

CECW-EH-D  Engineer Manual 1110-2-5026	Department of the Army U.S. Army Corps of Engineers Washington, DC 20314-1000	EM 1110-2-5026  30 June 1987
	Engineering and Design  BENEFICIAL USES OF DREDGED MATERIAL	
	<b>Distribution Restriction Statement</b> Approved for public release; distribution is unlimited.	



**US Army Corps  
of Engineers**

ENGINEERING AND DESIGN

---

# **Beneficial Uses of Dredged Material**

**ENGINEER MANUAL**

CEEC-EH-D

DEPARTMENT OF THE ARMY  
U. S. Army Corps of Engineers  
Washington, D. C. 20314-1000

EM 1110-2-5026

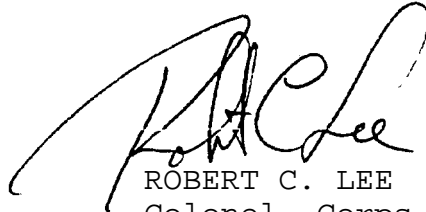
Engineer Manual  
No. 1110-2-5026

30 June 1987

Engineering and Design  
BENEFICIAL USES OF DREDGED MATERIAL

1. Purpose. This manual provides guidance for planning, designing, developing, and managing dredged material for beneficial uses, incorporating ecological concepts and engineering designs with biological, economical, and social feasibility.
2. Applicability. This manual applies to all HQUSACE/OCE elements and all field operating activities (FOA) having civil works design responsibilities.
3. General. Beneficial uses of dredged material have been proven on numerous sites in United States waterways. This manual will be helpful to Corps of Engineers scientists and engineers responsible for dredging and dredged material disposal using environmentally, economically, and socially sound techniques and beneficial use management strategies.

FOR THE COMMANDER:



ROBERT C. LEE  
Colonel, Corps of Engineers  
Chief of Staff

Engineer Manual  
No. 1110-2-5026

30 June 1987

Engineering and Design  
BENEFICIAL USES OF DREDGED MATERIAL

## Table of Contents

<u>Subject</u>		<u>Paragraph</u>	<u>Page</u>
CHAPTER 1	INTRODUCTION		
	Purpose . . . . .	1-1	1-1
	Applicability . . . . .	1-2	1-1
	Background . . . . .	1-3	1-1
	Environmental Considerations . . . . .	1-4	1-2
	References . . . . .	1-5	1-5
	Bibliography . . . . .	1-6	1-6
	Plant Material Recommendations . . . . .	1-7	1-6
	Beneficial Use Case Studies . . . . .	1-8	1-6
	Plant and Animal Species . . . . .	1-9	1-6
	Definitions . . . . .	1-10	1-6
CHAPTER 2	DREDGED MATERIAL AS A RESOURCE		
	General . . . . .	2-1	2-1
	Physical and Engineering Characteristics . . . . .	2-2	2-1
	Chemical Characteristics . . . . .	2-3	2-5
	Water Quality Considerations . . . . .	2-4	2-8
	Contaminated Dredged Material . . . . .	2-5	2-9
	Biological Limitations . . . . .	2-6	2-9
CHAPTER 3	LOGISTICAL CONSIDERATIONS		
	General . . . . .	3-1	3-1
	Dewatering . . . . .	3-2	3-1
	Transport, Handling, and Storage . . . . .	3-3	3-1
	Cost Analysis for Dewatering and Transport . . . . .	3-4	3-7
CHAPTER 4	HABITAT DEVELOPMENT		
	Definition and Application . . . . .	4-1	4-1
	Case Studies of Selected Habitat Development Sites . . . . .	4-2	4-2
	Habitat Development Selection Process . . . . .	4-3	4-7
CHAPTER 5	WETLAND HABITATS		
	Marshes . . . . .	5-1	5-1
	Marsh Development Considerations . . . . .	5-2	5-1
	Guidelines for Marsh Development . . . . .	5-3	5-3

	<u>Subject</u>	<u>Paragraph</u>	<u>Page</u>
	Engineering Aspects of Wetland Habitat Development . . . . .	5-4	5-16
	Wooded Wetland Habitats . . . . .	5-5	5-24
CHAPTER 6	UPLAND HABITATS		
	General . . . . .	6-1	6-1
	Upland Habitat Development Consideration . . . . .	6-2	6-1
	Guidelines for Upland Development . . . . .	6-3	6-2
	Upland Site Development . . . . .	6-4	6-5
	Engineering Design of Upland Sites . . . . .	6-5	6-10
	Ecological Design of Upland Sites . . . . .	6-6	6-13
	Dredging and Disposal Operations . . . . .	6-7	6-14
CHAPTER 7	ISLAND HABITATS		
	General . . . . .	7-1	7-1
	Island Development and Management . . . . .	7-2	7-3
	Development and Management Problems . . . . .	7-3	7-12
CHAPTER 8	AQUATIC HABITATS		
	General . . . . .	8-1	8-1
	Aquatic Habitat Development . . . . .	8-2	8-1
	Guidelines for Aquatic Habitat Development . . . . .	8-3	8-2
	Design of Seagrass Habitat . . . . .	8-4	8-2
CHAPTER 9	BEACHES AND BEACH NOURISHMENT		
	General . . . . .	9-1	9-1
	Types of Beach Nourishment . . . . .	9-2	9-1
	Environmental Considerations . . . . .	9-3	9-3
CHAPTER 10	AQUACULTURE		
	General . . . . .	10-1	10-1
	Aquaculture Concept . . . . .	10-2	10-1
	Aquaculture Considerations . . . . .	10-3	10-3
	Feasibility . . . . .	10-4	10-6
CHAPTER 11	PARKS AND RECREATION		
	General . . . . .	11-1	11-1
	Case Studies . . . . .	11-2	11-1
	Recreation Activities and Facilities . . . . .	11-3	11-5
	Recreation Carrying Capacity . . . . .	11-4	11-7
CHAPTER 12	AGRICULTURE, HORTICULTURE, AND FORESTRY		
	General . . . . .	12-1	12-1
	Agriculture . . . . .	12-2	12-1

<u>Subject</u>	<u>Paragraph</u>	<u>Page</u>
Horticulture . . . . .	12-3	12-9
Forestry . . . . .	12-4	12-10
CHAPTER 13 STRIP MINE RECLAMATION AND SOLID WASTE LANDFILL		
General . . . . .	13-1	13-1
Strip Mine Reclamation . . . . .	13-2	13-1
Solid Waste Landfills . . . . .	13-3	13-7
CHAPTER 14 MULTIPURPOSE USES AND OTHER LAND USE CONCEPTS		
General . . . . .	14-1	14-1
Case Studies . . . . .	14-2	14-1
Other Land Use Concepts . . . . .	14-3	14-4
CHAPTER 15 CONSTRUCTION AND INDUSTRIAL/COMMERCIAL USES		
Harbor and Port Facilities . . . . .	15-1	15-1
Residential and Urban Use . . . . .	15-2	15-3
Airports . . . . .	15-3	15-6
Dikes, Levees, and Containment Facilities . . . . .	15-4	15-6
Fill Material and Roads . . . . .	15-5	15-6
Islands and Historic Preservation . . . . .	15-6	15-6
Considerations . . . . .	15-7	15-7
CHAPTER 16 BASELINE AND MONITORING STUDIES		
General . . . . .	16-1	16-1
Monitoring . . . . .	16-2	16-1
CHAPTER 17 SITE VALUATION		
Evaluation . . . . .	17-1	17-1
Methodology . . . . .	17-2	17-1
Case Studies . . . . .	17-3	17-4
Use of the Methodology . . . . .	17-4	17-4
APPENDIX A BIBLIOGRAPHY		A-1
APPENDIX B PLANT MATERIALS FOR BENEFICIAL USE SITES		B-1
APPENDIX C EXAMPLES OF BENEFICIAL USE DEVELOPMENT ON DREDGED MATERIAL SITES IN NORTH AMERICAN WATERWAYS		C-1

EM 1110-2-5026  
30 Jun 87

<u>Subject</u>	<u>Paragraph</u>	<u>Page</u>
APPENDIX D COMMON AND SCIENTIFIC NAMES OF PLANTS AND ANIMALS MENTIONED IN THE TEXT, IN ALPHABETICAL ORDER		D-1
GLOSSARY	GLOSSARY-1	

## CHAPTER 1

### INTRODUCTION

1-1. Purpose. This manual provides guidance for planning, designing, developing, and managing dredged material for beneficial uses, incorporating ecological concepts and engineering designs with biological, economical, and social feasibility.

