover	*Charadrius melodus*	TH
Brown Pelican	*Pelecanus occidentalis*	E
Whooping Crane	*Grus americana*	E

E - Endangered TH - Threatened

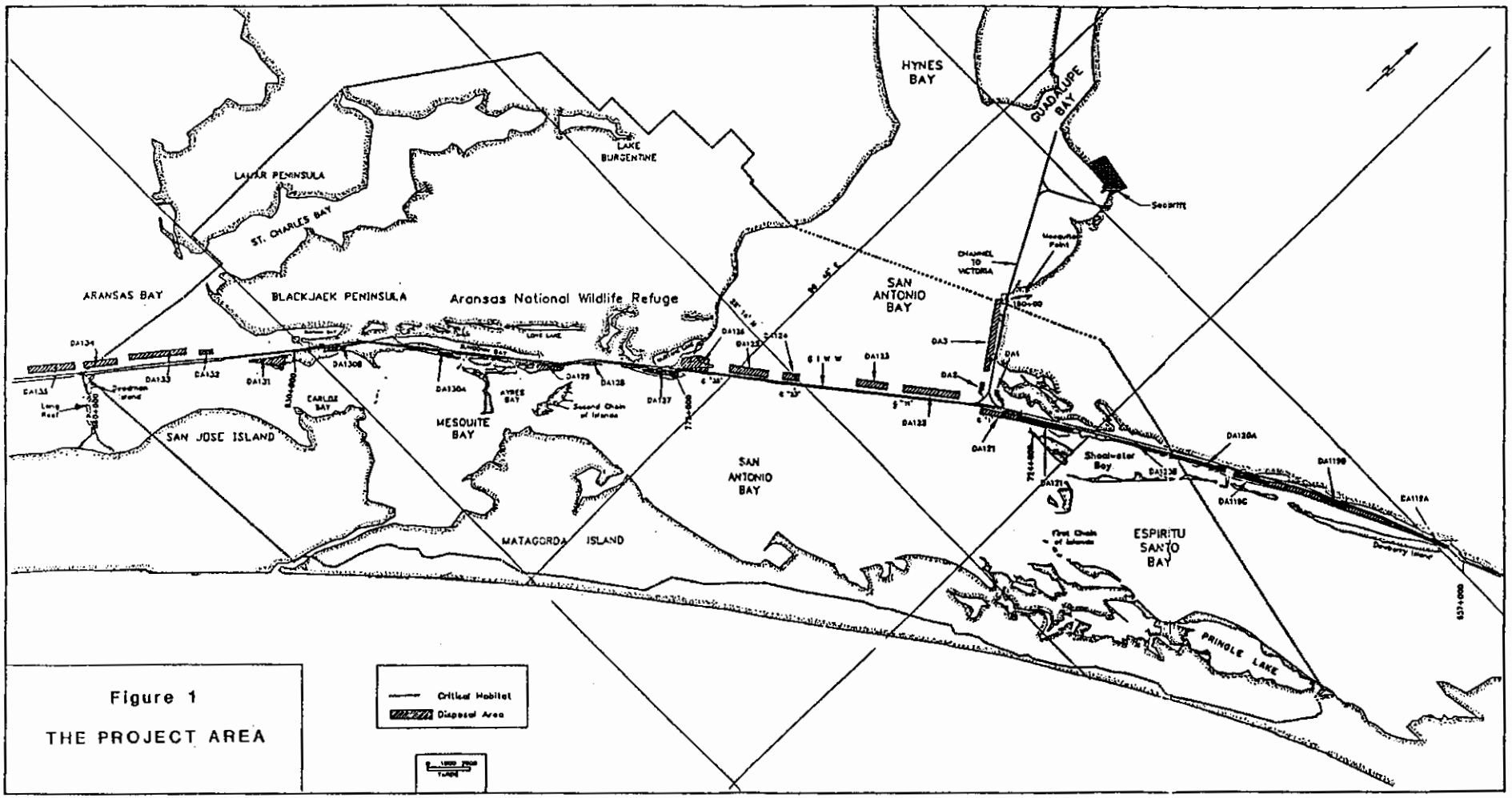


Figure 1

THE PROJECT AREA

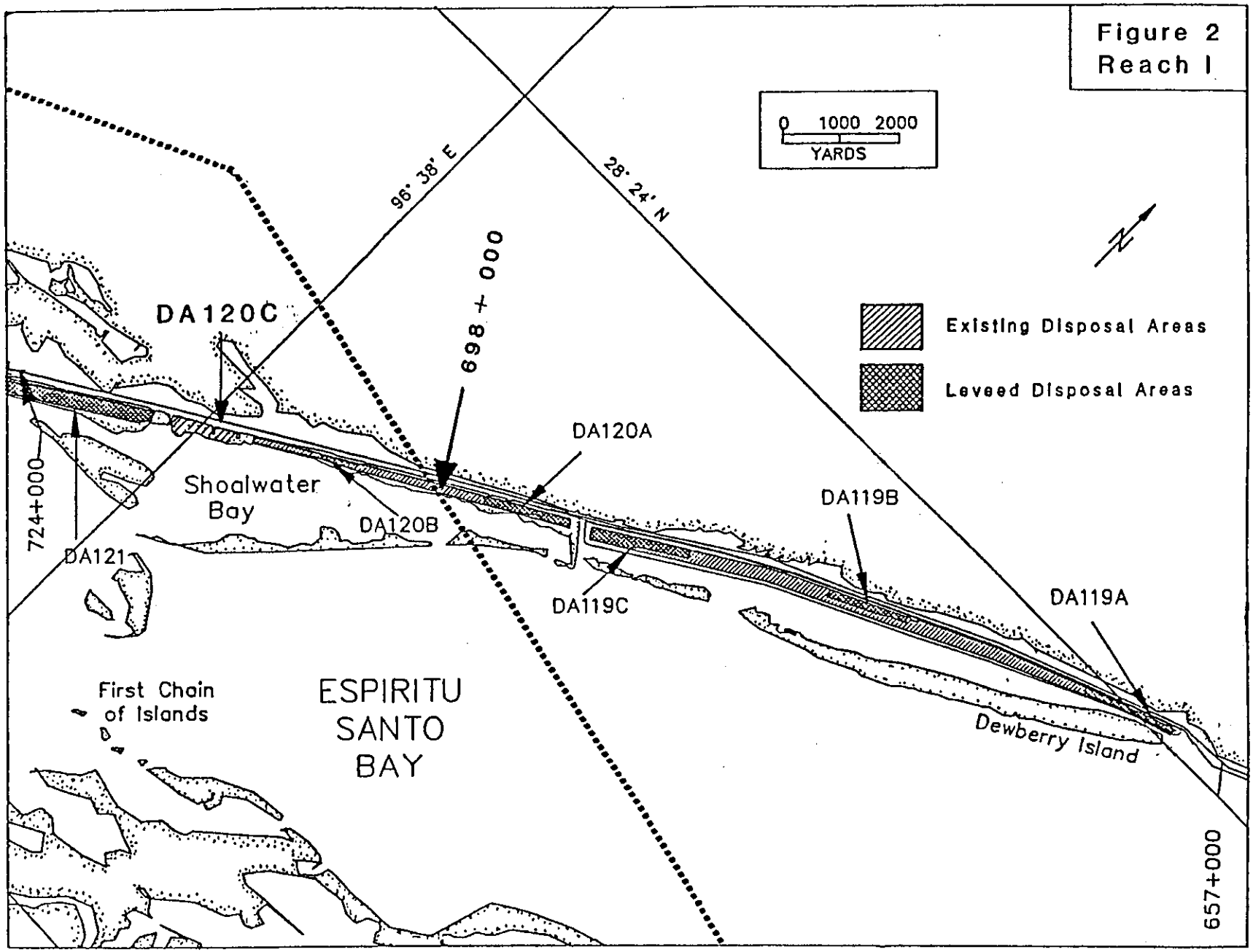


Figure 2
Reach I
0 1000 2000
YARDS
N
Existing Disposal Areas
Leveed Disposal Areas
96° 38' E
28° 24' N
698 + 000
DA120C
DA120A
DA120B
DA119B
DA119C
DA119A
DA121
724+000
657+000
Shoalwater Bay
First Chain of Islands
ESPIRITU SANTO BAY
Dewberry Island

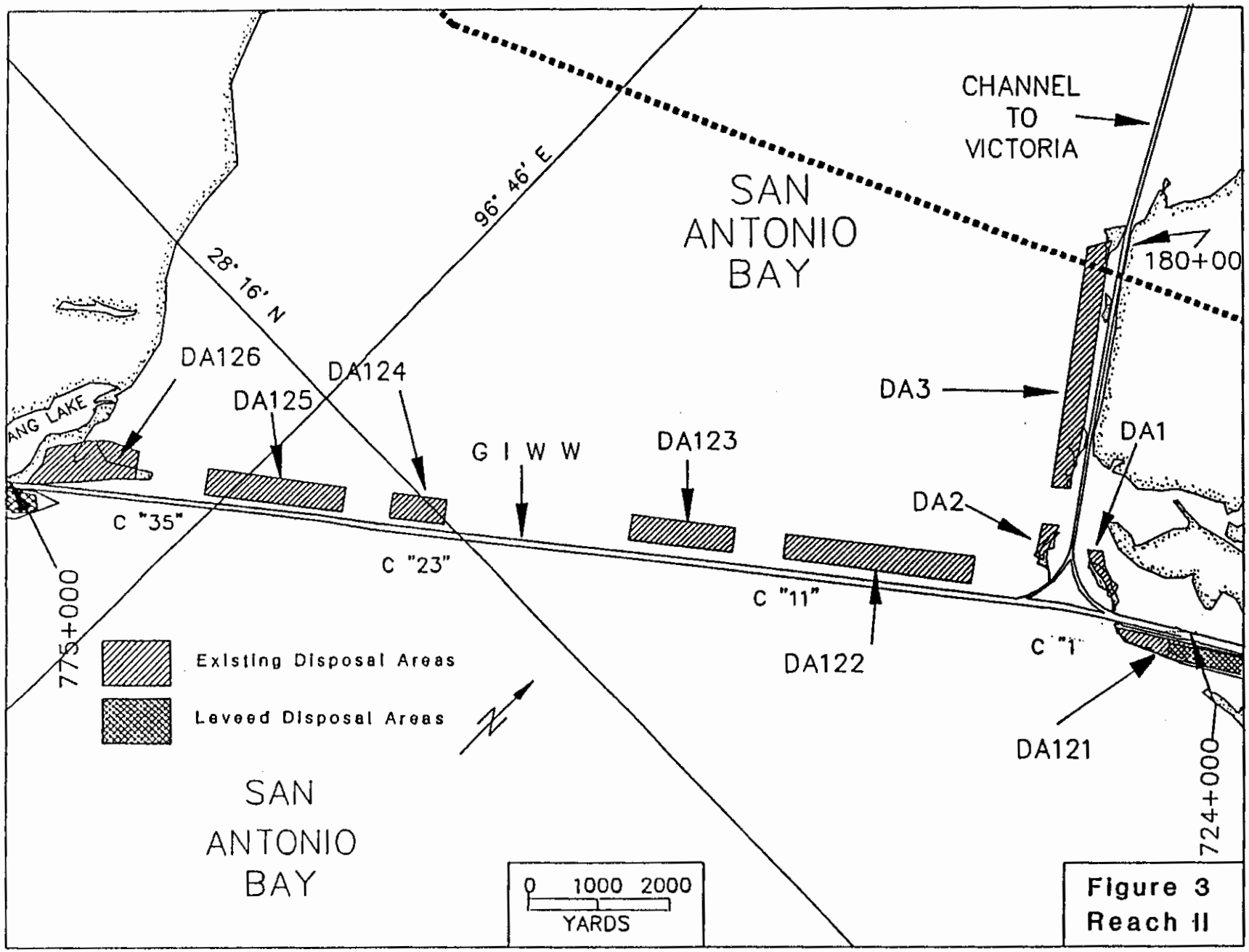


Figure 3
Reach II

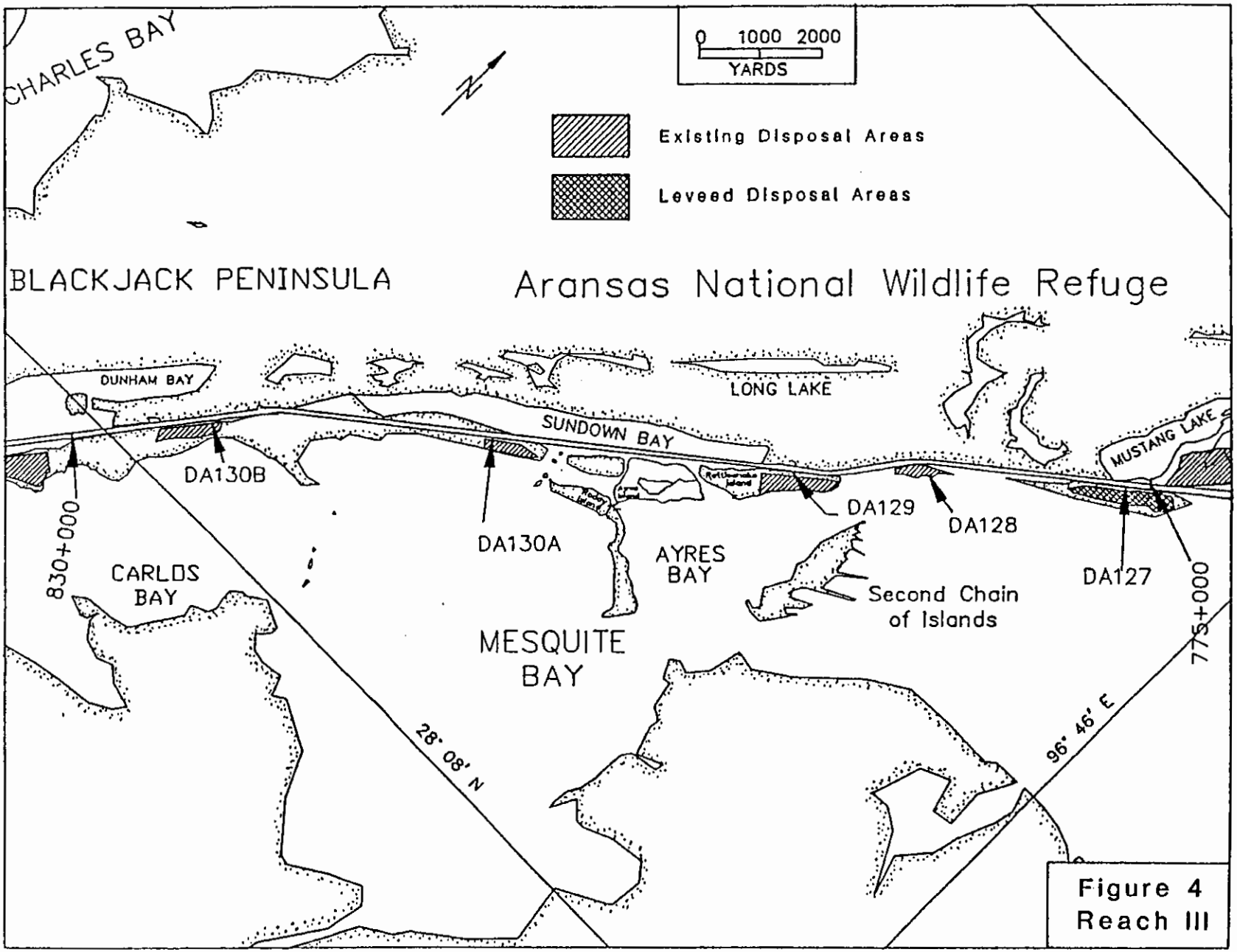


Figure 4
Reach III

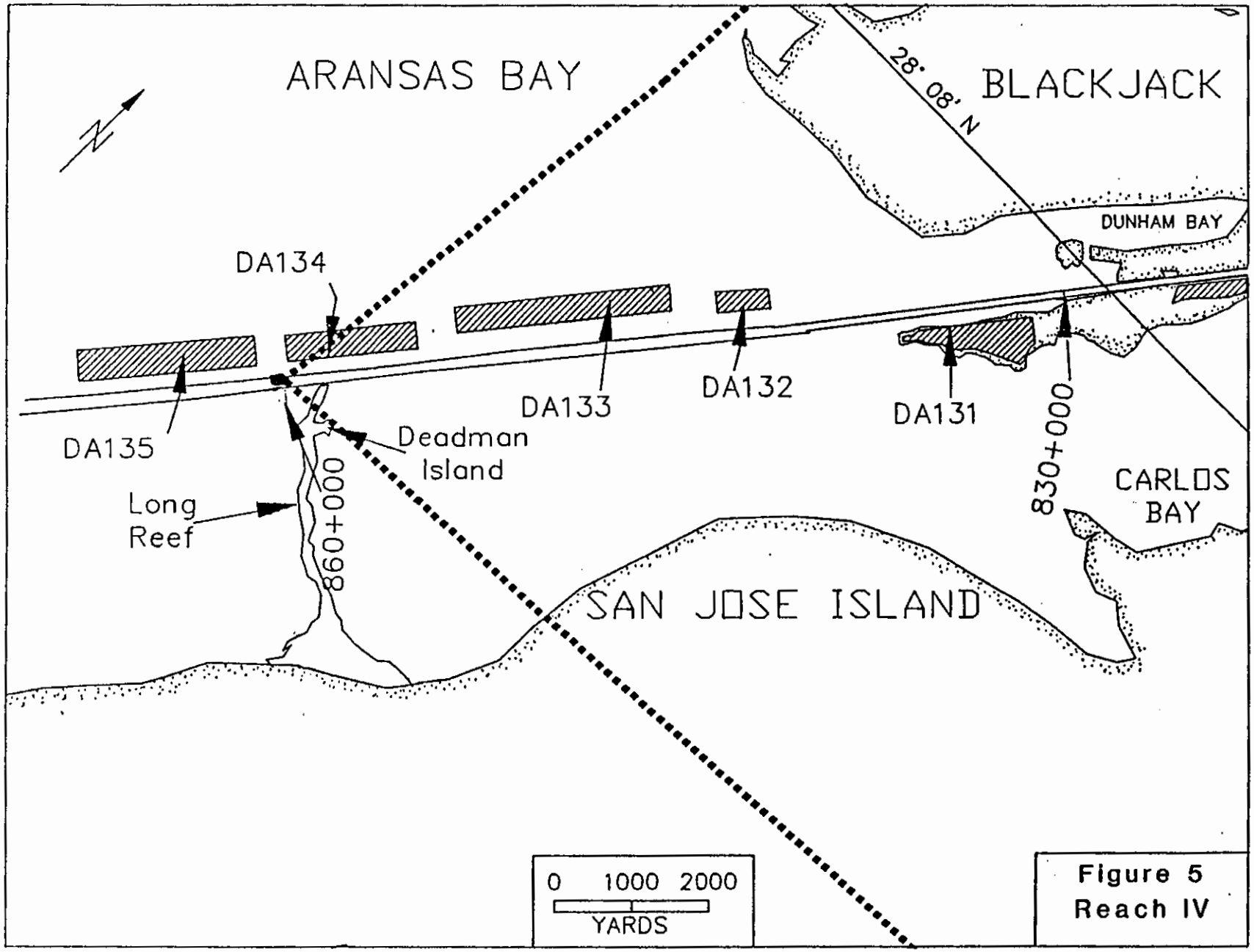


Figure 5
Reach IV

4.1 Gulf Intracoastal Waterway

Disposal Area (DA) No. 120-B. This area is the unleveed portion of the emergent island located south of the GIWW. Much of the island was created from the unconfined deposition of dredged material. As a result, elevations range from +9 feet Mean Low Tide (MLT) along the channel to +0 feet MLT along the bay shoreline. The bay shoreline is characterized by a thin belt of smooth cordgrass, *Spartina alterniflora*. Behind this fringe are the typical flats of glasswort and salt-flat grass. This area will be leveed prior to its next use. Since the island is so narrow, only the area located between approximate COE stations 702+000 - 707+000 has sufficient width to construct a levee system.

Disposal Area No. 120-C. This area is similar to DA 120-B and is located at the western end of the island between stations 713+000 - 715+000. This portion of the area has an existing levee on three sides. The eastern side is unleveed. Prior to the next dredging in this reach, the east levee will be constructed to prevent material from entering Shoalwater Bay.

Disposal Area No. 121. The western two-thirds of the upland portion of this area was completely leveed and utilized during the 1986 dredging across San Antonio Bay. On the eastern one-third of the area, the back levees have been breached by tides and two shallow ponds have formed within the disposal area. The ponds are vegetated with *Salicornia* grading into *Borrichia* moving away from the GIWW. Since Refuge personnel expressed concern that these ponds may be of potential use to cranes and the area was outside the limits of dredging, this portion was not utilized in 1986. The eastern portion will continue to be avoided until dredging occurs in this reach of the channel. When used, the existing levees will be reconstructed and no material will be allowed to flow into Shoalwater Bay.

4.2 Channel to Victoria

Disposal Area No. 1. This is a partially emergent area located along the east wye of the Channel to Victoria. There is a substantial island along the front limit. The island was created from past deposition of dredged material. The backside of the island is extremely shallow. To minimize impacts to the shallow area behind the island, this area will not be used as long as DA 2 is available.

Disposal Area No. 2. This area is similar to DA 1 and is located on the west wye. Material is deposited on the emergent island and allowed to flow into San Antonio Bay.

Disposal Area No. 3. This is a partially emergent area with several islands located on the west side of the Channel to Victoria. Some small oyster beds are located along the front limit and *Spartina* fringes the island shoreline. To minimize impacts to oyster reefs, disposal will be limited to the rear half of the area within specific limits. In addition, turbidity barriers will be used to help protect the reefs.

4.3 Direct Impacts to Disposal Areas.

Impacts to these and the other disposal areas within the critical habitat will occur as a result of open water disposal in San Antonio and Aransas Bays and upland disposal within the land-locked reaches.

The most commercially important benthic invertebrate in the bay systems is the oyster (Crassostrea virginica), which grows in reefs at several localities in the bays. The marsh clam (Rangia cuneata) occupies a wider variety of shallow water habitats in the bay area. Commercially important motile invertebrates are the blue crab (Callinectes sapidus), brown shrimp (Penaeus aztecus), and white shrimp (Penaeus setiferus). The blue crab is found in the bays, brackish flats, marsh edges and mud bottoms. The most important commercial and sport fishes are spotted seatrout (Cynoscion nebulosus), red drum (Sciaenops ocellata), and Gulf flounder (Paralichthys lethostigma).

The direct impact to these species will be from physical burial. Some immobile benthic species will be lost, while other more hardy species will survive the physical disturbance. Recolonization of the areas will generally occur in 6-12 months. Sport fishes will avoid the areas for feeding or spawning during disposal operations. Since use of these areas has occurred on a regular basis for over 40 years, these species are tolerant of these and similar disturbances resulting from hurricanes, northers, shrimping and extreme tidal fluctuations. A temporary increase in turbidity will result from disposal operations, but should subside within a few weeks. Given the naturally high turbidity levels in the bays, this impact should be minimal.

Within the leveed areas, the placement of dredged material will initially cover all vegetation inside the area and transform the habitat into a type closely resembling mudflats. For most of the first year after disposal and after heavy rains for several years, standing water would remain over much of the area. This standing water/mudflat habitat often attracts large numbers of shorebirds and some waterfowl due to the nutrient-rich, recently mixed mud with its associated invertebrate fauna. As aquatic plants become established, marshy fringes and islands are created. As supernatant water drains, the habitat succeeds from an isolated marsh-type habitat to an upland-type community.

5.0 DIRECT EFFECTS TO LISTED SPECIES

5.1 Whales

The five species of whales listed by the NMFS are known to occur in the Gulf of Mexico. Records indicate that of these species, the sperm whale is the most common along the Texas Coast (Schmidly and Shane, 1978). Sperm whales apparently prefer deeper waters and only approach shorelines characterized by shelves that drop off rapidly in depth. The gradual slope of Texas' continental shelf may account for the fact that few stranding records of this species have been recorded. Strandings for the right, sei, finback,

and humpback whales are even more rare. Since the nearest opening to the Gulf from either end of the project area is over 15 miles away, it is unlikely that any whales would be encountered. Therefore, no effects to these species are expected.

5.2 Turtles

Of the five sea turtle species which are known to occur in the Gulf of Mexico, only the green, Kemp's ridley and loggerhead normally enter bays. The hawksbill is very rare in the Gulf (NMFS, 1985) and the leatherback is an oceanic species which prefers offshore waters (Ernst and Barbour, 1972). Each of the three species that normally enter bays is discussed in more detail in the 1988 BA for Aransas Bay (COE, 1988a). These species would be expected to utilize the seagrass beds present in scattered locations, usually near shorelines adjacent to San Jose Island and the mainland. No seagrass beds are in the area to be dredged or within disposal areas.

Although some turtle species are known to possibly hibernate in channels, there is no documentation of this occurring in Texas. NMFS, however, has identified Aransas Bay as an area that may have a high potential for hibernating turtles. In January 1987 and September-October 1988, the COE funded NMFS to perform turtle trawling surveys in the GIWW in Aransas Bay. The surveys were performed in the channel prior to and during dredging operations associated with maintenance dredging of two portions of Aransas Bay. The purpose of the surveys was to insure that sea turtles were not in the channel prior to dredging. No sea turtles were taken in any trawls. Therefore, no effects to these species are expected. The COE will continue to coordinate with NMFS concerning hibernation of turtles in these channels.

5.3 Ocelot and Jaguarundi

In Texas, ocelots and jaguarundi occur in the Rio Grande Valley in the dense thorny chaparral dominated by mesquite and white brush. It has been estimated that only 1% of the South Texas area currently supports optimal habitat for these species. In southern Texas, ocelots have been observed resting in depressions in the ground, usually at the base of a large tree such as mesquite. For jaguarundi's, thickets need not be continuous, but may be interspersed with open areas (Tewes and Schmidly, 1987). The present range of the small and disjunct populations are confined to native brushlands of the lower Rio Grande Valley and possibly north along the coast to Corpus Christi. The last confirmed report of a jaguarundi was from a road-kill in Cameron County in 1986. This species may be nearly extirpated (USFWS, 1987a).

Within the project area, dense brush communities exist within the Aransas National Wildlife Refuge (ANWR) which are preferred by these species. These communities are primarily on the mainland. ANWR personnel report no record of ocelots at the Refuge. Numerous sightings of jaguarundi's have been reported, but no confirmed sightings. They have been reported on the oak uplands on the mainland (T. Stehn, ANWR, Austwell, Tx, pers. comm.). No effects to these species are expected.

5.4 American Alligator

The USFWS has recently removed the American alligator from classification as a Threatened and Endangered species. It remains, however, under a "Threatened due to Similarity of Appearance" classification as a means of protecting still jeopardized crocodilian species that have similar hides. The American alligator is no longer believed to be in danger of extinction (USFWS, 1987b). Approximately 250 alligators are at the ANWR, mostly in freshwater ponds and sloughs on the mainland (Stehn, pers. comm.). Based upon its reclassification, no effects are expected.

5.5 Attwater's Prairie Chicken

The present range of the Attwater's prairie chicken has been reduced to several coastal counties in Texas, including Aransas, Refugio, Goliad, and Victoria counties. The optimum habitat includes interspersion of short-, mid-, and tallgrass prairie, soils varying from loose sand to tight clay or silt, and close permanent sources of water (USFWS, 1980). The greatest threat to existing populations is from habitat loss due to farmland conversion, urban development, and overgrazing. The Texas population has been estimated at 452 birds in 1989. The Attwater Prairie Chicken National Wildlife Refuge was established in 1972 in Colorado County to protect the species.

ANWR personnel have reported a limited population of prairie chickens (6 birds) in the northwestern portion of the Refuge. The disposal areas do not contain the preferred habitat and are lacking in permanent sources of water. Refuge personnel report that it is unlikely the birds would be encountered within the project area (Stehn, pers. comm.). No effect on this species is expected.

5.6 Interior Least Tern

In Texas, the interior least tern is rare, numbering about 80 birds on segments of the Canadian and Red Rivers in the Texas panhandle and 60 birds on the Rio Grande River (Federal Register, 1985a). Breeding habitat characteristics include bare or nearly bare ground and alluvial islands or sandbars for nesting, availability of food, and favorable water levels during the nesting season.

At present, terns occur as small remnant colonies within their historic distribution (USFWS, 1987a). In Texas, the interior least tern's historic range includes the entire State except the coast and a 50 mile zone inland from the coast (Federal Register, 1985a). Along the coast, it is difficult to distinguish from the coastal tern. Since the project area lies within 10 miles of the coast, no effect on this species is expected.

5.7 Aplomado Falcon

The preferred habitat of this species is open terrain with scattered trees, relatively low ground cover, an abundance of small to medium-sized birds, and a supply of suitable nesting platforms, particularly yuccas and

mesquite. No nests have been verified in the United States since 1952 and they are now known to nest only in Mexico. ANWR records report only accidental occurrences of this species in the Refuge. It is unlikely that this species would be encountered within the project area, therefore, no effects are expected.

5.8 Arctic Peregrine Falcon

This species is discussed in each of the previously referenced BA's. In summary, the Texas coast from Matagorda Island southward has been found to be an important migration pathway for the arctic peregrine falcon during spring and fall migrations. South Padre Island is a major migration stopover point for the species during the periods September 22-October 25 and April 1-May 15. While not as great in numbers, falcons are frequently seen at Matagorda Island, San Jose Island and in the Welder Marsh area. There are no natural marshes or mudflats to be impacted within the project area. The interior of some confined disposal areas, with its open, rather barren aquatic habitat can attract shorebirds and therefore, falcons. Since dredging is performed between April 15 - October 15, when the birds are least likely to be present, this activity should have no effect on the species.

5.9 Bald Eagle

The bald eagle has also been discussed in previous BA's. In summary, bald eagles in Texas frequent the Gulf Coast, estuaries, rivers, and lakes (Oberholser, et al., 1974). High unobstructed perches, near water with abundant fish, are required for nesting. Only a few sightings have been reported in Aransas, Refugio, Victoria, and San Patricio Counties. Within the project area, the disposal areas do not provide suitable habitat and no known areas of eagle use will be impacted. Because of the apparent rarity of the bald eagle in the project area, no effects to the species are expected.

5.10 Piping Plover

The piping plover is usually found along the coast of Texas as a migrant from fall through spring (Science Incorporated, 1981), and breeds along the north Atlantic coast and in the northern Great Plains (USFWS, 1984). This species leaves the breeding grounds early and is one of the first birds to return north in the spring (Oberholser, et al., 1974). It feeds primarily in moist sand along beaches and sand flats adjacent to beaches and inlets (Chapman, 1984), but appears to prefer the beach habitat in fall and spring months and the sand flats during the winter months (Haig, 1987).

The plover is listed as threatened or endangered throughout its range due to disturbance from recreational vehicles and pedestrian traffic and habitat loss from commercial development of beaches and the concomitant loss of adjacent sand flats through stabilization of sand movement (USFWS, 1984, 1986; Federal Register, 1985b; Haig, 1987). Loss of wintering habitat is a significant threat to the plover, particularly in Texas, because the major portion of the population now winters along North and South Padre Island and Bolivar Flats (Federal Register, 1985b; Haig and Oring, 1985; Haig, 1987).

The dredging and disposal areas do not contain preferred habitat for the plover. In addition, plovers are not usually present during the time period dredging is performed. No effects to this species are expected.

5.11 Brown Pelican

The brown pelican is discussed in each of the previously referenced BA's. In summary, the major nesting colony is located at Brown Pelican island in Corpus Christi Bay, approximately 17 miles south of the project area (USFWS, 1987a). This colony produced 350 breeding pairs in 1987 (Texas Parks and Wildlife Department, 1987). A past colony, within the project area, has varied in location between Second Chain of Islands and Long Reef. Nesting did not occur in this area between 1983 and 1988. In 1989, 26 pairs have been observed nesting on Second Chain of Islands (Stehn, pers. comm.).

The National Audubon Society (NAS) has expressed concern that Long Reef, located within DA 134, is eroding away and could benefit from periodic replenishment with dredged material (J. Grantham, pers. comm.). However, it is necessary that disposal on Long Reef not occur during nesting season, usually March 1 - mid July. As a result, during the 1988 dredging across Aransas Bay, dredged material was deposited on the backside of Long Reef. The efficacy of this operation is still being evaluated. The COE will continue to coordinate with the NAS on nesting activities and the need for material from future dredging operations. Since disposal activities either do not impact nesting areas or are performed during non-nesting periods, no effects to this species are expected.

5.12 Whooping Crane

The whooping crane is discussed in each of the previously referenced BA's. In summary, almost the entire wild population of whooping cranes spends the winter at or near the ANWR. Along the Texas coast, the preferred habitat are permanent ponds subject to bay tides, fringe marshes in shallow bays, semi-permanent ponds connected to bayous and ephemeral ponds with superior feeding places (Allen, 1952). The cranes also use the shallow open water areas of Dunham, St. Charles and Sundown Bays. Whooping cranes begin arriving at their wintering grounds in mid-October and remain until mid-April, although some linger until mid-May. During the 1988-1989 season, 137 cranes wintered at the ANWR and one near Ganado. Of this number, one was killed and four have been unaccounted for, leaving the flock at 133 (Stehn, pers. comm.).

Whooping cranes are extremely wary of human activity and will avoid areas of human disturbance despite suitability of the habitat. For this reason, dredging and other activities are prohibited within the critical habitat between October 15 and April 15 when the whooping cranes are present in the area (USFWS, 1985). While the dredging and disposal operations are within the critical habitat of the whooping crane, no direct effect on cranes is expected since these operations are performed when the cranes are not at the critical habitat.

6.0 DIRECT EFFECTS OF DREDGING AND DISPOSAL ON CRITICAL HABITAT

Direct effects on critical habitat are related to changes in habitat from dredging and disposal operations. Effects on critical habitat from erosion are an indirect effect and are discussed in Section 7.0.

Two studies have been performed to evaluate the changes in habitat as a result of channel construction and maintenance dredging along the GIWW and CV within the critical habitat. The first study was performed by Stehn (1986) and the second in 1987 by EH&A. The EH&A study is included in EH&A (1988). Another study by Ramirez et al., (1988) also discussed habitat changes and erosion, but utilizes the data from Stehn (1986) and will not be discussed here. Both studies utilized the identical 1930 black and white and 1986 color aerial photographs to measure habitat changes. Both studies were limited by the coverage provided by the 1930 photos, which did not include most of San Antonio and Aransas Bays. In addition, both studies include habitat located outside the critical habitat boundary. This area extends east of the critical habitat for a distance of approximately eight miles along the GIWW.

6.1 Stehn Study

Stehn (1986) plotted broad habitat classes from the photos on to topographic maps and measured the changes in habitat. Aerial photographs from intermittent years were also used to identify progressive changes, although no measurements were made. The Channel to Victoria is not included in Stehn (1986). No maps are included in the report. The analysis is divided into two segments, the portion through the ANWR and the Dewberry Island to Welder Point area. Within each segment, a narrative of the changes is also provided.

The habitat changes in Stehn (1986) are summarized in Table 2. These results show a net degradation of 2,410 acres along the GIWW. Stehn (1986) indirectly attempted to distinguish between channel construction and subsequent operations and maintenance (O & M) activities by estimating the amount of channel erosion that had occurred in each segment. These estimates are discussed later.

6.2 EH&A Study

In the EH&A study (EH&A, 1988), 13 habitat types were delineated and plotted using a Computer-Aided Drafting system (AUTOCAD) and digitized to compute the differences between the photos. EH&A (1988) provides a complete description of the methods, results, and detailed maps. EH&A (1988) also included the Channel to Victoria.

While EH&A (1988) divided the area of coverage into 10 individual segments, these have been combined into two segments similar to Stehn (1986) and are summarized in Table 2. EH&A (1988) shows a net degradation of 1,985 acres on the GIWW and 71 acres on the CV. EH&A also distinguished between habitat changes associated with channel construction and O & M activities. This showed a net O & M change of 1,152 acres for the GIWW and 5 acres for the CV. The O & M period utilized is from 1941 to 1986 which represents the start of

TABLE 2

COMPARISON OF HABITAT CHANGES STUDIES

	Stehn (1986)		EHA (1988)	
Dewberry Island to Welder Point				
Acres of Habitat Loss	-1,561		-1,762	
Acres of Habitat Gain	301		654	
Net Acres	-1,260		-1,108	
Loss/Gain Ratio		5.2:1		2.7:1
Avg Acres Loss/Yr	-28		-25	
Through Aransas National Wildlife Refuge				
Acres of Habitat Loss	-1,485		-1,324	
Acres of Habitat Gain	335		447	
Net Acres	-1,150		-877	
Loss/Gain Ratio		4.4:1		3.0:1
Avg Acres Loss/Yr	-26		-19	
Total GIWW				
Acres of Habitat Loss (incl Ch)	-3,047		-3,086	
Acres of Habitat Gain	636		1,101	
Total Net Acres	-2,410		-1,985	
Total Loss/Gain Ratio		4.8:1		2.8:1
Avg Acres Loss/Yr	-54		-44	
Acres of Habitat Loss (excl Ch)	-		-2,253	
Acres of Habitat Gain	-		1,101	
O & M Net Acres	-		-1,152	
O & M Loss/Gain Ratio		-		2.0:1
Avg Acres Loss/Yr			-26	
Channel to Victoria				
Acres of Habitat Loss (incl Ch)	-		-114	
Acres of Habitat Gain	-		43	
Total Net Acres	-		-71	
Total Loss/Gain Ratio		-		2.6:1
Avg Acres Loss/Yr			-3	
Acres of Habitat Loss (excl Ch)	-		-48	
Acres of Habitat Gain	-		43	
O & M Net Acres	-		-5	
O & M Loss/Gain Ratio		-		1.1:1
Avg Acres Loss/Yr			0	

construction of the 12-foot channel and the date of the aerial photos. Over the 45-year O & M period for the GIWW, this represents a net loss of habitat of 25.6 acres per year.

EH&A (1988) states an important qualifier for this data, which would apply to Stehn (1986) as well:

> "While it can be assumed that the majority of changes have been the direct or indirect result of the construction, operation and maintenance of the GIWW, some changes are attributable to other processes such as natural erosion and accretion, subsidence, reef building or decline, natural marsh evolution and succession, fire, influence of cattle grazing and range management, and other human activities. It is not possible with this limited analysis to be able to distinguish specifically between GIWW caused changes and changes attributable to other processes."

6.3 Revised EH&A (1988) Data

Neither EH&A (1988) nor Stehn (1986) classified the habitat changes based upon the reaches and channel stations described in Section 3.0. In addition, both studies included habitat changes from an approximate 8 mile stretch of the GIWW located east of the critical habitat boundary. Since this area is located outside the critical habitat, the values have been revised to reflect this and divided into reaches. Errors found in EH&A (1988) were also corrected. These were related to acreages associated with the original channel construction. EH&A had assumed a uniform top width of channel of 210 feet. In reviewing historical dredging plans, the depth of dredging and side slopes varied among the reaches, which in turn affected the top width of channel. The maximum top width of channel constructed for each reach was:

Reach I - 210 feet
Reach II - 305 feet
Reach III - 265 feet
Reach IV - 305 feet
Ch to Vic - 166 feet

The revised EH&A data are shown in Table 3. The total net change on the GIWW within the critical habitat is reduced from 1,985 acres to 1,373 acres. The O & M loss is reduced from 1,152 acres to 540 acres. The average O & M loss is 12 acres/year rather than 26. These differences represent the net change from the excluded portion located outside of the critical habitat as well as the changes in channel top width. The construction of the channel accounts for nearly 40 % of the total change in habitat and 60 % of the net change in habitat. Of the 15,747 acres within the coverage of the aerial photographs, the 1,373 and 540 acres changed represent 8.7 % and 3.4 %, respectively, of the total habitat.

6.4 Habitat Changes Since 1974

The average O & M loss per year has been taken out of context by many resource agencies and the news media. As discussed above, within the critical

TABLE 3

REVISION OF EH&A (1988) HABITAT CHANGES DATA

	REACH I	II	III	IV	TOTAL
Including Original Channel					
Acres of Habitat Loss	-439	-350	-1,110	-215	-2,114
Acres of Habitat Gain	201	93	354	93	741
Total Net Acres	-238	-257	-756	-122	-1,373
Total Loss/Gain Ratio	2.2:1	3.8:1	3.1:1	2.3:1	2.9:1
Avg Acres Loss/Yr	-5.3	-5.7	-16.8	-2.7	-30.5
Excluding Original Channel					
Acres of Habitat Loss	-323	-234	-726	2	-1,281
Acres of Habitat Gain	201	93	354	93	741
O & M Net Acres	-122	-141	-372	95	-540
O & M Loss/Gain Ratio	1.6:1	2.5:1	2.1:1	na	1.7:1
Avg Acres Loss/Yr	-2.7	-3.1	-8.3	2.1	-12.0

habitat, the O & M loss is approximately 12 acres/year rather than 26 acres/year. This value represents an average over the 45-year time period. It does not mean that 12 acres of habitat were lost in each of 1987, 1988, and 1989. Nor does it mean that 12 acres per year have eroded away. As will be discussed below, a more appropriate time period for measurement of the 530 acre change in habitat is between 1941 and 1974.

The year 1974 is significant as it relates to habitat changes as a result of maintenance dredging and disposal activities. Prior to 1974, unconfined disposal occurred on the land portions within Reaches I and III. In this manner, habitat was always being altered, some was degraded while some was enhanced. In 1974, based on recommendations from USFWS, levees were constructed to create part of DA 120-B, DA 120-C, two-thirds of DA 121, DA 127, DA 129, and DA 131. Alteration of crane habitat as a result of disposal activities ended, for the most part, with the construction of these leveed disposal areas.

No disposal has occurred in DA 120-B or DA 120-C since 1974. At DA 121, the eastern two-thirds of the area was leveed in 1974. In subsequent uses, material flowed out of the western end until completely leveed in 1986. This form of disposal created the tidal flats behind the area, which Refuge personnel report has contributed to an increase in crane usage since 1973 (COE, 1986a). The 1986 levee was constructed on existing upland portions of the area at the request of the USFWS to prevent further material from entering San Antonio Bay.

Within the ANWR, disposal activities occurred only within leveed DA's 127, 129, and 131 between 1974 and 1985. In 1985, DA's 130-A and 130-B were constructed on upland portions of Blackjack Peninsula which cranes did not use (COE, 1984; USFWS, 1985). Comparison with 1975 aerial photos indicates that the location of these areas were densely vegetated uplands in 1975 as well.

In summary, changes in critical habitat since 1974 have not been occurring at the rate of 12 or 26 acres/year (180 or 390 acres between 1974 and 1989) as a result of disposal operations. Losses during this time period, however, have occurred as a result of erosion and other natural processes and these effects are more fully discussed in Section 7.0. Therefore, since (1) upland and open water disposal areas are being used that are not suitable crane habitat, (2) these are substantially the same areas today as they were in 1974, and (3) these areas were being utilized prior to designation of critical habitat in 1978, no adverse modification of critical habitat is occurring as a result of disposal operations.

7.0 INDIRECT AND CUMULATIVE EFFECTS OF DREDGING AND DISPOSAL

Potential indirect or cumulative effects of dredging and disposal are from resuspension of any pollutants during dredging and disposal, erosion, and levee failure.

7.1 Water and Sediment Quality

Extensive chemical and biological data have been collected by the COE within and adjacent to the project area. Table 4 summarizes the data collected by the COE and USFWS. Except as noted in the table, these data have been thoroughly discussed in EH&A (1988) and in each previously referenced BA. EH&A (1988) also contains an extensive annotated bibliography of the impacts of dredging and dredged material disposal and a review of the literature as related to chemical and biological effects.

7.1.1 Chemistry Data

Water, sediment, and elutriate analyses have been performed for a variety of heavy metals and organic compounds on samples from each dredging reach. These historical data do not indicate any significant water or sediment quality problem within the project area. Ambient water and elutriate analyses indicate that most parameters do not generally exceed EPA water quality criteria, where they exist. No EPA criteria exist for marine sediments. Sediment values are generally below detection limits for most organic compounds. While high oil and grease values were found in the project area in 1984-1985, subsequent analyses have not detected these high levels. Analysis for PAH's are all below minimum detection levels.

The potential toxicological effects of contaminants associated with bottom sediments are a function of an extremely complex array of environmental variables. Many studies have indicated that there is generally not significant release of contaminants, e.g. oil and grease, pesticides, PCB's, and heavy metals, into the water column during the discharge of dredged material (May, 1973; Fulk et al., 1975; Chen et al., 1976; Lee, 1977). DiSalvo, et al., (1977) specifically assessed sediment associated oil and grease in aquatic environments and concluded that the hydrocarbon components were not readily transferred from sediments to the tissues of estuarine species tested (USFWS, 1985).

Chemical analyses data not included in EH&A (1988) or referenced BA's are included in Appendix B. These data are from samples collected in 1988 and 1989 from the GIWW-Turnstake Island to Live Oak Point (Reach II) and the Channel to Victoria. Samples were analyzed for heavy metals, pesticides, and 16 specific PAH's. On both channels, ambient water and elutriate analyses were below the detection level for all parameters. Sediment values for heavy metals that were not below detection limits were either within or below their historical range. None of the specific PAH's were detected in any sample.

7.1.2 Bioassessment Studies

Bioassays and bioaccumulation studies have been performed on Reaches I, II, III, CV, and in Aransas Bay adjacent to Reach IV. These included liquid, suspended particulate, and solid phase bioassays from channel sediments and disposal areas. In the liquid and suspended phase tests, there were either no statistically significant differences between tests and reference or no 96-hr LC 50 could be calculated. In the solid phase bioassays, survival of individual and total organisms was not significantly different from the

TABLE 4

SUMMARY OF BIOLOGICAL AND CHEMICAL DATA COLLECTED

	DATE	TYPE OF ANALYSES	PERFORMED BY
REACH I	1985	Water/Sediment/Elutriate	COE
	* 1985	Sediment	USFWS
	1986	Bioassay/Bioaccumulation	COE
REACH II	1976	Water/Sediment	COE
	1979	Water/Sediment	COE
	1981	Water/Sediment	COE
	1983	Water/Sediment/Elutriate	COE
	1985	Water/Sediment/Elutriate	COE
	* 1985	Sediment	USFWS
	1986	Bioassay/Bioaccumulation	COE
	1987	Benthic Study	COE
	** 1988	Water/Sediment/Elutriate	COE
REACH III	1983	Water/Sediment/Elutriate	COE
	1984	Water/Sediment/Elutriate	COE
	1984	Crab & Willet Tissue	COE
	1985	Crab, Fish, & Willet Tissue	COE
	1985	Crab & Shrimp Tissue	USFWS
	* 1985	Sediment	USFWS
	1986	Disposal Area Effluent & Bioassays	COE
	1987	Disposal Area Bioassays/ Bioaccumulation	COE
	1987	Plant Tissue	USFWS
REACH IV	1977	Water/Sediment	COE
	1981	Water/Sediment	COE
	1984	Water/Sediment/Elutriate	COE
	* 1985	Sediment	USFWS
	1986	Water/Sediment/Elutriate	COE
	1986	Bioassay/Bioaccumulation	COE
	1986	Benthic Study	COE
	*** 1988	Water/Sediment/Elutriate	COE
CH TO VIC	1976	Water/Sediment	COE
	1979	Water/Sediment	COE
	1982	Water/Sediment/Elutriate	COE
	1985	Water/Sediment/Elutriate	COE
	* 1985	Sediment	USFWS
	1986	Bioassay/Bioaccumulation	COE
	** 1989	Water/Sediment/Elutriate	COE

* Reference Ramirez, et al., (1988).
** Data included in Appendix B.
*** Reference COE (1988a).

reference. In Reach III, bioassays were performed using dredged material from the confined DA's and sediment from Sundown and Dunham Bays, areas of known crane use. These bioassays showed no significant difference in survival between the bay sediments and DA sediments.

Benthic assessment studies including physical and biological characterizations have been conducted in both Aransas and San Antonio Bays. Ten disposal area stations and ten non-disposal area stations in each bay were sampled for grain-size and benthic macroinfaunal analyses. Both studies show that no major distinctions can be made between control areas and DA's based on benthic macroinfauna and sediment texture (EH&A, 1988).

7.1.3 USFWS Data

In 1985, the USFWS analyzed tissues of crab and shrimp collected in Reach III for several PAH's. With one exception, tissue levels were below detection limits and were consistent with previous COE data. The USFWS reports that the significance of this one finding can not be determined with the limited amount of data (USFWS, 1985). In 1987, samples of wolfberry from DA 129 and from Burgentine Lake were analyzed for possible uptake of trace metals. The USFWS found some metals in the DA sample higher and some lower as compared to the Burgentine Lake samples. The USFWS concluded, however, that the levels were within the range expected in background samples (EH&A, 1988).

Ramirez, et al., (1988) reports on a preliminary study conducted by the USFWS in 1985 in which oil and grease levels were analyzed in 373 sediment samples. The samples were collected from throughout the various bay systems between Port O'Connor and Rockport. Only 5 % of these samples had levels considered by Ramirez, et al., (1988) to be polluted. The majority of these higher levels were from samples collected near the many known oil and gas fields and pipelines which are within the critical habitat. While Ramirez, et al., (1988) reports that higher oil and grease levels were found in the GIWW than in the surrounding bays, no data are provided to quantify the extent and magnitude of these levels.

7.1.4 Conclusion

The results of extensive chemical analyses, bioassays and tissue analyses show that (1) resuspension of contaminants is not likely to occur, (2) contaminants are not bioaccumulating in sensitive marine species, and (3) the data support the conclusions in the literature that no unacceptable impacts will occur as a result of dredging and disposal.

7.2 Erosion

7.2.1 COE Study - ANWR

In 1988, the COE performed a study to evaluate the erosion occurring along the GIWW in the ANWR. The purpose of the study was to define the magnitude of the problem, evaluate potential solutions, and determine applicable

Federal authorities which may be used to provide erosion control in the area. The study limits were between stations 775+000 and 840+000 (COE, 1988b). Copies of this study have been previously furnished USFWS and NMFS.

The study found that two types of erosion are occurring (1) a gradual and continual overall widening of the GIWW and (2) a more rapid land loss in isolated areas. Most of the erosion is occurring along the north side of the GIWW with only minor erosion along the south side. On the north side, the average rate of erosion has been estimated at 1.5 to 3 feet per year. The average rate on the south side is one foot per year. It is estimated that 44,000 feet out of 140,000 feet of bank line (both banks) is eroding. These rates are based on comparison of 1950 and 1986 aerial photos. The areas and their erosion rates are shown on Figure 6. This indicates that 31 percent of the total reach is erosional and the remaining 69 percent is either stable, has erosion rates of less than 0.5 feet per year, or is in open water. This eroded area equates to a loss of approximately 2 feet per year (2 acres per year) or about 90 acres since 1944.

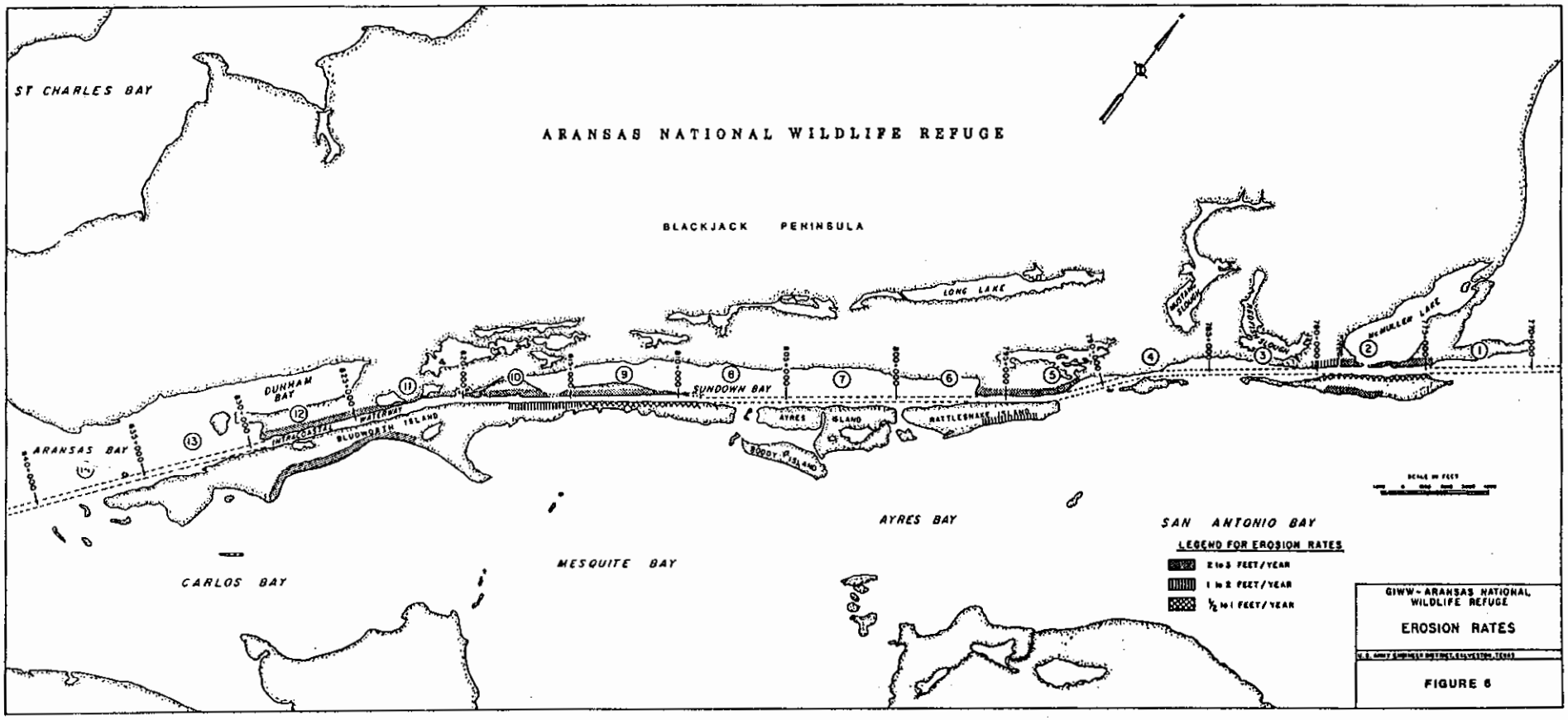
Erosion concerns along the north bank are related to breaches that have formed between the channel and isolated ponds that represent crane feeding areas. As these breaches continue to occur, the ponds will be scoured out through wave action and will lose their value as feeding areas. In addition, narrow strips of land that provided wave protection at McMullen Lake (Mustang Lake) and Sundown Bay are being lost, thus exposing greater portions of these areas to further erosion. Along the south bank, uplands are being eroded to create shallow areas of marginal crane value.

An attempt was made to correlate possible causes of the erosion and shoaling with various factors which may influence either or both of these. Factors considered were effects of GIWW traffic, river discharges, wind and wave exposure, hurricanes, and dredged material placement procedures.

Due to the general erosion in the area, it can be concluded that vessel waves are a contributing cause of the erosion. The amount of erosion caused by vessel wakes is related to a number of factors and by a complicated combination of forces as a vessel passes a location. If traffic was the only cause of the erosion, it would follow that the erosion would be equal along the opposite banks. However, since erosion has occurred at a greater rate along the north bank, there are other factors contributing to the erosion.

While most of the study area is protected from wind-generated, long fetched waves, there are several areas which are exposed to waves generated over a considerable expanse of water. Because of the northeast-southwest alignment of the channel, wind-generated waves moving across the GIWW from the prevailing southeast direction would directly strike the northern bank of the GIWW while the southern bank is protected from such waves. These south-southeast waves occur 50 percent of the time.

The shoaling rate analysis shows an extremely high shoaling rate immediately after channel construction followed by a more stable period as the channel dimensions stabilized. Since 1974, the shoaling rate has decreased. It is estimated that the portion of the eroding bank contributing to shoaling


ST CHARLES BAY
ARANSAS NATIONAL WILDLIFE REFUGE
BLACKJACK PENINSULA
LONG LAKE
MOTAL ISLAND
SALT LAKE
MULLER LAKE
DUNHAM BAY
SUNDOWN BAY
INTRACOASTAL WATERWAY
BLUNDEN ISLAND
AYRES ISLAND
RATTLESNAKE
BOOBY ISLAND
ARANSAS BAY
CARLOS BAY
MESQUITE BAY
AYRES BAY
SAN ANTONIO BAY
SCALE IN FEET
LEGEND FOR EROSION RATES
2 to 3 FEET/YEAR
1 to 2 FEET/YEAR
½ to 1 FEET/YEAR
GIWW - ARANSAS NATIONAL WILDLIFE REFUGE
EROSION RATES
U.S. ARMY ENGINEER DISTRICT, GALVESTON, TEXAS
FIGURE 6

is approximately 20 percent. The remaining 80 percent is thought to be loose bay bottom sediments that move along the bay bottom by currents generated by the wind and eventually accumulates in the channel.

In summary, the erosion within the ANWR is occurring at an average rate of 2 acres per year since 1944. The erosion is caused by a combination of traffic on the waterway and wave action from exposure to open expanses of bay waters south and southeast of the channel. To a lesser extent, hurricanes and other infrequent events cause erosion and/or shoaling in the waterway. Adequate data do not exist to quantify the amount from the various contributing agents.

7.2.2 COE Study - Shoalwater Bay/Welder Point

A limited evaluation was made of the erosion occurring within the Shoalwater Bay to Welder Point reach of the GIWW. A comparison was made of 1975 and 1986 aerial photos at ten locations where banks existed on both sides of the channel. For this time period, the erosion along the channel is estimated at 3.2 feet per year per bank. Most of this is occurring along the south bank and a portion of the north bank. This results in a loss of approximately 2.5 acres per year within this reach. It is also noted that the backside of the emergent bank accreted approximately one foot per year or 0.7 acres per year. Since no disposal has occurred in this area since 1974, with the exception of DA 121, this accretion appears to represent a marsh fringe resulting from the 1974 dredging which had not yet established in the 1975 photos.

While erosion is occurring within this reach of channel, the effects on cranes are uncertain. The high upland banks created from past unconfined disposal are being eroded to create a shallow water area between the channel top width and the emergent bank. Stehn (1986) states that this area is of marginal quality with limited crane use. Therefore, upland areas with no crane use are being eroded to create shallow areas of marginal crane use.

7.2.3 USFWS Study

Stehn (1986) estimated the amount of erosion along the GIWW within the Dewberry Island to Welder Point portion and through the ANWR. Using 1986 aerial photos, measurements were made at various points of the bank-to-bank width and an average width determined. The annual rate of erosion was then determined by subtracting the channel width and dividing by the 45 year time period.

In the Welder Point area, Stehn (1986) estimated the 1986 average width at 526 feet and the erosion rate at 7.0 feet per year (or 3.5 feet for each bank per year). Through the ANWR, the channel width was estimated at 419 feet and the erosion rate at 4.6 feet per year (or 2.3 feet for each bank per year).

Stehn (1986) used a channel width of 210 feet. As explained in Section 6.3, the constructed top widths of the channel were 210 feet and 265 feet, respectively, for Welder Point and the ANWR. Applying this correction to the ANWR data results in a revised erosion rate of 3.4 feet per year (1.7 feet per bank). These estimates are consistent with the COE studies.

7.3 Levee Failure

The USFWS has expressed concern over the potential impact of a levee failure as a result of two incidents during dredging of the GIWW through the ANWR in 1985. The ANWR areas were "repaired as necessary". Only specific sections were repaired, with the remainder of the levee system left as is. The two failures occurred in sections not designated for repairs. No failures occurred in the repaired areas. Since then, disposal area levees have been newly constructed or reconstructed. This is an important distinction from that performed at the Refuge. For all areas, the levees will be reconstructed prior to use, thus reducing the potential for failure from unrepaired sections. In addition, the levee crown width has been increased from 6 feet to 8 feet, thus providing greater levee stability.

As a result of these past failures, a Dredged Material Spill Contingency Plan has been implemented for dredging operations involving confined disposal areas. The plan requirements are shown in Table 5. These measures should reduce the potential for a levee failure and minimize any impacts. Should a breach occur, the impacts would be similar to those that created much of the existing areas.

The other major concern is the erosion occurring along the bay side of DA's 127 and 129 which is threatening to breach the levees and expose the contained dredged material to the bay (Figure 6). The primary cause of the erosion is wind-generated waves from the predominant southeast direction and is further enhanced during storm conditions. The COE is currently evaluating the most effective remedy to this problem.

The concern from this problem is whether potentially contaminated material from within the DA's will re-enter the bay system and pose a threat to cranes. As discussed in Section 7.1, the material being dredged is not considered contaminated. In addition, bioassays of the dried dredged material indicate no significant difference when compared to surrounding bay bottoms and known crane use areas. While efforts are being made to prevent the erosion of the levees, no impact to crane habitat is expected should this occur.

