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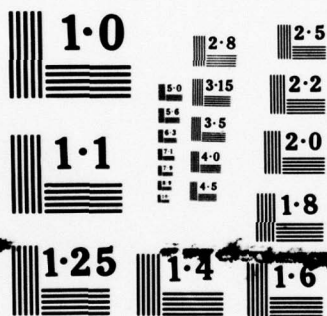
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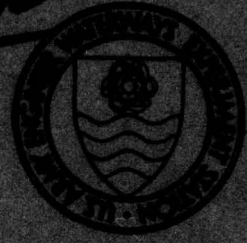


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# LEVEL II DREDGED MATERIAL RESEARCH PROGRAM



TECHNICAL REPORT D-78-32

## HABITAT DEVELOPMENT FIELD INVESTIGATIONS APALACHICOLA BAY MARSH DEVELOPMENT SITE APALACHICOLA BAY, FLORIDA SUMMARY REPORT

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30 September 1978

SUBJECT: Transmittal of Technical Report D-78-32

TO: All Report Recipients

1. The technical report transmitted herewith represents the results of one of a series of research efforts (work units) undertaken as part of Task 4A (Marsh Development) of the Corps of Engineers' Dredged Material Research Program. Task 4A was part of the Habitat Development Project (HDP) and had as its objective the development and testing of the environmental and economic feasibility of using dredged material as a substrate for marsh development.
2. Marsh development using dredged material was investigated by the HDP under both laboratory and field conditions. This report, "Habitat Development Field Investigations, Apalachicola Bay Marsh Development Site, Apalachicola Bay, Florida," (Work Unit 4A19A) presents and discusses the results of salt marsh development studies at Apalachicola, Florida, in 1976 and 1977.
3. A total of nine marsh development sites were selected and designed by the HDP at various locations throughout the United States. Six sites were subsequently constructed. Those, in addition to Apalachicola Bay, include: Windmill Point on the James River, Virginia (4A11); Buttermilk Sound, Atlantic Intracoastal Waterway, Georgia (4A12); Bolivar Peninsula, Galveston Bay, Texas (4A13); Pond #3, San Francisco Bay, California (4A18); and Miller Sands, Columbia River, Oregon (4B05). Detailed design for marsh restoration at Dyke Marsh on the Potomac River (4A17) was completed, but project construction was delayed in the coordination process. Marsh development at Branford Harbor, Connecticut (4A10) and Grays Harbor, Washington (4A14) was terminated because of local opposition and engineering infeasibility, respectively.
4. Evaluated together, the field site studies plus ancillary field and laboratory evaluations conducted in Task 4A establish and define the range of conditions under which marsh habitat development is feasible.

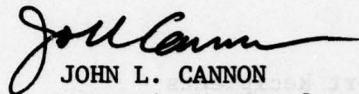
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Data presented in the research reports prepared under this task will be synthesized in the technical reports entitled "Upland and Wetland Habitat Development with Dredged Material: Ecological Considerations" (2A08) and "Wetland Habitat Development with Dredged Material: Engineering and Plant Propagation" (4A24).



JOHN L. CANNON  
Colonel, Corps of Engineers  
Commander and Director

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## PREFACE

This report summarizes the study of salt marsh development on a dredged material island in Apalachicola Bay, Florida. The effort was conducted as part of the U. S. Army Corps of Engineers (CE) Dredged Material Research Program (DMRP), under Task 4A, "Marsh Development," Work Unit No. 4A19A, of the Habitat Development Project (HDP). Fieldwork and monitoring of the project were conducted under DMRP Work Unit No. 4A19, "Marsh Development, Apalachicola Bay, Florida."

The DMRP Civil Works Program was sponsored by the Office, Chief of Engineers, U. S. Army (DAEN-CWO-M), and administration of the program was assigned to the Environmental Laboratory (EL) of the U. S. Army Engineer Waterways Experiment Station (WES), Vicksburg, Mississippi.

Planting of the marsh grass sprigs was accomplished through a cooperative effort by personnel from the Mobile District, CE, and the HDP. Monitoring of the growth and development of the marsh plants was contracted through the Mobile District to Environmental Systems Service of Tallahassee, Inc., Tallahassee, Florida (Contract No. DACW01-77-C-0022), with Dr. William L. Kruczynski, Florida A&M University, Tallahassee, Florida, as the principal investigator.

The plan of study for the project was developed under the guidance of HDP Botanist, Dr. Luther F. Holloway, EL. Contract No. DACW01-77-C-0022 was managed by Drs. Holloway and Robert Terry Huffman, Research Botanist, HDP. The project was under the general administrative supervision of Drs. Hanley K. Smith, Manager, HDP, Roger T. Saucier, Special Assistant, DMRP, and John Harrison, Chief, EL. This report was prepared by Drs. Kruczynski and Huffman and Ms. Mary K. Vincent, Physical Scientist, HDP.

Drafts of this report were critically reviewed and edited by Dr. Richard A. Cole of the Natural Resources Development Branch, EL, and of the Department of Fisheries and Wildlife, Michigan State University, East Lansing, Michigan.

The Commander and Director of WES during the period of study and report preparation was COL John L. Cannon, CE. Technical Director of WES was Mr. Fred R. Brown.

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HABITAT DEVELOPMENT FIELD INVESTIGATIONS, APALACHICOLA BAY  
MARSH DEVELOPMENT SITE, APALACHICOLA BAY, FLORIDA

SUMMARY REPORT

PART I: INTRODUCTION

Background

1. In response to growing environmental awareness and the increasing problem of acceptable disposal of dredged material, Congress authorized the Dredged Material Research Program (DMRP) in 1970. Assigned to the U. S. Army Engineer Waterways Experiment Station (WES), Vicksburg, Mississippi, the overall objectives of the DMRP were:

To provide through research, definitive information on the environmental impact of dredging and dredged material disposal operations, and to develop technically satisfactory, environmentally compatible, and economically feasible dredging and disposal alternatives, including consideration of dredged material as a manageable resource.

One of the primary efforts of the DMRP was to assess the feasibility of developing habitat on dredged material substrate. To accomplish this the Habitat Development Project (HDP) conducted several field studies in marsh, island, upland, and aquatic habitats. In the studies of marsh habitat development, the HDP specifically sought to demonstrate and evaluate the environmental, economic, and engineering feasibility of using dredged material as a substrate for marsh habitat development.

Purpose of Study

3. The Apalachicola field project, located in Apalachicola Bay, Florida (Figure 1), was designed primarily to test the feasibility of propagating selected marsh plants on fine-grained and coarse-grained dredged materials that had been placed in a saline intertidal environment. Additionally, studies were conducted in order to determine the optimum spacing intervals for planting the selected species. The project design permitted results to be applicable to efforts in stabilizing dredged material in environments similar to that at the study site.