1-2. Applicability. This manual applies to all HQUSACE/OCE elements and all field operating activities having Civil Works design responsibilities.

1-3. Background. Dredged material disposal provides opportunities for a number of environmental, economic, and aesthetic beneficial uses. Innovative beneficial uses appear to be unlimited, and over 1,300 cases of beneficial uses of disposal sites have been documented in North America alone.

a. Ten broad categories of beneficial uses have been identified, based on their functional use of dredged material at disposal sites. They are:

(1) Habitat development (wetland, upland, island, aquatic, including migratory and nesting use by waterbirds, shorebirds, waterfowl, and other groups).

(2) Beach nourishment.

(3) Aquaculture.

(4) Parks and recreation (commercial and noncommercial).

(5) Agriculture, forestry, and horticulture.

(6) Strip mine reclamation and solid waste management.

(7) Shoreline stabilization and erosion control.

(8) Construction and industrial use (including port development, airports, urban, and residential).

(9) Material transfer (fill, dikes, levees, parking lots, roads).

(10) Multiple purpose.

b. Recognition of the ecological value of many areas that have been historically used as dredged material disposal sites has resulted in severe environmental constraints on location and placement of disposal sites, especially those in open water and wetlands. These constraints have increased the values placed on coastal and riparian wetlands and aquatic areas, and have



increasingly accented the need for alternate methods of dredged material disposal. As land uses have changed and areas once available for dredged material disposal have become scarce, the concept of beneficial use of dredged material disposal sites, such as land improvement and habitat development, have become more attractive economically and more environmentally acceptable. Dredged material is a manageable, valuable soil resource, with beneficial uses of such importance that plans for ultimate use of disposal sites should be incorporated into project plans and goals at the project's inception.

c. The known and potential effects of dredging and dredged material disposal on the environment in and around U. S. waterways has led to considerable research efforts and interagency and intraagency coordination. Many waterway projects involving dredging have purposes which require consideration of ecological effects. While maintenance of navigable channels is the prime objective, the development and application of beneficial alternatives for dredged material disposal must receive appropriate consideration.

#### 1-4. Environmental Considerations.

a. Since enactment in 1969 of the National Environmental Policy Act (NEPA) with its requirement for environmental full disclosure (including, in this case, a detailed accounting of disposal alternatives), pressure for greater reliance on confined or on-land disposal of dredged material has increased significantly. At the same time, upland disposal sites are being rapidly depleted due to urbanization, agriculture, and utilization of available capacity in existing sites. Concerns for improvement and/or maintenance of water quality and protection of aquatic nursery, spawning, fish passage and migration, and feeding areas have been factors in removing open-water and peripheral wetlands from the inventory of potential disposal sites (Item 81). It should be noted that, except in cases of contaminated material, the dredging operation does not cause a great deal of concern with regulatory agencies. Although neither open waters nor wetlands can be categorically dismissed from consideration as disposal options, dredgers have generally turned their attention toward uplands, transferring the disposal problem from an aquatic to a land environment except in specific cases such as the lower Mississippi River where 50 square miles of marsh are being lost each year to subsidence and erosion. There, marsh is being purposefully created by disposal in shallow open water. Efforts to control land use have increased and intensified due to advancing urban sprawl, its attendant reduction in natural or open areas, and, even more recently, a heightened awareness of the socioeconomic and environmental impacts associated with uncontrolled development. In recent years, only in the special case of the Great Lakes where in-lake confined disposal facility (CDF) islands have been built, and in certain harbors where CDF's and islands were permitted, has land been created where an aquatic environment previously existed.

b. In this context, the legal/regulatory framework associated with control of the entire dredging and disposal operation must be considered. Degrading water quality has caused greater emphasis to be placed on assessing

hypothetical impacts of disposal operations in open waters and wetlands. These concerns have led to a profusion of legislation at the Federal, state, and local levels designed to control nearly every facet of the dredging and disposal operation.

c. With the realization of the expanding and changing legal framework, keeping abreast of variations in legislative trends and societal attitudes is necessary to ensure comprehensive planning and development of all projects. Federal and state roles and interactions affect implementation of the beneficial use of dredged material. Although the primary impact and concern of legislation is associated with the disposal operation, most laws make no distinction between dredging and disposal. The state regulatory agencies have a major role in the implementation of programs designed to beneficially use dredged material in state-controlled waters or under the jurisdiction of approved state coastal zone management programs. As societal pressures for the wise use of environmental resources grow, changes in institutional arrangements are likely to continue.

d. The Federal Government is a major landholder, but is not a major land controller. As derived from their police powers, state and local governments retain most of the land use control authority. The Federal role is founded upon the Commerce Clause (Article I, Section 8, U.S. Constitution), which limits the Police Power insofar as local, state, and private activities adversely affect interstate commerce. This regulatory power has been defined to include regulation of the use and development of navigable bodies of waters and their beds in the public interest. Such power is referred to as "navigation servitude" and is vested in the Corps of Engineers (CE). This navigational servitude, and Federal grants, technical assistance, and aid programs, causes a predominant role in the regulatory hierarchy. Primarily, the Federal government provides legislative leadership.

e. Although there are more than 30 Federal laws and Presidential Executive Orders (EOs) applicable to beneficial use activities, documentation or public coordination is only required when a beneficial use falls within the specific jurisdiction of a law or EO. The requirement to demonstrate compliance in some cases, such as in EO 11988, is little more than a sentence or two in the NEPA document. In other instances, such as the Clean Water Act of 1977 (CWA), extensive coordination and environmental evaluations may be required. Further, the environmental compliance process for private versus CE dredging and disposal is different. All activities in navigable waters and wetlands require authorization by permit from the CE, while CE activities must demonstrate compliance with the applicable environmental laws. State requirements are independent of the Federal environmental compliance process. However, all state requirements should have Federal statutory reference.

f. Federal institutional constraints are manifested through the Federal environmental protection statutes. Some of the statutes provide categorical protection for certain animal species or prohibit any activity in a particular area, i.e. the Endangered Species Act and cultural resource laws. Other laws

require a step-by-step approach to demonstrate compliance before an action may proceed. Careful evaluation of the proposed beneficial use activity against the requirements of environmental protection statutes is essential to ensure that the public does not perceive the action solely as a means of "disposing" of dredged material. Appropriate actions should be undertaken to mitigate for those unacceptable adverse environmental consequences. It is expected that beneficial use projects will result in environmental benefits that can offset adverse consequences of existing projects and future projects as well.