7.4 Other Effects

Another indirect effect as a result of maintenance dredging is the continued risk of oil or chemical spills on the GIWW and CV. As the channels are maintained, barge traffic carrying hazardous or toxic material will continue to use the channels. The risk of a spill from a collision will continue to exist.

Conversely, if the channels are not maintained, the channels will shoal to depths unsafe for this same barge traffic. Barges will continue to use the channels, thus increasing the risk of spill from a grounding or collision. Alternatively, a reduced depth would force barges to "light-load" in order to avoid grounding. This would increase the number of barges on the channels necessary to carry the same tonnage. The increased traffic would also increase the risk of a spill.

TABLE 5

DREDGED MATERIAL SPILL CONTINGENCY PLAN

Dredged Material Spill Contingency Plan. The Contractor will provide and maintain an effective dredged material spill contingency plan that includes the following as a minimum:

a) The Contractor will be required to have 24-hour a day monitoring of each confined disposal area during disposal operations. The personnel monitoring the levees will be in radio contact with the dredge. The number and qualifications of personnel to be used for this purpose should be included in the plan.

b) The Contractor will be required to identify and have available the names and phone numbers of companies having silt curtains which can contain any dredged material discharged from the disposal area.

c) The Contractor's Dredged Material Spill Contingency Plan will include the following procedures to be followed in the event of a spill:

1) The dredge will cease operations in the disposal area.

2) The Contractor will immediately notify the Contracting Officer who in turn will notify the U. S. Fish and Wildlife Service, the Texas Parks and Wildlife Department, and General Land Office.

3) The Contractor will submit a specific clean-up plan to the Contracting Officer for approval. No clean-up actions will commence until the plan has been approved by the Contracting Officer. The clean-up of misplaced material will be at the Contractor's expense.

d) The contractor will be required to submit the Dredged Material Spill Contingency Plan to the Contracting Officer for approval.

8.0 SUMMARY OF EFFECTS

Maintenance dredging of the Gulf Intracoastal Waterway and Channel to Victoria has been evaluated for direct and indirect effects on endangered and threatened species and modification of critical habitat. The following summarizes these effects:

a. No direct effect on any of the 21 listed species is expected to occur as a result of dredging and disposal operations.

b. The presently utilized upland disposal areas were created prior to critical habitat designation and impacts have been limited to these areas since 1974; therefore, no adverse modification of critical habitat is occurring as a result of disposal operations.

c. The existing open water disposal areas are not utilized by any listed species.

d. Based on extensive chemical analyses, bioassays, and tissue analyses, no direct or indirect effect to any species is expected as a result of resuspension of contaminants from dredging and disposal operations within the critical habitat.

e. Erosion along the GIWW within the Aransas National Wildlife Refuge is occurring at an average rate of 2 feet per year. This loss of approximately 2 acres per year of critical habitat is an indirect effect of the channel.

f. Erosion along the GIWW in the vicinity of Welder Point, based on limited data, is occurring at an average rate of 3 feet per year, principally along the south bank. This loss of approximately 2.5 acres per year of critical habitat is an indirect effect of the channel.

g. There is no evidence that erosion is occurring along that portion of the Channel to Victoria that is within the critical habitat.

h. The potential for levee failure has been reduced through better construction of levees.

i. Maintenance of the channel will continue the risk of oil or chemical spills. However, failure to maintain the channel may increase the risk of a spill.

9.0 CONCLUSION

Based on this assessment, modification of whooping crane critical habitat is occurring from the indirect effects of erosion along the Gulf Intracoastal Waterway between Corps of Engineers stations 698+000 - 728+000 (critical habitat boundary to Turnstake Island) and 770+000 - 838+000 (False Live Oak Point to Dunham Island). Formal consultation with the U. S. Fish and Wildlife Service will be requested for this effect to critical habitat within these areas.

10.0 LITERATURE CITED

Allen, R. P., 1952. The Whooping Crane. National Audubon Society Research Report 2. New York.

Chapman, B. R., 1984. Seasonal Abundance and Habitat Use Patterns of Coastal Bird Populations on Padre and Mustang Island Barrier Beaches. National Coastal Ecosystems Team, USFWS, FWS/OBS-83/81.

Chen K. Y., S. K. Gupta, A. Z. Sycip, J. C. S. Lu, 1976. Research Study on the Effect of Dispersion, Settling, and Resedimentation on Migration of Chemical Constituents during Open-water Disposal of Dredged Materials. Technical Report D-76-1. U. S. Army Corps of Engineers, Waterways Experiment Station, Vicksburg, MS.

DiSalvo, L. H., H. E. Guard, N. D. Hirsch, and J. Ng, 1977. Assessment and Significance of Sediment-associated Oil and Grease in Aquatic Environments. Technical Report D-77-26. U. S. Army Corps of Engineers, Waterways Experiment Station, Vicksburg, MS.

Ernst, C. H. and R. W. Barbour, 1972. Turtles of the United States. Univ. of Kentucky Press, Lexington, Ky. 347 p.

Espey, Huston and Associates, 1988. Disposal Plan for Maintenance Dredging of the Gulf Intracoastal Waterway through the Critical Habitat of the Whooping Crane (Draft, August 1988). Austin, TX.

Federal Register, 1978. Endangered and Threatened Wildlife and Plants; Determination of Critical Habitat for the Whooping Crane. 50 CFR Part 17, Vol. 43, No. 94:20937-20942.

_____, 1985a. Endangered and Threatened Wildlife and Plants; Interior Population of the Least Tern Determined to be Endangered. 50 CFR Part 17, Vol. 50, No. 102:21784-21792.

_____, 1985b. Endangered and Threatened Wildlife and Plants; Determination of Endangered and Threatened Status for the Piping Plover. 50 CFR Part 17, Vol. 50, No. 238:50726-50733.

Fulk, P., D. Cruver, and R. Wullschleger, 1975. Laboratory Study of the Release of Pesticide and PCB Materials to the Water Column during Dredging and Disposal Operations. Technical Report D-75-6. U. S. Army Corps of Engineers, Waterways Experiment Station, Vicksburg, MS.

Haig, S. M., 1987. Winter Distribution and Status of Piping Plovers on the Gulf of Mexico. Presented at Canadian Wildlife Service Symposium on Prairie Endangered Species.

Haig, S. M. and L. W. Oring, 1985. Distribution and Status of the Piping Plover Throughout the Annual Cycle. J. Field Ornithology, 56(4):334-345.

Lee, G. F., 1977. Significance of Chemical Contaminants in Dredged Sediment on Estuarine Water Quality. Proceedings of the Estuarine Pollution Control and Assessment Conference. USEPA, Washington, D. C., Vol. 1, pp. 211-216.

May, E. B., 1973. Environmental Effects of Hydraulic Dredging in Estuaries. Ala. Mar. Resour. Bull. 9:1-85.

National Marine Fisheries Service, 1985. Biological Opinion for Proposed City of Corpus Christi (Landmass) Permit Activity, NMFS, St. Petersburg, FL.

Oberholser, H. C., L. S. Fuertes and E. B. Kincaid, Jr., 1974. The Bird Life of Texas. Univ. of Texas Press, Austin, TX, 2 Vols., 1067 p.

Ramirez, P. Jr., T. V. Stehn, G. A. Jackson, and T. C. Maurer, 1988. Physical and Chemical Impacts on Whooping Crane Wintering Habitat - The Role of the Gulf Intracoastal Waterway (Draft, 1988). U. S. Fish and Wildlife Service, Corpus Christi, TX.

Science Incorporated, 1981. A Checklist to the Birds of Galveston. Compiled by A. J. Mueller. Pamphlet.

Schmidly, D. J. and S. H. Shane, 1978. A Biological Assessment of the Cetacean Fauna of the Texas Coast. Report No. MMC-74/05. Prepared for the U. S. Marine Mammal Commission.

Stehn, Tom, 1986. Impacts of the Gulf Intracoastal Waterway on the Endangered Whooping Crane (Draft, October 1986). Aransas National Wildlife Refuge, Austwell, TX.

Tewes, M. E. and D. J. Schmidly, 1987. The Neotropical Felids: Jaguar, Ocelot, Margay, and Jaguarundi. In Wild Furbearer Management and Conservation in North America, edited by M. Novak, Ontario, Canada.

Texas Parks and Wildlife Department, 1987. Texas Colonial Waterbird Census Summary-1987. Special Administrative Report, TPWD, Austin, TX.

U. S. Army Corps of Engineers, 1984. Biological Assessment of Impacts to Endangered or Threatened Species, GIWW - San Antonio Bay to Aransas Bay, Texas, June 1984. U. S. Army Engineer District, Galveston, TX.

_____, 1986a. Biological Assessment of Impacts to Endangered or Threatened Species, GIWW - Matagorda Bay to Shoalwater Bay, Texas, February 1986. U. S. Army Engineer District, Galveston, TX.

_____, 1986b. Biological Assessment of Impacts to Endangered or Threatened Species, GIWW - Channel to Victoria and Channel to Seadrift, Texas, February 1986. U. S. Army Engineer District, Galveston, TX.

_____, 1986c. Biological Assessment of Impacts to Endangered or Threatened Species, GIWW - Across San Antonio Bay, Texas, April 1986. U. S. Army Engineer District, Galveston, TX.

_____, 1986d. Biological Assessment of Impacts to Endangered or Threatened Species, GIWW - Across Aransas Bay, Texas, October 1986. U. S. Army Engineer District, Galveston, TX.

_____, 1988a. Biological Assessment of Impacts to Endangered or Threatened Species, GIWW - Across Aransas Bay, Texas, April 1988. U. S. Army Engineer District, Galveston, TX.

_____, 1988b. Study of Erosion Along GIWW in the Aransas National Wildlife Refuge, May 1988. U. S. Army Engineer District, Galveston, TX.

U. S. Fish and Wildlife Service, 1980. The Attwater's Greater Prairie Chicken. FWS/OBS-80/01.10.

_____, 1984. Listing Proposed for Four Animals: Piping Plover. Endangered Species Technical Bulletin, Vol. IX, No. 12:4-5.

_____, 1985. Biological Opinion on the Proposed Dredging of the GIWW, San Antonio Bay to Aransas Bay, Texas. U. S. Fish and Wildlife Service, Corpus Christi, TX.

_____, 1986. Three Animals Added to List of Endangered and Threatened Wildlife: Piping Plover. Endangered Species Technical Bulletin, Vol. XI, No. 1:3.

_____, 1987a. Endangered and Threatened Species of Texas and Oklahoma, 1987. U. S. Fish and Wildlife Service, Albuquerque, NM.

_____, 1987b. Alligator Reclassified Rangewide. Endangered Species Technical Bulletin, Vol. XII, No. 7:1.

APPENDIX A

CORRESPONDENCE

MAY 1 6 1989

Operations &
Maintenance Branch

Mr. Roy Perez
Field Supervisor
U.S. Fish & Wildlife Service
c/o CCSU, Box 338
6300 Ocean Drive
Corpus Christi, Texas 78412

Dear Mr. Perez:

Pursuant to Section 7(c) of the Endangered Species Act, a biological assessment for impacts to endangered and threatened species has been prepared for the maintenance dredging of the Gulf Intracoastal Waterway (GIWW) and the Channel to Victoria, Texas, within the critical habitat of the whooping crane (Enclosure). Based on this assessment, no direct or indirect effects on listed species are expected. No direct effects on critical habitat are expected. Indirect effects of erosion upon critical habitat of the whooping crane, however, are occurring.

Therefore, I request initiation of formal consultation for the indirect effects of erosion upon critical habitat of the whooping crane occurring along the GIWW between stations 698+000 - 728+000 and 770+000 - 838+000. In accordance with Section 402.14 (g)(5) of 50 CFR 402, I request that a draft copy of the biological opinion be furnished. We appreciate your continued cooperation in allowing us to fulfill our responsibilities under the Endangered Species Act.

Sincerely,

John A. Tudela
Colonel, Corps of Engineers
District Engineer

Enclosure

Copies Furnished w/encl:

USFWS, Albuquerque, New Mexico
USFWS, Aransas National Wildlife Refuge, Austwell, Texas
SDHPT, Austin, Texas
TPWD, Austin, Texas
GLO, Austin, Texas
National Audubon Society, Corpus Christi, Texas
Sierra Club Legal Defense Fund, Ms. Lori Potter, Denver, Colorado
Sierra Club, Mr. Brandt Hannchen, Houston, Texas
NMFS, St. Petersburg, Florida (w/o encl)
NMFS, Galveston, Texas (w/o encl)

UNITED STATES
DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
ECOLOGICAL SERVICES
c/o CCSU, Campus Box 338
6300 Ocean Drive
Corpus Christi, Texas 78412

March 31, 1989

George R. Rochen
Chief, Construction-Operations
Division
U.S. Army, Corps of Engineers
P. O. Box 1229
Galveston, Texas 77553

Consultation No. 2-11-89-I-77

Dear Mr. Rochen:

In a certified letter dated March 21, 1989, you requested that this office provide the Galveston District with a list of endangered, threatened, or proposed species which might occur along the Gulf Intracoastal Waterway within the critical habitat of the whooping crane. Because your letter was not received until March 29, and to prevent further delays, that list was telephoned on March 29 and 30 to Mr. Richard Medina of your Operations and Maintenance Branch. Consequently, the following list of endangered (E) and threatened (T) species is simply a confirmation of the information already provided:

Whooping Crane - E
Grus Americana

Ocelot - E
Felis pardalis

Kemp's Ridley Sea Turtle - E
Lepidochelys kempii

Piping Plover - T
Charadrius melodus

Attwater's Prairie Chicken - E
Tympanuchus cupido attwateri

Loggerhead Sea Turtle - T
Caretta caretta

Bald Eagle - E
Haliaeetus leucocephalus

American Alligator - T
Alligator mississippiensis

Jaguarundi - E
Felis yagouaroundi

Eastern Brown Pelican - E
Pelecanus occidentalis

Aplomado Falcon - E
Falco femoralis

Green Sea Turtle - T
Chelonia mydas

Arctic Peregrine Falcon - E
Falco peregrinus tundrius

Interior Least Tern - T
Sterna antillarium

Hawksbill Sea Turtle - E
Eretmochelys imbricata

We look forward to reviewing your Biological Assessment covering these species.

Sincerely,

ROGELIO PEREZ
Field Supervisor

cc:
Director, U.S. Fish and Wildlife Service, Washington, D. C.
Regional Director, U.S. Fish & Wildlife Service, Albuquerque, NM (FWE/SE)

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

Southeast Regional Office
9450 Koger Boulevard
St. Petersburg, FL 33702

March 29, 1989 F/SER23:TAH:td

Mr. George R. Rochen
Chief, Construction Operations
Division
U.S. Dept. of the Army
Galveston District, COE
Post Office Box 1229
Galveston, TX 77553-1229

Dear Mr. Rochen:

This responds to your March 21, 1989, letter requesting information on threatened and endangered species under the jurisdiction of the National Marine Fisheries Service (NOAA Fisheries) which might occur in the vicinity of the proposed project. The enclosed list contains species under NOAA Fisheries purview that may be present in the Texas marine environment.

If you have any questions, please contact Dr. Terry Henwood, Fishery Biologist, FTS 826-3366.

Sincerely yours,

Charles A. Oravetz

Charles A. Oravetz, Chief
Protected Species Management
Branch

Enclosure

Endangered and Threatened Species and Critical Habitats
under NMFS Jurisdiction

Texas

Listed species	Scientific Name	Status	Date Listed
fin whale	*Balaenoptera physalus*	E	12/02/70
humpback whale	*Megaptera novaeangliae*	E	12/02/70
right whale	*Eubaleana glacialis*	E	12/02/70
sei whale	*Balaenoptera borealis*	E	12/02/70
sperm whale	*Physeter catodon*	E	12/02/70
green sea turtle	*Chelonia mydas*	TH	07/28/78
hawksbill sea turtle	*Eretmochelys imbricata*	E	06/02/70
Kemp's (Atlantic) ridley sea turtle	*Lepidochelys kempi*	E	12/02/70
leatherback sea turtle	*Dermochelys coriacea*	E	06/02/70
loggerhead sea turtle	*Caretta caretta*	TH	07/28/78

SPECIES PROPOSED FOR LISTING
None

CRITICAL HABITAT
None

CRITICAL HABITAT PROPOSED FOR LISTING
None

APPENDIX B

WATER, SEDIMENT AND ELUTRIATE ANALYSES

GULF INTRACOASTAL WATERWAY

TURNSTAKE ISLAND TO LIVE OAK POINT

	Sample No.	Date Sampled	Station	Arsenic ug/l	Arsenic mg/kg	Cadmium ug/l	Cadmium mg/kg	Chromium ug/l	Chromium mg/kg	Copper ug/l	Copper mg/kg	Lead ug/l	Lead mg/kg
Detection Limits				2.0	1.0	2.0	0.1	10.0	1.0	1.0	1.0	5.0	1.0
Criteria (See Notes)				69.0		43.0		1100.0		2.9		140.0	
Sediment	GIC-SAB-88-1	21 Nov 88	725+000		BDL		BDL		3.4		2.8		BDL
Water	GIC-SAB-88-1	21 Nov 88	725+000	BDL		BDL		BDL		BDL		BDL	
Elutriate	GIC-SAB-88-1	21 Nov 88	725+000	BDL		BDL		BDL		BDL		BDL	
Sediment	GIC-SAB-88-2	21 Nov 88	730+000		BDL		BDL		3.2		2.4		BDL
Water	GIC-SAB-88-2	21 Nov 88	730+000	BDL		BDL		BDL		BDL		BDL	
Elutriate	GIC-SAB-88-2	21 Nov 88	730+000	BDL		BDL		BDL		BDL		BDL	
Sediment	GIC-SAB-88-3	21 Nov 88	735+000		BDL		BDL		3.7		2.6		BDL
Water	GIC-SAB-88-3	21 Nov 88	735+000	BDL		BDL		BDL		BDL		BDL	
Elutriate	GIC-SAB-88-3	21 Nov 88	735+000	BDL		BDL		BDL		BDL		BDL	
Sediment	GIC-SAB-88-4	21 Nov 88	740+000		BDL		BDL		4.2		2.8		BDL
Water	GIC-SAB-88-4	21 Nov 88	740+000	BDL		BDL		BDL		BDL		BDL	
Elutriate	GIC-SAB-88-4	21 Nov 88	740+000	BDL		BDL		BDL		BDL		BDL	
Sediment	GIC-SAB-88-5	21 Nov 88	745+000		BDL		BDL		2.8		2.6		BDL
Water	GIC-SAB-88-5	21 Nov 88	745+000	BDL		BDL		BDL		BDL		BDL	
Elutriate	GIC-SAB-88-5	21 Nov 88	745+000	BDL		BDL		BDL		BDL		BDL	
Sediment	GIC-SAB-88-DA123	21 Nov 88	745+000		BDL		BDL		1.8		1.5		BDL
Water	GIC-SAB-88-DA123	21 Nov 88	745+000	BDL		BDL		BDL		BDL		BDL	
Elutriate	GIC-SAB-88-DA123	21 Nov 88	745+000	NOTE 8									
Sediment	GIC-SAB-88-REF123	21 Nov 88	745+000		BDL		BDL		2.7		2.2		BDL
Water	GIC-SAB-88-REF123	21 Nov 88	745+000	BDL		BDL		BDL		BDL		BDL	
Elutriate	GIC-SAB-88-REF123	21 Nov 88	745+000	BDL		BDL		BDL		BDL		BDL	
Sediment	GIC-SAB-88-6	21 Nov 88	750+000		BDL		BDL		2.9		2.6		BDL
Water	GIC-SAB-88-6	21 Nov 88	750+000	BDL		BDL		BDL		BDL		BDL	
Elutriate	GIC-SAB-88-6	21 Nov 88	750+000	BDL		BDL		BDL		BDL		BDL	
Sediment	GIC-SAB-88-7	21 Nov 88	755+000		BDL		DDL		3.8		3.1		BDL
Water	GIC-SAB-88-7	21 Nov 88	755+000	BDL		BDL		BDL		BDL		BDL	
Elutriate	GIC-SAB-88-7	21 Nov 88	755+000	BDL		BDL		BDL		BDL		BDL	
Sediment	GIC-SAB-88-8	21 Nov 88	760+000		BDL		BDL		3.6		2.5		BDL
Water	GIC-SAB-88-8	21 Nov 88	760+000	BDL		BDL		BDL		BDL		BDL	
Elutriate	GIC-SAB-88-8	21 Nov 88	760+000	BDL		BDL		BDL		BDL		BDL	
Sediment	GIC-SAB-88-9	21 Nov 88	765+000		BDL		BDL		3.7		2.5		BDL
Water	GIC-SAB-88-9	21 Nov 88	765+000	BDL		BDL		BDL		BDL		BDL	
Elutriate	GIC-SAB-88-9	21 Nov 88	765+000	BDL		BDL		BDL		BDL		BDL	

GULF INTRACOASTAL WATERWAY

TURNSTAKE ISLAND TO LIVE OAK POINT

	Sample No.	Date Sampled	Station	Arsenic ug/l	Arsenic mg/kg	Cadmium ug/l	Cadmium mg/kg	Chromium ug/l	Chromium mg/kg	Copper ug/l	Copper mg/kg	Lead ug/l	Lead mg/kg
Detection Limits				2.0	1.0	2.0	0.1	10.0	1.0	1.0	1.0	5.0	1.0
Criteria (See Notes)				69.0		43.0		1100.0		2.9		140.0	
Sediment	GIC-SAB-88-DA125	21 Nov 88	765+000		BDL		<0.6		2.6		2.1		BDL
Water	GIC-SAB-88-DA125	21 Nov 88	765+000	BDL		BDL		BDL		BDL		BDL	
Elutriate	GIC-SAB-88-DA125	21 Nov 88	765+000	NOTE 8									
Sediment	GIC-SAB-88-REF125	21 Nov 88	765+000		BDL		BDL		2.9		2.4		BDL
Water	GIC-SAB-88-REF125	21 Nov 88	765+000	BDL		BDL		BDL		BDL		BDL	
Elutriate	GIC-SAB-88-REF125	21 Nov 88	765+000	BDL		BDL		BDL		BDL		BDL	
Sediment	GIC-SAB-88-10	21 Nov 88	770+000		BDL		BDL		3.1		2.4		BDL
Water	GIC-SAB-88-10	21 Nov 88	770+000	BDL		BDL		BDL		BDL		BDL	
Elutriate	GIC-SAB-88-10	21 Nov 88	770+000	BDL		BDL		BDL		BDL		BDL	
Sediment	GIC-SAB-88-11	21 Nov 88	775+000		BDL		BDL		4.0		2.9		BDL
Water	GIC-SAB-88-11	21 Nov 88	775+000	BDL		BDL		BDL		BDL		BDL	
Elutriate	GIC-SAB-88-11	21 Nov 88	775+000	BDL		BDL		BDL		BDL		BDL	

GULF INTRACOASTAL WATERWAY

TURNSTAKE ISLAND TO LIVE OAK POINT

Date Sampled: 21 Nov 88

	Sample No.	Mercury ug/l	Mercury mg/kg	Nickel ug/l	Nickel mg/kg	Selenium ug/l	Selenium mg/kg	Zinc ug/l	Zinc mg/kg	Total PCB ug/l	Total PCB ug/kg	4,4'-DDT ug/l	4,4'-DDT ug/kg	Chlordane ug/l	Chlordane ug/kg
Detection Limits		0.2	0.1	5.0	1.0	2.0	0.5	5.0	1.0	0.5	5.0	0.02	0.2	0.02	0.2
Criteria (See Notes)		2.1		75.0		300.0		95.0		10.0		0.13		0.09	
Sediment	SAB-88-1		BDL		3.2		BDL		10.6		BDL		BDL		BDL
Water	SAB-88-1	BDL		BDL		BDL		BDL		BDL		BDL		BDL	
Elutriate	SAB-88-1	BDL		BDL		BDL		BDL		BDL		BDL		BDL	
Sediment	SAB-88-2		BDL		2.7		BDL		10.3		BDL		BDL		BDL
Water	SAB-88-2	BDL		BDL		BDL		BDL		BDL		BDL		BDL	
Elutriate	SAB-88-2	BDL		BDL		BDL		BDL		BDL		BDL		BDL	
Sediment	SAB-88-3		BDL		3.2		BDL		11.1		BDL		BDL		BDL
Water	SAB-88-3	BDL		BDL		BDL		BDL		BDL		BDL		BDL	
Elutriate	SAB-88-3	BDL		BDL		BDL		BDL		BDL		BDL		BDL	
Sediment	SAB-88-4		BDL		3.6		BDL		12.8		BDL		BDL		BDL
Water	SAB-88-4	BDL		BDL		BDL		BDL		BDL		BDL		BDL	
Elutriate	SAB-88-4	BDL		BDL		BDL		BDL		BDL		BDL		BDL	
Sediment	SAB-88-5		BDL		2.6		BDL		10.8		BDL		BDL		BDL
Water	SAB-88-5	BDL		BDL		BDL		BDL		BDL		BDL		BDL	
Elutriate	SAB-88-5	BDL		BDL		BDL		BDL		BDL		BDL		BDL	
Sediment	SAB-88-DA123		BDL		1.7		BDL		7.6		BDL		BDL		BDL
Water	SAB-88-DA123	BDL		BDL		BDL		BDL		BDL		BDL		BDL	
Elutriate	SAB-88-DA123	NOTE 8													
Sediment	SAB-88-REF123		BDL		2.9		BDL		10.8		BDL		BDL		BDL
Water	SAB-88-REF123	BDL		BDL		BDL		BDL		BDL		BDL		BDL	
Elutriate	SAB-88-REF123	BDL		BDL		BDL		BDL		BDL		BDL		BDL	
Sediment	SAB-88-6		BDL		3.0		BDL		10.2		BDL		BDL		BDL
Water	SAB-88-6	BDL		BDL		BDL		BDL		BDL		BDL		BDL	
Elutriate	SAB-88-6	BDL		BDL		BDL		BDL		BDL		BDL		BDL	
Sediment	SAB-88-7		BDL		3.2		BDL		13.0		BDL		BDL		BDL
Water	SAB-88-7	BDL		BDL		BDL		BDL		BDL		BDL		BDL	
Elutriate	SAB-88-7	BDL		BDL		BDL		BDL		BDL		BDL		BDL	
Sediment	SAB-88-8		BDL		3.0		BDL		11.4		BDL		BDL		BDL
Water	SAB-88-8	BDL		BDL		BDL		BDL		BDL		BDL		BDL	
Elutriate	SAB-88-8	BDL		BDL		BDL		BDL		BDL		BDL		BDL	
Sediment	SAB-88-9		BDL		3.2		BDL		11.7		BDL		BDL		BDL
Water	SAB-88-9	BDL		BDL		BDL		BDL		BDL		BDL		BDL	
Elutriate	SAB-88-9	BDL		BDL		BDL		BDL		BDL		BDL		BDL	

GULF INTRACOASTAL WATERWAY

TURNSTAKE ISLAND TO LIVE OAK POINT

Date Sampled: 21 Nov 88

	Sample No.	Mercury ug/l	Mercury mg/kg	Nickel ug/l	Nickel mg/kg	Selenium ug/l	Selenium mg/kg	Zinc ug/l	Zinc mg/kg	Total PCB ug/l	Total PCB ug/kg	4,4'-DDT ug/l	4,4'-DDT ug/kg	Chlordane ug/l	Chlordane ug/kg
Detection Limits		0.2	0.1	5.0	1.0	2.0	0.5	5.0	1.0	0.5	5.0	0.02	0.2	0.02	0.2
Criteria (See Notes)		2.1		75.0		300.0		95.0		10.0		0.13		0.09	
Sediment	SAB-88-DA125		BDL		2.4		BDL		9.9		BDL		BDL		BDL
Water	SAB-88-DA125	BDL		BDL		BDL		BDL		BDL		BDL		BDL	
Elutriate	SAB-88-DA125	NOTE 8													
Sediment	SAB-88-REF125		BDL		2.6		BDL		10.9		BDL		BDL		BDL
Water	SAB-88-REF125	BDL		BDL		BDL		BDL		BDL		BDL		BDL	
Elutriate	SAB-88-REF125	BDL		BDL		BDL		BDL		BDL		BDL		BDL	
Sediment	SAB-88-10		BDL		2.7		BDL		10.0		BDL		BDL		BDL
Water	SAB-88-10	BDL		BDL		BDL		BDL		BDL		BDL		BDL	
Elutriate	SAB-88-10	BDL		BDL		BDL		BDL		BDL		BDL		BDL	
Sediment	SAB-88-11		BDL		3.5		BDL		12.2		BDL		BDL		BDL
Water	SAB-88-11	BDL		BDL		BDL		BDL		BDL		BDL		BDL	
Elutriate	SAB-88-11	BDL		BDL		BDL		BDL		BDL		BDL		BDL	

GULF INTRACOASTAL WATERWAY

TURNSTAKE ISLAND TO LIVE OAK POINT

Date Sampled: 21 Nov 88

	Sample No.	Toxaphene ug/l	Toxaphene ug/kg	Total PAH ug/l	Total PAH mg/kg	Naphthalene ug/l	Naphthalene ug/kg	Acenaphthene ug/l	Acenaphthene ug/kg	Fluoranthene ug/l	Fluoranthene ug/kg	Benzo(a)pyrene ug/l	Benzo(a)pyrene ug/kg
Detection Limits		0.5	5.0	5.0	0.5	2.0	50.0	2.0	50.0	0.5	10.0	0.5	10.0
Criteria (See Notes)		0.21		300.0		2350.0		970.0		40.0			
Sediment	SAB-88-1		BDL		BDL		BDL		BDL		BDL		BDL
Water	SAB-88-1	BDL		BDL		BDL		BDL		BDL		BDL	
Elutriate	SAB-88-1	BDL		BDL		BDL		BDL		BDL		BDL	
Sediment	SAB-88-2		BDL		BDL		BDL		BDL		BDL		BDL
Water	SAB-88-2	BDL		BDL		BDL		BDL		BDL		BDL	
Elutriate	SAB-88-2	BDL		BDL		BDL		BDL		BDL		BDL	
Sediment	SAB-88-3		BDL		BDL		BDL		BDL		BDL		BDL
Water	SAB-88-3	BDL		BDL		BDL		BDL		BDL		BDL	
Elutriate	SAB-88-3	BDL		BDL		BDL		BDL		BDL		BDL	
Sediment	SAB-88-4		BDL		BDL		BDL		BDL		BDL		BDL
Water	SAB-88-4	BDL		BDL		BDL		BDL		BDL		BDL	
Elutriate	SAB-88-4	BDL		BDL		BDL		BDL		BDL		BDL	
Sediment	SAB-88-5		BDL		BDL		BDL		BDL		BDL		BDL
Water	SAB-88-5	BDL		BDL		BDL		BDL		BDL		BDL	
Elutriate	SAB-88-5	BDL		BDL		BDL		BDL		BDL		BDL	
Sediment	SAB-88-DA123		BDL		BDL		BDL		BDL		BDL		BDL
Water	SAB-88-DA123	BDL		BDL		BDL		BDL		BDL		BDL	
Elutriate	SAB-88-DA123	NOTE 8											
Sediment	SAB-88-REF123		BDL		BDL		BDL		BDL		BDL		BDL
Water	SAB-88-REF123	BDL		BDL		BDL		BDL		BDL		BDL	
Elutriate	SAB-88-REF123	BDL		BDL		BDL		BDL		BDL		BDL	
Sediment	SAB-88-6		BDL		BDL		BDL		BDL		BDL		BDL
Water	SAB-88-6	BDL		BDL		BDL		BDL		BDL		BDL	
Elutriate	SAB-88-6	BDL		BDL		BDL		BDL		BDL		BDL	
Sediment	SAB-88-7		BDL		BDL		BDL		BDL		BDL		BDL
Water	SAB-88-7	BDL		BDL		BDL		BDL		BDL		BDL	
Elutriate	SAB-88-7	BDL		BDL		BDL		BDL		BDL		BDL	
Sediment	SAB-88-8		BDL		BDL		BDL		BDL		BDL		BDL
Water	SAB-88-8	BDL		BDL		BDL		BDL		BDL		BDL	
Elutriate	SAB-88-8	BDL		BDL		BDL		BDL		BDL		BDL	
Sediment	SAB-88-9		BDL		BDL		BDL		BDL		BDL		BDL
Water	SAB-88-9	BDL		BDL		BDL		BDL		BDL		BDL	
Elutriate	SAB-88-9	BDL		BDL		BDL		BDL		BDL		BDL	

GULF INTRACOASTAL WATERWAY

TURNSTAKE ISLAND TO LIVE OAK POINT

Date Sampled: 21 Nov 88

	Sample No.	Toxaphene ug/l	Toxaphene ug/kg	Total PAH ug/l	Total PAH mg/kg	Naphthalene ug/l	Naphthalene ug/kg	Acenaphthene ug/l	Acenaphthene ug/kg	Fluoranthene ug/l	Fluoranthene ug/kg	Benzo(a)pyrene ug/l	Benzo(a)pyrene ug/kg
Detection Limits		0.50	5.0	5.0	0.5	2.00	50.0	2.0	50.0	0.5	10.0	0.50	10.0
Criteria (See Notes)		0.21		300.0		2350.00		970.0		40.0			
Sediment	SAB-88-DA125		BDL		BDL		BDL		BDL		BDL		BDL
Water	SAB-88-DA125	BDL		BDL		BDL		BDL		BDL		BDL	
Elutriate	SAB-88-DA125	NOTE 8											
Sediment	SAB-88-REF125		BDL		BDL		BDL		BDL		BDL		BDL
Water	SAB-88-REF125	BDL		BDL		BDL		BDL		BDL		BDL	
Elutriate	SAB-88-REF125	BDL		BDL		BDL		BDL		BDL		BDL	
Sediment	SAB-88-10		BDL		BDL		BDL		BDL		BDL		BDL
Water	SAB-88-10	BDL		BDL		BDL		BDL		BDL		BDL	
Elutriate	SAB-88-10	BDL		BDL		BDL		BDL		BDL		BDL	
Sediment	SAB-88-11		BDL		BDL		BDL		BDL		BDL		BDL
Water	SAB-88-11	BDL		BDL		BDL		BDL		BDL		BDL	
Elutriate	SAB-88-11	BDL		BDL		BDL		BDL		BDL		BDL	

GULF INTRACOASTAL WATERWAY

TURNSTAKE ISLAND TO LIVE OAK POINT

Date Sampled: 21 Nov 88

	Sample No.	Acenaphthylene ug/l	Acenaphthylene ug/kg	Fluorene ug/l	Fluorene ug/kg	Phenanthrene ug/l	Phenanthrene ug/kg	Anthracene ug/l	Anthracene ug/kg	Pyrene ug/l	Pyrene ug/kg	Benzo(a)anthra ug/l	Benzo(a)anthra ug/kg
Detection Limits		2.5	50.0	0.5	10.0	1.0	20.0	1.0	20.0	0.5	10.0	1.0	20.0
Criteria (See Notes)													
Sediment	SAB-88-1		BDL		BDL		BDL		BDL		BDL		BDL
Water	SAB-88-1	BDL		BDL		BDL		BDL		BDL		BDL	
Elutriate	SAB-88-1	BDL		BDL		BDL		BDL		BDL		BDL	
Sediment	SAB-88-2		BDL		BDL		BDL		BDL		BDL		BDL
Water	SAB-88-2	BDL		BDL		BDL		BDL		BDL		BDL	
Elutriate	SAB-88-2	BDL		BDL		BDL		BDL		BDL		BDL	
Sediment	SAB-88-3		BDL		BDL		BDL		BDL		BDL		BDL
Water	SAB-88-3	BDL		BDL		BDL		BDL		BDL		BDL	
Elutriate	SAB-88-3	BDL		BDL		BDL		BDL		BDL		BDL	
Sediment	SAB-88-4		BDL		BDL		BDL		BDL		BDL		BDL
Water	SAB-88-4	BDL		BDL		BDL		BDL		BDL		BDL	
Elutriate	SAB-88-4	BDL		BDL		BDL		BDL		BDL		BDL	
Sediment	SAB-88-5		BDL		BDL		BDL		BDL		BDL		BDL
Water	SAB-88-5	BDL		BDL		BDL		BDL		BDL		BDL	
Elutriate	SAB-88-5	BDL		BDL		BDL		BDL		BDL		BDL	
Sediment	SAB-88-DA123		BDL		BDL		BDL		BDL		BDL		BDL
Water	SAB-88-DA123	BDL		BDL		BDL		BDL		BDL		BDL	
Elutriate	SAB-88-DA123	NOTE 8											
Sediment	SAB-88-REF123		BDL		BDL		BDL		BDL		BDL		BDL
Water	SAB-88-REF123	BDL		BDL		BDL		BDL		BDL		BDL	
Elutriate	SAB-88-REF123	BDL		BDL		BDL		BDL		BDL		BDL	
Sediment	SAB-88-6		BDL		BDL		BDL		BDL		BDL		BDL
Water	SAB-88-6	BDL		BDL		BDL		BDL		BDL		BDL	
Elutriate	SAB-88-6	BDL		BDL		BDL		BDL		BDL		BDL	
Sediment	SAB-88-7		BDL		BDL		BDL		BDL		BDL		BDL
Water	SAB-88-7	BDL		BDL		BDL		BDL		BDL		BDL	
Elutriate	SAB-88-7	BDL		BDL		BDL		BDL		BDL		BDL	
Sediment	SAB-88-8		BDL		BDL		BDL		BDL		BDL		BDL
Water	SAB-88-8	BDL		BDL		BDL		BDL		BDL		BDL	
Elutriate	SAB-88-8	BDL		BDL		BDL		BDL		BDL		BDL	
Sediment	SAB-88-9		BDL		BDL		BDL		BDL		BDL		BDL
Water	SAB-88-9	BDL		BDL		BDL		BDL		BDL		BDL	
Elutriate	SAB-88-9	BDL		BDL		BDL		BDL		BDL		BDL	

GULF INTRACOASTAL WATERWAY

TURNSTAKE ISLAND TO LIVE OAK POINT

Date Sampled: 21 Nov 88

	Sample No.	Acenaphthylene ug/l	Acenaphthylene ug/kg	Fluorene ug/l	Fluorene ug/kg	Phenanthrene ug/l	Phenanthrene ug/kg	Anthracene ug/l	Anthracene ug/kg	Pyrene ug/l	Pyrene ug/kg	Benzo(a)anthra ug/l	Benzo(a)anthra ug/kg
Detection Limits		2.5	50.0	0.5	10.0	1.0	20.0	1.0	20.0	0.5	10.0	1.0	20.0
Criteria (See Notes)													
Sediment	SAB-88-DA125		BDL		BDL		BDL		BDL		BDL		BDL
Water	SAB-88-DA125	BDL		BDL		BDL		BDL		BDL		BDL	
Elutriate	SAB-88-DA125	NOTE 8											
Sediment	SAB-88-REF125		BDL		BDL		BDL		BDL		BDL		BDL
Water	SAB-88-REF125	BDL		BDL		BDL		BDL		BDL		BDL	
Elutriate	SAB-88-REF125	BDL		BDL		BDL		BDL		BDL		BDL	
Sediment	SAB-88-10		BDL		BDL		BDL		BDL		BDL		BDL
Water	SAB-88-10	BDL		BDL		BDL		BDL		BDL		BDL	
Elutriate	SAB-88-10	BDL		BDL		BDL		BDL		BDL		BDL	
Sediment	SAB-88-11		BDL		BDL		BDL		BDL		BDL		BDL
Water	SAB-88-11	BDL		BDL		BDL		BDL		BDL		BDL	
Elutriate	SAB-88-11	BDL		BDL		BDL		BDL		BDL		BDL	

GULF INTRACOASTAL WATERWAY

TURNSTAKE ISLAND TO LIVE OAK POINT

Date Sampled: 21 Nov 88

	Sample No.	Chrysene ug/l	Chrysene ug/kg	Benzo(b)fluor ug/l	Benzo(b)fluor ug/kg	Benzo(k)fluor ug/l	Benzo(k)fluor ug/kg	Benzo(ghi)per ug/l	Benzo(ghi)per ug/kg	Dibenzo(ah)an ug/l	Dibenzo(ah)an ug/kg	Indeno(123cd)py ug/l	Indeno(123cd)py ug/kg
Detection Limits		0.5	10.0	0.1	2.0	0.1	2.0	0.1	2.0	0.5	10.0	0.5	10.0
Criteria (See Notes)													
Sediment	SAB-88-1		BDL		BDL		BDL		BDL		BDL		BDL
Water	SAB-88-1	BDL		BDL		BDL		BDL		BDL		BDL	
Elutriate	SAB-88-1	BDL		BDL		BDL		BDL		BDL		BDL	
Sediment	SAB-88-2		BDL		BDL		BDL		BDL		BDL		BDL
Water	SAB-88-2	BDL		BDL		BDL		BDL		BDL		BDL	
Elutriate	SAB-88-2	BDL		BDL		BDL		BDL		BDL		BDL	
Sediment	SAB-88-3		BDL		BDL		BDL		BDL		BDL		BDL
Water	SAB-88-3	BDL		BDL		BDL		BDL		BDL		BDL	
Elutriate	SAB-88-3	BDL		BDL		BDL		BDL		BDL		BDL	
Sediment	SAB-88-4		BDL		BDL		BDL		BDL		BDL		BDL
Water	SAB-88-4	BDL		BDL		BDL		BDL		BDL		BDL	
Elutriate	SAB-88-4	BDL		BDL		BDL		BDL		BDL		BDL	
Sediment	SAB-88-5		BDL		BDL		BDL		BDL		BDL		BDL
Water	SAB-88-5	BDL		BDL		BDL		BDL		BDL		BDL	
Elutriate	SAB-88-5	BDL		BDL		BDL		BDL		BDL		BDL	
Sediment	SAB-88-DA123		BDL		BDL		BDL		BDL		BDL		BDL
Water	SAB-88-DA123	BDL		BDL		BDL		BDL		BDL		BDL	
Elutriate	SAB-88-DA123	NOTE 8											
Sediment	SAB-88-REF123		BDL		BDL		BDL		BDL		BDL		BDL
Water	SAB-88-REF123	BDL		BDL		BDL		BDL		BDL		BDL	
Elutriate	SAB-88-REF123	BDL		BDL		BDL		BDL		BDL		BDL	
Sediment	SAB-88-6		BDL		BDL		BDL		BDL		BDL		BDL
Water	SAB-88-6	BDL		BDL		BDL		BDL		BDL		BDL	
Elutriate	SAB-88-6	BDL		BDL		BDL		BDL		BDL		BDL	
Sediment	SAB-88-7		BDL		BDL		BDL		BDL		BDL		BDL
Water	SAB-88-7	BDL		BDL		BDL		BDL		BDL		BDL	
Elutriate	SAB-88-7	BDL		BDL		BDL		BDL		BDL		BDL	
Sediment	SAB-88-8		BDL		BDL		BDL		BDL		BDL		BDL
Water	SAB-88-8	BDL		BDL		BDL		BDL		BDL		BDL	
Elutriate	SAB-88-8	BDL		BDL		BDL		BDL		BDL		BDL	
Sediment	SAB-88-9		BDL		BDL		BDL		BDL		BDL		BDL
Water	SAB-88-9	BDL		BDL		BDL		BDL		BDL		BDL	
Elutriate	SAB-88-9	BDL		BDL		BDL		BDL		BDL		BDL	

GULF INTRACOASTAL WATERWAY

TURNSTAKE ISLAND TO LIVE OAK POINT

Date Sampled: 21 Nov 88

	Sample No.	Chrysene ug/l	Chrysene ug/kg	Benzo(b)fluor ug/l	Benzo(b)fluor ug/kg	Benzo(k)fluor ug/l	Benzo(k)fluor ug/kg	Benzo(ghi)per ug/l	Benzo(ghi)per ug/kg	Dibenzo(ah)an ug/l	Dibenzo(ah)an ug/kg	Indeno(123cd)py ug/l	Indeno(123cd)py ug/kg
Detection Limits		0.5	10.0	0.1	2.0	0.1	2.0	0.1	2.0	0.5	10.0	0.5	10.0
Criteria (See Notes)													
Sediment	SAB-88-DA125		BDL		BDL		BDL		BDL		BDL		BDL
Water	SAB-88-DA125	BDL		BDL		BDL		BDL		BDL		BDL	
Elutriate	SAB-88-DA125	NOTE 8											
Sediment	SAB-88-REF125		BDL		BDL		BDL		BDL		BDL		BDL
Water	SAB-88-REF125	BDL		BDL		BDL		BDL		BDL		BDL	
Elutriate	SAB-88-REF125	BDL		BDL		BDL		BDL		BDL		BDL	
Sediment	SAB-88-10		BDL		BDL		BDL		BDL		BDL		BDL
Water	SAB-88-10	BDL		BDL		BDL		BDL		BDL		BDL	
Elutriate	SAB-88-10	BDL		BDL		BDL		BDL		BDL		BDL	
Sediment	SAB-88-11		BDL		BDL		BDL		BDL		BDL		BDL
Water	SAB-88-11	BDL		BDL		BDL		BDL		BDL		BDL	
Elutriate	SAB-88-11	BDL		BDL		BDL		BDL		BDL		BDL	

NOTES:

1. Criteria shown are EPA Quality Criteria for Water, 1986; March 1987 and January 1988. These water quality criteria are shown only for comparative purposes since there is no regulatory requirement for the discharge of dredge material to meet these criteria. Presently, no EPA criteria exist for marine sediment.

2. No EPA criteria presently exist for the following parameters: total PAH; acenaphthene; fluoranthene and naphthalene. The value shown is that concentration at which acute toxicity to saltwater aquatic life has been observed.

3. The criterion for toxaphene lies below the detection limit which is routinely attainable by commercial laboratories. Consequently, this minimum detection limit is used as a reference value.

4. Chromium is expressed as total chromium.

5. Total PAH is expressed as fluoranthene equivalents.

6. BDL = Below Detection Limits.

7. Dredging Invitation No. DACW64-89-B-0014.

8. Analyses not performed.

9. [illegible]

GULF INTRACOASTAL WATERWAY

CHANNEL TO VICTORIA & SEADRIFT

	Sample No.	Date Sampled	Station	Arsenic ug/l	Arsenic mg/kg	Cadmium ug/l	Cadmium mg/kg	Chromium ug/l	Chromium mg/kg	Copper ug/l	Copper mg/kg	Lead ug/l	Lead mg/kg
Detection Limits				2.0	1.0	2.0	0.1	10.0	1.0	1.0	1.0	5.0	1.0
Criteria (See Notes)				69.0		43.0		1100.0		2.9		140.0	
Sediment	GIC-89-V-3	31 Jan 89	50+00		BDL		BDL		3.8		3.5		<1.2
Water	GIC-89-V-3	31 Jan 89	50+00	BDL		BDL		BDL		BDL		BDL	
Elutriate	GIC-89-V-3	31 Jan 89	50+00	BDL		BDL		BDL		BDL		BDL	
Sediment	GIC-89-V-4	31 Jan 89	100+00		BDL		BDL		4.6		6.0		<1.1
Water	GIC-89-V-4	31 Jan 89	100+00	BDL		BDL		BDL		BDL		BDL	
Elutriate	GIC-89-V-4	31 Jan 89	100+00	BDL		BDL		BDL		BDL		BDL	
Sediment	GIC-89-V-5	31 Jan 89	150+00		BDL		BDL		3.7		2.7		BDL
Water	GIC-89-V-5	31 Jan 89	150+00	BDL		BDL		BDL		BDL		BDL	
Elutriate	GIC-89-V-5	31 Jan 89	150+00	BDL		BDL		BDL		BDL		BDL	
Sediment	GIC-89-V-DA3	31 Jan 89	170+00		BDL		BDL		2.2		1.5		<1.3
Water	GIC-89-V-DA3	31 Jan 89	170+00	BDL		BDL		BDL		BDL		BDL	
Elutriate	GIC-89-V-DA3	31 Jan 89	170+00	NOTE 8									
Sediment	GIC-88-V6	17 Dec 88	200+00		BDL		BDL		3.9		2.7		BDL
Water	GIC-88-V6	17 Dec 88	200+00	BDL		BDL		BDL		BDL		BDL	
Elutriate	GIC-88-V6	17 Dec 88	200+00	BDL		BDL		BDL		BDL		BDL	
Sediment	GIC-88-V7	17 Dec 88	250+00		BDL		BDL		3.9		2.8		BDL
Water	GIC-88-V7	17 Dec 88	250+00	BDL		BDL		BDL		BDL		BDL	
Elutriate	GIC-88-V7	17 Dec 88	250+00	BDL		BDL		BDL		BDL		BDL	
Sediment	GIC-88-V-DA7	17 Dec 88	280+00		BDL		BDL		2.0		2.1		BDL
Water	GIC-88-V-DA7	17 Dec 88	280+00	BDL		BDL		BDL		BDL		BDL	
Elutriate	GIC-88-V-DA7	17 Dec 88	280+00	NOTE 8									
Sediment	GIC-88-V-REF7	17 Dec 88	280+00		BDL		BDL		2.3		2.5		BDL
Water	GIV-88-V-REF7	17 Dec 88	280+00	BDL		BDL		BDL		BDL		BDL	
Elutriate	GIC-88-V-REF7	17 Dec 88	280+00	BDL		BDL		BDL		BDL		BDL	
Sediment	GIC-88-V-8	17 Dec 88	300+00		BDL		BDL		3.6		2.4		BDL
Water	GIC-88-V-8	17 Dec 88	300+00	BDL		BDL		BDL		BDL		BDL	
Elutriate	GIC-88-V-8	17 Dec 88	300+00	BDL		BDL		BDL		BDL		BDL	
Sediment	GIV-88-V-9	17 Dec 88	350+00		BDL		BDL		2.9		2.6		1.2
Water	GIC-88-V-9	17 Dec 88	350+00	BDL		BDL		BDL		BDL		BDL	
Elutriate	GIC-88-V-9	17 Dec 88	350+00	BDL		BDL		BDL		BDL		BDL	
Sediment	GIC-88-V-DA13	17 Dec 88	390+00		BDL		BDL		2.3		1.8		1.5
Water	GIC-88-V-DA13	17 Dec 88	390+00	BDL		BDL		BDL		BDL		BDL	
Elutriate	GIC-88-V-DA13	17 Dec 88	390+00	NOTE 8									

GULF INTRACOASTAL WATERWAY

CHANNEL TO VICTORIA & SEADRIFT

	Sample No.	Date Sampled	Station	Arsenic ug/l	Arsenic mg/kg	Cadmium ug/l	Cadmium mg/kg	Chromium ug/l	Chromium mg/kg	Copper ug/l	Copper mg/kg	Lead ug/l	Lead mg/kg
Detection Limits				2.0	1.0	2.0	0.1	10.0	1.0	1.0	1.0	5.0	1.0
Criteria (See Notes)				69.0		43.0		1100.0		2.9		140.0	
Sediment	GIC-88-REF13	17 Dec 88	390+00		BDL		BDL		2.5		2.6		BDL
Water	GIC-88-REF13	17 Dec 88	390+00	BDL		BDL		BDL		BDL		BDL	
Elutriate	GIC-88-REF13	17 Dec 88	390+00	BDL		BDL		BDL		BDL		BDL	
Sediment	GIC-88-V-10	17 Dec 88	400+00		BDL		BDL		3.1		2.9		2.3
Water	GIC-88-V-10	17 Dec 88	400+00	BDL		BDL		BDL		BDL		BDL	
Elutriate	GIC-88-V-10	17 Dec 88	400+00	BDL		BDL		BDL		BDL		BDL	
Sediment	GIC-88-V-11	17 Dec 88	450+00		BDL		BDL		3.4		3.0		BDL
Water	GIC-88-V-11	17 Dec 88	450+00	BDL		BDL		BDL		BDL		BDL	
Elutriate	GIC-88-V-11	17 Dec 88	450+00	BDL		BDL		BDL		BDL		BDL	
Sediment	GIC-88-V-12	17 Dec 88	500+00		BDL		BDL		3.3		3.0		BDL
Water	GIC-88-V-12	17 Dec 88	500+00	BDL		BDL		BDL		BDL		BDL	
Elutriate	GIC-88-V-12	17 Dec 88	500+00	BDL		BDL		BDL		BDL		BDL	
Sediment	GIC-88-S-3	17 Dec 88	60+00		BDL		BDL		2.8		2.4		BDL
Water	GIC-88-S-3	17 Dec 88	60+00	BDL		BDL		BDL		BDL		BDL	
Elutriate	GIC-88-S-3	17 Dec 88	60+00	BDL		BDL		BDL		BDL		BDL	
Sediment	GIC-88-S-4	17 Dec 88	108+00		BDL		BDL		3.8		5.4		BDL
Water	GIC-88-S-4	17 Dec 88	108+00	BDL		BDL		BDL		BDL		BDL	
Elutriate	GIC-88-S-4	17 Dec 88	108+00	BDL		BDL		BDL		BDL		BDL	

GULF INTRACOASTAL WATERWAY

CHANNEL TO VICTORIA & SEADRIFT

Dates Sampled: 17 Dec 88, 31 Jan 89

	Sample No.	Mercury ug/l	Mercury mg/kg	Nickel ug/l	Nickel mg/kg	Selenium ug/l	Selenium mg/kg	Zinc ug/l	Zinc mg/kg	Total PCB ug/l	Total PCB ug/kg	4,4'-DDT ug/l	4,4'-DDT ug/kg	Chlordane ug/l	Chlordane ug/kg
Detection Limits		0.2	0.1	5.0	1.0	2.0	0.5	5.0	1.0	0.5	5.0	0.02	0.2	0.02	0.2
Criteria (See Notes)		2.1		75.0		300.0		95.0		10.0		0.13		0.09	
Sediment	GIC-89-V-3		BDL		3.7		BDL		10.7		BDL		BDL		BDL
Water	GIC-89-V-3	BDL		BDL		BDL		BDL		BDL		BDL		BDL	
Elutriate	GIC-89-V-3	BDL		BDL		BDL		BDL		BDL		BDL		BDL	
Sediment	GIC-89-V-4		BDL		4.2		BDL		12.9		BDL		BDL		BDL
Water	GIC-89-V-4	BDL		BDL		BDL		BDL		BDL		BDL		BDL	
Elutriate	GIC-89-V-4	BDL		BDL		BDL		BDL		BDL		BDL		BDL	
Sediment	GIC-89-V-5		BDL		3.3		BDL		10.2		BDL		BDL		BDL
Water	GIC-89-V-5	BDL		BDL		BDL		BDL		BDL		BDL		BDL	
Elutriate	GIC-89-V-5	BDL		BDL		BDL		BDL		BDL		BDL		BDL	
Sediment	GIC-89-V-DA3		BDL		1.6		BDL		5.6		BDL		BDL		BDL
Water	GIC-89-V-DA3	BDL		BDL		BDL		BDL		BDL		BDL		BDL	
Elutriate	GIC-89-V-DA3	NOTE 8													
Sediment	GIC-88-V6		BDL		3.1		BDL		11.4		BDL		BDL		BDL
Water	GIC-88-V6	BDL		BDL		BDL		BDL		BDL		BDL		BDL	
Elutriate	GIC-88-V6	BDL		BDL		BDL		BDL		BDL		BDL		BDL	
Sediment	GIC-88-V7		BDL		2.8		BDL		11.5		BDL		BDL		BDL
Water	GIC-88-V7	BDL		BDL		BDL		BDL		BDL		BDL		BDL	
Elutriate	GIC-88-V7	BDL		BDL		BDL		BDL		BDL		BDL		BDL	
Sediment	GIC-88-V-DA7		BDL		2.4		BDL		7.4		BDL		BDL		BDL
Water	GIC-88-V-DA7	BDL		BDL		BDL		BDL		BDL		BDL		BDL	
Elutriate	GIC-88-V-DA7	NOTE 8													
Sediment	GIC-88-REF7		BDL		2.1		BDL		8.0		BDL		BDL		BDL
Water	GIC-88-REF7	BDL		BDL		BDL		BDL		BDL		BDL		BDL	
Elutriate	GIC-88-REF7	BDL		BDL		BDL		BDL		BDL		BDL		BDL	
Sediment	GIC-88-V-8		BDL		3.0		BDL		10.2		BDL		BDL		BDL
Water	GIC-88-V-8	BDL		BDL		BDL		BDL		BDL		BDL		BDL	
Elutriate	GIC-88-V-8	BDL		BDL		BDL		BDL		BDL		BDL		BDL	
Sediment	GIC-88-V-9		BDL		2.8		BDL		9.0		BDL		BDL		BDL
Water	GIC-88-V-9	BDL		BDL		BDL		BDL		BDL		BDL		BDL	
Elutriate	GIC-88-V-9	BDL		BDL		BDL		BDL		BDL		BDL		BDL	
Sediment	GIC-88-V-DA13		BDL		2.7		BDL		8.0		BDL		BDL		BDL
Water	GIC-88-V-DA13	BDL		BDL		BDL		BDL		BDL		BDL		BDL	
Elutriate	GIC-88-V-DA13	NOTE 8													

GULF INTRACOASTAL WATERWAY

CHANNEL TO VICTORIA & SEADRIFT

Dates Sampled: 17 Dec 88, 31 Jan 89

	Sample No.	Mercury ug/l	Mercury mg/kg	Nickel ug/l	Nickel mg/kg	Selenium ug/l	Selenium mg/kg	Zinc ug/l	Zinc mg/kg	Total PCB ug/l	Total PCB ug/kg	4,4'-DDT ug/l	4,4'-DDT ug/kg	Chlordane ug/l	Chlordane ug/kg
Detection Limits		0.2	0.1	5.0	1.0	2.0	0.5	5.0	1.0	0.5	5.0	0.02	0.2	0.02	0.2
Criteria (See Notes)		2.1		75.0		300.0		95.0		10.0		0.13		0.09	
Sediment	GIC-88-REF13		BDL		2.9		BDL		8.5		BDL		BDL		BDL
Water	GIC-88-REF13	BDL		BDL		BDL		BDL		BDL		BDL		BDL	
Elutriate	GIC-88-REF13	BDL		BDL		BDL		BDL		BDL		BDL		BDL	
Sediment	GIC-88-V-10		BDL		3.2		BDL		10.0		BDL		BDL		BDL
Water	GIC-88-V-10	BDL		BDL		BDL		BDL		BDL		BDL		BDL	
Elutriate	GIC-88-V-10	BDL		BDL		BDL		BDL		BDL		BDL		BDL	
Sediment	GIC-88-V-10		BDL		3.0		BDL		10.4		BDL		BDL		BDL
Water	GIC-88-V-10	BDL		BDL		BDL		BDL		BDL		BDL		BDL	
Elutriate	GIC-88-V-10	BDL		BDL		BDL		BDL		BDL		BDL		BDL	
Sediment	GIC-88-V-12		BDL		3.1		BDL		10.0		BDL		BDL		BDL
Water	GIC-88-V-12	BDL		BDL		BDL		BDL		BDL		BDL		BDL	
Elutriate	GIC-88-V-12	BDL		BDL		BDL		BDL		BDL		BDL		BDL	
Sediment	GIC-88-S-3		BDL		2.7		BDL		9.5		BDL		BDL		BDL
Water	GIC-88-S-3	BDL		BDL		BDL		BDL		BDL		BDL		BDL	
Elutriate	GIC-88-S-3	BDL		BDL		BDL		BDL		BDL		BDL		BDL	
Sediment	GIC-88-S-4		BDL		3.0		BDL		17.6		BDL		BDL		BDL
Water	GIC-88-S-4	BDL		BDL		BDL		BDL		BDL		BDL		BDL	
Elutriate	GIC-88-S-4	BDL		BDL		BDL		BDL		BDL		BDL		BDL	

GULF INTRACOASTAL WATERWAY

CHANNEL TO VICTORIA & SEADRIFT

Dates Sampled: 17 Dec 88, 31 Jan 89

	Sample No.	Toxaphene ug/l	Toxaphene ug/kg	Total PAH ug/l	Total PAH mg/kg	Naphthalene ug/l	Naphthalene ug/kg	Acenaphthene ug/l	Acenaphthene ug/kg	Fluoranthene ug/l	Fluoranthene ug/kg	Benzo(a)pyrene ug/l	Benzo(a)pyrene ug/kg
Detection Limits		0.5	5.0	5.0	0.5	2.0	50.0	2.0	50.0	0.5	10.0	0.5	10.0
Criteria (See Notes)		0.21		300.0		2350.0		970.0		40.0			
Sediment	GIC-89-V-3		BDL		BDL		BDL		BDL		BDL		BDL
Water	GIC-89-V-3	BDL		BDL		BDL		BDL		BDL		BDL	
Elutriate	GIC-89-V-3	BDL		BDL		BDL		BDL		BDL		BDL	
Sediment	GIC-89-V-4		BDL		BDL		BDL		BDL		BDL		BDL
Water	GIC-89-V-4	BDL		BDL		BDL		BDL		BDL		BDL	
Elutriate	GIC-89-V-4	BDL		BDL		BDL		BDL		BDL		BDL	
Sediment	GIC-89-V-5		BDL		BDL		BDL		BDL		BDL		BDL
Water	GIC-89-V-5	BDL		BDL		BDL		BDL		BDL		BDL	
Elutriate	GIC-89-V-5	BDL		BDL		BDL		BDL		BDL		BDL	
Sediment	GIC-89-V-DA3		BDL		BDL		BDL		BDL		BDL		BDL
Water	GIC-89-V-DA3	BDL		BDL		BDL		BDL		BDL		BDL	
Elutriate	GIC-89-V-DA3	NOTE 8											
Sediment	GIC-88-V6		BDL		BDL		BDL		BDL		BDL		BDL
Water	GIC-88-V6	BDL		BDL		BDL		BDL		BDL		BDL	
Elutriate	GIC-88-V6	BDL		BDL		BDL		BDL		BDL		BDL	
Sediment	GIC-88-V7		BDL		BDL		BDL		BDL		BDL		BDL
Water	GIC-88-V7	BDL		BDL		BDL		BDL		BDL		BDL	
Elutriate	GIC-88-V7	BDL		BDL		BDL		BDL		BDL		BDL	
Sediment	GIC-88-V-DA7		BDL		BDL		BDL		BDL		BDL		BDL
Water	GIC-88-V-DA7	BDL		BDL		BDL		BDL		BDL		BDL	
Elutriate	GIC-88-V-DA7	NOTE 8											
Sediment	GIC-88-V-REF7		BDL		BDL		BDL		BDL		BDL		BDL
Water	GIC-88-V-REF7	BDL		BDL		BDL		BDL		BDL		BDL	
Elutriate	GIC-88-V-REF7	BDL		BDL		BDL		BDL		BDL		BDL	
Sediment	GIC-88-V-8		BDL		BDL		BDL		BDL		BDL		BDL
Water	GIC-88-V-8	BDL		BDL		BDL		BDL		BDL		BDL	
Elutriate	GIC-88-V-8	BDL		BDL		BDL		BDL		BDL		BDL	
Sediment	GIC-88-V-9		BDL		BDL		BDL		BDL		BDL		BDL
Water	GIC-88-V-9	BDL		BDL		BDL		BDL		BDL		BDL	
Elutriate	GIC-88-V-9	BDL		BDL		BDL		BDL		BDL		BDL	
Sediment	GIC-88-V-DA13		BDL		BDL		BDL		BDL		BDL		BDL
Water	GIC-88-V-DA13	BDL		BDL		BDL		BDL		BDL		BDL	
Elutriate	GIC-88-V-DA13	NOTE 8											

GULF INTRACOASTAL WATERWAY

CHANNEL TO VICTORIA & SEADRIFT

Dates Sampled: 17 Dec 88, 31 Jan 89

	Sample No.	Toxaphene ug/l	Toxaphene ug/kg	Total PAH ug/l	Total PAH mg/kg	Naphthalene ug/l	Naphthalene ug/kg	Acenaphthene ug/l	Acenaphthene ug/kg	Fluoranthene ug/l	Fluoranthene ug/kg	Benzo(a)pyrene ug/l	Benzo(a)pyrene ug/kg
Detection Limits		0.50	5.0	5.0	0.5	2.00	50.0	2.0	50.0	0.5	10.0	0.50	10.0
Criteria (See Notes)		0.21		300.0		2350.00		970.0		40.0			
Sediment	GIC-88-V-REF13		BDL		BDL		BDL		BDL		BDL		BDL
Water	GIC-88-V-REF13	BDL		BDL		BDL		BDL		BDL		BDL	
Elutriate	GIC-88-V-REF13	BDL		BDL		BDL		BDL		BDL		BDL	
Sediment	GIC-88-V-10		BDL		BDL		BDL		BDL		BDL		BDL
Water	GIC-88-V-10	BDL		BDL		BDL		BDL		BDL		BDL	
Elutriate	GIC-88-V-10	BDL		BDL		BDL		BDL		BDL		BDL	
Sediment	GIC-88-V-11		BDL		BDL		BDL		BDL		BDL		BDL
Water	GIC-88-V-11	BDL		BDL		BDL		BDL		BDL		BDL	
Elutriate	GIC-88-V-11	BDL		BDL		BDL		BDL		BDL		BDL	
Sediment	GIC-88-V-12		BDL		BDL		BDL		BDL		BDL		BDL
Water	GIC-88-V-12	BDL		BDL		BDL		BDL		BDL		BDL	
Elutriate	GIC-88-V-12	BDL		BDL		BDL		BDL		BDL		BDL	
Sediment	GIC-88-S-3		BDL		BDL		BDL		BDL		BDL		BDL
Water	GIC-88-S-3	BDL		BDL		BDL		BDL		BDL		BDL	
Elutriate	GIC-88-S-3	BDL		BDL		BDL		BDL		BDL		BDL	
Sediment	GIC-88-S-4		BDL		BDL		BDL		BDL		BDL		BDL
Water	GIC-88-S-4	BDL		BDL		BDL		BDL		BDL		BDL	
Elutriate	GIC-88-S-4	BDL		BDL		BDL		BDL		BDL		BDL	

GULF INTRACOASTAL WATERWAY

CHANNEL TO VICTORIA & SEADRIFT

Dates Sampled: 17 Dec 88, 31 Jan 89

	Sample No.	Acenaphthylene ug/l	Acenaphthylene ug/kg	Fluorene ug/l	Fluorene ug/kg	Phenanthrene ug/l	Phenanthrene ug/kg	Anthracene ug/l	Anthracene ug/kg	Pyrene ug/l	Pyrene ug/kg	Benzo(a)anthra ug/l	Benzo(a)anthra ug/kg
Detection Limits		2.5	50.0	0.5	10.0	1.0	20.0	1.0	20.0	0.5	10.0	1.0	20.0
Criteria (See Notes)													
Sediment	GIC-89-V-3		BDL		BDL		BDL		BDL		BDL		BDL
Water	GIC-89-V-3	BDL		BDL		BDL		BDL		BDL		BDL	
Elutriate	GIC-89-V-3	BDL		BDL		BDL		BDL		BDL		BDL	
Sediment	GIC-89-V-4		BDL		BDL		BDL		BDL		BDL		BDL
Water	GIC-89-V-4	BDL		BDL		BDL		BDL		BDL		BDL	
Elutriate	GIC-89-V-4	BDL		BDL		BDL		BDL		BDL		BDL	
Sediment	GIC-89-V-5		BDL		BDL		BDL		BDL		BDL		BDL
Water	GIC-89-V-5	BDL		BDL		BDL		BDL		BDL		BDL	
Elutriate	GIC-89-V-5	BDL		BDL		BDL		BDL		BDL		BDL	
Sediment	GIC-89-V-DA3		BDL		BDL		BDL		BDL		BDL		BDL
Water	GIC-89-V-DA3	BDL		BDL		BDL		BDL		BDL		BDL	
Elutriate	GIC-89-V-DA3	NOTE 8											

GULF INTRACOASTAL WATERWAY

CHANNEL TO VICTORIA & SEADRIFT

Dates Sampled: 17 Dec 88, 31 Jan 89

	Sample No.	Chrysene ug/l	Chrysene ug/kg	Benzo(b)fluor ug/l	Benzo(b)fluor ug/kg	Benzo(k)fluor ug/l	Benzo(k)fluor ug/kg	Benzo(ghi)per ug/l	Benzo(ghi)per ug/kg	Dibenzo(ah)an ug/l	Dibenzo(ah)an ug/kg	Indeno(123cd)py ug/l	Indeno(123cd)py ug/kg
Detection Limits		0.5	10.0	0.1	2.0	0.1	2.0	0.1	2.0	0.5	10.0	0.5	10.0
Criteria (See Notes)													
Sediment	GIC-89-V-3		BDL		BDL		BDL		BDL		BDL		BDL
Water	GIC-89-V-3	BDL		BDL		BDL		BDL		BDL		BDL	
Elutriate	GIC-89-V-3	BDL		BDL		BDL		BDL		BDL		BDL	
Sediment	GIC-89-V-4		BDL		BDL		BDL		BDL		BDL		BDL
Water	GIC-89-V-4	BDL		BDL		BDL		BDL		BDL		BDL	
Elutriate	GIC-89-V-4	BDL		BDL		BDL		BDL		BDL		BDL	
Sediment	GIC-89-V-5		BDL		BDL		BDL		BDL		BDL		BDL
Water	GIC-89-V-5	BDL		BDL		BDL		BDL		BDL		BDL	
Elutriate	GIC-89-V-5	BDL		BDL		BDL		BDL		BDL		BDL	
Sediment	GIC-89-V-DA3		BDL		BDL		BDL		BDL		BDL		BDL
Water	GIC-89-V-DA3	BDL		BDL		BDL		BDL		BDL		BDL	
Elutriate	GIC-89-V-DA3	NOTE 8											

NOTES:

1. Criteria shown are EPA Quality Criteria for Water, 1986; March 1987 and January 1988. These water quality criteria are shown only for comparative purposes since there is no regulatory requirement for the discharge of dredge material to meet these criteria. Presently, no EPA criteria exist for marine sediment.