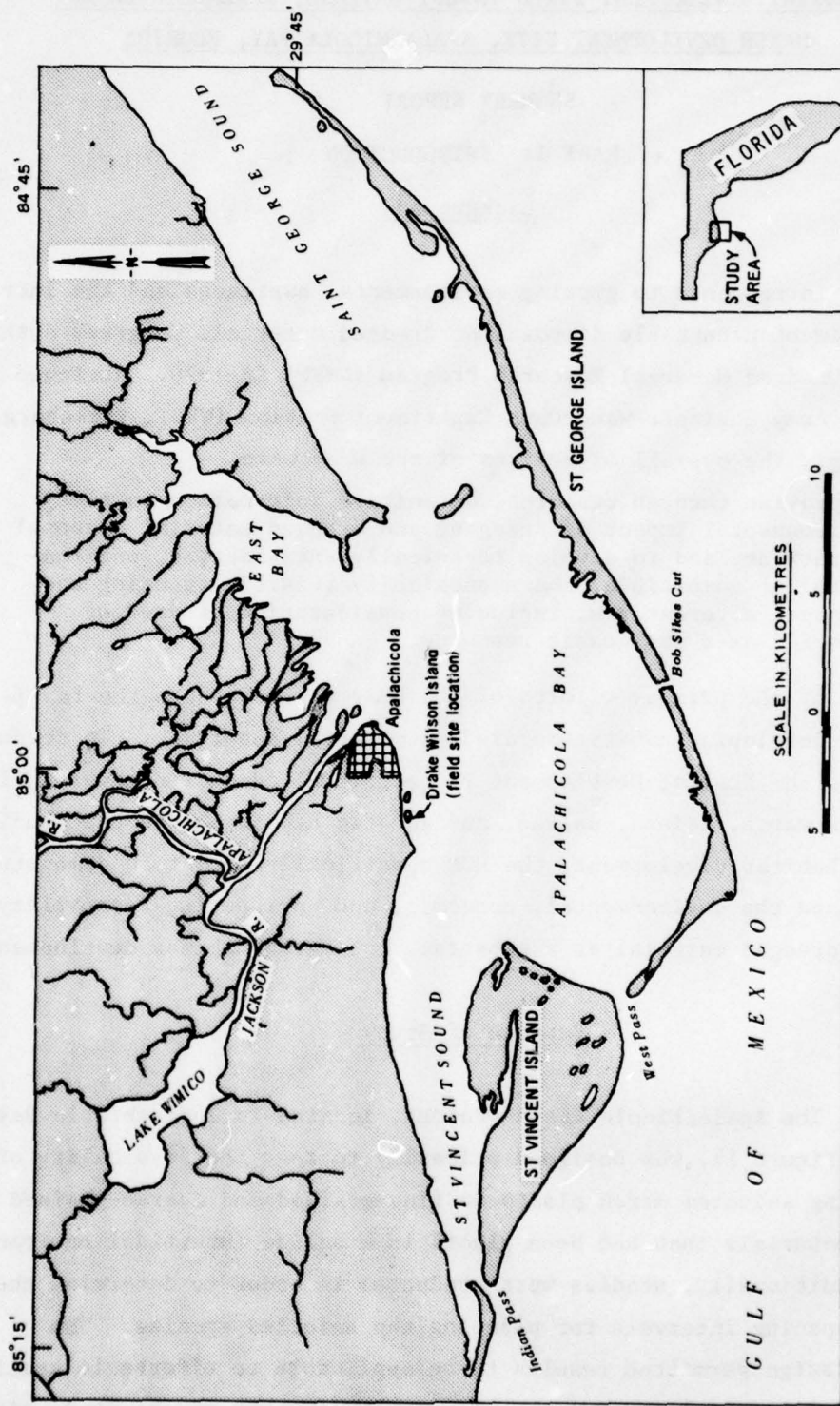


Figure 1. Locational map of Apalachicola Bay area and field study site

## PART II: SITE CHARACTERIZATION

### Description of General Area

4. Apalachicola Bay, a lagoon and barrier island complex on the upper gulf coast of Florida (Figure 1), is one of the most productive and least polluted estuaries in the country. The bay area, including St. George Sound, is about 65 km long and 5 to 10 km wide, and is separated from the Gulf of Mexico by Dog, St. George, and St. Vincent Islands. Within the bay's shallow waters (average depth mlw is about 3 m) are numerous oyster reefs and sandy shoals. The surrounding wooded lowlands consist of saltwater and freshwater marshes, and freshwater swamps (Environmental Laboratory 1978).

5. The subtropical climate is controlled chiefly by latitude and location on the gulf. The average annual temperature at the weather station at Apalachicola is 20.4° C (Water Information Center 1974). Summers are long, warm, and humid while winters are mild. Normally, only five days per year have a minimum below 0° C. Annual precipitation averages 142.8 cm, but varies greatly from year to year. Months with highest rainfall coincide with the tropical storm season.

6. Riverine discharge, principally from the Apalachicola River, is an important factor in the bay's ecology; salinity, nutrient, and turbidity levels are seasonal and related to the discharge. Tides are diurnal but irregular. At Apalachicola the diurnal range is 0.5 m and mean tide level is 0.3 m (Livingston et al. 1974).

7. The local economy is based on the productive commercial fisheries such as oysters (Crassostrea virginica), blue crabs (Callinectes sapidus), and shrimp (Penaeus spp.). Sports fishery is also extensive and is based on seatrout (Cynoscion spp.), redfish (Sciaenops ocellatus), sheepshead (Archosargus probatocephalus), whiting (Menticirrhus americanus), and flounder (Paralichthys spp.).

### Site Preparation

8. In March 1976, as part of an ongoing maintenance project in Apalachicola Bay, the U. S. Army Engineer District, Mobile, dredged Two Mile Channel, a navigation channel that leads northward for 1.9 km from the open bay into a lateral east-west channel along the shore (Figure 2). As part of the operation, dredged material was placed on two previously used disposal sites at the junction of the two channels.

9. The disposal sites, two small triangular islands, had been diked from January to March 1976 with sandy clay material from the bay. During April and May, coarse-grained sandy material from the Two Mile Channel maintenance dredging was pumped into the diked areas and the breakwaters were graded. Photographs of the site preparation are given in Figure 3.

10. The larger island (19.2 ha), Drake Wilson Island, located west of Two Mile Channel, was selected for the study site. In order to prepare the site for marsh plant propagation, an intertidal area was formed by placing a weir in the containment dike on the bay side of Drake Wilson Island (Figure 4). The weir permitted tidal influx, thus providing a tidal regime similar to that in local intertidal marshes. To provide suitable substrate, fine-grained dredged material was pumped over the coarse-grained sandy material that had been deposited earlier. Within 30 days (by May 1976) the fine-grained material had dispersed into the intertidal area and had accumulated to a depth of 0.6 to 1.0 m and to a surface elevation of about 0.3 m below mlw. The supratidal substrate of the island, particularly in the highest areas, consisted largely of coarse-grained sand.

### Substrate Characterization

11. General chemical and physical analyses of the dredged material substrates at Drake Wilson Island indicate a distinct difference between the fine-grained surface sediments (0-30 cm) of the intertidal area and the coarse-grained dredged material that comprises much of the

