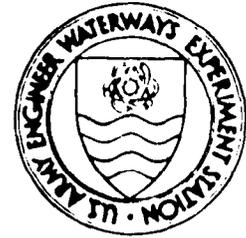


DREDGED MATERIAL RESEARCH PROGRAM



TECHNICAL REPORT D-77-23

HABITAT DEVELOPMENT FIELD INVESTIGATIONS
WINDMILL POINT MARSH DEVELOPMENT SITE
JAMES RIVER, VIRGINIA

APPENDIX B: PROPAGATION OF VASCULAR PLANTS

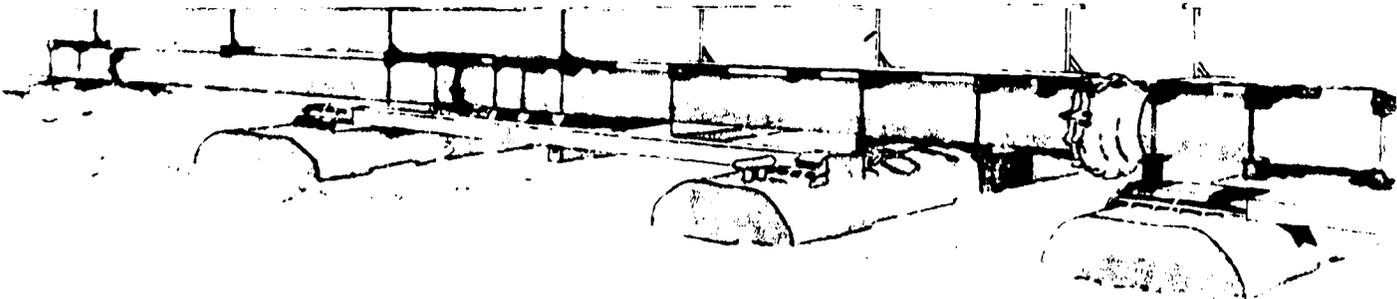
by

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April 1978

Final Report

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Prepared for Office, Chief of Engineers, U. S. Army
Washington, D. C. 20314

Under Contract No. DACW65-75-C-0054
(DMRP Work Unit No. 4A11J)

Monitored by Environmental Laboratory
U. S. Army Engineer Waterways Experiment Station
P. O. Box 631, Vicksburg, Miss. 39180

HABITAT DEVELOPMENT FIELD INVESTIGATIONS, WINDMILL POINT
MARSH DEVELOPMENT SITE, JAMES RIVER, VIRGINIA

- Appendix A: Assessment of Vegetation on Existing Dredged Material Island
- Appendix B: Propagation of Vascular Plants
- Appendix C: Environmental Impacts of Marsh Development with Dredged Material: Acute Impacts on the Macrobenthic Community
- Appendix D: Environmental Impacts of Marsh Development with Dredged Material: Botany, Soils, Aquatic Biology, and Wildlife
- Appendix E: Environmental Impacts of Marsh Development with Dredged Material: Metals and Chlorinated Hydrocarbons in Vascular Plants and Marsh Invertebrates
- Appendix F: Environmental Impacts of Marsh Development with Dredged Material: Sediment and Water Quality

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IN REPLY REFER TO: WESYV

31 May 1978

SUBJECT: Transmittal of Technical Report D-77-23, Appendix B

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 (DMRP). Task 4A is part of the Habitat Development Project (HDP) and has 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 has been investigated by the HDP under both laboratory and field conditions. The study reported herein (Work Unit 4A11J) was an integral part of a series of research contracts jointly developed to achieve Task 4A objectives at the Windmill Point Marsh Development Site, James River, Virginia, one of eight marsh establishment sites located in several geographic regions of the United States. Interpretations of this report's findings and recommendations are best made in context with the other reports in the Windmill Point site series (4A11A-M).
3. This report, "Appendix B: Propagation of Vascular Plants," is one of six contractor-prepared appendices published relative to Waterways Experiment Station's Technical Report D-77-23, entitled "Habitat Development Field Investigations, Windmill Point Marsh Development Site, James River, Virginia; Summary Report" (4A11M). The appendices to the summary report involve studies that provide technical background and supporting data and may or may not represent discrete research products. Appendices that are largely data tabulations or that clearly have only site-specific relevance are published as microfiche; those with more general application are published as printed reports.
4. The purpose of Work Unit 4A11J was to establish vegetation on the dikes and unconfined portions of the man-made marsh island complex at Windmill Point. Planting techniques and elevation and fertilizer effects

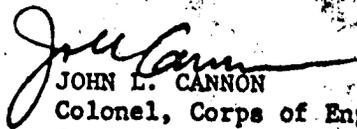
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were tested for several species of plants. Within one year of planting, virtually all of the intertidal plantings had been destroyed by animal degradation or erosion. The upland plantings were severely impacted by invasion of natural vegetation.

5. Data from this report will be included in the Windmill Point summary report and synthesized in 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" (4A22).



JOHN L. CANNON

Colonel, Corps of Engineers
Commander and Director

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) This report describes and documents photographically all vegetative establishment work conducted during the summer of 1975 throughout the dike, on a small confined upland dredged material area, and on unconfined dredged material contiguous to the dike at the James River Habitat Development Site. The results of laboratory germination tests on all of the species of seeds utilized at the Site are presented and discussed.		

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SUMMARY

This report describes through the extensive use of photographs and accompanying text the results of marshscaping and landscaping the dike and the propagation of vegetation on off-dike unconfined dredged materials at the James River Habitat Development Site near Windmill Point, Prince George County, Virginia. The results of laboratory test germinations of all seeds utilized in the aforementioned work are also provided.

All work on location was accomplished during the summer of 1975. The dike was cleaned of plastic and of extensive debris deposits, reshaped and graded for transplanting to the exterior intertidal zone and seeding elsewhere, and then planted.

Common Threesquare (Scirpus americanus) and Cordgrass (Spartina alterniflora) were transplanted to the exterior intertidal zone of the dike. The balance of the dike was fertilized and seeded to a mixture of Tall Fescue (Festuca elatior), Orchard Grass (Dactylis glomerata), Ladina White Clover (Trifolium repens), Switchgrass (Panicum virgatum), and Coastal Panic Grass (Panicum amarulum).

By October 1975, the exterior intertidal zone of the dike

was well stabilized by transplanted Common Threesquare and Cordgrass, and the balance of the dike had a generally dense ground cover that was dominated by Switchgrass, Coastal Panic Grass, and Ladina Clover. At this time large populations of Canada geese were residing near the Habitat Development Site and WES was advised by the contractor that unless the planted intertidal marsh somehow was protected, it probably would suffer an "eat-out" during the forthcoming winter. The decision was made by WES to observe the consequences of not protecting the planted marsh. On 30 September 1976, one year later, little intertidal marsh along the exterior of the dike remained and the vegetation throughout the balance of the dike was dominated by dense stands of Switchgrass and Coastal Panic Grass.

Eight blocks each containing 16 plots of either seeded or sprigged and either fertilized or unfertilized monotypic Cordgrass, Big Cordgrass (Spartina cynosuroides), Arrow Arum (Peltandra virginica) or Saltmarsh Bulrush (Scirpus robustus) were constructed on the intertidal unconfined dredged materials contiguous to the east end of the dike. The purpose of this work was to determine the optimum elevations and the need for fertilization for the successful propagation of the selected marsh plant species through seeding and sprigging the unconfined dredged materials represented at the site. Planting of the plots was conducted between July 14th and 23rd and

all plots containing plants that suffered mortalities were replanted prior to the contractor's departing the site on 31 July.

By October 16th, essentially all of the plots below MHW (ca. 80% of the total plots) had been completely denuded of vegetation through excavations of the plants or clipping of the aboveground plant parts by birds, waterfowl, and fish. Although the planted vegetation in the plots above MHW was relatively undisturbed at this time, the area had been nearly completely covered by dense growths of foreign vegetation. On 30 September 1976, one year later, only one plot of sprigged Big Cordgrass and one plot of sprigged Cordgrass had any visible planted vegetation remaining.

The successful establishment of intertidal marsh vegetation at locations similar to the James River Habitat Development Site will require the use of enclosures to temporarily exclude fish and wildlife access to the planted areas.

Laboratory test germinations of seed of all plant species that were field-seeded were conducted in the various sediment types represented at the Site. All of the seed proved viable and germinated satisfactorily in all of the sediment types. Several statistically significant trends were noted between germination percentages and the seed planting depths for the

upland species. Most species germinated significantly better at the higher moisture contents of the coarse-grained sediment type representative of the dike sediments.

PREFACE

The study described in this report was conducted by Environmental Concern, Inc., under Contract No. DACW65-75-C-0054 to the U. S. Army Engineer Waterways Experiment Station (WES). The study constitutes Work Unit No. 4A11J of the Dredged Material Research Program (DMRP), which is sponsored by the Office, Chief of Engineers, U. S. Army, and is being managed by the Environmental Laboratory (EL), WES.

This report was written by Dr. E. W. Garbisch, Jr., President of Environmental Concern, Inc. The contract was monitored by Mr. E. P. Peloquin, Natural Resources Development Branch (NRDB), under the supervision of Dr. T. J. Wood and Dr. W. B. Gallaher, former Chief and Chief, respectively, NRDB, and Dr. C. J. Kirby, Jr., Chief, Environmental Resources Division. Mr. J. D. Lutz coordinated marsh development activities at the study site. The study was part of the Habitat Development Project managed by Dr. H. K. Smith under the direction of Dr. John Harrison, Chief, EL. LTC R. H. Routh, CE, of the U. S. Army Engineer District, Norfolk, was the Contracting Officer.

Directors of WES during the study were COL G. H. Hilt, CE, and COL J. L. Cannon, CE. Technical Director was Mr. F. R. Brown.

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

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

<u>Multiply</u>	<u>by</u>	<u>To Obtain</u>
inches	0.0254	metres
feet	0.3048	metres
miles (U.S. statute)	1.609344	kilometres
acres	4046.856	square metres
ounces (U.S. fluid)	29.57353	cubic centimetres
pounds (mass)	0.45359237	kilograms

INTRODUCTION

In conjunction with the Norfolk District Corps of Engineers maintenance dredging of the Jordan Point, Va. Navigation channel, the Waterways Experiment Station (WES) designed and implemented the James River Habitat Development Site (hereafter referred to as the Site) at approximately River Mile 58* and just east of Windmill Point, Prince George County, Virginia (Fig. 1). The project was monitored by the Environmental Laboratory at WES under the Habitat Development Research Project of the Dredged Material Research Program.

The Site consists of a sand and gravel diked island and contained intertidal and upland fine-grained dredged materials. Contiguous to the east end of the dike is an area of unconfined fine-grained dredged materials. The Site is located in a freshwater region of the James River where the mean semi-diurnal tidal amplitude is 2.5 feet. Development of the Site was accomplished between 12 January and 13 February, 1975. Figure 2 provides a schematic representation of the Site.

Overall Site objectives of an interdisciplinary research program include:

1. Determine which species of plants invade undisturbed

* A table of factors for converting U.S. customary units of measurement to metric (SI) units is presented on page 23.

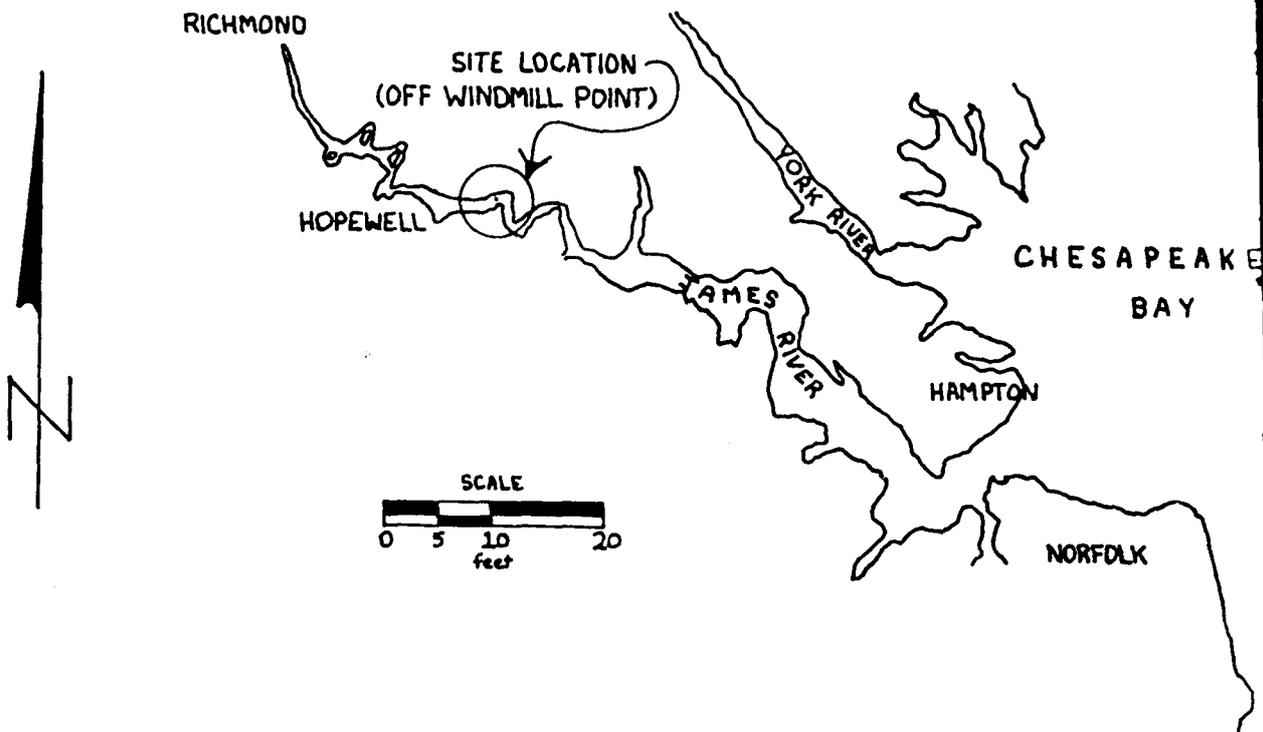
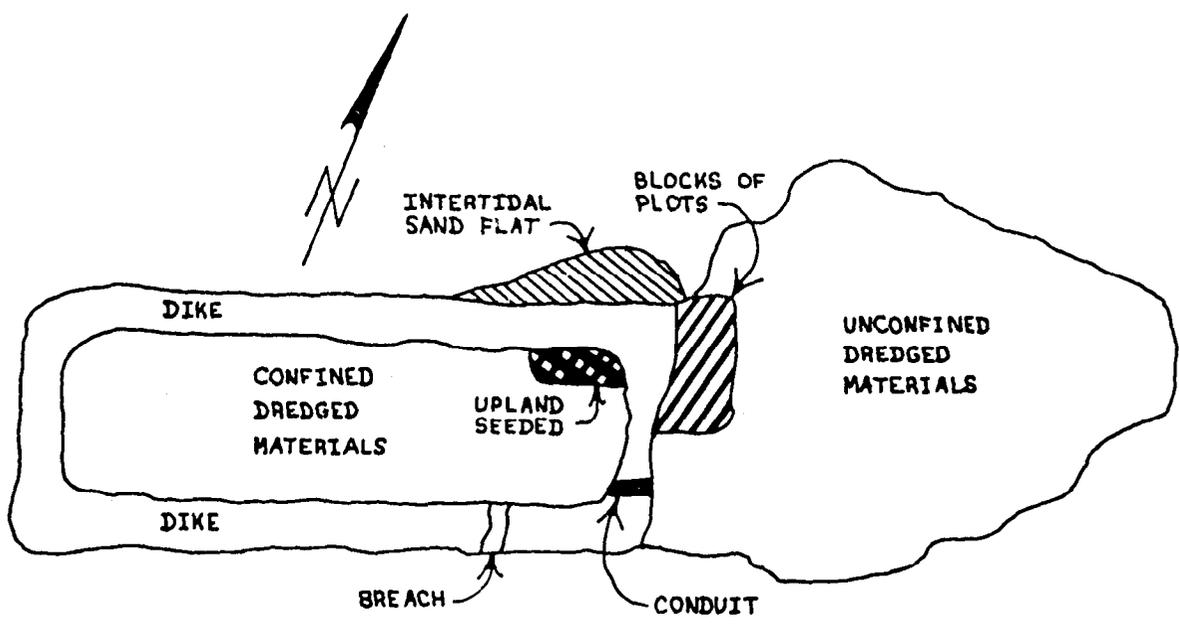


Figure 1. Vicinity Map, James River Habitat Development Site, James River, Virginia



ONE INCH IS APPROXIMATELY 400 FEET.

Figure 2. A schematic representation of the James River Habitat Development Site, James River, Virginia. Both confined and unconfined dredged material areas are shown.

areas composed of dredged materials.

2. Relate the productivity of various plant species propagated on dredged materials to the varying chemical and physical properties of the location.
3. Relate avian patterns of use and activities to the physical characteristics of the plant community.

The specific objectives of the contracted work described herein are a combination of landscaping of the dike and pragmatic research and include:

1. Dike Landscaping

- a. Remove the plastic that was used to stabilize a berm constructed on the north and west sides of the dike. Stockpile the wood and debris deposited throughout the exterior and interior of the dike. Burn the stockpiled wood and plastic. Grade the dike to suitable slopes (ca. 10:1) for vegetative establishment.
- b. Seed approximately one acre of intertidal sand flat at the exterior northeast side of the dike (see Fig. 2) with a mixture of Spartina alterniflora (Cordgrass), Spartina cynosuroides

(Big Cordgrass), Scirpus robustus (Saltmarsh Bulrush), and Peltandra virginica (Arrow Arum).

c. Transplant Scirpus americanus (Common Three-square) and S. alterniflora throughout upper half of the intertidal zone of the exterior of the dike.

d. Seed the dike interior and an upland area of ca. 0.3 acre located at the northeast corner of the confined dredged materials (see Fig. 2) with a mixture of Festuca elatior var. Arundinacea (Tall Fescue), Dactylis glomerata (Orchard Grass), and Trifolium repens (Ladina White Clover). Seed the dike exterior from the highest elevation seaward down to MHW with a mixture of Panicum virgatum (Switchgrass) and Panicum amarulum (Coastal Panic Grass).

2. Construct eight blocks of sixteen plots of seeded, sprigged, fertilized, or unfertilized P. virginica, S. cynosuroides, S. robustus, and S. alterniflora on the unconfined dredged materials contiguous to the exterior east end of the dike (see Fig. 2).

3. Test germinate the seeds at various planting depths

of all plant species utilized at the Site in sediments of various moisture contents that represent the range of those encountered while performing the work in items 1 and 2 above.

The purpose of the dike landscaping (item 1 above) was to aesthetically enhance the Site, to biologically stabilize the coarse-grained sediments of the dike, and to provide habitat diversity at the Site. Construction of the blocks of plots on the unconfined dredged materials (item 2 above) was pursued as an alternative to similar work originally planned for the confined dredged materials after discovering that the latter materials became naturally colonized by a high density and diversity of aquatic and upland plant species by June 1975 following the construction of the Site (see Figs. 3-6). The purpose of this work was to determine the optimum elevations and the need for fertilization for the successful propagation of the selected marsh plant species through seeding and sprigging the unconfined dredged materials represented at the Site. The purpose of item 3 above was to test the viability of the seeds used and to determine whether the depth of planting the seed species utilized at the Site and the soil moisture contents, particularly of the supratidal dike sediments, are limiting to seed germination.

All work at the Site that is reported herein was conducted during the period of 20 June 1975 through 29 September 1975.

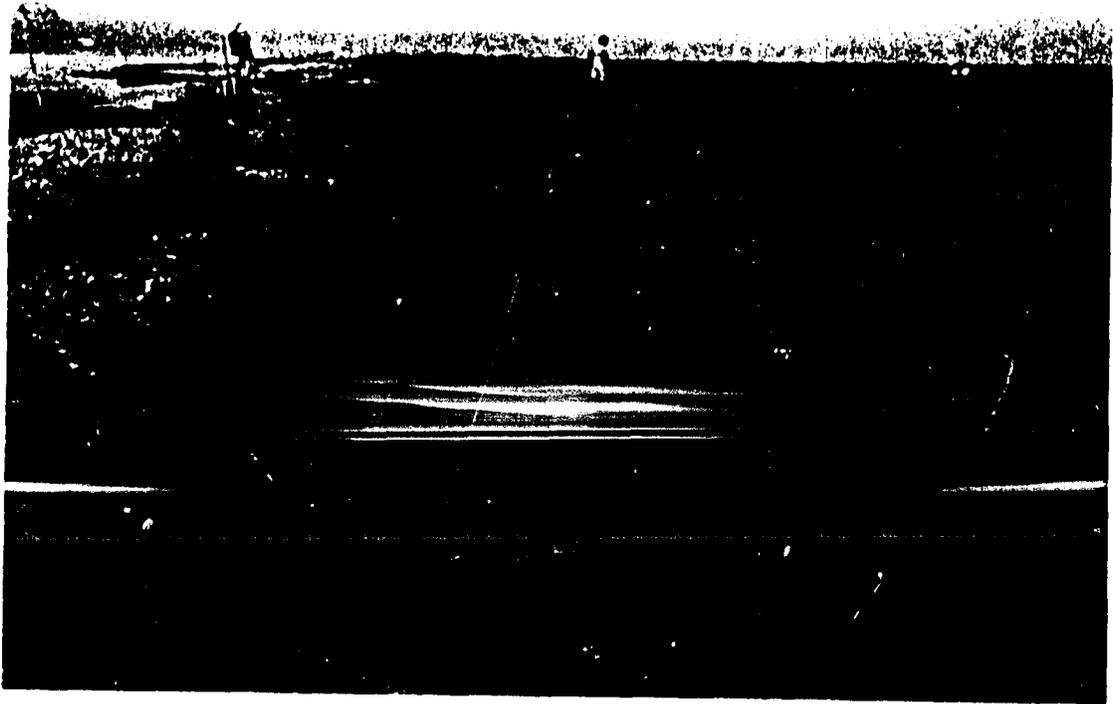


Figure 3. Looking west from the southeast end of the dike at the Site on 18 June 1975.

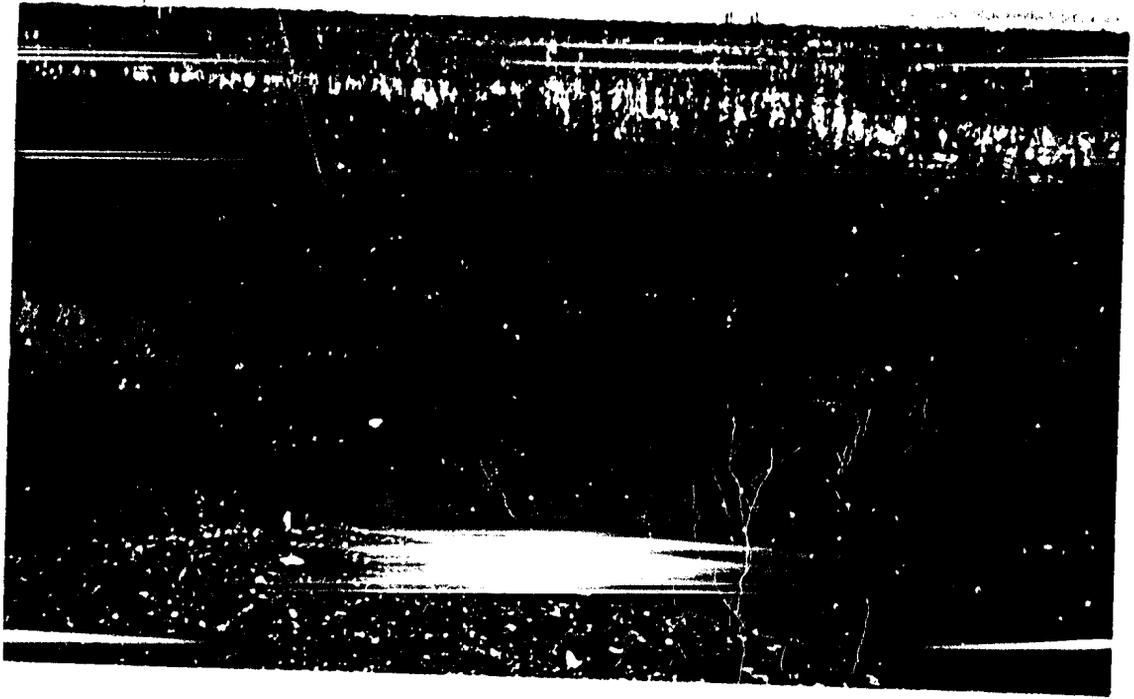


Figure 4. Looking northwest across the contained dredged materials at the Site on 18 June 1975.