g. Laws in many states can be categorized as state zoning laws, where the state has taken express and direct control over land use. The states traditionally ceded a large portion of land use regulation to local government, but a reversal of that tradition is occurring. Over half the states have general land-use programs. Twenty-four of these programs establish state authority to coordinate major local land-use decisions, nine take the more traditional approach of mandatory local planning, and five are comprehensive state, programs involving land-use permits to deal directly with land development. Thirty eligible states participate in the CZMA, five had special laws to protect their shorelines, 22 had wetlands protection laws, 26 regulated development in the floodplain, and 13 had legislation to protect defined critical areas. Item 14 surveyed a 16-state sample of laws impacting on the planning and implementation of dredged material containment areas. These state laws generally fall into two major categories: those directed primarily toward environmental protection and those directed toward land-use control. The two categories are not mutually exclusive, and much crossover exists. The environmental laws are generally more recent and broader in scope in their emphasis on the preservation of land, water, and other natural resources. The land-use control laws reflect a trend away from local control and toward state regulation.

h. Land use plans developed by local, regional, or state management agencies may necessitate coordination for beneficial use activities such as borrow pit or land fill reclamation. Development of the beneficial use activity in conjunction with the appropriate planning agency normally satisfies the applicable land use requirements. State regulation of beneficial use activities is based in the Federal statutes. Activities occurring in state waters, to include the territorial sea, or in approved coastal zones may be regulated by the state under the provisions of the CWA or Coastal Zone Management Act (CZMA). Depending upon the nature and location of the proposed activity, certifications and/or consistency determinations may be required.

i. Through the provisions of the CWA and CZMA, states have the authority to regulate most beneficial use activities. State procedural requirements are independent of Federal compliance. Although the CE and most states have established joint evaluation procedures, about 30 days should be added to the compliance process to accommodate state review. States may, as a prerequisite to the required certifications, add conditions or controls to the proposed beneficial use activity. Such conditions or controls should be directly related to state water quality standards or coastal zone program.

State fish and game agencies under the authority of the Fish and Wildlife Coordination Act of 1958 (FWCA) may recommend conditions to protect environmental resources of concern, i.e., oyster reefs, shrimp, wetlands, or other sensitive resources. Further, state-listed endangered species not on the Federal list will be of concern to state fish and game agencies. Coordination with state agencies is accomplished through the public notification process.

1-5. References. References which can provide guidance leading to this manual are:

a. 16 U.S.C. 661, Public Law 85-624, Fish and Wildlife Coordination Act of 1958.

b. 42 U.S.C. 4321 et seq., Public Law 91-190, National Environmental Policy Act.

c. 33 U.S.C. 1251 et seq., Public Law 92-500, Clean Water Act of 1977.

d. 33 U.S.C. 1401 et seq., Public Law 92-532, Marine Protection, Research, and Sanctuaries Act of 1972.

e. 16 U.S.C. 1451, Public Law 92-583, Coastal Zone Management Act.

f. 33 U.S.C. 426, Public Law 94-587, Water Resources Development Act of 1976.

g. Executive Order 11988, May 1977, Floodplain Management.

h. ER 1105-2-35, Public Involvement and Coordination.

i. ER 1105-2-40, Economic Considerations (CH 1-3).

j. ER 1105-2-50, Environmental Resources (CH 1-2).

k. ER 1110-2-400, Design of Recreation Sites, and Areas and Facilities (CH 1).

l. ER 1165-2-27, Establishment of Wetlands Areas in Connection with Dredging.

m. EM 1110-2-1902, Stability of Earth and Rock Fill Dams.

n. EM 1110-2-2300, Earth and Rock-fill Dams; General Design and Construction Considerations.

o. EM 1110-2-5025, Dredging and Dredged Material Disposal.

p. EP 1165-2-1, Digest of Water Resources Policies and Authorities.

EM 1110-2-5026  
30 Jun 87

1-6. Bibliography. Bibliographic items are indicated throughout the manual by numbers (item 1, 2, etc.) that correspond to similarly numbered items in Appendix A. They are available on loan from the Technical Information Center, U. S. Army Engineer Waterways Experiment Station, P. O. Box 631, Vicksburg, MS 39180-0631.

1-7. Plant Material Recommendations. Appendix B contains detailed information for propagation and planting of 359 native and cultivated upland plant species and 105 wetland plant species that can be used for beneficial use development on dredged material and other disturbed sites.

1-8. Beneficial Use Case Studies. Over 1,300 examples of beneficial uses of dredged material in the United States and Canada are given by region in Appendix C. These indicate the extent to which dredged material is now being used as a resource and as a valuable commodity.

1-9. Plant and Animal Species. Common and scientific names of all plant and animal species are listed in Appendix D, by alphabetical order according to common name.

1-10. Definitions. A glossary of key environmental, dredging, and engineering terms follows the appendixes.

## CHAPTER 2

### DREDGED MATERIAL AS A RESOURCE

#### 2-1. General.

a. The Dredged Material Research Program (1973-1978), the Dredging Operations Technical Support Program (1978-present), and the Environmental Effects of Dredging Program (1982-present) have determined the environmental impacts of dredged material disposal, alternatives to increase the beneficial use of dredged material, and means to reduce the adverse effects of both land and water dredged material disposal. Increased interest in dredged material as a manageable, beneficial resource as an alternative to conventional disposal practices is due to the fact that, while the amount of material dredged each year continues to rise, increasing urbanization around waterways and ports has made it difficult to locate new sites for containment areas. New environmental regulations have further restricted both land and water disposal options. Costs of dredged material disposal have increased rapidly as disposal sites are located at greater distances from the dredging site and environmental controls are added. By considering dredged material as a resource, a dual objective can be achieved. The dredged material from needed navigation projects can be disposed of with minimal environmental damage, and benefits can accrue from its use.

b. Physical, engineering, and chemical characteristics of dredged material proposed for beneficial use and land enhancement projects must be identified. This includes examination of contaminants. Such information is essential for evaluating the suitability of the material for numerous alternative uses. These characteristics must be determined during the initial stages of planning since proposed uses may prove infeasible due to unsuitable material. Chapter 2 presents discussions of the physical, engineering, and chemical characteristics of dredged material, contaminant and water quality considerations, and some of the limitations which may be encountered with dredged material substrates that may preclude alternatives. Most dredged material is below contaminant levels that would preclude a beneficial use.

#### 2-2. Physical and Engineering Characteristics.

a. Physical Characteristics. A number of standard soil properties are used to determine the physical and engineering characteristics of dredged material (item 3). Soil tests include grain-size, plasticity, and organic content determinations. Engineering tests include compaction, consolidation, and shear strength. Item 4 indicates that dredged material is made up of various types of soil that can be classified under the Unified Soil Classification System (USCS) (item 60).

(1) Grain size. Grain size is the principal physical characteristic to be determined when considering dredged material for beneficial uses, and grain size is also the basis for most soil classification systems. Land enhancement

guidelines presented in this EM for the beneficial uses of dredged material include engineering, environmental, and agricultural projects. For this reason, both the USCS (item 60) and U.S. Department of Agriculture (USDA) (items 6 and 38) classifications are used. The USCS method emphasizes characteristics of a construction material, whereas the USDA method emphasizes soil agricultural properties. The USCS method is the method most often used for classifying dredged material, but for certain beneficial uses it may be necessary to use the USDA method.