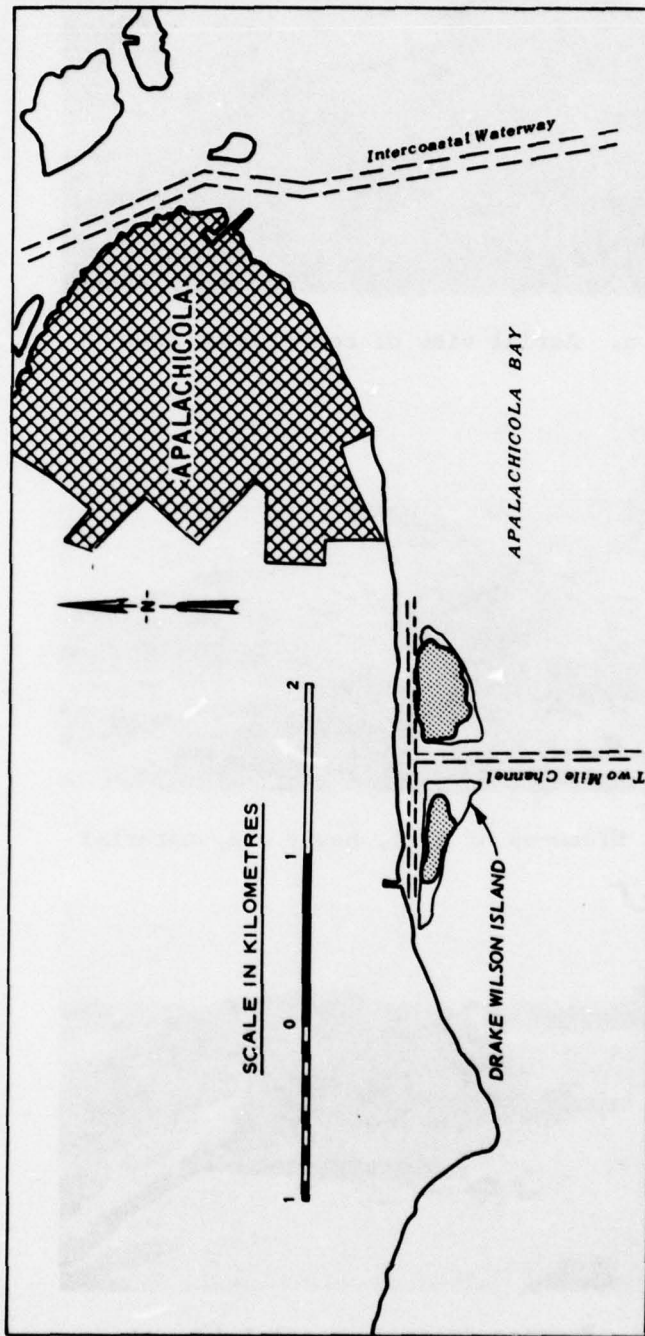


Figure 2. Location of Two Mile Channel and the two disposal sites that resulted from construction of Two Mile Channel. The shaded areas indicate the approximate sizes of the disposal sites prior to the 1976 maintenance operation.



a. Aerial view of containment area

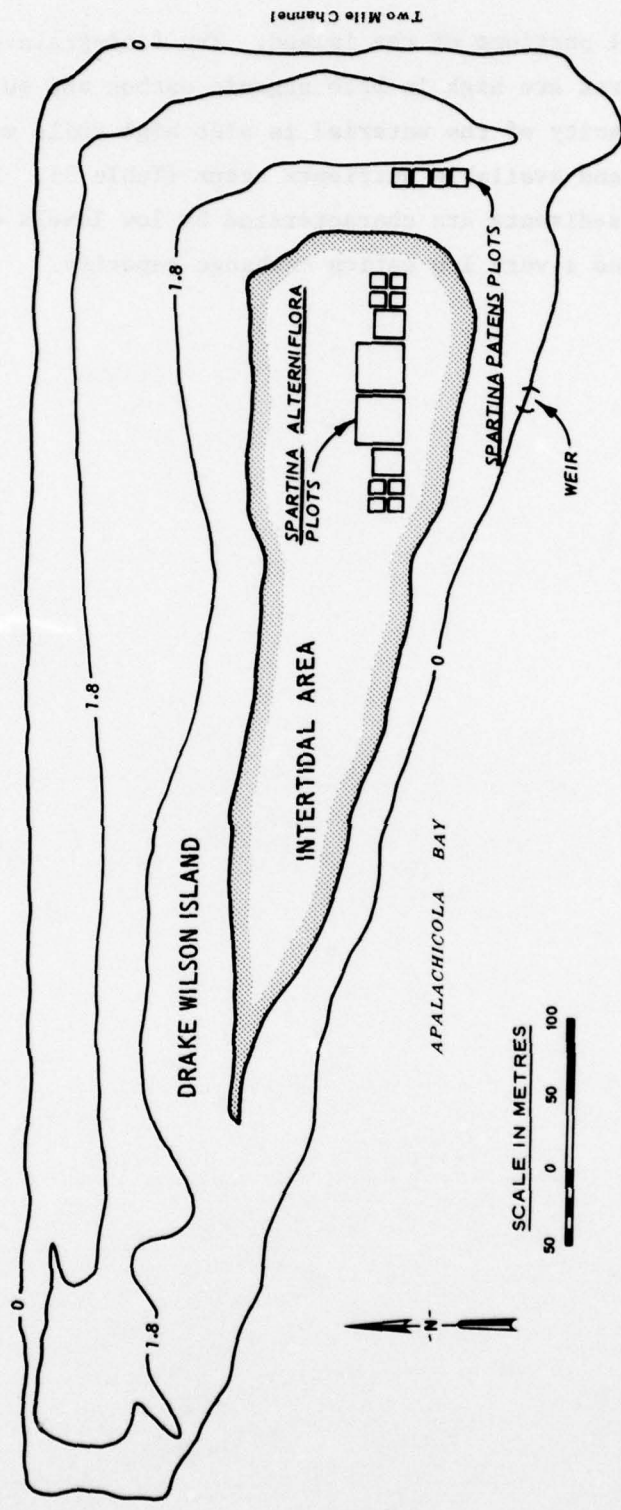


b. Close-up of dike, heavy clay material



c. Pumping dredged material into the  
containment area

Figure 3. Site preparation, spring 1976



NOTE: CONTOURS ARE IN METRES, MLW

Figure 4. Study site on Drake Wilson Island, June 1976

remaining supratidal portions of the island. The fine-grained sediments of the intertidal area are high in both organic carbon and sulfides. The cation exchange capacity of the material is also high while moderate levels of salinity and available nutrients occur (Table 1). In contrast, the coarse-grained sediments are characterized by low levels of organic carbon, sulfides, and a very low cation exchange capacity.

Table 1

Substrate Properties of the Fine-grained and Coarse-grained  
Dredged Material on Drake Wilson Island  
September 1977

Property*	Fine-grained†	Coarse-grained††
Grain size	67 to 87% <32 $\mu$	80% >32 $\mu$ and <500 $\mu$ 20% >500 $\mu$
Organic carbon	4.53 to 6.10%	Slight
Cation exchange capacity	46.7 to 59.8 mg/100g	0.31-0.52 mg/100g
Salinity	14.5 to 18 ‰	10 ‰
pH	7.88 to 8.21	5.22 to 8.00
Total sulfide	47.3 to 350 mg/kg	3.2 to 28.5 mg/kg
Total Kjeldahl nitrogen	moderate	very low
Ammonium nitrogen	moderate	very low
Nitrate nitrogen	moderate	very low
Nitrite nitrogen	moderate	very low

\* Methods for soil analysis were techniques given by:

1) Black et al. (1965) for organic carbon (pp. 1372-1376), pH (pp. 922-923), grain size (pp. 552-562), cation exchange capacity (pp. 899-900), salinity (pp. 933-940) and nitrogen forms (pp. 1149-1254).

2) Goldhaber (1974) for total sulfide

† The fine-grained dredged material samples were collected within experimental plots planted with smooth cordgrass (Spartina alterniflora)

†† The coarse-grained dredged material samples were collected within experimental plots planted with saltmeadow cordgrass (Spartina patens).

### PART III: METHODS

#### Marsh Plant Propagation

12. Two marsh plant species, which commonly occur in coastal areas of the Gulf of Mexico, were selected for planting on Drake Wilson Island: smooth cordgrass (Spartina alterniflora) and saltmeadow cordgrass (Spartina patens). These species were selected for two reasons. They are known to colonize brackish water environments (Eleuterius 1972) and transplant material was readily available from native marsh communities in the Apalachicola Bay area.

13. The study site was planted during July 1976. Transplants were obtained from established intertidal marsh communities on St. Vincent Island (Figure 1). Sprigs were spade-dug from the natural marshes and included aboveground stems with attached underground roots and rhizomes. Care was taken to keep the sprigs moist and undamaged during transplanting. Smooth cordgrass sprigs consisted of single untrimmed culms (inflorescence bearing culm) attached to a 7- to 13-cm rhizome. Saltmeadow cordgrass sprigs consisted of mature plants with 5 to 10 untrimmed leaves attached to a section of rhizome.

#### Experimental Design

14. Both of the plant species selected for this feasibility study were planted at elevations, with respect to tidal fluctuation regime, that corresponded as closely as possible to those at which the plants were originally growing. The fine-grained dredged material in the intertidal area was planted with smooth cordgrass. Saltmeadow cordgrass was planted in coarse-grained dredged material at an elevational range from approximately 0.3 m below mean high water to approximately 1.5 m above this point.