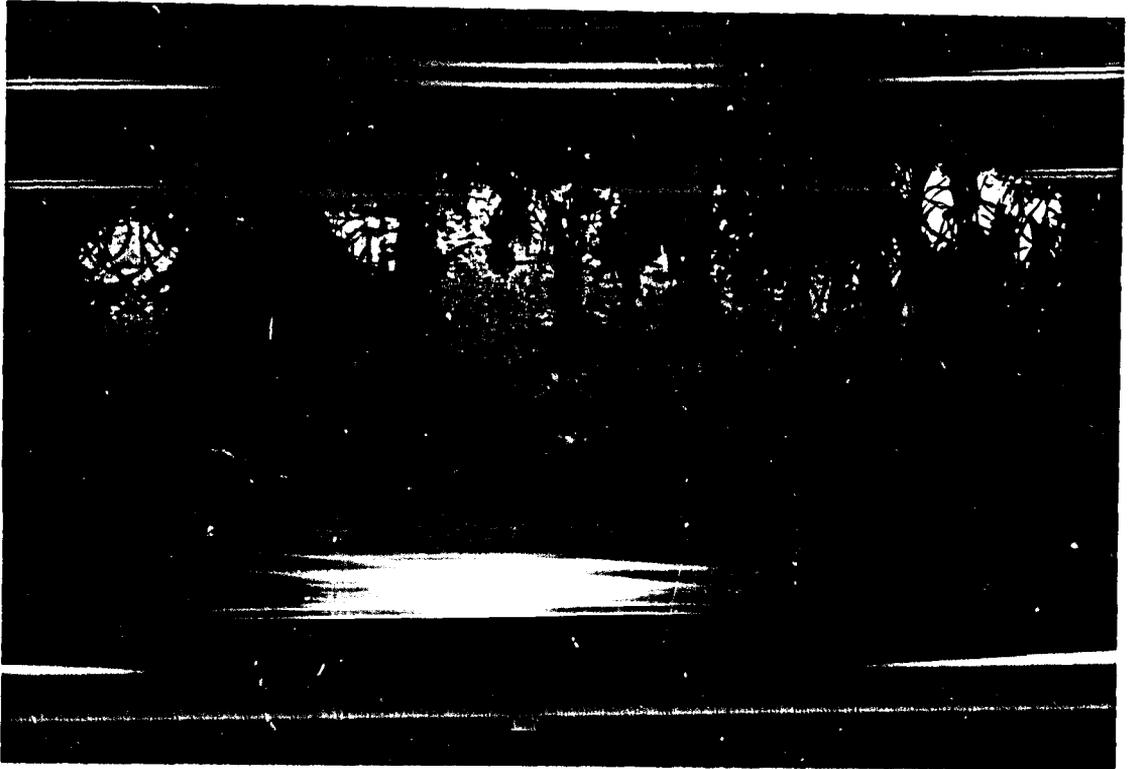


Figure 5. Marsh plant seedlings that naturally volunteered the contained dredged materials at the Site on 18 June 1975.



Figure 6. Volunteer seedling of *P. cordata* growing on the contained dredged materials at the Site on 18 June 1975.

Photographic documentation of all such work was made during this period. Additional photographs of the results of the field work were taken on 16 October 1975 and on 30 September 1976. Many of these photographs are included in this report.

DESCRIPTION OF WORK AND DISCUSSION OF RESULTS

1. Dike Landscaping

Upon arrival at the Site on 18 June 1975, extensive quantities of driftwood and debris were found deposited about the exposed north and west sides of the dike (see Fig. 7), plastic that had been sandbagged down over a constructed berm on the north and west sides of the dike was found both buried and strewn throughout the dike (see Fig. 8), and the constructed berm on the dike was found either severely eroding (see Fig. 9) or too steep (see Figs. 10-12) to plant directly. Prior to grading the dike to suitable slopes (10 or greater:1) for planting, the plastic, driftwood, and debris were collected, stockpiled, and burned (see Fig. 13).

a. Dike Grading. Grading of the dike was accomplished with a low ground pressure vehicle equipped with a hydraulic lift plow (see Figs. 14 and 15). Although the grading process was slow, it eliminated the risk of having a



Figure 7. Looking east on 22 June 1975 along the north side of the dike at the steep berm and at the deposits of driftwood, debris, and plastic.



Figure 8. Plastic strewn about the dike on 22 June 1975.

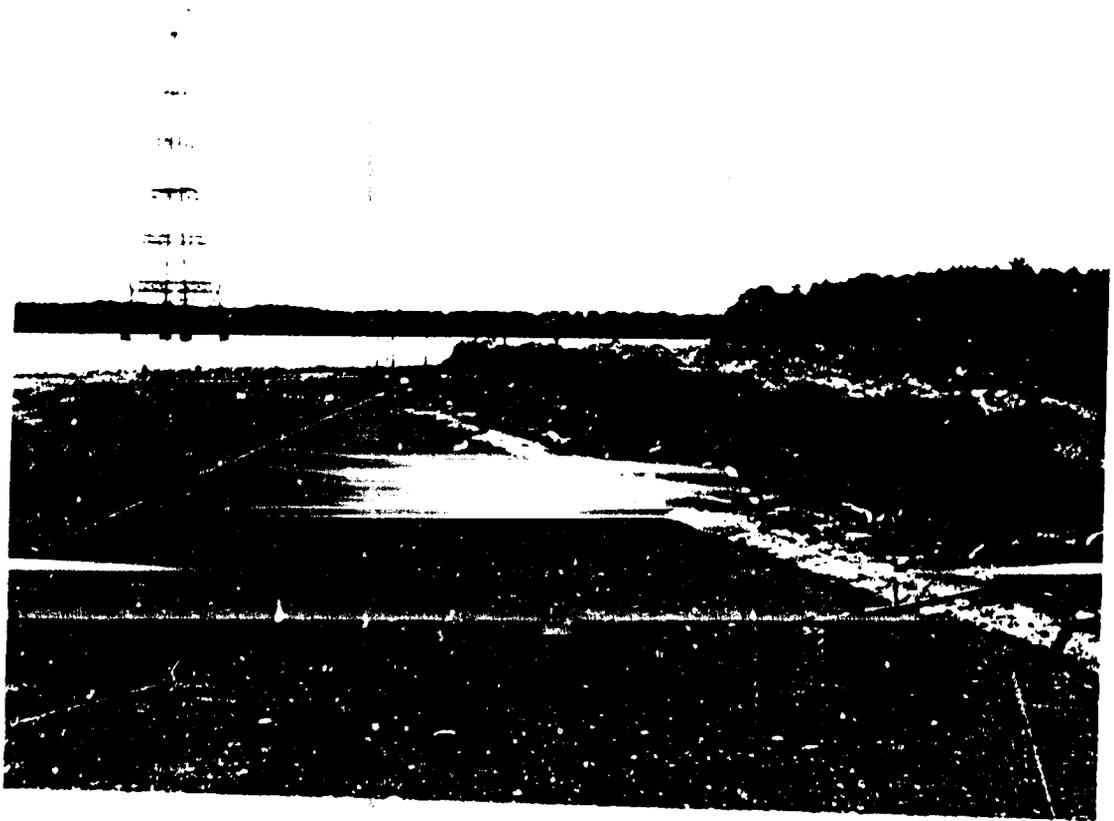


Figure 9. A steep, eroding section of the berm at the north-east end of the dike on 22 June 1975.



Figure 10. A section of steep berm at the northwest end of the dike on 22 June 1975.

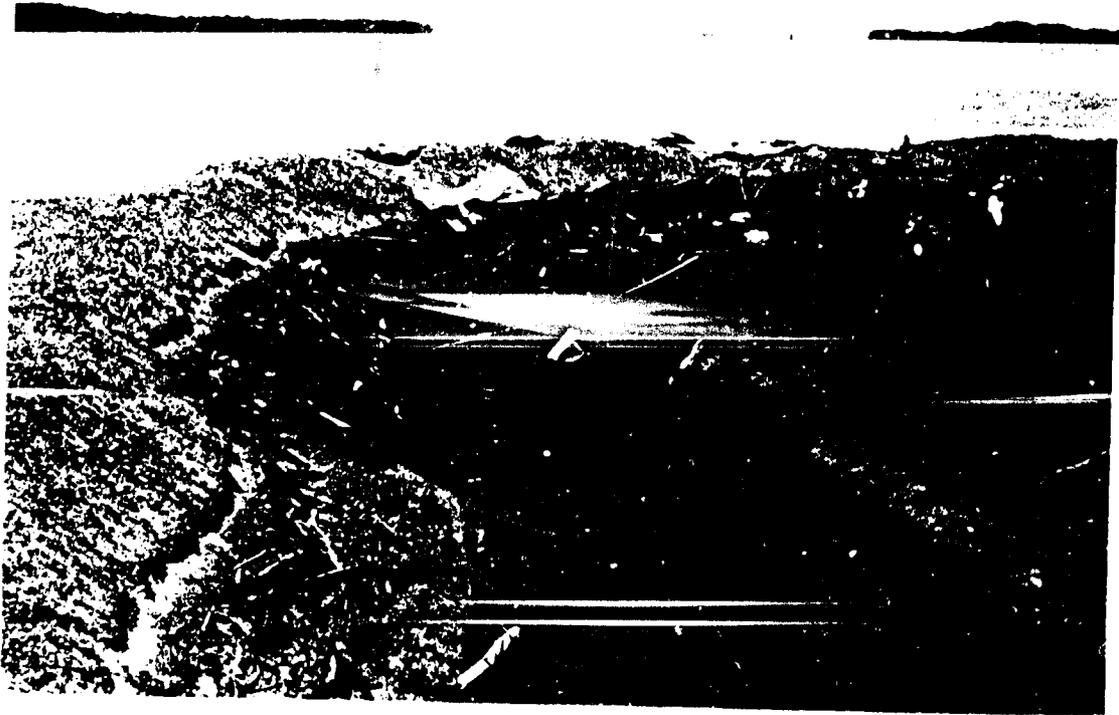


Figure 11. A section of steep berm at the southwest corner of the dike on 22 June 1975.

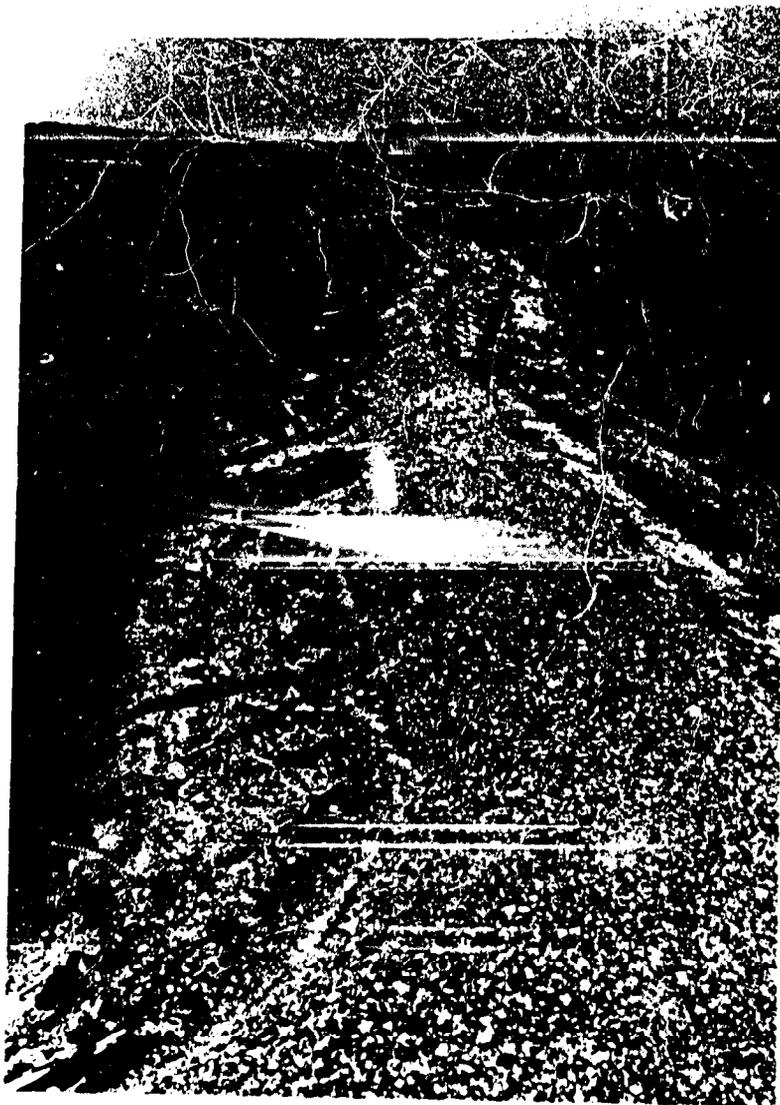


Figure 12. The steep berm along the west side of the dike on 22 June 1975.



Figure 13. Burning of stockpiled plastic, driftwood, and debris at the Site.



Figure 14. Grading operation using a low ground pressure vehicle.



Figure 15. Grading operation using a low ground pressure vehicle.

heavier machine push sections of the dike into the soft underlying sediments and disrupt the dike's integrity.

Figure 16 shows a graded and ungraded section of the south side of the dike. Figures 17 and 18 show the north side of the dike before and after grading, respectively. All sections of the graded dike, with exception of the high elevation east side, were overtopped by spring tides (ca. 1-1.5 ft above MHW) approximately eight times per month.

b. Seeding the Intertidal Sand Flat. On 22 July 1975, approximately 0.5 acre of intertidal sand flat at the northeast end of the dike exterior (see Fig. 2) was fertilized with 150 lb of OSMOCOTE 3- to 4-month release 19-6-12 fertilizer and seeded with a mixture of S. alterniflora, S. cynosuroides, S. robustus, and P. virginica at approximate rates of 10,3,1, and 0.2 seeds per square foot.

The fertilizer and seed mixture was hand broadcasted on the sediment surface from the approximate Mean (mid) tide elevation to MHW and then worked into subsurface depths of 0-3 inches utilizing a low ground pressure all terrain vehicle equipped with a tool bar with cultivator attachment (see Figs. 19 and 20). Following cultivation, the sediment surface was smoothed using a wood platform drag.



Figure 16. Graded and ungraded section of the south side of the dike.



Figure 17. The north side of the dike looking west, before grading.

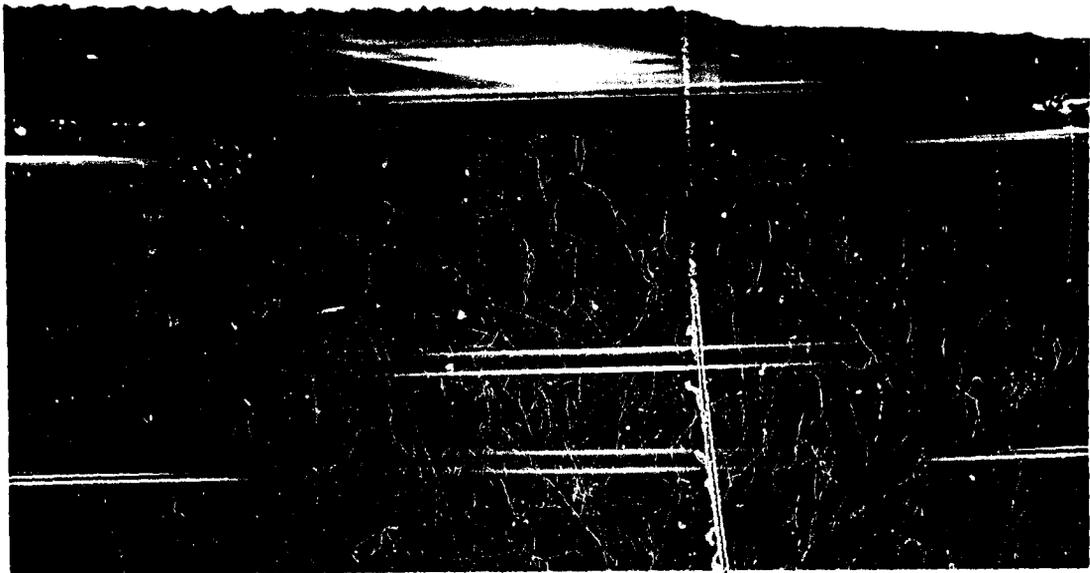


Figure 18. The north side of the dike looking west, after grading.

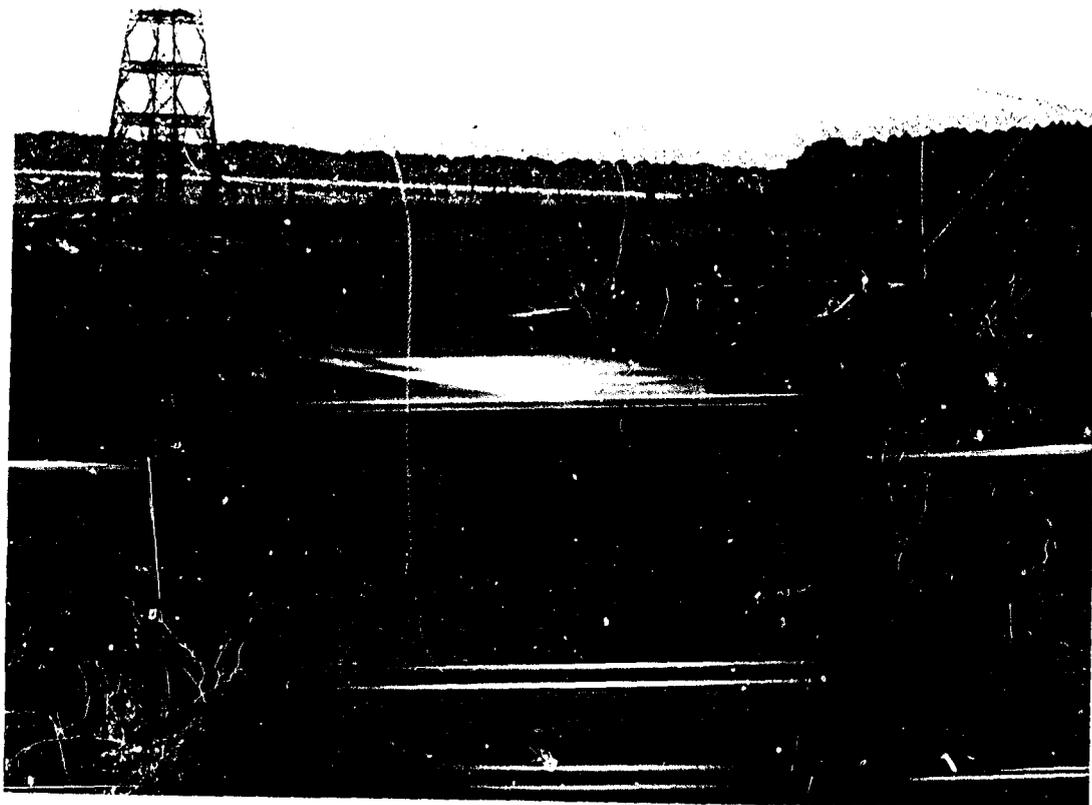


Figure 19. Seeding the intertidal sand flat at the northeast end of the dike on 22 July 1975.

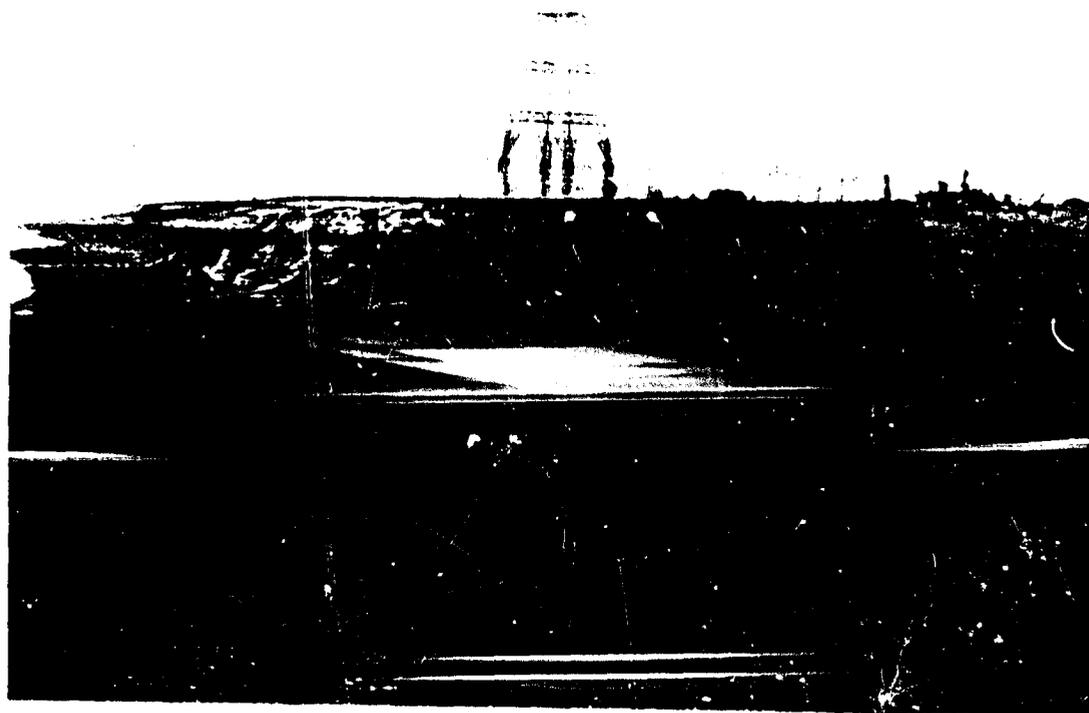


Figure 20. Seeding the intertidal sand flat at the northeast end of the dike on 22 July 1975.

By 26 July, S. alterniflora and P. virginica seedlings were observed throughout the entire seeded area. At this time noticeable quantities of seeds of all four species had washed out and were being deposited in the area of the blocks of plots just southeast of the seeded area (see Fig. 2). On 29 August only the uppermost elevations of the seeded area (ca. 20% of total area) had any seedlings developing (see Fig. 21 and Fig. 20 for comparison). These seedlings were dominated by S. alterniflora with minor numbers of S. cynosuroides at the highest elevations and P. virginica throughout. By 16 October essentially all of these plants had been dug out by Canada geese (see Figs. 22 and 23) leaving the area covered with potholes (see Fig. 24) and strewn with excavated plant parts at the highest elevations (see Fig. 25).