(2) Bulk density. Bulk density is a weight measurement by which the entire soil volume is taken into consideration. The bulk density of dredged material is usually low for fine-grained material, but a highly productive agricultural loam soil can range from 70 to 86 pounds per cubic foot (item 38). These low bulk densities in fine-grained dredged material can be attributed to the sedimentation process and the amorphous nature of the clay. Bulk density data are needed for converting water percentage by weight to water content by volume for estimating the weight of a large volume of material. Examples are the weight of dredged material in a disposal site or estimating the volume of dredged material in a dump truck, barge, or railroad car.

(3) Plasticity. For USCS classification, the Atterburg liquid limit (LL) and plastic limit (PL) must be determined to evaluate the plasticity of fine-grained sediment samples. The LL is that water content above which the material is said to be in a semiliquid state and below which the material is in a plastic state. Water content (item 68) which defines the lower limit of the plastic state and the upper limit of the semisolid state is termed the PL. The plasticity index (PI), defined as the numerical difference between the LL and the PL, is used to express the plasticity of the sediment. Plasticity analyses should be performed on the separated fine-grained fraction of dredged material samples.

(4) Specific gravity. Values for the specific gravity of solids for fine-grained sediments and dredged material are required for determining void ratios, conducting hydrometer analyses, and consolidation testing.

(5) Water retention and permeability. Water retention characteristics of soil describe the energy relation of soil to water, can be used to determine the availability of water to plants, describe the moisture-storing capacity of a soil (dredged material), and are strongly influenced by the arrangement of the solid components and the quantity of fine particles and organic matter (Table 2-1). The potential available water capacity of a field soil is defined as the amount of water a crop can remove from the soil before its yield is seriously affected by drought (Table 2-2). The permeability and sorptive properties of a material express the ease with which water will move or pass through (Figure 2-1). Permeability is determined by a number of factors; however, size of soil pores and magnitude of soil water retention are most important.

Table 2-1

Available Water Capacity of Soils of Different Grain Size Range\*

<u>Grain Size Range</u>	<u>Available Water Capacity at Saturation, Inch of Water per Inch of Soil Depth</u>
Sand	0.015
Loamy sand	0.074
Sandy loam	0.121
Fine sandy loam	0.171
Very fine sandy loam	0.257
Loam	0.191
Silt loam	0.234
Silt	0.256
Sandy clay loam	0.209
Silty clay loam	0.204
Sandy clay	0.185
Silty clay	0.180
Clay	0.156

\* Source: item 25.

Table 2-2

Available Water Capacity Suitable for Agricultural Crops\*

<u>Available Water Capacity, Inch Water/Inch of Soil</u>	<u>Total Available Water Capacity, Inches per Yard of Soil Depth</u>	<u>Recommended Plants</u>
0.05	1.8	Not suitable for most agricultural crops unless irrigated
>0.05-0.075	>1.8-2.7	Best suited for grasses
>0.075	>2.7	Suitable for most agricultural crops

Source: item 25.



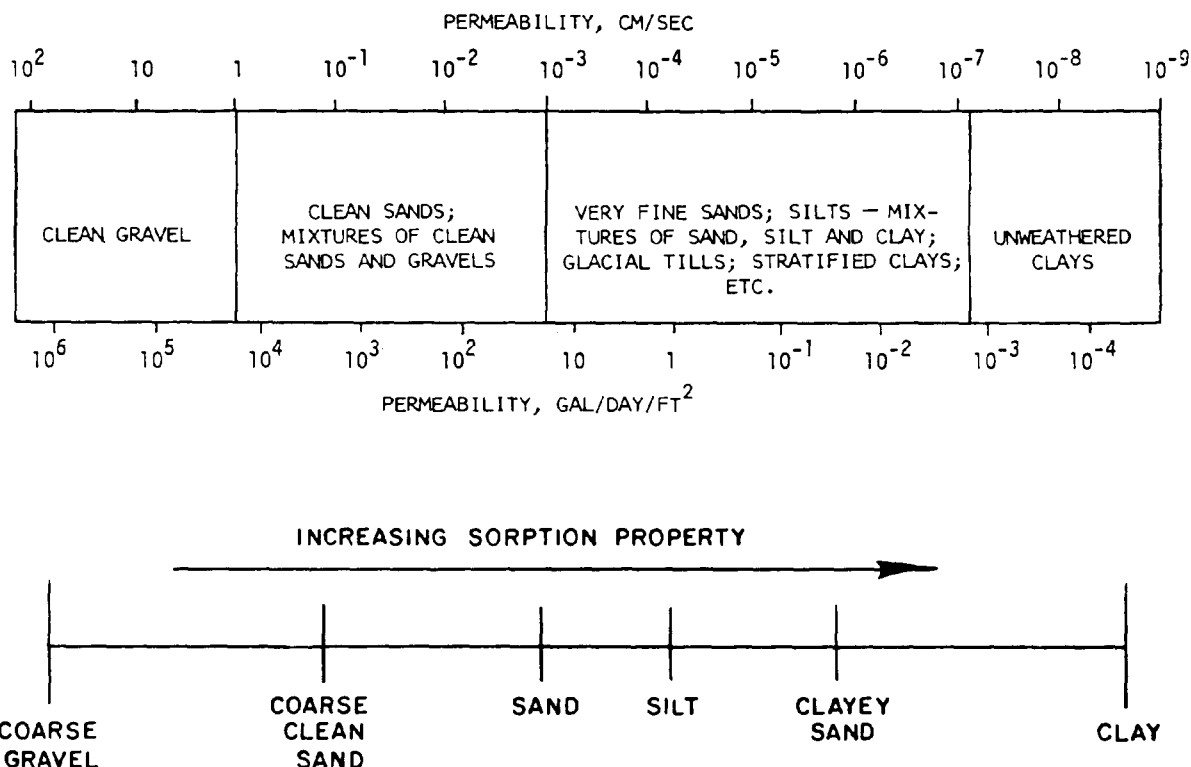


Figure 2-1. Range in permeability and sorptive properties of different soil classes (item 68)

(6) Volatile solids. Volatile solids are important in determining contaminant retention within a soil or dredged material, and for the material's capacity for plant growth and beneficial use.

b. Physical properties of dredged material. When hydraulically placed into a disposal area, dredged slurry can have a dry solids content ranging from near 0 to approximately 20 percent by weight (item 33). Generally, this value is about 13 percent. As the slurry flows across the disposal area, the solid particles settle from suspension: coarse particles near the inlet (dredge pipe), fine particles farther into the area, and finest materials in the immediate vicinity of the outlet weir. As a disposal operation progresses, coarse-grained dredged material may accumulate in a mound and displace the soft fine-grained dredged material.

(1) During and after the disposal operation, surface water is drained from the disposal area. A surface crust begins to form on fine-grained dredged material as it desiccates. Over time, surface and base drainage cause some lowering of the ground-water table, the surface crust continues to increase in thickness, secondary compression effects develop, and

consolidation occurs as the effective material weight above the ground-water level is increased from a submerged weight to a saturated weight. The dredged material below the surface crust remains very soft and weak.

(2) The water content of fine-grained dredged material in disposal areas is generally less than 1.5 times the LL of the material, and it is possible that in freshwater areas the water content is about equal to the LL. The LL of dredged material is generally less than 200, with most values being between 50 and 100.

c. Engineering Properties of Dredged Material.

(1) Engineering properties are critical to determining the types of beneficial uses possible. Soft, fine-grained dredged material has little load-bearing capacity, and can generally be used only on sites not involving heavy structures or intensive activities (urban, recreational, other). EM 1110-2-5025 contains more detailed information concerning physical and engineering properties.