15. The experimental efforts consisted of:
- a. Assessing the feasibility of planting smooth cordgrass sprigs on a fine-grained dredged material.

- b. Assessing the feasibility of planting saltmeadow cordgrass sprigs on a coarse-grained dredged material.
- c. Determining the optimum spacing interval to plant smooth cordgrass on a confined fine-grained dredged material to obtain a plant cover in a 1- to 3-yr period, that is relatively comparable to naturally occurring stands of smooth cordgrass within the study area.
- d. Determining the optimum spacing interval and elevation (in relation to mhw) to plant saltmeadow cordgrass on a confined coarse-grained dredged material to obtain a plant cover in a 1- to 3-yr period, that is relatively comparable to naturally occurring cordgrass within the study area.

#### Smooth cordgrass

16. Sprigs of smooth cordgrass were planted during July 1976 in portions of the intertidal area (Figure 4 and 5). Elevations within the planting area were nearly uniform with a gentle bayward slope of about 15 cm in 90 m. The planting design consisted of sprigs planted at 0.3-, 0.6-, 0.9-, 1.8-, and 2.7-m spacing intervals within separate experimental plots (Figure 6). Each sprig was planted approximately 10.2 cm deep in the substrate.

#### Saltmeadow cordgrass

17. Sprigs of saltmeadow cordgrass were also planted during July 1976. The planting design consisted of four experimental plots situated on an increasing elevational gradient (about 1 to 1.8 m mlw). The plots were planted with sprigs spaced at 0.3-, 0.9-, 1.8-, and 2.7-m intervals. Control plots consisted of the unplanted 1.8-m spacing intervals between each of the four plots (Figure 7). Sprigs were planted approximately 10 cm deep in the sandy substrate.

#### Mechanically assisted planting

18. Because of the difficulties (indicated in Figure 5) of planting smooth cordgrass in the unconsolidated fine-grained dredged material, the feasibility of using a Riverine Utility Craft (RUC) to better traverse the soft fluid-like material and thus reduce planting time was also tested (Figure 8). Around the perimeter of the smooth cordgrass spacing study plot, the RUC towed a 1.2- by 2.4-m sheet plywood sled that served as a platform from which to sprig the plants.



Figure 5. Sprigging smooth cordgrass (*Spartina alterniflora*)  
by hand in fine-grained unconsolidated dredged material

PLOT	SIZE, M	SPACING, M	NO. OF SPRIGS
A AND A'	9.1 x 9.1	0.3	900
B AND B'	9.1 x 9.1	0.6	225
C AND C'	9.1 x 9.1	0.9	100
D AND D'	9.1 x 9.1	UNPLANTED	0
E AND E'	18.2 x 18.2	1.8	100
F AND F'	27.3 x 27.3	2.7	100

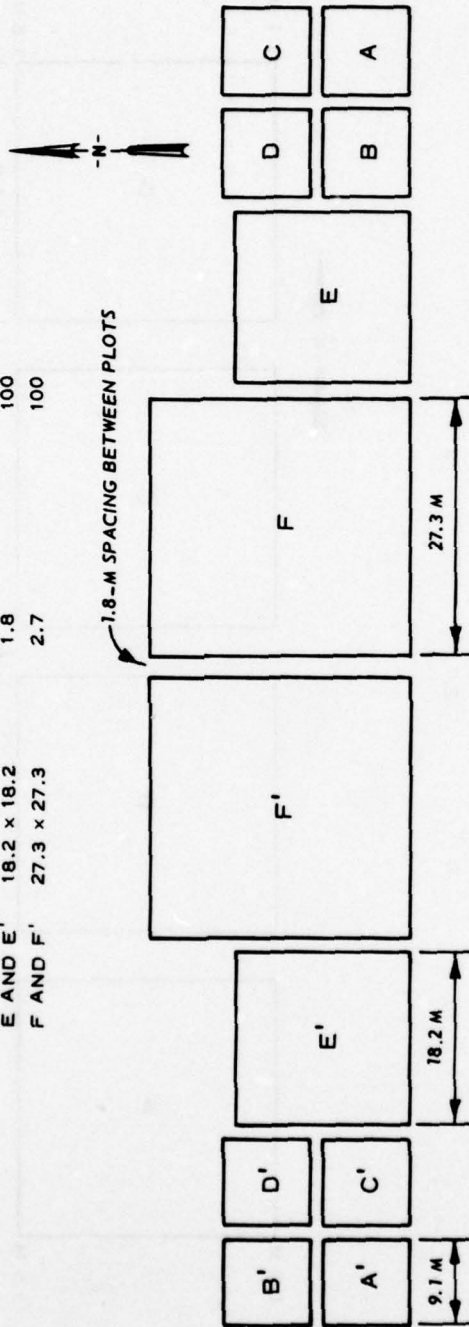


Figure 6. Plot design for smooth cordgrass (*Spartina alterniflora*) plantings. Plots A' through F' are replicates of A through F. Plots D and D' are unplanted control plots.

PLOT	SPACING, M	NO. SPRIGS
A	0.3	900
B	0.9	100
C	1.8	39
D	2.7	9

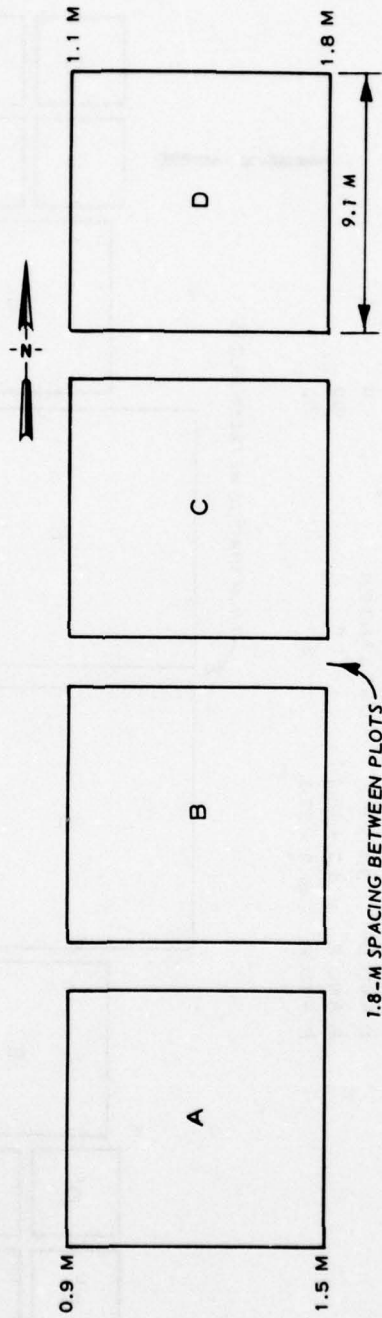


Figure 7. Plot design for saltmeadow cordgrass (*Spartina patens*) plantings. Elevations above mean low water are indicated on the four outside corners

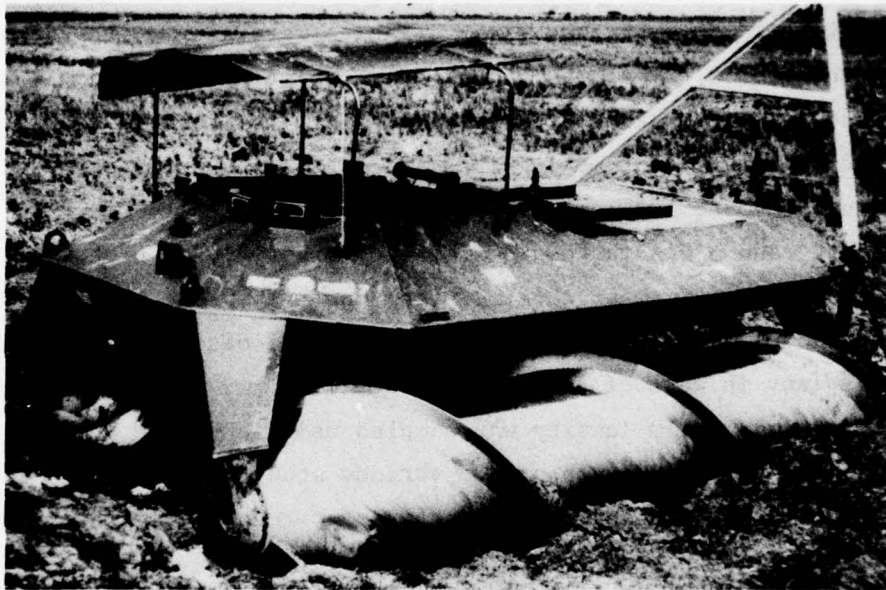


Figure 8. A Riverine Utility Craft

### Monitoring Plant Development

19. To assess transplant growth and development in relation to elevation and/or spacing, several variables were monitored within the experimental plots at five, nine, and fourteen months (December 1976, April 1977, September 1977) after sprigging (Table 2). Detailed information on how the various plant growth and development variables were monitored are discussed in the paragraphs that follow.