Aside from the geese depredation, the intertidal sand flat is in a location that is too exposed to the wakes of large commercial boat traffic for successful intertidal plant establishment by seeding. Except for the elevation about MHW, the majority of seedlings had been washed out or had suffered mortalities from wave stress by 29 August before large numbers of Canada geese resided near the Site.

c. Transplanting the Exterior of the Dike. The exterior of the dike from the Mean Tide elevation (+1.3 ft relative to MLW) up to MHW (+2.5 ft relative to MLW) was

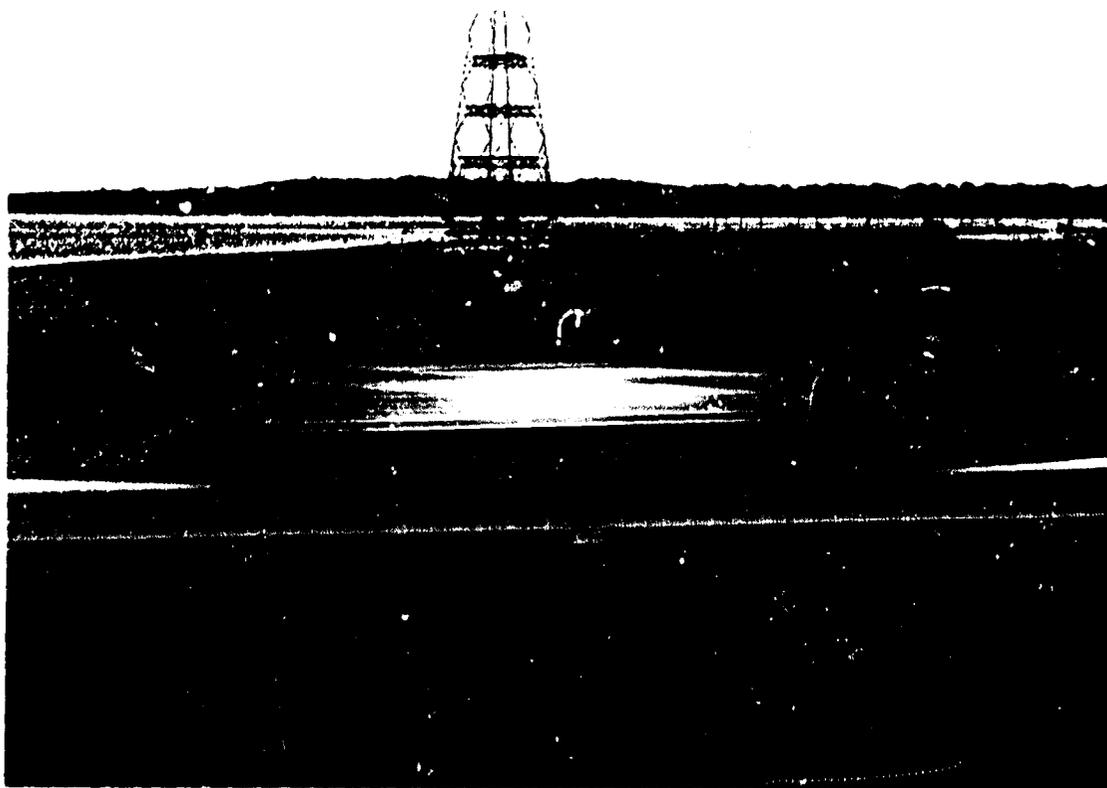


Figure 21. Seeded area of the intertidal sand flat at the northeast end of the dike on 29 August 1975.

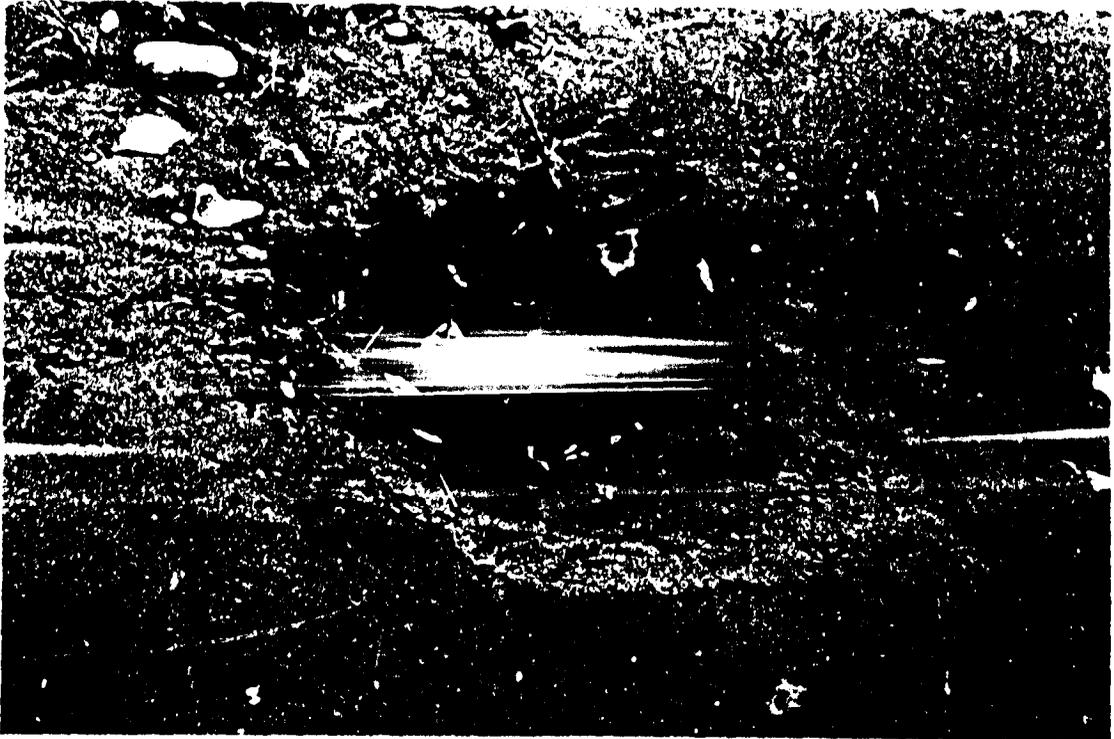


Figure 22. Canada goose excavation site of seedlings developing on the intertidal sand flat at the northeast end of the dike on 16 October 1975.

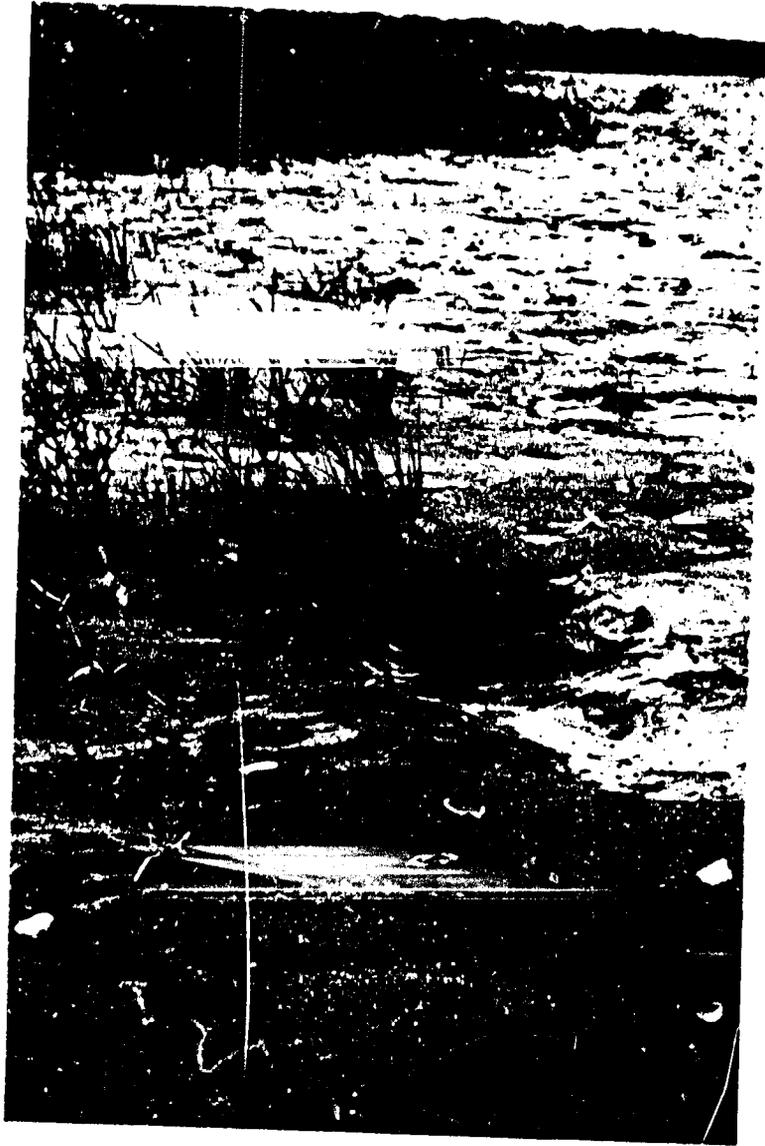


Figure 23. Canada geese excavations of seedlings developing on the intertidal sand flat at the northeast end of the dike on 16 October 1975.



Figure 24. Depredated intertidal sand flat at the northeast end of the dike on 16 October 1975.



Figure 25. Excavated plant parts deposited along the highest elevations of the intertidal sand flat at the northeast end of the dike on 16 October 1975.

transplanted to 3- to 4-inch peat-potted S. alterniflora stock and bare root S. americanus (see Fig. 26), excavated nearby the Site, in alternate rows and on 18 inch centers. Transplanting began on 3 July and all but a small area left for removing equipment was planted by 10 July. The width of the transplanted area varied from 10 to 15 feet throughout the approximately 3,600 linear feet of dike.

Although S. alterniflora is not generally found in tidal freshwater areas, it grows well in freshwater but is gradually outcompeted by indigenous aquatic plants. Because of its ready establishment on relatively high wave energy shores, its rapid lateral spread, and its high sediment stabilizing characteristics, S. alterniflora has a potential for use in freshwater areas to provide a rapid ground cover of the intertidal zone and a trap and a shelter for propagules of other aquatic plants. For these reasons S. alterniflora was selected as one of the two species to transplant on the exterior of the dike. Scirpus americanus was selected as the second species because of its abilities to grow satisfactorily on relatively high wave energy sandy freshwater shores.

Transplanting was accomplished by machine augering a hole ca. 4 inches deep, placing 20 grams (ca. 1/2 fluid ounce) of OSMOCOTE 3- to 4-month release 19-6-12 fertilizer in the hole, and then planting the peat-potted S. alterniflora or group of



Figure 26. Transplanting S. alterniflora and S. americanus to the exterior intertidal area of the south side of the dike on 2 July 1975.

four stems of bare root S. americanus. The approximately 5% of transplants that washed out after planting were replanted before departing the Site on 31 July. No transplant mortalities were observed other than those derived from animal depredation.

The only naturally occurring S. americanus within six miles up-or downriver from the Site was a monotypic stand in sand and peaty substrates located on the south shore approximately two miles upriver from the Site. Transplant material was excavated from this site from 20 June through 9 July. Excavations were conducted at high tide to facilitate washing away the attached substrate (see Fig. 27). Single stems or groups of up to four stems were separated from the washed out clumps of plants or cut from the rhizome sections (see Figs. 28 and 29). Dead (dark brown) root parts were cut away, the top half of the mature (flowering) plants were clipped to provide ca. 18-inch tall transplants, and the plant materials stored in tubs of water until transplanting (see Fig. 30).

Trial transplantings of naturally occurring Acorus calamus (Sweetflag), Scirpus validus (Softstem Bulrush), and Decodon verticillatus (Water Willow) were made along the external north, south, and east sides of the dike about midway in the intertidal transplanted zone. Transplanting was accomplished as described for S. americanus and S. alterniflora.



Figure 27. Excavating S. americanus near the Site on the James River.



Figure 28. Cutting apart excavated S. americanus to provide transplant material.



Figure 29. Single stem transplant of
S. americanus.

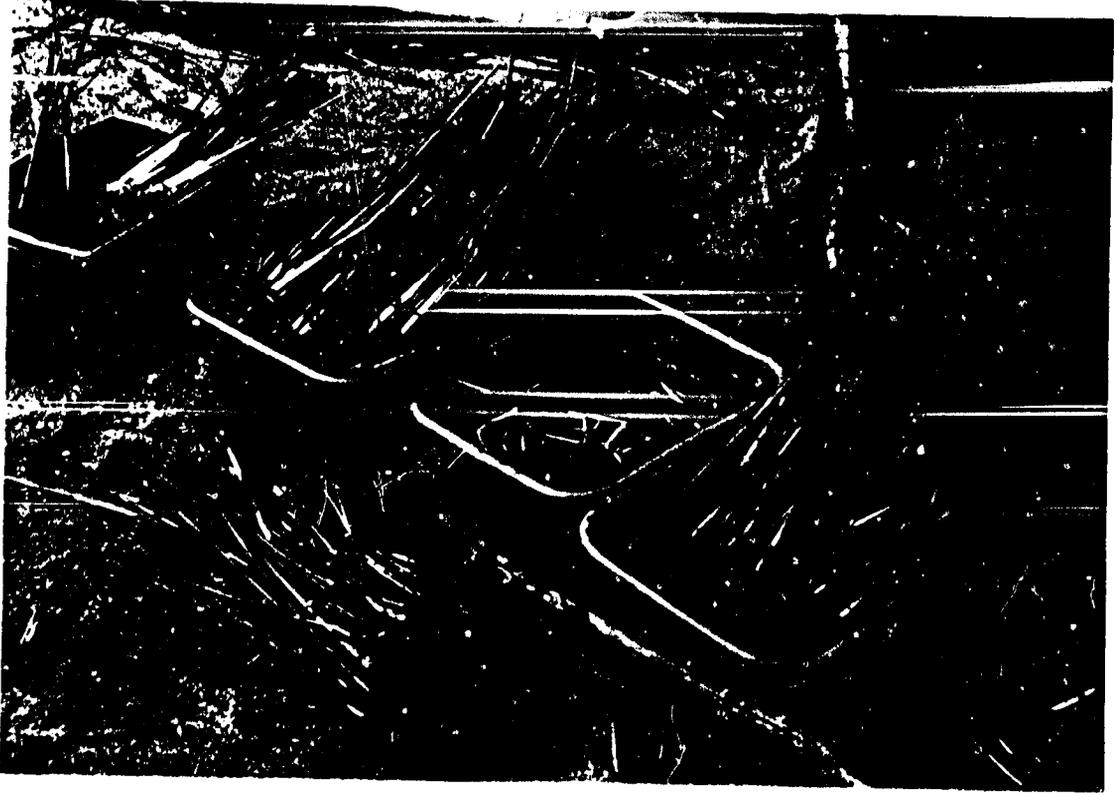


Figure 30. Storing of S. americanus transplant materials.

Although all bare root transplants survived and grew, Water Willow showed the most promise for ready establishment and rapid stabilization of sand and gravel intertidal sediments on relatively high wave energy freshwater shores. Figure 31 shows a D. verticillatus transplant on 20 July two weeks after planting and Figures 32 and 33 show partial rows of D. verticillatus transplants (arrow) on the south and west sides of the dike, respectively, on 16 October over three months after transplanting.

d. Seeding of the Dike and the Contained Upland Dredged Materials Area. The dike and the contained upland dredged materials area at the northeast corner of the dike (see Fig. 2) were seeded during 24 July through 30 July. The seeds, fertilizer, and amounts of both that were used on the four sides of the dike are summarized in Table 1.

The dike interior (from the highest elevation inward) and the upland area of ca. 0.3 acre were seeded to I. repens, D. glomerata, and F. elatior. The dike exterior (from the highest elevation seaward down to MHW) was seeded to P. virgatum and P. amarulum. The seeds were surface broadcasted (separately by species) using a 'Cyclone' rotary spreader pulled by an all terrain vehicle. Settings on the spreader were selected so that broadcasting of the seed was completed in three round-trip passes. The fertilizer was similarly



Figure 31. Transplant of D. verticillatus
two weeks after planting.



Figure 32. Partial row (arrow) of D. verticillatus transplants on the south side of the dike, over three months after planting.



Figure 33. Partial row (arrow) of D. verticillatus transplants on the west side of the dike, over three months after planting.

Table 1. Summary of seeds, fertilizer, and respective amounts used in seeding the dike and the contained upland dredged materials area at the Site.

Seed	Amounts Used (lbs)			
	South Side of Dike	West Side of Dike	East Side of Dike	North Side of Dike and Upland Area
<u>P. virgatum</u> (var. Blackwell)	15	6	11	18
<u>P. amarulum</u>	12	4	9	15
<u>T. repens</u> ^a	15	6	11	18
<u>D. glomerata</u>	30	11	22	37
<u>F. elatior</u> (var. Arundinacea)	30	11	22	37
Fertilizer (10-10-10) ^b		112	240	368

a. Seeds were inoculated with 'NITRAGIN' using the slurry method (4.5 fluid ounce of inoculant, 6 ounce of water, 15 lb of seed. B. Southern States formulation.

broadcasted. The seed and fertilizer then were cultivated to subsurface depths of 0 - 2 inches utilizing a low ground pressure all terrain vehicle equipped with a tool bar with cultivator attachment. Following cultivation, the sediment surface was smoothed using a wood platform drag. The spreader broadcasted seed and fertilizer over a width of approximately 10 feet. Consequently, there was considerable overlap of the dike exterior and dike interior seed mixtures.

The east end of the dike was seeded on 24 July. Following seeding, 1/4 inch of rain fell. The south side of the dike was seeded on 25 July, and 1/2 inch of rain fell following seeding. The balance of the areas were seeded between 27 and 30 July. Little rain fell in the area between this time and 27 September when tropical storm Eloise passed inland through Virginia causing widespread flooding (pers. comm. with local residents). Prior to departing the Site on 31 July, it was noted that seeds were germinating in abundance throughout the east and south sides of the dike.

The interior and exterior sections of the dike that were seeded and fertilized during 24 - 30 July were partially fertilized again on 30 September 1975 using Southern States medium release 10-10-10 fertilizer. The fertilization scheme used was established by WES. Starting at the southeast corner of the dike and proceeding west, then north, then east, and

finally south around the dike, alternate 150 foot and 50 foot sections of the dike were established as shown in Figure 34. Fourty pounds of fertilizer was applied to each 150 foot section using a hand operated 'Cyclone' broadcaster. The rate of broadcasting was set so that three passes were required to apply the 40 lbs of fertilizer. This procedure provided relatively uniform coverage over each 150 foot section.

On 16 October 1975, it was observed that most of the fertilized 150 foot sections of vegetation were clearly delineated by having greater chlorophyll pigmentation than the vegetation in the contiguous unfertilized 50 foot sections.

e. Overview of Dike Transplanting and Dike and Upland Area Seeding. Figures 35, 36, 37, and 38 show views of the east end of the dike looking north before grading on 2 July 1975, after grading and seeding on 31 July 1975, on 16 October 1975, and on 30 September 1976, respectively. By 30 September 1976 this area of the dike was dominated by P. amarulum and P. virgatum. Figures 39, 40, and 41 provide views at the east end of the dike looking south after seeding on 31 July 1975, on 16 October 1975, and on 30 September 1976, respectively. By the latter date, this area was dominated by P. amarulum and P. virgatum.

Figures 42, 43, 44, and 45 show views from the northeast

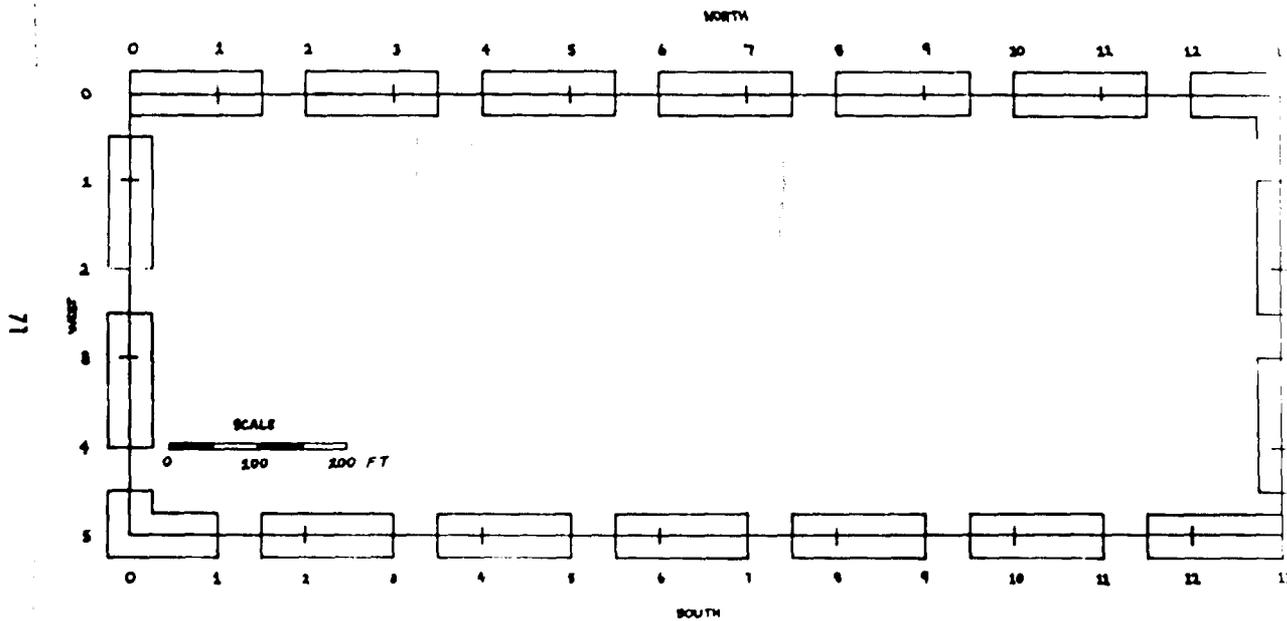


Figure 34. A schematic representation of the dike showing alternate 150 foot and 50 foot sections. The entire dike area was fertilized upon seeding during 24-30 July. Fertilizer was again applied to the 150 foot sections on 30 September.



Figure 35. East end of the dike looking north before grading on 2 July 1975.

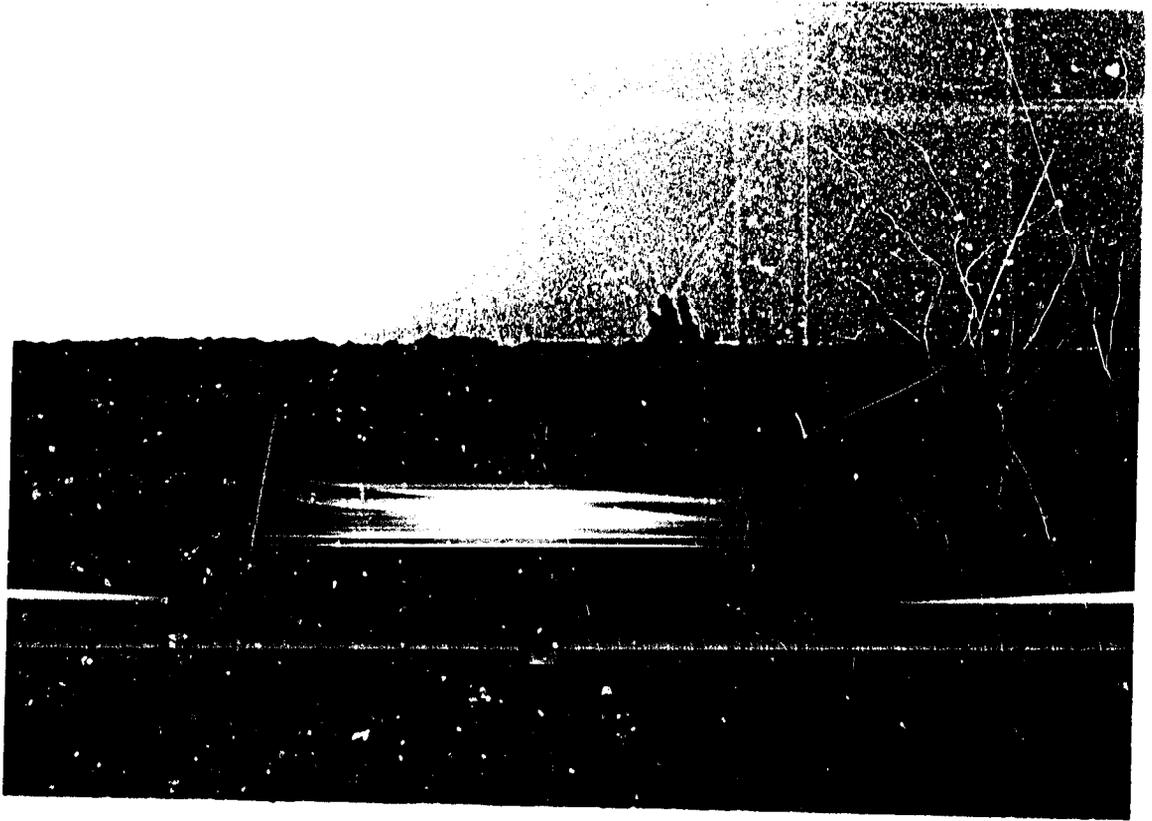


Figure 36. East end of the dike looking north after grading and seeding on 31 July 1975.