2. No EPA criteria presently exist for the following parameters: total PAH; acenaphthene; fluoranthene and naphthalene. The value shown is that concentration at which acute toxicity to saltwater aquatic life has been observed.

3. The criterion for toxaphene lies below the detection limit which is routinely attainable by commercial laboratories. Consequently, this minimum detection limit is used as a reference value.

4. Chromium is expressed as total chromium.

5. Total PAH is expressed as fluoranthene equivalents.

6. BDL = Below Detection Limits.

7. Dredging Invitation No. DACW64-89-B-0022.

8. Analyses not performed.

9. Data for sample nos. 3, 4, 5, and DA3 are mean values calculated from duplicate sample analyses.

0 4 JUN 199

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Ecological Services
c/o CCSU, Campus Box 338
6300 Ocean Drive
Corpus Christi, Texas 78412

TAKE PRIDE IN AMERICA

May 25, 1993

Colonel John P. Basilotto
District Engineer
U.S. Army Corps of Engineers
P.O. Box 1229
Galveston, TX 77553

Consultation No. 2-11-89-F-77

Dear Colonel Basilotto:

Enclosed is the final version of the biological opinion on the indirect effects of erosion associated with the existence of the Gulf Intracoastal Waterway (GIWW) upon the whooping crane critical habitat. This version reflects your April 30, 1993 letter of comments on the April 7, 1993 draft of the opinion, as well as the commitments mentioned in your March 24, 1993 letter to Refuge Manager Brent Geizentanner. As I promised in my April 7, 1993 cover letter conveying the last draft, the Corps' willingness to implement the elements of that draft's reasonable and prudent alternatives into its current GIWW maintenance program has allowed the Service to conclude a non-adverse biological opinion.

We have added a footnote to the biological opinion pointing out the reasoning behind not accepting as sufficiently conservative the spill projections of the Gulf Engineers report. We will accept your April 30, 1993 letter's characterization of this reasoning as "intuition" if we may choose to define intuition as meaning "a keen and quick insight." Congress clearly intended the Service to produce biological opinions with insufficient data and time to be certain; hence, intuition can be an appropriate tool, if backed by reasoning, for rendering biological opinions.

In regards to your comments in the April 30, 1993 letter concerning the requirements in Reasonable and Prudent Alternative 1 for the Corps to provide transfer funding to and a single point of contact with the Aransas National Wildlife Refuge Manager, it appears the elimination of the Reasonable and Prudent Alternatives section from the biological opinion will leave you to resolve these issues with the Refuge Manager. When you apply for the refuge use permit necessary to carry out the project-related activities on refuge property, you will find that the draft biological opinion had anticipated the permit conditions and was attempting to facilitate your acquisition of that permit.

We have added language to the incidental take section of the biological opinion to clarify that although some erosion will continue after September 1994, the shoreline protection to which the Corps is committed before and after that date will minimize that erosion to the level of anticipated incidental take. As concerns your letter's other comments, we believe the deletion of the reasonable and prudent alternative section moots the issues raised.

This concludes a long but positive process for the endangered whooping crane. Please contact me if you have any questions about the final biological opinion.

Sincerely,

ROGELIO PEREZ
Field Supervisor

Enclosure

cc:
Regional Director, U.S. Fish and Wildlife Service, Albuquerque, NM (FWE/SE)
Refuge Manager, Aransas National Wildlife Refuge, Austwell, Texas
State Administrator, U.S. Fish and Wildlife Service, Austin, Texas (ES)

Colonel John P. Basilotto
District Engineer
U.S. Army Corps of Engineers
P.O. Box 1229
Galveston, Texas 77553

Consultation No. 2-11-89-F-77

Dear Colonel Basilotto:

This responds to Colonel John A. Tudela's request of May 16, 1989, for formal consultation pursuant to Section 7 of the Endangered Species Act (Act) of 1973, as amended, on the indirect effects of erosion associated with the existence of the Gulf Intracoastal Waterway (GIWW) and the Channel to Victoria, Texas (CV), upon the critical habitat of the endangered whooping crane (Grus americana). The project areas over which consultation was requested are the segments of these channels between U.S. Army Corps of Engineers (Corps) Stations 698 + 000 to 728 + 000, and 770 + 000 to 838 + 000 on the GIWW. These segments are within the critical habitat of the whooping crane. This consultation was initiated on May 17, 1989, the date the request was received by the Fish and Wildlife Service (Service).

CONSULTATION HISTORY

By letter dated April 12, 1988, the Corps submitted to the Service a biological assessment on the impacts to endangered and threatened species occurring in the vicinity of the proposed maintenance dredging of the GIWW main channel across Aransas Bay, Texas. The assessment concluded that no direct or indirect impacts

to listed species would occur and that no critical habitat would be adversely modified because the dredging would occur in the open bay.

On May 12, 1988, the Service responded in a letter, generally concurring with the Corps' findings regarding all species except the whooping crane, but, citing the previous loss due to erosion along the GIWW of at least 230 acres of whooping crane critical habitat, requested that the Corps initiate formal consultation under Section 7 of the Act.

By letter dated May 26, 1988, the Corps declined to initiate formal consultation. The letter expressed a belief by the Corps that there existed insufficient data to support the Service's contentions about erosion, and stated that, "At present, the Corps of Engineers has no authority to provide erosion protection."

In a letter dated August 2, 1988, the Service asked for reconsideration of the decision not to consult, emphasizing that without formal consultation the Corps could not fulfill its requirements under the Act.

The Corps responded with another letter, dated August 31, 1988, disagreeing that formal consultation was mandatory and expressing the belief that the Corps had complied with the procedural requirements of the Act.

The Service's September 27, 1988, letter countered by informing the Corps that formal consultation was mandatory not because the Service requested it, but because it was a non-discretionary regulatory requirement. The Service persisted in its request for formal consultation.

By certified mail, the Sierra Club Legal Defense Fund, on behalf of the National Audubon Society and the Coastal Bend Audubon Society, sent a letter dated January 30, 1989, to the Corps and the Secretary of the Interior notifying them of their intent to sue the Galveston District for failure to consult formally with the Service over the loss of whooping crane critical habitat in connection with the GIWW.

In a letter dated March 21, 1989, and received March 29, 1989, the Corps informed the Service that it would be coordinating with the Service and other Federal, state, and local agencies concerning the erosion occurring along the GIWW within the critical habitat of the whooping crane, and asked for a list of endangered, threatened, or proposed species in the project area. The Service provided this list by telephone on March 29 and 30, and, in a letter dated March 31, 1989, confirmed that list of the following threatened (T) and endangered (E) species:

Whooping Crane - E
Grus americana

Jaguarundi - E
Felis yagouaroundi

Ocelot - E
Felis pardalis

Eastern Brown Pelican - E
Pelecanus occidentalis

Kemp's Ridley Sea Turtle - E
Lepidochelys kempii

Aplomado Falcon - E
Falco femoralis

Piping Plover - T
Charadrius melodus

Green Sea Turtle - T
Chelonia mydas

Attwater's Prairie Chicken - E

Tympanuchus cupido attwateri

Arctic Peregrine Falcon - E

Falco peregrinus tundrius

Loggerhead Sea Turtle - T

Caretta caretta

Interior Least Tern - T

Sterna antillarium

Bald Eagle - E

Haliaeetus leucocephalus

Hawksbill Sea Turtle - E

Eretmochelys imbricata

American Alligator - T

Alligator mississippiensis

On April 11, 1989, the Service received from the Corps a letter dated March 30, 1989, requesting documents relating to the erosion of the critical habitat to assist the Corps in the preparation of a biological assessment addressing erosion and maintenance dredging. These documents were mailed to the Corps on April 12, and 14, 1989.

With a letter dated May 16, 1989, the Corps submitted to the Service and the National Marine Fisheries Service copies of the Corps' "Biological Assessment for Impacts to Endangered and

Threatened Species Maintenance Dredging, Gulf Intracoastal Waterway, Texas (Stations 698 + 000 to 860 + 000) and Channel to Victoria, Texas (Stations 0 + 00 to 180 + 000)" (Biological Assessment). The letter stated, based on this Biological Assessment, no direct or indirect effects were occurring on listed species. The letter requested initiation of formal consultation specifically on areas in which the

erosion had been found to affect the critical habitat: along the GIWW between Stations 698 + 000 to 728 + 000, and 770 + 000 to 838 + 000. The letter also requested the Corps be furnished a draft copy of the biological opinion the Service was being asked to provide.

On June 14, 1989, the Service wrote back acknowledging receipt of the Biological Assessment, concurring in part with its conclusions, and asking for additional information and clarification to aid in the consultation.

The Corps responded with a letter of July 13, 1989, transmitting its "Supplement to Biological Assessment for Impacts to Endangered and Threatened Species - Maintenance Dredging of the Gulf Intracoastal Waterway (GIWW) and Channel to Victoria, Texas." (Supplement). The Supplement revised the Corps' findings in the Biological Assessment to state that indirect effects upon the whooping crane, as well as upon its critical habitat, may occur as a result of the indirect effects of erosion. The supplement also provided information on the types and quantities of commodities shipped on the GIWW and agreed to provide additional records of spills when they became available. Such records were subsequently transmitted to the Service via letters dated September 1 and 13, 1989.

The Corps initiated a study under authority of Section 216 of the 1970 Flood Control Act (Section 216 Study) in November 1988, and in November 1989 completed the Reconnaissance phase of the Section 216 Study. During this first study phase, the Corps examined an alternative for rerouting the GIWW north and west of the critical habitat at an estimated cost of $153 million, as well as alternatives for armoring 29.7 miles of existing channel banks with articulated concrete mats, at an estimated cost

of $29 million (USCE 1989a; USCE 1989b). The Corps did not state whether either alternative was considered practicable, although it noted that the rerouting had questionable environmental consequences, and that some natural erosion would continue to affect the critical habitat along the existing channel (USCE 1989b). If this alternative were chosen, construction could begin in 1997 and take 4 to 6 years to complete; the concrete mat alternative would take only 2 years to install (USCE 1989b). During the Section 216 feasibility phase study, an activity expected to take 4 years to complete (USCE 1989a), alternative methods of bank protection, and three rerouting alternatives will be studied, along with beneficial uses of dredged material, a reach-specific spill contingency plan, and a quantification of the difference between natural erosion impacts and traffic-generated erosion impacts to critical habitat (USCE 1989b). Feasibility investigations were initiated in September 1990 and are scheduled for completion in September 1994. The completed Feasibility Report will include an EIS, and subsequent project construction would depend upon congressional authorization and funding of the recommended plan (USCE 1989a).

Between 1989 and 1991, the Service and the Corps conducted several activities aimed at stopping erosion of whooping crane critical habitat. It was agreed by the Service and the Corps to immediately implement temporary actions that would reduce the "may effect" to the whooping crane and its critical habitat while the long-term alternatives were studied under Section 216 of the 1970 Flood Control Act. Several meetings were held during the spring of 1989 to assess measures including:

1. Beneficial uses of dredged material to protect and create whooping crane habitat; and,

2. Placing sand bags/concrete mixtures, riprap, rubble, or other suitable material into the eroded areas. This has culminated in four separate public/private shoreline stabilization projects being carried out under the coordination and direction of the Service and the Corps. Using volunteer labor and donated bags of sacrete and transportation vessels, these four projects were carried out during August 1989 and 1990 and June 1991 and 1992, resulting in 57,000 bags of concrete being placed along 8,750 feet of the most eroded parts of the GIWW in whooping crane critical habitat.

Additionally, two concrete matting projects are being evaluated in other areas of the critical habitat: Mitchell Energy's 30-acre mitigation project initiated in the summer of 1991, and a "Coastal America" project (450 linear feet) implemented in the fall of 1991.

In an August 1, 1991, draft of this biological opinion, the Service notified the Corps of its belief that reasonable and prudent alternatives existed which would halt erosion of whooping crane critical habitat adjacent to the GIWW:

1. Halt all erosion of whooping crane critical habitat on the mainland between Corps' GIWW Stations 698 + 000 to 728 + 000, and 770 + 000 to 838 + 000. This was to be completed by November 15, 1992.

2. Establish a toxic spill and traffic control plan, with required on-site equipment, to minimize the risk of toxic spills and boat collisions within whooping crane critical habitat. This was to be accomplished by November 15, 1992, and included:

a) establishment of a no-wake zone; and

b) establishment of special rules, including active monitoring of traffic, enforcement of one-way traffic guidelines for unwieldy vessels and those carrying oil or other hazardous cargoes, and restriction of traffic movement during inclement weather.

The Service subsequently met on September 5, 1991, with the Corps to clarify its belief that the erosion of critical habitat could and should be halted as soon as possible by hiring a contractor to complete the sacrete emplacement project begun in 1989 with volunteer labor during the next construction season (i.e., when the cranes were not present). The Service also made it clear that this sacrete project was not intended to substitute for the Section 216 Study; rather, its purpose was to provide temporary, but timely, compliance with Section 7(a)(2) until the Section 216 Study provided long-term solutions. The Corps responded that this scenario was technically feasible and could be carried out because the Service stated mistakenly that the Service could obtain the Congressional authorization and funding for the sacrete project; the Corps stated its regulations restricted it from seeking such emergency funding and authorization. The Corps also said it had no jurisdiction over vessel traffic, which was a responsibility of the U.S. Coast Guard. The Corps' opinions were restated in District Engineer Brink P. Miller's letter to the Service dated October 21, 1991:

> Pertaining to the reasonable and prudent alternatives specified in this draft biological opinion (August 1, 1991),

the following comments are offered. With regard to alternative No. 2, although these issues are being considered in the Section 216 Study, the authorities and responsibility for toxic spills and speed limits lie within the purview of the Coast Guard.

Concerning the halting of all erosion along the shoreline, the Galveston District is presently unaware of any authority under the existing project that would permit the commitment of Federal funds to construct the desired erosion prevention measure. I am, however, in the process of researching all existing authorities to determine if they can be applied for the protection of the whooping crane critical habitat. Additionally, I am requesting my higher headquarters to assist me in this task. Considering that the District is currently lacking in both authority and funds, I consider the November 1992 deadline unattainable for halting all erosion and request that you withhold issuance of your biological opinion pending the completion of our research efforts.

As you are aware, reaches of the GIWW within the critical habitat have a high shoaling rate and maintenance of this project is scheduled for Fiscal Year 1992. Recognizing the very serious nature of the habitat loss as well as the economic impacts and safety issues associated with the

> inability to maintain the GIWW, I will expedite my research with the expectation that authority will be found for a positive resolution of this matter. In the interim, I will keep you advised of our progress on this issue.

In a letter dated September 12, 1991, the Service corrected the misstatement made at the September 5 meeting that the Service would get the funding and authority to complete the sacrete emplacement by November 15, 1992. The Service advised that its role in this consultation was to suggest reasonable and prudent alternatives, not carry them out.

Service and Corps representatives met to discuss the October 21, 1991, letter on December 18, 1991. The Corps' representatives stated they were concerned about the release of the biological opinion because the jeopardy opinion could prevent the continued maintenance of the GIWW in the critical habitat of the whooping crane. The Service representatives stated that halting maintenance in that reach was not the intended outcome of this consultation because halting maintenance would actually increase the likelihood of a toxic spill. The Corps then agreed that the biological opinion should be finalized and released.

The Service, in a letter to the Corps dated January 24, 1992, attempted to persuade the Corps to change its position on the lack of availability of reasonable and prudent alternatives. Colonel Miller responded with a letter telefaxed to the Service on February 12, 1992. On the following day, representatives from the Corps' Southwestern Division and Galveston District Offices and from the Service's Region 2 Regional and Corpus Christi Field Offices met in Dallas to see if appealing the

matter to higher levels of authority might result in agreement. The Corps reiterated that it lacked the authority and funding to immediately halt all erosion of critical habitat, but acknowledged the feasibility of temporarily instituting partial erosion control measures until the permanent control measures to be identified by the Section 216 Study could be put into effect. Such temporary measures might include placing sacrete along the most vulnerable sections of the critical habitat (in addition to those areas protected each year by the volunteer Aransas Shoreline Preservation Project) and beneficial uses of dredged material, such as placing dredged material along shorelines and/or between islands to serve as wave barriers and/or creation of whooping crane habitat. These activities would be carried out when and as proper authority and funding could be acquired.

The Corps was asked at the February 13, 1992, meeting whether the timetable for the Section 216 Study could be accelerated. The response was that, after the Final Feasibility Report was completed in September 1994, it might be possible to obtain design funds during the review period in Washington, D.C., thereby cutting as much as a year off the projected start of construction date, currently seen as sometime in Fiscal Year 1997 or Fiscal Year 1998, most probably the latter. The Corps agreed to review the schedule in an effort to identify opportunities to reduce the time required to complete the long-term solution.

Finally, the attendees at the February 13, 1992, meeting addressed the issue of the Corps' role in controlling navigation of the GIWW. The Service acknowledged the Coast Guard's paramount authority in matters of vessel traffic control, but explained that the Service perceived the Corps as the lead agency with regard to the operation of the GIWW, regardless of which agency actually carried out the alternative found

necessary to avoid jeopardy. The Corps continued to dispute the lead agency role as it pertains to what it perceives as Coast Guard responsibilities. The Corps expressed a willingness to look into the ramifications of this lead agency role, while the Service agreed that it would assist in soliciting the Coast Guard's participation in developing the envisioned element 3 of the reasonable and prudent alternative.

The Service rewrote its draft of the biological opinion and on February 18, 1992, submitted revised copies to your office for review and comment. That draft featured the following items as the proposed reasonable and prudent alternative:

1. The Section 216 Final Feasibility Report will be completed no later than September 1994. The Corps of Engineers will expedite this study and all subsequent handling of the selected long-term erosion control plan so as to implement its construction no later than Fiscal Year 1997. Any facilities thus constructed shall be maintained in good repair in perpetuity.

2. Together with the Fish and Wildlife Service, the Corps of Engineers shall monitor erosion along the GIWW in the critical habitat of the whooping crane. The Corps of Engineers shall, until the above cited long-term erosion control plan is implemented, actively seek the authority and funding to carry out temporary erosion control measures in the critical habitat reach of the GIWW. Such measures shall be approved by the Fish and Wildlife Service, shall be compatible with the on-going Aransas Shoreline Protection Project, shall not interfere significantly with any long-term erosion control alternative, and shall be instituted on a priority basis. Priority shall be assigned annually to identifying and protecting

as much as possible of those areas of critical habitat which without human intervention would be adversely modified or destroyed by erosion within the next year.

3. The Corps of Engineers shall take the lead agency role in all matters pertaining to the operation and maintenance of the GIWW within the critical habitat of the whooping crane. The Corps of Engineers shall petition the assistance of the U.S. Coast Guard as a cooperating agency in the formulation and institution of actions designed to avoid and to respond to the spillage of oil and other hazardous materials within the pertinent reach of the GIWW. Such actions as establishing a no-wake zone, active monitoring of traffic, enforcement of one-way traffic guidelines for unwieldy vessels and hazardous cargoes, restriction of traffic movement during inclement weather conditions, and on-site installation of spill control equipment shall be considered and, if determined feasible by the Coast Guard, Corps of Engineers, and Fish and Wildlife Service, made a part of an over-all toxic spill and traffic control plan. The features approved for this plan shall be put into operation no later than 1 year from the date of this opinion.

On February 25, 1992, the Service wrote a letter to the Corps explaining its position regarding the lead agency role discussed at the February 13 meeting and expressed in the February 18 draft biological opinion by way of element 3 of the reasonable and prudent alternative.

Under cover of a letter dated February 26, 1992, the Galveston District's Chief of Planning Division, William Fickel, Jr., submitted your office's comments on the February 18 draft biological opinion. Among those comments were the following recommended changes to the proposed reasonable and prudent alternative [the Corps' recommended additions are underlined, while its recommended deletions are struck through]:

1. The Galveston District Feasibility Report and EIS for the Section 216 Study will be completed ~~no later than~~ in September 1994. This report will contain recommendations for a long term solution to the erosion problem occurring in the critical habitat of the whooping crane. This report will be processed to the Congress for project authorization. The Corps of Engineers will expedite this study and all subsequent handling of the selected long-term erosion control plan ~~so as~~ with a goal to implement its construction ~~no later than~~ in the Fiscal Year 1997/Fiscal Year 1998 time frame. Any facilities thus constructed shall be maintained in good repair in perpetuity.

2. Together with the Fish and Wildlife Service, the Corps of Engineers shall monitor erosion along the GIWW in the critical habitat of the whooping crane. The Corps of Engineers shall, until the above cited long-term erosion control plan is implemented, actively explore its authorities and seek ~~the authority and~~ funding to carry out temporary erosion control measures in the critical habitat reach of the GIWW. Such measures shall be approved by the Fish and Wildlife Service, shall be compatible with the on-going Aransas Shoreline Protection Project, shall not interfere

significantly with any long-term erosion control alternative, and shall be instituted on a priority basis. Such measures may include beneficial uses of dredged material. Priority shall be assigned annually to identifying and protecting as much as possible of those areas of critical habitat which without human intervention would be adversely modified or destroyed by erosion within the next year.

3. The Corps of Engineers shall take the lead agency role in all matters pertaining to ~~the operation and maintenance of~~ dredging activities on the GIWW within the critical habitat of the whooping crane. The Corps of Engineers shall petition the assistance of the U.S. Coast Guard as a cooperating agency in the preparation of an EIS in connection with the Section 216 Study.

4. The U.S. Coast Guard has the responsibility for ~~in~~ the formulation and institution of actions designed to avoid and to respond to the spillage of oil and other hazardous materials within the pertinent reach of the GIWW. The Corps will offer its assistance to the Coast Guard in these actions. Such actions as establishing a no-wake zone, active monitoring of traffic, enforcement of one-way traffic guidelines for unwieldy vessels and hazardous cargoes, restriction of traffic movement during inclement weather conditions, and on-site installation of spill control equipment shall be considered and, if determined feasible by the Coast Guard, Corps of Engineers, and Fish and Wildlife Service, made a part of an over-all toxic spill and traffic control plan under the authority of the Coast Guard. The features approved for this plan shall be put into operation not later than

one year from the date of this opinion. (Since these actions will be the responsibility of the Coast Guard, the one year time frame should not be a condition on the Corps).

The Service sent its next draft of the biological opinion to the Corps on March 30, 1992. This version advocated an increased effort by the Corps to explore its authorities and to seek funding to carry out temporary erosion control measures because, if the Corps were successful, the revised program would, by halting erosion until the Section 216 Study provided a permanent fix, merit a non-adverse opinion. Meanwhile, volunteer efforts placed more concrete sacks along critical shoreline areas in June of 1992.

The "Final Report - Spill Contingency and Prevention Plan for the Gulf Intracoastal Waterway at the Aransas National Wildlife Refuge," (Spill Contingency Report), a contract report prepared for the Corps by Gulf Engineers and Consultants, Inc., was released in June 1992. Of significant importance was the Spill Contingency Report's finding that the mean probabilities of the most likely and worst-case vessel spill occurrences in the critical habitat of the whooping crane along the GIWW are one spill per 1,075 years and one spill per 7,982 years, respectively.

On July 13, 1992, the Service wrote to the Corps to confirm a notice from the Corps that they had found the authority to provide short-term shoreline protection and also were seeking funding to protect the most highly erosive areas in the whooping crane critical habitat reach of the GIWW. On the same day, the Corps wrote to the Service providing a brief assessment of the impact of a proposal to emplace concrete matting

to armor 2,000 feet of shoreline in that same reach as a prototype of one of the possible solutions that would be further developed in the Section 216 Study.

By letter dated September 16, 1992, the Corps confirmed that it had received limited authority to perform short-term shoreline protection until the Section 216 project is implemented; however, "while authority was granted, no additional funds were provided, requiring the judicious use of existing O&M funds." The letter continued that, beginning with the 2,000 feet of concrete matting identified in July and under construction in September 1992, a minimum of 2,000 feet of shoreline could be protected by the Corps each year, subject to the availability of funds. The letter expressed the hope that this amount of protection could be exceeded each year, but acknowledged that receipt of funding is subject to Congressional priorities and fiscal constraints. It added that if the Section 216 project is authorized and funded in Fiscal Year 1996, construction could begin as early as Fiscal Year 1998.

The Corps' September 16, 1992, letter also provided comments on the March 30, 1992, draft biological opinion. One of these comments dealt with a semantic problem; that draft opinion associated channel maintenance and maintenance dredging with jeopardy and taking. The association was a consequence of the Corps' wording of the original May 15, 1989, request for consultation: "Pursuant to Section 7(c) of the Endangered Species Act, a biological assessment for impacts to endangered and threatened species has been prepared for the <u>maintenance dredging</u> of the Gulf Intracoastal Waterway (GIWW) and the Channel to Victoria, Texas, within the critical habitat of the whooping crane." (Emphasis added.) An attempt was made in an April 7, 1993 draft to infer that it is the GIWW's presence or existence that leads to erosion and its impacts on the species and its habitat. The September 16, 1992, letter also

mentions the need to make changes in light of developments since March 30, 1992, including the new-found authority and funding to carry out a degree of interim shoreline protection, as well as the findings of the Spill Contingency Report. Finally, the letter states that, pursuant to the Council on Environmental Quality regulations for implementing the National Environmental Policy Act, the Corps is formally requesting that the Coast Guard be a cooperating agency in the preparation of the EIS for the Section 216 project. These items were reflected in the April 7, 1993 draft biological opinion.

In the Corps' March 24, 1993, letter to the Service, which responded to a phone call from the Service, the Corps committed to install 7,000 feet of shoreline protection during Fiscal Year 1993, and to protect an additional 7,000 feet of shoreline by September 1994. If additional funding is available, the Corps indicated it would provide additional shoreline protection.

The last draft biological opinion, transmitted to the Corps on April 7, 1993, found that both erosion and spills from vessels navigating the GIWW had resulted in and/or would be likely to continue to contribute to the destruction and adverse modification of the whooping crane critical habitat. The draft opinion also found that such destruction and adverse modification was likely to jeopardize the continued existence of the whooping crane. However, the draft opinion cited reasonable and prudent alternatives to avoid adverse modification/jeopardy, and was accompanied by a cover letter stating the adverse modification and jeopardy findings would be removed from the final biological opinion if the Corps were willing to commit to the implementation of all the elements of the reasonable and prudent alternative in the Corps' current GIWW maintenance program. The Corps responded to the April 7, 1993 draft

biological opinion and its cover letter in a letter dated April 30, 1993. While expressing some dissatisfaction with the draft opinion's findings and pointing out areas in need of clarification, the April 30, 1993 letter announced in summary the Corps' ability to commit to the elements of the draft opinion's reasonable and prudent alternative, subject to the comments expressed. The comments have been considered by the Service and are reflected in the final biological opinion.

This biological opinion is based upon the information provided by the Corps in its Biological Assessment, the Supplement, related records and contractor's reports; available literature and data in Service files; and consultation with experts.

BIOLOGICAL OPINION

It is my biological opinion that erosion indirectly associated with the presence of the Gulf Intracoastal Waterway within the critical habitat of the whooping crane has resulted in the destruction and adverse modification of that critical habitat, and that toxic spills on that reach of the GIWW likewise threaten its destruction and adverse modification. However, it is also my biological opinion that temporary and long-term features presently incorporated into the Corps' programs, especially those associated with the Section 216 study, will avoid significant destruction and adverse modification of the critical habitat from erosion and spills, and as a consequence avoid erosion-and spill-related jeopardy to the whooping crane's continued existence.

BACKGROUND INFORMATION: PROJECT DESCRIPTION:

Construction of the GIWW between the Sabine River and Aransas Pass, Texas, at its presently authorized location and dimensions of 12 x 125 feet, began in 1941 and was completed in 1944, supplanting a 9 x 100-foot channel completed in 1940 (USCE 1989b). Due to the channel's proximity to the mainland, the initial deposition of dredged material, and subsequent levying of many of these disposal areas in 1974 (USCE 1989a), the GIWW in the area under consultation is today nearly landlocked, with the major exception of the reach across San Antonio Bay (see Figure 1). The project area became part of the whooping crane's critical habitat when this was designated on May 15, 1978 (USFWS 1980b).

WHOOPING CRANE

Habitat Requirements

The whooping crane is an omnivore, but its diet on its wintering grounds on the Texas Coast consists predominately of animal food, especially blue crabs and clams (USFWS 1986). Other known food items include marine worms, amphibians, fish, crayfish, insects, sedge tubers, fiddler crabs, other crabs, acorns, wolfberries, oak galls, and green vegetation (NAS 1986; USFWS 1986; Hunt and Slack 1987). Most foraging occurs in salts flats, salt marshes, and coastal lagoons with brackish water (USFWS 1980a; USFWS 1986). Upon arrival on the wintering grounds in mid-November, it feeds almost exclusively on blue crabs in seasonally flooded tidal flats, but becomes more dependent upon clams taken from shallow bays and channels when tides and temperatures become lower in December and January (USFWS 1980b;

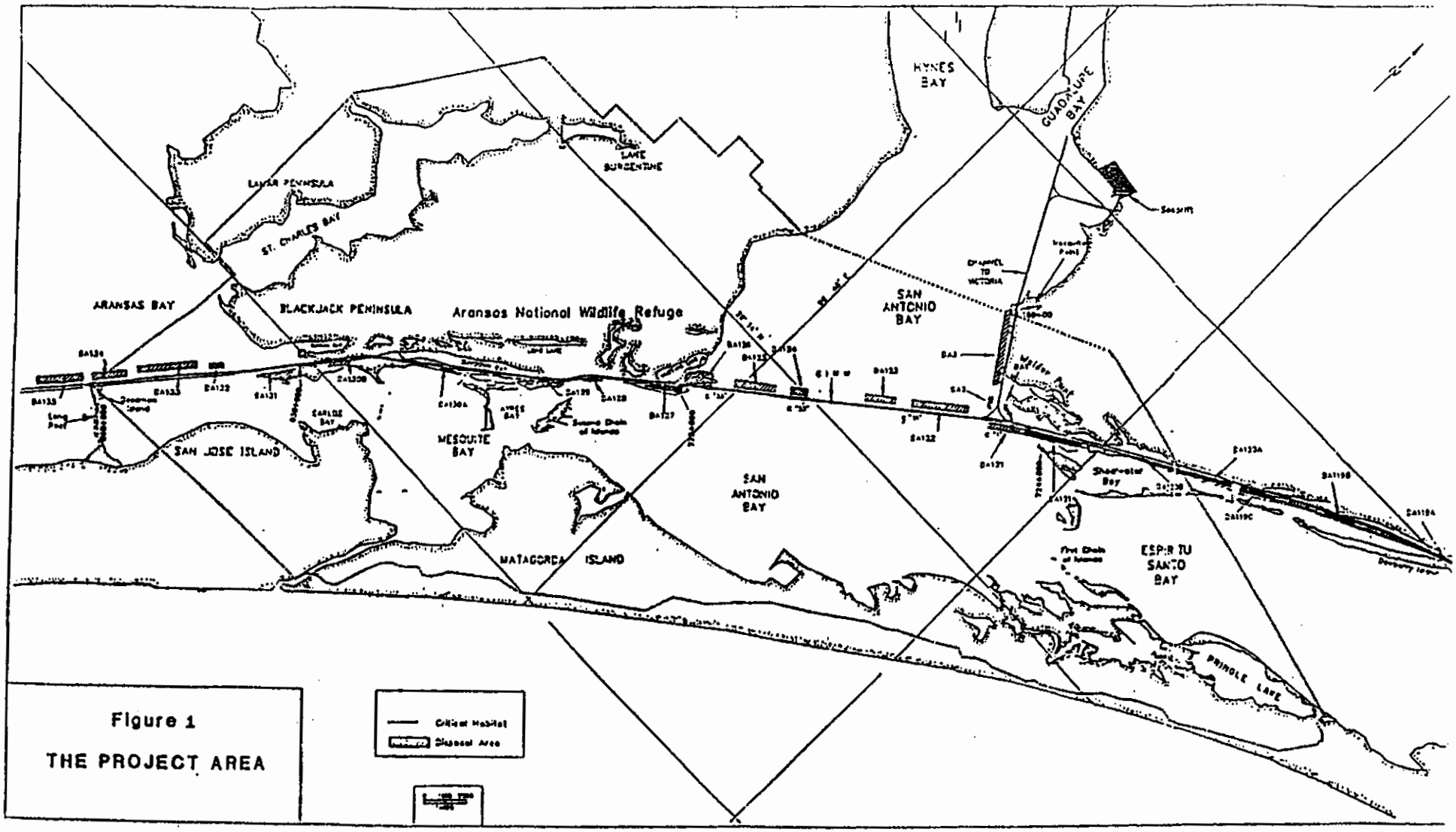


Figure 1

THE PROJECT AREA

USFWS 1986). Clams are also important foods items whenever high salinities encountered during drought periods reduce the blue crab population (USFWS 1980b; USFWS 1986). Whooping cranes spend relatively little time away from the coastal saline wetlands, although they will forage opportunely whenever uplands are flooded by rainfall or upland crops of acorns are made particularly accessible by burning off the undergrowth (USFWS 1980b; USFWS 1986; Stehn 1990). They will also fly inland to drink fresh water whenever marsh salinities exceed 24 parts per thousand (Stehn 1990). However, whooping cranes generally return to the salt marshes and ponds each evening to roost in 5 to 8 inches of water; water roosts protect the bird from predators such as coyotes (NAS 1986).

A major criterion for whooping crane wintering habitat is space; mated pairs upon arriving quickly establish and defend territories for themselves and their young-of-the-year, if any, against all other whooping cranes. Unmated subadults also require suitable habitat, not just the mated pairs. Winter territory size varies from 136 to 2,557 acres (Stehn and Johnson 1987).

Distribution and Population

When construction of the GIWW began in 1941, there were only 15 whooping cranes remaining. In the spring of 1993, the Aransas-Wood Buffalo flock numbered 136 birds. The majority of this flock has established territories in suitable marshes along the GIWW, including areas on the Aransas National Wildlife Refuge (ANWR), San Jose Island, Lamar Peninsula, and an area on the east side of San Antonio Bay known as Welder Point (USFWS 1986; Stehn and Johnson 1987). Their distribution is not uniform; of the approximately 54,362 acres of apparently suitable marshland

in the general wintering grounds, only 37 percent (20,200 acres) was being used by whooping cranes during the winter of 1984-85 (NAS 1986; USFWS 1986; Stehn and Johnson 1987). It appears there is ample habitat remaining to allow for expansion of the flock (USFWS 1980b; NAS 1986), but the species seems reluctant to pioneer in unoccupied habitat (USFWS 1980b). The average size of territories on the mainland side of the ANWR has decreased as the number of territories increased, apparently because offspring upon pairing tend to establish territories adjacent to where they spent their first winter at the ANWR (Stehn and Johnson 1987). Thus, the smallest territories adjoin the GIWW. Furthermore, in the winter of 1989-90, 94 out of 146 whooping cranes (64 percent) used areas adjoining the GIWW (Stehn 1990).

Reasons for Decline

Agricultural development and hunting were the major factors in reducing whooping crane numbers from an estimated population of 500 to 1,500 in 1870 to only 15 in 1941 (USFWS 1980a; USFWS 1980b; NAS 1986). Hunting losses were particularly high on the Gulf Coast wintering grounds (USFWS 1980a); by the early 1900's documented kills throughout its range probably exceeded the species' rate of reproduction (USFWS 1980b). The draining of land and human presence associated with the growth of farming in former nesting areas of the northern Great Plains and the prairie provinces of Canada left the remainder of the breeding population too far north to allow renesting if the first clutches failed (USFWS 1980b). Recovery is very slow because a pair generally only produces one chick per year (USFWS 1980a), and as few as one chick in four survives to reach Texas (USFWS 1980b).

Vulnerability to Extinction

Although its remaining nesting grounds are now protected from further agricultural encroachment, the whooping crane still suffers from the effects of weather, disease, collisions with powerlines, and occasional shooting (NAS 1986). Despite efforts to establish another self-sustaining wild population (the goal established for downlisting the species' status to threatened is the creation of at least 2 flocks with 25 nesting pairs each, in addition to having at least 40 nesting pairs in the Aransas-Wood Buffalo flock and populations stable or exceeding these numbers for a decade (USFWS 1980b), the only self-sustaining wild population is still vulnerable to a single catastrophic event, like a hailstorm on the nesting grounds or a late-season hurricane on the wintering grounds. A non-migratory flock in Louisiana lost half its birds in a 1940 hurricane and never recovered (USFWS 1980b). Another such catastrophic event might be an oil or chemical spill on the GIWW. So far, such spills have been more a threat than an actuality, although 25 to 50 barrels of crude petroleum did spill at the ANWR in the summer of 1974, extending as far as 16 km along the GIWW before it was contained (USFWS 1986). However, the Supplement to the Biological Assessment provides lists of materials and tonnages transported through the critical habitat that illustrate to some extent the seriousness of the spill threat. For example, the total tonnage transported in 1987 was almost 10 million tons, including 616,872 tons of crude petroleum; 2,399,018 tons of gasoline; 2,361,249 tons of benzene, and 1,049,509 tons of basic industrial chemicals. Each of these cargoes is chronically to acutely toxic and has the potential, if it were spilled or carried by the action of wind and tides into the critical habitat, to destroy and/or degrade that habitat and to affect whooping cranes adversely, perhaps even fatally. It must be noted that it is the use of the GIWW to transport such cargoes

that poses the threat of spills; maintenance of the GIWW is necessary to remove navigational hazards that would increase the threat.

Other insidious threats of extinction are the buildup of toxic chemicals in the whooping crane's food supply and the loss of freshwater inflows. One might expect that agricultural pesticides from nearby croplands would drain into areas used on migration or for wintering, but whooping crane egg and tissue samples examined for pesticide residues so far indicate concentrations well below those found in other migratory birds (USFWS 1986, Lewis et. al. 1992). Concerns have also been expressed that environmental contaminants like those so often found in association with navigation projects might be present in the sediments dredged to maintain the reach of the GIWW in the critical habitat. Fortunately, extensive sampling conducted by the Service and the Corps, often in association with other consultations, has yet to disclose other than minor and localized evidence of contaminants in the sediments, water, and food organisms the whooping crane may encounter.

The Spill Contingency Report (Gulf Engineers & Consultants, Inc. 1992) evaluated the effect of potential spill incidents associated with vessels and their cargoes and addressed how those spills might be controlled or prevented in the 50-mile reach of the GIWW (Miles 475 to 525, as measured from Harvey Locks, Louisiana) that crosses the critical habitat of the whooping crane. The report considered all the kinds and amounts of cargoes transported annually, each cargo's potential to cause harm to the crane and its habitat, each cargo's relative frequency of occurrence in the study area, and the likely causes and volumes of spills. From this the Spill Contingency Report determined that the spill most likely to occur in the 50-mile reach would be the releases of over 100 barrels of gasoline through a rupture in the hull of a barge

as the result of a collision with another barge or a grounding in which a hard bottom or object played a part. The report estimated the probability of occurrence of the most likely spill as 1 spill per 1,075 years. The report further found that although gasoline was the cargo most likely to be spilled, based upon its proportion of the total cargoes conveyed annually, its potential to harm whooping cranes and their habitat was reduced because it is often (and increasingly) carried in double hull barges and its volatility lessens it chances to reach and persist in the cranes' vicinity.

The Spill Contingency Report found the worst-case spill to consist of half a barge compartment load (1500 barrels) of a floatable crude, residual, or lubricating oil from a head-on collision of barges. Although less likely to occur (1 spill per 7,982 years), such a spill would be worse than a gasoline spill because of its potential to persist in the environment, both as a mobile, floating menace and as a contaminant on substrates and foods available to the cranes. "The oil and heavily tainted soils and vegetation would have to be removed, and additional habitat damage would occur from the movement of workers and equipment to these difficult-to-access locations." (Gulf Engineers & Consultants, Inc. 1992)

Besides worst-case spills, the Spill Contingency Report also considered worst-case scenarios, i.e., the worst conditions of wind and location for the worst-case spill. The worst of these scenarios describes a spill occurring at Wynne's Cut, near mile 507 of the GIWW, during prevailing southeasterly wind conditions; much of the spill would reach the marshes on Sundown Bay's northern shore. Assuming floating booms could be brought into play to at least contain the oil on that shoreline, the report estimated "About 10 acres of submerged vegetation and about a mile of marsh

banks could be damaged, some quite severely. If whooping cranes were feeding in the area and were not deliberately and continually frightened away, they could be exposed to a fatal oil coating." "Since the whooping cranes occupy large areas in territorial family units, a worst-case event would most likely involve killing several families of whooping cranes within a high use area. An example of a high use area is Wynne's Cut, near mile 507 of the GIWW, where up to 22 cranes have been observed feeding simultaneously in the vicinity." (Gulf Engineers & Consultants, Inc. 1992).

The Spill Contingency Report also provides very useful information about existing spill control organizations, spill contingency plans, navigational hazards in the study reach, histories of grounding and spill events, and measures to control spills. Among the latter is the placement of piles at gaps in the shoreline erosion protection features already constructed and under consideration as a Section 216 Study alternative to provide anchors for floating booms, thus creating almost a continuous part-time barrier to floating pollutants in the critical habitat reach of the GIWW. Among the hazard areas identified are the intersection of the GIWW and the Victoria Barge Canal and the rocky ledges lining the GIWW south of mile 525.

In a letter to the Service dated October 28, 1992, William L. Cox, Chief of Federal Assistance Section for the Environmental Protection Agency's (EPA) Region 6, provided a supplemental Biological Assessment regarding the expected impacts of Formosa Plastics Corporation's facilities expansion at Point Comfort that concluded there is an "extremely remote" possibility that a spill of toxic materials associated with that expansion might impact the whooping crane and/or the Aransas National Wildlife Refuge and adjacent water bodies. Asked by the Service to quantify the

worst-case spill necessary to affect the crane and its habitat, Norm Thomas, Chief of Federal Activities Branch at EPA's Region 6, responded in another letter dated December 2, 1992, that the most reasonable catastrophic incident would be a tanker/barge tow collision or a barge/barge tow collision, with a worst-case release of either the full 20,000-barrel contents of one barge (approximately 3, 000 tons of liquid) plus the contents of the two largest wing tanks (approximately 2,000 tons of liquid) of a 35,000-DWT tanker, or the loss of the contents of two full barges (i.e., 6,000 tons of liquid). According to the December 2 letter, the worst location for such a spill would be near the intersection of the Matagorda Ship Channel and the GIWW where winds and currents could under the worst of circumstances carry the spilled materials via Pass Cavallo and Saluria Bayou into Espiritu Santo Bay. The worst-case materials that might be spilled were stated in the letter to be petroleum oils (wash oil, pyrolysis oil and natural fuel oil), 50 percent caustic solution, and ethylene dichloride. The December 2 letter estimated the Formosa expansion would increase barge traffic by 73.5 percent and ship traffic by 60.5 percent, and, taking into consideration U.S. Coast Guard data from 1982 to 1991 during which 6,500 ships and barge round trips resulted in 24 spills of generally less than 10 gallons of liquid each from marine transportation, for a calculated spill rate of 0.0037 spill events per ship or barge trip, concluded with EPA's assessment that the probability of a catastrophic collision event is very low and that the probability of a worst-case location scenario is even lower.

Project Impacts

Estimates vary regarding the extent of critical habitat loss due to erosion. The Corps (USCE 1988; USCE 1989b; USCE 1990) claims that in the ANWR reach alone

erosion has accounted for a loss of 2 acres per year since 1944, or about 90 acres in all (USCE 1988), mainly on the north bank. Stehn (1988) claims the rate in the ANWR reach was more like 3 to 4 acres per year, totaling 230 acres, and that another 172 acres were eroded north of San Antonio Bay. The Biological Assessment estimates this northern reach has sustained a loss of approximately 2.5 acres per year, and accounts for the difference in estimates by explaining that Stehn (1988) assumed different construction top widths than those the Corps determined had actually been employed. Although it is not known how much of this erosion is due to vessel wakes and how much to wind-driven waves, halting the maintenance and/or use of the GIWW would not bring about the complete cessation of wind-driven erosion in the critical habitat, which the Corps views to be the more detrimental component of the erosion problem.

The Corps currently has a contract study under way to gather additional details on the erosion in the critical habitat.

Volunteer efforts have provided temporary erosion protection along 8,750 feet of the most sensitive shorelines in the critical habitat reach of the GIWW. The Corps added 2,000 feet of protection in the form of concrete matting in the Fall of 1992, and was by that time committed to at least an additional 2,000 feet of matting or similar protection in each year until the Section 216 project is constructed. Stehn stated in an October 23, 1992, memorandum to the ANWR Manager that approximately 14, 650 feet of shoreline would be severely eroded, threatening much of the refuge's best whooping crane habitat, if not protected by the end of the 1994 summer construction season. If, by a combination of marsh creation and concrete matting, the Corps is only able to halt erosion along another 5,500 feet of shoreline as expected during

1993 and 1994, then over 9,000 feet will be left in immediate need of protection. (See Figure 2.) In a letter dated March 12, 1993, Refuge Manager Brent Geizantanner outlined " . . . the urgent need for 14, 650-feet of shoreline protection by September 1994. Areas designated for protection are those that contain the best whooping crane habitat, are used by the highest density of cranes, and are eroding the fastest. An average of 37 whoopers (27 percent of the flock) resided along this 14,650-foot section of the refuge this winter. The habitat must be protected since the impacts of the loss of habitat go far beyond the estimated 3-feet of bank lost annually along the GIWW. For example, the loss of a narrow peninsula at the mouth of Mustang Lake threatens seagrass beds and shallow whooping crane feeding areas over a much larger portion of the lake bed. An estimated 22 ponds, including two large lakes that total 24 acres in size, will be lost in the next 2 years to erosion along the 14,650-foot stretch if nothing is done." On March 23, 1993, the Corps responded in a letter to the Refuge Manager that the Corps was committed to protecting an additional 14,000 feet of shoreline by September 1994.

Conclusions

By the most conservative estimates, over 200 acres of whooping crane critical habitat have been lost due to erosion along the GIWW. This is a well-documented adverse modification of that critical habitat. Volunteer efforts have significantly contributed to temporarily halting the worst of the erosion and saving the best of the habitat. A permanent solution to the problem of erosion is in the planning stages (Section 216 Study) and will be in the hands of Congress in Fiscal Year 1996, with construction projected to begin as early as Fiscal Year 1998. The Corps as of March 14, 1993, was committed to temporarily halting significant erosion in the Aransas Reach of the GIWW

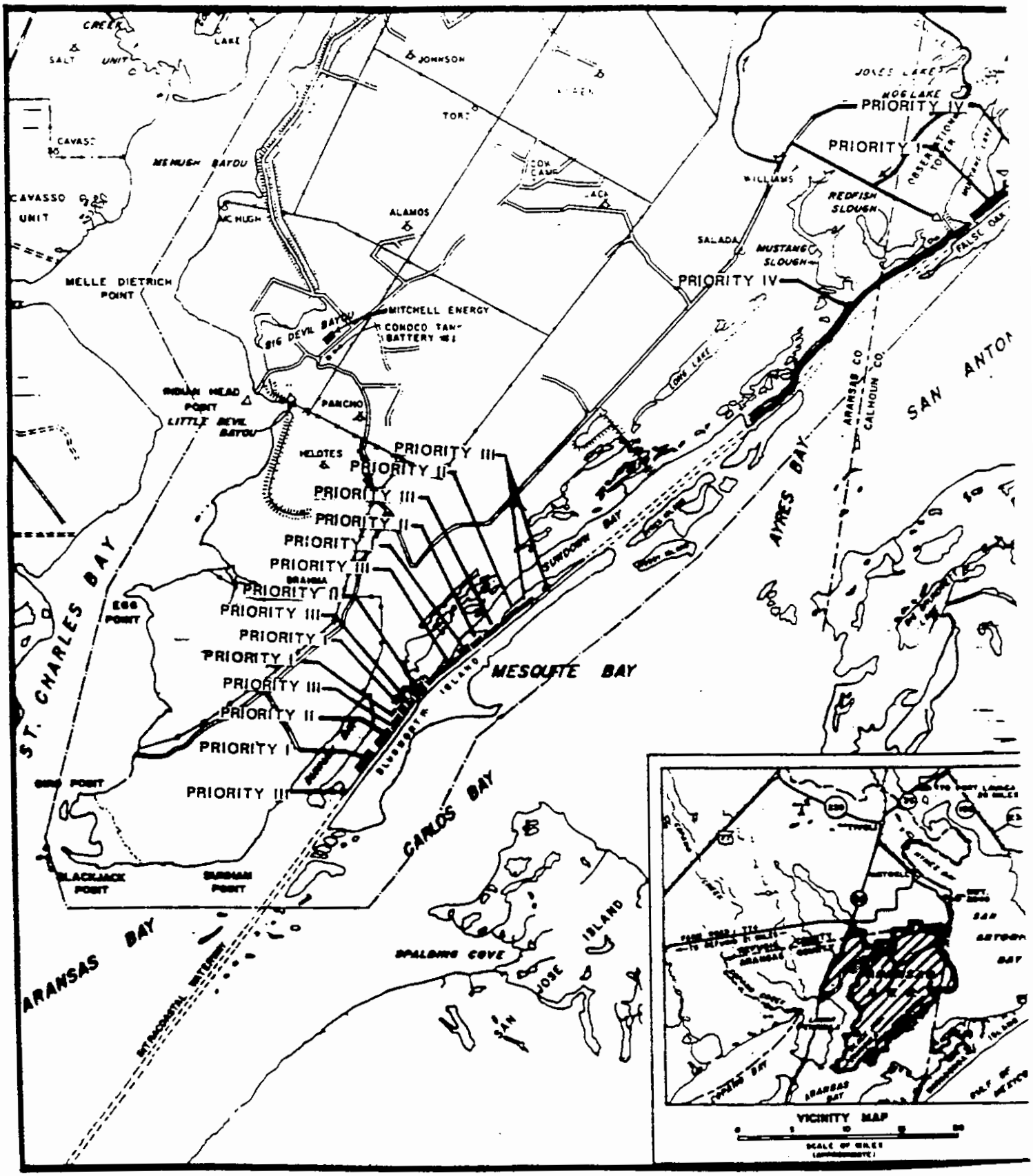


Figure 2. WHOOPING CRANE CRITICAL HABITAT EROSION CONTROL AREAS
(depicts all areas except these by Welder Flats)

by protecting another 14,000 feet of shoreline by September, 1994 and adding at least 2,000 more feet of shoreline protection in each succeeding year until the Section 216 Study's solution can be initiated. The Service interprets these commitments as resulting in successive additions of new shoreline protection footage; i.e., maintenance of existing footage is not assumed to be part of the cited figures.

The Corps' consultant and EPA assessed threats to the whooping crane and its critical habitat from the spills of vessel fuels and cargos. Although they differed on the details, each concluded that the hazards of spills exist, but the probability of their occurrence is low. The Service, however, is aware of the difficulty of accurately predicting spill events. The GIWW has been in operation about 50 years and the associated traffic has been increasing and the amount of hazardous cargo is increasing and changing. There is a great potential for acceleration of traffic, and an increase in accidents, if the North American Free Trade Agreement is ratified by Congress as traffic increases from Mexico. The difficulty in predicting 1 in 100 year spill events on the waterway that has a limited sample basis, with increasing traffic, and having a potential for significant traffic increases in the near future, is evident. The Service therefore believes that the estimates of probability of occurrence of the most likely spill and the worst-case spill (Gulf Engineers and Consultants, Inc. 1992; USEPA 1992) are conservative and may seriously underestimate the potential spill frequency in the future.[1] However, the Corps' contractor has identified ways in which the threat of spills and their consequences may be minimized and the Corps

[1]The Corps' letter of April 30, 1993 criticized the Service's belief that the Gulf Engineers and Consultants, Inc. report underestimates the probability and frequency of spill events, stating "The biological opinion would be improved if the Service would provide the data, rather than just intuition, upon which the Service concludes differently." The Service gave its reasoning for adopting this belief, rather than relying upon the consultant's data alone, in the preceding four sentences.

has obtained the U.S. Coast Guard's assistance as a cooperating agency in preparing the EIS for the Section 216 Study.