(2) The surface crust associated with fine-grained material usually has a very low water content (often near the shrinkage limit) that increases slightly with increasing depth of the crust. The crust is usually overconsolidated due to the increase in effective stress caused by high negative pore pressure resulting from evaporation. Below the surface crust, however, the fine-grained material is extremely soft, with water content usually showing little change from the time of deposition. Density and shear strength increase very slightly, if at all, with increasing depth. Data show that engineering properties are generally better near the inlet than the outlet because the coarse-grained material settles near the dredge discharge. The engineering properties of the fine-grained material in the containment area near the outlet are poorer and improve very slowly with time. In general, dredged material is soil with a high water content, that upon dewatering exhibits soil properties with a high beneficial use potential.

2-3. Chemical Characteristics.

a. General. Dredged material characteristics reflect the population, industry, and land uses of an area (item 81). The chemical constituents of dredged material help determine the suitability of that material for a particular land use (item 11). Chemical analysis of the dredged material must be made to indicate potential detrimental effects on the environment in the disposal area. Four potential problem areas exist depending on the presence of available chemical constituents in the dredged material: plant toxicity, animal toxicity, surface water contamination and ground-water contamination (items 44 and 53). Plant uptake of chemicals may also present problems if growth or reproduction potential of the plant is altered or if harmful chemicals are passed via the food web into higher organisms.

b. Cation Exchange Capacity. The capacity of soil particulates to adsorb nutrients which become available for plant growth is called the cation exchange capacity (CEC). Adsorbed or sorbed nutrients are readily available to higher plants and easily find their way into the soil solution. The grain size and organic content of sediments determine to a large extent the capacity of that material to sorb and desorb cations, anions, oil and grease, and pesticides. Silts and clays with relatively high organic contents can sorb and fix large amounts of plant nutrients as well as many other constituents (Figure 2-1). The CEC of dredged material governs the sorption of nitrogen and potassium, heavy metals, and some pesticides. The nutrient content of dredged material varies widely, as does that of different soils. Generally, fine-grained dredged material contains considerably more nutrients than coarse-grained material and is also more likely to contain one or more contaminants.

c. Nitrogen. The total nitrogen content of dredged material varies widely with geographic location. The most predominant form of nitrogen in inorganic sediments is ammonium nitrogen. In organically enriched sediments, organic nitrogen predominates, even though ammonium concentrations can be very high.

d. Sulfur. Item 44 indicates that sediments in a South Carolina tidal marsh developed high acidity when drained and dried. These sediments contained up to 5.5 percent total sulfur. When drained, sulfides were oxidized to sulfate with a resultant decrease in sediment pH from 6.4 to as low as 2.0. This effect may be a serious problem in dredged material containing high levels (usually greater than 0.1 percent) of nonvolatile sulfide, predominantly iron and manganese sulfide. This is especially true if the dredged material is not limed or its acidity is not otherwise counteracted by application to an alkaline upland soil.

e. Heavy Metals.

(1) A wide range of heavy metal concentrations has been reported in a number of sediments from rivers, harbors, and bays throughout the United States and Canada, primarily in intensely urban and highly industrialized regions. Some of the major sources of heavy metals include industrial and sewage discharges, urban and highway runoff waters, and snow removal. Wastes from metal plating industries that have found their way into some sediments contain significant amounts of copper, chromium, zinc, nickel, and cadmium. Chemical partitioning studies of sediments have shown that these metals occupy the least stable of the sediment fractions and that the sediment chemistry dominates the mobility and availability of the contaminant as well as the indigenous metals.

(2) An important heavy metal consideration is the solubility of specific constituents whose concentrations are high, since soluble forms are readily available to the biological food web. The potential of a heavy metal to become a contaminant depends greatly on its form and availability rather

than on its total concentration within a dredged sediment (item 44). Heavy metals may be fixed in a slightly soluble form in dredged material containing excessive sulfide. The land application of dry oxidized dredged material may increase the solubility of heavy metal sulfides. However, under oxidizing conditions, the levels of pH and heavy metal hydroxyl and oxide formation become the important factors, and sulfur no longer governs the solubility and availability of heavy metals (item 25).

(3) Until Federal standards are set for sediments, guidelines for dredged material disposal must be taken from other research areas such as sludge disposal. The USDA has been investigating the application of sewage sludge to agricultural lands. Recommended maximum limits on the metal content of sludge are shown in Table 2-3.

Table 2-3

Recommended Maximum Limits for  
Metal Content in Digested Sewage Sludges\*

<u>Element</u>	<u>Domestic Sludge Concentration, ppm</u>
Zinc	2,000
Copper	1,000
Nickel	200
Cadmium	15 or 1.0% of zinc
Boron	100
Lead	1,000
Mercury	10
Chromium	1,000

Source: item 9.

\* Typical sludge from communities without excessive industrial waste inputs or with adequate abatement.

In most cases, the heavy metal contents of dredged material fall below the maximum allowable limits recommended in domestic sewage applied to land. If higher concentrations of chemical constituents are found in dredged material, it should not be used in a land improvement project without prior treatment to remove or reduce contaminants.

2-4. Water Quality Considerations.

a. Ecological impacts of the discharge of dredged or fill material can be divided into two main categories: physical effects and chemical-biological interactive effects. Physical effects are often straightforward, and evaluation may often be made without laboratory tests by examining both the character of the dredged or fill material proposed for discharge and the sediments of the disposal area. On the other hand, chemical-biological interactive effects resulting from the discharge of dredged or fill material are usually difficult to predict.

b. Natural processes in aquatic ecosystems tend to concentrate heavy metals, chlorinated hydrocarbons, pesticides, nutrients, and oil and grease compounds in bottom sediments. These contaminants are not very soluble in water under the conditions that normally occur in oxygenated uncontaminated surface waters. Therefore, introducing high concentrations of these contaminants into aquatic ecosystems will generally result in an equilibrium condition where most of the contaminant will be sorbed (adsorbed and absorbed) by suspended particulate material and then deposited on the bottom when the suspended material settles. The time necessary to achieve the equilibrium condition depends upon the physicochemical conditions in the aquatic system and the quantity and duration of the contaminant introduction. There has been concern that dredging and open-water disposal operations may release these trapped contaminants again, and thus have the potential to damage wetland, upland, and aquatic environments. WES reports (items 7 and 23) and other literature indicate that dredging operations have the potential to temporarily mobilize or release some contaminants from the sediments. During disposal operations, the anaerobic sediments are mixed with aerated surface water, and a complex chemical interaction occurs. Heavy metals such as cadmium, copper, chromium, lead, and zinc, which had been stabilized in oxygen-free sediments, form precipitates and coagulate in the presence of oxygen. Phosphorus and nitrogen can be temporarily released into the water column, while pesticides and oils and grease are usually not very water soluble. However, all of these contaminants have the potential to affect a proposed beneficial use project.

c. The Environmental Protection Agency (EPA), in conjunction with the CE, has published a comprehensive procedure manual (items 23 and 66) that contains summaries and descriptions of tests, definitions, sample collection and preservation procedures, analytical procedures, calculations, and references required for detailed water quality evaluations. The purpose of this is to provide state-of-the-art guidance on the subjects of sampling, preservation, and analysis of water and dredged and fill material. The interim guidance for implementing Section 404(b) of the Clean Water Act was published in 1976 (item 18). It has also been published jointly by the EPA and the CE pursuant to the Marine Protection, Research, and Sanctuaries Act of 1972, which addresses the primary intent of Section 103 of regulating and limiting adverse ecological effects of ocean dumping.