Figure 37. East end of the dike looking north on 16 October 1975.

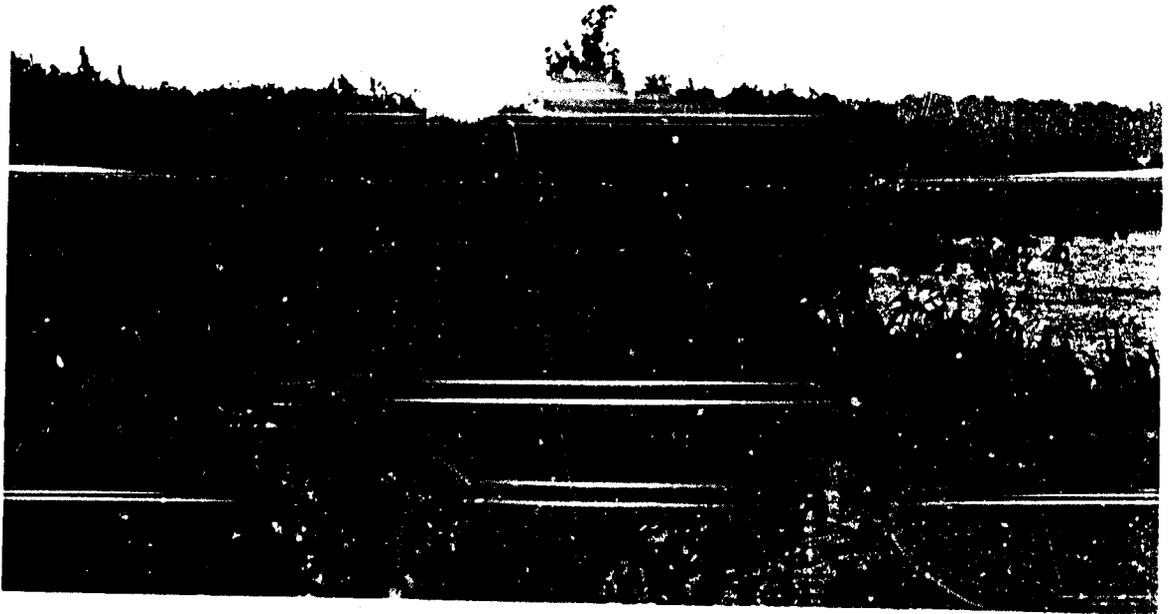


Figure 38. East end of the dike looking north on 30 September 1976.



Figure 39. East end of the dike looking south after seeding on 31 July 1975.

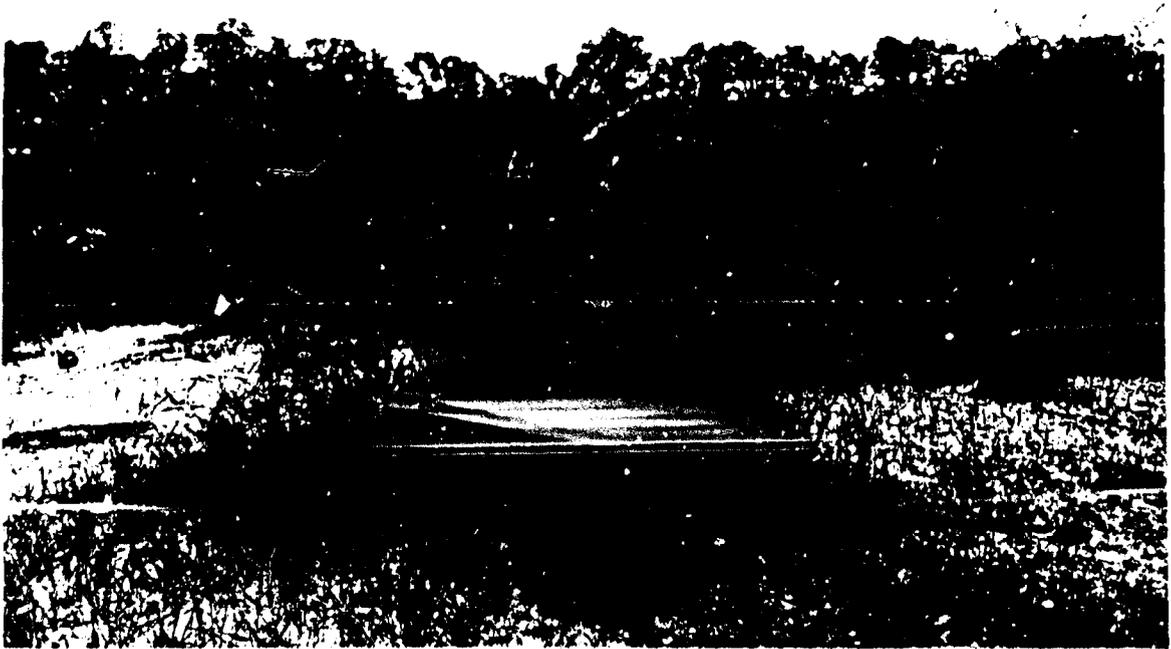


Figure 40. East end of the dike looking south on 16 October 1975.



Figure 41. East end of the dike looking south on 30 September 1976.



Figure 42. Northeast corner of the dike looking west along the north side during the grading operation on 24 June 1975.

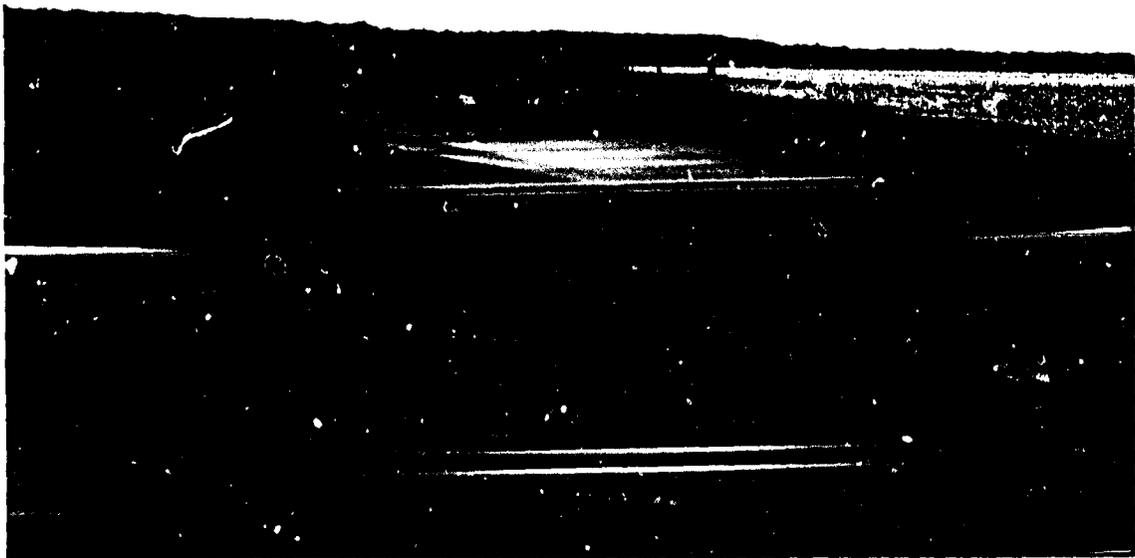


Figure 43. Northeast corner of the dike looking west along the north side on 31 July 1975 just following seeding.

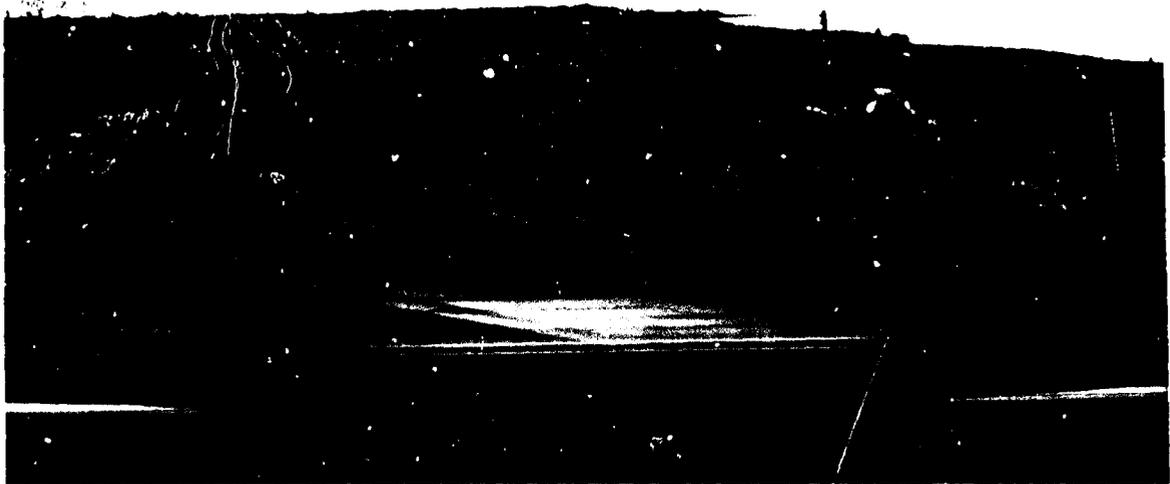


Figure 44. Northeast corner of the dike looking west along
the north side on 16 October 1975.

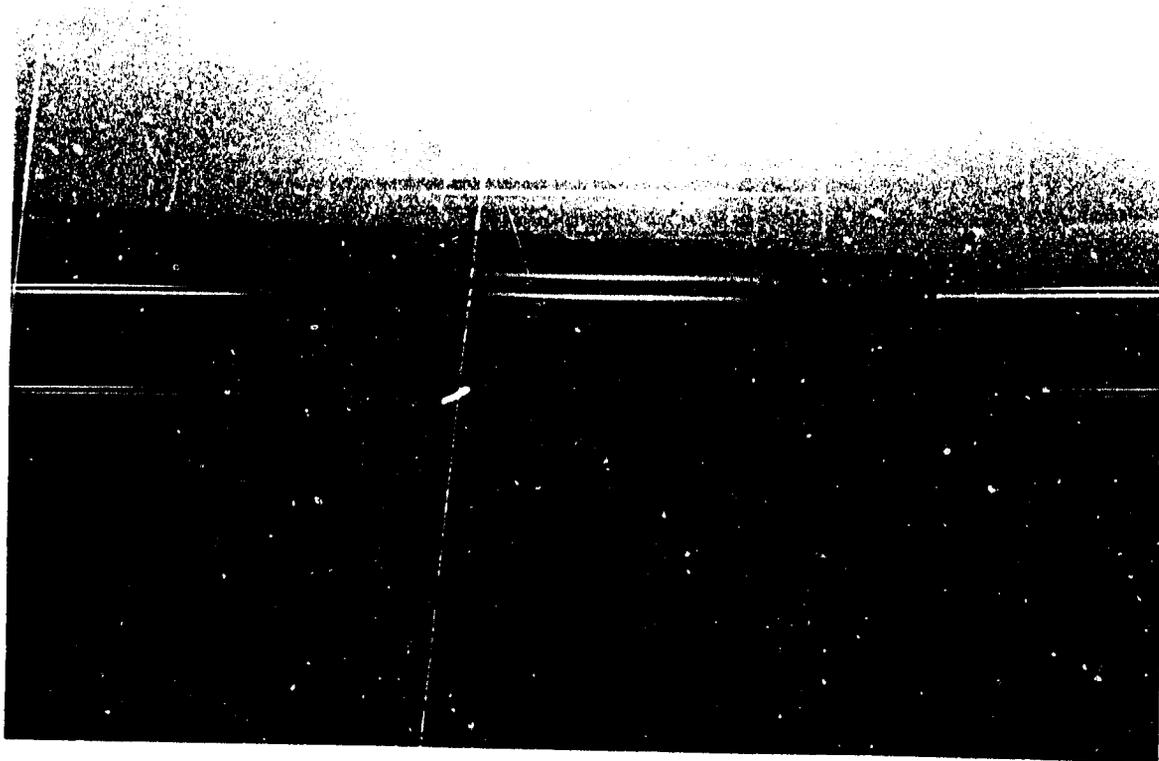


Figure 45. Northeast corner of the dike looking west along the north side on 30 September 1976.

corner of the dike looking west along the north side on 24 June 1975 during the grading operation, on 31 July 1975 just following the seeding, on 16 October 1975, and on 30 September 1976, respectively. Figures 46 and 47 show the contained upland dredged material area at the northeast corner of the dike on 29 August 1975, one month after seeding, and on 16 October 1975, respectively.

Figures 48, 49, and 50 show views at the mid-north side of the dike looking west along the fringe marsh on 31 July 1975, 16 October 1975, and 30 September 1976, respectively. The band of S. alterniflora and S. americanus shown in these figures is the only significant fringe marsh remaining on 30 September 1976 at the Site. Extensive Canada geese "eat-out" during the winter of 1976 led to the loss of most of the balance of the fringe marsh along the dike exterior.

Views at the mid-north side of the dike looking east along the seeded portion on 29 August 1975, on 16 October 1975, and on 30 September 1976 are provided in Figures 51, 52, and 53, respectively. Note the sections of P. virginica marsh deposited on the highest elevations of the dike in the foreground and background of Fig. 51. Eroded sections of P. virginica marsh were frequently observed floating downriver (see Fig. 54). Seeds and seedlings of P. virginica also were noted floating downriver and many of these were deposited throughout the Site. The view in Figure 53 is dominated by P. amarulum and tall



Figure 46. Upland dredged material area at the northeast corner of the dike on 29 August 1975, one month after seedling



Figure 47. Upland dredged material area at the northeast corner of the dike on 16 October 1975.

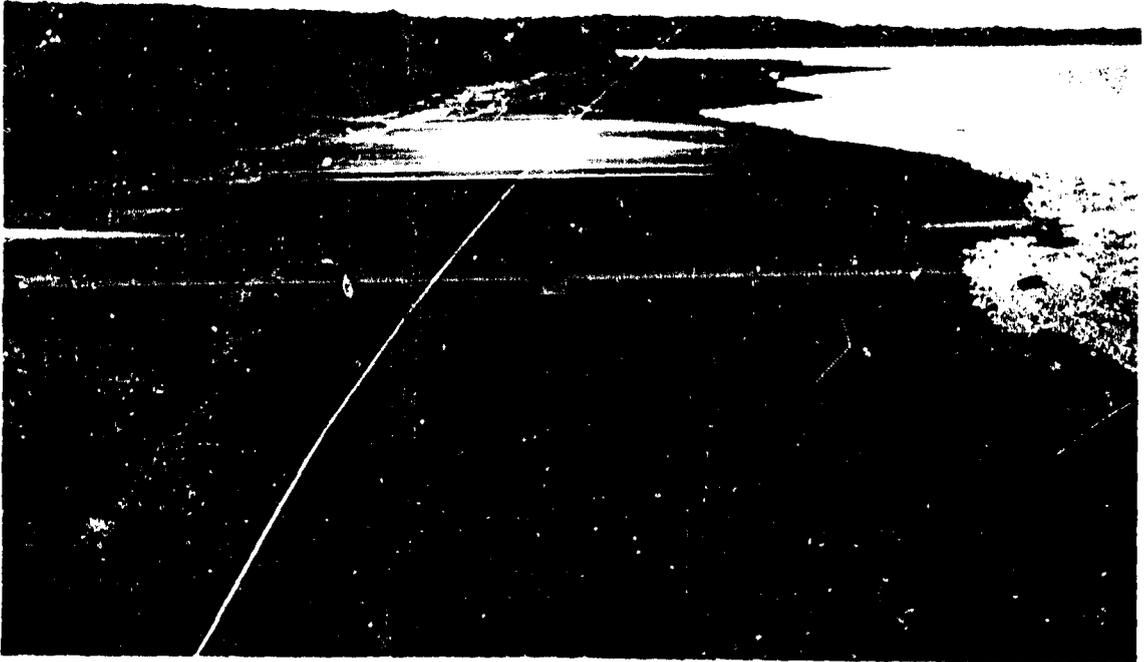


Figure 48. Mid-north side of the dike looking west along the fringe marsh on 31 July 1975.



Figure 49. Mid-north side of the dike looking west along the fringe marsh on 16 October 1975.

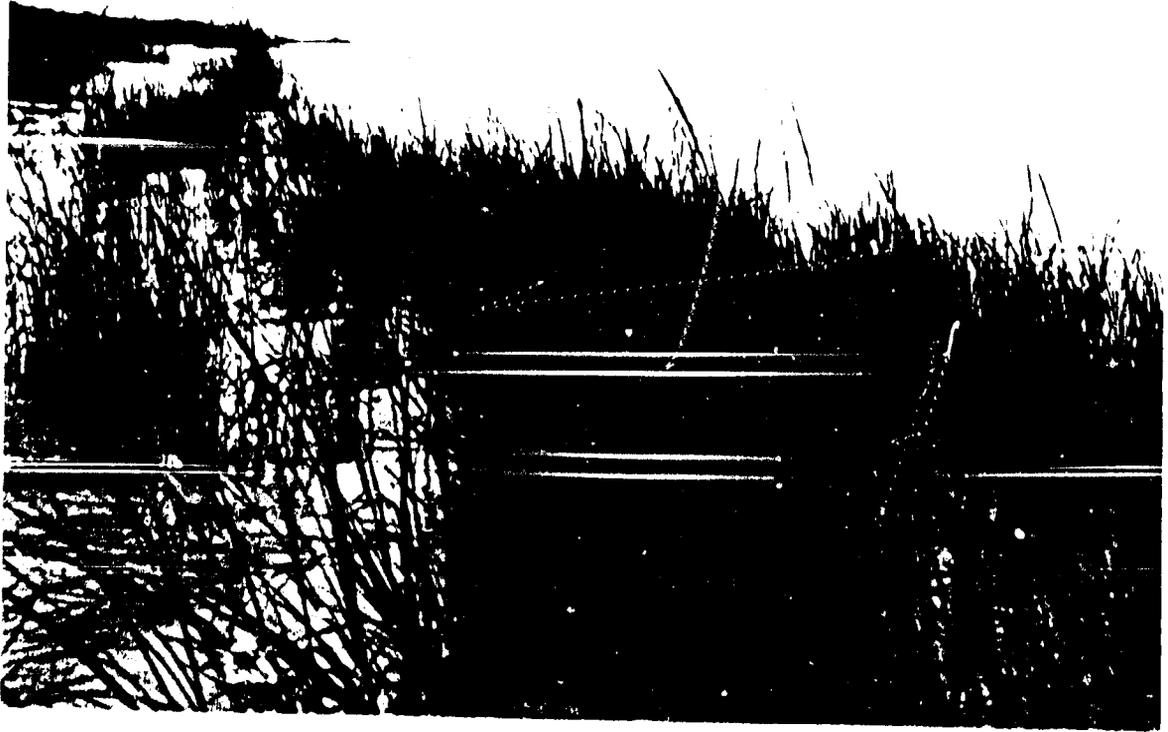


Figure 50. Mid-north side of the dike looking west along the fringe marsh on 30 September 1976.

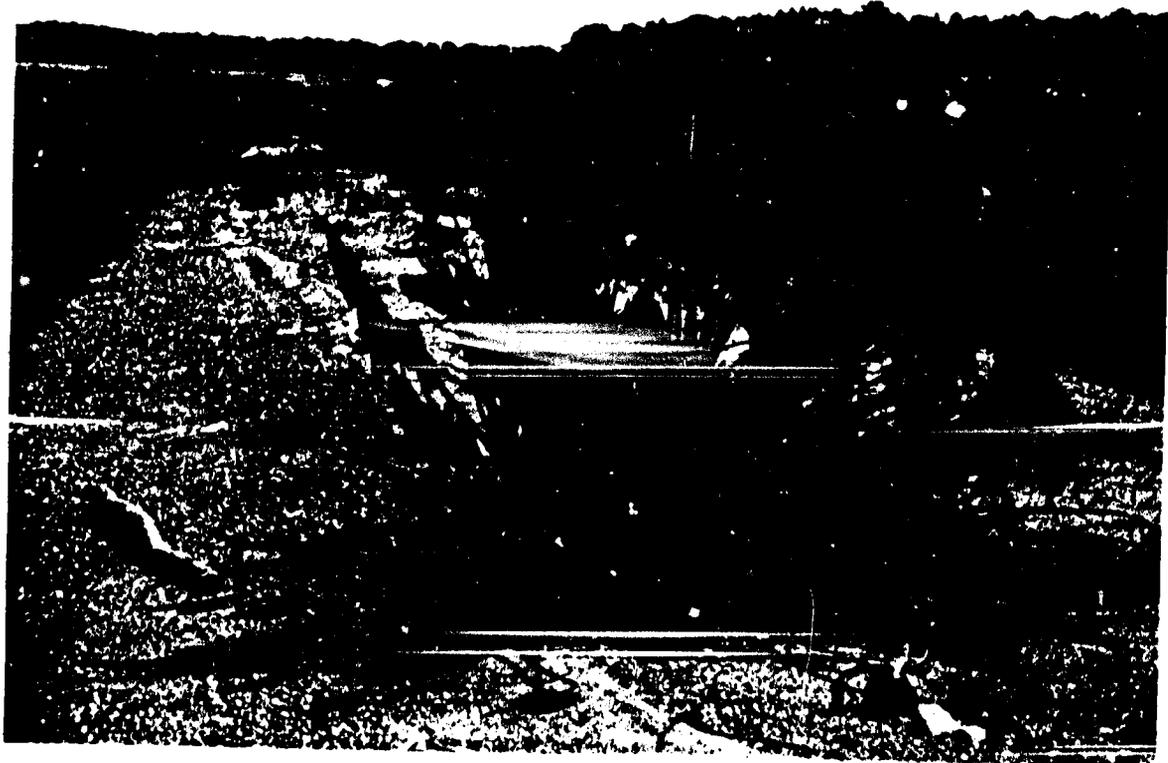


Figure 51. Mid-north side of the dike looking east along the seeded area on 29 August 1975.



Figure 52. Mid-north side of the dike looking east along
the seeded area on 16 October 1975.

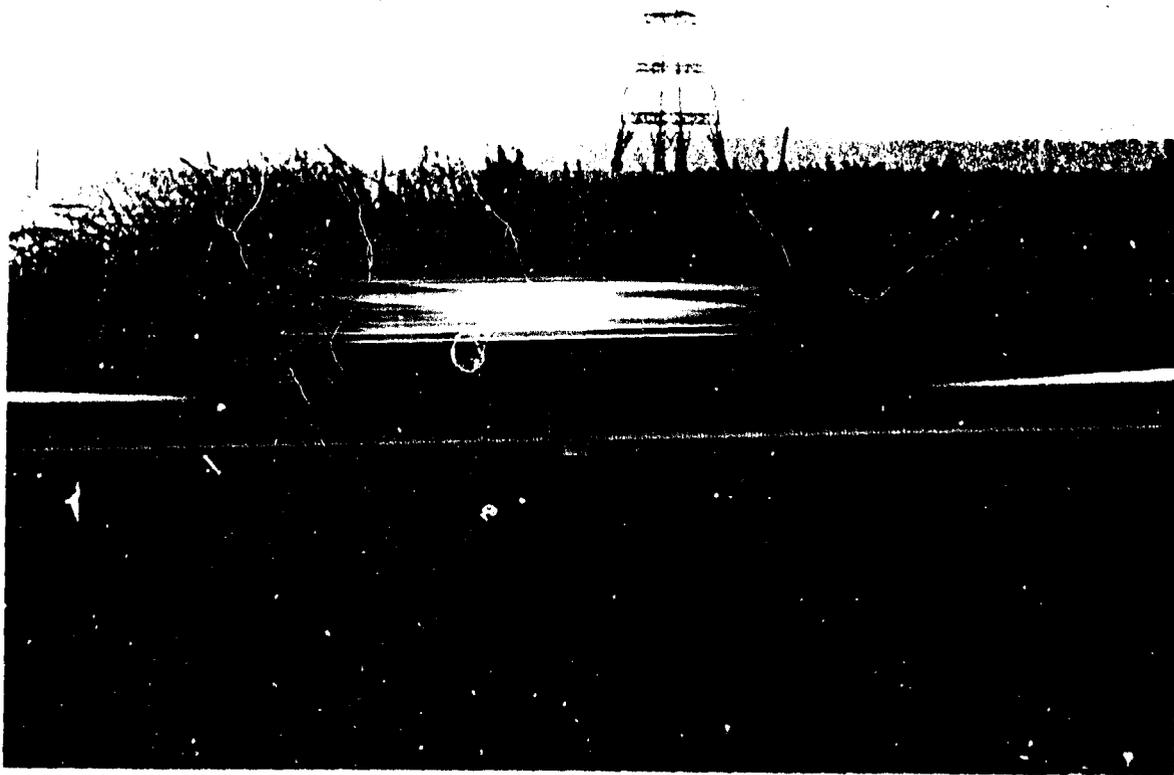


Figure 53. Mid-north side of the dike looking east along the seeded area on 30 September 1976.