Incidental Take

Section 9 of the Act, as amended, prohibits any taking (harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or attempt to engage in any such conduct) of listed species without a special exemption. Under the terms of Section 7 (b)(4) and Section 7 (0)(2), taking that is incidental to and not intended as part of the agency action is not considered taking within the bounds of the Act, provided that such taking is in compliance with the incidental take statement. Furthermore, "harm", in the definition of "take" in the Act means an act which actually kills or injures wildlife. Such an act may include significant habitat modification or degradation where it actually kills or injures wildlife by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering.

The Service anticipates the erosion of critical habitat that occurs in unprotected areas remaining after September 1994 is not expected to reach the threshold of adverse modification of critical habitat. We anticipate less than one acre annual average incidental take of whooping crane critical habitat and no incidental take of individual whooping cranes.

The Service believes the following reasonable and prudent measure is necessary and appropriate to minimize the take. Utilize the latest erosion control technology to protect eroding whooping crane critical habitat and monitor your erosion control progress.

In order to be exempt from the prohibitions of Section 9 of the Act, the following terms and conditions, which implement the reasonable and prudent measure described above, must be complied with:

1. Keep abreast of the latest technology for shoreline protection measures suitable for whooping crane critical habitat and utilize that which is most appropriate.

2. Report the annual progress of erosion control accomplishments to the Corpus Christi Ecological Services Field Office.

If during the course of the action, the amount or extent of the incidental take limit is exceeded, the Federal agency must immediately reinitiate consultation with the Service to avoid violation of Section 9. Operations must be stopped in the interim period between the initiation and completion of the new consultation if it is determined that the impact of the additional taking will cause an irreversible and adverse impact on the species. The Corps should provide an explanation of the causes of the taking.

Conservation Recommendations

Section 7(a)(1) of the Endangered Species Act directs Federal agencies to utilize their authorities to further the purposes of the Act by carrying out conservation programs for the benefit of endangered and threatened species. The term "conservation recommendations" has been defined as suggestions of the Service

regarding discretionary measure to minimize or avoid adverse effects of a proposed action on listed species or critical habitat or regarding the development of information.

Several thousand acres of marsh and shallow water habitats have been eliminated by the construction and maintenance of the GIWW, in addition to the losses due to erosion, within what is now the whooping crane critical habitat. The Corps is going to need additional dredged material disposal sites, and is already experimenting with the beneficial uses of dredged material for erosion control and/or marsh restoration in the Aransas reach. The Corps is encouraged to pursue this beneficial uses program to protect and restore whooping crane habitat. The Service recommends that the material be used, in order of preference, to control erosion, to restore previously eroded habitat, and to create replacement habitat elsewhere.

The Spill Contingency Report contains valuable suggestions for ways in which navigational hazards might be reduced and by which spills might be minimized or controlled. The Service recommends that information in the Spill Contingency Report, Section XIII, Erosion and Spill Effects Mitigation Plans (Gulf Engineers and Consultants, Inc., 1992), be given strong consideration during production of the Final Feasibility Report and the EIS, and that implementation of the most effective and practicable of the measures identified in the Spill Contingency Report be made part of the Corps' recommendations to Congress.

In order for the Service to be kept informed of actions that either minimize or avoid adverse effects or benefit listed species or their habitat, the Service is requesting notification of the implementation of any conservation recommendations.

Conclusion

This concludes formal consultation on the indirect effects of erosion associated with the existence of the GIWW. As required by 50 CFR 402.16, reinitiation of formal consultation is required if: (1) new information reveals effects of the agency action that may impact listed species or critical habitat in a manner or to an extent not considered in this biological opinion; (2) the agency action is subsequently modified in a manner that causes an effect to the listed species or critical habitat that was not considered in this biological opinion; (3) a new species is listed or critical habitat designated that may be affected by the action; or (4) the anticipated incidental take amount or extent is exceeded.

The Service appreciates the cooperation the Corps provided in this consultation. If you have any questions about this biological opinion, please contact me at (512) 944-9005.

Sincerely,

Field Supervisor

cc:

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BIBLIOGRAPHY

Brinkley, C.S., and R.S. Miller. 1983. Population characteristics of the whooping crane, Grus americana. In Canadian Journal of Zoology, Vol. 61, No. 12, pp. 2768-2776.

Espey, Huston & Associates, Inc. 1987 a. Analysis of habitat changes from 1930 to 1986 along the Gulf Intracoastal Waterway of Aransas National Wildlife Refuge and San Antonio Bay, Texas. Draft report prepared for U.S. Army Corps of Engineers, Contract No. DACW 64-87-D-0002. Austin, TX., 15 pp. + figs.

_____. 1987b. 50-year disposal plan, maintenance dredging - GIWW, Aransas National Wildlife Refuge. Prepared for U.S. Army Corps of Engineers, Document No. 870700. Austin, TX., 128 pp. + append.

Fjetland, C.A. 1987. Comments on whooping crane recovery activities. In Proceedings 1985 Crane Workshop, J.C. Lewis, ed., Grand Island, NE., pp. 312-314.

Gulf Engineers & Consultants, Inc. 1992. Spill contingency and prevention plan for the Gulf Intracoastal Waterway at the Aransas National Wildlife Refuge. Report prepared for U.S. Army Corps of Engineers, Contract No. DACW 64-91-D-0002. Baton Rouge, La. 93 pp. + Append.

Hunt, H.E., and R.D. Slack. 1987. Winter foods of the whooping crane based upon stomach content analyses. In Proceedings 1985 Crane Workshop, J.C. Lewis, ed., Grand Island, NE., pp. 217-218.

Kretzschmar, G.E., Executive Administrator, Texas Water Development Board.[Letter to T. Grahl, USFWS]. 1990, December 5. Located at: USFWS, Corpus Christi, TX.

Lewis, J.C., Whooping Crane Recovery Team Leader. [Letter to M. Spear, Regional Director, USFWS]. 1988, March 15. Located at USFWS, Corpus Christi, TX.

Lewis, J.C., R.C. Drewien, E. Kuyt, and C. Sanchez, Jr. 1992. Contaminants in habitat tissues, and eggs of whooping cranes. Proc. North Am. Crane Workshop 6:159-165.

Perez, R. 1985. Biological opinion - Maintenance dredging of the Gulf Intracoastal Waterway, Aransas and Calhoun counties, Texas. USFWS, Corpus Christi, TX. 21 pp.

National Audubon Society. 1986. Audubon wildlife report 1986. NAS, N.Y., N.Y., 1094 pp.

Stehn, T.V. 1988. Impacts of the Gulf Intracoastal Waterway on the endangered whooping crane. In Proceedings 1988 Crane Workshop. Reprint located at USFWS, Corpus Christi, TX.

_____. 1990. Refuge Biologist, USFWS. [Letter to T. Roberts, SWGPL-R, U.S. Army Corps of Engineers]. February 6. Located at USFWS, Corpus Christi, TX.

_____. 1991. Personal communications with J. French, USFWS, Corpus Christi, TX. July 1991.

Stehn, T.V., and E.F. Johnson. 1987. Distribution of winter territories of whooping cranes on the Texas Coast. In Proceedings 1985 Crane Workshop, J.C. Lewis, ed., Grand Island, NE., pp. 180-195.

Texas Department of Water Resources. 1980. Guadalupe Estuary: a study of the influence of freshwater inflows. LP-107, August 1980. Austin, Tx., 321 pp.

U.S. Army Corps of Engineers. 1988. Study of erosion along GIWW in the Aransas National Wildlife Refuge, May 1988. U.S. Army Engineer District, Galveston, Tx. 15 pp.

_____. 1989a. Biological assessment for impacts to endangered and threatened species-maintenance dredging Gulf Intracoastal Waterway, Texas (Stations 698 + 000 + 860 + 000) and Channel to Victoria (Stations 0 + 000 + 180 + 000), May 1989. U.S. Army Engineer District, Galveston, TX. 31 pp. + append.

_____. 1989b. Gulf Intracoastal Waterway, Texas - Section 216 reconnaissance report, November 1989. U.S. Army Engineer District, Galveston, TX. 38 pp. + append.

_____. 1990. Public notice - Gulf Intracoastal Waterway - Aransas National Wildlife Refuge, Texas, August 3, 1990. U.S. Army Engineer District, Galveston, TX. 5 pp.

U.S. Environmental Protection Agency. 1992. Supplemental assessment, Section 7 consultation, Formosa Point Comfort Expansion. October 28, 1992. Dallas, TX. 1p.

U.S. Fish and Wildlife Service. 1980a. Selected vertebrate endangered species of the seacoast of the United States - The whooping crane. FWS/OBS-80/01.3. Slidell, La. 10 pp.

_____. 1980b. Whooping crane recovery plan. USFWS Albuquerque, NM., 206 pp.

_____. 1986. Whooping crane recovery plan. USFWS Albuquerque, NM., 283pp.

APPENDIX B - SECTION 7

COMPATIBILITY DETERMINATION FOR THE ARANSAS NATIONAL WILDLIFE REFUGE

COMPATIBILITY DETERMINATION

STATION NAME: Aransas National Wildlife Refuge

DATE ESTABLISHED: December 31, 1937.

ESTABLISHING AND ACQUISITION AUTHORITIES:

Executive Order 7784, dated December 31, 1937.

PURPOSE(S) FOR WHICH ESTABLISHED:

"...as a refuge and breeding ground for migratory birds and other wildlife." EO 7784, December 31, 1937.

"...for use as an inviolate sanctuary, or for any other management purpose, for migratory birds." Migratory Bird Conservation Act.

"...particular value in carrying out the national migratory bird management program." 16 U.S.C.667b (An Act Authorizing the Transfer of Certain Real Property for Wildlife)

"...to conserve (A) fish or wildlife which are listed as endangered species or threatened species...of (B) plants..." 16U.S.C. 1534 (Endangered Species Act of 1973)

MANAGEMENT GOALS AND OBJECTIVES: (from 7/85 Planning Needs Assessment)

A. Provide an environment that will enhance the recovery of endangered and threatened species.

B. Maintain stable populations of American alligator.

C. Provide for long-term security of refuge resources.

D. Provide safe habitat for migratory birds.

E. Provide on-refuge environmental education opportunities for area schools, including training assistance and materials for teachers.

F. Continue to provide interpretive facilities for the public.

G. Provide facilities for increased demand in wildlife recreation and observation.

H. Provide for quality hunting and fishing opportunity.

OTHER APPLICABLE LAWS, REGULATIONS AND POLICIES:

Antiquities Act of 1906 (34 Stat. 225).

Migratory Bird Treaty Act of 1918, as amended (16 U.S.C. 703-711; 40 Stat. 755).

Migratory Bird Conservation Act of 1929 (16 U.S.C. 715r; 45 Stat. 1222).

Migratory Bird Hunting Stamp Act of 1934 (16 U.S.C. 718-178h; 48 Stat. 451).

Bald and Golden Eagle Protection Act (16 U.S.C. 668-668d; 54 Stat. 250).

Fish and Wildlife Act of 1956, as amended (16 U.S.C. 742a-742J; 70 Stat. 1119).

Refuge Recreation Act of 1962, as amended (16 U.S.C 460K-460L4; 76 Stat. 653).

Land and Water Conservation Fund Act of 1965.

National Historic Preservation Act of 1966, as amended (16 U.S.C 470, et seq.; 80 Stat. 915).

National Wildlife Refuge System Administration Act of 1966, as amended (16 U.S.C. 668dd-668ee; 80 Stat. 927)

The National Environmental Policy Act of 1969, NEPA (42 U.S.C. 4321, et seq; 83 Stat. 852).

Endangered Species Act of 1973, as amended (16 U.S.C 1531-1543 et seq; 87 Stat. 884)

Refuge Revenue Sharing Act of 1935; as amended in 1978 (16 U.S.C. 715s; 92 Stat. 1319).

National Wildlife Refuge Regulations for the Most Recent Fiscal Year (50 CFR Subchapter C; 43 CFR 3101.3-3).

Emergency Wetlands Resource Act of 1986 (Public Law 99-645).

North American Wetlands Conservation Act of 1990.

DESCRIPTION OF PROPOSED USE: The U.S. Army Corps of Engineers (COE), as part of the Section 216 study, proposes to place 44,000 feet of cellular concrete mats along the banks of the Gulf Intracoastal Waterway (GIWW) along a 13-mile corridor through the refuge. They also plan to install permanent structures for deployment of spill control equipment.

ANTICIPATED IMPACTS ON SERVICE LANDS, WATERS, OR INTERESTS:

The proposed actions are being initiated and are designed to benefit the endangered whooping crane. The erosion control structures will prevent the loss of critical habitat. Spill structures would greatly aid in containment of a local chemical spill to minimize impacts to the cranes. No detrimental impacts are anticipated.

A copy of the Draft Study has been sent to the Corpus Christi Ecological Services Field Office of the USFWS for Section 7 review under the Endangered Species Act requirements. A response is due to the Corps in July, 1995.

DETERMINATION: (check one)
This use is compatible XXX This use is not compatible _____

THE FOLLOWING STIPULATIONS ARE REQUIRED TO ENSURE COMPATIBILITY:

The COE will continue to work closely with the refuge in all actions proposed by the Section 216 study. As currently described in the Corps of Engineers' May, 1995, Draft GIWW, Aransas NWR (Section 216) Feasibility Study the plan of work is Compatible. Any substantial changes from the Draft Study may require a new Compatibility Determination from the Refuge Manager.

JUSTIFICATION:

In May 1989, COE entered into formal consultation under the Endangered Species Act over the loss of whooping crane critical habitat within the refuge. The proposed actions were recommended as reasonable and prudent measures by USFWS Ecological Services - Corpus Christi in their Biological Opinion of May 1993 to stop loss of crane marshes along the GIWW due to erosion, and to try to prevent damage in case of a spill event. USFWS installed 400 feet of mats in 1991 as a demonstration project. An additional 16,000 feet of mats were installed in the past three years by COE. Since the proposed actions are designed primarily to benefit the endangered whooping crane, and since endangered species conservation is a primary management goal of the refuge, the proposed actions are deemed compatible with regulations of the National Wildlife Refuge System Administartion Act.

Project Leader J. Brent Giezentanner, Ref.Mgr. J Brent Giezentanner 5/25/
(Name/Title/Signature/Date)

Review and Concurrence: Gary D Burke 6/28/95
(Name/Title/Signature/Date)

[illegible] 7/3/95
(Name/Title/Signature/Date)

APPENDIX B - SECTION 8

COMMENTS ON EIS AND RESPONSES

United States Department of the Interior

OFFICE OF THE SECRETARY
Office of Environmental Policy and Compliance
Post Office Box 649
Albuquerque, New Mexico 87103

IN REPLY REFER TO:

August 11, 1995

ER 95/456

Colonel Robert B. Gatlin
District Engineer, Galveston District
Department of the Army, Corps of Engineers
PO Box 1229
Galveston, Texas 77553-1229

Dear Colonel Gatlin:

The U.S. Department of the Interior has reviewed the Draft Feasibility (Section 216) Study and Environmental Impact Statement for the Gulf Intracoastal Waterway—Aransas National Wildlife Refuge, Texas. The following comments are provided for your consideration during development of the final document(s).

The draft documents are very well written and reflect a high degree of attention to alternatives, avoidance of impacts, and in particular, species listed as threatened or endangered. We concur with major conclusions presented in this document that the proposed erosion control, spill control, and 50-year disposal plans would help avoid adverse modification to the whooping crane's critical habitat; that the plans should be overwhelmingly beneficial to the environment; and that other listed species would either be beneficially impacted or not significantly affected by the proposed actions. 1

However, we do not agree with the document's inferences that the U.S. Fish and Wildlife Service (FWS), rather than the Corps of Engineers, should maintain the erosion control and spill control facilities once they are constructed. It is our position that the Galveston District is the sole Federal agency to fund, authorize, and carry out maintenance activities on the GIWW, and since the GIWW's existence indirectly leads to the adverse modification of the critical habitat via erosion and spills, Section 7(a)(2) of the Endangered Species Act requires that the Galveston District construct and maintain the erosion control and spill control facilities. The FWS role in the consultation process established by Section 7(a)(2) requires them to propose, not carry out, reasonable and prudent alternatives that would avoid adverse modifications. 2

Thank you for the opportunity to review these draft documents. We trust our comments will be useful during the development of your future documents.

Sincerely,

Glenn B. Sekavec
Regional Environmental Officer

RESPONSE TO COMMENTS

Mr. Glenn B. Sekavec
Regional Environmental Officer
Office of Environmental Policy and Compliance
United States Department of the Interior
P.O. Box 649
Albuquerque, New Mexico 87103

Comment No.	Response
1	Thank you for your concurrence.
2	The Final Feasibility Report and Environmental Impact Statement have been modified to state the U.S. Army Corps of Engineers (USCE) will be responsible for constructing and maintaining the erosion constrol and spill containment features. However, the USCE has no responsibility for deploying the spill containment booms or any clean-up should an accidental spill occur. The Texas General Land Office (TGLO) and U.S. Coast Guard have these responsibilities as the designated State and Federal spill response agencies. The U.S. Fish and Wildlife Service (USFWS) will also be responsible for spill response and clean-up so far as it applies to the Aransas National Wildlife Refuge (ANWR).

UNITED STATES DEPARTMENT OF COMMERCE
Office of the Under Secretary for
Oceans and Atmosphere
Washington, D.C. 20230

July 12, 1995

Colonel Robert B. Gatlin
District Engineer, Galveston District
Department of the Army, Corps of Engineers
P.O. Box 1229
Galveston, TX 77551-1229

Dear Colonel Gatlin:

Enclosed are comments on the Draft Environmental Impact Statement for Gulf Intercoastal Waterway - Aransas National Wildlife Refuge (Section 216) Feasibility Study Galveston, Texas. We hope our comments will assist you. Thank you for giving us an opportunity to review the document.

Sincerely,

Donna Wieting

Donna S. Wieting
Acting Director
Ecology and Conservation Office

Enclosure

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Southeast Regional Office
9721 Executive Center Drive N.
St. Petersburg, Florida 33702

July 7, 1995

Colonel Robert B. Gatlin
District Engineer, Galveston District
Department of the Army, Corps of Engineers
P.O. Box 1229
Galveston, Texas 77551-1229

Dear Colonel Gatlin:

We have reviewed the Draft Feasibility Study and Environmental Impact Statement for the Gulf Intracoastal Waterway-Aransas National Wildlife Refuge (Section 216) dated May 1995. The purpose of the proposed project is to provide protection to the critical habitat of the endangered whooping crane along a 31-mile stretch of the Gulf Intracoastal Waterway (GIWW), which includes portions of the Aransas National Wildlife Refuge (ANWR) and the privately owned Welder Flats. Critical habitat for the whooping crane has been impacted by erosion along the GIWW channel banks. This erosion is occurring due to erosion from vessel traffic and natural processes. The findings of the Feasibility Study recommend that 62,000 feet of bank protection be installed for erosion control; permanent facilities for ready deployment of spill control measures be constructed; and a long-term dredged material maintenance plan be implemented. The following are our comments regarding the subject document.

GENERAL COMMENTS:

Representatives of the National Marine Fisheries Service (NMFS) have been working on this project with the Galveston District Corps of Engineers (COE) since 1989. The recommended plan has been extensively coordinated with the NMFS and other federal and state agency representatives and generally reflects NMFS recommendations. The plan proposes to create over 1,600 acres of new marsh and provide protection to at least 64 acres of existing marsh and 1,075 acres of shallow ponds. Marsh and pond habitats of the project area provide valuable nursery,
1 foraging and cover habitats for a variety of commercially and recreationally important living marine resources. Consequently, if the constructed marshes become functionally equivalent to the natural marshes in the area, the proposed project would provide a benefit to the estuarine-dependent fishery species that utilize marshes, such as brown, white and pink shrimp (Penaeus spp.), blue crab (Callinectes sapidus), spotted seatrout (Cynoscion nebulosus), red drum (Sciaenops ocellatus) and southern flounder (Paralichthyes lethostigma).

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SPECIFIC COMMENTS:

Section 4.2 ALTERNATIVE 2 - EXISTING ALIGNMENT
Section 4.2.4 50-YEAR DISPOSAL PLAN

Page 4-10, par. 2 - Levee failures at existing upland confined disposal areas have been a serious problem with the existing maintenance program for several years. These problems even include a failure at a beneficial uses of dredged material site in the critical habitat of the whooping crane. We commend the COE for finally recognizing this problem. To prevent future levee failures, the COE proposes to increase the minimum freeboard from one foot to two feet and to increase the frequency of inspections.

We believe additional measures could be taken to alleviate this problem. Specifically, we recommend that the COE require all dredging contractors, including the onsite job supervisor, to attend a predredging conference with the COE, ANWR representatives and other federal and state resource agency personnel. The purpose of the meeting would be to educate the dredging contractors on the environmental sensitivity of the project area and to develop a contingency plan should problems arise during the dredging job. This plan should clearly identify points of contact and lines of responsibilities. Additionally, if the ANWR representatives have reasonable cause to believe that a levee is in eminent danger of failing or that the dredge contractor is not maintaining the required two feet minimum freeboard, they should be given authority to temporarily shut down dredging operations until COE inspectors arrive on site. 2

Page 4-12, par. 2 and 3 - The NMFS will provide personnel to participate in the proposed Interagency Coordination Team (ICT) for the long-term disposal plan. The ICT is a multidisciplinary approach to project planning that has been successfully applied during the planning of the Houston-Galveston Ship Channels Project. According to the subject document, the NMFS will also be tasked with the responsibility of designing a monitoring plan and providing recommendations to modify cell design as the project progresses. On page 4-6, the COE identifies a budget of $15,000 per year for periodic maintenance of concrete mats and grout tubes. However, the COE has not committed to a budget for the required monitoring and cell modification. To receive the ecological benefits anticipated by converting an existing bay habitat from open water to marsh, it is vital to commit the funding necessary to properly design, construct, and monitor marshes to ensure they are functionally equivalent to natural marshes. 3

If we can be of further assistance, please contact Mr. Rusty Swafford at (409) 766-3699.

Sincerely,

Andreas Mager, Jr.
Assistant Regional Director
Habitat Conservation Division

RESPONSE TO COMMENTS

Mr. Andreas Mager, Jr.
Assistant Regional Director
Habitat Conservation Division
National Marine Fisheries Service
Southeast Regional Office
9721 Executive Center Drive N.
St. Petersburg, Florida 33702

Comment No.	Response
1	Thank you for your comment.
2	We agree that additional measures to prevent future levee failures may be necessary. Your suggestion for holding a predredging conference for contractors, supervisors, USCE and ANWR representatives to emphasize the environmental sensitivity of the project area and to develop contingency plans will be incorporated into future dredging contracts upon authorization of the project. Your suggestion for giving an ANWR representative authority to temporarily shut down dredging operations, however, raises certain legal and contract issues. The USCE will investigate this issue further during the Preconstruction Engineering and Design (PED) phase before making a final determination.
3	We welcome the National Marine Fisheries Service's (NMFS) participation in an Interagency Coordination Team (ICT) and in developing and implementing a monitoring plan for the beneficial use sites, as well as providing recommendations for ensuring the success of each beneficial use site. Funding for the ICT and monitoring was not identified in the project budget because the 50-year disposal plan does not need Congressional authorization. This plan will be carried out under current Operation & Maintenance (O&M) authority and will be subject to funds in the O&M budget. Also, the extent of monitoring effort is unknown at this time and should be subject to consensus of the ICT. With these unknowns, it is very difficult to determine what funding will be necessary.

U.S. Department
of Transportation
United States
Coast Guard

Commanding Officer
U. S. Coast Guard
Marine Safety Office

P. O. Box 1621
Corpus Christi, TX
78403-1621
Phone: (512) 888-3162

16000
July 6, 1995

Department of the Army
Galveston District, Corps of Engineers
Attn: Mr. James M. Kieslich
Chief, Planning Division
P.O. Box 1229
Galveston, TX 77553-1229

Dear Mr. Kieslich:

I am responding to your letter of May 24, 1995, in which you asked for comments on the operation, maintenance, repair, rehabilitation, and replacement (OMRR&R) of spill containment equipment for the Aransas National Wildlife Refuge (ANWR).

Pre-deployment of equipment is admirable, and in keeping with the oil spill prevention and mitigation efforts of Federal, State and local governments. The Coast Guard is, however, unable to take on the responsibility for the OMRR&R of this equipment.

As discussed at the coordination meeting held on April 28, 1995, the Coast Guard is not in the position to provide the manpower, time, and expertise necessary to be responsible for the spill equipment. In addition, any involvement in the OMRR&R of this equipment would place the Coast Guard in competition with private entities that are in the business of spill response.

My staff expressed our concerns at the coordination meeting and recommended that the Corps establish a contract with one of the spill response companies for the OMRR&R of the equipment. I still believe that this would be the most appropriate solution.

I also take this opportunity to clarify comments in your Draft Gulf Intracoastal Waterway - Aransas National Wildlife Refuge (Section 216) Feasibility Study, regarding the establishment and enforcement of speed limits. You have concluded that speed limits through the 31-mile reach of critical habitat would not be practical, and the recommendation to impose such limits was removed from further consideration. The Coast Guard could only enforce such a restriction in speed if it was established by the Eighth Coast Guard District office in New Orleans or by Coast Guard Headquarters in Washington D.C. The ANWR would become a Regulated Navigation Area (RNA), as defined in 33 CFR 165.10 - 165.13. 1

16000
July 6, 1995

The process to obtain Coast Guard approval to establish an RNA is significant and time consuming. Local entities can also establish speed limits through areas where they have concurrent jurisdiction with the Federal government. The Coast Guard, however, could not enforce local restrictions.

Please contact LCDR Kasparek at (512) 888-3162 if you have any further questions regarding this matter.

Sincerely,

THOMAS B. RODINO
Captain, U.S. Coast Guard
Captain of the Port

RESPONSE TO COMMENTS

Capt. Thomas B. Rodino
Captain of the Port
U.S. Coast Guard
P.O. Box 1621
Corpus Christi, Texas 78403

Comment No.	Response
1	Comment noted. The statement on speed restrictions in the ANWR has been modified to include the difficulty in designating the area for enforcement under Coast Guard regulations.

COMMISSIONERS

LEE M. BASS
Chairman, Ft. Worth

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Ft. Worth

TEXAS
PARKS AND WILDLIFE DEPARTMENT
4200 Smith School Road • Austin, Texas 78744 • 512-389-4800

ANDREW SANSOM
Executive Director

July 13, 1995

Mr. Sidney Tanner
Planning Division
U.S. Army Corps of Engineers
P. O. Box 1229
Galveston, Texas 77553-1229

Re: Section 216, Draft Feasibility Study (DFS), Aransas National Wildlife Refuge (ANWR), Gulf Intracoastal Waterway (GIWW), Environmental Impact Statement (EIS)

Dear Mr. Tanner:

The ANWR is a world renowned natural resource. In addition to being the winter home of the endangered Whooping Crane, it is an excellent blend of upland and estuarine ecosystems that makes it one of the most diverse and productive sites for important fauna and flora. Great care must be exercised in attempts to alter portions of it, especially when considering the size (1,614 acres) of these proposed alterations.

1. Beneficial Use Site J. The width of this site appears to be approximately 1,200 feet. It is recommended that this width be reduced to approximately 600 feet. This will decrease the adverse effect the chronic erosion and sloughing off of the 7,000-foot long constructed levee/bank on the east side will have in slowly filling in the shallow bay (Dunham Bay) area between Site J and Blackjack Peninsula. Long term circulation must be maintained in this very productive inlet. 1

2. Beneficial Use Site K. Some additional protection must be provided to Pelican Reef (immediately adjacent to, and south of the west tip of Site K). This is a highly productive oyster reef and is very near (less than 200-foot distance from) Site K. Siltation/turbidity generated during the construction of the Site and any accidents during the use of the site could have adverse effects on this reef's ecology. Protective measures should be employed for this reef and sufficient quality control should be maintained during the use of this Site. 2

3. Beneficial Use Site I. The placement of this site will involve the covering of two small shell reefs (each reef approximately 40 by 100-feet). The size
3 of this site should be reduced to avoid these reefs, unless other mitigation is provided.

4. Beneficial Site H. The size of this site should be reduced and/or relocated to retain a larger amount of this opening for water circulation purposes into the southwestern end of Sundown Bay. A minimum of 400 feet of opening
4 should be retained.

It appears that there are designed, boomable openings of approximately 40 feet or so, every 1,100 feet in the geotextile tubes separating most of Sundown Bay from the GIWW. Either these openings should be larger or there should be more of them to allow the needed circulation of water into the bay. In addition, there
5 should be one large circulation opening (400 feet) at the northeast end of Sundown Bay. Without adequate water circulation these tidal inlets and peripheral marshes cannot maintain sufficient water quality to allow normal estuarine populations to flourish. This would not be beneficial to the Whooping Crane or to many other species of important estuarine finfish, shellfish, and shore birds.

It is again recommended that these beneficial dredge disposal features be given special treatment in their planning, construction, and operation. Increased attention
6 to monitoring and quality control during the construction and operation phases will greatly increase the likelihood that a quality result, one that will be beneficial, will be realized.

Questions can be directed to Dick Harrington in Corpus Christi (512-993-4491), or Roger Petkoff and Rollin MacRae in Austin (512-389-4583).

Sincerely,

Larry D. McKinney, Ph.D., Director
Resource Protection Division

LDM:RAH:rwp:JRM:fmd

RESPONSE TO COMMENTS

Larry D. McKinney, Ph.D.
Director, Resource Protection Division
Texas Parks and Wildlife Department
4200 Smith School Road
Austin, Texas 78744

Comment No.	Response
1	All beneficial use sites were sized, configured, and located for the Feasibility Report and EIS as a reference/guide for preparing a 50-year disposal plan in the ANWR area. Because the long-term disposal plan will be constructed under O&M authority, it is not included with the erosion and spill protection plans being recommended for Congressional authorization. Therefore, each site will be reviewed by an ICT composed of appropriate State and Federal resource agencies to be formed during the PED phase of the project. The ICT will recommend final adjustments to each site to ensure maximum benefit to the area's ecology. For this reason, the USCE will refrain from further refinements to the sites until the ICT has had an opportunity to review them. There also appears to be a misunderstanding about the potential for erosion of levees/banks at Site J. As shown in Plate 22 of the Engineering Appendix (Appendix C in the Draft Report), the levees will be constructed with geotextile tubes to prevent erosion. Also, there will be a rock breakwater placed on the end of the site exposed to prevailing waves from Aransas Bay to further reduce erosion potential.
2	As explained in Comment No. 1, an ICT will be formed to review and oversee planning, construction, filling, and planting of each beneficial use site. The USCE will follow their recommendations after full coordination between members and all engineering refinements are completed.
3	Please see responses to Comment Nos. 1 and 2.
4	Please see responses to Comment Nos. 1 and 2. Furthermore, aerial photos from 1950 show no opening at this location, indicating erosion has created the opening since that time and is currently increasing its size.

Larry D. McKinney, Ph.D.
Director, Resource Protection Division
Texas Parks and Wildlife Department
4200 Smith School Road
Austin, Texas 78744

Comment No.	Response
5	As explained on Page 4-5 of the EIS in the May 1995 Draft Report, the openings between the grout tubes are currently designed to be 100 feet wide at intervals of 1,000 feet across Sundown Bay. As further explained on the same page, the USCE will survey the area and apply a hydrodynamic model to the data to determine the proper number and width of openings needed to maintain circulation in Sundown Bay during the PED phase. These refinements will be included in the Final Plans & Specifications for the project.
6	Please see responses to Comment Nos. 1 and 2.

July 21, 1995

Colonel Robert B. Gatlin
District Engineer, Galveston District
Department of the Army, Corps of Engineers
P. O. Box 1229
Galveston, Texas 77551-1229

Dear Colonel Gatlin:

The Texas General Land Office (GLO) has reviewed the Draft Gulf Intracoastal Waterway-Aransas National Wildlife Refuge (ANWR) Section 216 Feasibility Study and Draft Environmental Impact Statement (EIS) made available for a 45-day public comment period on June 2, 1995. The document addresses environmental losses of critical habitat of the whooping crane.

The Act requires any federal agency to ensure that any action it authorizes, funds, or carries out is not likely to jeopardize the continued existence of any listed species. Since the erosion losses are in part caused by the Gulf Intracoastal Waterway (GIWW), a federal navigation project, this report addresses the requirements of the Endangered Species Act. Also reviewed in this report are oil spill contingency plans and development of a long-term dredged material disposal plan.

The GLO is pleased to have been included in the planning process that generated this document over the last three years, and is supportive of the effort. The GLO strongly supports the beneficial use of dredged material as well as the development of a long-term dredged material management plan. Some issues, however, have not been adequately addressed by the draft document. We want to bring these to your attention so that they can be addressed in the final document.

Garry Mauro
Commissioner
Texas General Land Office

Stephen F. Austin Building
1700 North Congress Avenue
Austin, Texas 78701-1495
(512) 463-5256

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Mineral Development Issues

An issue that has not been addressed is energy development, including the production of state-owned minerals and access to or allocation of adequate sites for future energy production. The project area has significant potential for future oil and gas development, evidenced by the fact that Mitchell Energy operates four wells in the area. The State of Texas retains its mineral interest in the beneficial use sites. Although the value of the minerals may be reduced because the beneficial use sites make exploration and production more difficult, under the navigational servitude doctrine, the Corps of Engineers (COE) does not compensate the state for any such loss. Therefore, the GLO requests that an agreement be signed, prior to final design
1 completion, that will allocate a certain percentage (e.g., 5%) of the beneficial use sites for future access for mineral development. This would be similar to a development bank from which credits could be taken without a mitigation requirement to be used at the state's discretion, whether for seismic operations, an access channel, a drill site, or a pipeline. Again, the GLO asks that an agreement be negotiated and signed by all interested parties before construction is initiated, and that this request be reflected in the final document.

Erosion Response Issues

As the state agency that is responsible under state statute for coordination of erosion response issues, the GLO has several concerns regarding the use of articulated concrete mats in the project area. On pages 64-75, citing the National Wildlife Refuge System Administration Act, is the comment that "refuge personnel indicate that only the concrete mat structures would be considered compatible with the refuge purpose." The GLO does not question the legal authority of this statement, but we do believe that there are erosion response techniques that are more cost-effective over time than the concrete mat structures and that would also be considered "compatible with the refuge purpose" by
2 refuge personnel. Unquestionably, many areas are so severely impacted by shoreline erosion that articulated concrete mat structures are the most appropriate structures, but several areas both on and off the refuge would benefit from other types of structures. Specifically, irregular stone breakwaters dissipate wave and wake energy, have higher habitat value, require less maintenance, and should also be acceptable to refuge personnel. Where appropriate, such as on vegetated slopes and scarps fronted by shallow benches, this type of armoring should be placed offshore of the present waterline to facilitate natural stabilization and vegetation of the newly protected shoreline.

GLO staff recently observed outflanking and undermining of the 3
concrete mat, and it appears that failure of the mat armor can
propagate. Additionally, it was noticed that concrete mats were 4
not readily colonized by vegetation. The GLO agrees that
transplanting smooth cordgrass on the mats might help to replace
the functions and values initially lost to erosion.

Erosive forces have enlarged the openings to several natural
embayments like McMullen Lake, further subjecting the interior
shorelines of the embayments to wake erosion. Opportunities to 5
restore the smaller gaps should be investigated. This
restoration could also be accomplished with appropriate use of
low riprap structures. Conversely, the constriction of
circulation with the placement of grout tubes and boom anchor
points across Sundown Bay is of concern. A substantial change in 6
hydrodynamic circulation and salinity would have a serious impact
on living marine resources.

State Land/Coastal Preserve Issues

Nowhere in the document is any reference made to state-owned
submerged lands currently under lease to the Texas Parks and
Wildlife Department (TPWD) as a designated state coastal
preserve. The Welder Flats Coastal Preserve, a cooperative
project between the GLO and TPWD, is scheduled for armoring this 7
summer, but no coordination has taken place to date between the
COE, TPWD, and GLO. The GLO staff raised this issue with the COE
at the scoping meeting on August 9, 1994, but no schedule for
construction was discussed at that time. The GLO requests that 8
no action be taken on this aspect of the project until legal and
environmental issues have been adequately addressed.

Other Issues

Resolution of the spill contingency and prevention plan is also
of continuing concern to GLO. As Russel Lutz, Deputy Land
Commissioner, indicated in his letter of June 13, 1995 to James
Kieslich, the U. S. Coast Guard is the logical candidate to
assume responsibility for the operation, maintenance, repair,
rehabilitation, and replacement of spill containment equipment. 9
We will, however, as Mr. Lutz indicated, commit to replacement of
all oil spill equipment that has exceeded its useful life. The
GLO concurs that this critical issue must be completely resolved
and any agreements included in the final document.

Based on the experience with the Houston-Galveston Navigation
Channels, Texas project, the GLO suggests that pre- and post-bid
conferences be coordinated to assure quality control of this
project. Similarly, the COE should consider delegating certain 10

responsibility to ANWR personnel to control and stop work should a mishap occur. This was a key component in the successful construction of the demonstration marsh in Galveston Bay.

The ANWR and surrounding bays and estuaries are a unique complex of geologic and biological resources duplicated nowhere else on earth. I urge the utmost care and caution in coordination of erosion response issues, and look forward to working with the COE to protect this valuable natural resource.

Thank you for the opportunity to comment. Please advise me how the GLO can be of further assistance.

Sincerely,

Garry Mauro
Texas Land Commissioner

GM/CKC/wdg

RESPONSE TO COMMENTS

Mr. Gary Mauro
Commissioner
Texas General Land Office
Stephen F. Austin Building
1700 North Congress Avenue
Austin, Texas 78701

Comment No.	Response
1	The wetlands to be created with dredged maintenance material are for the purpose of replacing prime whooping crane habitat lost since the GIWW was constructed. The mineral development activities you propose are not compatible with this purpose. Also, given the vociferous agency protests in the past over accidental spills from leveed disposal sites and the effects of burying several acres of crane feeding habitat, the work you suggest in the beneficial use sites will have more potentially damaging side effects (mechanical destruction of marsh, disruption of marsh circulation, and accidental spills of hazardous materials). These are the impacts this project was designed to prevent or minimize. The final design, location, configuration, construction, filling, planting, and monitoring of the beneficial use sites will be based on recommendations from an ICT made up of appropriate State and Federal resource agencies. The use of these valuable new wetlands for such purposes runs counter to the goals we all have strived so long and hard to achieve. On the issue of mineral development, the United States (USCE) does not wish to preclude any mineral development which would deprive the State of mineral royalties. We do not believe the beneficial use plan would do so. The areas are small enough (less than 3,500 feet wide, including breakwaters) to allow for production with fairly minimal directional drilling, if it was necessary to drill below one of the sites. Furthermore, the proposed beneficial use sites are subject to navigation servitude and even the minerals underlying navigable waters have been held to be subject to the right of the United States to use without payment of just compensation (see Coastal Petroleum Co. v. United States, 524 F. 2d 1206 (Ct. Cl. 1976)). Since we believe these sites are necessary and that mineral development inside these sites would be incompatible with the purposes for which the

Mr. Gary Mauro
Commissioner
Texas General Land Office
Stephen F. Austin Building
1700 North Congress Avenue
Austin, Texas 78701

Comment No.	Response
	sites are to be developed, we cannot agree to any allocation of part of the sites for mineral production. We further believe that the environmental and economic benefits (preservation and enhancement of the fragile ecology of the area with its concomitant recreational use) to the State of Texas, which these sites will help to promote, far outweigh any possible diminution of revenues from mineral leases.
2	We agree that different erosion control techniques have different advantages and disadvantages, depending on erosive forces applied to the area of concern, type of sediment underlying the affected area, type of bank to be protected, and desired area function/aesthetics to be maintained. The USCE evaluated 10 different types of erosion protection and compared the advantages/disadvantages in Table 13 of both the Draft and Final Report. As explained in the text, the mat protection was chosen because of its advantages of flexibility (especially important if a barge accidently runs up on it), low profile (allows tidal inundation of the marsh behind it), lack of interference with water circulation in the marsh behind it, and desirability by refuge personnel. It was not the cheapest protection plan, but construction cost is comparable to riprap and it requires less maintenance than the riprap protection you suggest. The navigation industry also strongly objects to riprap because of the increased danger of ripping the bottom of a barge if it strikes the rocks. The rock protection will not flex under the barge as a mat would. Thus, for navigation safety, this type of protection must be at least 200 feet away from the channel edge. Maintenance is more expensive for rock protection because the rocks are subject to scattering in storm conditions (unless large rocks are used which increases costs, potential damage to barges, and depth of settling because of weight increase) and differential settling in the soft sediments in the area which will cause the rocks to slough off. For these

Comment No.	Response
	reasons, the USCE restricted the use of rock breakwaters to those areas where it was absolutely essential (e.g., around some beneficial use sites). Even in these areas, there is some concern about soft foundation conditions. These areas will be investigated further during the PED phase to determine if some other wave protection may be more suitable if foundation conditions will not permit the use of rock.
3	We are aware of only one site (near McMullen Lake) where there is possible undermining of the mats taking place. Apparently, this is an area of suspect foundation conditions. Also, the problem could have been compounded if the contractor attempted to fill in existing bank irregularities with nearby soft sediments while preparing the bank for the mats. However, this is the only spot with potential undermining reported in the 18,000 feet of mat work completed to date. There are other areas that dip lower than surrounding sections of the mat, but these are probably the result of the mats following natural bank contours or, possibly, impacts by barges. At least one area of known barge impact has been reported by refuge personnel. The mat at this site has been shoved inland and upward by the barge, but has not lost its protective integrity. This is ample proof the mats are accomplishing their desired task; protecting the banks from erosion even after barge impact (which rock protection could not do) and provide flexibility to prevent major damage to the barge. This section of mat can easily be repaired at a convenient time (e.g., during the next scheduled dredging work in the area) without any loss of erosion protection in the interim. The USCE assumes that the outflanking you refer to is erosion around the ends of each section of mats that have been placed since the summer of 1992. This erosion is expected since the ground on either end of the mat sections remains unprotected. If this project is authorized by Congress, the remaining sections of

Mr. Gary Mauro
Commissioner
Texas General Land Office
Stephen F. Austin Building
1700 North Congress Avenue
Austin, Texas 78701

Comment No.	Response
	bank will be armored and all the different sections of mat currently in place will be tied together, preventing any further outflanking due to erosion.
4	Revegetation of the voids between the blocks composing the mats was not expected to occur until sediment filled the voids. Reports from refuge personnel indicate saltgrass (Distichlis spicata) is colonizing the higher parts of the older mats. Spartina colonization will be slower since this species tends to spread faster by vegetative outgrowth from existing stocks and more slowly from spread of seeds. Colonization of the voids is dependant on seeds washing onto the mats once the voids are filled with sediment.
5	As shown in Figure 6 of the EIS and Plates 8, 9, 16, and 20 of the Engineering Appendix (Appendix C) in both the Draft and Final Report, the USCE will constrict the openings at McMullen Lake and at Sundown Bay as part of the 50-year disposal plan. This work will complement the bank protection work at these sites and prevent further boat wake erosion inside these lakes. Additional details of this work have been added to the Final EIS.
6	The USCE has noted previous concerns about maintaining circulation within Sundown Bay by several resource agencies. As explained in both the Draft and Final EIS, the number and width of openings in the grout tubes across Sundown Bay as shown in the report are preliminary and used at this stage for planning purposes only. The final configuration of the openings will be determined after circulation studies have been completed during the PED phase and revised in the Final Plans & Specifications.
7	Reference to the Welder Flat area as a coastal preserve has been included in the Final Report. However, designation as such by the State does not alter the powers of navigation servitude and the rights of the United States to protect the area from adverse

Comment No.	Response
	impacts created unintentionally by nearby Federal projects, as needed. This protection is especially important since it is needed to preserve critical habitat for the endangered whooping crane under the Endangered Species Act. Fortunately, this protection serves a dual purpose since the same erosion protection planned for protecting critical habitat will also protect lands in the coastal preserve and the flora and fauna the preserve was established to preserve. The area is scheduled for protection in summer 1999 as part of the recommended plan if the project is authorized by Congress.
8	Your comment that TGLO staff raised the issue of coordination between agencies on armoring banks in the coastal preserve is undocumented. A review of the minutes of the agency scoping meeting on August 9, 1994, revealed no such issue being raised. The minutes summarizing the meeting were sent to all agencies attending the meeting (including TGLO) on August 21, 1994, with a request to review and revise it if any issues/concerns were inadvertently omitted. Although several agencies responded, we have no record of any response from TGLO. Because there have been no objections to the protection measures by any agency during the coordination meetings, we believe that all environmental issues have been adequately addressed. However, during the PED phase, we will review your concerns.
9	The issue of agency identification in the role and responsibility for operation, maintenance, repair, rehabilitation, and replacement for spill containment equipment and structures has been coordinated between the USCE, TGLO, USFWS, and Coast Guard. The USCE will assume responsibility for constructing and maintaining the erosion constrol and spill containment features. However, the USCE will not be responsible for deploying the spill containment booms or any clean-up should an accidental spill occur. The TGLO and U.S. Coast Guard have these responsibilities as the designated

Mr. Gary Mauro
Commissioner
Texas General Land Office
Stephen F. Austin Building
1700 North Congress Avenue
Austin, Texas 78701

Comment No.	Response
	State and Federal spill response agencies. The USFWS will also be responsible for spill response and clean-up so far as it applies to the ANWR. We appreciate TGLO's commitment to replace any spill containment equipment that has exceeded its useful life.
10	Please see response to Comment No. 2 from NMFS.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 6
1445 ROSS AVENUE, SUITE 1200
DALLAS, TX 75202-2733

AUG 03 1998

Colonel Robert B. Gatlin, District Engineer
U.S. Army Corps of Engineers, Galveston District
P.O. Box 1229
Galveston, TX 77553-1229

Dear Colonel Gatlin:

In accordance with our responsibilities under Section 309 of the Clean Air Act, the National Environmental Policy Act (NEPA), and the Council on Environmental Quality Regulations for Implementing NEPA, the U.S. Environmental Protection Agency (EPA) Region 6 office in Dallas, Texas has completed its review of the U.S. Army Corps of Engineers's Feasibility Study and Draft Environmental Impact Statement (DEIS) for the Gulf Intracoastal Waterway-Aransas National Wildlife Refuge (Section 216).

The purpose of the proposed project is to provide protection to the critical habitat of the endangered whooping crane along a 31-mile stretch of the Gulf Intracoastal Waterway (GIWW), which includes portions of the Aransas National Wildlife Refuge and the privately owned Welder Flats. Whooping Crane critical habitat has been impacted by erosion from vessel traffic and natural processes along the GIWW channel banks. The recommended plan proposes to create over 1,600 acres of new marsh and provide protection to at least 64 acres of existing marsh and 1,075 acres of shallow ponds by installation of 62,000 feet of bank protection, construction of permanent facilities for spill control measures, and implementation of a long-term dredged material maintenance plan.

EPA rates this proposed action/DEIS as "LO," i.e., EPA has "Lack of Objections" with regards to this proposal. Our classification will be published in the Federal Register according to our responsibility under Section 309 of the Clean Air Act, to inform the public of our views on proposed Federal actions. 1

We appreciate the opportunity to review this DEIS. We request that you send our office two (2) copies of the Final EIS at the same time that it is sent to the Office of Federal Activities, EPA, 401 M Street S.W., Washington, DC 20460.

Sincerely yours,

A. Stanley Meiburg
Acting Regional Administrator

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contains at least 50% recycled fiber

RESPONSE TO COMMENTS

Mr. A. Stanley Meiburg
Acting Regional Administrator
U.S. Environmental Protection Agency
Region 6
1445 Ross Avenue, Suite 1200
Dallas, Texas 75202

Comment No.	Response
1	Thank you for your comment.

Texas Department of Transportation

DEWITT C. GREER STATE HIGHWAY BLDG. • 125 E. 11TH STREET • AUSTIN, TEXAS 78701-2483 • (512) 463-8585

August 8, 1995

Mr. James M. Kieslich
Chief, Planning Division
U.S. Army Corps of Engineers
P. O. Box 1229
Galveston, Texas 77553-1229

Dear Mr. Kieslich:

The Texas Department of Transportation (TxDOT), as the nonfederal sponsor of the Gulf Intracoastal Waterway (GIWW), offers the following comments, concerning the draft Feasibility Report and Environmental Impact Statement for the GIWW - Aransas National Wildlife Refuge. Our comments address two items involving the 50-year disposal plan, referred to on page 107 of the report.

- Upon the U.S. Army Corps of Engineers' written request, TxDOT will pursue acquisition of necessary right-of-way for the 153-acre upland disposal area and disposal pipeline corridor, pending specific location identification and final environmental coordination of the site. 1

- In keeping with past projects, where the U.S. Army Corps of Engineers provided for the construction of levees, TxDOT would prefer that the Corps continue its responsibility for the levees. 2

We appreciate the opportunity to comment on this study. If you need additional information, please contact Raul Cantu, P.E. at 512/416-2344.

Sincerely,

James L. Randall

James L. Randall, P.E.
Director
Multimodal Operations Office

RESPONSE TO COMMENTS

Mr. James L. Randall, P.E.
Director, Multimodal Operations Office
Texas Department of Transportation
125 E. 11th Street
Austin, Texas 78701

Comment No.	Response
1	A review of USCE real estate records regarding the proposed disposal area containing 153 acres (inclusive of pipeline routes) revealed the United States acquired a perpetual easement on February 16, 1938 for the deposit of dredged material on the area encompassing the proposed site. We do not believe we need additional rights on the property. Therefore, at this time, there is no requirement upon the Texas Department of Transportation to acquire this property.
2	The USCE will continue its responsibility for all levee work. The sentence on Page 107 of the Draft Report, which could be misread to indicate Texas Department of Transportation responsibility for levees, has been revised.

GARY P. LaGRANGE
President & Chairman
of Executive Committee
Franklin, Louisiana

MUNSON SMITH
President Elect
Victoria, Texas

VERNON BEHRHORST
Chairman of the Board
Lafayette, Louisiana

J. MERRICK JONES, JR.
Vice Chairman of the Board
New Orleans, Louisiana

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Chicasaw, Alabama

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Vice President for Mississippi
Columbus, Mississippi

DAVID A. WAGNER
Vice President for Louisiana
New Orleans, Louisiana

RAYMOND BUTLER
Vice President for Texas
Houston, Texas

GICA
GULF INTRACOASTAL
CANAL ASSOCIATION

Organized At Victoria, Texas - August 8, 1905

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Lafayette, Louisiana 70504
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DOUGLASS W. SVENDSON,
Executive Dire
Lafayette, Louis

PAST PRESIDE

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President Eme
Washington, I

KING FISH
Immediate Past Presi
Port Lavaca, Te

CHARLES E. BROUSSA
Kaplan, Louis

W. H. "Bill" BAUER,
Port Lavaca, Te

R. H. "Bob" PARKER,
Houston, Te

July 13, 1995

Mr. James Kieslich, Chief
Planning Division
Environmental Resources Branch
Galveston District, Corps of Engineers
P.O. Box 1229
Galveston, Texas 77553-1229

Dear Mr. Kieslich:

The Gulf Intracoastal Canal Association's comments on the Draft GIWW-ANWR (Section 216) Feasibility study are as follows.

We are struck by the enormous costs, roughly $19,000,000, to preserve an almost insignificant amount (64 acres) of habitat for the Whooping Crane. 1

Congressional dissatisfaction with exaggerated outcomes of environmental mandates has produced the reaction we see in Washington today. In addition, the other reality is a shrinking Civil Works budget. If the Galveston District's O & M budget moves downward over the next 3-5 years, as projected, the expenditures called for by this Section 216 proposal could easily be between 10 and 15 percent of your entire budget. We do not view this as a wise or cost effective use of financial resources. 2

Sincerely,

Doug Svendson Jr

Doug Svendson, Jr.
Executive Director

DS/thv

RESPONSE TO COMMENTS

Mr. Doug Svendson, Jr.
Executive Director
Gulf Intracoastal Canal Association
P.O. Box 44050
Lafayette, Louisiana 70504

Comment No.	Response
1	The costs you refer to are to protect not only 64 acres of prime whooping crane feeding habitat, but also another 1,075 acres of marsh lakes and ponds that would be lost once the marsh separating them from the GIWW is eroded away. These marsh lands represent the core of the whooping crane wintering home territories and are designated as critical habitat under the Endangered Species Act. As such, the area has the same protection from adverse impacts caused by Federal projects as those afforded species listed as threatened or endangered under Federal law.
2	Comment noted. However, we believe that a plan to protect whooping crane critical habitat while providing a long-term disposal plan for continued maintenance of the GIWW is a wise and effective use of financial resources.

THE PORT of
Port Lavaca –
Point Comfort

P.O. Box Drawer 397
Point Comfort, Texas 77978
(512) 987-2813
Fax: (512) 987-2189

July 11, 1995

Colonel Robert B. Gatlin , District Engineer
Galveston District , U.S. Army Corp of Engineers
P.O. Box 1229
Galveston , Texas 77550

RE: 216 ARANSAS WILDLIFE STUDY

Dear Colonel Gatlin :

It has come to the attention of the Calhoun County Navigation District that the 216 ARANSAS WILDLIFE STUDY recommends that privately owned lands in Calhoun County will be taken for the purpose of the disposal of dredged material from the GIWW. As you know , the Calhoun County Navigation District has long been active in the utilization and promotion of the GIWW in Calhoun County. The GIWW is a tremendous resource to the industries of Calhoun County.

As Chairman of the Calhoun County Navigation District, I recommend that the Galveston District further research modifications to the existing dredge material disposal areas which would accommodate the placement of dredged material from the GIWW through the Aransas Wildlife Area for the long term future. We feel that modifications to the existing dredged material disposal areas will also minimize any future increase to maintenance dredging costs. 1

Thank you for consideration of these comments. I look forward to further discussions with you and your staff members regarding this matter of extreme importance to industries and property owners in Calhoun County .

With Best Regards,

Frank H. Diebel , Chairman
Board of Navigation District Commissioners
Calhoun County Navigation District

cc: W.H. Bauer , Sr.

CALHOUN COUNTY NAVIGATION DISTRICT
Frank H. Diebel, Chairman: Leo J. Kainer, Secretary/Treasurer; Tom Flores, Asst. Secretary/Treasurer;
H.C. Wehmeyer, Jr., Commissioner; Tony Holladay, Commissioner; J.C. Melcher, Jr., Commissioner.
Lawrence A. Dio, Counsel; Robert H. Van Borssum, Port Director.

RESPONSE TO COMMENTS

Mr. Frank H. Diebel, Chairman
Board of Navigation District Commissioners
Calhoun County Navigation District
P.O. Box Drawer 397
Point Comfort, Texas 77978

Comment No.	Response
1	The USCE will continue to review the 50-year disposal plan described in the Final Report in order to identify the most cost efficient and environmentally least damaging plan appropriate for protecting whooping crane critical habitat.

W. H. Bauer
P.O. Box BB
La Ward, Texas 77970

June 14, 1995

Corps of Engineers
Galveston District
P.O. Box 1229
Galveston, Texas 77553-1229

K 6/19

ATTENTION: District Engineer
Mr. James M. Kieslich

Gentlemen:

Am in receipt of copy of the Draft Gulf Intracoastal Waterway - Aransas National Wildlife Refuge Feasibility Study and Environmental Impact Statement for protecting critical habitat for the endangered whooping crane.

I ask that my letter be made part of your report of the 50 year program you have in mind. 1

I was born, February 14, 1907, and reared in Calhoun County. My father was the first Deputy Game, Fish and Oyster Commissioner of Texas and I followed him a few years later. I obtained for Calhoun County the Intracoastal Canal right-of-ways. I discovered the first 7 whooping cranes along Dewberry Island and Blackberry Island. Was present at the dredging of the first section of the waterway at Port O' Connor, Texas by Standard Dredging Company. Mr. Cleve Scarborough was Captain of the Dredge Diesel. I followed the dredging of each section of the canal from Galveston to Brownsville. I was present when all the sections were inaugurated. I had the pleasure of meeting the great leaders, Judge Mansfield, Roy Miller, Clarence Holland and the developer of the waterway. I named a dredge after them.

Back in those days they knew what they were doing by placing the canal along the northside of the

Welder property and American National Realty, which I purchased from Mr. W.L. Moody, 13,000 acres.

I was in the salvage business for 40 years. I was also in the dredging business for 50 years and owned one of the largest dredging companies in the world. Later I was president of the World Dredging Association in Rotterdam. I was also president of the Intracoastal Canal Association and a member of the Panama Canal Company.

We oldtimers like Leonard Fisher, who is 92 years old and his brother, King Fisher, is 73 years old know all about this business. Mr. Tim Milliet, 3200 Eugenia Drive, Groves, Texas 77619, also knows as he was an engineer with Standard Dredging Company and later with Bauer Dredging Company.

There are no better environmentalists than we oldtimers who have seen the changes of our environment. We think you should obtain a statement from each of us and make it part of your records as it is so important for the good of our country.

The bootheels of the owners of the properties along the canal have the best conservation practice.

You have the world's finest engineering establishment. I have known every Chief of Engineers of the last 50 years. I look forward to seeing the Chief of Engineers, the Division and the District Engineers at the annual meeting which will be held in Victoria in September. I want the privilege of shaking the hand of the gentlemen who can maintain our great waterways.

Sincerely,

W.H. Bauer

cc: Mr. E.H. Thornton,Jr.
Congressman Greg Laughlin
Mr. King Fisher

July 14, 1995

Mr. Richard Medina
U.S. Army Engineer District, Galveston
P.O. Box 1229
Galveston, Texas 77553-1229

RE: Gulf Intracoastal Waterway - Aransas National Wildlife Refuge (Section 216) Feasibility Study

Dear Sir:

In further comment on the subject study, I respectfully submit:

1. Implementing a new 50 year spoil disposal plan is not justified because existing spoil areas are adequate for another 50 years or can be made so by rebuilding levees where necessary, by using a smaller dredge (12" maximum) for maintenance purposes, and 2
by using a dragline to remove the spoil which accumulates at or near the mouth of the Victoria Channel and depositing the same on the opposite side of the present drainage structures which serve said channel.

2. Substantially increasing the cost of maintenance of the Gulf Intracoastal Waterway Canal by having to pump greater distances the spoil dredged from the Canal and to deposit the same in San Antonio Bay for the purpose of building an additional 1650 acres of wildlife habitat, is not justified when said habitat now 3
has 114,000 acres, which should be more than sufficient to accommodate the flock of 136 whooping cranes now using the same six months in the year, as well as any foreseeable increase in said flock, and is also not justified in view of the tremendous debt repayment with which our nation is now confronted.

3. Expending 20 million dollars to prevent an annual erosion of 2.5 acres per year of the marshlands of the aforesaid wildlife 4
habitat is not justified at this time, and a much less costly plan should be devised.

4. Although the cost benefit ratio of maintaining the Gulf Intracoastal Waterway Canal might still be favorable after 5
burdening maintenance costs of said waterway with an additional $80,904,000, being the estimated cost of the proposed plans, such

benefit could be jeopardized if Congress refused to increase by a like amount the operating and maintenance budget of the Corps for use on the Canal and the Corps had to fund the cost of such plans out of its normal budget. Just as important, the expenditure of an additional $80,904,000 of public funds, when the same is not necessary, cannot be justified, even though such expenditure may not substantially impair the cost effectiveness of the canal.

5. Any long-range (50 years) spoil disposal plan for the area covered by the study should be a part of a master plan devised for the entire Gulf Intracoastal Waterway Canal in Texas, and the
6 same then submitted to the Congress for approval. A part of such plan should not be initiated unilaterally for this area on the guise of an assumed need to construct an additional, but not needed, 1650 acres of habitat for wildlife.

Very truly yours,

W. H. Bauer

W. H. Bauer
P.O. Box B B
Laward, Texas 77970

RESPONSE TO COMMENTS

Mr. W.H. Bauer
P.O. Box BB
La Ward, Texas 77970

Comment No.	Response
1	Your letter has been included as requested.
2	Our engineering analyses indicates that the existing disposal areas do not have sufficient capacity for the next 50 years. The 50-year plan attempts to utilize the existing sites to the extent possible. The USCE will continue to review its 50-year disposal plan to identify the most cost efficient and least environmentally damaging plan appropriate for protecting whooping crane critical habitat as required by the Endangered Species Act.
3	The purpose of the 50-year plan is to provide the most cost effective long-term disposal plan which will ensure the continued operation and maintenance of the GIWW while contributing to the benefit of the whooping crane. The increased maintenance costs are considered justified when compared to other alternatives.
4	A variety of protection measures and alternative alignments were evaluated. The selected erosion control plan was found to be the most cost effective plan compatible with the purposes of the Refuge.
5	We share your concern with the increased costs associated with the 50-year disposal plan. However, we believe that the benefits provided by a safe and navigable GIWW and the preservation of one of America's premier endangered species warrant these costs.
6	The Aransas - 216 study was not initiated unilaterally as a separate study of the GIWW. Initial funding for a study of the entire length of the Texas section of the GIWW under authority of Section 216 of the 1970 Flood Control Act was received in 1988. A Reconnaissance Study of the entire length revealed two sites in immediate need of further studies because of erosion problems that either threatened the future use of the channel (Sargent Beach) or threatened officially designated critical habitat for an endangered species (Aransas). Because of the urgency, these two

Mr. W.H. Bauer
P.O. Box BB
La Ward, Texas 77970

Comment No.	Response
	sites immediately entered the feasibility stage of studies. The rest of the GIWW was divided into five sections for later study because of the great length of channel involved (423 miles), the difference in urgency to correct problems associated with certain sections of the channel, and the manpower needed to study the entire length of waterway simultaneously. The five sections were separated based on similarity of climate, geology, ecology, and problems and solutions. Furthermore, the sections and priorities for studying them were coordinated with several resource agencies and waterway users. Studies of two other sections of the GIWW have already started.
	The 1,614 acres of marsh to be created for the Aransas - 216 project represents a unique solution to two problems in the area. One was how to replace the 2,078 acres of wetlands lost in the area as a result of construction and maintenance of the GIWW. The other was how to beneficially use the dredged maintenance material over the next 50 years of project life. Creating new marsh to replace some of the lost marsh was an ideal solution that will be closely followed by all resource agencies to ensure its success.