2-5. Contaminated Dredged Material. Over 90 percent of the total volume of dredged material is considered acceptable for disposal at a wide range of disposal alternatives. However, the presence of contamination in some locations has generated concern that dredged material disposal may adversely affect water quality and aquatic or terrestrial organisms. Since many of the waterways are located in industrial and urban areas, some sediments may be highly contaminated with wastes from these sources. In addition, sediments may be contaminated with chemicals from agricultural practices. The EPA guidance in Section 230.60 (Federal Register, Vol. 45, No. 249) should be used to determine whether there is sufficient cause for concern to warrant testing for contaminants and to identify the contaminants of concern.

2-6. Biological Limitations. Although dredged material has been generally found to be a soil resource of great value and use, it has some limitations as a beneficial product.

a. Texture and Physical Characteristics. Dredged material is composed predominantly of mineral particles ranging in size from coarse sand to fine/clay and can have an extremely mixed mineralogy (item 44). Dredged material deposits within one disposal site can vary from well-ordered sand to organic clay. In addition to soil, dredged material may contain other solids such as rock, wood, pieces of metal, glass, and other debris. Contamination of these sediments in the form of organic material, elevated concentration of heavy metals, a vast array of chlorinated hydrocarbons, oil and grease, and other organics reflects the influences of population and industry in the area. The actual physical texture of the material on a site may limit its use; i.e., pure sand dredged material would not be suitable for agricultural land applications. However, as fill material and for some dike construction, it may be excellent. Predominantly uncontaminated silt would not be well suited for waterbird island construction, but would make an excellent soil addition for agriculture and forestry, and for some habitat development sites.

b. Contamination.

(1) In certain areas of the United States, such as near certain industries or extensive agriculture, contamination is an important factor to be considered. If the dredged material contains contaminants, it may have to be placed in a confined disposal site, which will probably limit its beneficial use. Planning for beneficial use of contaminated dredged material should consider the following factors:

(a) Amounts and type of contaminants in the material, possibly to include heavy metals, fertilizers, sewer wastes, pesticides, or petroleum products.

(b) Maximum acceptable levels for pollutants in water, soils, plants, and animals as set by the EPA.

(c) Kinds of plants and animals that will be on the site, their abilities to regulate uptake of these pollutants, and their tolerance levels before life efficiency is reduced, reproduction ceases, or death occurs.

(d) Chances of biomagnification via the food chain from plants, invertebrates, and microbes to animals on the site or to humans.

(e) Impact of contaminants on the site and surrounding areas.

(2) Item 46 and other studies have shown that plants grown in dredged material wetlands absorb heavy metals in varying degrees depending upon the plant species. These contaminants in most cases are not generally translocated into the top shoots but are retained primarily in the root systems. Most potential danger is limited to users of the root systems, such as waterfowl that feed on plant tubers. However, research on plants grown in dredged material upland areas indicates a tendency to accumulate heavy metals in all plant parts, including stems and seeds.

(3) Many pesticides, chemical by-products, and petroleum products in dredged material have unknown biomagnification abilities. It is known that some pesticides have affected reproductive abilities of birds by causing eggshell thinning and behavior modification. Petroleum products can smother small organisms (potential food items). Fertilizers and sewer wastes in dredged material alter the habitats where they accumulate by changing plant growth habits and species composition and by reducing dissolved oxygen levels in water. This affects the food supply of fish-eating animals. Highly acidic dredged material can severely limit beneficial use options unless corrected with lime. The contaminant problem can be minimized on most beneficial use sites through these management procedures:

(a) Stabilizing the areas with plant species that do not transport contaminants into their top shoots.

(b) Avoiding management for wildlife grazing, fish nursery use, or intense human use to reduce danger of a biomagnification problem.

(c) Managing for animals that will not feed on the site, such as fish-eating birds that use the site for nesting and roosting purposes only. A good example of this is the Toledo Harbor, Ohio, disposal site in Lake Erie that is being filled over a 20- to 30-year period with contaminated dredged material. Common terns, ring-billed gulls, and herring gulls are nesting inside the dikes but do not feed there since they are all fish-eating species.

(4) Contaminated sites can be capped with about 2 feet of clean soil or dredged material. This will allow use of the site for a number of beneficial uses involving shallow-rooted plants, i.e., nesting meadows, recreational sites, etc.

c. Site Habitat Changes. Beneficial uses can frequently mean the replacement of one desirable habitat with another. This will likely be a source of some opposition. There are few reliable methods for comparing the various losses and gains associated with this habitat conversion; consequently, the determination of relative impact may best be made on the basis of relative scarcity or abundance of the new habitat, environmental regulations, or of professional opinions. An example would be changing aquatic or marine habitat to an emergent wetland or an upland site.

d. Impacts on Surrounding Land and Animals. When dredged material is placed on a site for a beneficial use, there may be a number of associated impacts. Examples are increased runoff of nutrient-charged or contaminant-charged effluent, increased human or other animal use, interference on surrounding land such as from increased bird activity at disposal sites near airport runways, increased recreational use in disposal sites subject to heavy industrial and shipping use, and changes in hydrology from additions of water-charged dredged material to new or existing sites.



## CHAPTER 3

### LOGISTICAL CONSIDERATIONS

3-1. General. With the huge quantities of dredged material created during dredging operations, site utilization, economic transport handling, and storage plans become critical to the overall life and use of a project. This section will discuss procedures for dewatering, transporting, handling and storage, and cost analyses of these activities in determining beneficial use of dredged material. It should be remembered that dewatering is not applicable for some types of beneficial uses such as wetland and aquatic habitat development and aquaculture. However, dewatering is critical to nesting islands, upland habitat development, most kinds of recreational use, agriculture, forestry, horticulture, and other types of beneficial uses.

3-2. Dewatering. Dredged material is usually placed hydraulically into confined disposal areas in a slurry state. Although a significant amount of water is removed from it through the overflow weirs of the disposal area, the confined fine-grained dredged material usually consolidates to a semifluid consistency that still contains large amounts of water. The volume occupied by the liquid portion of the dredged material greatly reduces available future disposal volume. The extremely high water content also may make the dredged material unsuitable or undesirable for commercial or beneficial use. Two dewatering methods, fully described and discussed in items 24, 28, 29, 31, 57, and 84, are generally used. The first method is allowing evaporative forces to dry fine-grained dredged material into a crust while gradually lowering the internal water table. This has been the least expensive and most widely applicable dewatering method identified through dredging research. Good surface drainage, which rapidly removes precipitation and prevents ponding of surface water, accelerates evaporative drying. Shrinkage forces developed during drying return the material to a more stable form, and lowering of the internal water table results in further consolidation. The second method of promoting good surface drainage is by constructing drainage trenches in the disposal area using heavy equipment. Use of a Riverine Utility Craft to make trenches proved successful on disposal sites with fine-grained material. A site must be dewatered sufficiently to accept heavy equipment, which limits the second method in its application as long as 2 years after a disposal site has been filled, depending upon the soil characteristics of the dredged material. A less frequently used method, rarely applied to disposal sites, includes installation of underground drainage tiles or sand layers prior to filling the site.