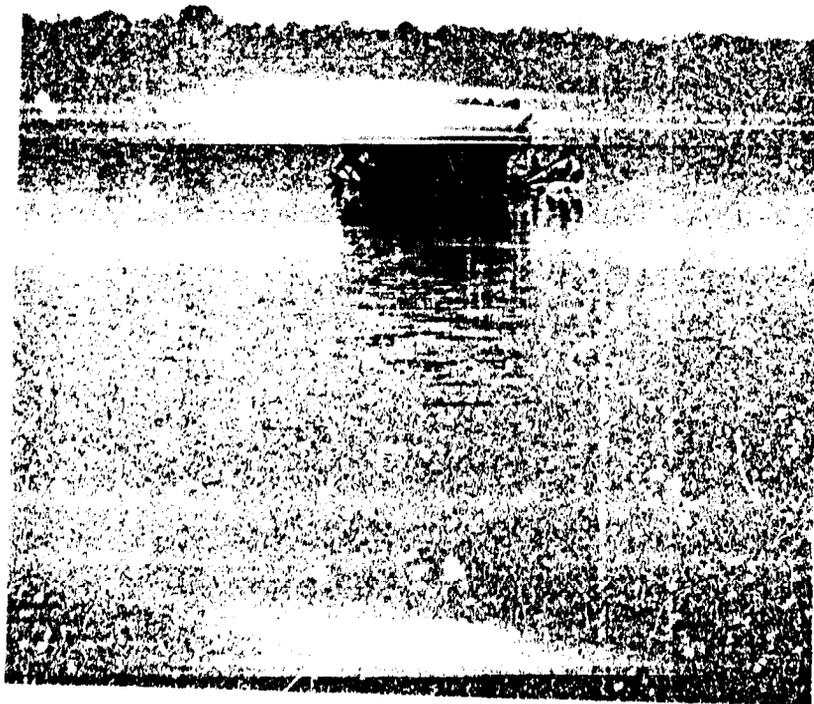


Figure 54. Eroded section of P. virginica marsh drifting down the James River just north of the Site on 6 July 1975.

clumps of P. virgatum at lower left.

Views of the west end of the dike from the northwest corner looking south on 31 July 1975, on 16 October 1975, and on 30 September 1976 are shown in Figures 55, 56, and 57, respectively. The vegetation seen in Figure 57 is dominated by P. amarulum. The volunteer marsh on the contained dredged materials, as viewed on 31 July 1975 from the mid-west end of the dike looking east, is shown in Figure 58. The person in this figure is 5 feet 4 inches tall and the dominant vegetation seen is P. cordata.

The marsh fringe along the exterior southern side of the dike, as seen on 31 July 1975, 16 October 1975, and 30 September 1976 from the south, looking east, is shown in Figures 59, 60, and 61, respectively. Approximately 80% of the marsh, as seen in Figure 60, was "eaten-out" during the winter of 1976 and is missing in Figure 61.

Views of the seeded portion of the dike looking east from the mid-south side on 31 July 1975, on 16 October 1975, and on 30 September 1976 are shown in Figures 62, 63, and 64, respectively. The dominant vegetation seen in Figure 64 is P. amarulum. Views looking west from the mid-south side of the dike on 29 August 1975, on 16 October 1975, and on 30 September 1976 are provided in Figures 65, 66, and 67, respectively. Note the complete loss of the fringe marsh on the dike exterior



Figure 55. Northwest corner of the dike looking south along the west side on 31 July 1975.



Figure 56. Northwest corner of the dike looking south along the west side on 16 October 1975.

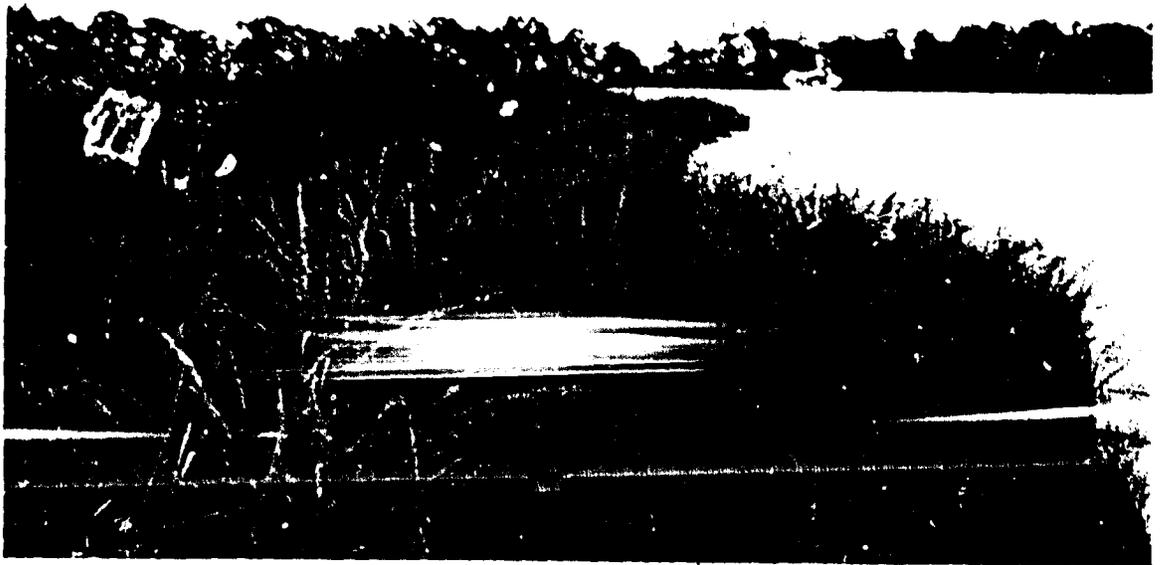


Figure 57. Northwest corner of the dike looking south along the west side on 30 September 1976.

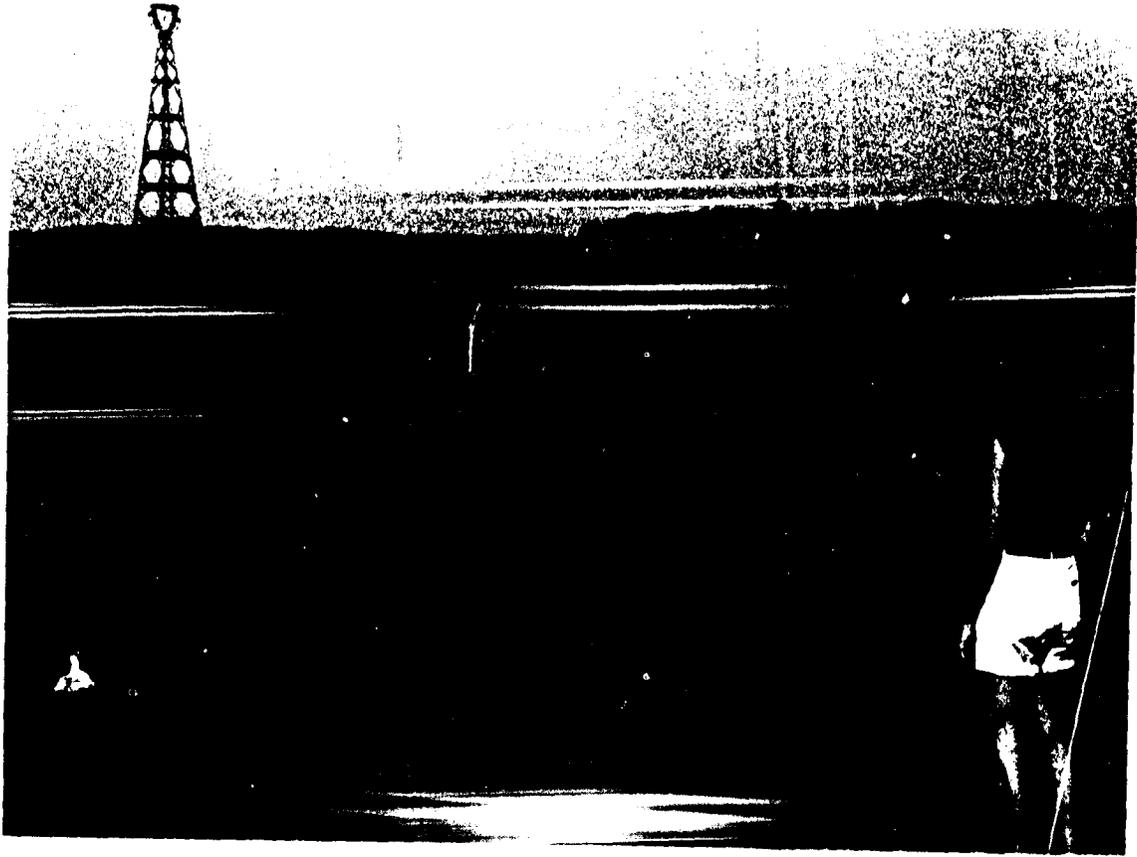


Figure 58. Looking east on 31 July 1975 from the mid-west end of the dike across the volunteer marsh on the contained dredged materials.

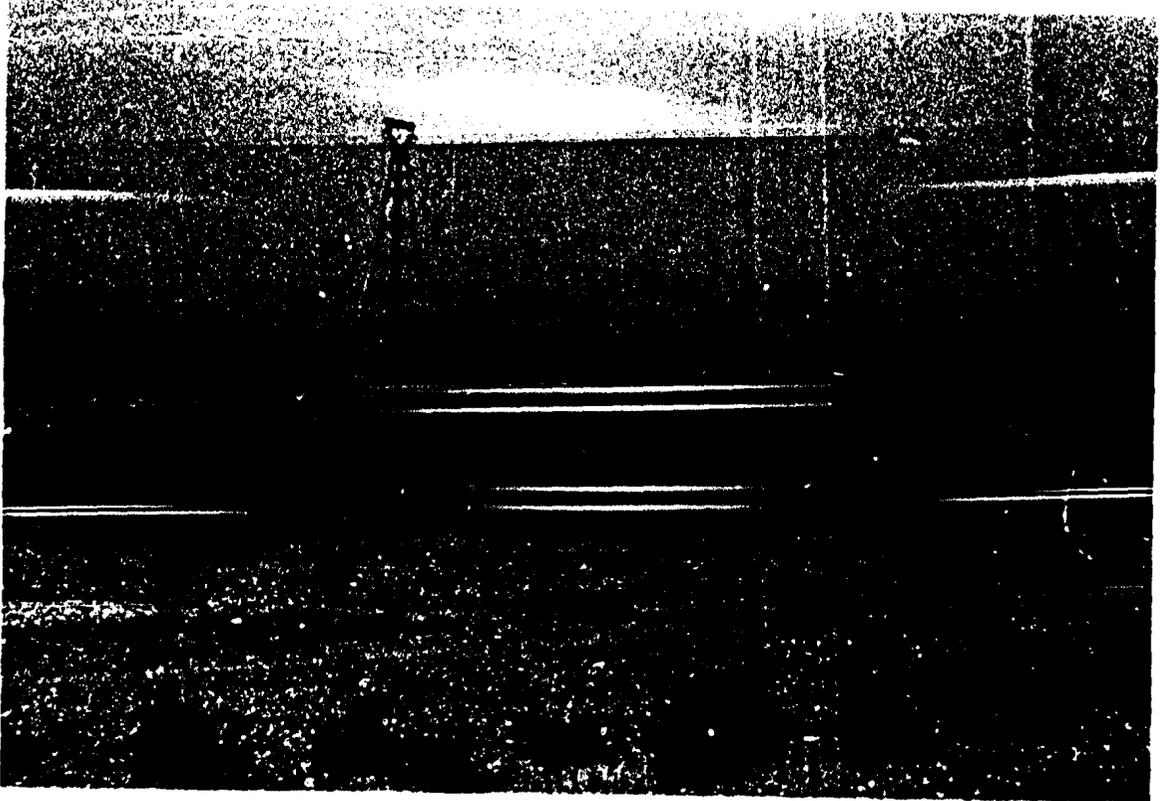


Figure 59. Looking east at the fringe marsh along the exterior southern side of the dike from the southwest corner on 31 July 1975.



Figure 60. Looking east at the fringe marsh along the exterior southern side of the dike from the southwest corner on 16 October 1975.



Figure 61. Looking east at the fringe marsh along the exterior southern side of the dike from the southwest corner on 30 September 1976.

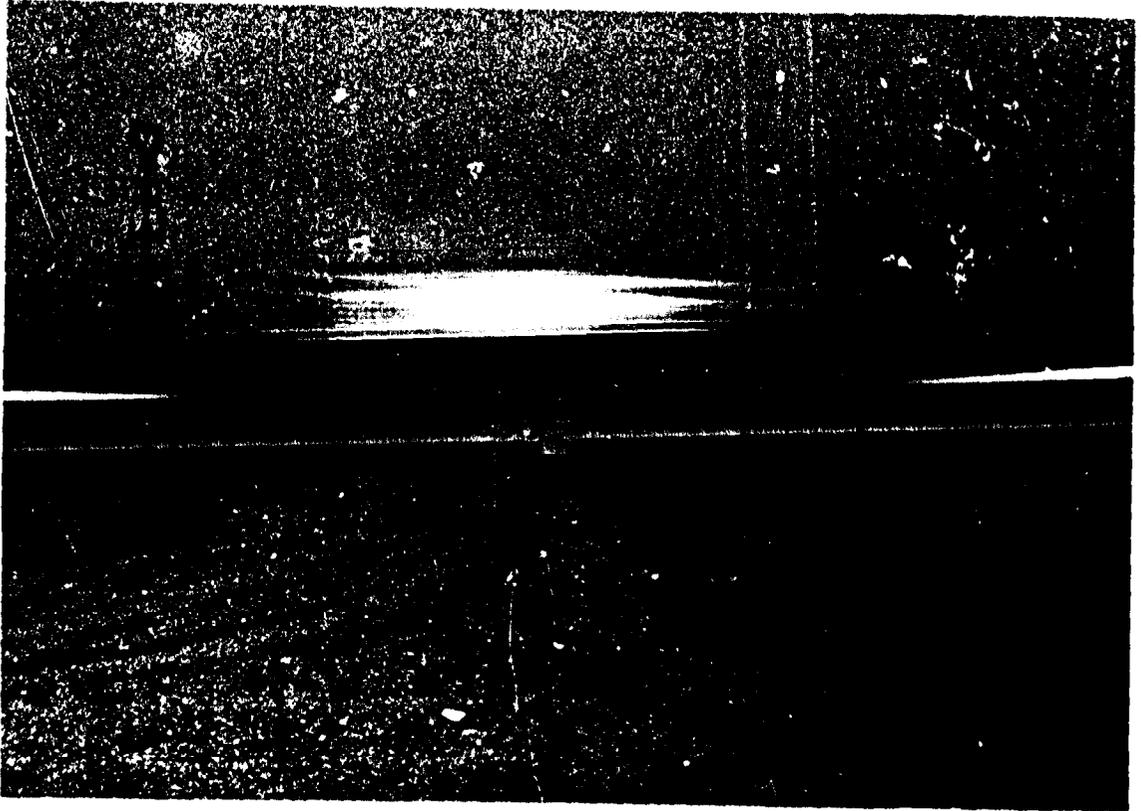


Figure 62. Looking east from the mid-south side of the dike
on 31 July 1975.



Figure 63. Looking east from the mid-south side of the dike
on 16 October 1975.



Figure 64. Looking east from the mid-south side of the dike
on 30 September 1976.



Figure 65. Looking west from the mid-south side of the dike on 29 August 1975.



Figure 66. Looking west from the mid-south side of the dike
on 16 October 1975.

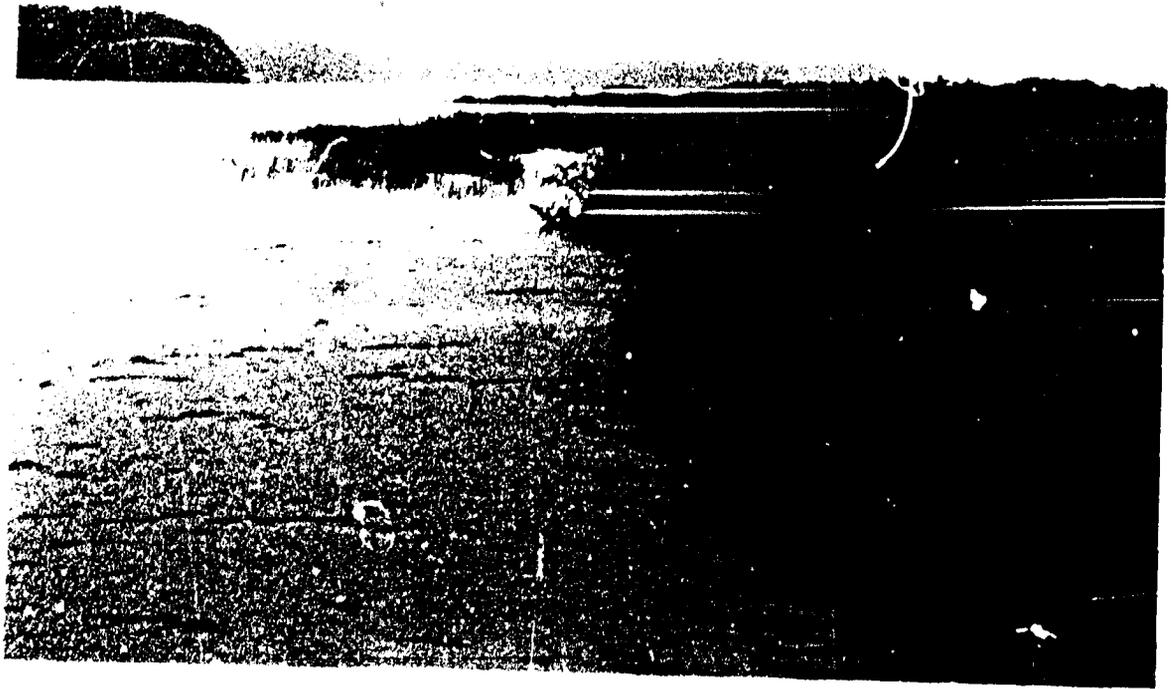


Figure 67. Looking west from the mid-south side of the dike
on 30 September 1976.

in the foreground of Figure 67.

Portions of the south and north dike interiors that were seeded to I. repens, D. glomerata, and F. elatior and that were essentially monotypic I. repens on 16 October 1975 are shown in Figures 68 and 69, respectively. A greater diversity of plants were present in these areas on 30 September 1976.

2. Blocks of Plots on Unconfined Dredged Materials

Eight replicated blocks of 16 plots of seeded and sprigged marsh plants were established on the unconfined dredged materials just east of the northeast side of the dike (see Fig. 2). The physical and statistical design of these blocks of plots were provided by WES and are indicated in Figures 70 and 71. Each 10' X 10' plot contains 49 replicated treatments on 1.25 foot centers. The block of plots were staked out on July 12th and 13th from the approximate Mean Tide (+1.3 ft relative to MLW) at the eastern ends of the blocks to approximately MHW (+2.5 ft relative to MLW) at the western ends. Mean Tide and MHW elevations throughout the area of the blocks of plots were qualitatively determined by placing stakes at the water-land interface at the time predicted (tide tables) for high tide at Jordan Point (ca. 9 miles upriver from the Site) and at 3 hrs after this time (for approx Mean Tide) on a day when high tide was predicted to be at MHW.



Figure 68. A section of the interior south side of the dike that is dominated by I. repens on 16 October 1975.



Figure 69. A section of the interior north side of the dike that is dominated by I. repens on 16 October 1975.

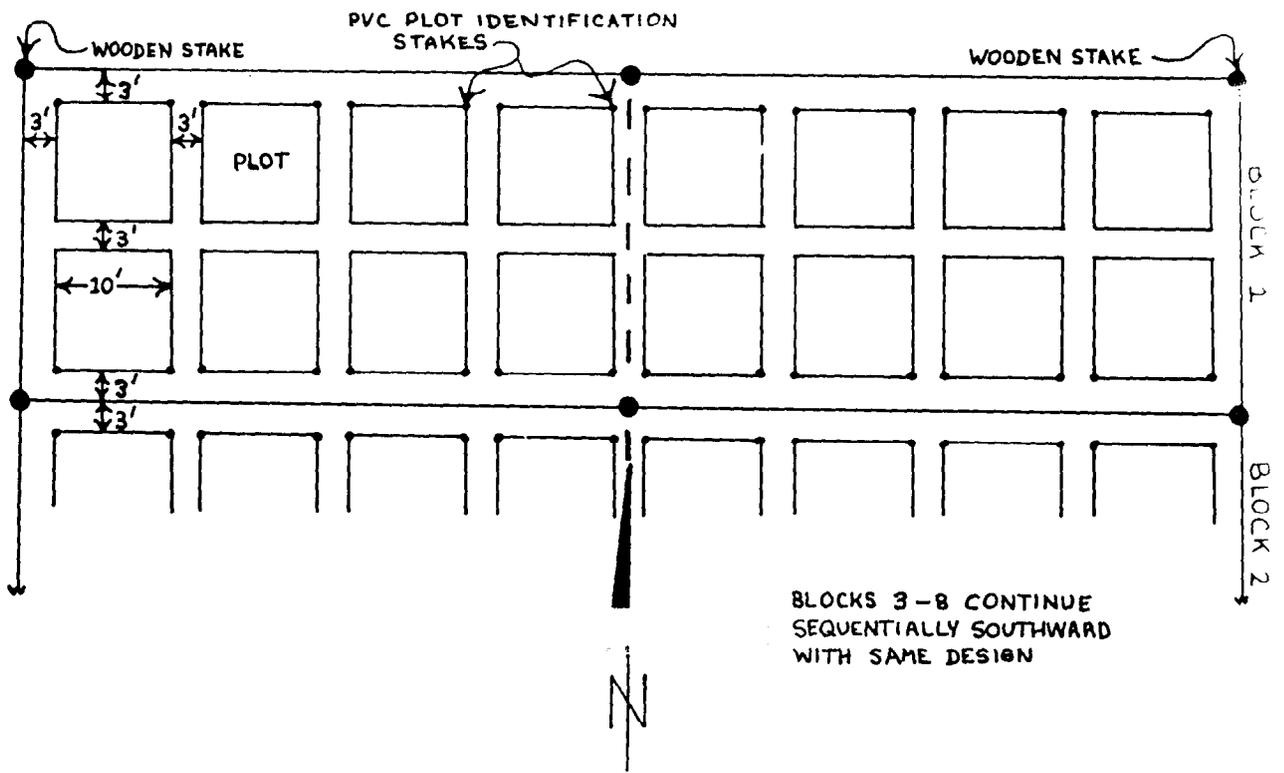


Figure 70. A schematic representation of the physical design of the blocks of plots.