APPENDIX C

ENGINEERING APPENDIX

ENGINEERING APPENDIX

ARANSAS NATIONAL WILDLIFE REFUGE
SECTION 216 STUDY

May 1995

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ILLUSTRATION AND EXHIBITS

ARANSAS NATIONAL WILDLIFE REFUGE
SECTION 216 STUDY
ENGINEERING APPENDIX

1. General

1.1 Brief Project History. A 31-mile reach of the Gulf Intracoastal Waterway (GIWW) crosses the critical wintering habitat of the rare and endangered whooping crane, including a 13.25-mile reach within the boundary of the Aransas National Wildlife Refuge (ANWR). Whooping crane habitat losses of about two acres per year are caused by combinations of waves generated by vessel traffic on the GIWW, wind generated waves, and to some extent, dredged material disposal practices. In May 1989, formal consultation with the U.S. Fish and Wildlife Service (USFWS) was requested under the Endangered Species Act for possible impacts to the whooping crane. Compliance with the Endangered Species Act is proposed to be accomplished by reducing the erosion of critical habitat, thereby allowing the cranes to coexist with the continued commercial use of the GIWW. Reconnaissance studies, completed in November 1989, investigated rerouting the channel on a northerly course to avoid the critical habitat and to minimize the required bank protection for the existing alignment. A plan for implementing the erosion protection for the existing alignment, presented herein, is in the format of a 50-year operations and maintenance (O&M) disposal plan and the placement of articulated concrete mats and grout tubes. Drawings showing the proposed locations, configurations, and sizes of the erosion protection, beneficial use sites and the upland disposal site for the 50-year O&M disposal plan are provided on Plates 1 through 23. The State of Texas is the local sponsor of the GIWW.

1.2 Initial Erosion Protection Efforts. Until the proposed project is implemented and funded, short- and mid-term solutions have been undertaken. Short-term efforts have included the ANWR Shoreline Preservation Project where approximately 7,000 feet of critical shoreline was protected between 1989 and 1992. For these efforts, volunteers placed concrete bags directly on the ANWR shoreline. Current short-term efforts include a minimum of 2,000 feet of refuge shoreline being protected each year with articulated concrete mats. Refuge personnel have identified these critically eroding locations, within the critical habitat, and as a result, approximately 16,000 feet of refuge shoreline has been protected through 1994. Mid-term efforts at the refuge include an ongoing experimental beneficial uses of dredged material site, conducted by the Waterways Experiment Station (WES), and the incorporation of grout tubes as a wave barrier. The concrete mat design used in the O&M contracts and the grout tube design by WES, as listed below, are proposed for the remaining areas to receive erosion protection and for marsh creation, respectively. Drawings showing typical plans and cross-sections of these in-place erosion protection projects are provided on Plate 13.

1.2.1 Two contracts have been awarded, utilizing O&M funds, to place articulated concrete mats as erosion protection along the critical shoreline of the ANWR. Contract DACW64-

92-C-0050, completed in October 1992, placed 2,000 feet of articulated concrete mats along the Sundown Bay Peninsula, on the north side of the GIWW. Contract DACW64-93-C-0030, completed in September 1993, placed 7,000 feet of articulated concrete mats in several reaches along the north side of GIWW at Mesquite Bay and at the north end of the refuge. The articulated concrete mat design is performing satisfactorily at these two critically-identified shoreline reaches. A third contract was awarded in April 1994 to place approximately 6,600 feet of articulated concrete mats in several reaches between Sundown Bay and Dunham Bay, on the north side of the GIWW. The same mat design and placement was used for this reach.

1.2.2 In cooperation with WES, a demonstration marsh site within the critical habitat was constructed during May-June 1993 to coincide with a maintenance dredging cycle. This demonstration site uses various erosion control techniques, including the placement of geotubes as containment structures in conjunction with using dredged material for marsh creation. The geotube design is performing satisfactorily at this site.

2. Hydrology and Hydraulics. This section presents hydrologic and hydraulic data for the GIWW, located inside the ANWR. The purpose of the proposed shoreline protection is to minimize the daily erosion that is destroying acres of valuable habitat for the whooping crane, an endangered species.

2.1 Shore Protection. The proposed design of shore protection allows for tidal exchange between the GIWW and the adjacent marshlands. This tidal exchange will be accomplished by utilizing erosion protection, which will be porous for fluid flow, and establishing the structure's height, such that tidal flows and wave actions overtop the protection. This protection, considered for the entire north side of the GIWW within the ANWR, will continue to be installed at existing ground elevations to minimize any changes to the environment. Openings into the marshes are not being altered by placement of the articulated concrete mat protection. Exceptions to this, are openings which have been recently created or enlarged by erosive forces along the GIWW. These openings will be "reset" or modified to dimensions specified by the refuge personnel.

2.2 Beneficial Use Sites. Beneficial use sites will be located and developed to increase the acreage of suitable marshlands available for the wildlife species (the whooping cranes, for example) located in ANWR. These areas, generally south of the GIWW, will provide new habitat for the species whose feeding grounds have been impacted by erosion.

2.3 Climate. The climate of this area is humid subtropical. Summers are warm to hot, and humid. The dominant air mass is maritime tropical in which sea breezes moderate afternoon heat and keep maximum temperatures a few degrees cooler than areas farther inland. Occasional showers or thunderstorms may also occur. Winter is typically mild; which is also the season during which a maximum alternation between the maritime tropical air mass and modified continental polar and maritime polar air masses occurs, creating considerable day-to-day variation. Periods of freezing temperatures are infrequent

and usually last no longer than two or three days. Average annual rainfall along this portion of the coast is about 36 inches. Temperatures range from an average winter minimum of 47 degrees F, to an average summer maximum of 92 degrees F. Two principle wind regimes dominate the area and include persistent, southeasterly winds occurring from March through November and strong, short-lived northerly winds from December through February.

2.4 Precipitation. A study (of unknown record) by Texas A&M University has determined the annual rainfall probabilities at Corpus Christi:

20 inches or less	16-percent of the years
20 to 30 inches	61-percent of the years
30 to 40 inches	17-percent of the years
40 inches or more	6-percent of the years

According to this report, the average annual precipitation is 28.0 inches at Corpus Christi. The normal precipitation reported from the National Oceanic and Atmospheric Administration (NOAA) is 30.13 inches and 35.08 inches for Corpus Christi and Rockport, respectively. The difference indicates that the percentages quoted above can be increased by 2 or 3 inches to match with NOAA/NOS data. The rainiest month on record, prior to 1978, was September 1967, with 20.3 inches. The maximum yearly precipitation, before 1978, was 44.0 inches in 1960 and the minimum yearly precipitation, before 1978, was 15.0 inches in 1963. Generally, the rainiest months of the year are May and September with an average of 3 to 4 inches of rainfall. December through April and August are usually the driest months. (This information is from the Draft Environmental Impact Statement, July 1978, by Nueces County Navigation District No. 1 for Permit Application No. 9563 to construct a deep draft inshore port at Harbor Island, Nueces County, Texas).

2.4.1 Erosion Due to Rainfall. Rainfall runoff will either pass through, or over, the erosion protection currently in place, and, that which will be installed at other critical shoreline reaches. Arbitrary streams have been analyzed for a variety of drainage area sizes and openings to estimate probable velocities. Velocities were examined for openings 20 to 100 feet wide and 3 to 5 feet in depth. The drainage area used to estimate the outflow velocities was 1,200 acres, generally in a rectangular shape extending in a line perpendicular to the GIWW. A worst case example is a resultant velocity of 5 feet-per-second (fps) for an estimated 10-year rainfall with an opening 3 feet deep and 20 feet wide. Velocities for other conditions (openings of 5-foot depth and up to several hundred feet wide) were all significantly lower. The lower outflow velocities are partially due to the ground cover that slows the draining water and the distance involved for the water flow to travel. Since a large number of small openings are expected along the bank in a marsh area, consideration of larger drainage areas is unnecessary. Velocities through bank openings are not expected to significantly contribute to erosion along the GIWW inside the ANWR. Another consideration is that a vegetated opening could resist a higher velocity (considered to not exceed 4 to 5 fps) than an unvegetated opening. Additionally, the bank

protection planned will not be placed to block the natural flow of water (i.e., small bank openings) draining during a storm.

2.5 Winds. The annual winds for the Corpus Christi Naval Air Station (CCNAS), the closest location to subject project known to have tabulated data, are summarized by direction and speed from 1943 to 1976, and are shown in Table 1. The predominating winds, by percent of total time, are from the southeast quadrant, (62.7-percent of the time) as marked by an asterisk. The last two columns provide percentage total and average wind speed for each direction.

2.5.1 Storm Generated Winds. Winds generated from hurricanes will be higher than those listed in Table 1, above. Also, due to the nature of hurricanes, the direction of wind associated with the hurricane may come from any direction depending on the location of these tropical cyclones. These winds are accompanied by storm surges of several feet and the winds also generate substantial wave fields. Listed below is a partial summary of major hurricanes that have caused high surge in the coastal region of ANWR:

a. Hurricane GLASSCOCK, 6-7 September 1955, (locally applied name). Sustained winds generated offshore of Port Aransas were NNE at 75 to 80 miles-per-hour (mph). The airport west of Corpus Christi reported winds NNE at 31 mph. (Information from Technical Memorandum No. 78, Hurricanes Affecting the Coast of Texas from Galveston to Rio Grande).

b. Hurricane CARLA, 9-12 September 1961. Winds were estimated to exceed 150 mph at Port Aransas. A 153 mph velocity wind gust was recorded at Port Lavaca. (Information obtained from USACE report on Hurricane CARLA).

c. Hurricane CELIA, 30 July - 5 August 1970. Sustained winds at Rockport were from the SE in excess of 60 mph. (Information obtained from USACE report on Hurricane CELIA).

d. Hurricane ALLEN, 3-10 August 1980. Winds reported at Aransas Pass were 109 mph. The Corpus Christi airport reported winds of 92 mph. (Information obtained from USACE report on Hurricane ALLEN).

2.6 Annual Tides and Storm Surges. Long term tide data are not available within the refuge at this time. The Blucher Institute (Blucher Institute for Surveying and Science at Corpus Christi State University, A Campus of the Texas A&M University System) and the USACE through WES have cooperated in placing gages within the refuge; however, the period of record is of short duration, therefore, the collected data may not be useful. Available data include summary tidal data statistics from Rockport on Aransas Bay and data recorded at the Copano Bay bridge.

Table 1
Annual Winds for the Corpus Christi Naval Air Station

Wind Dir.	1-3 knots	4-6 knots	7-10 knots	11-16 knots	17-21 knots	>21 knots	Percent Total	Avg. Spd. knots
N	0.70	1.49	2.54	3.77	1.23	0.19	9.92	11.30
NNE	0.54	1.23	2.03	1.99	0.26	0.06	6.11	9.70
NE	0.49	1.03	1.64	1.35	0.15	0.03	4.69	9.20
ENE	0.53	1.17	2.05	1.13	0.09	0.03	5.00	8.60
E*	1.01	2.31	3.51	1.70	0.07	0.05	8.65*	8.30
ESE*	0.80	1.91	4.02	3.88	0.22	0.02	10.85*	9.60
SE*	0.91	2.13	5.45	6.20	1.10	0.03	15.82*	10.90
SSE*	1.00	2.21	5.62	6.94	1.13	0.08	16.98*	10.70
S*	1.29	2.08	3.00	2.06	0.22	0.01	8.66*	8.50
SSW	0.51	0.62	0.41	0.13	0**	0**	1.67	5.90
SW	0.44	0.42	0.19	0.02	0**	0**	1.08	4.80
WSW	0.40	0.40	0.13	0.03	0**	0**	0.96	4.80
W	0.46	0.51	0.24	0.10	0.01	0.02	1.34	5.90
WNW	0.28	0.24	0.16	0.08	0.04	0.03	0.83	7.10
NW	0.18	0.25	0.44	0.45	0.13	0.08	1.53	10.8
NNW	0.34	0.69	0.98	1.34	0.44	0.10	3.89	11.00
Total	9.88	18.69	32.41	31.17	5.09	0.73	97.98	9.40

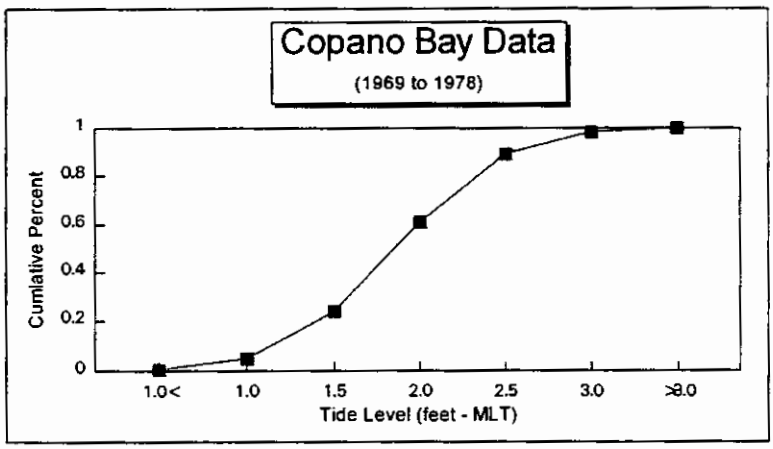
Notes: *These winds generate waves that strike the "north" bank of the GIWW; **Values are less than 0.01 percent occurrences

2.6.1 Rockport, Aransas Bay. Tide data at this location have been available for over 30 years, from 1960 to present. The following data are referenced to the national geodetic vertical datum (NGVD). The daily variation between mean high tide and mean low tide is 0.35 foot. The adjustment from NGVD to mean high water (MHW) is 0.95 foot. The adjustment from NGVD to mean low water (MLW) is 0.6 foot. The adjustment from NGVD

to mean sea level (MSL) is 0.78 foot. The highest observed recent water level was in 1980, during Hurricane ALLEN. This storm produced water levels of 4.7 feet. The lowest observed recent water level was -2.0 feet in February 1984.

2.6.2 Copano Bay Bridge. The short period of record for the Copano Bay bridge does not have the expected distribution of water level vs. duration of time. The available data, 10 years (less than a tidal epoch), had daily cycles that were higher than mean low tide (MLT) by approximately 0.5 to 1 foot. From 1969 to 1979, the period of record, the tidal range was between 1.7 to 2.9 feet MLT, approximately 80-percent of the time. This tidal record consists of data that are higher than expected. A review of the tide data available from Rockport suggests that land subsidence is the likely cause of this skewing. Graph 1 shows the cumulative percent of time for various tide levels.

Graph 1



2.6.3 Recorded Storm Surges. Below is a listing of known storm surge levels for Port Aransas, Texas.

a. 1919, 'Greatest Storm of the Century', 16.0 feet MSL (Information from Technical Memorandum #78 of the Beach Erosion Board)

b. 1961, Hurricane CARLA, 9.1 feet MSL

c. 1970, Hurricane CELIA, 6.0 feet MSL

d. 1980, Hurricane ALLEN, 8.9 feet MSL

2.7 Waves, Runup and Overtopping. Six sites represent the different wave fetches within the refuge. Illustration 1 depicts these six locations, fetches A through F. The six fetches, listed alphabetically, are described as follows:

a. Fetch A. Located at the southern most tip of the refuge mainland.

b. Fetch B. A typical section of the GIWW where a barrier island is located opposite of the mainland location and completely blocks longer fetches from developing.

c. Fetch C. Inside Sundown Bay with partial exposure of the mainland to longer fetches between the islands.

d. Fetch D. Typical section along the mainland with only sparse protection from the wave climate by the islands.

e. Fetch E. The northern tip of the main refuge by McMullen Lake with exposure to San Antonio Bay.

f. Fetch F. On the secondary land mass of the refuge close to Welder Flats with exposure to San Antonio Bay.

2.7.1 Wind Waves. Wind waves are described by individual fetches as follows:

a. Fetch A. Winds from the south develop waves approximately 0.7 foot that occur 9-percent of the time. Fifty-percent of the other waves are between 0.2 and 0.5 foot with the remainder of the wave climate below this range.

b. Fetch B. Due to the shortness of the fetches, (across the GIWW) the depth is not a critical factor. Waves due to wind are between 0.1 and 0.2 foot.

c. Fetch C. Waves across Sundown Bay are usually less than 0.2 foot. Approximately 30-percent of the time the waves are between 0.3 and 0.5 foot. These "larger" waves are due to a southerly wind blowing through the openings between the barrier islands.

d. Fetch D. Waves impacting an exposed section of the coast (i.e., not protected by a barrier island on the south side of the GIWW) are in the range of 0.3 to 0.5 foot, 47-percent of the time. Approximately 12-percent of the annual waves are between 0.5 and 0.7 foot. The remainder of the annual wave climate is less than 0.3 foot.

e. Fetch E. On the side of the mainland exposed to San Antonio Bay, 40-percent of the annual wave climate is 0.3 to 0.5 foot; 16-percent is 0.5 to 0.7 foot; and 2-percent is 0.8 to 1.0 foot. The remainder (42-percent) is less than 0.3 foot.

f. Fetch F. The wave climate on the southern tip of this landmass is less than the opposite side of the bay due to the predominating wind directions. Twelve-percent

of the annual wave climate is in the range of 0.5 to 0.7 foot. Thirty-two-percent of the annual wave climate is between 0.3 to 0.5 foot. The remainder of the annual wave climate is less than 0.3 foot.

2.7.2 Storm Induced Wave Heights and Frequencies, and Runup. At each of the six locations (A, B, C, D, E, and F) wave heights and runup were calculated for the 1-, 2-, and 5-year storm surges and estimated storm winds. Higher recurrence intervals were not used because the frequencies studied attained a depth to completely cover the existing ground elevations.

2.7.2.1 Table 2a lists the longest radial fetch at each of the fetch sites analyzed. Table 2b contains the wind speed and the surges used for runup analysis. Table 3 contains the runups for different slopes at each analysis site evaluated for 1- and 2-year interval conditions listed in table 2b. The average depth of these fetches was considered to be 5 feet. There are no runup results for the 5-year storm since this storm's surge would be greater than the average ground elevation being protected. The cases in Table 3 with vertical wall structures are to simulate the effects of large grout tubes in place.

Table 2a
Length of Longest Radial at
Fetch Analysis Location

Fetch	A	B	C	D	E	F
Length	12. mi.	1,200'	5.0 mi.	6.6 mi.	26. mi.	14. mi.

Table 2b
Analysis Conditions

Interval (year)	1	2	5
Wind (mph)	35	49	60
Storm Surge (ft)	2.2	2.8	4

Note: The wind information was generated from analysis of extreme winds recorded at Corpus Christi, Texas from 1943 to 1976 as published in U.S. Department of Commerce, "Extreme Wind Speeds at 129 Stations in the Contiguous United States."

2.7.3 Erosion from Wind Waves. Apparently, wind waves are partially responsible for erosion occurring within the refuge. Particularly, when waves are aligned parallel with the length of the GIWW, fetches of several miles are possible. The waves causing the worst

erosion result from SW or NE winds blowing up the GIWW parallel to the shore (This event has an occurrence of approximately 20 percent for different directions). These waves can have a fetch of several miles that, accompanied by wind generated currents, can remove sediment from the shores.

Table 3
Wave Runup

Fetch	Wave Climate			Smooth Slope			Rough Slope	
	Int. year	Wv Ht. (feet)	WvPer. (sec.)	Vert. Wall	1:2.5	1:6	1:2.5	1:6
A	1	2.2	3.4	2.6	4.6	1.9	2.4	1.4
	2	3.0	3.9	3.6	6.2	2.6	3.2	1.8
B	1	0.6	1.2	0.7	0.8	0.4	0.5	0.3
	2	0.9	1.3	1.0	1.1	0.5	0.7	0.4
C	1	1.8	2.7	2.1	3.3	1.4	1.8	1.0
	2	2.6	3.2	3.0	4.7	2.0	2.6	1.4
D	1	1.9	2.9	2.2	3.6	1.5	2.0	1.1
	2	2.7	3.4	3.2	5.1	2.1	2.7	1.5
E	1	2.3	3.8	2.7	5.2	2.2	2.6	1.5
	2	3.1	4.4	3.8	7.1	2.9	3.5	2.0
F	1	2.3	3.5	2.7	4.8	2.0	2.5	1.4
	2	3.0	4.0	3.6	6.3	2.6	3.3	1.9

Note: Calculations were developed using the Automated Coastal Engineering Services (ACES) version 1.07 software package from the Waterways Experiment Center/Coastal Engineering Research Center

2.7.4 Vessel Generated Waves. Currently, data indicate that vessel-generated waves contribute to the erosion observed within the refuge. Barges, shrimp boats, pleasure craft, tour boats and crew boats accelerate and leave wakes that reach shore, causing erosion. Preliminary data from a study (the report is in draft form at the time of this writing), done by Texas A&M University for WES, indicate that energy generated by vessels in motion, contributing to shore line erosion, was twice as great as energy produced by wind waves contributing to shore erosion. The author of subject report stated that this energy estimate

may be greatly underestimated due to the behavior of vessels in the vicinity of the researchers.

2.8 Tributary and Inlet Velocity Predictions. Velocity predictions were determined using the Coastal Engineering Research Center's (CERC, located at WES) program "DYNLET1", September 1991 version. DYNLET1 is a numerically stable one dimensional tidal flow analysis program. The sites, as shown in Illustration 1, examined for velocity analysis were the channels between the two small islands at the west end of Sundown Bay (site "X") and the entrance to McMullen Lake (site "Y"). These two sites were selected because refuge personnel wanted to prevent erosion and deepening of the bays/lakes in the critical habitat. The purpose was to stabilize the current channels or to reconfigure them with erosion protection to approximate the original depths. Various models that were run, show that tidal induced velocities are small and not an erosion factor for the systems as modelled. The tidal elevation parameter used for both system models was a 1.8-foot variation in the daily tide cycle with a small reduction at an opposite end to "drive" the model.

2.8.1 Sundown Bay. The model used for Sundown Bay was comprised of 11 channels, 6 junctions, and 41 nodes. The model was constructed assuming the GIWW depth is 12 feet and that Sundown Bay area depths vary from 3 to 5 feet depending on location. The input driving condition is tidal flow through the GIWW. The model was also run with the tidal forcing function between the two island openings across from Sundown Bay. The simulation was run for three complete tidal cycles of daily magnitude. Velocities throughout the system remained below 1 fps for most of the nodes in the model system. Tidal velocities approached 2 fps in the region of the small island channels on the western edge of Sundown Bay near and in the GIWW.

2.8.2 McMullen Lake. The model used for McMullen Lake was comprised of 3 channels, 1 junction, and 19 nodes. The model was developed assuming the GIWW depth is 12 feet and that the lake has a depth of 3 to 5 feet depending on location. The input driving condition was the tidal flow through the openings into the lake. The simulation was run for three cycles of daily magnitude. Velocities throughout the system remained below 2 fps in the region of the openings.

3. Survey and Mapping Requirements. Relatively few surveys were taken for the Section 216 Study. During project refinement, surveys will be taken at three types of locations, each for a different purpose as described in the following paragraphs.

3.1 Erosion Protection. Cross sections will be taken along the existing shoreline in reaches where erosion protection is required. These surveys will be used to determine locations and quantities of earthwork and will allow for final design and quantity calculations for the shore protection.

3.2 Upland Disposal Areas. Profile and cross section surveys of the existing disposal area levees and the proposed levee alignment at the new upland disposal area site will be performed to verify ultimate capacities of the disposal areas. Additionally, these surveys will be used for computing future levee enlargement quantities.

3.3 Marsh Creation Sites. Cross-sections of the proposed marsh creation sites will be taken to more accurately size each of the sites. The purpose of the marsh creation plan is to size each site such that the proposed marshes (or proposed marsh cells) can be completed with each dredging contract. The particular size of a marsh cell is a function of the amount and type of dredged material available and the average depth of the bay bottom to be filled. A change in either variable can increase or decrease the size of the marsh cell. One variable will be eliminated after cross sections of the bay bottom are performed by Galveston District. The proposed marsh creation sites will be resized during project refinement based on the results of surveys and geotechnical investigations. Additionally, a few surveys will be performed in adjacent existing marshes to help define what range of elevations is considered acceptable for the artificially created marshes.

4. Geotechnical. The purposes of this section include the following:

a. To describe the various preliminary geotechnical investigations conducted for the project and to outline future investigations required for final design.

b. To discuss the various geotechnical considerations on which the design of various features are based, and to review the bases for the preliminary designs included in the engineering appendix.

c. To outline future analysis and design requirements that will be required for final design. Future project operation and maintenance, specifically disposal area use and management, as it relates to geotechnical design of the project, is also discussed.

4.1 Subsurface Investigations.

4.1.1 Grout Tubes and Piling For Containment Booms. Plates 24 through 27 show the locations of ten (10) borings drilled at the ANWR site in 1993. Plate 28 contains the plotted logs of the borings. The purpose of these borings was to examine foundation conditions at the sites where the proposed grout tube erosion protection will be constructed and at some of the proposed locations where the pile supports for the containment booms will be installed. The borings were drilled to obtain 3-inch diameter undisturbed samples of cohesive materials and disturbed samples of cohesionless materials. Consistencies of cohesive materials were determined in the field using a pocket penetrometer or a Torvane Shear test device. Where cohesionless materials were encountered, disturbed samples were taken at approximately 5-foot depth intervals during the performance of standard penetration tests (SPT). Laboratory testing of cohesive material included determining

moisture content, unit dry weight, grain size distribution, liquid limit, and plastic limit. Grain size analyses were performed on typical samples of cohesionless materials and selected samples of cohesive materials. The results of these tests were used directly to classify typical materials and to aid in visually classifying the remaining samples. Unconsolidated, undrained shear strengths of typical samples of cohesive materials were determined in the laboratory by performing unconfined compression tests.

4.1.2 Bay Disposal Areas For Beneficial Use Sites. Preliminary investigations of bottom materials in bay areas were conducted by Galveston District personnel using a 1/2-inch outside diameter (OD) probe, a standard hand vane shear device and a 3-inch diameter section of PVC pipe for sampling. Plates 24 through 27 show the approximate locations of these investigations which were based on visual estimates determined in the field. The 1/2-inch probe and vane shear devices were used to provide general data regarding consistency of materials near the existing bay bottom. The 3-inch diameter pipe was manually pushed into the bay bottom to recover disturbed samples of near surface materials. The maximum depth of penetration was about 4 feet. Testing was performed on the sampled materials to determine moisture content, Atterberg limits, and sieve analyses, and all samples were visually classified. The information obtained from these preliminary investigations was used to provide a general characterization of relative site conditions throughout the considered areas. Additionally, the information was used to make general changes to locations and sizes of initially proposed beneficial use (marsh creation) sites, based on foundation conditions. Summaries of information and observations at each site, and approximate depths of samples, are contained in Exhibit 2. Exhibit 1 summarizes test results for the samples.

4.1.3 Marsh Creation Demonstration Areas. Sampling and testing of materials were performed by the WES in 1989, 1991 and 1993, before, and during the design of the two O&M demonstration beneficial use (marsh creation) sites constructed in 1993. Sampling consisted of vibracore samples, hand-pushed PVC cores and "grab" samples of surface sediments. A hand operated vane shear device was used to measure material consistency. Testing performed on the various samples included sieve analyses, moisture content, Atterberg limits and two One-Dimensional Consolidation Tests. Locations of the sampling are shown on Plates 24 through 27. Material descriptions and results of field tests are contained in Exhibit 2.

4.2 Site Conditions.

4.2.1 Existing Disposal Areas. The conditions of the existing areas and the levee heights varied significantly. In general, all disposal areas appeared to have been drained since the previous use, with each exhibiting some degree of crust development. Previously constructed levees appeared reasonably firm at all sites with the exception of an approximate 1,000-foot reach at DA 127, located along the southeast side of the area. The original levee at this location had been subjected to severe erosion prior to the most recent channel maintenance contract. Therefore, a new levee had recently been constructed at

a location somewhat to the interior of the original levee. The new levee had been constructed of soft, moist clays from the interior of the disposal area. The levee had apparently performed satisfactorily during the contract, but when observed shortly afterward, appeared to be undergoing slow failure, with several tension cracks observed along the crown. The interior of the levee was noted to be extremely soft when penetrated with a lath. Materials contained within the areas consisted generally of silts and clays, with some sand deposits confined to the dredge discharge locations. The levees at several of the areas were exhibiting significant erosion at locations, both along the bay-side and the GIWW-side. Since no subsurface information is available at the sites, descriptions of foundation conditions are limited to general statements based on field observations made in 1993, and adjacent core borings and vibracore sampling. Based on this information, natural materials apparently are encountered somewhere near or slightly below the mean water level, and tend to consist of soft sand, silt and clay mixtures near the surface, becoming sandier and denser with depth. The areas closer to San Antonio Bay apparently contain higher percentages of sand as compared to the areas nearer Aransas Bay. The upper level of these natural deposits becomes significantly firmer when at or slightly above the mean water level, probably as a result of overconsolidation due to desiccation. Material lying directly above the natural deposits, which could be observed at various eroded shoreline locations, generally consisted of sand in the San Antonio Bay area, and predominantly silts and clays near Aransas Bay. The materials had been deposited during channel dredging early in the project life. No assessment could be made of the material within the existing levees, or foundation materials on which the enlargements had been placed; however, shallow probings at scattered locations encountered generally firm fill materials. The results of the probings indicate that some crust development had occurred at these locations, providing acceptable fill materials. One exception to this, however, occurred at DA 127, as described previously. Probings of interior areas generally indicated alternating layers of firm and very soft materials.

4.2.2 Proposed Marsh Construction Sites. In describing the proposed beneficial use (marsh creation) sites, it is advantageous to separate them into two groups having somewhat similar conditions. Group 1 consists of Sites A, B, D and E; and Group 2 includes Sites C, F, G, H, I, J and K. These beneficial use sites are shown on Plates 14 through 23. Group 1 sites are characterized by the presence of a surface layer of sand, overlying soft silty, clayey material. This layer appears thickest near the shoreline and appears to diminish in thickness as distance from shore increases. It could not be determined based on the widely spaced investigation sites if the diminishing occurs gradually, or suddenly. The locations, and presence of sand on the bay bottom appeared to correspond with lighter colored areas shown on aerial photos of the sites. At distances further from the shoreline, the material consisted generally of a sandy, silty clay, with some shell hash and interbedded sand and shell hash layers. Resistance to pushing a probe through the materials varied considerably from layer to layer, with the clayier layers appearing to be very soft, and the layers with high sand and shell content offering significant resistance. The material located beneath the sand layer, nearer to shore, appeared very similar to the material encountered further out from shore. The sand layer,

which was observed to be present at both of the previously constructed O&M demonstration marsh creation sites, played a major role in the successful levee construction, by providing a suitable foundation, minimizing opportunities for failures and settlement, and providing a very suitable and stable material for filling the geotubes. Group 2 includes areas which do not have significant coverage with sand, and in addition, appear generally to be more plastic, i.e. with a higher clay content. The layering of materials with higher sand and shell content was observed to various degrees at the sites; however, there was generally less shell hash and sand noted. The clayey materials occasionally were observed to contain shell or large shell fragments which were often dispersed somewhat uniformly throughout the clay. This material also appeared to have a generally very soft consistency. At the sites of both groups, the soft materials appeared to extend to depths of 6 feet or more below the bay bottom.

4.2.3 Proposed Grout Tube Sites. Borings at the proposed grout tube construction sites in Sundown Bay indicate conditions that appear very similar to those described for Group 2 of the proposed marsh creation sites. From the bay bottom to about elevation -10 feet mean low tide (MLT), the material consists of loose to very loose clayey sands, that generally contain 20- to 40-percent fines. Atterberg limits were obtained for one sample, taken at elevation -5 MLT, from boring 93-277. Tests of this boring also indicated a liquid limit (LL) = 22 and a plastic limit (PL) = 18, resulting in the material plotting in the "CL-ML" portion of the Plasticity Chart and indicates a very silt-like behavior. Although not identified in the borings, the presence of silty sand (SM) and silt (ML) at a boring drilled at a nearby containment boom site indicates that materials throughout the area apparently contain some proportion of silt, along with the sand and clay. The material below the surface layer appears to be similar in composition; however, density generally increases into the medium-dense range between elevations -10 and -22 MLT. Some loose- to medium-dense poorly graded sand was encountered between -10 and -20 feet MLT at two locations and medium clay (CL) was encountered at the bottom of one of the borings.

4.2.4 Containment Boom Sites. Preliminary borings at four sites proposed for installation of containment boom piling indicated that near surface conditions at the sites located adjacent to the refuge are very similar to conditions described for the grout tube sites, with the exception of one boring indicating silty sand (SM) instead of clayey sand (SC). Also at this site, boring location 93-271, material classified as silt (ML) was encountered from elevation -15 to -30 feet MLT. Material densities tend to increase somewhat from elevation -20 to -40 feet MLT, ranging from medium-dense to dense, with occasional very dense layers. Below approximately elevation -45 feet MLT, the borings encountered medium to hard clays or very dense silt. The one boring that was drilled on the northeast side of San Antonio Bay, near the Welder Flat area, encountered soft, fat clay (CH) in the upper 5-feet of the boring. The consistency of the clay increased to medium, and then was measured as being stiff from elevation -10 to -20 feet MLT. The CH layer is underlain by a 5-foot-thick layer of stiff lean clay (CL), with medium-dense silt encountered between elevations -26 and -44 feet MLT. Stiff and medium-dense lean sandy clay and clayey sands, were encountered from elevation -44 feet MLT to the bottom of the boring at -55 feet MLT.

4.2.5 New Upland Disposal Area Site. No information is available at the new upland disposal area site. Investigations to obtain information will be conducted during project refinement.

4.3 Additional Geotechnical Investigations. The intensity of subsurface investigations varies for the various features of the project. Core borings were drilled to investigate foundation conditions for proposed grout tube erosion protection; an element for which the need and location had been determined to be relatively certain. Four borings had also been located at probable sites of the proposed containment boom piling. Additional investigations for all of the containment boom sites will be conducted during project refinement. In addition, detailed investigations for the other features, including existing and new upland disposal areas and future marsh creation sites, will be conducted. The detailed investigations of the beneficial use sites will provide adequate information for designing all marsh containment levees, including those to be constructed during project O&M, with minimal, or no additional investigations required during preparation of plans and specifications. The benefits of this approach include the opportunity for accurate programming of O&M funding for future required construction, and minimizing the requirement to mobilize additional drilling and sampling, or other test equipment, within the whooping crane critical habitat area. Accordingly, the investigations are relatively comprehensive within the areas that have been selected, coordinated, and agreed upon for the project features. Investigations of the new and existing upland sites will allow for conducting analyses of the stability of existing levees and proposed future levee enlargements. The results of these analyses will be used to confirm the capabilities of the proposed areas during the project life, and allow for planning any major rehabilitation efforts that may be required in the future. The following paragraphs provide a summary of the proposed investigations to be performed during the next phase of the project.

4.3.1 Foundation Investigation of Beneficial Use Sites by WES Using Cone Penetrometer Testing (CPT). A comprehensive investigation of all proposed marsh creation areas will be conducted by WES in 1994. The investigation will consist of recording soil resistance to penetration of a cone penetrometer at points on an approximate 400-by-1,000-foot grid, at all proposed marsh creation sites. The information to be acquired will consist of approximate soil types and bearing capacities within the upper 15 feet of bay bottom material. This information will be used to adjust the preliminary locations of containment structures to make the most efficient use of the more favorable foundation areas. In addition, the information will be used for final design of the various levees that will be required for the construction of all marsh cells during the project life. Since no significant change in foundation conditions at the sites is expected during the project life, this information will continue to be applicable in the future. It is expected that the testing will be conducted at approximately 300 to 350 locations. Additionally, some CPT testing will be conducted at the grout tube site to supplement previous core borings for final design.

4.3.2 Core Drilling, Soil Sampling and Testing for Existing and New Upland Disposal Sites. Additional core drilling, soils sampling and laboratory testing will be conducted at all

existing upland disposal areas which are proposed for continued use. Borings will be spaced at approximately 1,500-foot intervals along the levee alignment and will extend to approximate elevation -20 feet MLT. Borings at this interval and depth will be sufficient to obtain information to allow a reasonable assessment of overall foundation conditions, to allow stability analyses to be performed of existing levees at various locations, and to project the stability as levees are enlarged to approach their ultimate heights. Since these analyses will be developed based partially on assumed strength gains resulting from consolidation of foundation materials under increasing overburden pressures as additional fill is placed at the site, some additional borings or *in situ* strength tests will be required in the future to verify the assumed strength gain. In addition, borings will be drilled at approximate 1,200-foot intervals along the proposed levee alignment at the new disposal site to obtain information for the design of initial levees and spillboxes, and to confirm the capability to contain the required quantity of materials through the 50-year project life.

4.3.3 Core Drilling, Soil Sampling and Testing for Beneficial Use Sites. A total of forty six (46) borings will be drilled at the proposed marsh creation sites, in addition to the CPT testing. These borings, which will be drilled to 15-foot depths, will be used to verify and correlate with the CPT information. In addition, the sampled material will undergo sieve and hydrometer analyses to determine the grain size distribution of potential borrow material for levee fill or for use in filling geotubes. This information, which cannot be obtained by the CPT, is necessary for the design of the geotubes and to evaluate the practicality, and the proper technique for use of various materials for filling of the geotubes.

4.3.4 Core Drilling for Containment Boom Structures. A total of sixteen (16) additional 50-foot deep borings will be drilled at the proposed sites of the containment boom structures. Information from these borings will be used for final pile design for the boom supports to be completed during project refinement.

4.4 Geotechnical Design Considerations. There are numerous geotechnical design considerations that had to be addressed to allow completion of the preliminary plan outlined in Paragraph 6.1.1.5. Following is a summary of the various items, indicating how they were addressed in the preliminary design. The use of subsequent data to verify and refine initial assumptions through additional analyses is also discussed.

4.4.1 Foundation Bearing Capacity of Grout Tube Sites at Sundown Bay. The generally poor bearing capacity of the materials, particularly the upper 10 feet at the sites, require that a relatively wide based structure be used. The use of three grout tubes for the base of the structure will distribute the structure weight over an area, such that a general bearing capacity failure will not occur. Additionally, the use of a high strength geotextile beneath the grout tubes will be required to prevent local failure of the foundation material beneath the individual tubes. Consequently, the tube would sink into, and displace, the soft underlying materials. This preliminary grout tube design, and the required strength of the geotextile will be verified by performing bearing capacity and slope stability analyses during

project refinement. These analyses will be also based on additional information to be obtained during CPT testing at the site.

4.4.2 Pile Lengths for Containment Booms. The preliminary assumed pile length was based generally on the information obtained from four borings which were located at some of the boom sites. Although soil strengths and densities appear to generally increase with depth, the preliminary borings also indicated that considerable variations in soil types and conditions occur within the elevations to be penetrated by the piles. Therefore, additional borings will be drilled to obtain soils information at all additional sites to determine the required pile lengths during project refinement.

4.4.3 Bearing Capacity of Foundation Materials at the Proposed Beneficial Use Sites. One of the primary design concerns for constructing the containment structures for the proposed marsh creations is the capability of the foundation materials to provide adequate bearing capacity. Preliminary investigations indicated that relatively poor foundation conditions exist over significant portions of the proposed sites. Based on these conditions, it was assumed that relatively large diameter geotubes, as indicated on the plates, would be required to adequately distribute the weight of the dike over a large enough area to avoid a failure. The geotubes will serve as a dike around the containment area. Bearing capacity failures of dikes during construction would require realignment of the failed portion of the dike, and likely, a redesign of the typical dike section. Therefore, all assumed typical dike sections will be analyzed for factors-of-safety against bearing capacity failure during project refinement, based on information obtained from the CPT testing and core borings to be performed at the site, as described in Paragraph 4.3. The use of scour pads, with filled tubes along the edges, and adjustments to the required number and widths of tubes in the typical dike sections, will be considered to provide adequate safety factors against bearing failures.

4.4.4 Levee Stability/Design at Existing and New Upland Disposal Area Sites. The preliminary design assumed that levees at all sites could be enlarged to approximate elevation 35 feet MLT, with adequate subsurface information and proper design. Slope stability analyses for all upland disposal areas will be conducted during project refinement to verify this assumption. The analyses will be based on soil strengths resulting from strength tests on samples obtained during core drilling at the sites, and on assumed strength gains of some of the weaker foundation materials prior to future enlargements. These strength gains will be based on published typical values for ratios of Undrained Shear Strength divided by Vertical Effective Stress (C/P) for normally consolidated materials and on the phi angle obtained from results of Consolidated-Undrained Triaxial Shear "R" Tests on samples obtained at the sites. Rates of strength gains will be estimated based on results of one-dimensional consolidation tests. The intent of the project refinement analyses will be to ensure that the projected levee heights at each of the areas do not exceed the "ultimate levee height" based on stability analyses. The ultimate levee height is defined as the maximum heights that all containment levees at a disposal area can be enlarged to without subjecting any significant reaches to widespread

deep-seated failures. Consequently, the ultimate levee height for a disposal area is dependent on the reach of levee having the worst foundation conditions. Reaches of levee, which may require extraordinary rehabilitation efforts at some point within the 50-year project life, will be identified and potential remediation will be developed during project refinement.

4.4.5 Long Term Shrinkage Factor for Upland Disposal Sites. The shrinkage factor is defined as the ratio of the long-term volume occupied by a certain quantity of maintenance material in a disposal area, to the volume occupied in the channel prior to dredging. The significance of this factor is that this value has a major impact on determining the ultimate capacity of a given disposal area, and consequently, may impact the validity of a long-term channel maintenance plan. One approach used to arrive at an average shrinkage factor for a particular disposal area is to compare the average density of shoaled materials before dredging a particular reach of channel to the average density of materials within a disposal area historically used to contain dredged material from the channel reach. The average densities of the materials in the two states are determined by sampling and performing moisture content or unit weight tests. The range of predicted and calculated long term shrinkage factors for clays and silts extends from about 0.4, for intensely managed disposal areas, to about 0.8 for unmanaged areas. It is generally accepted that shrinkage can be assumed negligible for coarse-grained materials. Based on results of previous investigations and studies for similar materials, at similarly operated sites, a shrinkage factor value of 0.7 was applied to all predicted maintenance material quantities to calculate long-term capacity requirements for upland sites. This value is believed to correspond to shrinkage that would occur if the areas are operated as in the past, without any additional management measures. Consequently, this factor can be considered adequately conservative for use in projecting future required levee heights at the areas, and will possibly result in some over-predicting of the required heights if any management activities are undertaken. Since there is no intent to achieve ultimate levee heights at any of the areas during the project life, some variation of the actual shrinkage from the assumed is not considered critical; therefore, no additional investigations or analyses are planned for the purpose of validating or refining the assumption for final design.

4.4.6 Long Term Shrinkage Factor for Marsh Fill. A conservatively estimated long term shrinkage factor of 1.0 was assumed, which means that the density in the marsh disposal areas is assumed to be the same as the density of the material in the shoaled state prior to dredging. The assumed conservatism of this estimate is based on the opinion that some additional consolidation of the material, beyond buoyant self-weight consolidation, will occur in the disposal area as a result of the intent to initially pump the dredge fill to an elevation above mean tide level. This increased elevation will be designed to allow for consolidation of the dredged material, after decant, resulting in settlement of the top of fill to a specified marsh surface elevation within the tidal range. Some refinement of this factor will be performed during project refinement by modeling the consolidation and desiccation shrinkage of a known material using the program entitled "Primary Consolidation and Desiccation of Dredged Fill (PCDDF)" documented in the Automated

Dredging and Disposal Alternatives Management System (ADDAMS) package. PCDDF simulates the consolidation and desiccation processes in fine-grained material using the finite strain theory of consolidation and an empirical desiccation model. Additionally, verification of the model will be conducted by measuring consolidation of materials in recently constructed marsh areas along the Houston Ship Channel. Final refinement and validation of assumed consolidation will take place after construction and filling of the initial cells at the proposed marsh creation sites. Conservatism of the factor assumed for design will result in the initial cells being designed with capacities slightly smaller than the corresponding volume of dredged material available to fill the sites to the design elevation. The intended result is a completely filled marsh site, with any additional material being placed in the adjacent upland sites. It is intended that effects of continued long-term settling of the marsh area, as a result of primary and secondary consolidation of the fill, will be remedied by periodic renourishment of the area using thin-layer disposal techniques described in Dredge Research Program reports.

4.4.7 Earth Borrow and Construction Material for Levees. Materials for constructing all levee enlargements at existing upland sites will continue to be obtained from excavating the crusted surface of the contained material placed within the disposal area during previous dredging contracts. Materials for constructing the new levees for the new disposal area are assumed to be obtained from designated areas at the site. This assumption will be confirmed by upcoming core drilling. Materials to be used for construction of the earth fill levees for the proposed marsh creation sites will consist of sandy material obtained from excavations immediately adjacent to the levees. Materials to be used for the filling of the geotube containment dikes will be obtained from designated areas within reasonable pumping distances from the dike sites. The locations of these areas will be determined during upcoming subsurface investigations discussed in Paragraph 4.3.

4.4.8 Management of Upland Disposal Areas. In order to comply with recently developed disposal area management guidelines, the plan assumes future attempts at managing the upland disposal areas will be initiated and continued throughout the project life. The intensity of the management could range from the simple removal of boards from the spillbox, and providing for drainage of low areas within the disposal area, to a comprehensive program of trenching, dewatering and crust development of each material lift. The requirement for management will vary from site to site. However, for preliminary determinations of future required levee heights described herein, the plan assumes no additional management of the areas. This assumption is intended to yield conservative results for this report; however, some change to current management practices may occur. During project refinement, the requirement for management will be reviewed based on results of borings at the sites and slope stability analyses of existing and projected levee enlargements. Detailed recommendations and guidelines for any proposed management will be outlined in the project O&M Manual, where appropriate adjustments to the future required levee heights will be shown.

4.4.9 Effects of Consolidation of Foundation Material/ Long Term Levee Settlement. It is obvious that some long term consolidation of foundation materials will occur at the grout tube shore protection and geotube dike sites. Consequently, analyses to predict the total amounts and approximate time-rates will be performed prior to final design. Since the grout tube performance is dependent on its long- term elevation, allowance for predicted settlement will be included in the final design. Since the geotubes' function is to provide containment of dredged material during marsh creation, no allowance for long term settlement will be included in the final design. Alternately, the amounts of predicted settlements will be evaluated for effects on potential erosion of the marshes by wave overtopping. Additionally, practical methods of nourishing marshes with dredged material, later in the project life, will be evaluated during the final design.

4.5 Cellular Concrete Revetment.

4.5.1 Design. The recommended method of protecting the ANWR from waves generated by wind and by vessel traffic along the GIWW is a combination of a cellular concrete mattress revetment and the use of concrete grout tubes, discussed in the following paragraph. The cellular concrete mattress revetment, proposed to be used for approximately 69,000 feet of shore protection in addition to the revetment already in place, will consist of cabled concrete blocks placed on an excavated 1 vertical on 3 horizontal (1V:3H) slope. The top of the revetment mattress will be placed on the existing marsh at the top of bank at an approximate elevation of 2.5 feet MLT. The lower end of the revetment will be placed at an elevation of -1.0 foot MLT. The mattress at the top of bank will be anchored to the marsh by flexible anchors. The mattress revetment will be placed on top of a woven geotextile fabric. The excavated material obtained from the placement of the mattress will be temporarily stockpiled at the top and toe of the excavated slope, and used to backfill the excavated areas. The revetment cable will be constructed of high tensile strength, low elongating, continuous filament polyester fibers contained within an outer braid jacket which is non-corrosive to the effects of saltwater. The cellular concrete blocks will be precast with a minimum compressive strength of 4,000 pounds-per-square-inch (psi). The blocks will include penetrations for revetment cables as necessary to securely bind the individual blocks into mattresses. The blocks will be open-cell type and must, as a system, be able to articulate. Conventional blocks will have tapered sides along the longitudinal side of the mattress to provide the articulation. This taper will not be less than a combined 7-degrees between blocks. Each block will exert an unsubmerged ground pressure of at least 40 pounds-per-square-foot (psf) on the total unit base area circumscribing the block. The concrete block revetment system is shown on Plate 13. Woven geotextile filter fabric will be required to protect the foundation material beneath the articulated concrete mats from hydrostatic pressures which could produce "piping" from the erosive action of waves. The proposed filter fabric will have an equivalent opening size (EOS) designed to help relieve the build-up of hydrostatic pressure and to prevent clogging. Acceptable values of EOS will be no finer than the U.S. Standard Sieve No. 100 and not coarser than the U.S. Standard No. 70. The percent of open area shall not be less

than 4.0 percent. Other minimum requirements for the geotextile filter fabric are shown below.

GEOTEXTILE FILTER DESIGN CRITERIA

Tensile Strength (Pounds)	250
Breaking Elongation (Percent)	15
Puncture Strength (Pounds)	130
Tear Strength (Pounds)	55
Abrasion Resistance (Pounds)	55

The mattress revetment system will protect against annual wind waves estimated to be 2.0 to 2.5 feet high in open bay areas and 1 foot high in areas protected by bayside barrier islands. The mattress system will also protect against 2.0-foot high waves generated by vessel traffic. The design of the system is based on the same type of mattress system already in place at certain reaches of the refuge. This revetment system is the desired protective system requested by the refuge personnel and recommended by the manufacturers' representatives. The existing mattress system has performed satisfactorily for approximately 3 years with no required maintenance.

4.5.2 Construction Procedure. The slope and bay bottom foundation areas for the cellular concrete mattress revetment will be shaped and excavated by the use of dragline, backhoe or other similar excavating equipment. The excavated material will be stockpiled at the top and the toe of the slope. The revetment will then be placed on a finished excavated slope on top of a woven geotextile fabric. Following the placement of the revetment, the excavated material will be used to backfill the excavated areas. Placement of geotextile fabric along the lower slope will require some underwater placement. The filter fabric can be pinned to the prepared bottom prior to placement of the concrete mattresses. Fabric units to be placed adjacent to each other will be overlapped to ensure good coverage of the foundation. Care will be taken to ensure that no construction equipment is allowed on the filter fabric at any time.

4.6 Grout Tube Breakwaters.

4.6.1 Design. The recommended method of protecting the ANWR from waves generated by wind and by vessel traffic along the GIWW at Sundown Bay, and other minor locations shown on the drawings, is the use of concrete grout tubes. A grout tube section of approximately 13,500 feet will be used to close or reduce the width of existing small marsh inlets and primarily reduce wave erosion within a large portion of Sundown Bay. The grout tubes will also serve as a hard surface for the start of oyster reefs. The grout tube section will consist of 6 single nylon woven fabric tubes which will be filled with grout to the dimensions shown on Plate 13. The grout tube section will have a minimum compressive strength of 2,000 psi. The nylon tube fabric will be degradable with time. The grout tube

section will be placed on a woven geotextile fabric which will be placed on the prepared bay bottom foundation. The bay bottom foundation along the proposed alignment may require a small amount of excavation in some reaches to establish the foundation elevation of -1.0 feet MLT. The geotextile fabric placed underneath the grout tube sections will protect against scour and minimize settlement. The size and weight of the grout tubes will be more than sufficient to withstand the expected wave action which is the same as expected for the cellular concrete mattresses. The woven geotextile fabric will meet the same criteria as the geotextile fabric for cellular concrete mattresses.

4.6.2 Construction Procedure. The bay bottom areas on which the grout tubes will be placed will be shaped and excavated by the use of a dragline, backhoe, or other similar excavating equipment. Excavated material required for the placement of the grout tube sections can be disposed off site or spread on the landward side of the excavation. The grout tubes shall be placed empty and filled at the site, or filled and transported to the site by barge and then placed.

5. Environmental Engineering. The recommended plan will incorporate positive environmental attributes, operations, maintenance, and management, and beneficial uses of dredged material. The features within this plan include protection of the critical habitat shoreline by articulated concrete mats and grout tubes; disposal of dredged material by developing marshes; and protection of the habitat's bays, inlets, and marshes from pollutant spills by strategic placement of pile anchor points to receive containment booms deployed during such an event.

5.1 Shoreline Protection. The proposed design of the shore protection, consisting of articulated concrete mats and grout tubes, allows for tidal exchange between the GIWW and adjacent marshlands. This protection is proposed for the north side of the GIWW and Welder Flat as shown on the plates. Refuge personnel have identified critically eroding locations, within the whooping crane's habitat, and as a result, nearly 10,000 LF of shoreline has been protected with articulated concrete mats to date. This protection is installed at existing ground elevations to minimize any changes to the environment. Openings into the marshes will not be altered by placement of subject protection. Geotubes filled with a grout mixture will protect the ANWR shoreline, along the GIWW at Sundown Bay and at other locations, from waves induced by wind and by vessel traffic. A grout tube reach of approximately 13,500 feet within Sundown Bay will be used to close or reduce the width of existing small marsh inlets and primarily reduce wave erosion. The grout tubes will also serve as a hard surface for oyster reefs.

5.2 Beneficial Use Sites. Beneficial use sites will be located and developed to increase the acreage of suitable marshlands available for the cranes located at ANWR. These sites, generally south of the GIWW, will provide new habitat for the species whose feeding grounds are continuously impacted by erosion. Marshes created under this project are strictly an application of beneficially using dredged material; the marshes will not be created for the purpose of mitigation or other reasons. No marshes will be created with

new work material, as no new work material is included in the recommended plan. The optimum result is to create a functional marsh cell under a single dredging contract; a cell would not require several dredging cycles to reach the proper elevation for marsh grasses to grow. Marsh containment structures will be generally constructed of geotubes filled with acceptable dredged material. In addition, preferable development of the marsh sites will require construction at alternating sites; one dredging cycle will place material in an upland site, the next cycle will use the material to construct the marsh. This approach will have the advantage of allowing extra drying time for the material in the upland site. See also Paragraph 6.1.1.5 and Tables 5 through 8.

5.3 Containment Boom System. Within subject reach of the GIWW, between Welder Flat (Station 696+000) to Aransas Bay, adjacent to Blackjack Peninsula (Station 860+000), approximately 30 inlets to various marshes and small bays are susceptible to a pollutant spill. The openings of these inlets vary in width from approximately 30 feet to over 8,000 feet. Timber piles, as anchorage points, will be permanently installed adjacent to the inlets. Should a pollutant spill occur, ANWR and/or U.S. Coast Guard personnel will deploy the containment booms to the affected area. Corrosion-resistant hardware, which will allow for vertical adjustment, will be installed on each piling as required to receive the containment booms when deployed. The containment boom system will be a standard-type that is readily available in the marine industry. The boom system, typically consisting of interlocking sections, will provide the flexibility required to control most pollutant spillage.

6. Project Design.

6.1 Site Selection and Project Development.

6.1.1 Civil Requirements.

6.1.1.1 Description of alternative alignments. Four distinct channel alignments were studied to determine the recommended plan. One alignment was that of the existing channel. The other three alignments were designed with the purpose of minimizing impacts to the critical habitat of the whooping crane. Each of these alignments maintained channel templates similar to that of the existing channel. The channel template maintained a bottom width of 125 feet, with the project depth remaining at 12 feet, referenced to MLT. Advance maintenance and overdepth were 2 feet and 0.5 foot, respectively. Side slopes were 1V:5H in bay reaches, and 1V:3H for landlocked reaches. New work dredging quantities were estimated based on topography from USGS quadrangle sheets. Shoaling rates for the realigned channels were estimated based on historical rates for geographically similar reaches of the existing channel. While not precise, these assumptions were considered sufficient for comparison purposes. The alignments are shown on Plates 2 through 5 and are briefly described as follows:

a. A northerly alignment, approximately 43.2 miles in length, avoided the critical habitat. The majority of this alignment cuts through existing prairie or farmland.

New work excavation, both by mechanical equipment and by hydraulic dredge, was estimated to be 31.8 million cubic yards (MCY). The majority of the new work material would be consumed in building earthen levees on each side of the channel. All new work and maintenance material dredged from the land-locked reaches and from San Antonio Bay would be placed into sixteen (16) newly constructed upland disposal sites. New work and maintenance material dredged from Aransas Bay would be placed into new unconfined open bay sites. The annual shoaling rate for the realigned portion of the channel was estimated to be 1.2 MCY per year.

b. A southerly alignment, approximately 44.1 miles in length, avoided the critical habitat by realigning the channel through the existing Matagorda Island barrier islands. Most of the alignment was considered hazardous since this route traversed an area that was formerly used as a gunnery and bombing range, and as a storage and disposal site for ordnance. The alignment was also viewed as dangerous because conditions similar to that presently being experienced at Sargent Beach (erosion of the land between the Gulf and the GIWW) were likely to occur. All new work and maintenance material would be deposited along the surf zone of the Gulf, adjacent to the existing islands. New work dredging was estimated to be 32.3 MCY. Annual shoaling was estimated to be 1.01 MCY per year.

c. An additional southerly alignment, approximately 18.6 miles in length, avoided the refuge by realigning the channel into the open bay between the existing channel and the barrier islands. Of the three new alignment alternatives, this alignment was the most promising from the standpoint of new work dredging quantities, estimated at 8.04 MCY. All new work would be pumped into existing disposal areas. Those areas, which are upland, would later be degraded to elevation 5.0 feet MLT and the material used to fill the existing channel to elevation 0.0 feet MLT. Maintenance material, estimated as 1.78 MCY per year, would be used to construct marshes adjacent to ANWR. This option was viewed as less expensive than pumping to new upland sites, because construction of new levees would be required.

6.1.1.2 Maintenance Dredging Requirements.

6.1.1.2.1 Estimation of Maintenance Dredging Rates. As noted, estimated shoaling rates were determined by analyzing historical data from dredging contracts. By taking the amount of material dredged, and the time between contracts, average annual rates were obtained for specific reaches of the project. Assuming uniform distribution of the shoaled material within each contract reach, annual rates per linear foot were determined. These rates are given below:

Location	Station to Station	Annual Shoaling Rate Cubic Yards per Linear Foot
Welder Flat	Sta. 696+000 to Sta. 724+000	1.60
San Antonio Bay	Sta. 724+000 to Sta. 775+000	14.00
Aransas NWR	Sta. 775+000 to Sta. 830+000	3.12
Aransas Bay	Sta. 830+000 to Sta. 860+000	10.50

Historical dredging records also provided an estimate of the average dredging frequency or interval. These intervals, combined with the estimated shoaling rates, were used to develop the 50-year disposal plan. Incremental reaches were laid out with respect to disposal areas. These incremental reaches facilitated estimating an amount of material for placement in disposal areas of a specific reach in a certain timeframe. For example, existing DA 129 lies within the ANWR reach. This area is dredged about every 3.9 years. Thus, the material going to DA 129 would be that from Station 785+000 to 805+000, and the amount would be 243,360 CY every cycle. This quantity of material was then used to determine ultimate disposal capacity of the existing disposal sites, and to size the marsh cells.

6.1.1.2.2 Methodology. Although this method is reasonable, it contains an inherent fallacy in that it assumes linear or uniform shoaling throughout a particular geographic reach. The method is considered, however, to be sufficient for the current level of detail. However, shoaling rates at the endpoints of geographical reaches are recognized to vary somewhat from the average. During project refinement, historical dredging records will be analyzed in greater detail to refine shoaling rates for smaller increments of the channel. These incremental rates will be used to refine the disposal plan.

6.1.1.3 Development of Marsh Parameters. The proposed locations and approximate overall sizes of the marshes are shown on Plates 6 through 12. The marshes are shown individually on Plates 14 through 23. The general locations and approximate sizes were determined through meetings with the resource agencies. A summary of the marsh sites and their maximum sizes, in acres, is given below:

Site "A"	392 ac.
Site "B"	407 ac.
Site "C"	43 ac.
Site "D"	90 ac.
Site "E"	147 ac.
Site "F"	96 ac.
Site "G"	24 ac.
Site "H"	10 ac.
Site "I"	222 ac.
Site "J"	148 ac.
Site "K"	35 ac.
Total:	1,614 ac.