#### Smooth cordgrass

20. Growth and development data were obtained on the plants growing within the various experimental plots on each of the three monitoring visits. However, the same variables were not monitored on each of the visits. This was because data collection on individual transplants was impossible by April 1977 since most of the transplants had grown together, thus making individual transplants indistinguishable. During the December 1976 sampling period, data were collected from plants selected at random within the rows of each experimental plot. For plots A and A', measurements were obtained from one transplant from every other row; for plots B, C, E, F, and their replicates, data were collected from one transplant in each of 10 rows. During the April and September 1977 sampling periods, culm density was sampled using a 0.1-m<sup>2</sup> quadrat placed at random within each of the various study plots. The presence of inflorescences and estimates of percent cover were also noted within each of the experimental plots.

#### Saltmeadow cordgrass

21. Plants in the study plots of saltmeadow cordgrass were monitored in December, April, and September (Table 2). Measurements were not made in September 1977 for new rhizomal or basal shoots because the individual transplants had grown together. As in the smooth cordgrass plantings, measurements were made at random. In plots A, B, and C

Table 2

Variables Measured or Observed within Smooth Cordgrass  
(Spartina alterniflora) and Saltmeadow  
Cordgrass (Spartina patens) Study Plots

Variable	Dates Measured or Observed		
	Dec 76	April 77	Sept 77
Percent survival	X	-	-
Percent cover	X	X	X
Presence of inflorescences	X	X	X
Culm density*	X	X	X
Increase in width of transplant**	X	X	X
Change in width of transplant***	X	X	X
Number of new basal and rhizomal shoots	X	X	-

\* Smooth cordgrass only

\*\* Saltmeadow cordgrass only

\*\*\* Saltmeadow cordgrass measured throughout the period of study; smooth cordgrass measured in December 1976 only.

(Figure 7), the measurements were obtained from three transplants from every other row. In plot D, measurements were obtained from all nine transplants. The presence of inflorescences and percent cover were also noted within each of the experimental plots.

#### Monitoring Invasion by Pioneer Plant Species

22. In addition to the marsh plant propagation efforts, a floristic survey of Drake Wilson Island was made during each of three sampling periods. This was done in order to document natural invasion by plants on the dredged material island. The invading plants were identified to species and the location where the plants were found on the island was noted. Voucher specimens were collected and placed in a reference collection maintained by WES.

## PART IV: RESULTS AND DISCUSSION

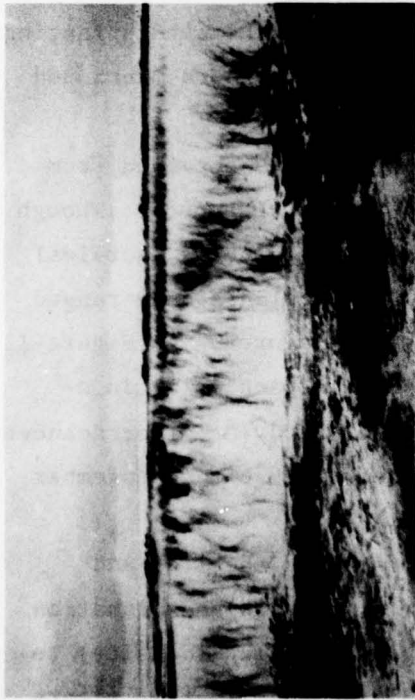
### Smooth Cordgrass Plantings

23. By December 1976, many of the originally planted sprigs had browned and withered away. However, upon examination of the below-ground portions of these plantings, it was found that their rhizomal masses were still viable. This observation of initial plant dieback of the aboveground portions of the sprigs during the first winter after planting is consistent with observations made at other HDP field sites where smooth cordgrass was planted.

24. In the 0.3-, 0.6-, and 0.9-m spacing study plots, a lush green coverage that was visually comparable to nearby natural smooth cordgrass marshes was complete by September 1977. Culm density appeared nearly uniform from December 1976 to April 1977, but near the end of the 1977 growing season, a relationship of closer plant spacing with greater culm density was obvious. Culm density for the three plots increased, respectively, from 14, 6, and  $6/m^2$  in December 1976 (5 months after planting) to 180, 166, and  $134/m^2$  in September (14 months after planting) (Figures 9 and 10). Plant cover values for all of the above mentioned spacing intervals was 100 percent by September 1977.

25. Contrary to the above observations, results obtained from sprigging at 1.8- or 2.7-m intervals after 14 months were poor. Though good growth was observed around a few of these planted culms, survival was apparently poor; cover values by September 1977 plants only ranged from 0 to 25 percent for the 1.8- and 2.7-m spacing intervals (Figure 11 and Table 3). Culm density for the 1.8- and 2.7-m spaced plantings averaged less than  $10/m^2$  throughout the period of study. Inflorescences were observed in all plots during both the December 1976 and September 1977 sampling periods (Table 3).

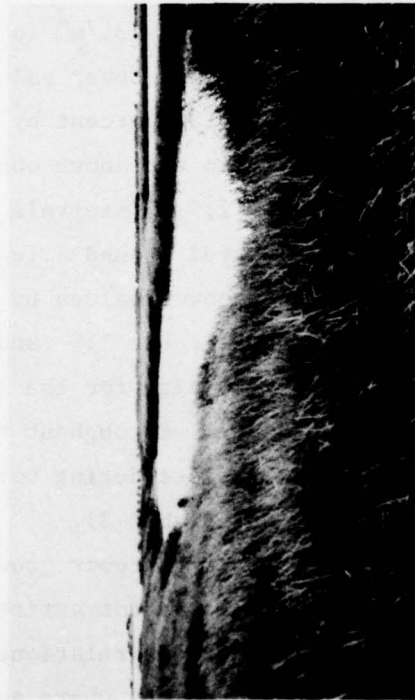
26. The reasons for poor growth response from the 1.8- and 2.7-m spacing interval are not entirely clear. A possible explanation for this observation is the relationship of plant spacing (density) to tidal energy. In situations where substrate is unconsolidated, plants



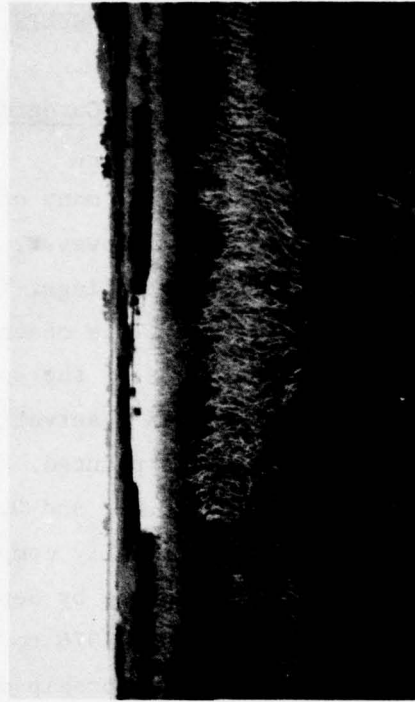
a. July 1976



b. November 1976



c. April 1977



d. September 1977

Figure 9. Photographs of smooth cordgrass (*Spartina alterniflora*) plantings during the study period