3-3. Transport, Handling, and Storage. Fundamental features of transport systems and general guidance for analysis of technical and economic feasibility are provided in item 74. They are presented to acquaint planners with the magnitude and scope of the transport system and provide some cost-effective analysis information for five transport modes: hydraulic pipeline, rail haul, barge movement, truck haul, and belt conveyor movement. Hydraulic pipeline

and truck haul have been the primary transportation methods used for most existing beneficial use sites. Since the transport of dredged material can be a major cost item in determining the economic feasibility of a project, the transport system should be evaluated early in the site selection stage, of the planning process. Legal, political, sociological, environmental, physical, technical, and economic aspects should be examined in relation to availability of transport routes, A sequence of five steps must be followed when selecting a transport route:

<u>Step</u>	<u>Information Source</u>
1. Identify available routes	Maps, ground reconnaissance
2. Classify nature (wet/dry) of dredged material	Beneficial use needs and sources of dredged material
3. Determine annual volume of dredged material and duration of project	Dredged material sources
4. Estimate cost of available transport modes	Item 74
5. Identify and evaluate technical, environmental, legal, and institutional requirements	Item 74 Specific sources: local, state, and Federal agency regulations

a. Elements of Transport Systems. Transport systems involve three major operations: loading, transporting, and unloading. The loading and unloading activities are situation dependent and are the major cost items for short distance transport. The hydraulic pipeline is the only mode which requires a unique rehandling activity; all other transport modes may interchange loading and unloading operations to suit the specific site needs. Loading, unloading, and transporting operations can be separated into detailed components (i.e., backhoes, service roads, rail spurs, cranes, conveyors, etc.) and each component examined for capacity, operational schedule and cycle, and costs of equipment and operation and maintenance.

b. Transport Modes.

(1) Hydraulic pipeline. The hydraulic pipeline is the only transport system recommended for movement of dredged material in slurry form. Assuming government construction of the disposal site, contractor operations of the dredging work, and no easement costs, this system can be economically competitive for distances up to several miles. The conditioning step requires a rehandling dredge and fluidizing system. Control of density and flow to minimize operational problems is an essential conditioning process unique to the hydraulic pipeline mode. Suggested criteria to be used in selecting a rehandling (or secondary) dredge for operation within a containment area include: unit cost of dredging; ease of transportation; minimum downtime; small size to allow maneuverability in a small basin; capability to dredge in

shallow water to minimize dike height; and maximum cutter width to reduce the number of passes. Numerous dredges fitting these criteria are on the market. Some have additional features, such as cutterheads capable of following natural contours of the basin bottom without damage to natural or man-made seals, wheel attachments for the cutterhead to allow dredging operations in plastic or rubber-lined basins, and capability of dredging forward and backward. The fluidizing system is needed to supply water from the closest source to maintain flotation of the dredge. Unloading facilities are unnecessary since the dredged material slurry is usually pumped out of the pipeline into a containment area. A schematic of rehandling operations for hydraulic pipeline transport is presented in Figure 3-1. The pipeline to the land improvement site would include a pneumatic or centrifugal hydraulic pump booster system and would be automated to the maximum extent possible.. The following items should be taken into consideration in any planning for pipeline transport:

(a) Slurry movement of saline dredged material to a freshwater environment is not recommended.

(b) Dewatering requirements before a beneficial use application may be a cost burden and may require treatment of decanted water.

(c) Building codes, easement acquisition, utility relocation, climatological factors, and urban area disruption from construction may be obstacles.

(d) Confining dikes must be provided and could be a significant cost item.

(e) Right-of-way acquisition.

(f) Federal, state, and local regulations and requirements.

Real estate and right-of-way~~Æ~~ easements are very site-specific items of political as well as economic concern. These items can impact greatly on the cost of hydraulic pipeline system and therefore should be given due consideration in any cost-benefit analysis and in the final cost evaluation. Cost guidelines do not take into account expenses due to the uniqueness of each situation.

(2) Rail haul. Rail haul using the unit train concept is technically feasible and economically competitive with other transport modes for hauling dredged material distances of 50 to 300 miles. A unit train is one reserved to carry one commodity (dredged material) from specific points on a tightly regulated schedule. Facilities are required for rapid loading and unloading to make the unit train concept work and to enable benefits from reduced rates on large volumes of bulk movement. Bottom dump cars or rotary car dumpers are needed to meet the rapid loading and unloading requirement. Economic feasibility demands the utilization of existing railroad tracks; however, the building of short intermediate spurs may be required to reach disposal areas.

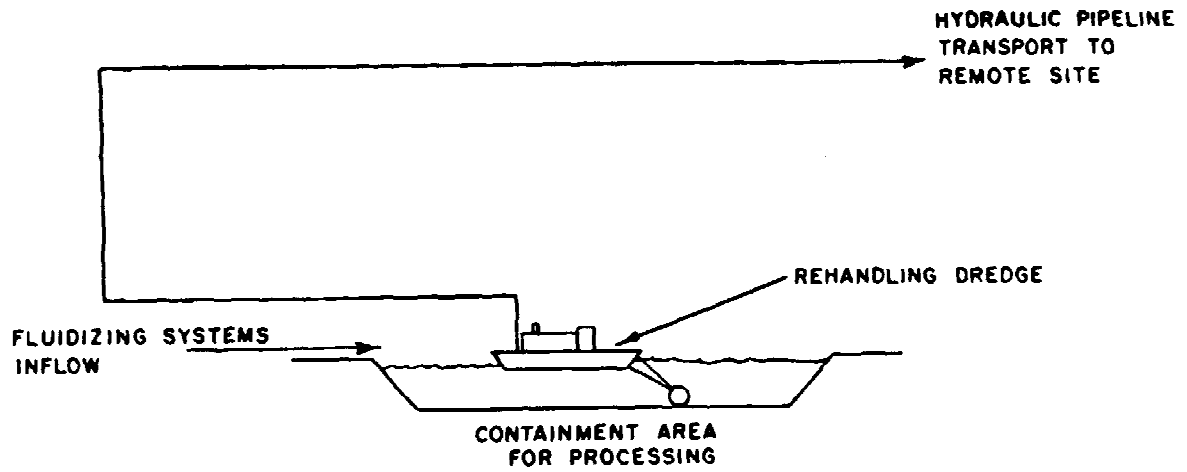


Figure 3-1. Schematic of rehandling system for hydraulic pipeline



Figure 3-2. Tugboat and barge transporting dredged material

The following items should be taken into consideration in any planning for rail haul transport to a beneficial use site:

- (a) Dredged material must be dry enough to free-fall from cars.
- (b) Scheduling and length of unit trains are often strictly regulated.
- (c) State regulations may require open hopper cars to be covered.

(d) Dual use of hopper cars may require washing of cars between use and treatment of wash water to prevent contaminant transfer.

(3) Barge movement. Depending upon the volume of material to be moved, barge movement can be an economically competitive transport mode for the movement of dredged material up to 300 miles. Barge haul was used in the Sacramento District to remove 7 million cubic yards (yd<sup>3</sup>) of dredged material from Grand Isle (Figure 3-2). To ensure reasonable costs, a barge unit should consist of familiar and available equipment. In addition, loading and unloading mooring docks capable of accommodating the two cargo scows simultaneously must exist with roadways between the docks and disposal areas to make barge transport practical. The following items should also be taken into consideration:

(a) Thorough information must be obtained about the waterway: navigation depth, allowable speed, lock size, traffic density and patterns, etc.

(b) Often, regulations exist concerning cleanup responsibilities with associated fines for spills in inland waters.

(c) Climatic conditions may affect operational schedules.

(d) A user charge for waterways may become a reality in the future.