Larger marshes were subdivided into functional marsh cells. The optimum result is to create a functional marsh cell under a single dredging contract; a cell would not require several dredging cycles to reach the proper elevation for marsh grass to grow. These cells were sized based on estimated dredging volumes to be pumped into the sites. The sizes will be re-analyzed during project refinement after performing more detailed shoaling studies, surveys of the marsh sites, and geotechnical investigations. The marsh plan is intended to be flexible. During the project life, cell sizes may be adjusted to meet actual dredging requirements, as determined by hydrographic surveys. These requirements will be accomplished by constructing confining levees for the marsh cells at the time of marsh construction.

6.1.1.3.1 In preliminary sizing of the marsh cells, a number of simplifying assumptions were made due to the lack of surveys or geotechnical data. Average final fill thickness of the dredged material was assumed to be 3.5 feet. The long-term shrinkage factor, discussed in paragraph 4, for all maintenance material used in marsh construction, was assumed to be 1.0. "Disposal area" capacity of the marsh cell was assumed to be 98-percent of the total (levee centerline) acreage, allowing for lost capacity due to levee sides. Finally, the marsh acreage was increased 10-percent to allow for ponds or waterways within the marsh cells. All of these factors will be validated during project refinement.

6.1.1.3.2 Since survey and geotechnical information were not available, certain assumptions regarding existing site conditions were required to estimate heights of marsh containment structures. In addition, certain simplifying assumptions were made in order to accomplish preliminary sizing of the geotubes to be used to construct some of the retaining structures. Required elevation of earth levee crowns and the tops of geotube containment structures was assumed to range between 3 and 6 feet MLT. The elevation 6 feet MLT portion of the containment system would be located near the intended discharge areas, which will eventually form the high points of the cell. The portions of the structure having lower elevations, which will consist of geotubes, will act as overflow weirs during filling, allowing water to return to the bay after material settling has been accomplished. Ground elevation at the sites was assumed to vary from - 4 to 1 foot MLT. It was assumed that the maximum height of the geotubes, after filling would equal approximately one-half of the circular diameter of the tube. It was further assumed that some displacement of soft foundation materials would occur beneath some of the tubes, resulting in the final position of the bottom of the tube being as much as 4 feet below the existing mudline. Using these assumptions, various levee and containment structural configurations were developed that were believed could result in achieving the required 3 to 6 feet MLT elevation range. Since a significant amount of critical data is still required for final design, this preliminary design should be considered adequately realistic for preliminary cost estimating purposes; however, it should be realized that the final design may be expected to deviate substantially from the preliminary design regarding geotube number, sizes, and locations.

6.1.1.3.3 The recommended plan includes armoring a large percentage of the shoreline. Additional armoring of the levees of the existing disposal areas may also be done as part of the O&M program. This armoring should reduce the shoaling rates from their present level, although it is not possible to determine a quantitative amount. In order to ensure a conservative 50-year disposal plan, the shoaling rates were not reduced from their historical amounts.

6.1.1.4 Ultimate Capacities of Existing Disposal Sites. As part of the 50-year disposal plan, a simplified investigation of the existing upland disposal areas was performed. The locations of these disposal areas are shown on Plates 6 through 12. Existing levee elevations and interior fill elevations were also based on field estimates and survey data obtained during a recent channel maintenance contract. Based on inspections of the existing levees, and available subsurface information, it was assumed that an enlargement of the existing levees to an elevation of about 35.0 feet MLT could be accomplished at each of the existing disposal areas. Disposal area acreage and perimeters were obtained from previous dredging contract drawings. The calculations were done in a spreadsheet format. This spreadsheet took the dredging quantity, converted to in-place disposal volume by an assumed bulking factor of 1.2, then calculated the fill thickness after first reducing the disposal area acreage by 2-percent to account for crown width and interior side slopes of the levee. An allowance of 4 feet for freeboard and ponding was included. These values were then compared to the existing freeboard to determine the new required levee raising. Where levee raisings of less than 3 feet were required, the value was rounded to 3 feet for economy of construction. Afterward, an assumed shrinkage factor of 0.70 was used to determine the interior elevation after shrinkage and consolidation (dredged material was assumed to shrink to 0.70 times its original dredged volume). This elevation was used for the interior elevation of the following dredge cycle. It was assumed that levee enlargements would be constructed on the existing crown and interior slope. Therefore, for each dredging cycle, the disposal area will lose about 2-percent of acreage. Finally, borrow volumes were calculated using a levee template with 1V:3H side slopes, a crown width of 10 feet, and an assumed borrow "loss" factor of 20-percent. All borrow material was assumed to be obtained by dragline from side-ditch borrow areas adjacent to the levees.

6.1.1.4.1 Using the spreadsheet noted above, ultimate project capacities of the existing upland sites were calculated assuming continuous disposal (no marsh creation). These capacities are given below:

6.1.1.5 Description of 50-Year O & M Disposal Plan. Using the estimated shoaling rates, the disposal capacity of the maximum allowable marsh site sizes, and the expected ultimate lives of the existing upland sites, more than sufficient capacity was determined to be available for the 50-year project life. Two options were then available:

a. Maximize the use of the upland sites, using the marsh sites only as required where upland sites did not have sufficient capacity for the 50-year project life.

b. Maximize the use of the marsh sites, reserving capacity in the upland sites.

Coordination meetings held between members of Engineering, Environmental, and Construction-Operations personnel in the Galveston District indicated a strong preference for the second option. The advantage of the second option is that should shoaling

Table 4
Ultimate Capacity of Existing Upland Disposal Sites

Disposal Area	Existing Elevation	Capacity (Cycles)	Years	Final Elevation
New Upland	5 (assumed)	6	43.2	17
DA 127	18	7	27.3	36
DA 129	18	13	50.7	33
DA 130A	16	12	46.8	34
DA 130B	14	13	50.7	26
DA 131	22	8	31.2	34

Note: No effort was made to determine the expected life of existing open bay unconfined sites. These sites were assumed to be sufficient for the project life.

suddenly increase due to some unforeseen event, such as a severe storm, or should some of the shoaled material become contaminated during a particular dredging cycle, capacity would be available in the upland sites. In addition, preferable development of the marsh sites provided for construction at alternating sites; one dredging cycle would place the material in an upland site, the next cycle would use the material to construct the marsh. This approach would have the advantage of allowing extra drying time for the material in the upland site. This alternating method was utilized to the maximum extent possible. In a few instances, capacity was not available using both the upland site and nearby marsh sites. In these cases, the nearest open bay site was utilized for the remaining balance. These open bay sites are DA 122 and DA 132. DA 122 was chosen due to concerns about increasing the size of Marsh Site "A" and the presumed loss of upland site DA 121. DA 132 was chosen in order to leave capacity for a dredging cycle in the upland sites. This reserve capacity would be used in the event of unanticipated shoaling such as after a major storm, or the discovery of contaminated material which would not be suitable for use in a marsh or open bay site.

6.1.1.5.1 In addition to the new marsh sites proposed, one new upland site will be utilized. This site will be used in lieu of existing upland sites DA 120 and DA 120A. These sites are located near the eastern end of the critical habitat, south of Welder Flat. DA 120 is characterized as long and narrow, and has experienced levee failures on the bay side. DA 120A is small, being less than 50 acres (due to the small size, the ultimate capacity of this site was not determined). The new disposal site was sized to handle material from Station 696+000, the approximate beginning of the critical habitat, to Station 716+000, when material would be placed into either DA 122 or a nearby marsh creation site. Depth of fill was held to not more than 2-feet to keep levee raisings to a reasonable height. Using these parameters, a size of 100 acres was found to be adequate. The location of the site was determined using aerial photos and quadrangle maps to avoid a salt flat, an existing road, and several existing ponds.

6.1.1.5.2 An agreement was also made to delete the use of existing DA 121 from the 50-year disposal plan. This site is also fairly small and narrow. Continued levee raisings towards the interior of the disposal area will soon render the area too small to be of any use. The existing levees are in poor shape and would require a major effort to rehab. The material from this reach of channel will be divided between the new marsh site "A" and existing unconfined open bay DA 122.

6.1.1.5.3 For the purposes of developing the 50-year disposal plan, existing DAs 120, 120A, and 121 are assumed to be depleted before implementation of subject plan. However, if there is capacity in any of these areas when the disposal plan is implemented, these areas will be used until filled to capacity.

6.1.1.5.4 A summary of the dredging quantities, dredging frequencies, and disposal areas used is shown in the Dredging and Disposal Summary, Table 5. Specific disposal areas and marshes to be created under each dredging cycle within the respective reaches are shown in each Disposal Plan for Maintenance Material, Tables 6, 7, and 8.

6.1.2 Structural Requirements.

6.1.2.1 General. This section presents the description of the timber piles used as anchorage points and the containment booms proposed at locations along the GIWW at ANWR. The critical boundary for the whooping crane extends from approximately Station 696+000 at Welder Flat, adjacent to Shoalwater Bay on the north end, to Station 860+000 in Aransas Bay, adjacent to Blackjack Peninsula, a total distance of about 31 miles. Within this reach of the GIWW, approximately 30 inlets to various marshes and small bays are susceptible to a pollutant spill. The openings of these inlets vary in width from approximately 30 feet to over 8,000 feet.

6.1.2.2 Timber Piles. Timber piles, as anchorage points, will be permanently installed adjacent to the inlets described in paragraph 6.1.2.1. Piles will be installed at approximately, 100 feet on-center across openings greater than 100 feet in width; for

Table 5

Dredging and Disposal Summary

Reach	Location	Station	CY/Cycle	Disposal Area	Disposal Method	Interval (yrs)
1	Welder Flat	696+000 to 716+000	230,600	New Upland Site	Upland	7.5
		716+000 to 724+000	92,240	DA 122/Marsh	Open Bay/Marsh	
2	San Antonio Bay	724+000 to 730+000	210,000	Site A/DA 122	Marsh/Open Bay	2.5
		730+000 to 742+000	420,000	DA 122	Open Bay	
		742+000 to 750+500	297,500	DA 123	Open Bay	
		750+500 to 759+500	315,000	DA 124	Open Bay	
		759+500 to 769+000	175,000	DA 125	Open Bay	
3	ANWR	769+000 to 785+000	449,280	Marsh/DA 127	Marsh/Upland	4.0
		785+000 to 805+000	243,360	Marsh/DA 129	Marsh/Upland	
		805+000 to 815+000	121,680	Marsh/DA 130A	Marsh/Upland	
		815+000 to 830+000	182,520	Marsh/DA 130B	Marsh/Upland	
		830+000 to 839+000	368,550	Marsh/DA 131	Marsh/Upland	
4	Aransas Bay	839+000 to 843+000	126,000	DA 132	Open Bay	3.0
		843+000 to 853+000	315,000	DA 133	Open Bay	
		853+000 to 860+000	220,500	DA 134	Open Bay	

Table 6
Disposal Plan for Maintenance Material
Reaches 1 and 2 - Station 696+000 to Station 769+000

Cycle	Year	Reach 1 Sta. 696+000 to Sta.716+000	Reach 1 Sta.716+000 to Sta. 724+000	Reach 2 Sta. 724+000 to Sta. 730+000	Reach 2 Sta. 730+000 to Sta. 742+000	Reach 2 Sta. 742+000 to Sta.750+500	Reach 2 Sta. 750+500 to Sta. 759+500	Reach 2 Sta. 759+500 to Sta. 769+000
CY/Cycle		230,600	92,240	210,000	420,000	297,500	315,000	332,500
1	2.5			Site A Marsh 42 ac	DA 122	DA 123	DA 124	DA 125
2	5.0			Site A Marsh 42 ac	DA 122	DA 123	DA 124	DA 125
3	7.5	New Upland Site	Site A Marsh, 18.5 ac	DA 122	DA 122	DA 123	DA 124	DA 125
4	10.0			Site A Marsh 42 ac	DA 122	DA 123	DA 124	DA 125
5	12.5			Site A Marsh 42 ac	DA 122	DA 123	DA 124	DA 125
6	15.0	New Upland Site	DA 122	DA 122	DA 122	DA 123	DA 124	DA 125
7	17.5			Site A Marsh 42 ac	DA 122	DA 123	DA 124	DA 125
8	20.0			Site A Marsh 42 ac	DA 122	DA 123	DA 124	DA 125
9	22.5	New Upland Site	Site A Marsh, 18.5 ac	DA 122	DA 122	DA 123	DA 124	DA 125
10	25.0			Site A Marsh 42 ac	DA 122	DA 123	DA 124	DA 125
11	27.5			Site A Marsh 42 ac	DA 122	DA 123	DA 124	DA 125
12	30.0	New Upland Site	DA 122	DA 122	DA 122	DA 123	DA 124	DA 125
13	32.5			DA 122	DA 122	DA 123	DA 124	DA 125
14	35.0			DA 122	DA 122	DA 123	DA 124	DA 125
15	37.5	New Upland Site	Site A Marsh, 18.5 ac	DA 122	DA 122	DA 123	DA 124	DA 125
16	40.0			DA 122	DA 122	DA 123	DA 124	DA 125
17	42.5			DA 122	DA 122	DA 123	DA 124	DA 125
18	45.0	New Upland Site	DA 122	DA 122	DA 122	DA 123	DA 124	DA 125
19	47.5			DA 122	DA 122	DA 123	DA 124	DA 125
20	50.0			DA 122	DA 122	DA 123	DA 124	DA 125

Table 7

Disposal Plan for Maintenance Material
Reach 3 - Station 769+000 to Station 839+000

Cycle	Year	Sta. 769+000 to Sta. 785+000	Sta. 785+000 to Sta. 805+000	Sta. 805+000 to Sta. 815+000	Sta. 815+000 to Sta. 830+000	Sta. 830+000 to Sta. 839+000
CY/Cycle		449,280	243,360	243,360	365,040	368,550
1	4	Marsh, 90 ac Site D	Marsh, 49 ac Site E	Marsh, Sites G & H, DA 130A	Marsh, 37 ac Site I DA 130B	Marsh, Site K DA 132
2	8	DA 127	DA 129	—	—	DA 131
3	12	Marsh, 47 ac Site B, 43 ac Site C	Marsh, 49 ac Site E	Marsh, 24 ac Site F DA 130A	Marsh, 37 ac Site I DA 130B	Marsh, 74 ac Site J
4	16	DA 127	DA 129	—	—	DA 131
5	20	Marsh, 90 ac Site B	Marsh, 49 ac Site E	Marsh, 24 ac Site F DA 130A	DA 130B	Marsh, 74 ac Site J
6	24	DA 127	DA 129	—	—	DA 131
7	28	Marsh, 90 ac Site B	DA 129	Marsh, 24 ac Site F DA 130A	DA 130B	Marsh, 74 ac Site
8	32	DA 127	DA 129	—	—	DA 131
9	36	Marsh, 90 ac Site B	DA 129	Marsh, 24 ac Site F DA 130A	DA 130B	Marsh, 74 ac Site I
10	40	DA 127	DA 129	—	—	DA 131
11	44	Marsh, 90 ac Site B	DA 129	DA 130A	DA 130B	DA 132
12	48	DA 127	DA 129	—	—	DA 131
13	52	DA 127	DA 129	DA 130A	DA 130B	DA 131

Final approximate levee heights at end of project:

DA 127: +36
DA 129: +30
DA 130A: +31
DA 130B: +26
DA 131: +31

Table 8

Disposal Plan for Maintenance Material
Reach 4 - Station 839+000 to Station 860+000

Cycle	Year	Sta. 839+000 to Sta. 843+000	Sta. 843+000 to Sta. 853+000	Sta. 853+000 to Sta. 860+000
CY/Cycle		126,000	315,000	220,500
1	3	DA 132	DA 133	DA 134
2	6	DA 132	DA 133	DA 134
3	9	DA 132	DA 133	DA 134
4	12	DA 132	DA 133	DA 134
5	15	DA 132	DA 133	DA 134
6	18	DA 132	DA 133	DA 134
7	21	DA 132	DA 133	DA 134
8	24	DA 132	DA 133	DA 134
9	27	DA 132	DA 133	DA 134
10	30	DA 132	DA 133	DA 134
11	33	DA 132	DA 133	DA 134
12	36	DA 132	DA 133	DA 134
13	39	DA 132	DA 133	DA 134
14	42	DA 132	DA 133	DA 134
15	45	DA 132	DA 133	DA 134
16	48	DA 132	DA 133	DA 134
17	51	DA 132	DA 133	DA 134

openings of 100 feet or less, piling will be installed on each side of inlet openings. Timber piles will be installed in locations that are as unobtrusive as possible, and still be effective. Generally, the top of pile will be located between elevation 1.5 and 3 feet above MLT. No timber pile shall be installed within any navigable waterway. Timber piling will be treated with an applicable wood preservative, in accordance with the American Wood Preservers' Association to protect against the marine environment. Corrosion-resistant hardware, which will allow for vertical adjustment, will be installed on each piling as required to receive the containment booms when deployed.

6.1.2.3 Deployment and Storage of Containment Booms. Should a pollutant spill occur, ANWR and/or U.S. Coast Guard personnel will deploy the containment booms to the affected area. Booms are proposed to be stored in trailers at the Refuge headquarters. This will provide safekeeping and access for inventory and maintenance, as well as allow for efficient deployment to the affected area. The initial pollutant spill response phase will require the trailers, loaded with containment booms, to be towed by truck to the Refuge boat ramp. From the boat ramp, the booms will be loaded onto a vessel that will be deployed to the pollutant spill area; an On-Scene Coordinator (OSC) will direct the pollutant spill response. During the initial response to the spill, these booms will be attached to the permanent anchor points in the affected area to minimize contamination into the environmentally-sensitive marshes and bays. Proposed permanent anchorage points for the containment booms and the adjacent areas to be protected from a pollutant spill are shown on Plates 7 - 9, 11 and 12.

6.1.2.4 Description of Containment Booms. The containment boom system will be a standard-type that is readily available in the marine industry. The boom system, typically consisting of interlocking sections, will provide the flexibility required to control most pollutant spillage. Standard booms utilize a solid molded, closed-cell polyethylene foam floatation with stainless steel hardware. An additional polyester fabric that encapsulates the foam floatation can be provided by the manufacturer. Also proposed is a polymer fabric skirt, extending below the boom, that will provide additional containment below the water surface.

6.1.2.5 Design Criteria. The timber pile analysis and design will be in accordance with applicable U.S. Army Corps of Engineers criteria and acceptable engineering practices, including the following:

COM 624 Laterally-Loaded Pile Computer Program by WES
Shore Protection Manual, Volumes 1 and 2, by WES
Safety and Health Requirements Manual, Engineer Manual (EM) 385-1-1

A preliminary assumed pile length of 30 feet was generally based on the information obtained from borings which were located adjacent to four of the proposed boom sites. Although soil strengths and densities appear to generally increase with depth, the preliminary borings indicated that considerable variations in soil types and conditions occur

within the elevations to be penetrated by the piles. Additional 50-foot borings will be drilled at approximately twelve of the proposed timber pile anchorage point sites. Information from these borings will be used for the final timber pile design which will be completed during project refinement. Based on previous experience in this area, an assumed 3-foot head differential of salt water (64 pounds-per-cubic-foot (pcf)) will be considered for the timber pile analysis. This 3-foot head differential is assumed to result from the deployment of the containment boom system. The timber piles will not be designed for mooring vessels or other craft. Further development and refinement of the timber pile anchorage points and containment booms will continue during project refinement.

6.1.3 Electrical and Mechanical Requirements. This project does not include any electrical or mechanical requirements.

6.1.4 Hazardous, Toxic, and Radioactive Waste. An assessment of the study area was conducted to determine the existence of, and potential for discovering, Hazardous, Toxic, and Radioactive Waste (HTRW) sites. HTRW sites pose a risk to public health and the environment, could affect, or be affected by the project activities, and have the potential for causing project delays and escalating project costs. As such, HTRW sites are identified and managed early in the study. Assessment findings indicate that there are no HTRW sites within the study area. Records from the Railroad Commission of Texas indicate a total of 24 oil and gas wells in the study area, two of which are active gas wells. There are 12 pipeline crossings within the study area.

6.2 Real Estate. The recommended plan will require acquisition of real estate for the new upland site. Approximately 135 acres will be required for the disposal area proper. In addition, an easement of 9 acres will be required to allow the dredge pipeline access to the site, and an additional 9 acre easement will be required for an effluent ditch from the site to the GIWW.

6.3 Relocations. No relocations are required by the proposed plan.

7. Construction Procedure and Water Control Plan.

7.1 Upland Sites. The majority of the existing upland sites will be constructed by incrementally raising levee heights toward the interior of the disposal area. These levee raisings will be constructed during regular maintenance contracts, as required by the amount of freeboard existing within the sites. The levees will utilize side-cast borrow construction, and will have 1V:3H side slopes, with a 10-foot crown. Water control for all upland sites will be provided by spillboxes, with stoplogs, to control the quality of the effluent. Levee construction for the new upland site will be accomplished using either side-cast borrow or hauled fill from within the disposal area. A spillbox and effluent ditch will also be provided for the new upland site. Intensive crust management techniques will not be utilized.

7.2 Marsh Sites. Confining levees for the marsh sites will be constructed immediately before dredging the channel to insure a good functioning condition, and to allow flexibility in modifying the marsh or marsh cell size to fit the amount of dredged material. Levees in areas of stiffer foundations will be constructed using cast-fill techniques, utilizing material available at the site. The minimum levee will have a 10-foot crown, 1V:3H side slopes, and will be designed to provide a minimum of 1-foot of freeboard. Levees located in areas of poorer foundation conditions will be constructed using geotubes filled with material located within the marsh site, placed on a geotextile scour pad with 4-foot diameter geotubes located on either side of the centerline. Bay bottom foundation conditions and elevations will dictate whether a single tube or three stacked tubes will be required for the levee. These types of constructions are shown on the plates of the individual marshes. Sizes of the tubes required will be verified during project refinement. Additionally, temporary spillboxes will be provided to allow the effluent to drain. After settlement and consolidation of the dredged fill material has occurred, mechanical equipment will be used to shape the sites to proper elevations and to provide circulation channels. Openings in the levees and breakwaters will also be provided to allow circulation. Approximately 25- to 30-percent of the marsh sites will be planted with marsh grass.

7.2.1 Breakwaters will be required adjacent to some of the marsh sites. These will be constructed of stone, as shown on the plates. The template of the breakwater is taken from a demonstration marsh constructed during June 1993. The required template and method of construction will be verified during project refinement.

8. Initial Reservoir Filling and Surveillance Plan. Not applicable.

9. Flood Emergency Plans for Areas Downstream of Corps Dams. Not applicable.

10. Construction Materials.

10.1 Grout Tubes and Cellular Concrete Mattresses. The construction materials required for the proposed revetment protection in the designated reaches include 1,239,700 square feet (SF) of cellular concrete mattress and 153,600 square yards (SY) of geotextile fabric. The construction materials required for the grout tube revetment include 29,140 SY of geotextile fabric, 20,175 cubic yards (CY) of grout and 8,965 geotextile tubes. The grout mixture will be 15-percent cement which will provide for the minimum grout strength of 2,000 psi.

10.2 Aggregate. Large commercial deposits of sand and gravel are available along the Colorado River near Eagle Lake and Columbus, Texas, approximately 80 miles from the project. Material from these sources has been used almost exclusively for all concrete in the Houston, Galveston and Texas City areas. Concrete containing coarse and fine aggregates produced from the Colorado River area has an excellent service record and

has been used for both civil and military projects in the Texas Gulf Coast area. The sands and gravel along the Colorado River occur in the floodplain and are covered with silty or sandy clay overburden 10 to 20 feet thick. Below the overburden, sand and gravel strata occur usually to depths of 30 to 40 feet. The deposits are worked by stripping and wasting the overburden and then washing and processing the sand and gravel. The various commercial producers use different methods; however, all could produce any size of gradation desired.

10.3 Cement and Fly Ash. Cement and fly ash of acceptable quality for use in the concrete mixtures are available within an economical haul distance of the project.

10.4 Geotextile Filter Fabric. Geotextile of acceptable quality for use as filter fabric in the project is available from distributors in the Houston area.

10.5 Geotube Containment Structures. The geotubes, which will be filled with earth materials to form the required containment structures, will be approximately 500 feet in length, and have various circular diameters. The geotubes will be constructed of a high-strength, woven, geotextile outer layer and an interior, nonwoven filter material. Opening "ports", to be used to introduce materials into the tube, and to expedite drainage of water from the top of the tube during filling, will be spaced approximately 50-feet apart, and no farther than 15 feet from the ends of the tubes. The required strength of the high-strength, woven geotextile will be determined during final design; however, it was assumed that a minimum strength of 500 pounds per linear inch (pli) will be required in both directions, with double-sewn seams having a minimum strength of 300 pli. Before tube placement, all required material and seam strengths will be confirmed by tests performed by an independent laboratory.

10.6 Scour Pads for Geotubes and Grout Tubes. The scour pads for use beneath geotubes and grout tubes will consist of high strength geotextile panels, sewn together to provide for the required pad widths. A 12-foot wide non-woven filter cloth will be sewn along each of the edges. The outer edge of this 12-foot strip along both edges of the pad shall be folded and sewn back to the pad to form an approximate 4-foot diameter tube along each edge. Material and seam strengths will be similar to that required for the Geotube Containment Structures.

10.7 Earth Fill. Construction of the marshes will be accomplished with dredged maintenance material; no new work material will be used. Cast levees for the marsh sites will utilize borrow material obtained at the levee site. Material to be used to fill the geotubes will also be obtained from near the levee site; however, attempts will be made to locate areas which contain significant amounts of granular materials to be used as geotube fill. It may be necessary to provide additional "booster" pumps at some locations to transport satisfactory granular materials to the geotube sites.

11. Reservoir Clearing. Not applicable.

12. Operation and Maintenance. Using the estimated shoaling rates, the disposal capacity of the maximum allowable marsh site sizes, and the expected ultimate lives of the existing upland sites, more than sufficient capacity was determined to be available for the 50-year project life. Two options were then available:

a. Maximize the use of the upland sites, using the marsh sites only as required where upland sites did not have sufficient capacity for the 50-year project life.

b. Maximize the use of the marsh sites, reserving capacity in the upland sites.

The advantage of the second option is that should shoaling suddenly increase due to some unforeseen event, such as a severe storm, or should some of the shoaled material become contaminated during a particular dredging cycle, capacity would be available in the upland sites. See also Paragraph 6.1.1.5 and Tables 5 through 8.

13. Access Roads. The existing state (Highway 35), farm-to-market (FMs 239, 774, and 2040) and Refuge roads will provide adequate access to the site. Vessels and other marine craft may be launched from various facilities within the area, including a boat ramp at the Refuge.

14. Corrosion Mitigation. Corrosion mitigation is not required for subject project.

15. Project Security. Development of a physical security plan is not required for subject project.

16. Cost Estimates. The baseline and Operations, Maintenance, Repair, Replacement, and Rehabilitation (OMRR&R) cost estimates are contained in the Cost Engineering Appendix of the Feasibility Report. The estimates were prepared in accordance with ER 1110-2-1302, Civil Works Cost Engineering, and organized using the Work Breakdown Structure (WBS) in the as yet unnumbered Engineer Regulation, dated 20 August 1993. Included in the subject appendix are the Total Project Cost Summary, the MCACES summary sheets for the baseline estimate, and Lotus spreadsheets for the OMRR&R estimates.

17. Schedule for Design and Construction.

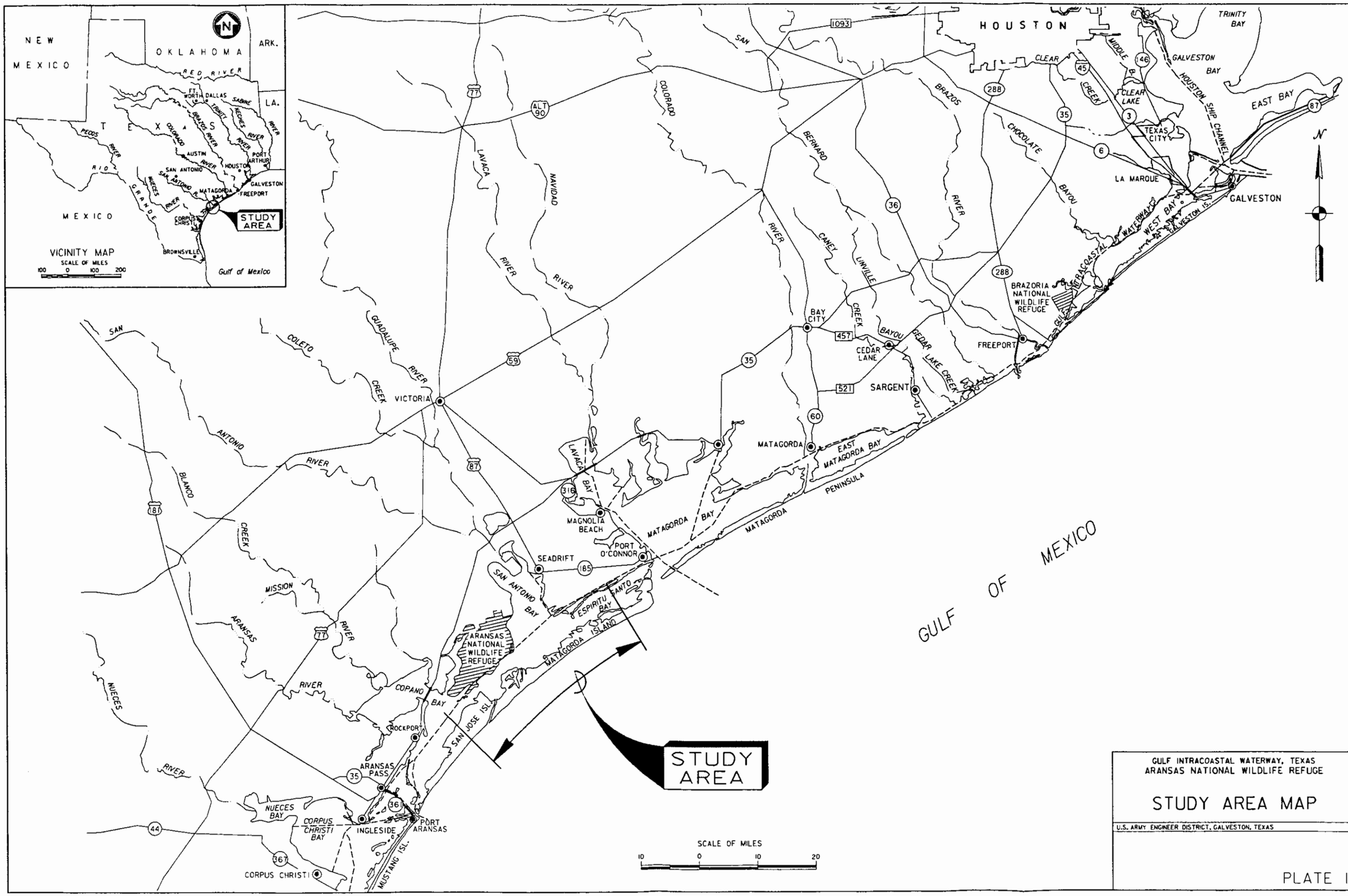
17.1 Engineering and Design Schedule. Exhibit No. 3 consists of a bar chart depicting the sequence of activities during the Pre-construction Engineering and Design (PED) Phase.

17.2 Construction Schedule. Exhibit No. 4 consists of a bar chart depicting the sequence of activities during the Construction Phase.

17.3 Funding Estimates by Fiscal Year. Exhibit No. 5 shows the funding requirements for Engineering and Design and Construction, respectively. These funding requirements are shown for each respective major task by fiscal year.

18. Special Studies. Detailed investigations of project features, including existing and new upland disposal areas, future marsh creation sites, and the containment boom timber pile locations will be conducted during Pre-construction Engineering and Design (PED). The intent of the detailed investigations of the marsh creation sites will be to provide adequate information for design of all marsh containment levees, including those to be constructed during project O&M, with minimal, or no additional investigations required during preparation of plans and specifications. The benefits of this approach include the opportunity for accurate programming of O&M funding for future required construction, and minimizing the requirement to mobilize additional drilling and sampling, or other test equipment, within the whooping crane critical habitat area. Accordingly, the investigations are relatively comprehensive within the areas that have been selected, coordinated, and agreed upon for the project features. Investigations of the new and existing upland sites will allow for conducting stability analyses of existing levees and proposed future levee enlargements. The results of these analyses will be used to confirm the capabilities of the proposed disposal areas during the project life, and allow for planning any major rehabilitation efforts that may be required in the future. The feasibility of constructing multiple marsh cells will be investigated during PED. The multiple cells, while providing an "overflow" cell to accommodate maintenance material that may exceed the estimated quantity, may reduce construction costs. During PED, shoaling rates will be refined by using smaller reaches and survey data will be available to more accurately size marshes and determine upland disposal area capacities. Based on data from core borings, the levee and breakwater designs will be refined. The feasibility of dewatering the upland disposal areas, to reduce the estimated ultimate levee heights, will be evaluated during PED. The ultimate levee heights will be based on environmental concerns and detailed geotechnical analyses.

PLATES

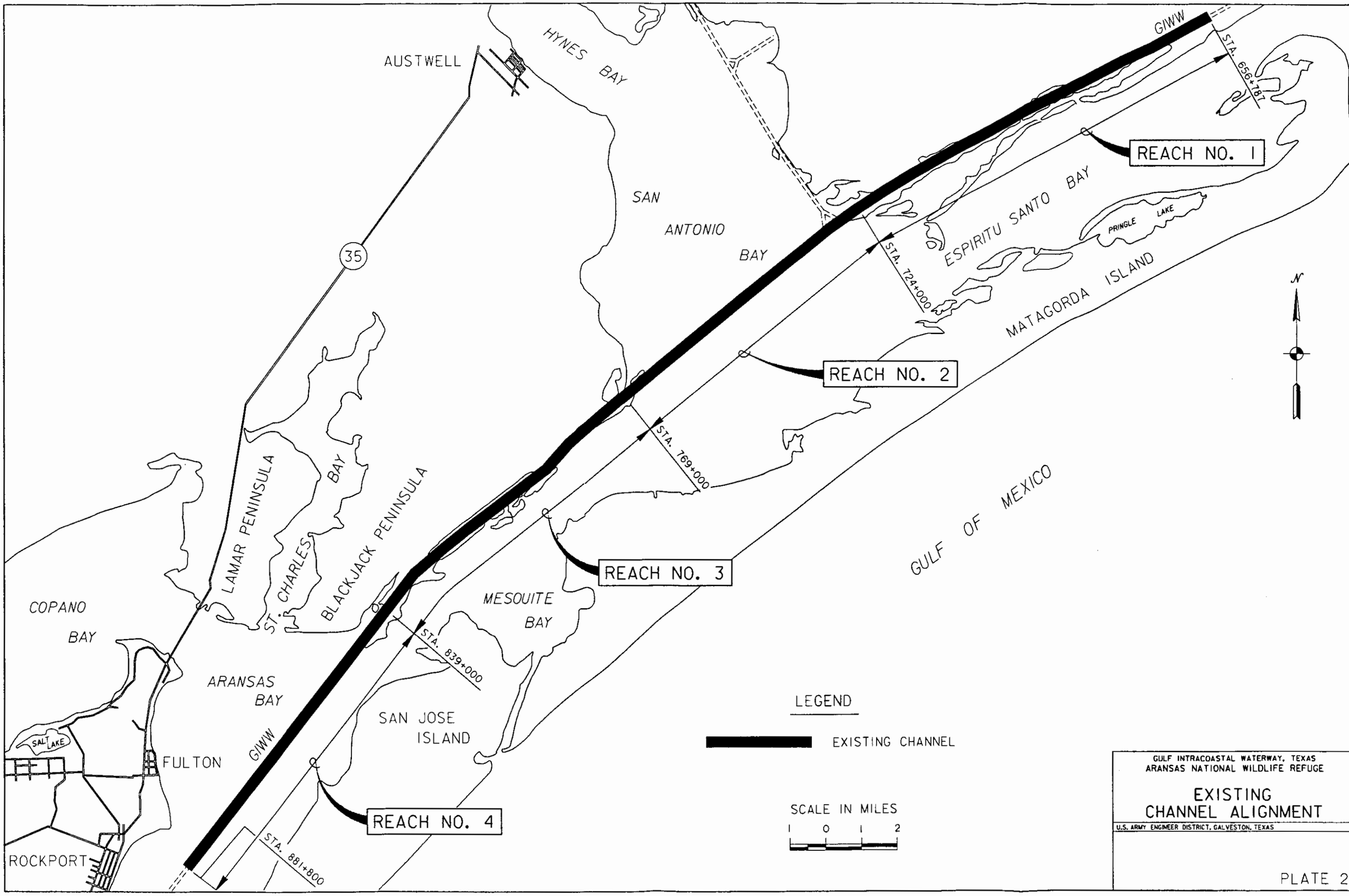


GULF INTRACOASTAL WATERWAY, TEXAS
ARANSAS NATIONAL WILDLIFE REFUGE

STUDY AREA MAP

U.S. ARMY ENGINEER DISTRICT, GALVESTON, TEXAS

PLATE I

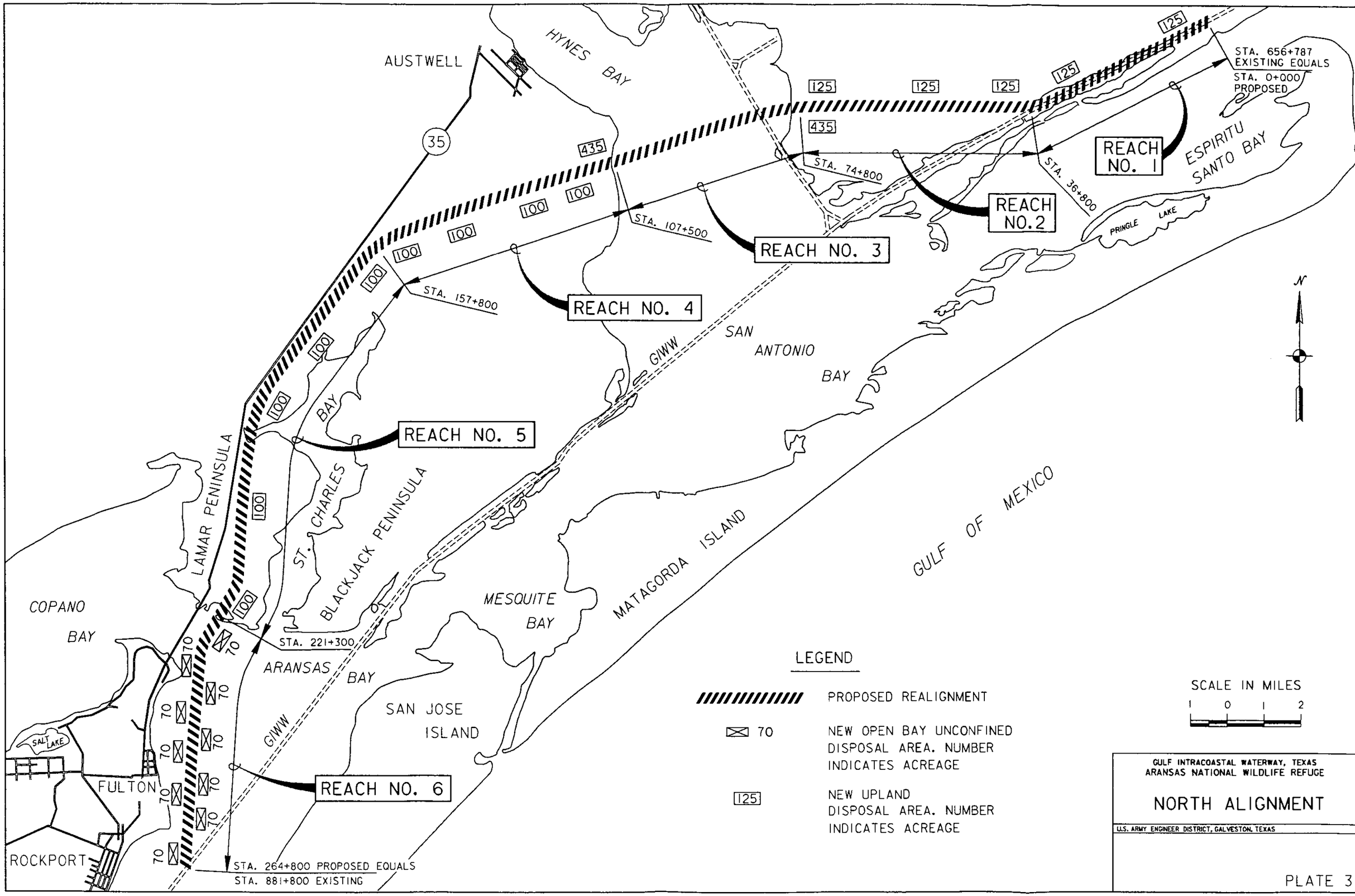


GULF INTRACOASTAL WATERWAY, TEXAS
ARANSAS NATIONAL WILDLIFE REFUGE

EXISTING CHANNEL ALIGNMENT

U.S. ARMY ENGINEER DISTRICT, GALVESTON, TEXAS

PLATE 2

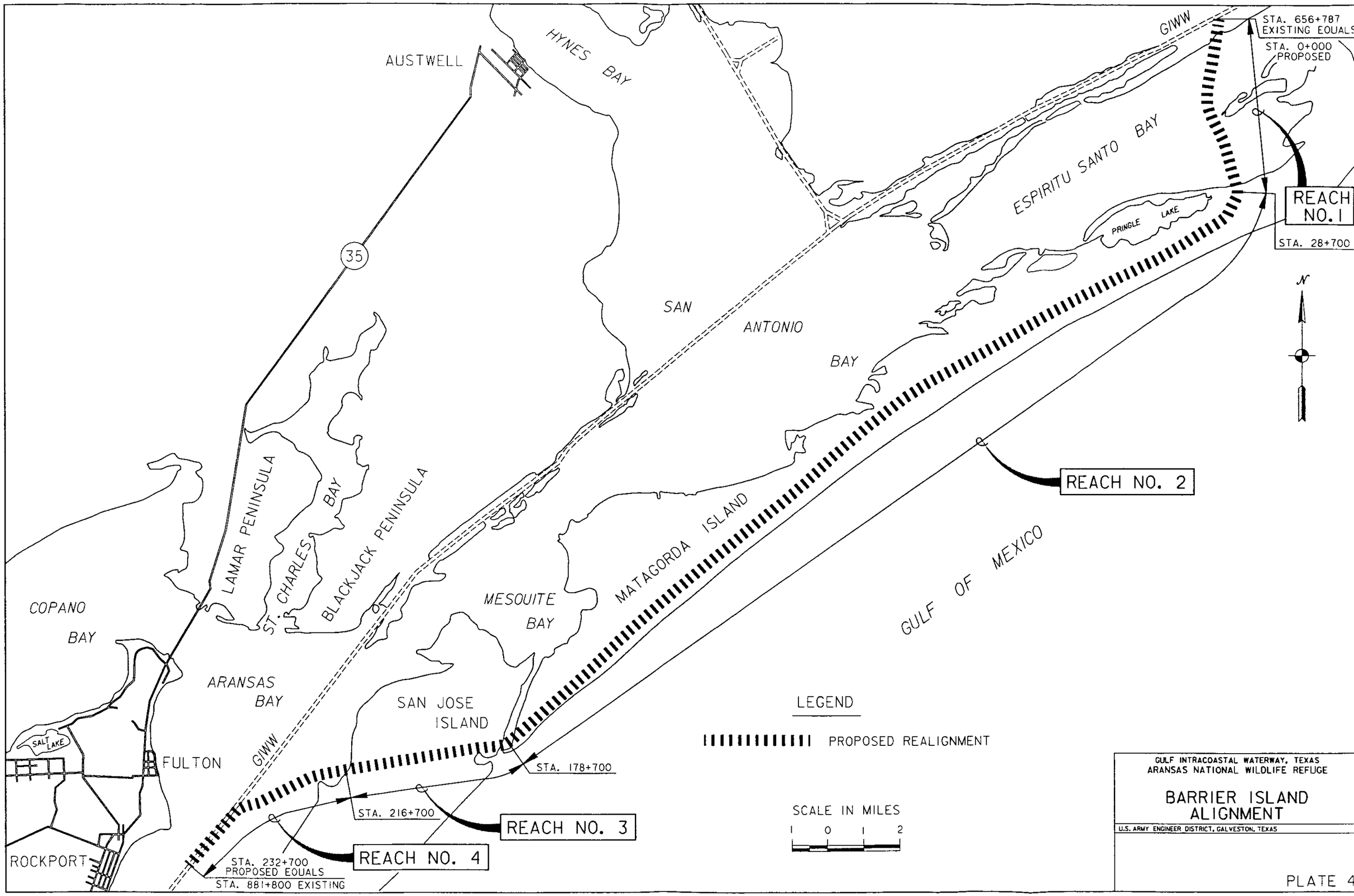


GULF INTRACOASTAL WATERWAY, TEXAS
ARANSAS NATIONAL WILDLIFE REFUGE

NORTH ALIGNMENT

U.S. ARMY ENGINEER DISTRICT, GALVESTON, TEXAS

PLATE 3

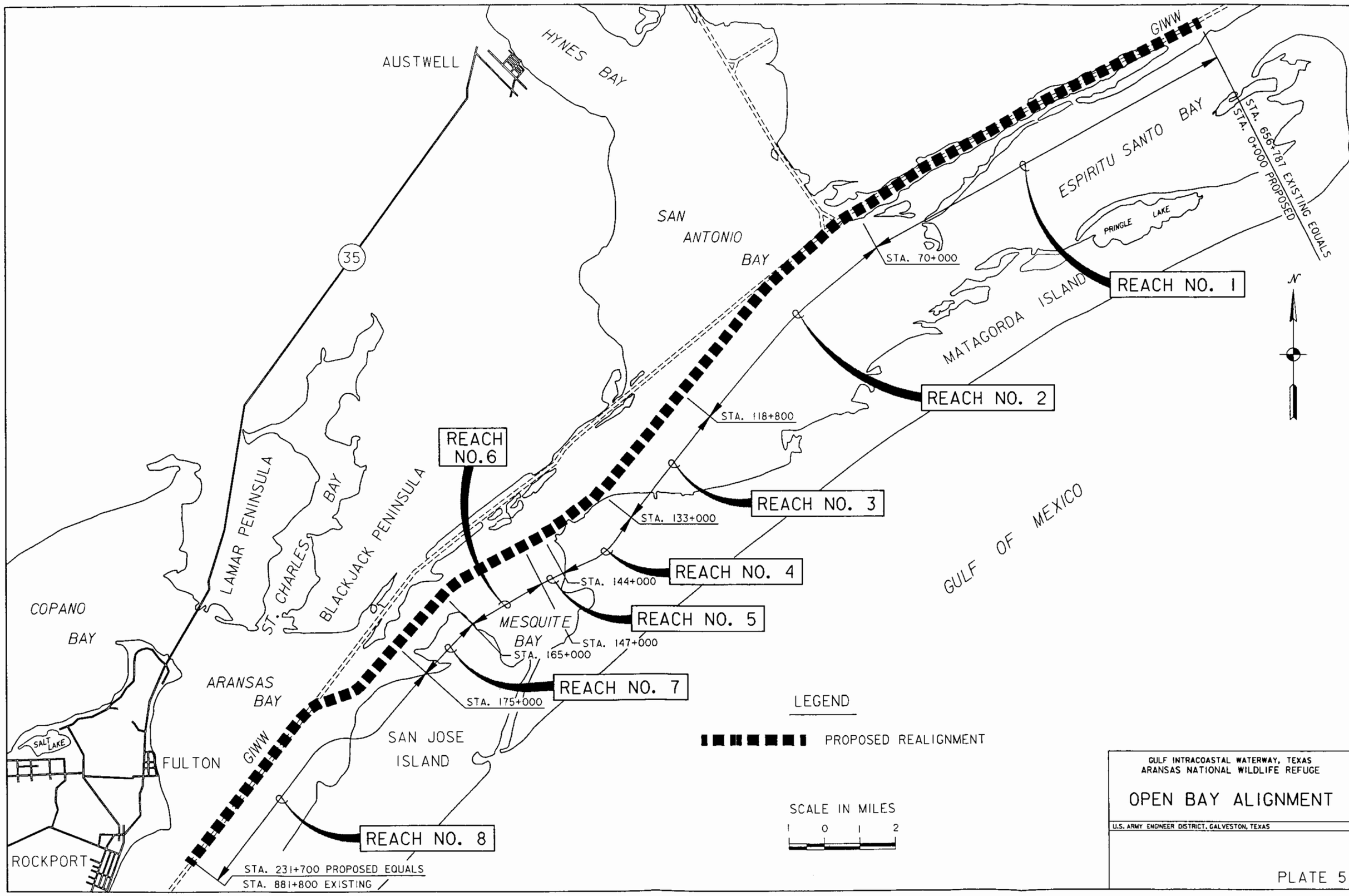


GULF INTRACOASTAL WATERWAY, TEXAS
ARANSAS NATIONAL WILDLIFE REFUGE

BARRIER ISLAND ALIGNMENT

U.S. ARMY ENGINEER DISTRICT, GALVESTON, TEXAS

PLATE 4

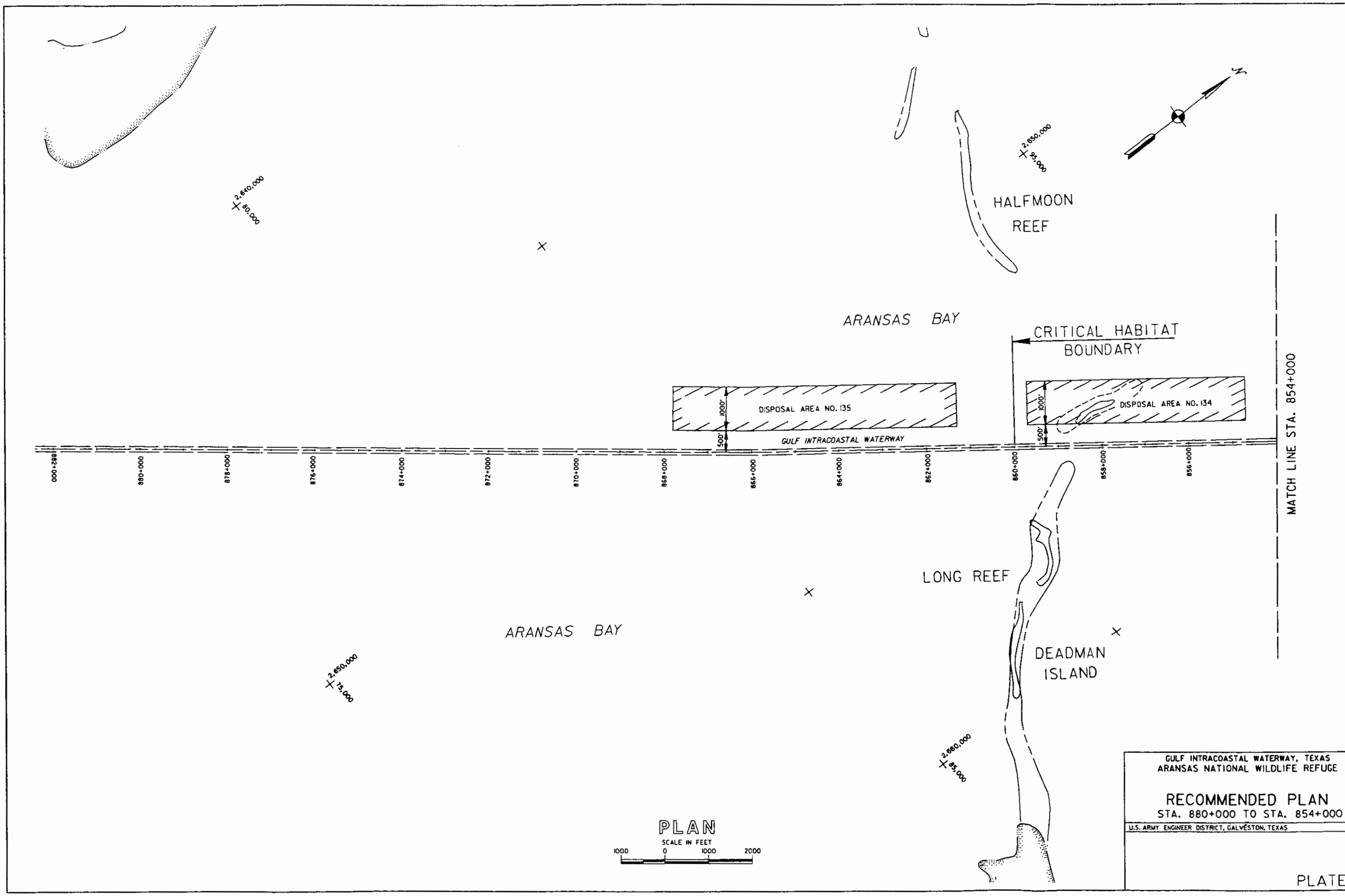


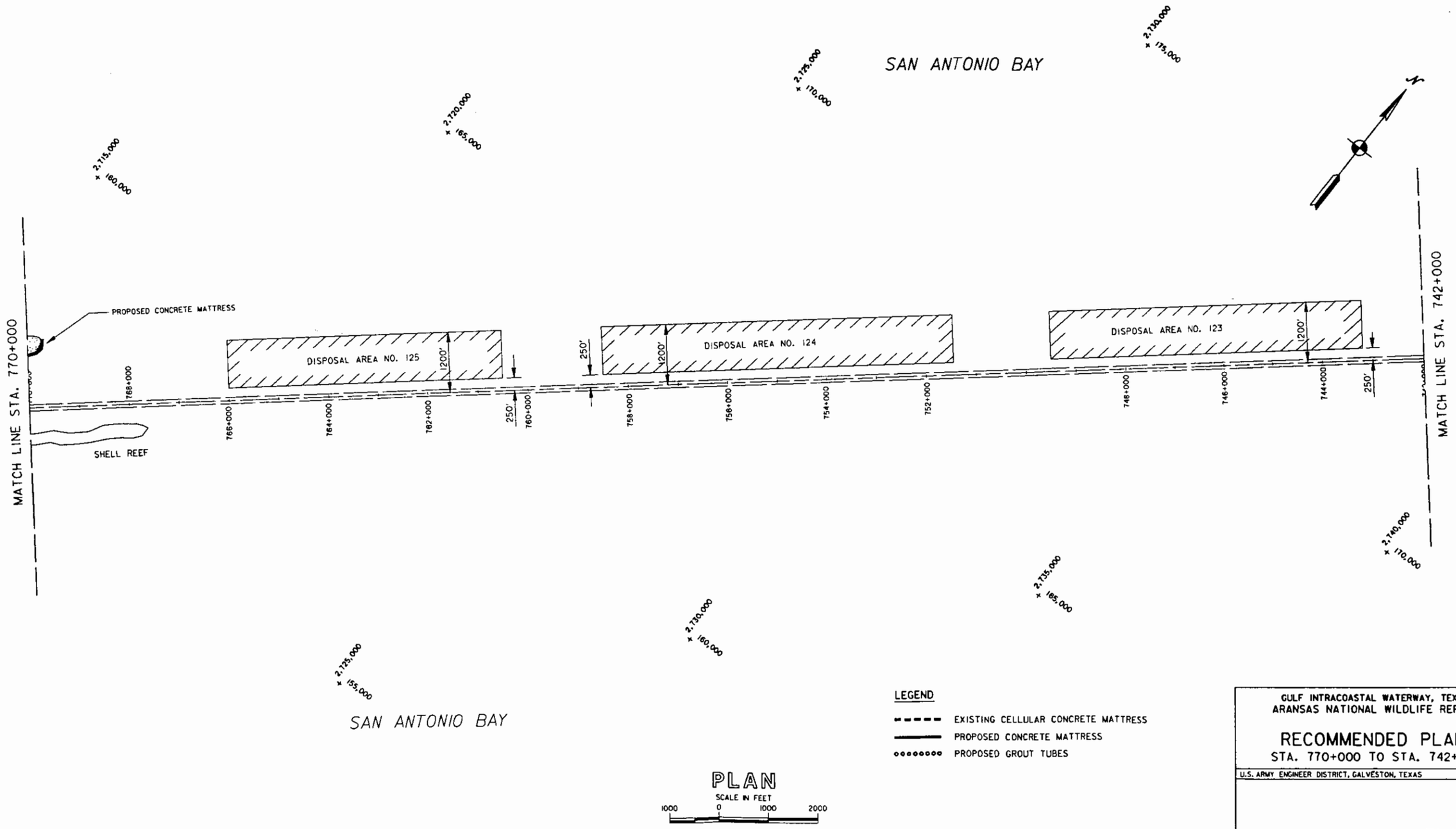
GULF INTRACOASTAL WATERWAY, TEXAS
ARANSAS NATIONAL WILDLIFE REFUGE

OPEN BAY ALIGNMENT

U.S. ARMY ENGINEER DISTRICT, GALVESTON, TEXAS

PLATE 5


N
HALFMOON REEF
2,650,000
95,000
2,640,000
80,000
ARANSAS BAY
CRITICAL HABITAT BOUNDARY
DISPOSAL AREA NO. 135
DISPOSAL AREA NO. 134
1000'
500'
GULF INTRACOASTAL WATERWAY
MATCH LINE STA. 854+000
882+000
880+000
878+000
876+000
874+000
872+000
870+000
868+000
866+000
864+000
862+000
860+000
858+000
856+000
LONG REEF
ARANSAS BAY
DEADMAN ISLAND
2,650,000
75,000
2,660,000
85,000
PLAN
SCALE IN FEET
1000 0 1000 2000
GULF INTRACOASTAL WATERWAY, TEXAS
ARANSAS NATIONAL WILDLIFE REFUGE
RECOMMENDED PLAN
STA. 880+000 TO STA. 854+000
U.S. ARMY ENGINEER DISTRICT, GALVESTON, TEXAS
PLATE