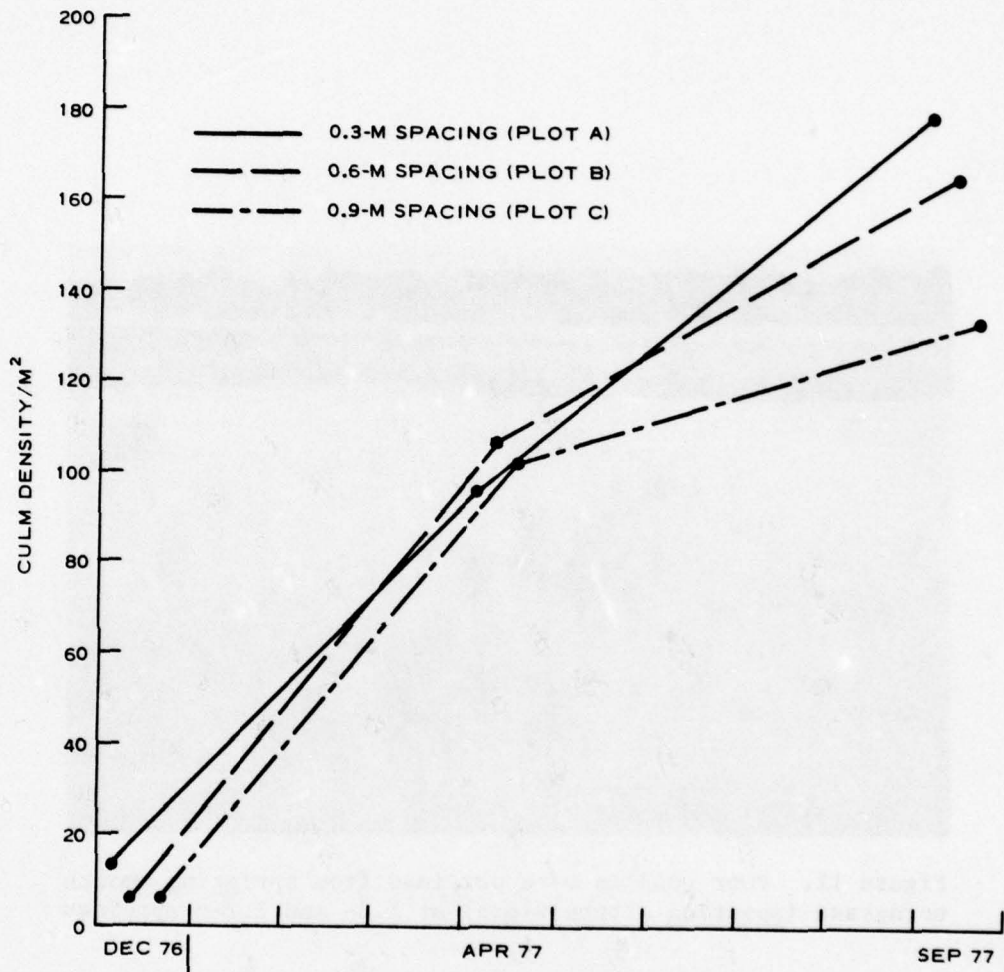


Figure 10. Increase in culm density per m<sup>2</sup> for the 0.3-, 0.6-, and 0.9-m spaced smooth cordgrass (*Spartina alterniflora*) plantings



Figure 11. Poor results were obtained from sprigging smooth cordgrass (Spartina alterniflora) at 1.8- and 2.7-m spacings

Table 3

Estimated Percent Cover per m<sup>2</sup> and Flower Presence In Smooth Cordgrass  
(Spartina alterniflora) and Saltmeadow Cordgrass (Spartina patens)  
On Three Sampling Dates

## a. Smooth Cordgrass

<u>Sample Date</u>	<u>Plot and Plot Spacing, m</u>					
	<u>A</u> 0.3	<u>B</u> 0.6	<u>C</u> 0.9	<u>D</u> Control	<u>E</u> 1.8	<u>F</u> 2.7
December 1976	% cover not estimated					
	+	+	+		+	+
April 1977	75-100%	50-75%	50-75%	0%	0-10%	0-10%
	-	-	-		-	-
September 1977	100%	100%	100%	0%	10-25%	0-10%

## b. Saltmeadow Cordgrass

<u>Sample Date</u>	<u>Plot and Plot Spacing, m</u>			
	<u>A</u> 0.3	<u>B</u> 0.6	<u>C</u> 1.8	<u>D</u> 2.7
December 1976	% cover not estimated			
	-	-	-	-
April 1977	25-50%	10-25%	10-25%	0-10%
	-	-	-	-
September 1977	75-100%	50-75%	25-50%	0-10%
	+	+	+	+

+Flowers present within plot

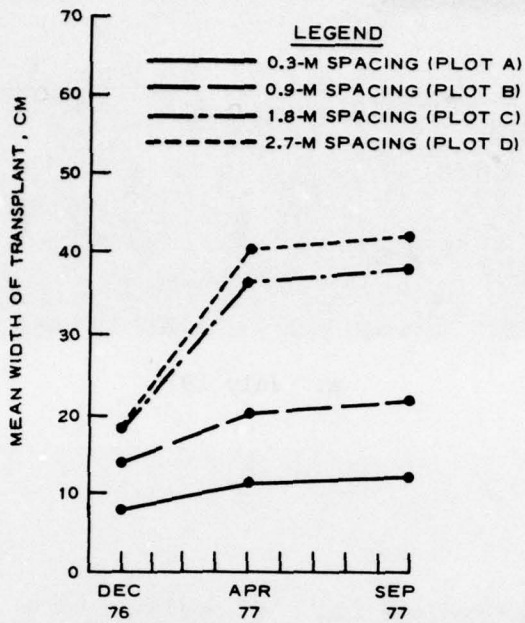
-Flowers not present within plot

subjected directly to incoming tidal energies may become loosened from their upright planted position, fall over, and thus either die or become less likely to develop properly if portions of their rhizome mass remain covered with substrate. Such was the case for smooth cordgrass planted at 1.8- and 2.7-m spacing intervals. These experimental plots were situated directly opposite the weir that was placed in the bay side dike and thus were most likely subjected to considerably higher tidal energies (Figure 4).

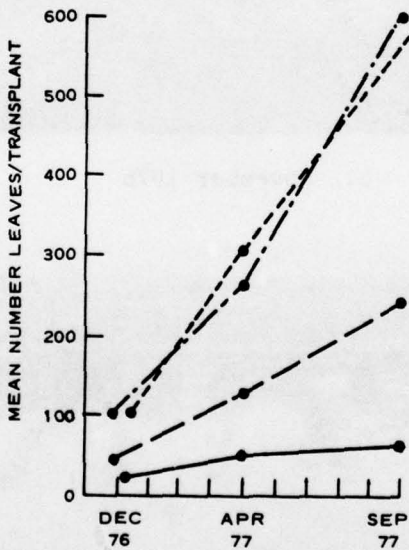
27. The Riverine Utility Craft operated well on the fluid-like fine-grained material and growth of surviving RUC-planted transplants was comparable to growth of those hand-planted in the 0.3-, 0.6-, and 0.9-m spacing plots. While the RUC operated satisfactorily on this type of material and as an aid in transplanting, it is not recommended in situations where accurate or close spacing of transplants is required. The wave action created by the turning screws moved transplants from their original planting location by as much as 0.5 m.