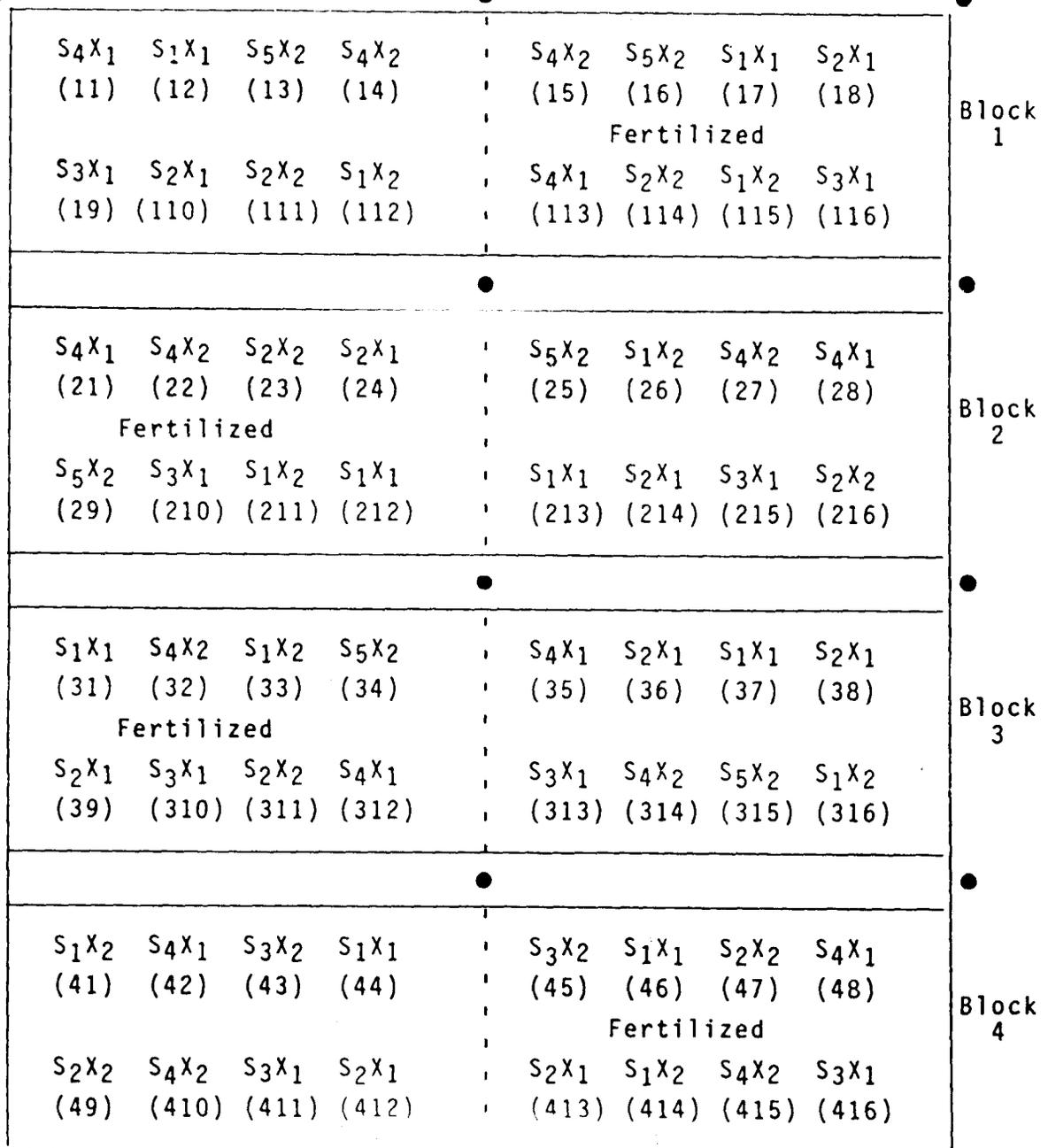


Figure 71. A schematic representation of the statistical design of the blocks of plots. Parenthetical numbers represent those placed twice on each of the two PVC plot identification stakes (see Fig. 70). X₁ = sprigging, X₂ = seeding, S₁ = *P. virginica*, S₂ = *S. cynosuroides*, S₃ = S₅ = *S. robustus*, S₄ = *S. alterniflora*. Blocks 5, 6, 7, and 8 are identical to blocks 1, 2, 3, 4, respectively, and continue sequentially in a southerly direction. The PVC plot identification stake numbers for these plots follow the scheme shown for Blocks 1-4.

Because of the contour of the unconfined dredged material area, it was not possible to establish the blocks so that substrate elevations were replicated in each. Additionally, the substrate composition varied in the area of the blocks of plots from coarse-grained (83% sand, 9% mud) throughout the westernmost plots of blocks 1-4 to finer grained (56% sand, 43% mud) throughout the east half of blocks 1-4 and throughout blocks 5-8.

a. Quantitative Elevation Determinations. On 28 July, elevations were determined at 5-foot intervals along nine transects paralleling the eight blocks of plots. Each transect was 150 feet long and extended seaward from and perpendicular to a baseline along the east side of the dike previously established by a survey team of the Norfolk District Corps of Engineers.

Elevations were read using an 18-inch Dumpy level and a level rod graduated in 0.01 ft. Elevations were made relative to the Corps of Engineers MLW (CE MLW) given as zero on the tide staff present at the Site. Personal communication with Mr. Van of the Norfolk District revealed that MLW at the Site is 1.5 feet above the CE MLW. Elevations of the Corps of Engineers benchmarks BM-1 (NE corner of the dike) and BM-2 (SE corner of the dike) were determined to be 5.03 ft and 4.31 ft, respectively, relative to CE MLW. These elevations

are slightly lower than those supplied by the Norfolk District (BM-1, 5.27 ft; BM-2, 4.38 ft). Figure 72 shows the 0.5 ft elevation contours relative to CE MLW throughout the blocks of plots. To convert these elevation contours to those relative to true MLW as zero, subtract 1.3 ft.

b. Plant Materials. Because of their small size, seeds of S. robustus, S. alterniflora, and S. cynosuroides were packaged (10 seeds per packet) in the laboratory. The large size of P. virginica seed made pre-packaging unnecessary.

With the exception of P. virginica, the seeds were removed from aqueous storage at 4°C, subjected to partial air drying at ambient temperature, and packaged (49 packets of seeds each for each plot to be seeded). All seeds were maintained in cold storage (3-5°C) until planted.

Seedlings of S. robustus, S. alterniflora, and P. virginica were greenhouse cultivated from seed at Environmental Concern, St. Michaels, Md. After being cultivated for approximately three months, the seedlings were washed free of soil and the resulting bare root materials (i.e., sprigs) were stored in tubs with the roots submerged in fresh water until planted. The S. cynosuroides sprig stock consisted of peat-potted seedlings that had been cultivated during the summer of 1974 and overwintered at Environmental Concern.

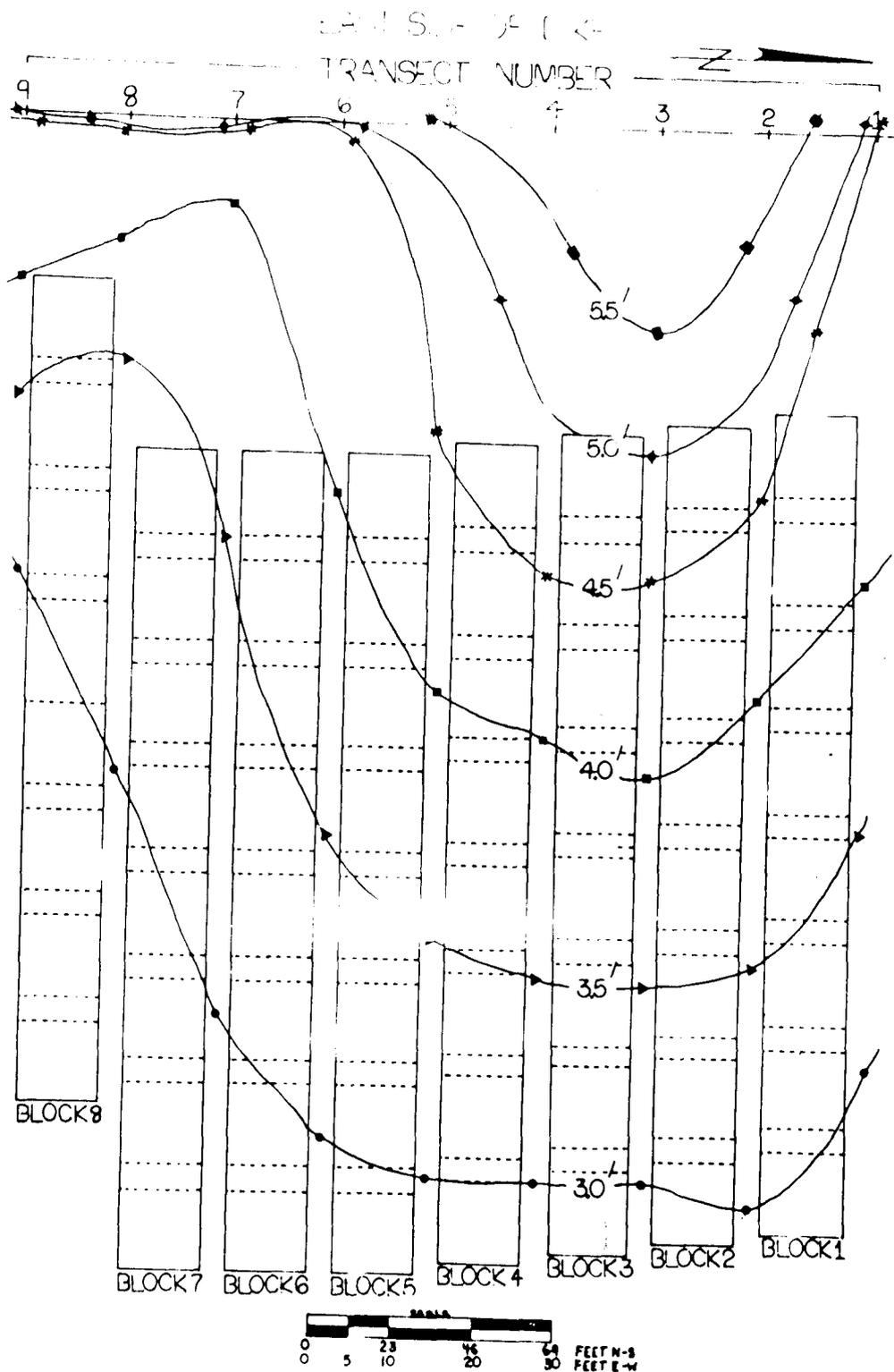


Figure 72. Elevation contours (0.5 ft) relative to CE MLW as zero throughout the blocks of plots.

Prior to transplanting to the blocks of plots, ten randomly selected transplants of each species were separated into aboveground and belowground portions and dried to constant weight at 80°C. The resulting dry weights are collected in Table 2.

Figures 73-76 show photographs of the four species of plant stock prior to transplanting to the blocks of plots.

c. Planting. Each plot was replicate planted 49 times on 1.25 ft centers. A portable frame was used which marked the location of each of the 49 plant sites within each plot. When fertilizer was required by the adopted fertilization scheme (see Fig. 71), 5.0 g of OSMOCOTE 7- to 8-month release 19-6-12 fertilizer was side-dressed with the seeds or sprigs. All the blocks of plots were planted between 14 July and 23 July.

Seeds were planted by making a 0.5 to 1.0 inch depression in the sediment. Seeds and fertilizer, when required, were placed in the depression and then covered with sediment. With the exception of P. virginica for which three seeds were planted at each seed site, 10 seeds were planted at each of the 40 seed sites in each seeded plot.

The peat-potted S. cynosuroides were transplanted using a shovel. The bare root plant stock (sprigs) were planted by

Table 2. Mean dry weights of plant stock used in the blocks of plots at the Site.^a

Species	Dry weight		
	Aboveground	Belowground	Total
<u>Peltandra virginica</u>	0.53 (0.11)	0.75 (0.20)	1.28 (0.28)
<u>Scirpus robustus</u>	0.04 (0.02)	0.03 (0.01)	0.07 (0.02)
<u>Spartina alterniflora</u>	0.27 (0.17)	0.28 (0.13)	0.55 (0.21)
<u>Spartina cynosuroides</u>	7.78 (3.57)	10.37 (4.59)	18.15 (8.14)

a. Tabulated values are the mean weights (in grams) of 10 transplants. Parenthetical values are standard deviations.

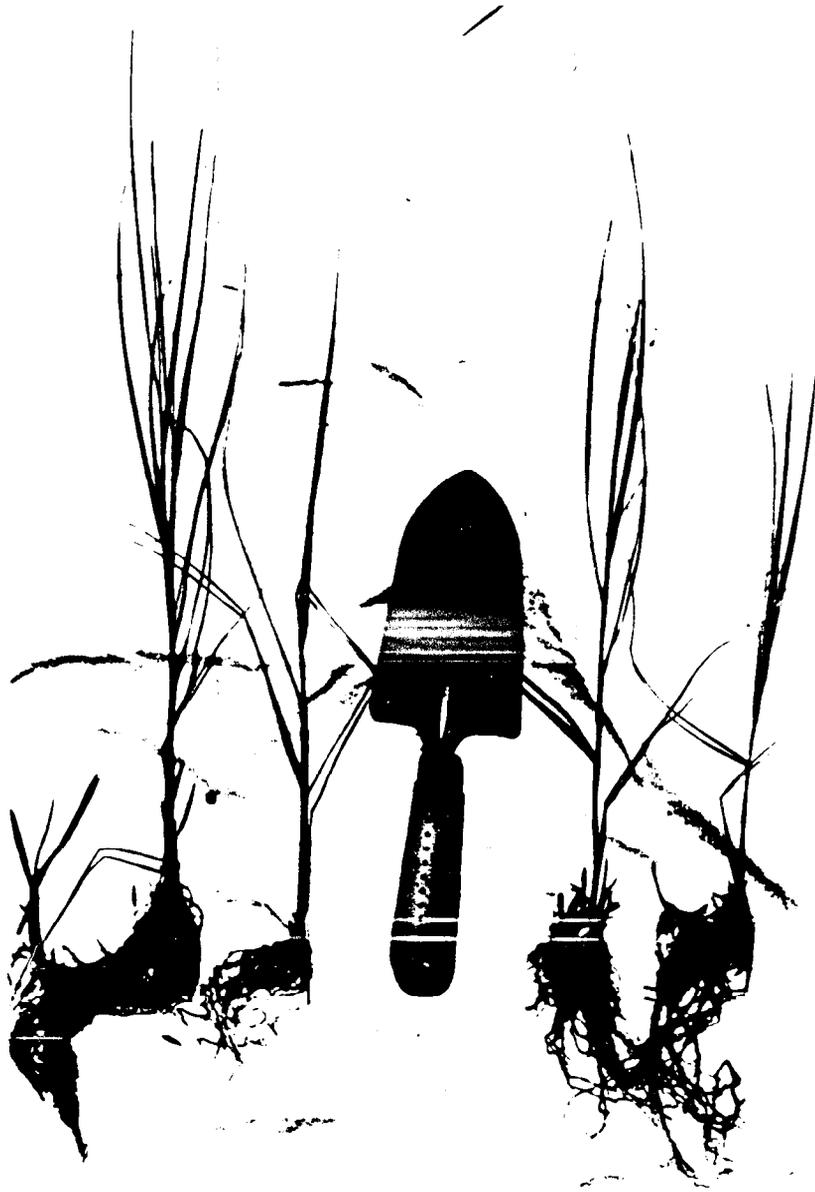


Figure 73. Representative specimens of S.
alterniflora transplanted to
the [unclear] plots.



Figure 74. Representative specimens of P.
virginica transplanted to the
blocks of plots.



Figure 75. Representative specimens of S.
robustus transplanted to the
blocks of plots.



Figure 76. Representative specimens of *S.*
cynosuroides transplanted to the
blocks of plots.

opening a hole in the sediment using a dibble. One pot or one sprig was planted at each plant site. All transplants that disappeared, or that were damaged by waves or animals, or that otherwise suffered mortalities between the period of 14 July and 31 July were replanted prior to departing the Site on 31 July. The number of replants so required were 107 P. virginica, 146 S. robustus, and 15 S. alterniflora. Blocks 1-4 received 98 replants and blocks 5-8 received 168 replants.

d. Initial Results. An overview of the eight blocks of plots after staking out and planting, is shown in Figure 77. By 31 July, seeds of P. virginica and S. alterniflora had germinated in all of the seeded plots. Seed germination of S. robustus and S. cynosuroides was never observed by Environmental Concern personnel.

On 29 August, extensive animal damage was observed throughout all of the eight blocks, particularly at the lower elevations. Aboveground parts of P. virginica had been clipped and were lying about the plots (see Fig. 78). S. robustus transplants were being disturbed (see Fig. 79). S. alterniflora transplants were being excavated (see Fig. 80 and note Canada goose and shorebird tracks at lower right), excavations had occurred at the base of each S. cynosuroides transplant (see Fig. 81), and the higher elevations of the blocks had been colonized by foreign vegetation (see Fig. 82). Figure

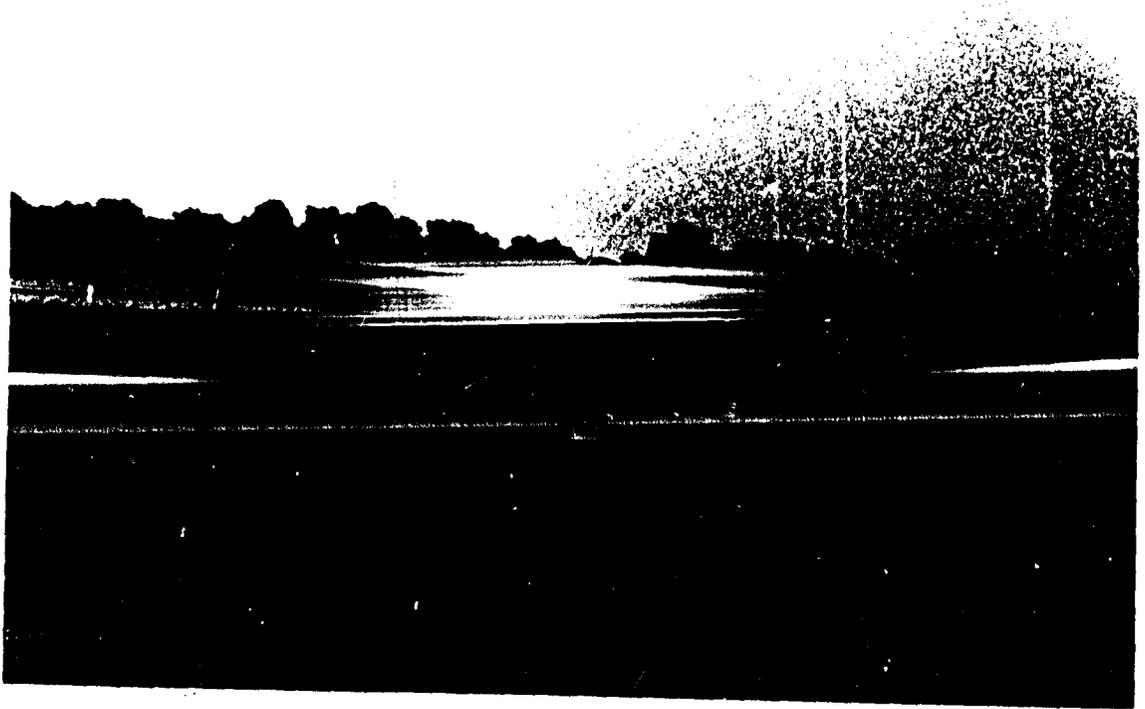


Figure 77. The eight blocks of plots as viewed from the northeast corner of the dike looking south.

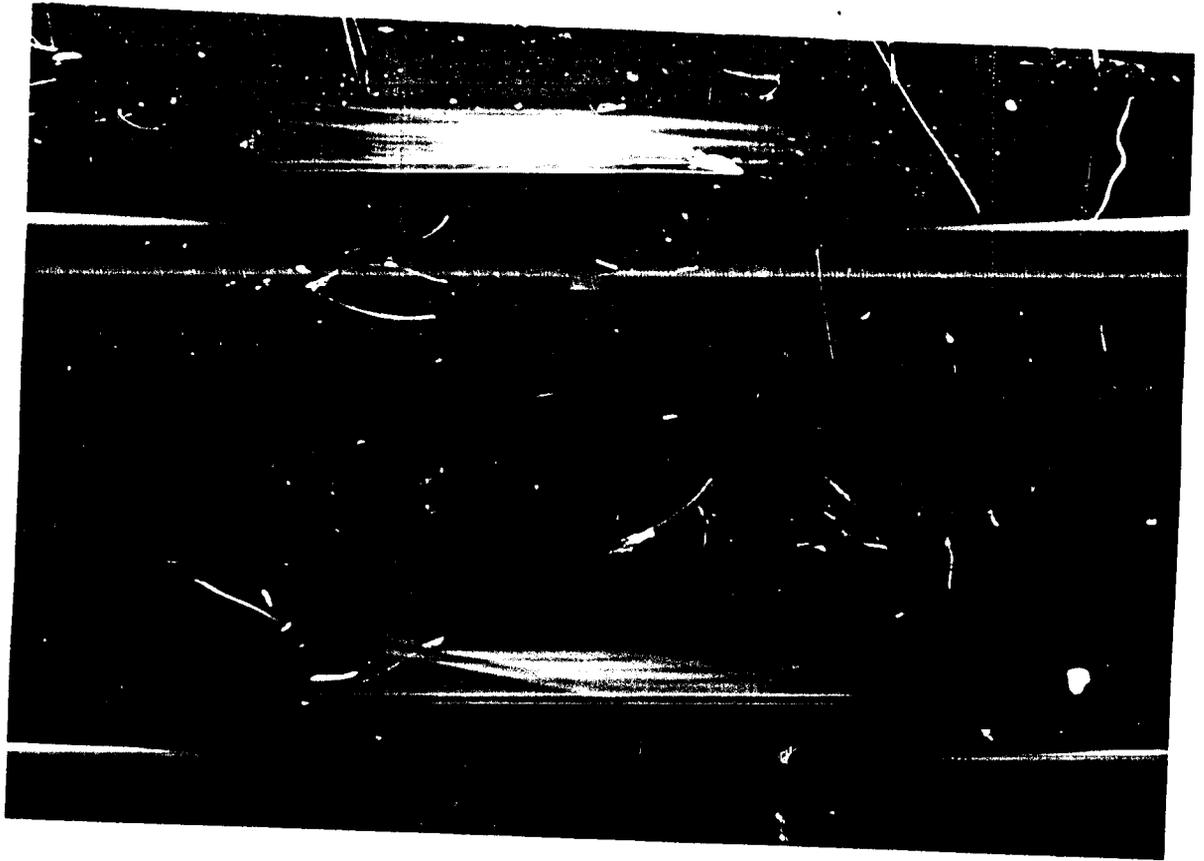


Figure 78. Animal clipping of P. virginica in sprigged plots as seen on 29 August 1975.