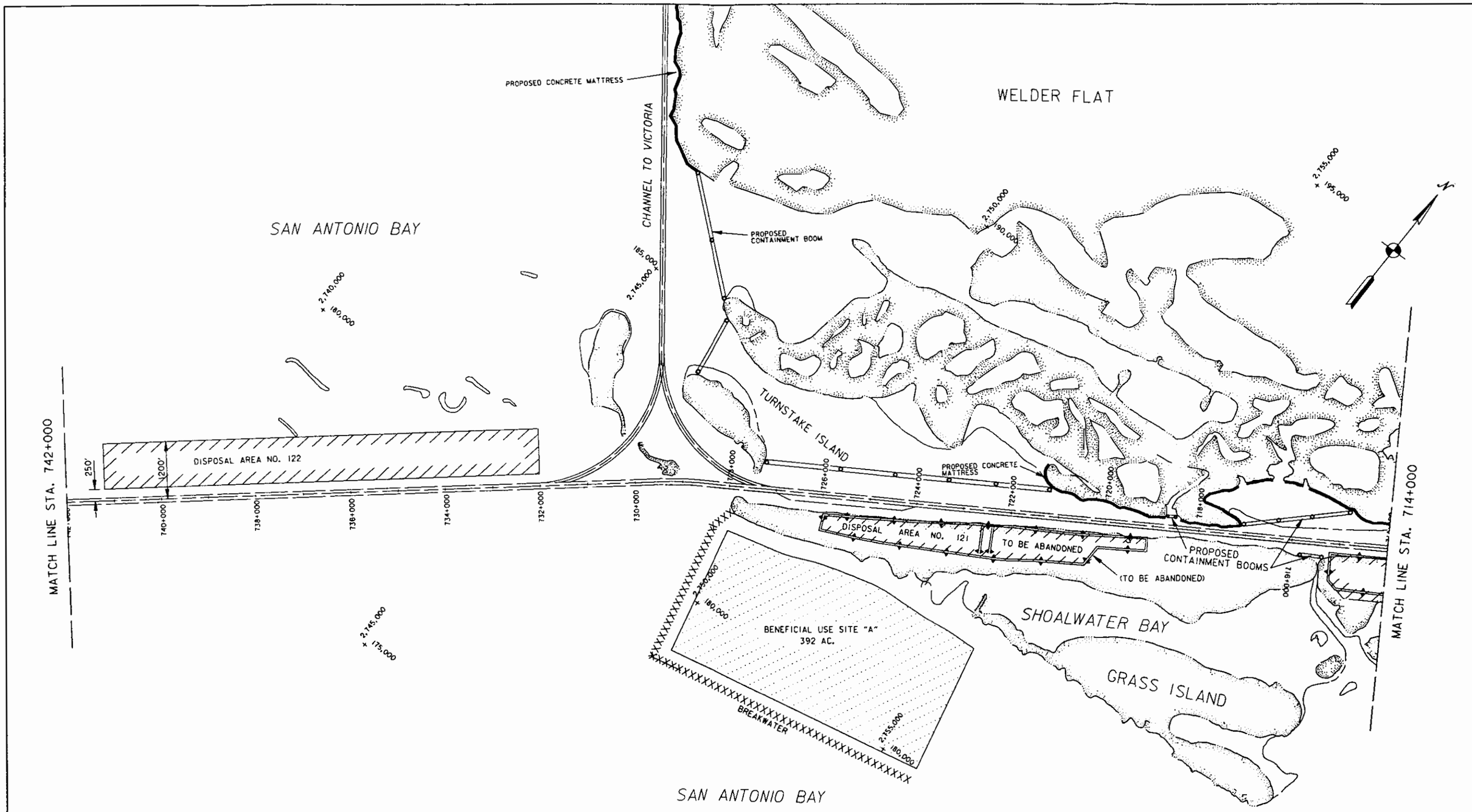


GULF INTRACOASTAL WATERWAY, TEXAS
ARANSAS NATIONAL WILDLIFE REFUGE

RECOMMENDED PLAN
STA. 770+000 TO STA. 742+000

U.S. ARMY ENGINEER DISTRICT, GALVESTON, TEXAS

PLATE 10



LEGEND

- EXISTING CELLULAR CONCRETE MATTRESS
- PROPOSED CONCRETE MATTRESS
- PROPOSED GROUT TUBES
- PROPOSED CONTAINMENT BOOM

PLAN

SCALE IN FEET

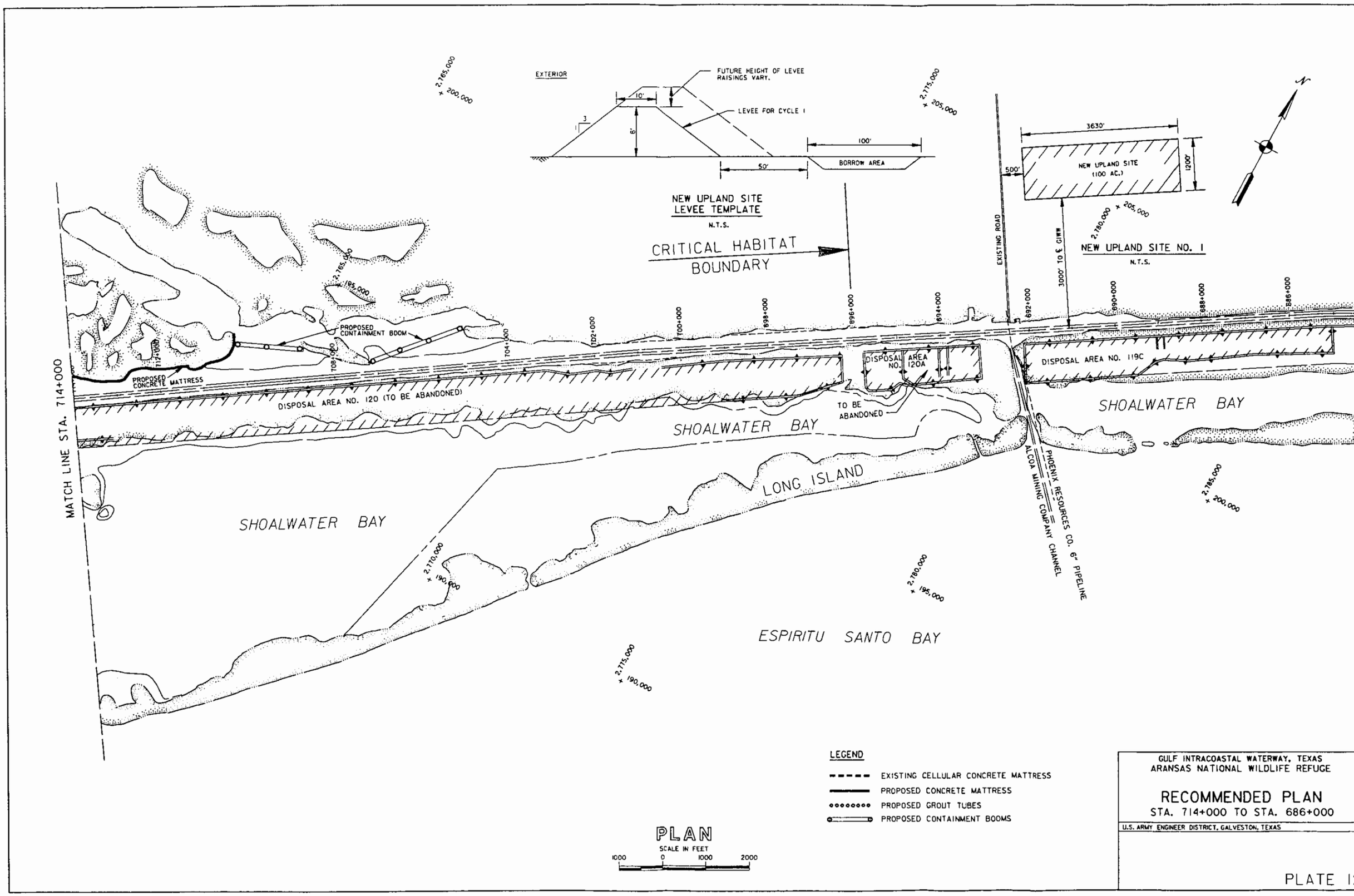
1000 0 1000 2000

GULF INTRACOASTAL WATERWAY, TEXAS
ARANSAS NATIONAL WILDLIFE REFUGE

RECOMMENDED PLAN
STA. 742+000 TO STA. 714+000

U.S. ARMY ENGINEER DISTRICT, GALVESTON, TEXAS

PLATE 1

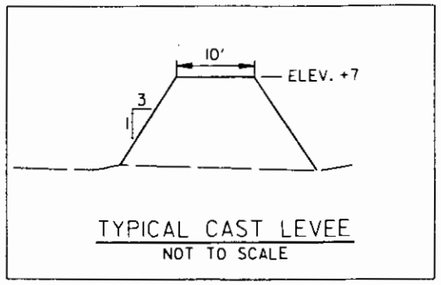


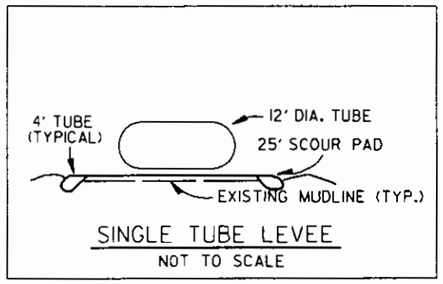
GULF INTRACOASTAL WATERWAY, TEXAS
ARANSAS NATIONAL WILDLIFE REFUGE

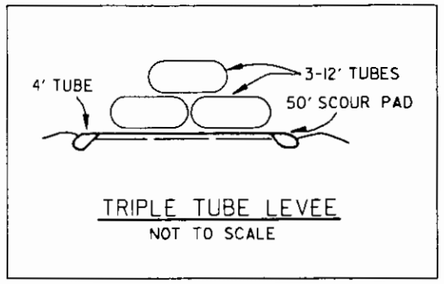
RECOMMENDED PLAN
STA. 714+000 TO STA. 686+000

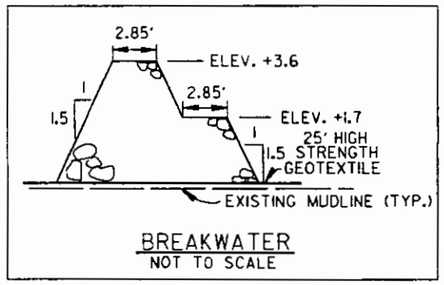
U.S. ARMY ENGINEER DISTRICT, GALVESTON, TEXAS

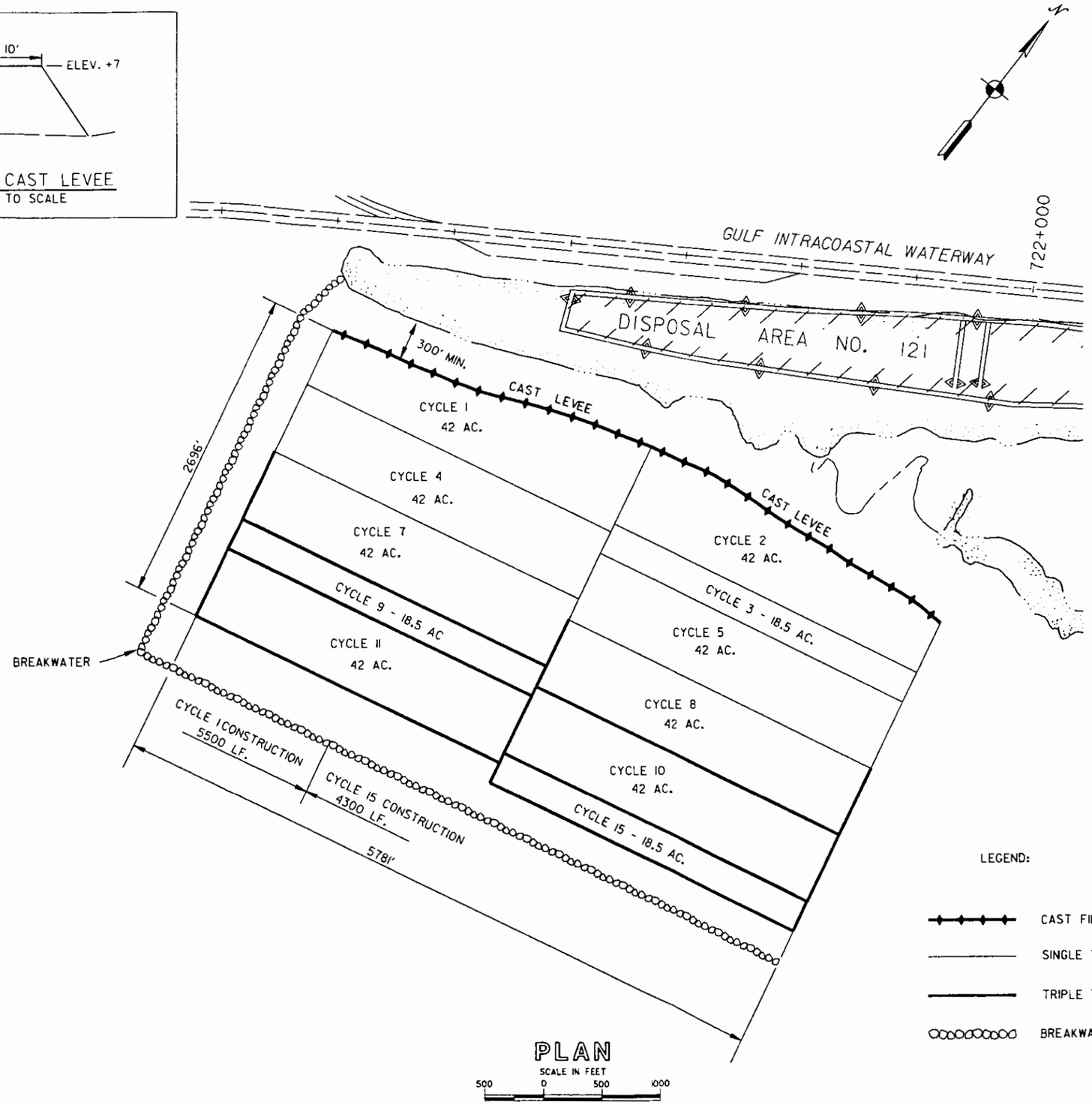
PLATE 1











LEGEND:

- CAST FILL LEVEE
- SINGLE TUBE LEVEE
- TRIPLE TUBE LEVEE
- BREAKWATER

NOTE: (THIS PLATE ONLY)

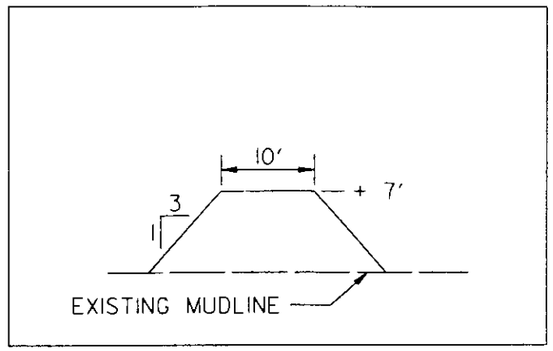
SEE PLATE 11 FOR LOCATION OF SITE.

GULF INTRACOASTAL WATERWAY, TEXAS
ARANSAS NATIONAL WILDLIFE REFUGE

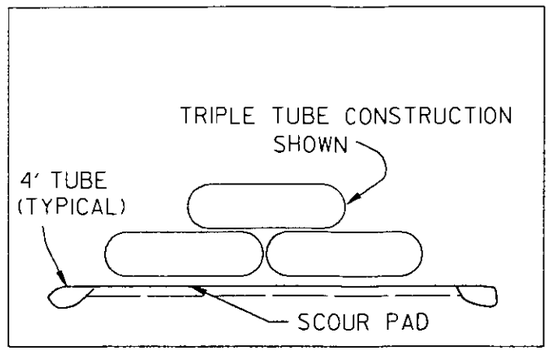
BENEFICIAL USE SITE "A"

U.S. ARMY ENGINEER DISTRICT, GALVESTON, TEXAS

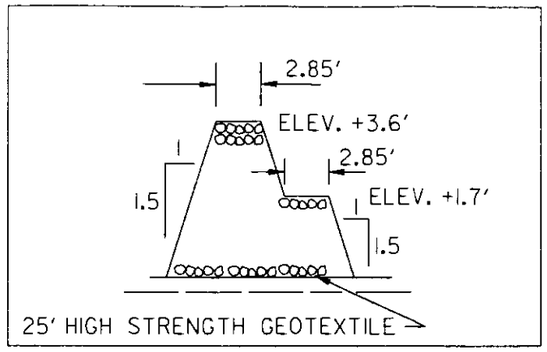
PLATE 14



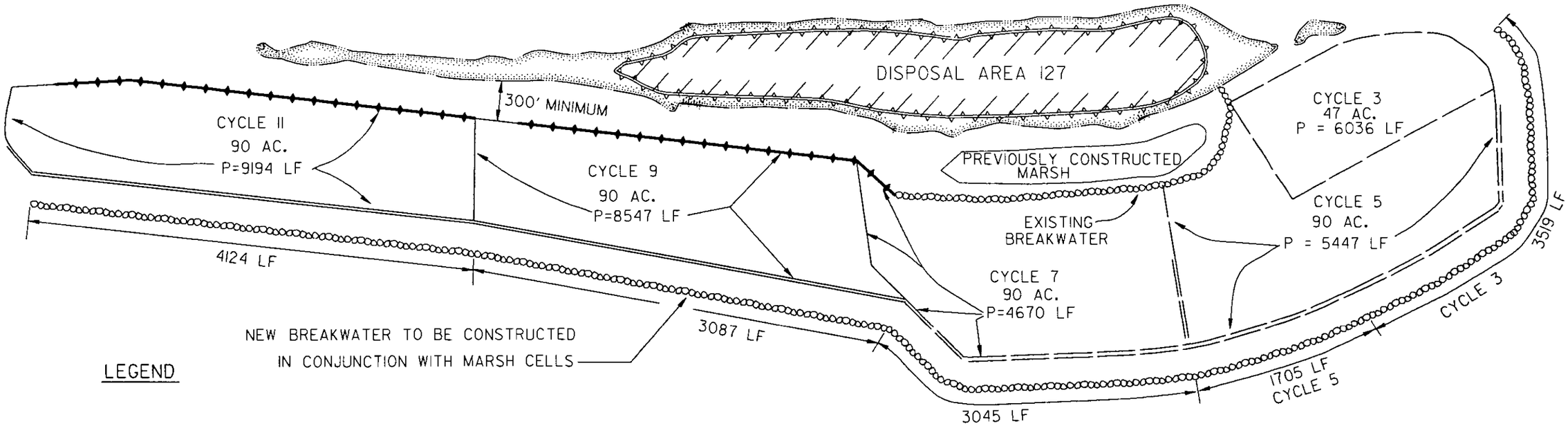
TYPICAL LEVEE
CAST FILL CONSTRUCTION
NOT TO SCALE



TYPICAL LEVEE
GEOTUBE CONSTRUCTION
NOT TO SCALE



TYPICAL BREAKWATER
CONSTRUCTION
NOT TO SCALE



LEGEND

= CAST FILL LEVEE

= 12' TUBE WITH 25' SCOUR PAD

= 3-10' TUBES WITH 40' SCOUR PAD

= 15' TUBE WITH 25' SCOUR PAD

= 3-12' TUBES WITH 50' SCOUR PAD

PLAN
SCALE IN FEET
500 0 500 1000

NOTES: (THIS PLATE ONLY)

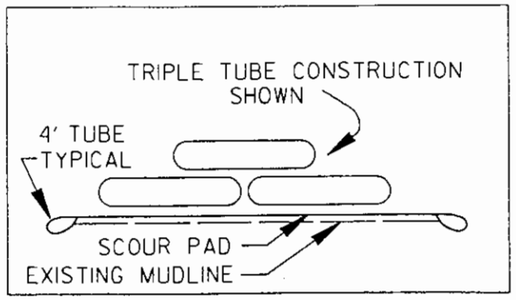
1. SEE PLATE 9 FOR SITE LOCATION.
2. USE GEOTEXTILE LINER ALONG EXISTING BREAKWATER.

GULF INTRACOASTAL WATERWAY, TEXAS
ARANSAS NATIONAL WILDLIFE REFUGE

BENEFICIAL USE SITE "B"

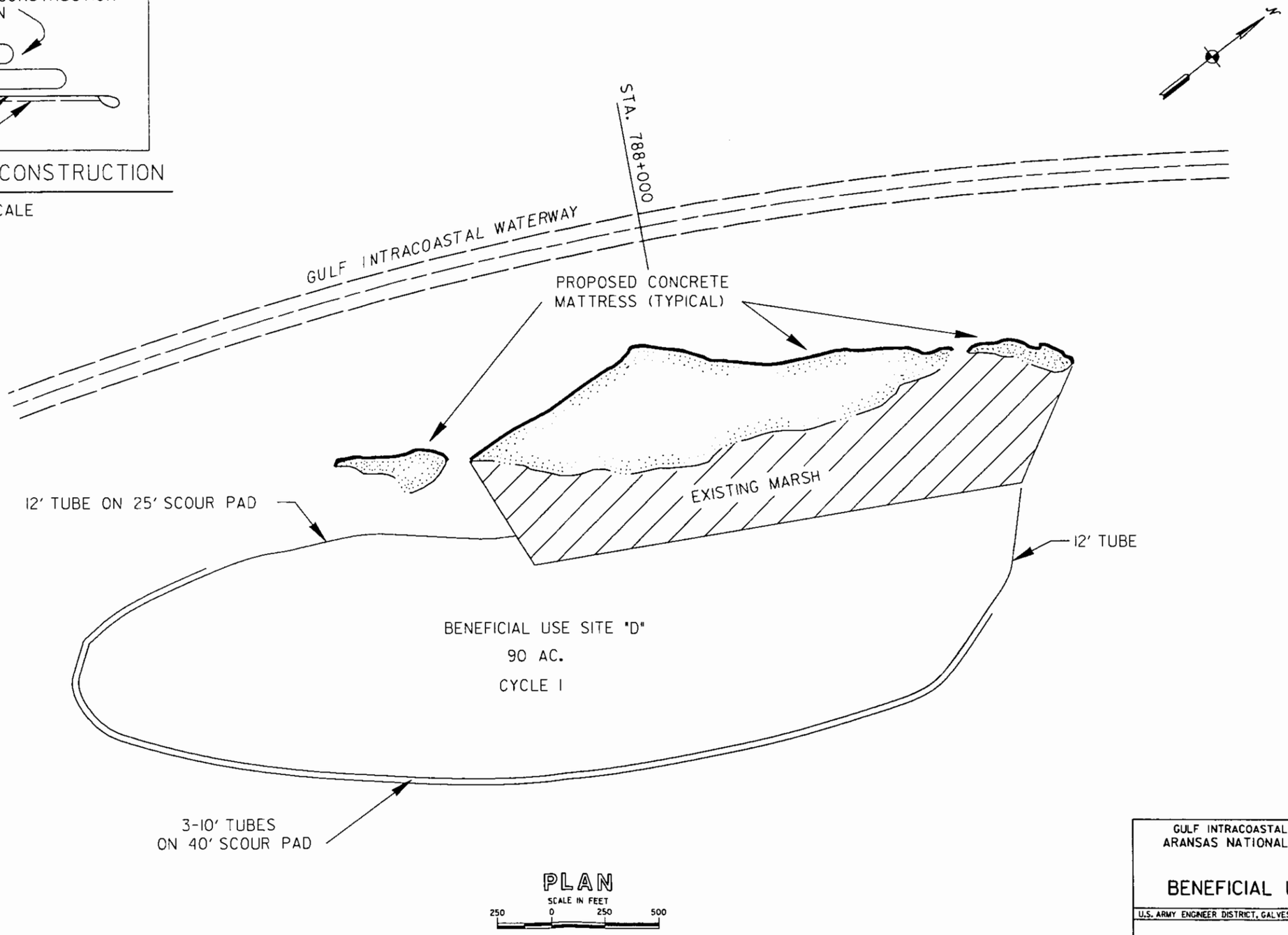
U.S. ARMY ENGINEER DISTRICT, GALVESTON, TEXAS

PLATE 15



PROPOSED LEVEE CONSTRUCTION

NOT TO SCALE

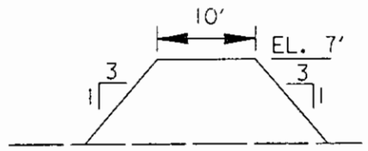


GULF INTRACOASTAL WATERWAY, TEXAS
ARANSAS NATIONAL WILDLIFE REFUGE

BENEFICIAL USE SITE "D"

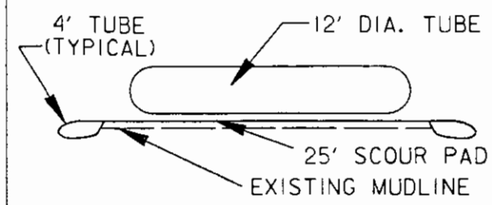
U.S. ARMY ENGINEER DISTRICT, GALVESTON, TEXAS

PLATE 17



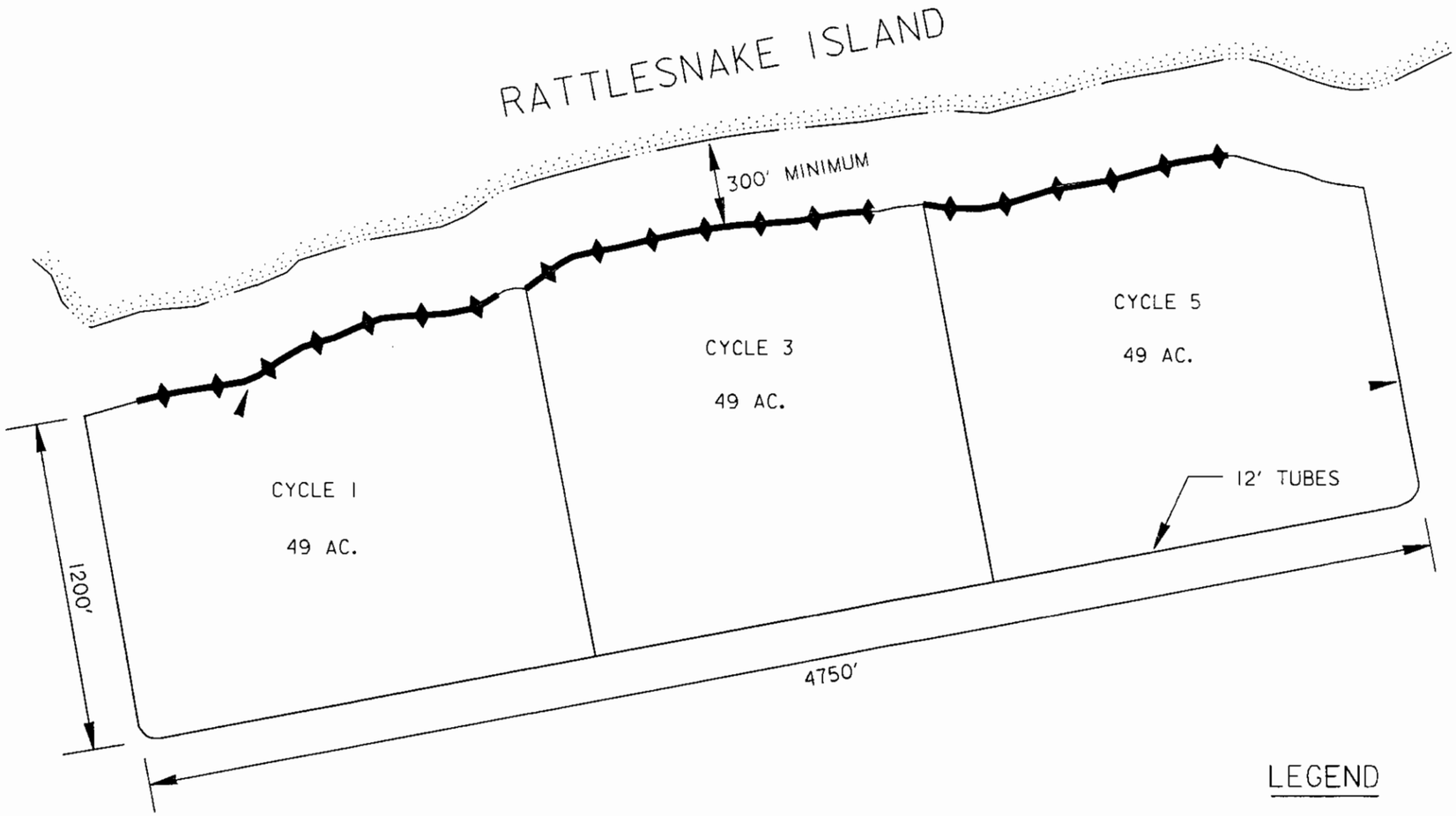
CAST LEVEE USING DRAGLINE OR BACKHOE

NOT TO SCALE



SINGLE TUBE LEVEE

NOT TO SCALE



NOTE: (THIS PLATE ONLY)

SEE PLATE 9 FOR LOCATION OF SITE.

LEGEND

CAST FILL LEVEE

SINGLE TUBE LEVEE

PLAN

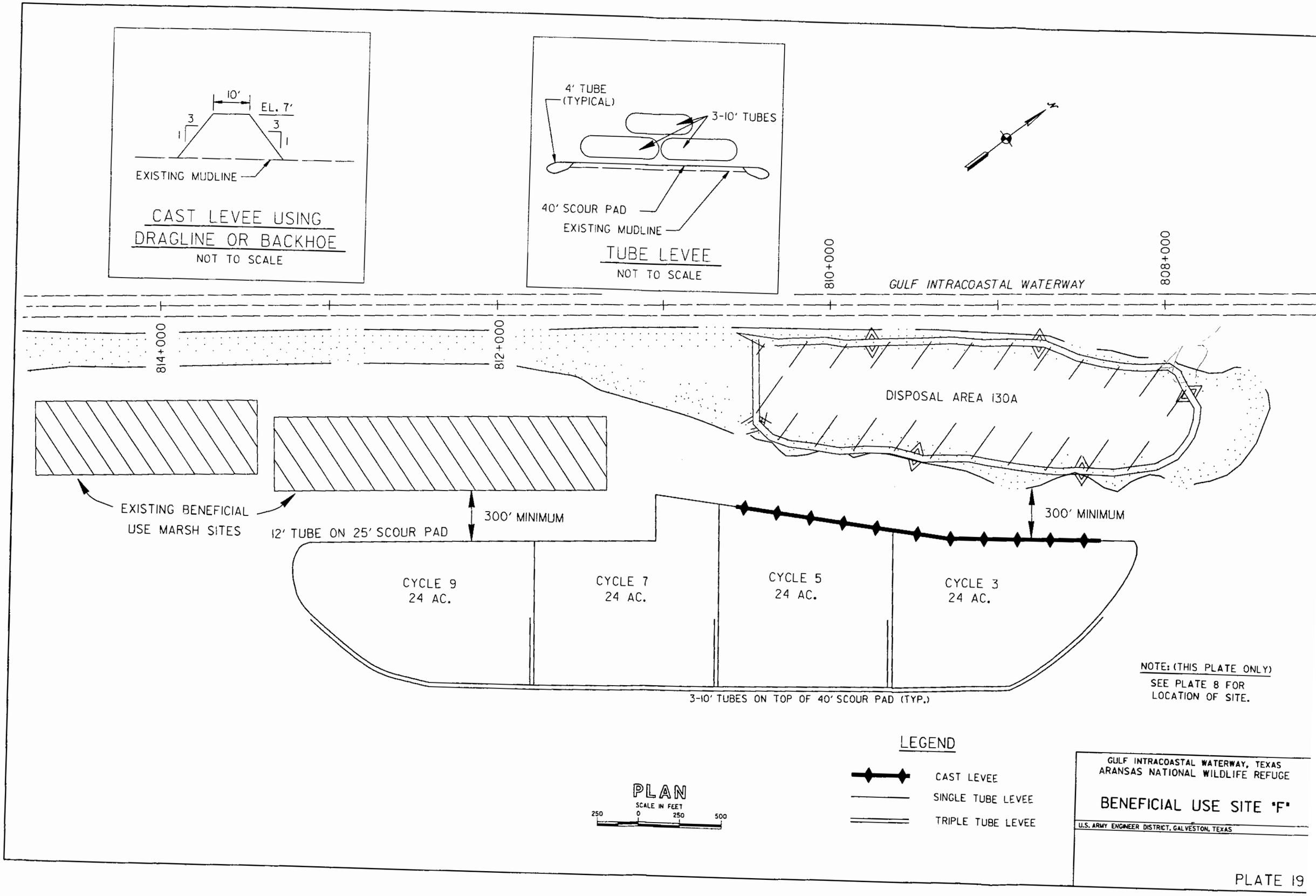
SCALE IN FEET

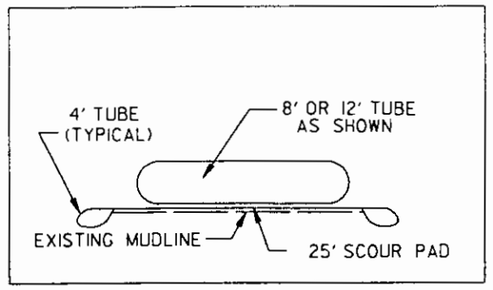
250 0 250 500

GULF INTRACOASTAL WATERWAY, TEXAS
ARANSAS NATIONAL WILDLIFE REFUGE

BENEFICIAL USE SITE "E"

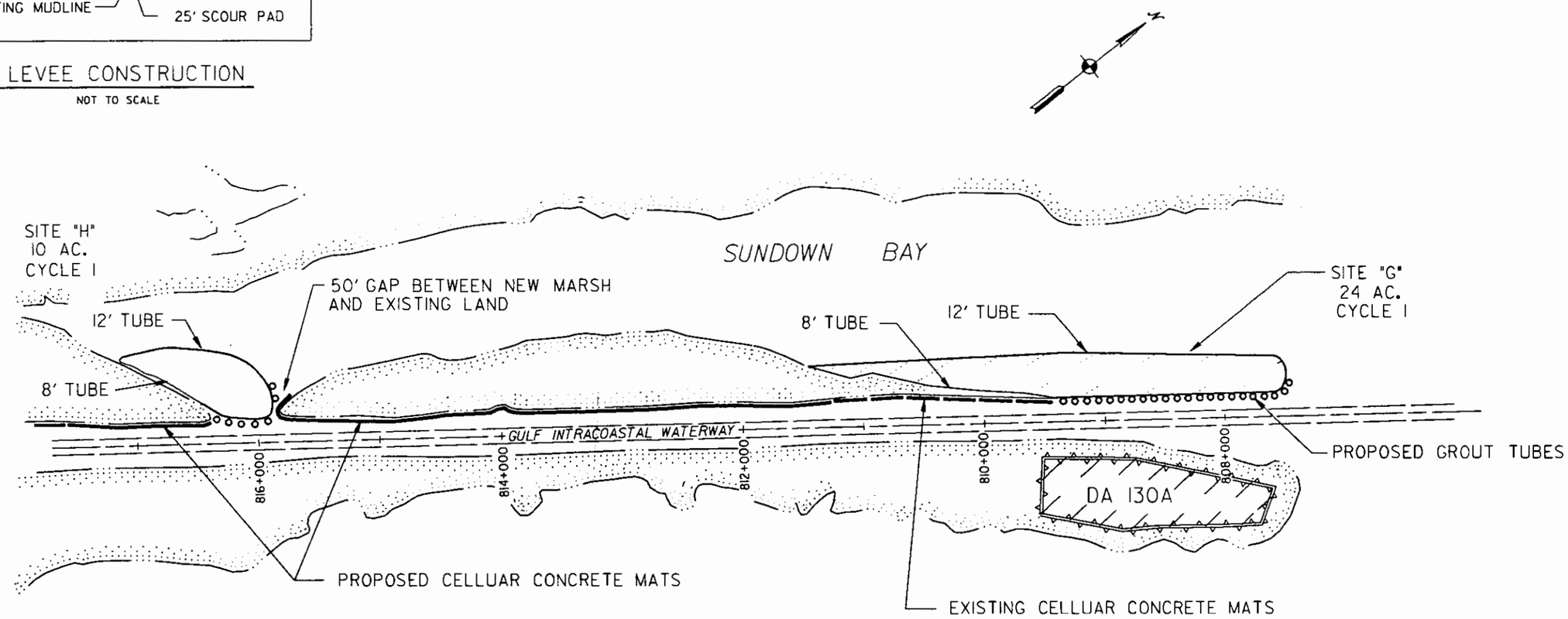
U.S. ARMY ENGINEER DISTRICT, GALVESTON, TEXAS


10'
EL. 7'
3
1
3
1
EXISTING MUDLINE
CAST LEVEE USING
DRAGLINE OR BACKHOE
NOT TO SCALE
4' TUBE
(TYPICAL)
3-10' TUBES
40' SCOUR PAD
EXISTING MUDLINE
TUBE LEVEE
NOT TO SCALE
N
810+000
808+000
GULF INTRACOASTAL WATERWAY
814+000
812+000
DISPOSAL AREA 130A
EXISTING BENEFICIAL
USE MARSH SITES
12' TUBE ON 25' SCOUR PAD
300' MINIMUM
300' MINIMUM
CYCLE 9
24 AC.
CYCLE 7
24 AC.
CYCLE 5
24 AC.
CYCLE 3
24 AC.
3-10' TUBES ON TOP OF 40' SCOUR PAD (TYP.)
NOTE: (THIS PLATE ONLY)
SEE PLATE 8 FOR
LOCATION OF SITE.
LEGEND
CAST LEVEE
SINGLE TUBE LEVEE
TRIPLE TUBE LEVEE
PLAN
SCALE IN FEET
250
0
250
500
GULF INTRACOASTAL WATERWAY, TEXAS
ARANSAS NATIONAL WILDLIFE REFUGE
BENEFICIAL USE SITE "F"
U.S. ARMY ENGINEER DISTRICT, GALVESTON, TEXAS
PLATE 19



LEVEE CONSTRUCTION

NOT TO SCALE



PLAN

SCALE IN FEET

500 0 500 1000

NOTES: (THIS PLATE ONLY)

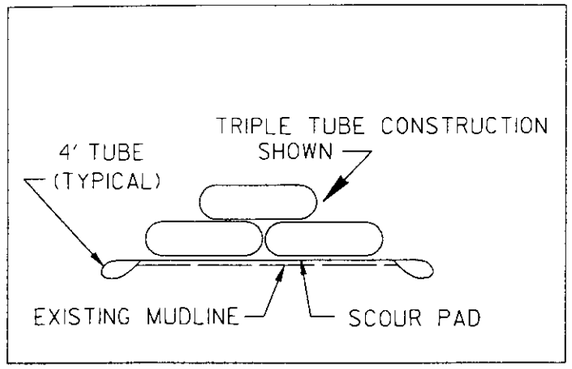
1. SEE PLATE 13 FOR SECTIONS ON GROUT TUBE AND CONCRETE MATS.
2. SEE PLATE 8 FOR SITE LOCATION.

GULF INTRACOASTAL WATERWAY, TEXAS
ARANSAS NATIONAL WILDLIFE REFUGE

BENEFICIAL USE SITES
"G" AND "H"

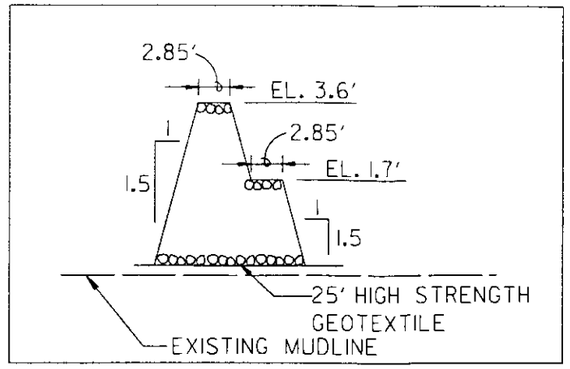
U.S. ARMY ENGINEER DISTRICT, GALVESTON, TEXAS

PLATE 20



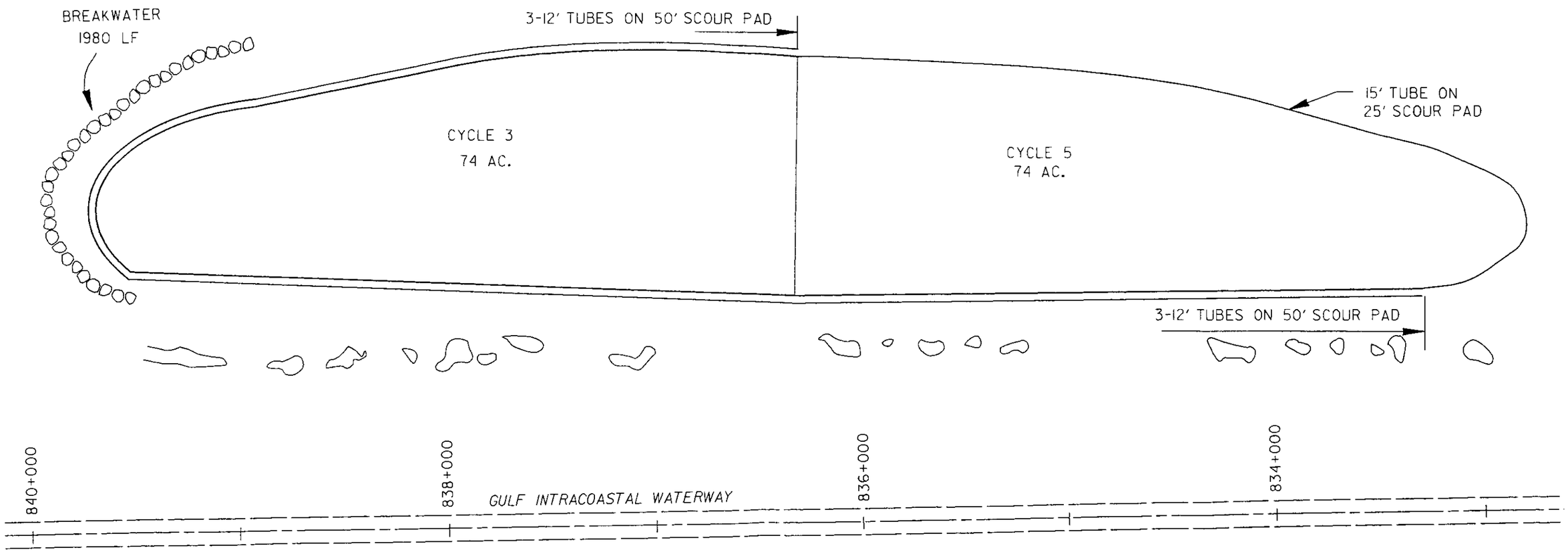
TYPICAL LEVEE SECTION

NOT TO SCALE



TYPICAL BREAKWATER SECTION

NOT TO SCALE



PLAN

SCALE IN FEET

250 0 250 500

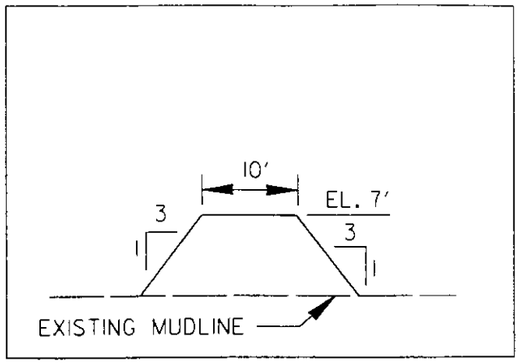
NOTE: (THIS PLATE ONLY)

SEE PLATE 7 FOR SITE LOCATION.

GULF INTRACOASTAL WATERWAY, TEXAS
ARANSAS NATIONAL WILDLIFE REFUGE

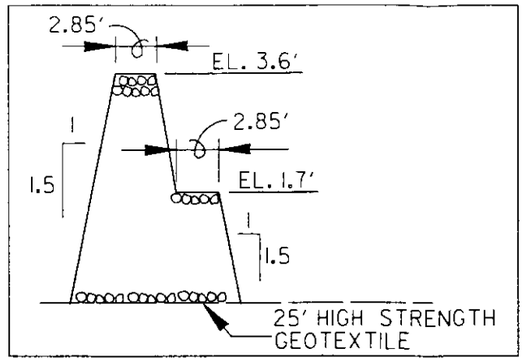
BENEFICIAL USE SITE "J"

U.S. ARMY ENGINEER DISTRICT, GALVESTON, TEXAS



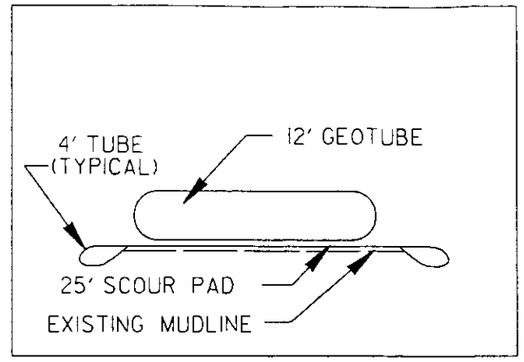
TYPICAL CAST LEVEE SECTION

NOT TO SCALE



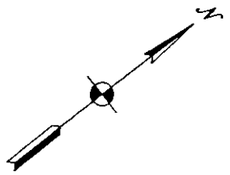
TYPICAL BREAKWATER SECTION

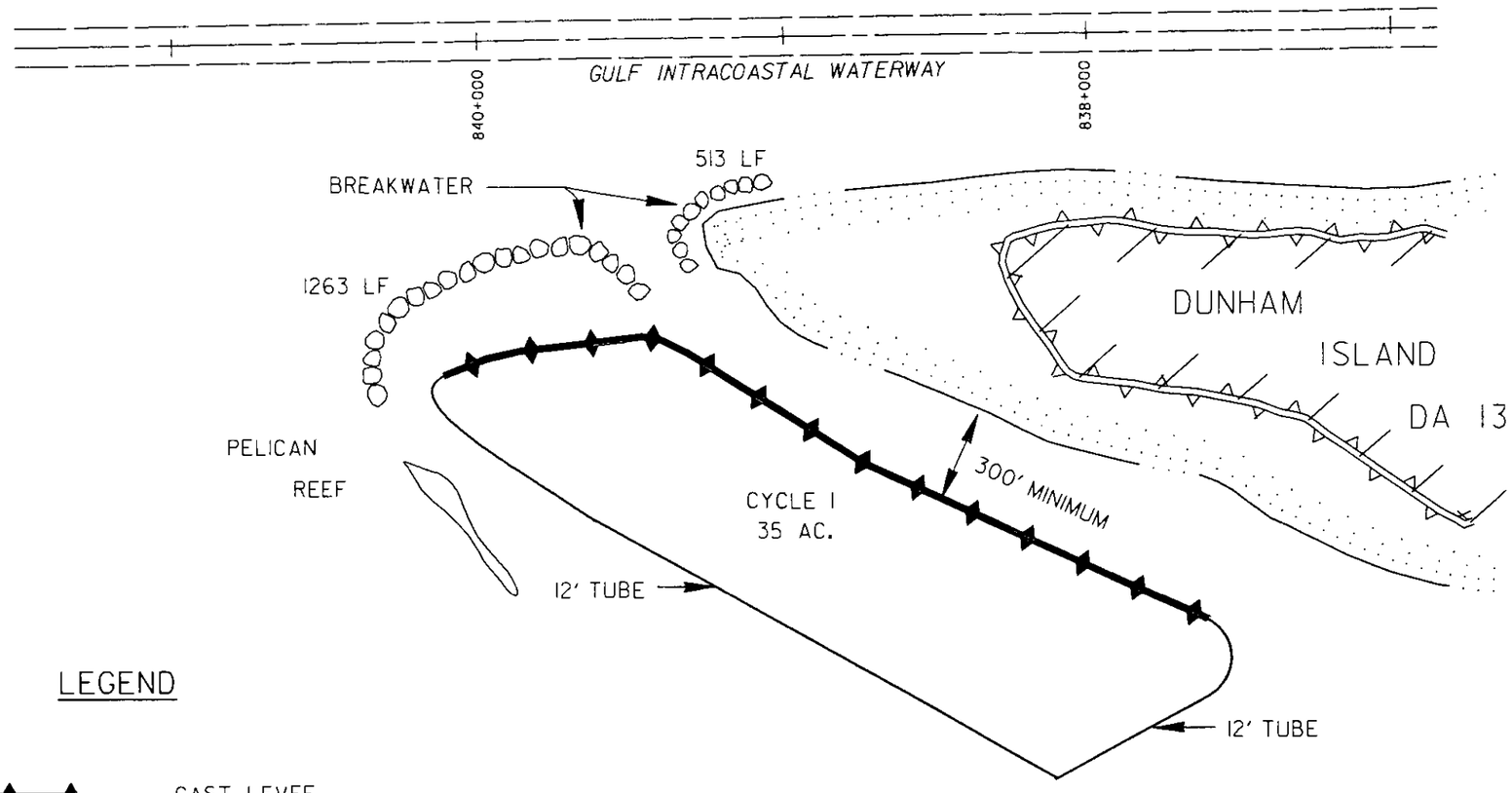
NOT TO SCALE



SINGLE TUBE LEVEE

NOT TO SCALE





NOTE: (THIS PLATE ONLY)

SEE PLATE 7 FOR SITE LOCATION.

LEGEND

CAST LEVEE

GEOTUBE LEVEE

BREAKWATER

PLAN

SCALE IN FEET

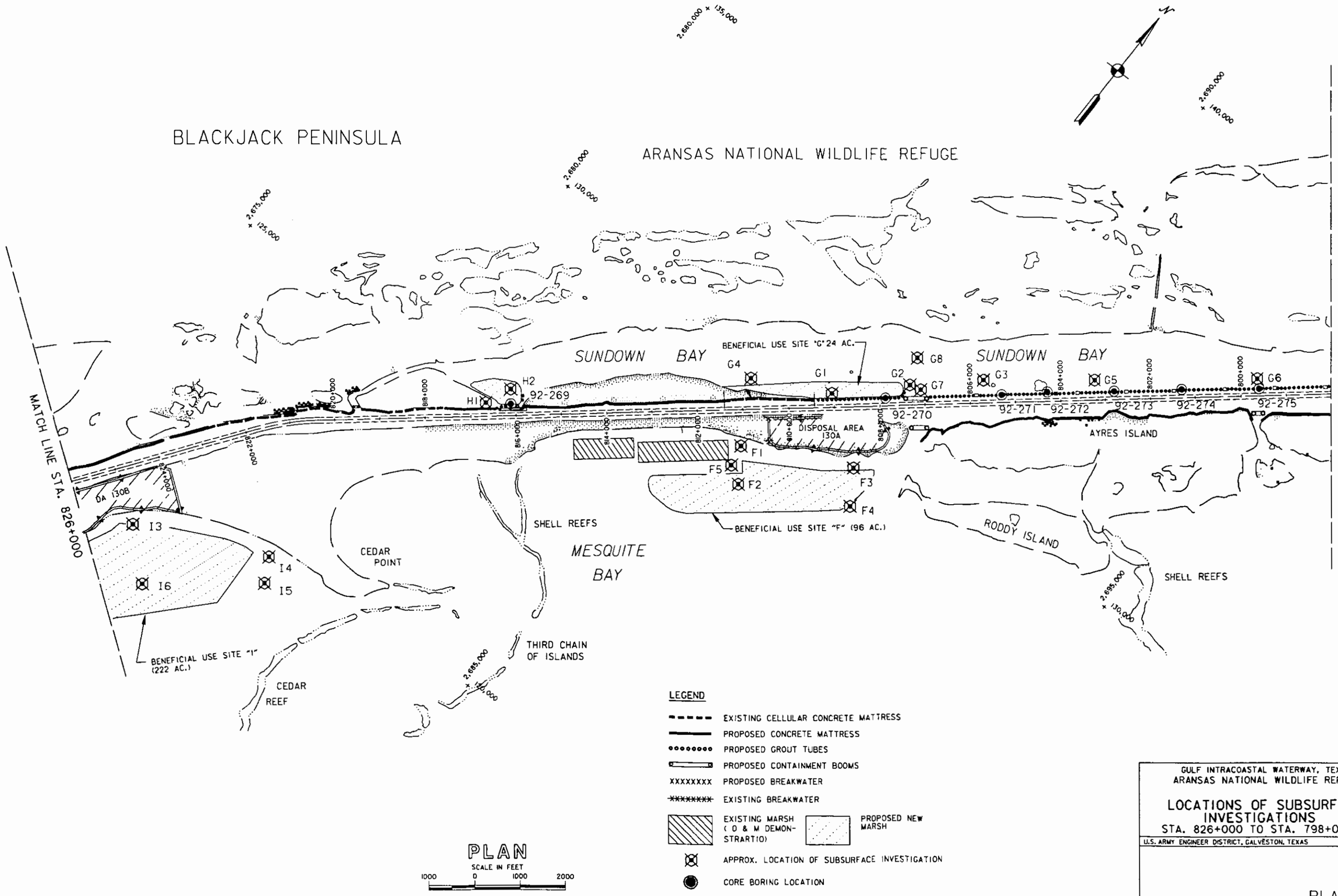
250 0 250 500

GULF INTRACOASTAL WATERWAY, TEXAS
ARANSAS NATIONAL WILDLIFE REFUGE

BENEFICIAL USE SITE "K"

U.S. ARMY ENGINEER DISTRICT, GALVESTON, TEXAS

PLATE 2

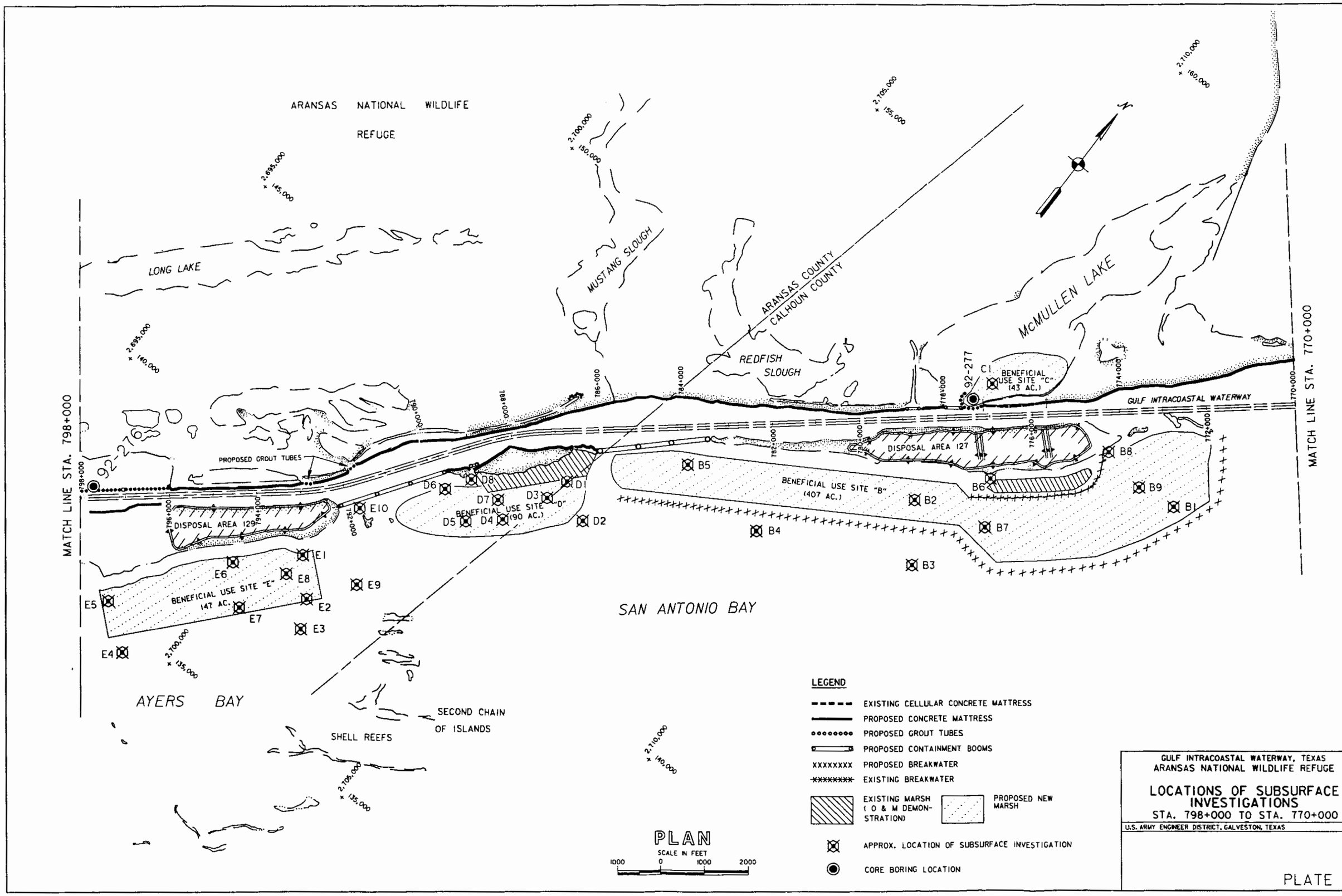


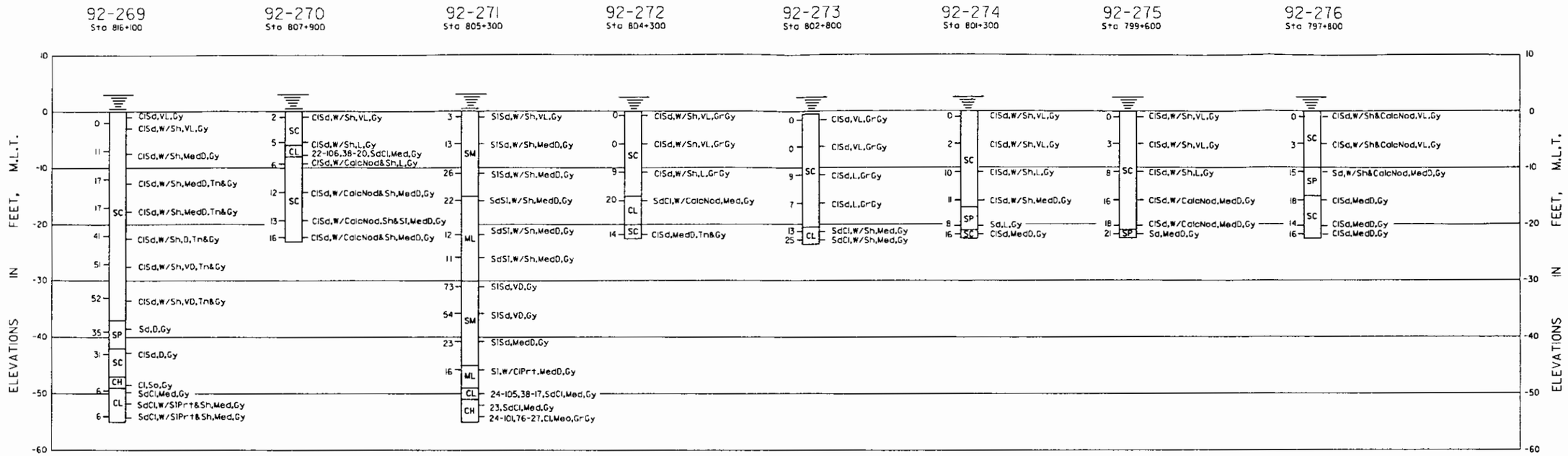
GULF INTRACOASTAL WATERWAY, TEXAS
ARANSAS NATIONAL WILDLIFE REFUGE

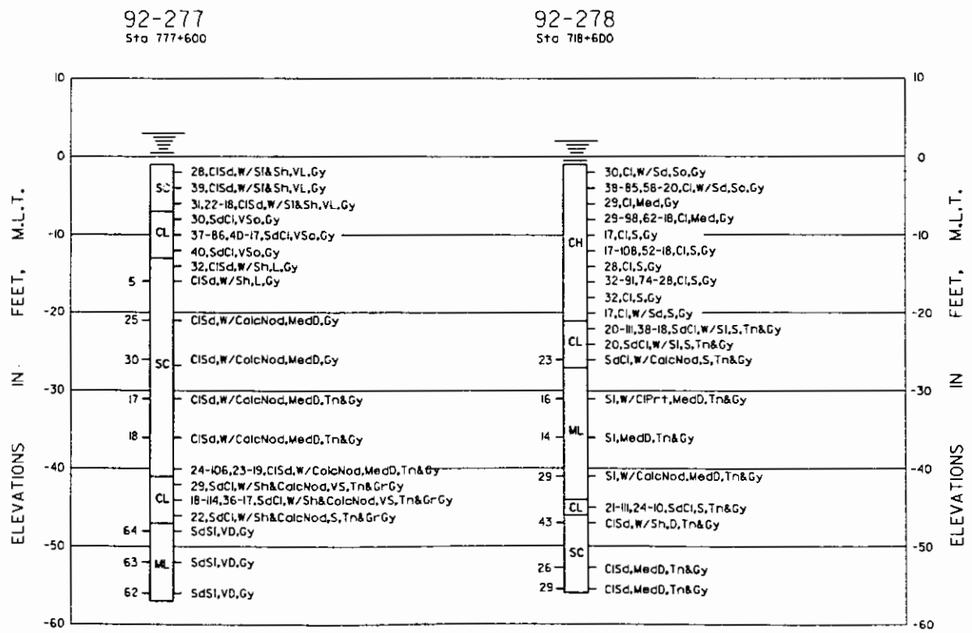
LOCATIONS OF SUBSURFACE INVESTIGATIONS
STA. 826+000 TO STA. 798+000

U.S. ARMY ENGINEER DISTRICT, GALVESTON, TEXAS

PLATE 25


ARANSAS NATIONAL WILDLIFE REFUGE
LONG LAKE
MUSTANG SLOUGH
ARANSAS COUNTY
CALHOUN COUNTY
REDFISH SLOUGH
McMULLEN LAKE
GULF INTRACOASTAL WATERWAY
MATCH LINE STA. 798+000
MATCH LINE STA. 770+000
92-276
92-277
C1
BENEFICIAL USE SITE "C" (143 AC.)
PROPOSED GROUT TUBES
DISPOSAL AREA 129
DISPOSAL AREA 127
BENEFICIAL USE SITE "B" (407 AC.)
BENEFICIAL USE SITE "D" (90 AC.)
BENEFICIAL USE SITE "E" 147 AC.
B1
B2
B3
B4
B5
B6
B7
B8
B9
D1
D2
D3
D4
D5
D6
D7
D8
E1
E2
E3
E4
E5
E6
E7
E8
E9
E10
SAN ANTONIO BAY
AYERS BAY
SHELL REEFS
SECOND CHAIN OF ISLANDS
LEGEND
EXISTING CELLULAR CONCRETE MATTRESS
PROPOSED CONCRETE MATTRESS
PROPOSED GROUT TUBES
PROPOSED CONTAINMENT BOOMS
PROPOSED BREAKWATER
EXISTING BREAKWATER
EXISTING MARSH (O & M DEMONSTRATION)
PROPOSED NEW MARSH
APPROX. LOCATION OF SUBSURFACE INVESTIGATION
CORE BORING LOCATION
PLAN
SCALE IN FEET
1000 0 1000 2000
GULF INTRACOASTAL WATERWAY, TEXAS
ARANSAS NATIONAL WILDLIFE REFUGE
LOCATIONS OF SUBSURFACE INVESTIGATIONS
STA. 798+000 TO STA. 770+000
U.S. ARMY ENGINEER DISTRICT, GALVESTON, TEXAS
PLATE 2





NOTES;

1. SOILS HAVE BEEN CLASSIFIED IN ACCORDANCE WITH MILITARY STANDARD 619B "UNIFIED SOIL CLASSIFICATION SYSTEM FOR ROADS, AIRFIELDS, EMBANKMENTS, AND FOUNDATIONS." CONSISTENCY OF SOILS SUCH AS SOFT, MEDIUM, HARD, LOOSE, DENSE, ETC., ARE RELATIVE TERMS BASED ON ESTIMATED UNDISTURBED SHEAR STRENGTH OF THE MATERIAL AS DETERMINED BY VISUAL CLASSIFICATION POCKET PENETROMETER TESTS AND PENETRATION RESISTANCE DURING SAMPLING.
2. FIGURES TO THE RIGHT OF BORING LOGS ARE WATER CONTENTS IN PERCENT OF THE DRY WEIGHT, DRY DENSITY, LIQUID LIMIT, PLASTIC LIMIT, AND BAR LINEAR SHRINKAGE. (MC-UDW),(LL-PL),(B.L.S.)•
3. FIGURES TO THE LEFT OF BORING LOGS ARE BLOWS PER FOOT OF PENETRATION FROM STANDARD PENETRATION TESTING.
4. BORINGS WERE DRILLED USING WET ROTARY DRILLING TECHNIQUES AND UNDISTURBED SAMPLES WHERE RECOVERED WITH A 3-INCH DIAMETER THIN WALL SAMPLER WHERE COHESIVE MATERIALS WERE ENCOUNTERED. WHERE COHESIONLESS MATERIALS WERE ENCOUNTERED, DISTURBED SAMPLES WERE TAKEN WITH A SPLIT SPOON SAMPLER DURING PERFORMANCE OF STANDARD PENETRATION TESTING.