#### Saltmeadow Cordgrass Plantings

28. The relationship of increased plant growth with increased plant spacing was dramatic. Highest values were obtained in plots with the 1.8- and 2.7-m spacing intervals. The greater growth experienced by the wider spaced plantings was particularly evidenced by greater spread and mean number of leaves per transplant (Figures 12 and 13). In contrast, cover values were higher in the more closely spaced plantings because of the greater number of plants. The total growth of these more closely spaced plantings is considerably less, however, as is indicated by width and number of leaves (Figure 12). Thus, in terms of material produced per unit area that is potentially available to the estuarine food chain, the closer spaced plantings produced less. Inflorescences were observed in about one half of the plots in December 1976 and all of the plots were flowering in September 1977. Plants at the crest of the elevational gradient that the experiments plots were

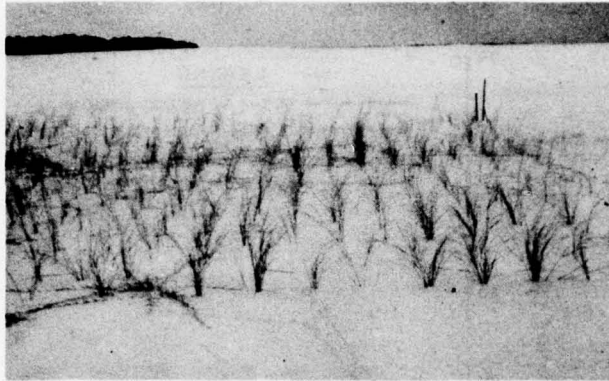


a. MEAN WIDTH OF TRANSPLANTS

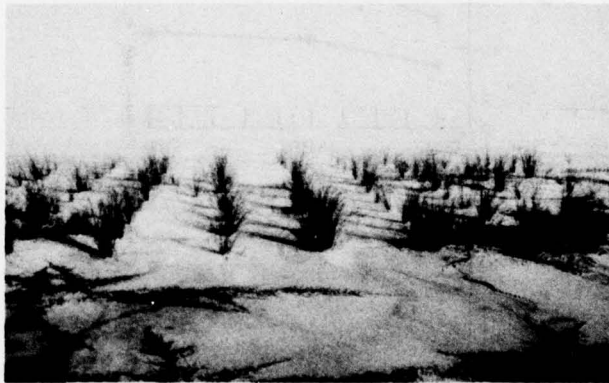


b. MEAN NUMBER OF LEAVES PER TRANSPLANT

Figure 12. Growth parameters of salt-meadow cordgrass (*Spartina patens*) plantings on each sampling date. Given as mean value per plot



a. July 1976



b. November 1976



c. April 1977

Figure 13. Photographs of saltmeadow cordgrass (Spartina patens) plantings during the study period (sheet 1 of 2)



d. July 1977



e. September 1977

Figure 13. (sheet 2 of 2)

established on were also observed to be partially covered by 30 to 50 cm of drifted sand. These plants appeared generally greener and had more inflorescences than the plants at lower elevations where sand coverage was less (Table 3). The reason for this variation is unknown. No other apparent differences were observed among the plantings with respect to elevation. Variations in the data obtained from the different plant spacings are interpreted to be primarily a function of plant competition for soil, water, and nutrients.

#### Plant Invasion

29. A list of plant invaders found on Drake Wilson Island during the study is given in Table 4. Fifteen species were documented in December 1976. In April 1977, 13 additional species were collected and in September, 14 more species were documented. A total of 42 species had invaded the island by the end of the study.

30. Of the species that invaded the island, salt grass (Distichlis spicata) grew particularly well and by the end of the study period covered a large area. Between the saltmeadow cordgrass and smooth cordgrass plantings (Figure 14) salt grass was especially abundant and completed the typical elevation-based distribution sequence for these three species.

31. It should be mentioned that besides the species planted for this study, several others were planted on Drake Wilson Island or had become established on the small existing disposal site prior to the 1976 disposal operation. A listing of these additional species is given in Table 5.

Table 4  
Invading Plant Species Collected on Drake Wilson Island  
During the Period of Study\*

Scientific Name	Common Name	Date First Collected		Location
		December 1976	April 1977	
<u>Alternanthera philoxeroides</u>	Alligator-weed	X		Sparse in moist, sandy areas
<u>Aster undulatus</u>	Aster		X	One plant, high, dry, sandy area
<u>Bacopa Monnieri</u>	Water-hyssop	X		Dense roots in moist sand along marsh area
<u>Borreria laevis</u>	Buttonweed		X	One plant in high, dry, sandy area
<u>Borreria frutescens</u>	Sea ox-eye daisy	X		Sparse in higher elevations near marsh
<u>Carya glabra</u>	Pignut hickory		X	Sandy area above mean high water
<u>Cassia obtusifolia</u>	Sickle-pod		X	One plant in high, dry, sandy area
<u>Cenchrus echinatus</u>	Sandbar		X	Scattered in sandy, infrequently inundated soils
<u>Citrullus vulgaris</u>	Watermelon		X	High, dry, sandy area in northeast corner
<u>Clethra alnifolia</u>	Pepperbush		X	One plant, high, dry, sandy area in northeast corner
<u>Cyperus globulosus</u>	Flatsedge		X	Dense, scattered stands in dry, sandy areas
<u>C. odoratus</u>	Flatsedge		X	Small stands above high water on southeast end
<u>Distichlis spicata</u>	Salt grass	X		Dense stand along upper reaches of intertidal area
<u>Echinochloa crusgalli</u>	Japanese millet		X	Bordering upper reaches of marsh
<u>Eclipta alba</u>	Elipta	X		Sparse along upper northeast edge of the island
<u>Eichhornia crassipes</u>	Water-hyacinth	X		Washed up along shoreline
<u>Eupatorium capillifolium</u>	Dog-fennel		X	Sparse in high, dry, sandy areas
<u>Gnaphalium falcatum</u>	Cudweed		X	Sparse along dry, sandy areas
<u>G. obtusifolium</u>	Cat-foot		X	One plant in high, dry, sandy area

\*Nomenclature for scientific names follows that of Correll and Johnston (1970) and Radford et al. (1968).

(Continued)

Table 4 (Concluded)

Scientific Name	Common Name	Date First Collected		Location
		December 1976	April 1977	
<u>Hydrocotyle bonariensis</u>	Pennywort	X		Sparse along northeast edge of marsh
<u>Ipomoea lacunosa</u>	Morning glory		X	Small mats above marsh border
<u>Juncus roemerianus</u>	Black needle rush	X		Sparse along tidal inlets
<u>Lolium multiflorum</u>	Ryegrass		X	Dense stands on high, dry, sandy areas
<u>Nyssa ogeche</u>	Ogeechee plum		X	Dense clumps along shore
<u>Physalis augustifolia</u>	Ground cherry		X	Sparse in dry, sandy areas
<u>Phytolacca americana</u>	Pokeweed		X	One plant above marsh fringe
<u>Plantago virginica</u>	Pale-seeded plantain		X	One specimen in high, dry, sandy area
<u>Pluchea purpurascens</u>	Saltmarsh fleabane		X	Scattered in high, dry, sandy area
<u>P. camphorata</u>	Camphor-weed	X		Sparse above marsh fringe
<u>Polygonum punctatum</u>	Water smartweed		X	Moist, sandy areas around entrapped tidal water
<u>Quercus lyrata</u>	Overcup oak		X	Dense clumps on north shore
<u>Rumex verticillatus</u>	Swamp dock		X	Abundant along marsh edge
<u>Scirpus americanus</u>	Freshwater three-square	X		Sparse stands along marsh area
<u>S. robustus</u>	Leafy three-square	X		Sparse on island edge and tidal creeks
<u>S. validus</u>	Softstem bulrush	X		Dense stands along landward edge
<u>Sesbania punicea</u>	Red rattlebox	X		High, dry, sandy areas
<u>S. vesicaria</u>	Bag-pod	X		High, dry, sandy areas
<u>Sesuvium portulacastrum</u>	Sea purslane	X		Dense creeping mats around upper reaches of marsh
<u>Taxodium distichum</u>	Bald cypress	X		Dense along north shore
<u>Tradescantia virginiana</u>	Spiderwort		X	Moist areas along marsh edge
<u>Typha domingensis</u>	Cattail	X		Dense stands along marsh edge
<u>Vigna luteola</u>	Deer pea		X	Dense mats in dry, sandy area
TOTAL SPECIES		15	13	14