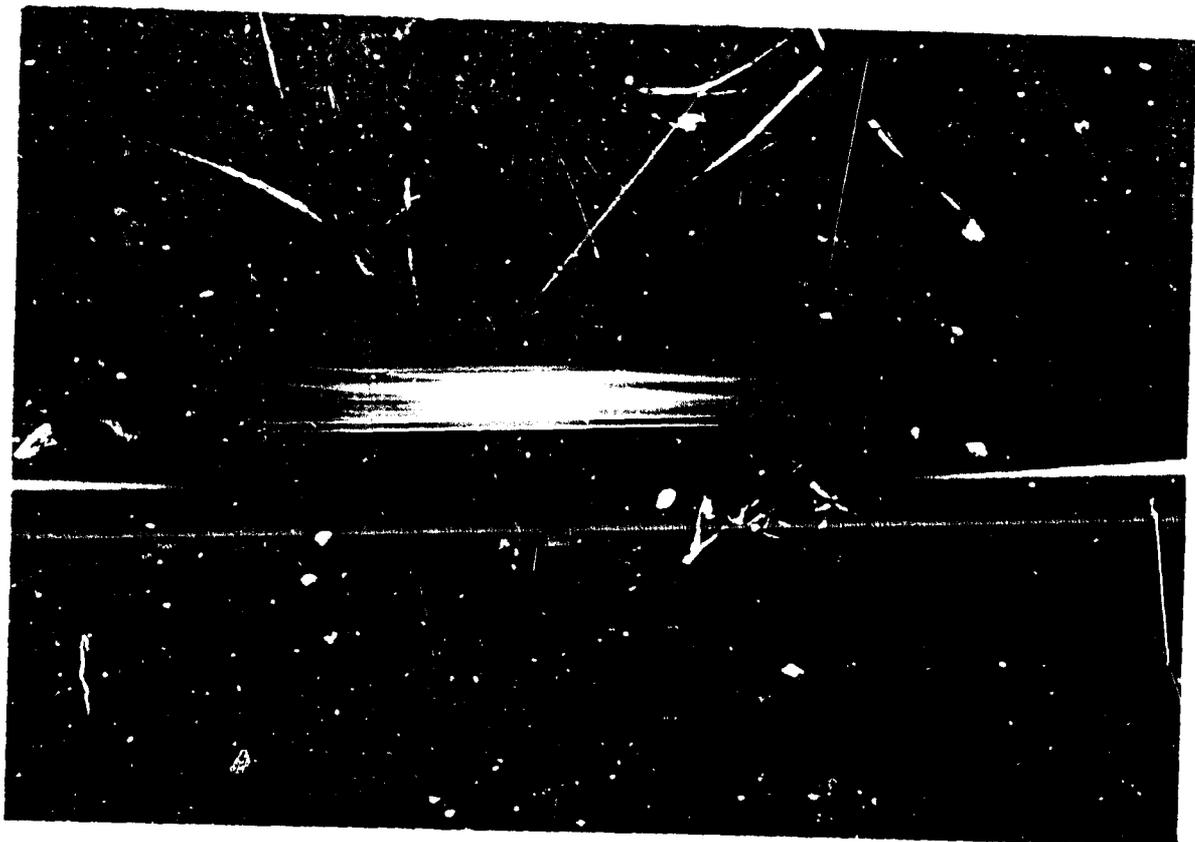


Figure 79. Animal damage of S. robustus in sprigged plots as seen on 29 August 1975.

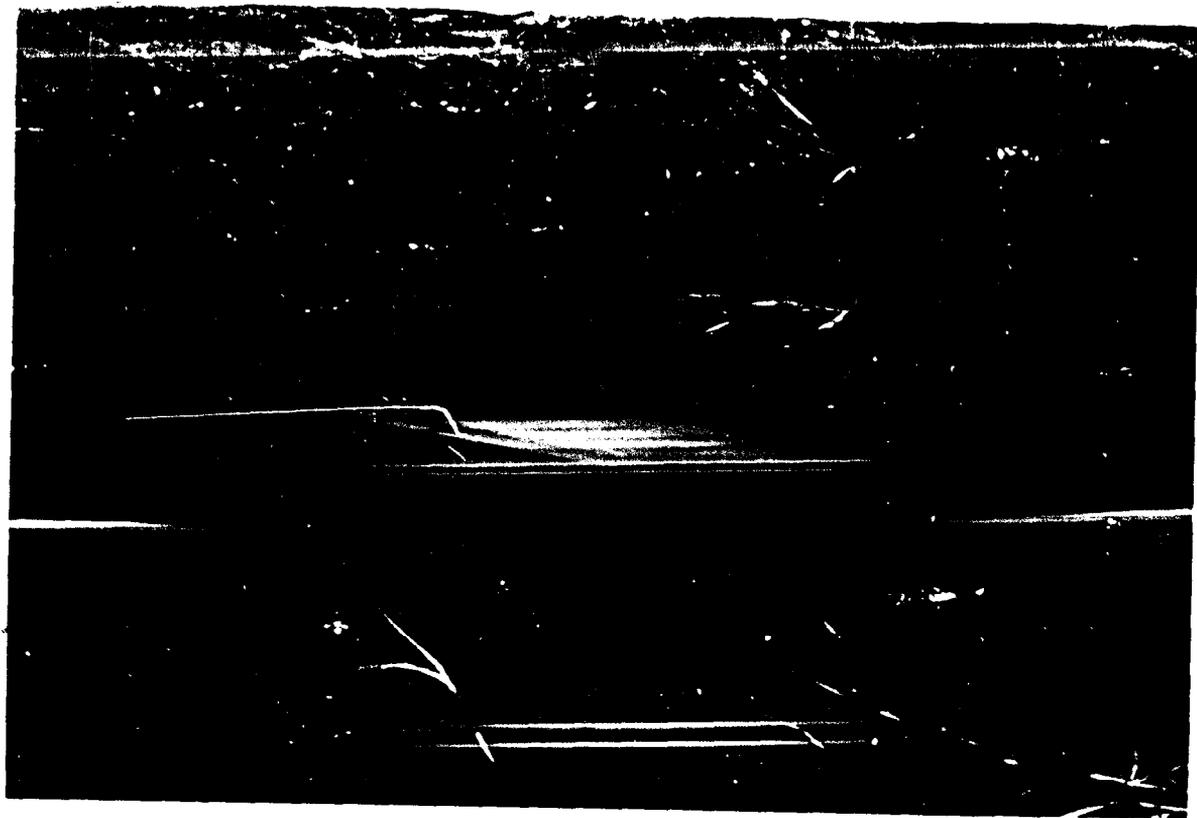


Figure 80. Animal excavations of S. alterniflora in sprigged plots as seen on 29 August 1975.

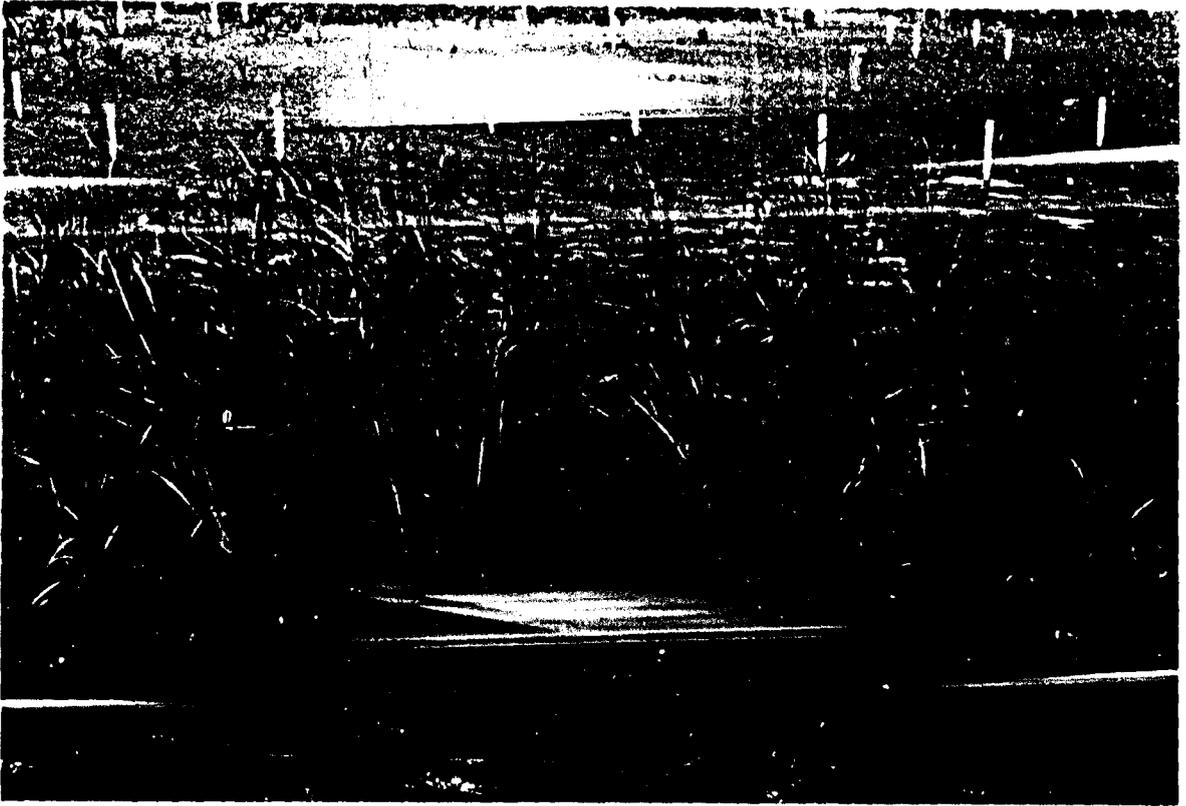


Figure 81. Animal excavations at the base of S. cynosuroides in sprigged plots as seen on 29 August 1975.

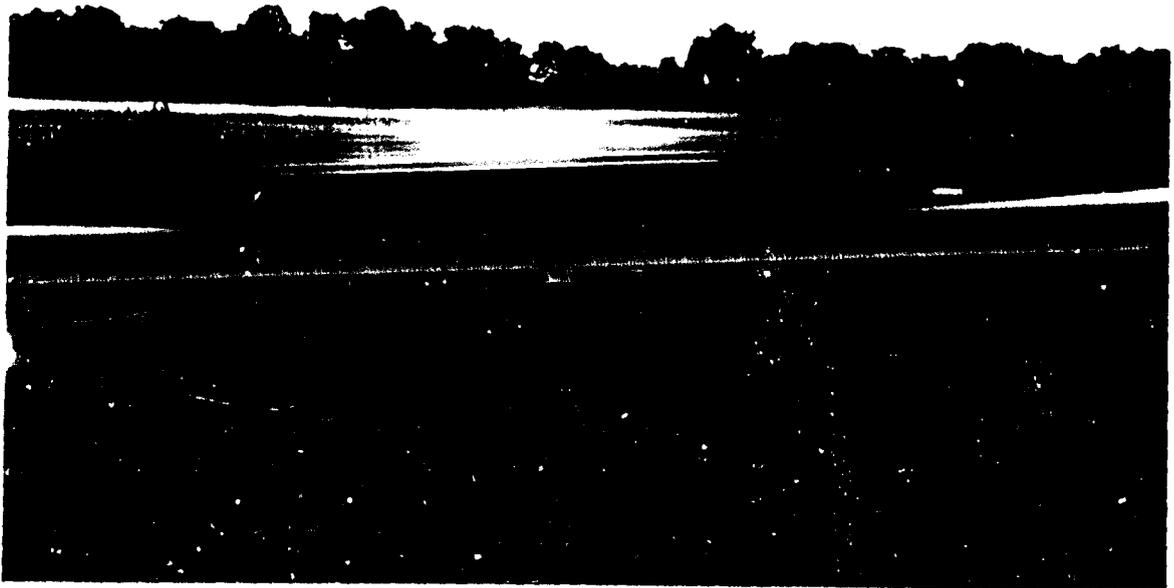


Figure 82. The uppermost elevations of the eight blocks of plots as viewed from the northeast corner of the dike looking south on 29 August 1975. Note extensive colonization of foreign plants.

83 shows the lowest elevations of the blocks with the fine-grained sediments extensively potholed and Figure 84 shows a view through the mid-elevation region of the blocks.

On 16 October, the damage was more extensive and no plots were unaffected. Figure 86 through 89 show the extent of the damage. Note the extensive shorebird tracks shown in Figure 88. By 30 September 1976, one year later, only one plot of S. alterniflora transplants (plot 113) and one plot of S. cynosuroides transplants (plot 24) out of the total of 128 plots had any planted vegetation visible (see Figs. 90 and 91).

It is thought that shorebirds were responsible for the extensive clipping of the aboveground parts of the plants. Fish may have been responsible for the shallow symmetrical excavations at the lower elevations as shown in Figures 80 and 81. The deeper and more extensive excavations shown in Figures 80 and 86 through 89 may have been caused by Canada geese, which were on and about the Site in large numbers by September. Goose and duck footprints and droppings were abundant throughout the blocks of plots and plant excavation sites were literally covered by shorebird tracks on 16 October.

3. Test Germinations of Seed Used at the Site

Specimens of all seeds that were used in seeding the



Figure 83. The lowermost elevations of the eight blocks of plots as viewed from the northeast corner of the dike looking south on 29 August 1975. Note extensive potholes throughout.



Figure 84. The mid-elevations of the eight blocks of plots as viewed from the northeast corner of the dike looking south on 29 August 1975.



Figure 85. The barren lowermost and mid-elevations of the eight blocks of plots as viewed from the northeast corner of the dike looking south on 16 October 1975.

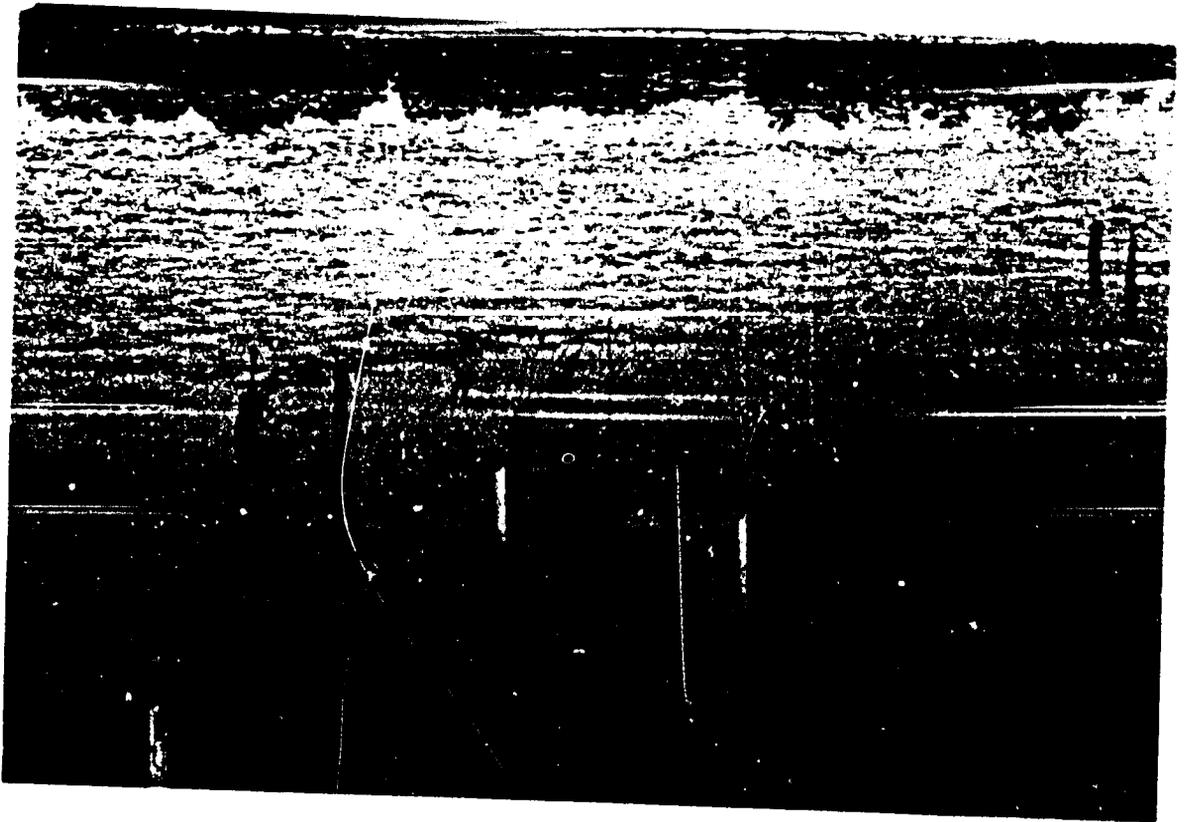


Figure 86. Plant excavations in the plots as seen on 16
October 1975.

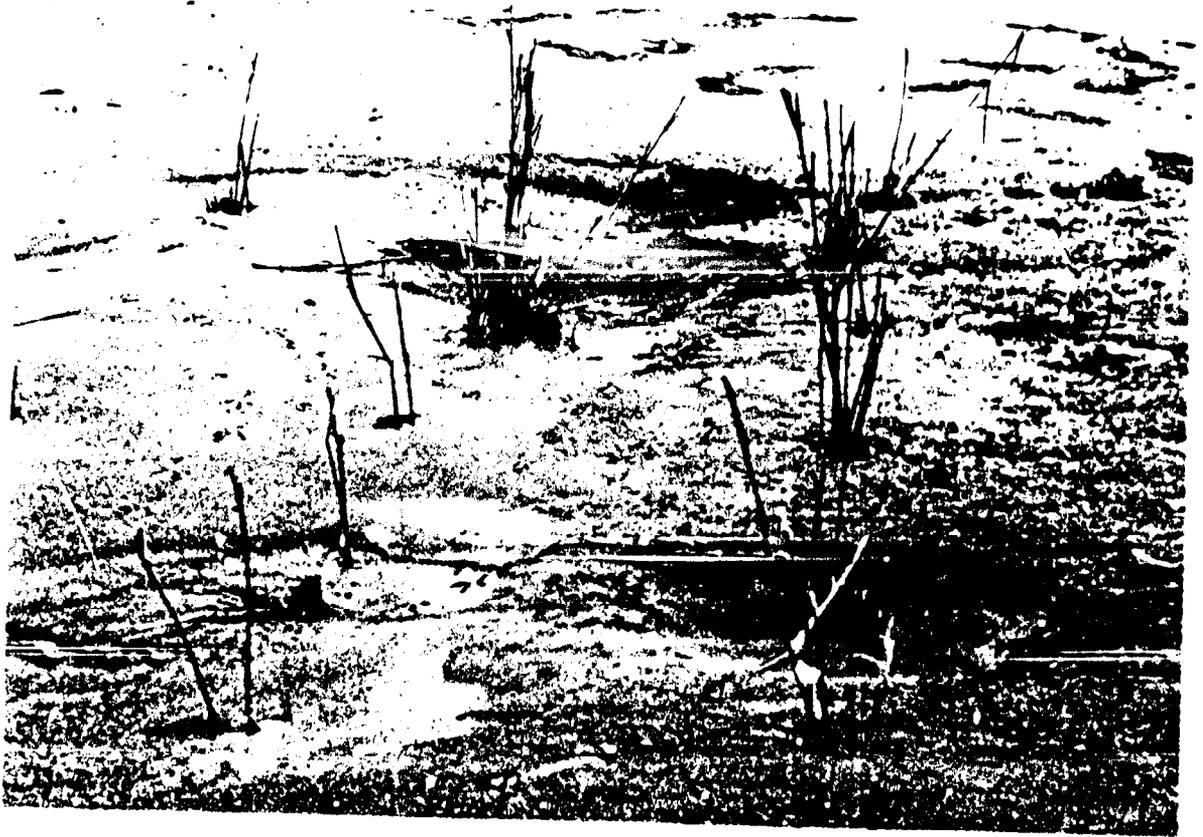


Figure 87. Plant excavations in the plots as seen on 16
October 1975.



Figure 88. Plant excavations in the plots as seen on 16
October 1975.



Figure 89. Plant excavations in the plots as seen on 16 October 1975.



Figure 90. S. alterniflora in sprigged plot 113 as seen on 30 September 1976. This is one of the two plots where planted vegetation remained.



Figure 91. S. cynosuroides in sprigged plot 24 as seen on
30 September. This is one of the two plots
where planted vegetation remained.

intertidal sand flat at the northeast end of the dike exterior, the exterior and interior portions of the dike, and the blocks of plots were retained for incubator germination tests after completing all work at the Site. The purpose of these tests was to determine the seed viability and to determine whether the depth of seed planting and the soil moisture content, particularly at the highest elevations of the dike, are limiting to seed germination. It was discussed earlier that droughty conditions prevailed at the Site during August and September and that the depth of seed planting in the plots was 0.5 to 1.0 inches and elsewhere ranged from 0 to 4 inches.

The sediment types represented throughout the seeded portions of the Site together with their physical and chemical properties are given in Table 3. The sand sediment type is representative of that present in the intertidal sand flat and in the westernmost eight plots of blocks -1 through -4. The mud sediment type is representative of that present throughout the balance of the blocks of plots. The dike sediment type is representative of that present throughout the seeded portions of the dike and in the western portions of the first two plots in blocks -1 through -4.

a. Experimental Design. Thirty (30) seeds of each species used at the Site was subjected to a two-week (14 day) germination test, with replications as described below.

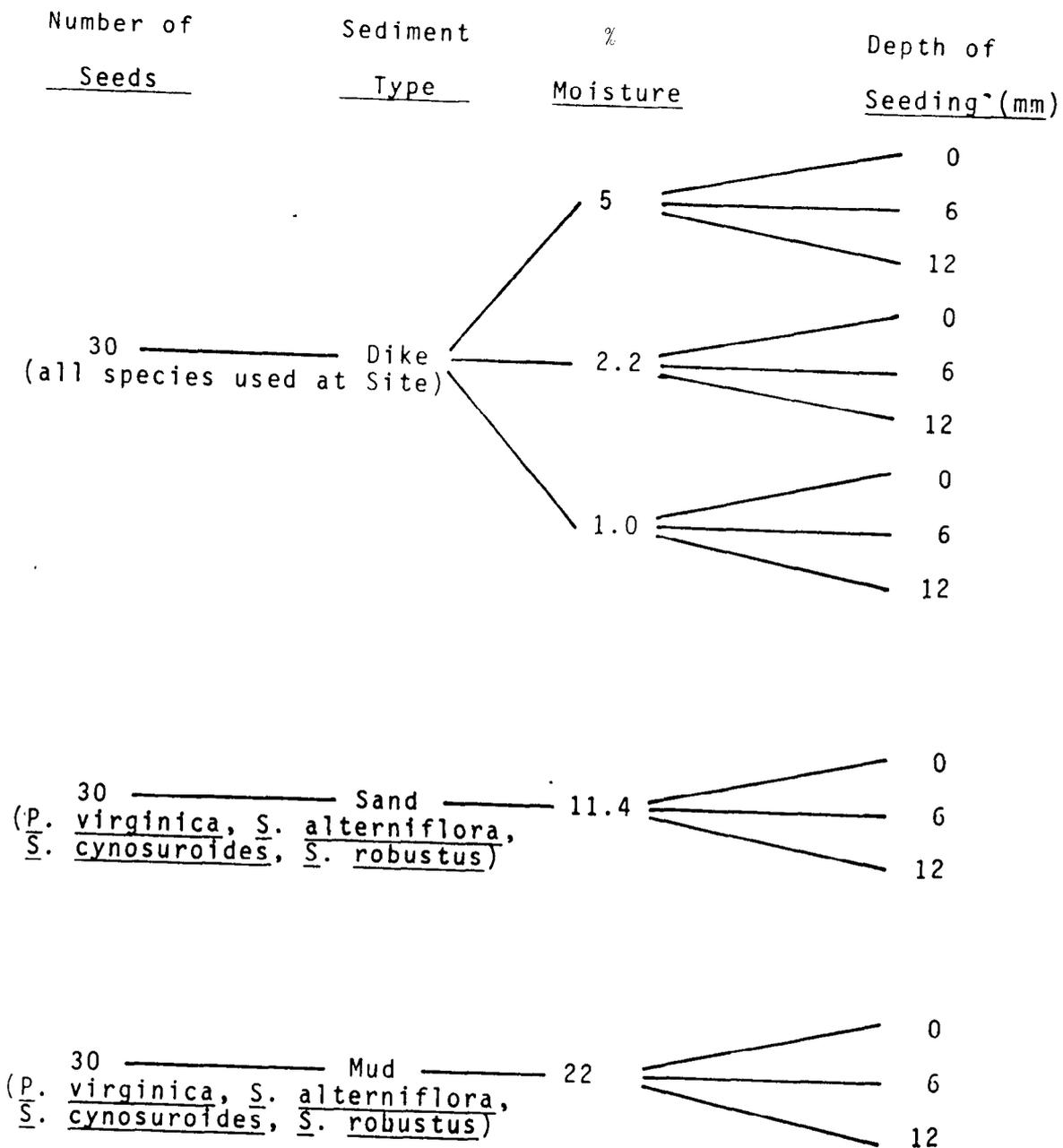
Table 3. Physical and chemical characteristics of the sediments collected at the Site and used for germination tests.^a

Characteristic Measured	Sediment Types		
	Dike	Sand	Mud
Percent Gravel ^b	7.9 (1.0)	1.0 (0.1)	0.1 (0.0)
Percent Sand ^b	88.9 (1.1)	76.4 (2.8)	56.5 (0.9)
Percent Mud ^b	9.1 (0.1)	22.6 (2.7)	43.4 (0.9)
Percent Moisture ^c	2.2	11.4	22.0
ph ^d	5.2	5.4	6.5
Magnesium Content ^d	medium	high	high
Phosphate (P ₂ O ₅) Content ^d	low	low	medium
Potash (K ₂ O) Content ^d	very low	low	medium
Percent Organic Matter ^d	0.1 (0.0)	0.3 (0.0)	1.1 (0.2)

a. Parenthetical values denote standard deviations. b. Percent by weight. Gravel has a particle size greater than 2.00 mm, sand has a particle size between 0.625 mm and 2.00 mm and mud has a particle size less than 0.625 mm. c. Percent by weight at time of collection. d. These values were obtained from the Soil Testing Laboratory of the University of Maryland.