VISUAL CLASSIFICATIONS

Bn Brown(ish)	H Hard	Sh Shell(y)
Calc Calcareous	L Loose	Sl Silty
Cl Clay(ey)	Med Medium	Sms Seams
D Dense	Nod Nodules	So Soft
Frag Fragment(s)	Prt Parting	Tn Tan(ish)
Gr Green(ish)	S Stiff	V Very
Gy Gray(ish)	Sd Sand(y)	W With

LABORATORY CLASSIFICATION

CH INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS.
CL INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, LEAN CLAYS.
ML INORGANIC SILTS AND VERY FINE SANDS, WITH SLIGHT PLASTICITY.
SC CLAYEY SANDS, SAND-CLAY MIXTURES.
SM SILTY SANDS, SAND-SILT MIXTURES.
SP POORLY GRADED SANDS OR GRAVELLY SANDS, LITTLE OR NO FINES.

NOTES: (THIS PLATE ONLY)

1. BORING STATIONS ARE APPROXIMATE.
2. ALL BORINGS WERE DRILLED APPROXIMATELY 300 FEET NW. OF CHANNEL CENTERLINE.

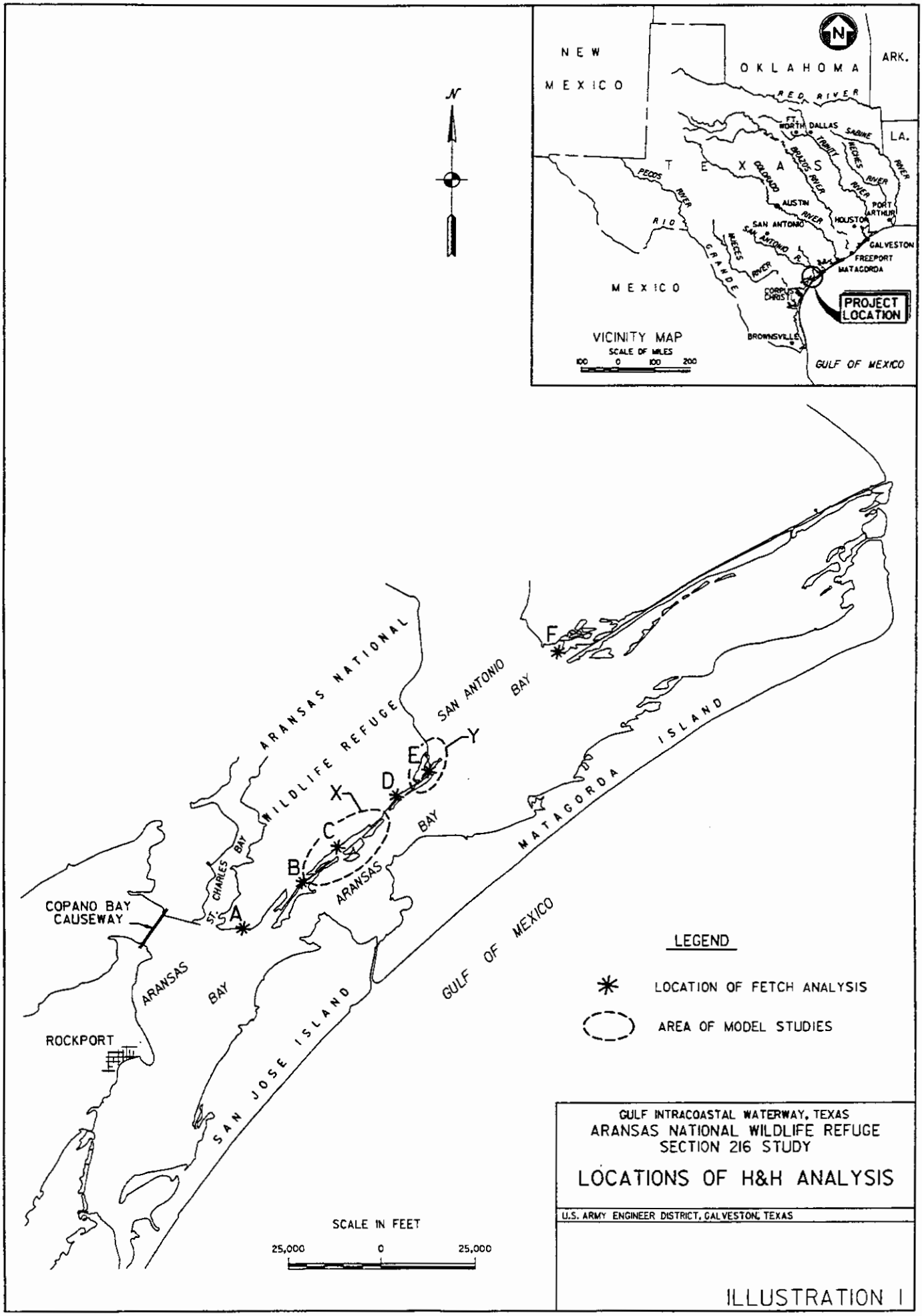
GULF INTRACOASTAL WATERWAY, TEXAS
ARANSAS NATIONAL WILDLIFE REFUGE

LOGS OF BORINGS

U.S. ARMY ENGINEER DISTRICT, GALVESTON, TEXAS

PLATE 2

ILLUSTRATIONS AND EXHIBITS



GULF INTRACOASTAL WATERWAY, TEXAS
ARANSAS NATIONAL WILDLIFE REFUGE
SECTION 216 STUDY

LOCATIONS OF H&H ANALYSIS

U.S. ARMY ENGINEER DISTRICT, GALVESTON, TEXAS

ILLUSTRATION I

SUMMARY OF LABORATORY TEST RESULTS

Project: Soil sediment Contract No. DACW84-92-D-0005 Boring No.

S#	Depth (ft.)	PP (tsf)	SPT Blows per foot	Visual Classification	U S C	M C (%)	Dry Unit Wt. (pcf)	Wet Unit Wt. (pcf)	LL (%)	PL (%)	Mechanical Analysis % passing					Torvane Shear Strength (tsf)	qu (tsf)
											#4	#10	#40	#100	#200		
1				Gray,Sand,Clayey,w/silt and shell fragments	SC-SM	28.7			25	21	99.9	99.3	98.0	83.3	38.5		
2				Gray,Sand,Clayey,w/silt and shell fragments	SC-SM	38.2			25	19	100.0	100.0	99.6	89.8	46.2		
3				Gray,Clay,Sandy,w/silt and shell fragments	CL	39.2			32	17	99.6	99.3	90.7	84.0	54.9		
4				Gray,Sand,Clayey,w/silt and shell fragments	SC-SM	31.7			24	19	99.9	98.8	97.5	84.8	39.4		
5				Gray,Sand,Clayey,w/silt and shell fragments	SC-SM	35.6			28	22	99.1	97.4	94.8	83.3	46.3		
6				Gray,Clay,Sandy,w/silt and shell fragments	CL	46.2			32	18	99.9	98.4	96.6	88.6	58.7		
7				Gray,Sand,Silty,w/shell fragments	SM	28.8					100.0	99.9	99.5	77.1	17.0		
8				Gray,Sand,Silty,w/shell fragments	SM	35.6			NP	NP	99.8	98.4	94.4	73.8	21.0		
9				Gray,Sand	SP	23.2					100.0	100.0	99.4	59.2	1.7		
10				Gray,Sand,Silty,w/shell and shell fragments	SM	37.7					85.4*	80.2*	75.2	52.4	19.2		
11				Gray,Clay,Sandy,w/silt and shell fragments	CL	51.4			40	20	100.0	99.1	97.1	78.7	56.1		
12				Gray,Sand,Silty,w/shell and shell fragments	SM	41.2					96.1*	74.4*	52.7	32.0	13.0		
13				Gray,Clay,Sandy,w/silt and shell fragments	CL	64.2			44	19	99.6*	96.9*	91	74.2	54.4		
14				Gray,Sand,Clayey,w/silt and shell fragments	SC-SM	55.4			23	17	100.0	100.0	99.0	81.0	47.0		
15				Gray,Sand,Silty,w/shell fragments	SM	25.9					100.0	99.4	96.8	76.5	16.9		

S#: Sample Number, PP: Pocket Penetrometer Reading, USC: Unified Soil Classification, MC: Moisture Content
qu: Unconfined Compressive Strength, WOH: Weight of Hammer, WOP: Weight of Pipe
* : Material retained are shell and shell fragments

GEOTEST ENGINEERING, INC.

Project: Soil sediment Contract No. DACW64-92-D-0005 Boring No.

S#	Depth (ft.)	PP (tsf)	SPT Blows per foot	Visual Classification	U S C	M C (%)	Dry Unit Wt. (pcf)	Wet Unit Wt. (pcf)	LL (%)	PL (%)	Mechanical Analysis % passing					Torvane Shear Strength (tsf)	qu (tsf)
											#4	#10	#40	#100	#200		
16				Gray,Sand,w/silt	SP-SM	28.1					100.0	99.9	99.4	74.3	7.7		

S#: Sample Number, PP: Pocket Penetrometer Reading, USC: Unified Soil Classification, MC: Moisture Content
qu: Unconfined Compressive Strength, WOH: Weight of Hammer, WOP: Weight of Pipe

GEOTEST ENGINEERING, INC.

SUMMARY OF LABORATORY TEST RESULTS

Project: Aransas National Wildlife Refuge
Contract No. DACW64-92-D-0005 Delivery Order No. 0026

Boring No.

S#	Depth (ft.)	PP (tsf)	SPT Blows per foot	Visual Classification	U S C	M C (%)	Dry Unit Wt. (pcf)	Wet Unit Wt. (pcf)	LL (%)	PL (%)	Mechanical Analysis % passing					Torvane Shear Strength (tsf)	qu (tsf)
											#4	#10	#40	#100	#200		
17				Gray,Sand,Silty,w/shell fragments	S M	29.0					100.0	99.8	99.3	84.1	19.2		
18				Gray,Sand,Silty,w/shell fragments	S M	28.9					100.0	99.9	99.6	82.8	13.1		
19				Gray,Sand,Silty,w/shell fragments	S M	27.2					100.0	99.4	98.6	83.2	21.2		
20				Gray,Sand,Silty,w/shell fragments	S M	29.5					100.0	99.8	99.2	82.3	21.1		
21				Gray,Sand,Silty,w/shell fragments	S M	28.1					99.9*	99.4*	98.5	82.6	25.2		
22				Gray,Sand,Silty,w/shell fragments	S M	24.9					99.8*	98.3*	96.8	79.4	19.1		
23				Gray,Clay,w/shell fragments	C H	52.2			72	28	100.0	100.0	100.0	97.4	94.9		
24				Gray,Clay,Sandy,w/shell fragments	C L	39.8			30	16	81.5*	76.6*	68.0	62.6	60.8		
25				Gray,Clay,Sandy,w/shell fragments	C L	55.9			47	20	100.0	100.0	98.3	87.4	77.5		
26				Gray,Clay,w/shell fragments	C H	45.2			81	30	98.2*	95.5*	94.6	93.4	91.8		
27				Gray,Clay,Sandy,w/shell fragments	C L	60.9			40	19	90.2*	79.6*	71.3	64.0	59.0		
28A				Gray,Sand,Silty,w/shell fragments	S P-S M	25.9					99.9*	98.6*	96.6	85.0	11.6		
28B				Gray,Clay,Sandy,w/shell fragments	C L	41.1			32	16	98.0*	97.6*	96.8	88.4	79.9		
29				Gray,Clay,w/shell fragments	C H	34.6			60	25	100.0	99.4	99.1	97.7	94.3		
30				Gray,Sand,w/shell fragments and silt	S P	25.7			N P	N P	100.0	100.0	98.7	43.8	3.2		

S#: Sample Number, PP: Pocket Penetrometer Reading, USC: Unified Soil Classification, MC: Moisture Content
qu: Unconfined Compressive Strength, WOH: Weight of Hammer, WOP: Weight of Pipe
*:Material retained are shell fragments

GEOTEST ENGINEERING, INC.

SUMMARY OF LABORATORY TEST RESULTS

Project: Aransas National Wildlife Refuge
Contract No. DACW64-92-D-0005 Delivery Order No. 0026

Boring No.

S#	Depth (ft.)	PP (tsf)	SPT Blows per foot	Visual Classification	U S C	M C (%)	Dry Unit Wt. (pcf)	Wet Unit Wt. (pcf)	LL (%)	PL (%)	Mechanical Analysis % passing #4	#10	#40	#100	#200	Torvane Shear Strength (tsf)	qu (tsf)
31				Gray,Clay,Sandy,w/shell fragments	C L	35.4			35	18	100.0	99.6	98.8	74.3	62.3		
32				Gray,Clay,Sandy,w/shell fragments	C L	37.4			30	18	100.0	100.0	98.9	67.6	61.2		
33				Gray,Clay,Sandy,w/shell fragments	C L	36.0			29	16	100.0	100.0	97.6	61.1	55.8		
34				Gray,Clay,Sandy,w/shell fragments	C L	56.2			28	14	100.0	100.0	99.3	66.1	59.9		
35				Gray,Sand,Silty,w/shell fragments	S P-S M	26.3			N P	N P	100.0	100.0	99.1	51.5	11.4		
36				Gray,Clay,Sandy,w/shell fragments	C L	31.7			33	17	100.0	100.0	99.2	68.3	57.2		
37				Gray,Sand,Silty,w/shell fragments	S M	24.6			N P	N P	100.0	100.0	99.4	56.3	23.4		
38A				Gray,Clay,Sandy,w/shell fragments	C L	31.2			25	15	100.0	98.9	95.7	66.5	61.3		
38B				Gray,Clay,Sandy,w/shell fragments	C L	32.6			24	15	100.0	100.0	99.7	82.3	58.2		
39				Gray,Clay,Sandy,w/shell fragments	C L	49.9			27	15	100.0	100.0	99.3	86.5	56.6		
40				Gray,Clay,Sandy,w/shell fragments	C L	56.8			39	19	100.0	99.1	98.2	82.9	61.4		
41				Gray,Clay,Sandy,w/shell fragments	C L	61.2			47	21	100.0	99.5	98.6	87.3	72.4		
42				Gray,Sand,Silty,w/shell fragments	S P-S M	24.7			N P	N P	100.0	100.0	99.0	63.5	5.3		
43				Gray,Clay,w/shell fragments and sand	C H	37.6			54	23	100.0	99.3	96.7	94.2	89.5		
44				Gray,Silt,Clayey,w/shell fragments and sand	M L-C L	31.3			22	18	94.9*	90.6*	83.7	71.9	53.1		

S#: Sample Number, PP: Pocket Penetrometer Reading, USC: Unified Soil Classification, MC: Moisture Content
qu: Unconfined Compressive Strength, WOH: Weight of Hammer, WOP: Weight of Pipe
*: Material retained are shell fragments

GEOTEST ENGINEERING, INC.

SUMMARY OF LABORATORY TEST RESULTS

Project: Aransas National Wildlife Refuge
Contract No. DACW64-92-D-0005 Delivery Order No. 0026

Boring No.

S#	Depth (ft.)	PP (tsf)	SPT Blows per foot	Visual Classification	U S C	M C (%)	Dry Unit Wt. (pcf)	Wet Unit Wt. (pcf)	LL (%)	PL (%)	Mechanical Analysis % passing					Torvane Shear Strength (tsf)	qu (tsf)
											#4	#10	#40	#100	#200		
45				Gray,Clay,Sandy,w/shell fragments	C L	41.8			38	17	90.9*	73.9*	69.9	67.6	56.9		
46				Gray,Silt,Clayey,w/shell fragments and sand	M L-C L	67.3			22	17	100.0	100.0	96.8	71.3	55.6		
47				Gray,Sand,Silty,w/shell fragments	S M	27.0			N P	N P	100.0	99.5	98.3	58.3	38.8		
48				Gray,Silt,Clayey,w/shell fragments and sand	M L-C L	32.5			21	15	100.0	99.0	94.1	69.7	57.1		
49				Gray,Sand,Silty,w/shell fragments	S P-S M	25.3					99.6*	98.5*	98.1	30.6	6.5		
50				Gray,Sand,Silty,w/shell fragments	S M	24.2					98.4*	96.9*	90.2	69.6	33.0		

S#: Sample Number, PP: Pocket Penetrometer Reading, USC: Unified Soil Classification, MC: Moisture Content
qu: Unconfined Compressive Strength, WOH: Weight of Hammer, WOP: Weight of Pipe
*: Material retained are shell fragments

GEOTEST ENGINEERING, INC.

GIWW AT ARANSAS NATIONAL WILDLIFE REFUGE

Section 216 Study
Preliminary Geotechnical Investigation for Marsh Creation Sites

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This information was obtained during field investigations and subsequent testing of material samples obtained as described in the Geotechnical Section of the Section 216 Study Report. Locations of the sites are shown on Plates 24 through 27.

SITE: A1 Water Depth = 1 foot

Hand Vane Shear Testing:

Depth (to vane bottom, feet below ground sfc.)	Torque Reading (ft-lbs)	Shear Strength[a] (psf)
2.5	20	119
3.5	30	180
6.5	57	340

Samples and Material Descriptions:

Sample No.	Depth (feet)	Material Descriptions
	0-2	Silty Sand

Comments: Approximately 300 feet from shoreline.

SITE: A2 Water Depth = Not Measured

Hand Vane Shear Testing:

Depth (to vane bottom, feet below ground sfc.)	Torque Reading (ft-lbs)	Shear Strength[a] (psf)
4	57	340

Samples and Material Descriptions:

Sample No.	Depth (feet)	Material Descriptions:
	0-4	Shelly, clayey sand

Comments: None

SITE: A3 Water Depth = 6 feet

Hand Vane Shear Testing:
None Performed

Samples and Material Descriptions:

Sample No.	Depth (feet)	Material Description
1	2	SC-SM; Gray Clayey Sand, with Silt and Shell Fragments, LI[b]= 1.9

[a] See Note 4
[b] See Note 3

2	3.5	SC-SM, Gray Clayey Sand, with Silt and Shell Fragments, LI[b] = 3.2

Comments: None

SITE: A4 Water Depth = 6 feet

Hand Vane Shear Testing:
None Performed

Samples and Material Descriptions:

Sample No.	Depth (feet)	Material Descriptions:
3	0-1	CL,Gray Sandy Clay, with Silt and Shell Fragment LI[b]= 1.5
	1-3	Very Soft Material (no sample retrieved)

Comments: Poor Foundation.

SITE: A5 Water Depth = 6 foot

Hand Vane Shear Testing:
None Performed

Samples and Material Descriptions:

Sample No.	Depth (feet)	Material Descriptions
4	0-2	SC-SM, Gray Clayey Sand, with Silt and Shell Fragments, LI[b]= 2.5 (Field ID - Muck)

Comments: None

SITE: A6 Water Depth = Not Measured

Hand Vane Shear Testing:

Depth (to vane bottom, feet below ground sfc.)	Torque Reading (ft-lbs)	Shear Strength[a] (psf)
2.5	20	119
3.5	30	180

Samples and Material Descriptions:

Sample No.	Depth (feet)	Material Descriptions:
	0-1	Sand
	below 1	Fines

Comments: None

SITE: A7 Water Depth = Not Measured

[a] See Note 4
[b] See Note 3

Hand Vane Shear Testing:

Depth (to vane bottom, feet below ground sfc.)	Torque Reading (ft-lbs)	Shear Strength[a] (psf)
1.7	25	150

Samples and Material Descriptions:

Sample No.	Depth (feet)	Material Description
	0-1	Sand
	below 1	Fines

Comments: Hand Proving Ring Penetrometer Readings

0-6	inches	120 tsf
2-12	inches	170 tsf
12-18	inches	147 tsf
18-24	inches	25 tsf

Notice drop in penetration resistance as penetrometer entered fines layer. Location approximately 300 feet from shore.

SITE: B1 Water Depth = 4 feet

Hand Vane Shear Testing:
None Taken

Samples and Material Descriptions:

Sample No.	Depth (feet)	Material Descriptions:
	0-2+	Dense Sand (Muck)

Comments: Could not completely penetrate through sand layer with pipe nor could retrieve sample.

SITE: B2 Water Depth = 4.5 feet

Hand Vane Shear Testing:
None Performed

Samples and Material Descriptions:

Sample No.	Depth (feet)	Material Descriptions:
		Sand

Comments: Sand observed at the surface. Could not be penetrated with pipe sampler.

SITE: B3 Water Depth = 5.5 feet

Hand Vane Shear Testing:
None Performed

[a] See Note 4

Samples and Material Descriptions:

Sample No.	Depth (feet)	Material Descriptions:
6	1-2	Gray Sandy Clay, w/Silt and Shell Fragments, LI[b]= 2.0

Comments: Field identification was Clayey Sand or Sandy Clay. Two-foot sampler push.

SITE: B4 Water Depth = 6 feet

Hand Vane Shear Testing:

Depth (to vane bottom, feet)	Torque Reading (in-lbs)
None Taken	

Samples and Material Descriptions:

Sample No.	Depth (feet)	Material Description
5	Not Recorded	Gray Clayey Sand, w/Silt and Shell Fragments, LI[b] = 2.3
2		3.5

Comments: None

SITE: B5 Water Depth = Not Recorded

Hand Vane Shear Testing:
None Performed

Samples and Material Descriptions:

Sample No.	Depth (feet)	Material Descriptions:
	0-below 1	Sand

Comments: None

SITE: B6 Water Depth = Not Recorded

Hand Vane Shear Testing:

Depth (to vane, feet below water sfc.)	Undrained Shear Strength (psf)
1	230
2	300
3	190
4	280
5	370
6	410
7	420
8	600+

Samples and Material Descriptions:
None Recovered

[b] See Note 3

Comments: Vane shear test information obtained by CERC.

SITE: B7 Water Depth = Not Recorded

Hand Vane Shear Testing:

Depth (to vane, feet below water sfc.)	Undrained Shear Strength (psf)
1	200
2	210
3	170
4	510
5	280
6	365
7	600+

Samples and Material Descriptions:
None Recovered

Comments: Vane shear test information obtained by CERC.

SITE: B8 Water Depth = Not Recorded

Hand Vane Shear Testing:

Depth (to vane, feet below water sfc.)	Undrained Shear Strength (psf)
1	230
2	310
3	300
4	300
5	600+

Samples and Material Descriptions:
None Recovered

Comments: Vane shear test information obtained by CERC.

SITE: B9 Water Depth = Not Recorded

Hand Vane Shear Testing:

Depth (to vane, feet below water sfc.)	Undrained Shear Strength (psf)
1	230
2	230
3	200
4	280
5	420
6	340
7	600+

Samples and Material Descriptions:
None Recovered

Comments: Vane shear test information obtained by CERC.

SITE: C1 Water Depth = 3 feet

Hand Vane Shear Testing:
None Performed.

Samples and Material Descriptions:

Sample No.	Depth (feet)	Material Descriptions:
28B	5	CH Gray Clay w/ Shell Fragments LI[b]= 1.57
29	2	CL Gray Sandy Clay w/ Shell Fragments LI[b]= 0.27

Comments: None

SITE: D1 Water Depth = 3 foot

Hand Vane Shear Testing:
None Performed.

Samples and Material Descriptions:

Sample No.	Depth (feet)	Material Descriptions
	At Sfc.	Silty Sand

Comments: None.

SITE: D2 Water Depth = 5 feet

Hand Vane Shear Testing:
None Performed.

Samples and Material Descriptions:

Sample No.	Depth (feet)	Material Descriptions:
7	0.5-1.5	SM, Gray Silty Sand with Shell Fragments,

Comments: Sand at surface. Eighteen-inch push.

SITE: D3 Water Depth = 5 feet

Hand Vane Shear Testing:
None Performed

Samples and Material Descriptions:

Sample No.	Depth (feet)	Material Description
	At Sfc.	Shell.

Comments: None

[b] See Note 3

SITE: D4 Water Depth = 2 feet

Hand Vane Shear Testing:
None Performed

Samples and Material Descriptions:
None Retrieved.

Comments: Reef.

SITE: D5 Water Depth = 4 feet

Hand Vane Shear Testing:
None Performed

Samples and Material Descriptions:

Sample No.	Depth (feet)	Material Descriptions
8	0.5-1.5	SM, Gray Silty Sand with Shell Fragments

Comments: Two foot penetration with sampler, no recovery.

SITE: D6 Water Depth = 2 feet

Hand Vane Shear Testing:

Depth (to vane bottom, feet below ground sfc.)	Torque Reading (ft-lbs)	Shear Strength[a] (psf)
3	25	148
4	15	90
5	18	110

Samples and Material Descriptions:

Sample No.	Depth (feet)	Material Descriptions:
9	At sfc.	SP, Gray Sand

Comments: None

SITE: D7 Water Depth = Not Recorded

Hand Vane Shear Testing:

Depth (to vane, feet below water sfc.)	Undrained Shear Strength (psf)
3	420
4	330
5	450
6	410
7	450

[a] See Note 4

Samples and Material Descriptions:
None Recovered

Comments: Vane shear test information obtained by CERC.

SITE: D8 Water Depth = Not Recorded

Hand Vane Shear Testing:

*Depth (to vane, feet below water sfc.)	Undrained Shear Strength (psf)
3	600+
4	600+

Samples and Material Descriptions:
None Recovered

Comments: Vane shear test information obtained by CERC.

SITE: E1 Water Depth = 2 feet

Hand Vane Shear Testing:

Depth (to vane bottom, feet below ground sfc.)	Torque Reading (ft-lbs)	Shear Strength[a] (psf)
4	36	214
5	32	190
6	28	170
7	26	155

Samples and Material Descriptions:

Sample No.	Depth (feet)	Material Description
10	At sfc.	SM, Gray Silty Sand with Shell and Shell Fragments

Comments: Three and one-half foot thick sand layer at the surface.

SITE: E2 Water Depth = 3 feet

Hand Vane Shear Testing:
None Taken

Samples and Material Descriptions:

Sample No.	Depth (feet)	Material Descriptions:
11	2	CL, Gray Sandy Clay with Silt and Shell Fragments, LI[b]= 1.57

Comments: Four-foot penetration with sampler. Soft material extends below 4 feet.

SITE: E3 Water Depth = 4 feet

[a] See Note 4
[b] See Note 3

Hand Vane Shear Testing:
None Performed

Samples and Material Descriptions:

Sample No.	Depth (feet)	Material Descriptions:
	0-2.5	Very Soft Gray Silty Clay
	2.5	Shell Layer

Comments: Near-surface material was too soft to be recovered with the sampler.

SITE: E4 Water Depth = 4 feet

Hand Vane Shear Testing:
None Performed

Samples and Material Descriptions:

Sample No.	Depth (feet)	Material Descriptions:
13	2	CL, Gray Sandy Clay with Silt and Shell Fragments, LI[b]= 1.81

Comments: Field identification was Clayey Sand or Sandy Clay.
Two-foot sampler push.

SITE: E5 Water Depth = 2.5 feet

Hand Vane Shear Testing:

Depth (to vane bottom, feet below ground sfc.)	Torque Reading (ft-lbs)	Shear Strength[a] (psf)
3.5	35	208
5.5	25	150
7	47	280

Samples and Material Descriptions:
None Recovered.

Comments: Top of firm material at depth of 7 feet below mudline.

SITE: E6 Water Depth = Not Recorded

Hand Vane Shear Testing:

Depth (to vane, feet below water sfc.)	Undrained Shear Strength (psf)
2	240
3	190
4	380
5	520
6	530

[a] See Note 4
[b] See Note 3

Samples and Material Descriptions:
None Recovered

Comments: Vane shear test information obtained by CERC.

SITE: E7 Water Depth = Not Recorded

Hand Vane Shear Testing:

Depth (to vane, feet below water sfc.)	Undrained Shear Strength (psf)
1	265
2	195
3	425
4	345
5	420
6	400
7	400
8	600

Samples and Material Descriptions:
None Recovered

Comments: Vane shear test information obtained by CERC.

SITE: E8 Water Depth = Not Recorded

Hand Vane Shear Testing:

Depth (to vane, feet below water sfc.)	Undrained Shear Strength (psf)
1	365
2	275
3	285
4	300
5	235
6	390

Samples and Material Descriptions:
None Recovered

Comments: Vane shear test information obtained by CERC.

SITE: E9 Water Depth = Not Recorded

Hand Vane Shear Testing:

Depth (to vane, feet below water sfc.)	Undrained Shear Strength (psf)
3	240
4	265
5	600
6	540

Samples and Material Descriptions:
None Recovered

Comments: Vane shear test information obtained by CERC.

SITE: F1 Water Depth = 2 feet

Hand Vane Shear Testing:
None Performed

Samples and Material Descriptions:

Sample No.	Depth (feet)	Material Descriptions
	At sfc.	Sand
	Not Recorded	SP-SM, Gray Silty Sand with Shell Fragments

Comments: Five-foot penetration with sampler.

SITE: F2 Water Depth = 4 feet

Hand Vane Shear Testing:
None Performed

Samples and Material Descriptions:

Sample No.	Depth (feet)	Material Descriptions:
36	1.5	CL, Gray Sandy Clay with Shell Fragments

Comments: Material became firm at depth of 1.5 feet below mudline.

SITE: F3 Water Depth = 2.3 feet

Hand Vane Shear Testing:
None Performed

Samples and Material Descriptions:

Sample No.	Depth (feet)	Material Description
30	1.5	SP, Gray Sand with Silt and Shell Fragments

Comments: None

SITE: F4 Water Depth = 3.6 feet

Hand Vane Shear Testing:
None Performed

Samples and Material Descriptions:

Sample No.	Depth (feet)	Material Descriptions:
32	1.5	CL, Gray Sandy Clay with Shell Fragments LI[b]= 1.62
31	3	CL, Gray Sandy clay with Shell Fragments LI[b]= 1.02

[b] See Note 3

Comments: Poor Foundation.

SITE: F5 Water Depth = 4 feet

Hand Vane Shear Testing:
None Performed

Samples and Material Descriptions:

Sample No.	Depth (feet)	Material Descriptions
37	At sfc.	SM, Gray Silty Sand with Shell Fragments
38	1.5	CL, Gray Sandy Clay with Shell Fragments

Comments: Samples taken near east corner of newest marsh site constructed by Mitchell Exploration.

SITE: F6 Water Depth = 4.4 feet

Hand Vane Shear Testing:
None Performed

Samples and Material Descriptions:

Sample No.	Depth (feet)	Material Descriptions:
34	2	CL, Gray Sandy Clay with Shell Fragments LI[b] = 3.01
33	4	CL, Gray Sandy Clay with Shell Fragments LI[b]= 2.0

Comments: Material appears to be highly sensitive.

SITE: G1 Water Depth = 2.5

Hand Vane Shear Testing:
None Performed

Samples and Material Descriptions:

Sample No.	Depth (feet)	Material Description
17	At sfc.	SM, Gray Silty Sand with Shell Fragments

Comments: None.

SITE: G2 Water Depth = 2.5 feet

Hand Vane Shear Testing:
None Taken

[b] See Note 3

Samples and Material Descriptions:

Sample No.	Depth (feet)	Material Descriptions:
18	0-2	SM, Gray Silty Sand with Shell Fragments

Comments: Three-foot penetration with sampler.

SITE: G3 Water Depth = Not Measured.

Hand Vane Shear Testing:
None Performed

Samples and Material Descriptions:

Sample No.	Depth (feet)	Material Descriptions:
20	At sfc.	SM, Gray Silty Sand with Shell Fragments.
19	3	SM, Gray Silty Sand with Shell Fragments.

Comments: None.

SITE: G4 Water Depth = Not measured.

Hand Vane Shear Testing:

Depth (to vane, feet below water sfc.)	Undrained Shear Strength (psf)
2	260
3	270
4	310
5	360
6	240
7	340

Samples and Material Descriptions:
None Recovered

Comments: Vane shear test information obtained by CERC.Hand Vane Shear Testing:

SITE: G5 Water Depth = 2.5 feet

Hand Vane Shear Testing:

Depth (to vane bottom, feet below ground sfc.)	Torque Reading (ft-lbs)	Shear Strength[a] (psf)
3.5	28	167
4	40	238

Samples and Material Descriptions:
None Recovered.

Comments: Material appears to be the same as that encountered at site G3.

SITE: G6 Water Depth = 2 feet

[a] See Note 4

Hand Vane Shear Testing:
None Performed

Samples and Material Descriptions:

Sample No.	Depth (feet)	Material Descriptions:
21	2-3	SM, Gray Silty Sand with Shell Fragments

Comments: Four foot penetration with sampler.

SITE: G7 Water Depth = Not Recorded

Hand Vane Shear Testing:

Depth (to vane, feet below water sfc.)	Undrained Shear Strength (psf)
1	560
2	700+

Samples and Material Descriptions:
None Recovered

Comments: Vane shear test information obtained by CERC.

SITE: G8 Water Depth = Not Recorded

Hand Vane Shear Testing:

Depth (to vane, feet below water sfc.)	Undrained Shear Strength (psf)
1	330
2	470
3	460
4	530
5	500
6	400

Samples and Material Descriptions:
None Recovered

Comments: Vane shear test information obtained by CERC.

SITE: G9 Water Depth = Not Recorded

Hand Vane Shear Testing:

Depth (to vane, feet below water sfc.)	Undrained Shear Strength (psf)
1	450
2	220
3	230
4	280
5	380
6	180
6.5	320

Samples and Material Descriptions:
None Recovered

Comments: Vane shear test information obtained by CERC.

SITE: H1 Water Depth = 2.5 feet

Hand Vane Shear Testing:
None Performed

Samples and Material Descriptions:

Sample No.	Depth (feet)	Material Descriptions:
22	0-1	SM, Gray Silty Sand with Shell Fragments

Comments: Hard bottom below depth of 1 foot.

SITE: H2 Water Depth = Material taken from bank above water.

Hand Vane Shear Testing:
None Performed.

Samples and Material Descriptions:

Sample No.	Depth (feet)	Material Descriptions:
23	-	CH Gray Clay w/ Shell Fragments LI[b] = 0.55

Comments: Sample taken of bank material above the waterline.

SITE: I1 Water Depth = 2.2 feet

Hand Vane Shear Testing:
None Performed.

Samples and Material Descriptions:

Sample No.	Depth (feet)	Material Descriptions
42	At Sfc.	SP-SM, Gray Silty Sand with Shell Fragments

Comments: Sampler penetration of 2.7 feet. No recovery. Sample obtained from anchor.

SITE: I2 Water Depth = 4 feet

Hand Vane Shear Testing:
None Performed.

[b] See Note 3

Samples and Material Descriptions:

Sample No.	Depth (feet)	Material Descriptions:
43	1-2	CH, Gray Clay with Sand and Shell Fragments, LI[b] = 0.47

Comments: Encountered reef shell layer at depth of 2.4 feet.

SITE: I3 Water Depth = 3.4 feet

Hand Vane Shear Testing:
None Performed

Samples and Material Descriptions:
None Recovered

Comments: Sampler penetration of 1.7 feet. Material appeared to be soft sandy clay similar to samples of material obtained at site I4.

SITE: I4 Water Depth = 3.7 feet

Hand Vane Shear Testing:
None Performed

Samples and Material Descriptions:

Sample No.	Depth (feet)	Material Descriptions
39	1	CL, Gray Sandy Clay with Shell Fragments LI[b] = 2.91
38B	2	CL, Gray Sandy Clay with Shell Fragments LI[b] = 1.96

Comments: None.

SITE: I5 Water Depth = 4 feet

Hand Vane Shear Testing:
None Performed.

Samples and Material Descriptions:

Sample No.	Depth (feet)	Material Descriptions
41	2	CL, Gray Sandy Clay with Shell Fragments LI[b] = 1.55

Comments: No bottom, very soft material beyond depth of 5.5 feet, which was deepest penetration with the sampler.

SITE: I6 Water Depth = 4 feet

[b] See Note 3

Hand Vane Shear Testing:
None Performed.

Samples and Material Descriptions:
None Recovered.

Comments: Numerous clusters of oyster shell lying on soft clay material.

SITE: J1 Water Depth = 3 feet

Hand Vane Shear Testing:
None Performed.

Samples and Material Descriptions:
None Recovered

Comments: No penetration with sampler. Bottom consists of oyster shell and soft mud.

SITE: J2 Water Depth = Not Recorded

Hand Vane Shear Testing:
None Performed.

Samples and Material Descriptions:

Sample No.	Depth (feet)	Material Description
26	3	CH, Gray Clay with Shell Fragments, LI[b] = 0.30

Comments: Shell below 3-foot depth.

SITE: J3 Water Depth = 3.5 feet

Hand Vane Shear Testing:
None Performed.

Samples and Material Descriptions:
None Recovered.

Comments: Shell below 3-foot depth.

SITE: J4 Water Depth = 4 feet

Hand Vane Shear Testing:
None Taken

Samples and Material Descriptions:

Sample No.	Depth (feet)	Material Descriptions:
25	1	CL, Gray Sandy Clay with Shell Fragments, LI[b] = 1.33

[b] See Note 3

24	3	CL, Gray Sandy Clay with Shell Fragments LI[b] = 1.70

Comments: Impenetrable shell layer encountered at depth of 3.3 feet.

SITE: K1 Water Depth = 2.3 feet

Hand Vane Shear Testing:
None Performed

Samples and Material Descriptions:

Sample No.	Depth (feet)	Material Descriptions:
48	1	Cl-ML, Gray Clayey Silt with Shell Fragments and Sand, LI[b]= 2.92
47	2	SM, Gray Silty Sand with Shell Fragments

Comments: None.

SITE: K2 Water Depth = 3 feet

Hand Vane Shear Testing:
None Performed.

Samples and Material Descriptions:
None Recovered.

Comments: Less than 1 foot of soft material overlies layer of shell fragments. Approximately 500 feet farther from shore, water depth increases to 4.5 feet and surface material consists of a 3-foot plus thick layer of very soft material.

SITE: K3 Water Depth = 2.3 feet

Hand Vane Shear Testing:
None Performed

Samples and Material Descriptions:

Sample No.	Depth (feet)	Material Descriptions:
46	1	CL-ML, Gray Clayey Silt with Shell Fragments and Sand, LI[b] = 10.1
45	2.5	CL, Gray Sandy Clay with Shell Fragments, LI[b] = 1.18

Comments: Sampler penetration of 2.5 feet.

SITE: K4 Water Depth = 3 feet

[b] See Note 3

Hand Vane Shear Testing:
None Performed

Samples and Material Descriptions:
None Recovered

Comments: Hard shell bottom.

SITE: K5 Water Depth = 2.1 feet

Hand Vane Shear Testing:
None Performed

Samples and Material Descriptions:

Sample No.	Depth (feet)	Material Descriptions:
44	1.6	CL-ML, Gray Clayey Silt With Shell Fragments and Sand, LI[b] = 3.33 LI[b] = 1.57

Comments: Sampler penetration of 1.6 feet.

---

[b] See Note 3

NOTES:

1. See Summary of Laboratory Test Results, Exhibit 1 for additional test data on samples 1 through 50.

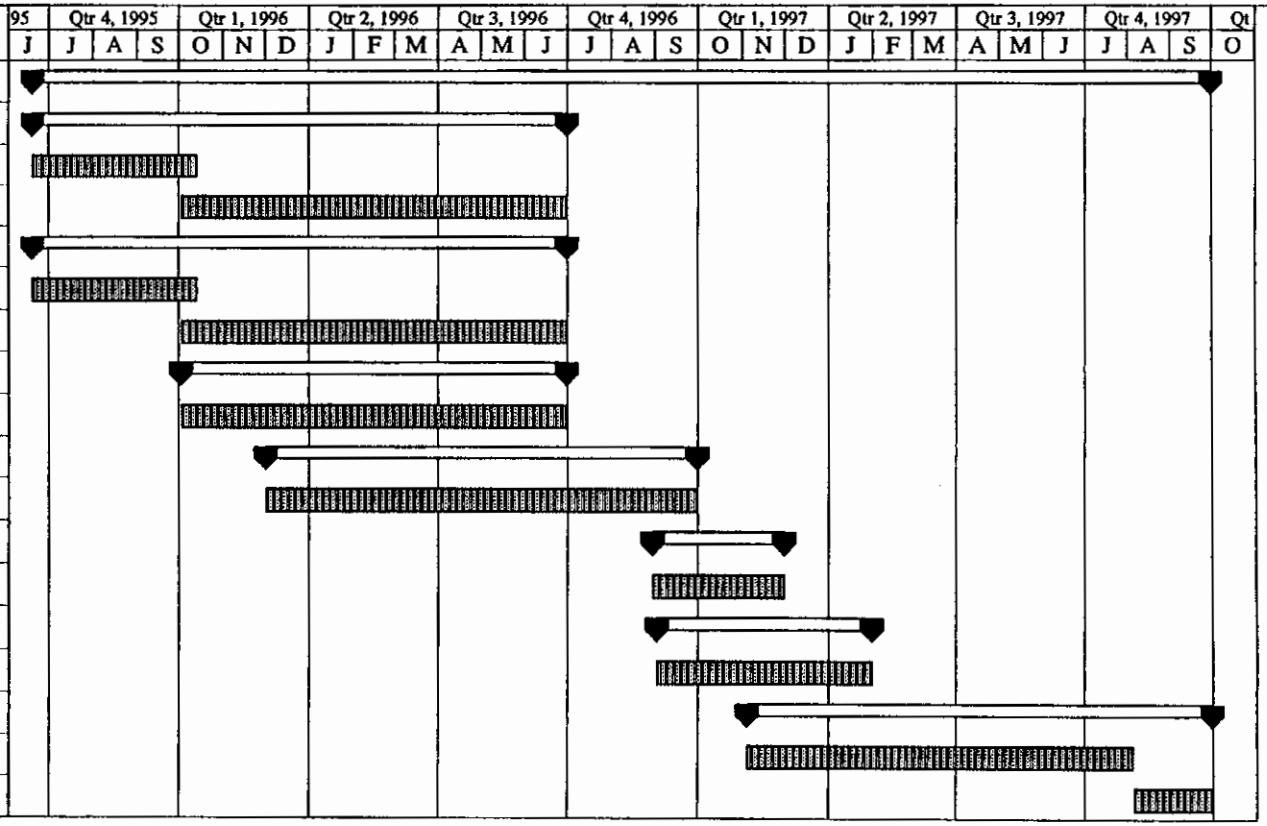
2. Tide elevations were between 2.5 to 3.0 feet MLT throughout the test period.

3. LI (Liquidity Index) $= \dfrac{MC - PL}{LL - PL}$ MC = percent of moisture content, PL = plastic limit, LL = liquid limit

4. Vane shear correction factor 0.8 is applied for computing the shear strength.

ARANSAS NATIONAL WILDLIFE REFUGE SECTION 216 STUDY
PRE-CONSTRUCTION ENGINEERING AND DESIGN SCHEDULE

ID	Project Task
1	**PED Studies**
2	**Refine Geotech**
3	Perform Geotech Field Work
4	Geotech Analysis
5	**Refine H&H**
6	Perform H&H Field Work
7	H&H Analysis
8	**Refine Structural**
9	Refine Timber Pile Design
10	**Refine Civil**
11	Refine Disposal Plan
12	**Refine Costs for Disposal Plan**
13	MCACES Completion
14	**Value Engineering**
15	Value Engineering Study
16	**Design**
17	Plans & Specs Constr. Contract #1
18	Review Plans & Specs Contract #1



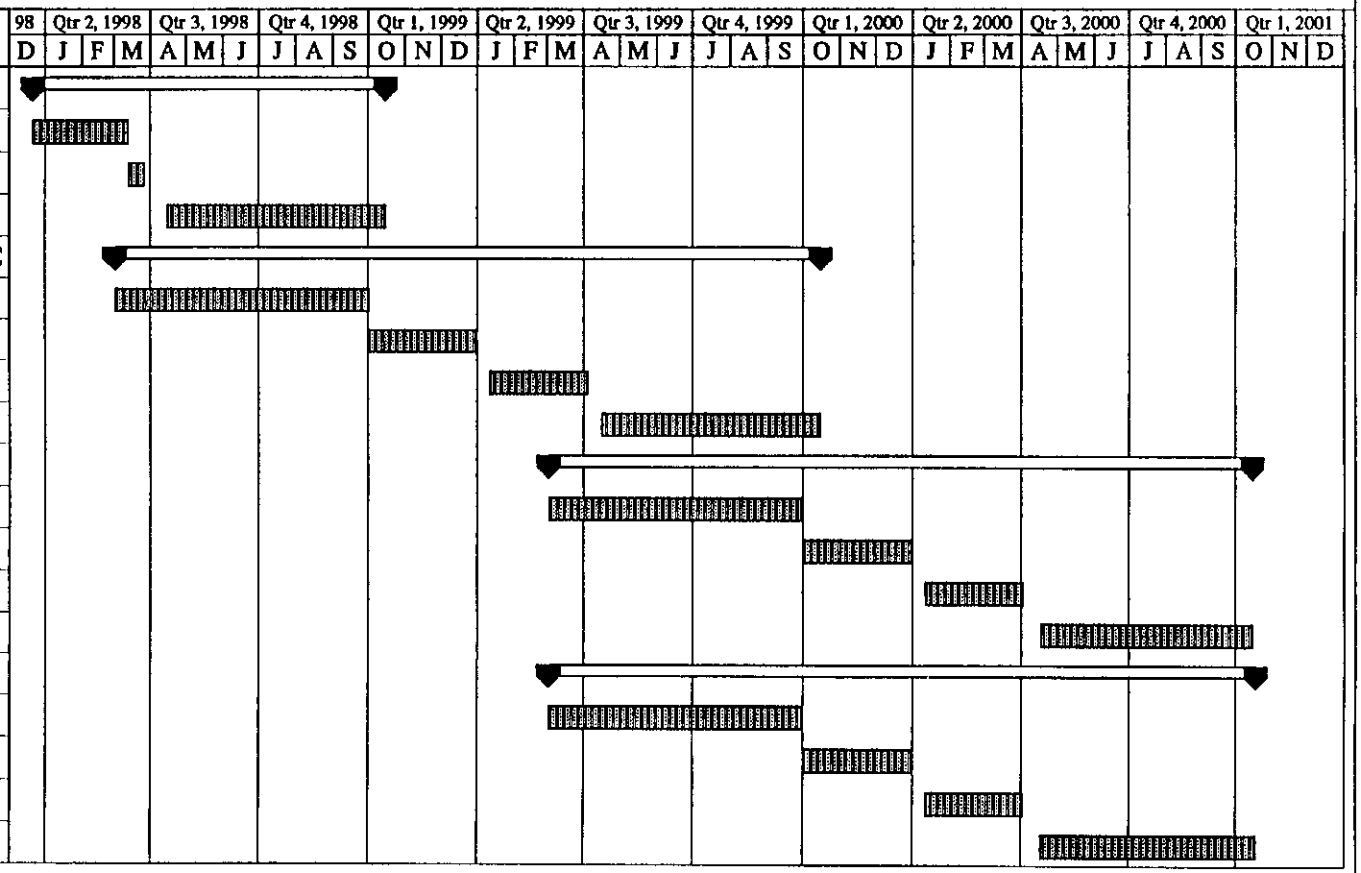
Project: ANWR Section 216 Study
Date: 5/8/95

Critical Task
Non-Critical Task
Milestone
Summary
Progress

EXHIBIT 3

ARANSAS NATIONAL WILDLIFE REFUGE SECTION 216 STUDY
CONSTRUCTION SCHEDULE

ID	Project Task
1	**Constr. Contract #1 - Mats (Refuge)**
2	Advertise
3	Award
4	Construction
5	**Constr. Contract #2 - Mats (Welder)**
6	Plans & Specifications
7	Review Plans & Specifications
8	Advertise
9	Construction
10	**Constr. Contract #3 - Grout Tubes**
11	Plans & Specifications
12	Review Plans & Specifications
13	Advertise
14	Construction
15	**Constr. Contract #4 - Timber Piles**
16	Plans & Specifications
17	Review Plans & Specifications
18	Advertise
19	Construction



Project: ANWR Section 216 Study
Date: 5/8/95

Critical Task
Non-Critical Task
Milestone
Summary
Progress

EXHIBIT4

FUNDING ESTIMATES BY FISCAL YEAR

Aransas National Wildlife Refuge

Engineering and Design**

Fiscal Year	1995					1996					1997					Grand
TASK	1st Q	2nd Q	3rd Q	4th Q	Total	1st Q	2nd Q	3rd Q	4th Q	Total	1st Q	2nd Q	3rd Q	4th Q	Total	Totals
Project Design Memorandum																
Refine Geotech & H&H	0	0	45,500	136,400	181,900	136,400	0	0	0	136,400	0	0	0	0	0	$318,300
Draft Appendices/Refine Costs-MCACES/Compile PDM	0	0	0	0	0	136,400	341,100	295,600	136,400	909,500	0	0	0	0	0	$909,500
Value Engineering Study	0	0	0	0	0	0	0	0	33,000	33,000	17,000	0	0	0	17,000	$50,000
Design																
Plans & Specs Constr. Contract #1	0	0	0	0	0	0	0	0	0	0	25,800	51,700	51,700	25,800	155,000	$155,000
Totals	$0	$0	$45,500	$136,400	$181,900	$272,800	$341,100	$295,600	$169,400	$1,078,900	$42,800	$51,700	$51,700	$25,800	$172,000	$1,432,800

**Note: Based on Oct 94 Price Levels

FUNDING ESTIMATES BY FISCAL YEAR

Aransas National Wildlife Refuge

Construction**

Fiscal Year	1998					1999					2000					Grand
TASK	1st Q	2nd Q	3rd Q	4th Q	Total	1st Q	2nd Q	3rd Q	4th Q	Total	1st Q	2nd Q	3rd Q	4th Q	Total	Totals
Construction Contract #1 - Mats (Refuge)																
Construction Management			79,700	95,600	175,300	16,000				16,000						$191,300
Fully Funded Cost			3,407,720	3,407,720	6,815,440	1,703,860				1,703,860						$8,519,300
Construction Contract #2 - Mats (Welder Flat)																
Plans & Specifications		17,900	53,700	53,700	125,300											$125,300
Construction Management								66,400	79,700	146,100	13,300				13,300	$159,400
Fully Funded Cost								1,669,960	1,669,960	3,339,920	834,980				834,980	$4,174,900
Construction Contract #3 - Grout Tubes																
Plans & Specifications							55,600	55,600	55,600	166,800						$166,800
Construction Management													48,000	48,000	96,000	$96,000
Fully Funded Cost													1,969,300	1,969,300	3,938,600	$3,938,600
Construction Contract #4 - Timber Piles for Booms																
Plans & Specifications								56,300	84,400	140,700	28,100				28,100	$168,800
Construction Management													32,000	32,000	64,000	$64,000
Fully Funded Cost													804,850	804,850	1,609,700	$1,609,700
Totals	$0	$17,900	$3,541,120	$3,557,020	$7,116,040	$1,719,860	$55,600	$1,848,260	$1,889,660	$5,513,380	$876,380	$0	$2,854,150	$2,854,150	$6,584,680	$19,214,100

**Note: Based on Oct 94 Price Levels

EXHIBIT 5

APPENDIX D

REAL ESTATE APPENDIX

GIWW - ARANSAS NATIONAL WILDLIFE REFUGE

REAL ESTATE PLANNING REPORT

General. The only real estate needs for this Section 216 study are for the erosion control measures. The marsh creation which is part of the long term dredged material management plan (DMMP) will be done under O&M authority. This project will protect approximately 62,000 feet of shoreline from erosion. Of this amount, approximately 17,870 feet are privately owned and require protection. If any private shoreline is protected under O&M authority before the 216 authorization, it will reduce the amount of easement required. This Section 216 project is 100 percent Federally funded, therefore the non-federal sponsor, Texas Department of Transportation (TxDOT), will have no cost sharing obligations. There is no standard estate for a bank protection easement, therefore we propose to acquire by donation, a $0 cost easement as follows:

> "A fifty (50) year easement for use by the government, its contractors, and assigns to construct and maintain interlocking concrete shore erosion protection mats upon lands of the grantors, reserving, however, to the grantors, their heirs, and assigns all such rights and privileges in the land as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines."

If the owner refuses to donate the $0 value easement, condemnation with a $1.00 deposit may be necessary. Since erosion protection provides a direct special benefit to the remainder parcel, this benefit can be offset against the value of the easement itself for a total compensation of $1.00 nominal consideration. Since we are impacting such a narrow strip of land with the erosion mats, mineral rights will not be acquired nor subordinated for the project.

Location and Description of the Area. The project is located in Calhoun County where the terrain is primarily Gulf Coast pasture land.

Federally-owned lands. The Aransas National Wildlife Refuge is the only Federally-owned land in the project area.

Lands, Easements and Rights-of-Way Required. Real Estate needs for this 216 study, for which we are seeking Congressional authority, are only for the erosion control measures. The long term dredged material management plan (DMMP) which includes marsh creation, will be done under O&M authority and is addressed herein for information only and not for authorization.

a. Bank protection easement. The landowner will grant to the United States Government, its contractors, or assigns a 50-year easement to enter upon their lands for

the purpose of placing mats on their shoreline to protect whooping crane critical habitat and the underlying property from erosion.

b. The spill containment areas will consist of driving pilings in navigable waters. Navigation servitude will be exercised and no real estate interest will be required.

c. Marsh creation is part of the DMMP and will be done under O&M authority. This will be done in navigable waters and navigation servitude will be exercised. No real estate interest will be required.

d. Recreation Features. There are no proposed recreation features.

e. Relocation Assistance (Public Law 91-646). There are no persons, farms, or businesses displaced by this project, therefore no relocation assistance benefits are payable under Public Law 91-646, and no 90 day notice to vacate is required.

f. There are no known HTRW or other environmental contaminants within the proposed project area.

g. All the construction areas for this project will fall within one of the following parameters: located within waters subject to tidal action and used under navigation servitude, located within the 66,000 linear foot area where a "Special Use Permit" is held from the Department of Interior until October 1, 1997, or located on approximately 17,870 feet of privately owned shoreline which will be used under no cost easements.

Landowner Attitude. The only private landowner (the Cliburn family) to be affected by the placement of the erosion protection mats has generally agreed to provide the necessary easements in return for receiving protection from erosion to their private property. Unless the Federal government receives additional acquisition authority pursuant to the Section 216 study, no authority to spend federal funds for real estate interests would exist. The 216 authority must provide for direct Federal acquisition in the event a 50-year easement for constructing and maintaining the erosion control mats requires condemnation. The Cliburn family acknowledges the erosion control mats will prevent further damage to their lands, but may still be reluctant to grant an easement for the entire 50 years which will be required for maintenance if the 216 project is authorized. Although erosion protection will prevent further damage to private land, the primary purpose for the mats is to protect critical habitat for the endangered whooping crane as provided in the Endangered Species Act. Due to the shore erosion benefits to be provided by the project to these lands, no cost is associated with the real estate except for labor costs. The non-federal sponsor, TxDOT, does acquire dredged material disposal sites and related pipeline routes for the GIWW project. However, the State statute authorizing it to be the sponsor does not allow them to acquire lands for items such as bank protection or mitigation. Until their authority is broadened, the United States would need to be given the authority by congressional authorization of this 216 project in order to acquire the bank protection easements.

Estimated Valuation. There are no real estate costs for lands and damages for this project. Labor costs plus contingencies are estimated to be $15,000.

UNITED STATES DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE

ARANSAS National Wildlife Refuge

SPECIAL USE PERMIT

Station Number to be Credited	Permit Number
21530	73673

Date: FEBRUARY 28, 1994

Period of Use (inclusive)

From 6/15 19 94,95,96,97

To 10/01 19 94,95,96,97

Permittee Name

US ARMY CORPS OF ENGINEERS
GALVESTON DISTRICT

Permittee Address

US ARMY CORPS OF ENGINEERS
GALVESTON DISTRICT
P O BOX 1229
GALVESTON, TX 77553-1229
OPERATIONS (409) 766-3385

Purpose (specify in detail privilege requested, or units of products involved)

Permit installation of interlocking concrete mats to stabilize eroding shoreline of GIWW within the Aransas NWR, Texas

Reference: Section 7 Biological Opinion and associated correspondence regarding operation of GIWW

Description (specify unit numbers; metes and bounds, or other recognizable designations)

Installation of 7000 ft. of interlocking concrete mats along shoreline of GIWW through Aransas NWR to halt erosion loss. Sites for installation selected by Refuge Manager or designee as described in correspondence with CE and discussed in on-site visits between USCE & FWS Refuge Personnel

Amount of fee $ n/a if not a fixed payment, specify rate and unit of charge: Waived

- ☐ Payment Exempt - Justification:
- ☐ Full Payment
- ☐ Partial Payment - Balance of payments to be made as follows:

Record of Payments

Waived

Special Conditions

See attached

This permit is issued by the U.S. Fish and Wildlife Service and accepted by the undersigned, subjected to the terms, covenants, obligations, and reservations, expressed or implied herein, and to the conditions and requirements appearing on the reverse side.

Permittee Signature	Issuing Officer Signature and Title
Richard M. Sullivan	J. Brent Giglinger
Chief, Real Estate Division, or ~~Acting Chief, Real Estate Division~~	Refuge Manager, Aransas NWR Complex

Form 3-1383 (Rev. 6/85)

SPECIAL CONDITIONS - SUP # 73678

1. This permit authorizes the U.S. Army Corps of Engineers, Galveston District, working through their designated contractor(s) to place interlocking concrete mats along the Aransas National Wildlife Refuge shoreline adjacent to the Gulf Intracoastal Waterway as described below.

2. All work shall be performed as described in US Army Corps of Engineer Bid Invitation and any subsequent contracts, invitations and amendments. Specific project sites for up to 7000 feet of protection have been selected by joint agreement of the Corps and the refuge and are described in an attachment to a February 24, 1994 letter from the Acting Chief, Real Estate Division to the Aransas NWR Manager and are further incorporated into this permit. Sites are from sta. #809+432 to sta. #829+213.

3. For work in 1995 and beyond, the permittee shall consult with the Refuge Manager or his designee about selection of specific work sites and amount of work to be performed prior to bid solicitation.

4. The Refuge Manager reserves the right to modify the conditions of this permit in subsequent years if experience deems it necessary to protect Refuge resources.

5. Permittee (or the Contractor if so assigned by the Permittee) shall notify the Refuge Manager or his designee at least one week prior to initiating work or moving equipment to the site.

6. Permittee (or Contractor if so assigned by the Permittee) shall keep the Refuge Manager or his designee informed on a daily basis of the status of work in progress.

7. On request of the Refuge Manager, the Permittee shall make space available for a refuge representative on site inspections.

8. Any deviations from the contract that are anticipated to significantly alter the sites chosen, method of installation, length/number of project segments, or modify the existing shoreline beyond that necessary to install the mats in the approved manner shall be coordinated with and approved in advance by the Refuge Manager or his designee.

9. The <u>Permittee (CE)</u> is authorized reasonable limited access for passenger vehicles and small boats to refuge roads, parking areas, boat ramp and boat channel as needed to <u>administer</u> this permit and the contract. Requests for such access must be coordinated in advance with the Refuge Manager or his designee, and may be subject to specific conditions and requirements as necessary to protect refuge resources and facilities. For Contractor access see item 8.

10. This permit does not authorize the Contractor or his assigns to use refuge facilities (roads, parking areas, boat ramp, boat channel, etc.) for performance of the work authorized by their contract. Any such access desired by the Contractor shall be negotiated by the Contractor with the Refuge Manager and covered under a separate Special Use Permit issued by the Refuge Manager.

11. The facilities granted under "6" above shall be kept neat and clean at all times. Parking shall not obstruct access by other users. All boat traffic in the refuge boat channel shall be "no wake" speed to minimize erosion of the banks.