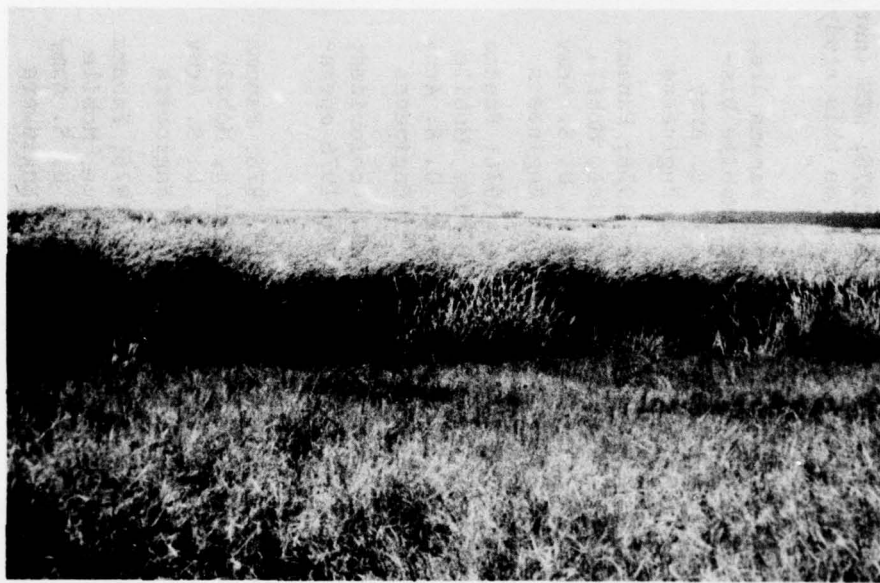


Figure 14. Abundant growth of salt grass (Distichlis spicata). Salt grass is shown in the foreground. Salt grass invaded between smooth cordgrass (Spartina alterniflora) and salt-meadow cordgrass (Spartina patens) plantings during the period of study

Table 5

Additional Species Planted or Naturally Established on Drake Wilson Island

<u>Scientific Name</u>	<u>Common Name</u>	<u>Source of Occurrence</u>	<u>Location</u>
<u>Fimbristylis castanea</u>	Coastal sedge	Planted 1976; WES (not reported on this study)	Scattered stands in marsh fringes at east end of island
<u>Panicum amarulum</u>	Beach panic	Planted; Panama Area Office, Mobile District, U. S. Army Corps of Engineers	Infrequently inundated areas
<u>Parthenocissus quinquefolia</u>	Virginia creeper	Planted 1976; Panama Area Office, Mobile District, U. S. Army Corps of Engineers	Supratidal elevations*
<u>Paspalum distichum</u>	Knotgrass	Planted 1976; Panama Area Office, Mobile District, U. S. Army Corps of Engineers	Supratidal elevations
<u>Phragmites australis</u>	Common reed	Naturally colonized; prior to 1976 operations	Supratidal elevations
<u>Pinus clausa</u>	Sand pine	Planted 1976; Panama Area Office, Mobile District, U. S. Army Corps of Engineers	Supratidal elevations
<u>Sabel palmetto</u>	Cabbage palmetto	Planted 1976; Panama Area Office, Mobile District, U. S. Army Corps of Engineers	Supratidal elevations
<u>Sporobolus virginicus</u>	Coastal dropseed	Naturally colonized; prior to 1976 operations	Supratidal elevations

\* Supratidal elevations are those areas above normal mean high tide.

## PART V: CONCLUSIONS AND RECOMMENDATIONS

32. Two species of marsh plants were successfully transplanted from natural stands and established on dredged material substrate. Fourteen months after planting, plots of saltmeadow cordgrass and smooth cordgrass exhibited substantial growth.

33. In the smooth cordgrass spacing study, growth measures were related to plant interval and, in general, growth improved as spacing decreased. Transplants did well in terms of plant cover at 0.3-, 0.6-, and 0.9-m spacing but poorly at 1.8- and 2.7-m spacings. This is most likely the result of the larger spacing interval. However, the amount of plant cover that resulted from transplanting sprigs at 0.3-, 0.6-, and 0.9-m spacing intervals were all visually comparable to nearby native smooth cordgrass marshes. It is recommended that adequate protection from tidal energies be given transplants planted on unconsolidated dredged material. In particular, care should be exercised in weir placement.

34. Use of a Riverine Utility Craft to reduce the difficulty of transplanting plant sprigs in unconsolidated dredged material proved quite feasible. The use of such equipment is recommended where environmental conditions are such that closeness and exactness of plant spacing for optimum growth in a specified period of time is not a major factor for success.

35. Unlike the smooth cordgrass plantings, general growth within the saltmeadow cordgrass plots improved as planting interval increased. No real significant relationship was found between the plant variables studied and the elevational range of the plantings during the period of study. The results indicate that for situations where xeric, nutrient-poor dredged materials are to be developed, excellent growth results can be expected using saltmeadow cordgrass planted at 1.8- or 2.7-m spacing intervals at elevational ranges from 1.0 to 1.4 m above mlw.

36. Reliance solely upon natural invasion to initially stabilize dredged material sites with environmental conditions similar to the ones described in this report is not recommended because the development

of sufficient ground cover is often happenstance.

37. Selection of plant species that provide ground cover in a short period of time, stabilize substrate, and become a predominant primary producer for the estuarine food chain should be of prime concern in any habitat development plan for a dredged material disposal site.

38. Steps prior to attempting marsh development on dredged material should include a careful floristic study of the flora that occurs on existing disposal sites or natural areas that have environmental conditions similar to the proposed project site. Also, prior to any large-scale artificial propagation effort, a small-scale feasibility study, such as the one described in this report, is highly recommended. These two preliminary studies will greatly enhance the ability to predictably engineer a desired wetland given the current state-of-the-art.

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In accordance with letter from DAEN-RDC, DAEN-ASI dated 22 July 1977, Subject: Facsimile Catalog Cards for Laboratory Technical Publications, a facsimile catalog card in Library of Congress MARC format is reproduced below.

Kruczynski, William L

Habitat development field investigations, Apalachicola Bay marsh development site, Apalachicola Bay, Florida; summary report / by William L. Kruczynski, Environmental Systems Service of Tallahassee, Inc., Tallahassee, Fla., and Robert T. Huffman, Mary K. Vincent, Environmental Laboratory, U. S. Army Engineer Waterways Experiment Station. Vicksburg, Miss. : U. S. Waterways Experiment Station ; Springfield, Va. : available from National Technical Information Service, 1978.

39 p. : ill. ; 27 cm. (Technical report - U. S. Army Engineer Waterways Experiment Station ; D-78-32)

Prepared for Office, Chief of Engineers, U. S. Army, Washington, D. C., under DMRP Work Unit 4A19A.

Literature cited: p. 39.

1. Apalachicola Bay, Fla. 2. Dredged material. 3. Feasibility studies. 4. Marsh development. 5. Salt marshes. 6. Vegetation establishment. 7. Waste disposal sites. I. Huffman, Robert T., joint author. II. Vincent, Mary K., joint author. III. Environmental Systems Service of Tallahassee, Inc. IV. United States Army. Corps of Engineers. V. Series: United States Waterways Experiment Station, Vicksburg, Miss. Technical report ; D-78-32. TA7.W34 no.D-78-32