For the species seeded in the sand and mud sediment types (P. virginica, S. alterniflora, S. cynosuroides, and S. robustus), only the sediment moisture content at the time of sediment collection (see Table 3) was tested. These sediment types are present throughout the intertidal areas of the Site and their moisture contents are regulated by periodic tidal inundation. For these sediment types, germinations were replicated thrice, once for each planting depth of 0 mm, 6 mm, and 12 mm.

For the species seeded in the dike sediment type (those seeded in sand and mud in addition to F. elatior, D. glomerata, I. repens, P. amarulum, and P. virgatum), germinations were replicated thrice, once for each planting depth of 0 mm, 6 mm, and 16 mm, and replicated again thrice, once for each sediment moisture content of 5.0%, 2.2%, and 1.0%. The experimental design is summarized below.



Control tests on 30 seeds of each species were replicated thrice on moist paper towels: untreated seed, unrinsed Clorox treated seed, and rinsed Clorox treated seed.

b. Materials. Seeds were subsamples of the stock used in all seeding at the Site. Appendix A' provides the origins of these seed. Seeds of T. repens were provided as a mixture of two distinct color types (ca. 70% red and 30% yellow). These two plants were separately subjected to the germination tests. Sediment samples collected at the Site were used in the test germinations.

Germination tests were conducted in 2-1/4 inch deep white translucent plastic containers sealed with plastic lids. A Forma Scientific Model No. 22 incubator was used. It provided 300 lumens of light intensity the light photoperiod. For the control tests, seeds were placed on Scott 140 one-ply paper towels. Clorox (5.25% sodium hypochlorite) was used in two of the three control tests (see later).

c. Methods. The physical characteristics of the sediment types given in Table 3 were determined using standard mechanical sieve analyses for the sand and gravel fractions and hydrometer analyses for the mud (silt and clay) fractions. The moisture contents at the time of collection were determined from the loss in weight upon oven drying subsamples to

constant weight at 80°C. The chemical characteristics of the sediment types given in Table 3 were determined on subsamples by the Soil Testing Laboratory of the University of Maryland.

All sediments used in the germination tests were predried in the greenhouse followed by drying to constant weight under infrared heat lamps.

Plastic seed germination containers, with exception of the controls, were filled with 12 mm of the designated sediment type. Thirty (30) seeds of each species were placed in rows on the sediment surface. The seeds then were covered by the designated depth of sediment (average for the 0 mm depth). Tapwater then was misted over the sediment surface until the designated percentage moisture (by weight) was achieved. The containers then were sealed.

Control tests on 30 seeds of each species were conducted on double layered paper towels moistened with deionized water in sealed plastic containers. For the untreated seed tests, seeds were placed directly on the towels. In the unrinsed Clorox treated seed tests, seeds were stirred in 25% Clorox for 15 minutes and then placed directly on the towels. The rinsed Clorox treated seed tests were prepared as above, but the seeds were transferred to deionized water following the Clorox soak and then air-dried for 20 minutes before being

placed on the towels.

All germination tests were subjected to a light period of 14 hours at 35°C and 10 hours of dark at 18°C for a period of 14 days. Preparation of the germination containers was staggered timewise so that the containers wouldn't be stockpiled during work-up. Each container, however, was placed in and removed from the incubator 14 days later, at the same time of day.

Every three days each germination container was weighed to determine any weight loss due to water evaporation through the lid seals. If loss occurred, the trays were misted with water to maintain the original moisture content. Observed moisture losses ranged from 0 % to 16% with the highest losses occurring in containers with the lowest moisture contents.

After 14 days of incubation, the containers were removed from the incubator and the germinated seeds counted. The emergence of either roots or shoots from the seed was considered germination. In subsurface sediment germination tests an attempt was made to locate every seed. The few seeds that were not located were assumed to be ungerminated for the purpose of statistical testing. The assumption is considered valid, as germinated seed are more voluminous and therefore more conspicuous than ungerminated ones.

Two-way chi-square tests were performed using the number of seeds of each species germinated to test for significant germination differences (1) in the three planting depths for a given sediment moisture content and (2) in the three dike sediment moisture contents for a given planting depth. Analysis of variance to test for a possible significant interaction between depth and moisture on germination was not conducted. Also, no statistical tests were conducted on germination versus sediment type.

d. Results and Discussion. Germination percentages for all of the test seed germination are summarized in Table 4. In this table, any two germination percentages for a given species or phenotype (e.g., I. repens) in the three planting depths for a given sediment moisture content that are assigned the same letter (A,B, or C) are not significantly different ($\sigma > 0.05$) while those assigned different letters (A,B, or C) are significantly different ($\sigma = 0.05$ or less). Additionally, in Table 4, any two germination percentages for a given species or phenotype (e.g., I. repens) in the three dike sediment moisture contents for a given planting depth that are assigned the same letter (D,E, or F) are not significantly different ($\sigma > 0.05$) while those assigned different letters (D,E, or F) are significantly different ($\sigma = 0.05$) or less). A single germination percentage assigned two letters of either the ABC or DEF groups is not significantly different

Table 4. Seed germination percentages of all species under all treatments tested ^a

Treatment ^b	Seed Species									
	<u>Peltandra virginica</u>	<u>Scirpus robustus</u>	<u>Spartina alterniflora</u>	<u>Spartina cynosuroides</u>	<u>Festuca pratensis</u>	<u>Dactylis glomerata</u>	<u>Panicum amarulum</u>	<u>Panicum virgatum</u>	<u>Trifolium repens</u> (yellow seed)	<u>Trifolium repens</u> (red seed)
Dike Sediment										
5.0% moisture										
0mm	80.0 A D	76.7 A F	36.7 A D	43.3 A D	43.3 A E	93.3 A E	80.0 A E	63.3 A F	73.3 A F	53.3 A F
6mm	90.0 A D	76.7 A F	46.7 A D	50.0 A D	60.0 A,B E	76.7 A,B E	73.3 A F	53.3 A E	83.3 A F	73.3 A E
12mm	86.7 A D,E	83.3 A F	53.3 A D	6.7 B D	70.0 B F	70.0 B E	76.7 A D	56.7 A D	70.0 A F	66.7 A F
2.2% moisture										
0mm	86.7 A D	20.0 A E	53.3 A D	33.3 A D	0.0 A D	0.0 A D	0.0 A D	10.0 A E	20.0 A E	20.0 A E
6mm	90.0 A D	46.7 B E	36.7 A D	56.7 A D	3.3 A,B D	3.3 A D	33.3 B E	10.0 A D	26.7 A E	20.0 A E
12mm	80.0 A D	23.3 A,B E	53.3 A D	50.0 A E	16.7 B E	53.3 B D	93.3 C D	70.0 B D	36.7 A E	20.0 A E
1.0% moisture										
0mm	76.7 A D	0.0 A D	33.3 A,B D	23.3 A D	0.0 A D	0.0 A D	0.0 A D	0.0 B D	0.0 A D	0.0 A D
6mm	73.3 A D	0.0 A D	46.7 B D	6.7 A E	6.7 A D	3.3 A D	0.0 A D	10.0 A D	3.3 A D	13.3 B D
12mm	96.7 B E	0.0 A D	13.3 A E	16.7 A D	0.0 A D	0.0 A E	16.7 B E	16.7 A E	0.0 A D	0.0 A D
Sand Sediment										
11.4% moisture										
0mm	86.7 A	73.3 A	50.0 A	53.3 A						
6mm	96.7 A	86.7 A	33.3 A	20.0 B						
12mm	83.3 A	70.0 A	40.0 A	40.0 A,B						
Mud Sediment										
22.0% moisture										
0mm	86.7 A	63.3 A	43.3 A	36.7 A						
6mm	90.0 A	46.7 A	6.7 B	0.0 B						
12mm	93.3 A	50.0 A	36.7 A	33.3 A						
Controls, Paper Towels										
untreated	100.0 A	60.0 A	50.0 B	70.0 A	90.0 B	70.0 A	73.3 A	70.0 A	83.3 A	40.0 A
Clorox, rinsed	83.3 B	93.3 B	20.0 A	46.7 A,B	80.0 A,B	70.0 A	83.3 A,B	73.3 A	70.0 A	36.7 A
Clorox, unrinsed	93.3 A,B	60.0 A	16.7 A	40.0 B	60.0 A	53.3 A	93.3 B	70.0 A	80.0 A	43.3 A

^a. Based on the number germinated out of 30. To convert to number germinated use formula: No. germinated = (0.3)(percentage germination).

^b. Letter designators A,B,C,D,E, and F that follow the tabulated percentages may be used to determine significant differences. See text for disc.

from an appropriately compared germination percentage assigned either one of these two letters (e.g., 86.7% D,E is not significantly different from 80.0% D and 96.7% E while 96.7% E is significantly different from 80.0% D for P. virginica seeded at a depth of 12 mm in the three dike sediment moisture contents in Table 4).

The data summarized in Table 4 show that all of the species of seed generally germinated satisfactorily at some depth in all sediment types with the exception of the 1.0% moisture dike sediment. Germination was significantly better at the higher moisture contents of the dike sediment, with the exceptions of P. virginica, S. alterniflora at the 0 mm and 6 mm planting depths, and S. cynosuroides at the 0 mm planting depth. Of the seed tested, P. virginica is the only one that is encapsulated by a succulent fruit. Additionally, this seed and those of S. alterniflora and S. cynosuroides were the only ones stored in aqueous media. Consequently, the seeds of these species had acquired maximum moisture contents prior to the test germinations.

None of the seed of the marsh species (P. virginica, S. robustus, S. cynosuroides, S. alterniflora) showed any clear relationship between depth of planting and germination percentage. Seeds of F. elatior (at the 5.0% and 2.2% dike

sediment moisture contents), P. amarulum and P. virgatum (at the 2.2% and 1.0% dike sediment moisture contents) germinated significantly better at the lower depths of planting.

Trifolium repens, the smallest seed of those tested, reflected no significant relationship between depth of planting and germination percentage.

Two-way chi-square tests showed no significant difference between the germination percentages of the yellow and red T. repens phenotypes in the dike sediments; however, in each control treatment the yellow phenotype germinated significantly better than did the red phenotype.

In the control germination tests, D. glomerata, P. virgatum and the two phenotypes of T. repens reflected no significant response to treatment, whereas S. robustus and P. amarulum germinated significantly better after a Clorox treatment and P. virginica, S. alterniflora, S. cynosuroides, and F. elatior germinated significantly better without a Clorox treatment. The germinations of S. alterniflora showed the clearest negative response to Clorox treatment.

APPENDIX A': ORIGIN OF PLANT MATERIALS

1. SEED

- a. Peltandra virginica: obtained from the Game Food Nurseries, P.O. Box 2371, Oshkosh, Wisconsin 54901. Received in May 1975 and stored as received at 3°C until used.
- b. Scirpus robustus: Harvested in Maryland during November 1974 and stored dry at 3°C until used.
- c. Spartina alterniflora: Harvested in Virginia during September 1974 and stored in tap water at 3°C until used.
- d. Spartina cynosuroides: Harvested in Virginia during September 1974 and stored in tap water at 3°C until used.
- e. Festuca elatior: Lot No. 37, 98.02% pure, 85% germination in April 1975, obtained from the Meyer Seed Co., 600 S. Caroline St., Baltimore, Maryland 21231. Received in June 1975 and stored as received at ambient temperatures until used.

- f. Dactylis glomerata: Lot No. 323, 90% pure, 85% germination in February 1975, obtained from the Meyer Seed Co., 600 S. Caroline St., Baltimore, Maryland 21231. Received in June 1975, and stored as received at ambient temperatures until used.
- g. Panicum amarulum: Lot No. NJ-49, 99.83% pure, 72% germination in October 1974, obtained from the Cape May Plant Materials Center, U.S. Department of Agriculture, Soil Conservation Service, Box 236A, R.D. No. 1, Cape May Court House, New Jersey 08210. Received in June 1975 and stored as received at ambient temperatures until used.
- h. Panicum virgatum var. Blackwell: Lot No. 22D-7203, 99.05% pure, 80% germination in January 1975, Kentucky grown, obtained from the Stanford Seed Co., P.O. Box 230, Plymouth Meeting, Pennsylvania 19462. Received in June 1975 and stored as received at ambient temperatures until used.
- i. Trifolium repens: Lot No. 13566, 99.80% pure, 87% germination in February 1975, obtained from the Meyer Seed Co., 600 S. Caroline St., Baltimore,

Maryland 21231. Received in June 1975 and stored as received at ambient temperatures until used.

2. SPRIGS

All bare root plant materials used in the blocks of plots were derived from seeds a - d.

APPENDIX B': CONTRACTOR STATUS REPORTS

Mr. Paul Peloquin
Environmental Effects Laboratory
Waterways Experiment Station
P.O. Box 631
Vicksburg, Mississippi 39180

4 September 1975

Dear Paul:

With reference to our telecon on 2 September, I am transmitting in writing my evaluation of the status of the artificial vegetative establishment at the James River site based on my 29 August visit.

I. DIKE

(1) Intertidal area. The transplants of Spartina alterniflora and Scirpus americanus appeared well established. Both species of transplants had flowered or were in the process of flowering. Vegetative spread of the S. americanus was so extensive that the original transplant sites were indistinguishable. The mortality percentage of transplants was essentially zero.

(2) Supratidal areas. Results of seeding with the upland and Panicum species appeared successful in view of the poor soil texture of the dike sediments and the lack of rainfall during the month following seeding.

(a) Seedlings of the Panicum species on the dike exterior were developing best along the eastern and southern sides. Seedlings were being washed out along the other two sides; such loss, however, is not expected to be serious.

(b) In areas of best seedling development, the Tall Fescue and Orchard Grass were flowering.

(c) The establishment of Ladina Clover appeared best on the interior lowest elevations of the dike where the Fescue and/or Orchard Grass density was lowest.

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(d) Seedling density and development of the upland species generally was poorest at the highest and driest sections of the dike. Ungerminated seeds were found within the sediments throughout these areas.

(e) Seedlings at the highest elevations appeared water- and/or heat-stressed (aerial plant parts were stunted and reduced in surface areas relative to those in areas of best plant development); however, similar appearing seedlings were seen at lower elevations where moisture was apparent at the surface to one cm below the surface of the sediment. Such seedlings are probably suffering from nutrient deficiency.

The chlorophyll content of the seedlings of the upland species was variable with occasional bands and other small areas of high pigment content (and corresponding exceptional plant development) reflecting, it is thought, the surges of fertilizer experienced when the mechanical broadcaster was started from a full stop position.

With cooler and wetter weather probably forthcoming, it is advised that a second fertilization of the dike be accomplished in late September. The existing density of both ungerminated seeds and poorly developing seedlings in the most sparse areas of the dike are considered sufficient to accomplish vegetative stability of the associated sediments if seedling development can be maximized for the balance of the growing season (30 November). It is felt that any additional seeding at this point would only complicate evaluation of the results of the initial seeding.

II. CONFINED DREDGED MATERIAL

(1) Upland area at northeast corner of the dike. The development of the upland mixture of seedlings throughout this area appeared intermediate between the best and poorest areas of the dike. Fertilization would probably be beneficial.

III. PLOTS IN UNCONFINED DREDGED MATERIAL

(1) All of the plots at and about MHW (about 20% of the total) have experienced extensive invasion and establishment by several plant species (refer to Dr. Jones) to such an extent to have an undeterminable impact on the results of seeding and sprigging of these plots.

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(2) Extensive clipping of plants in the sprigged plots is taking place, possibly by gulls and marshbirds. The Peltandra virginica was noted to have been most recently damaged by extensive clipping; however, animal clipping has had an impact on all sprigged plots.

(3) Sediment excavations around the plant culms were noted to be extensive in most of the sprigged plots within the intertidal zone. These excavations were probably accomplished while the sediments were inundated, as evidenced by the smooth and symmetrical mounding of sediments about the excavation site. The excavations often extended to and below the root zone of the sprigged plants, leading either to a reduction of the physical support of the plant or to the plant being washed out entirely. There was no evidence that such excavations were accomplished by plant feeding, as the partially excavated or the entirely washed out plants appeared intact. The entire intertidal area of the unconfined dredged materials, including the area of the plots, was extensively pockmarked. It is suspected that these excavations are being accomplished by bottom-feeding fish and that the plants in the sprigged plots somehow induce these fish to conduct excavations about the specific plant sites.

(4) On 29 August, only S. alterniflora appeared to be developing satisfactorily in the seeded plots. On 26 July, it was noted that both S. alterniflora and P. virginica seeds were germinating in abundance throughout the seeded plots; consequently, the latter seedlings have either been washed out or removed by animals during the following month.

I would like to visit the James River Site again at the end of September and tentatively plan a trip on 29 September. Low tide that day is at 3:30 PM. Please let me know if you could meet me there on that day. Also, if you would like is to accomplish a second fertilization of the dike, we would need a purchase order or some other authorization. Such a fertilization could be accomplished on the 29th of September.

Sincerely yours,

Edgar W. Garbisch

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Mr. E. Paul Peloquin
U.S. Army Corps of Engineers
Waterways Experiment Station
P.O. Box 631
Vicksburg, Mississippi 39180

30 October 1975

Dear Paul:

I am transmitting herewith my evaluation of the status of the artificial vegetative establishment at the James River Site based on my 16 October 1975 site inspection.

I. DIKE

(1) Intertidal Area. All transplants were well established and further developed relative to 29 August site inspection. The aerial parts of the Scirpus americanus transplants were dying back, whereas those of the Spartina alterniflora transplants were still partly green and producing. Essentially, all of the 1700 pots of S. alterniflora which were transplanted at the southeast section of the dike on 14 August 1975 had been coarsely chewed to ca. 15 cm. of the substrate surface, apparently by Canada geese. The older transplants around the balance of the dike appeared relatively undisturbed by animals; however, specific root excavations of S. americanus transplants were observed and photographed.

(2) Supratidal Areas. The supratidal areas of the dike were seeded during the last week in July. August was a particularly dry month and only moderate plant development was observed on 29 August (reported in letter dated 4 September). The Richmond area experienced above normal rains during September, primarily as a consequence of tropical storm Eloise which moved inland from the Gulf of Mexico on 26 September. On 29 September, the supratidal areas of the dike were fertilized according to the enclosed plan.

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(a) Seedlings of Panicum species dominated the vegetative cover throughout the exterior and top. The plants varied from 10 to 60 cm. in height. Density of cover was generally high except for several small areas along the south and northwest sides of the dike and for an approximate two-foot band around the dike extending upward from the uppermost row of transplants within the tidal zone. Throughout this band, essentially all of the Panicum spp. had washed out. New seedlings, presumably of Fescue and/or Orchard Grass were beginning to emerge throughout the upland dike area. Their frequent appearance in rows indicated that these seedlings are arising from cultivated seeds rather than from seeds washed in and trapped by the existing vegetation. No flowering Panicum, Fescue, Orchard Grass, or Ladina Clover seedlings were observed. What was reported on 4 September as flowering Fescue and Orchard Grass is in error. The vegetation in many of the 50-foot unfertilized sections showed up as being markedly chlorotic as compared with that in the fertilized sections. This situation is well demonstrated by color slides. Extensive grazing of the seeded vegetation (nearly to the sediment surface) was observed along the northeast section of the dike. Goose feces and footprints were observed throughout this area. Several excavations of the upland vegetation were observed along the north side of the dike. Excavation depths were less than 5 cm. and no animal footprints were detected.

(b) As reported in Section 2(c) of my letter dated 4 September 1975, Ladina Clover continues to dominate the vegetative composition throughout the interior lowest elevations of the south, west, and north sides of the dike. Clover development throughout the east end (highest in elevation) of the dike was minor.

II. CONFINED DREDGED MATERIAL

The development of the upland mixture of seedlings throughout this area continued (see letter dated 4 September 1975) to appear intermediate between the best and poorest areas of the dike. This area was not fertilized on 29 September.

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III. UNCONFINED DREDGED MATERIAL

(1) Plots. Essentially, all of the plots at and below MHW (ca. 80% of total) have been completely denuded. Whereas tidal waters were previously well drained from these plots at low tide, on 16 October several of the plots were large bowls of standing water resulting from the extensive plant excavations within. The craters of recent (probably on day of visit) plant site excavations (probably by Canada geese) were literally covered with the small prints of shorebirds. Goose and duck footprints and droppings were abundant throughout the area.

The planted vegetation in the plots above MHW (ca. 20% of total) was relatively undisturbed; however, the area has been substantially invaded by foreign vegetation as described in my letter of 4 September.

(2) Area Seeded With Intertidal Seed Mixture. On 29 August 1975, the uppermost one-third of this area contained an abundance of primarily well developing Spartina alterniflora seedlings. The seedlings which were noted earlier (31 July) throughout the lowermost two-thirds of this area are presumed to have subsequently washed out. On 16 October the uppermost one-third of this area was totally eaten out. Craters from recent excavations were abundant and plant remains (root hairs and culms) were deposited in abundance along the nearby drift line. With the exception of the presence of S. alterniflora and S. cynosuroides seedlings throughout the highest elevations of the area, it can be concluded that animal (probably Canada geese) depredation has denuded the entire area.

IV. RECOMMENDATIONS

On 16 October the Canada geese population in the immediate area of Windmill Point was estimated to be 3,000-5,000. The several acre pond and surrounding area on Mr. Harrison's property was black with geese. Several flocks of ca. 50 geese nearby lighted on the dike during the one hour that I was there. Geese damage to incorporated vegetation is progressing as it has in all of our former marsh sites - i.e., the youngest and least developed vegetation is excavated before the more established vegetation.

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In view of this situation and our past experience with geese damages to first-year plantings, I recommend that immediate temporary measures be taken to minimize the population of geese achieving access to the planted tidal areas of the dike exterior. Please contact me if you wish to pursue this matter.

Sincerely,

Edgar W. Garhisch
President

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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.

Garbisch, E W

Habitat development field investigations, Windmill Point Marsh Development Site, James River, Virginia; Appendix B: Propagation of vascular plants / by E. W. Garbisch, Jr., Environmental Concern, Inc., St. Michaels, Md. Vicksburg, Miss. : U. S. Waterways Experiment Station ; Springfield, Va. : available from National Technical Information Service, 1978.

148, 3, 7 p. : ill. ; 27 cm. (Technical report - U. S. Army Engineer Waterways Experiment Station ; D-77-23, Appendix B) Prepared for Office, Chief of Engineers, U. S. Army, Washington, D. C., under Contract No. DACW65-75-C-0054 (DMRP Work Unit No. 4A11J)

1. Dredged material. 2. Field investigations. 3. James River. 4. Plants (Botany). 5. Vascular plants. 6. Vegetation surveys. 7. Windmill Point. I. Environmental Concern, Inc. II. United States. Army. Corps of Engineers. III. Series: United States. Waterways Experiment Station, Vicksburg, Miss. Technical report D-77-23, Appendix B. TA7.W34 no.D-77-23 Appendix B