(4) Truck haul. Truck haul of dredged material can be economically competitive for distances up to 50 miles. At greater distances, transport by truck is labor- and fuel-intensive and not economically justifiable. The simplicity of loading and unloading requirements and the relative abundance of available roadways make truck hauling technically the most attractive transport mode, and it has wide District application (Figure 3-3). Costs analyses are based on utilizing 25-ton dump trucks with 8.5-yd<sup>3</sup> capacities and assume that routes exist which are adequately upgraded and maintained. Economic feasibility of truck hauling is based on rates established by negotiation with trucking companies and include all associated driver and fuel costs. The following items should also be taken into consideration:

(a) State highway and safety regulations cover a variety of elements (gross weights of trucks, weight per axle, etc.).

(b) Emission and noise standards.

EM 1110-2-5026  
30 Jun 87

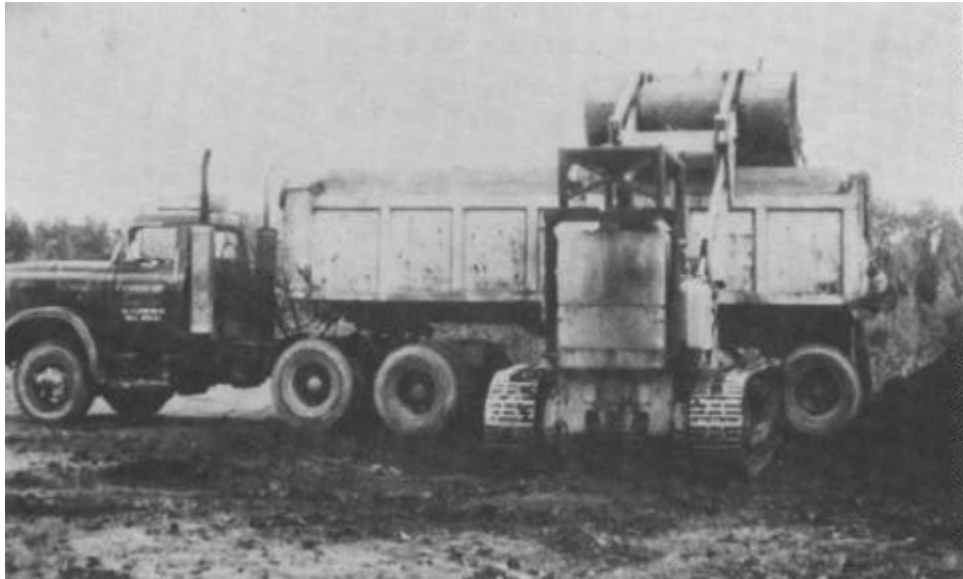


Figure 3-3. Truck haul utilized by the Chicago District



Figure 3-4. A 36-inch belt conveyer loading operation

(c) Local ordinances designating truck routes.

(d) Traffic control of truck operations during winter months in northern climates.

(e) Weight limits on bridges and roadways.

(5) Belt conveyor movement. Belt conveyor systems are employed on a limited basis to transport relatively dry dredged material for short distances. They are technically feasible and cost competitive. Belt specifications vary in width (30 to 70 inches), flight length (900 to 2,600 feet), and speed (7 to 90 miles per hour). Systems can be designed to suit project needs excluding certain terrain difficulties. Because of system flexibility, belt conveyors fit neatly into many loading and unloading operations. The California Highway Department, under an agreement with the Sacramento District, uses dozers and conveyors to load dredged material onto barges (Figure 3-4). The following items should be taken into consideration in any planning for belt conveyor transport:

(a) Building codes, easement acquisition, utility relocation, climatological factors, and urban area disruption for construction may be obstacles.

(b) Material pileup due to system failure.

(c) Malfunctions of sequential belt systems resulting in entire system stoppage.

c. Loading and Unloading Elements. Loading and unloading elements may incur high costs which can restrict project viability. Item 74 presents several examples of loading and unloading options and schematics of scenarios associated with various dry material transport modes; two examples are shown in Figures 3-5 and 3-6. Two other examples include a pair of backhoe excavators and a series of conveyor belts providing rapid loading of unit trains, and a barge haul scheme using backhoes for excavation and loading directly into dump trucks which make the intermediate haul to the scows. In this EM, cost comparisons are based on the loading and unloading component scenarios presented in Item 74. The truck haul loading element components are similar to the rail loading components which include excavation backhoes and a series of belt conveyors. The unloading system is simple back-dumping at the beneficial use site. Placement methods are important, and are discussed in Chapter 5 and other chapters where critical elevations are needed for beneficial use applications.

### 3-4. Cost Analysis for Dewatering and Transport.

a. Dewatering Costs. Costs associated with dewatering of dredged containment areas are directly related to the degree of trenching effort required and the type of heavy equipment necessary to accomplish dewatering. Thus, the program costs for progressive trenching are highly site-specific depending

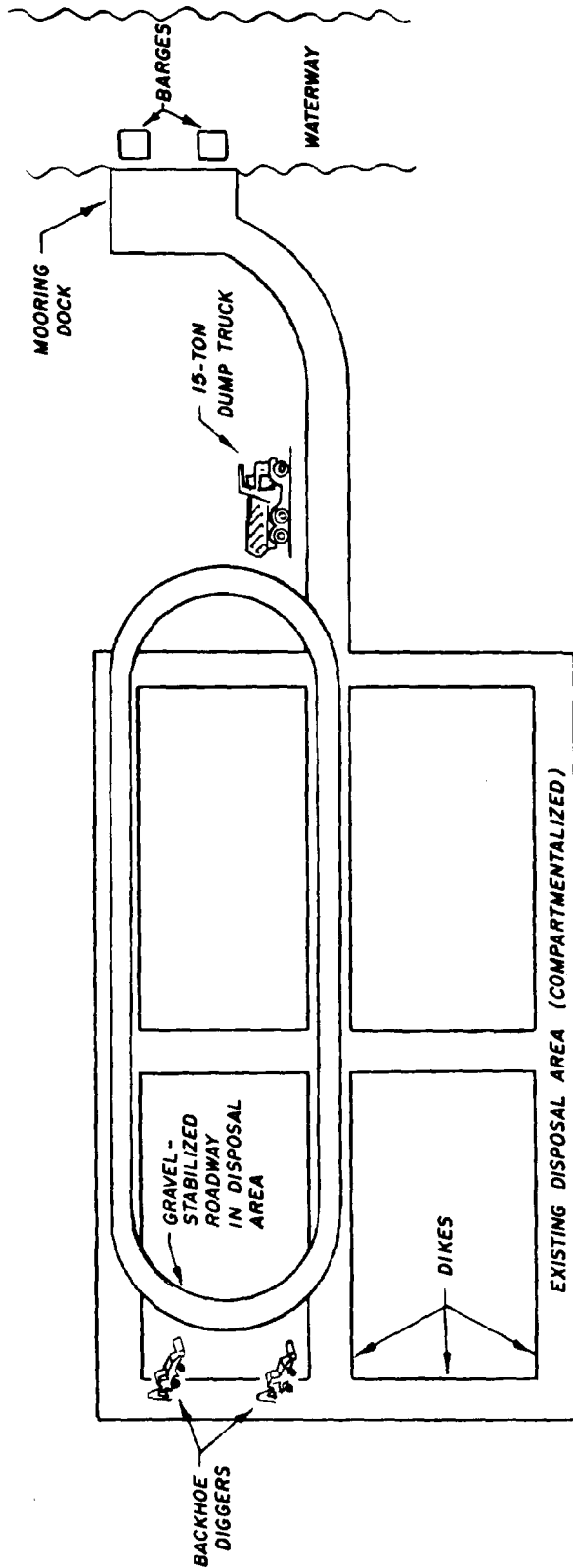


Figure 3-5. Barge loading operation



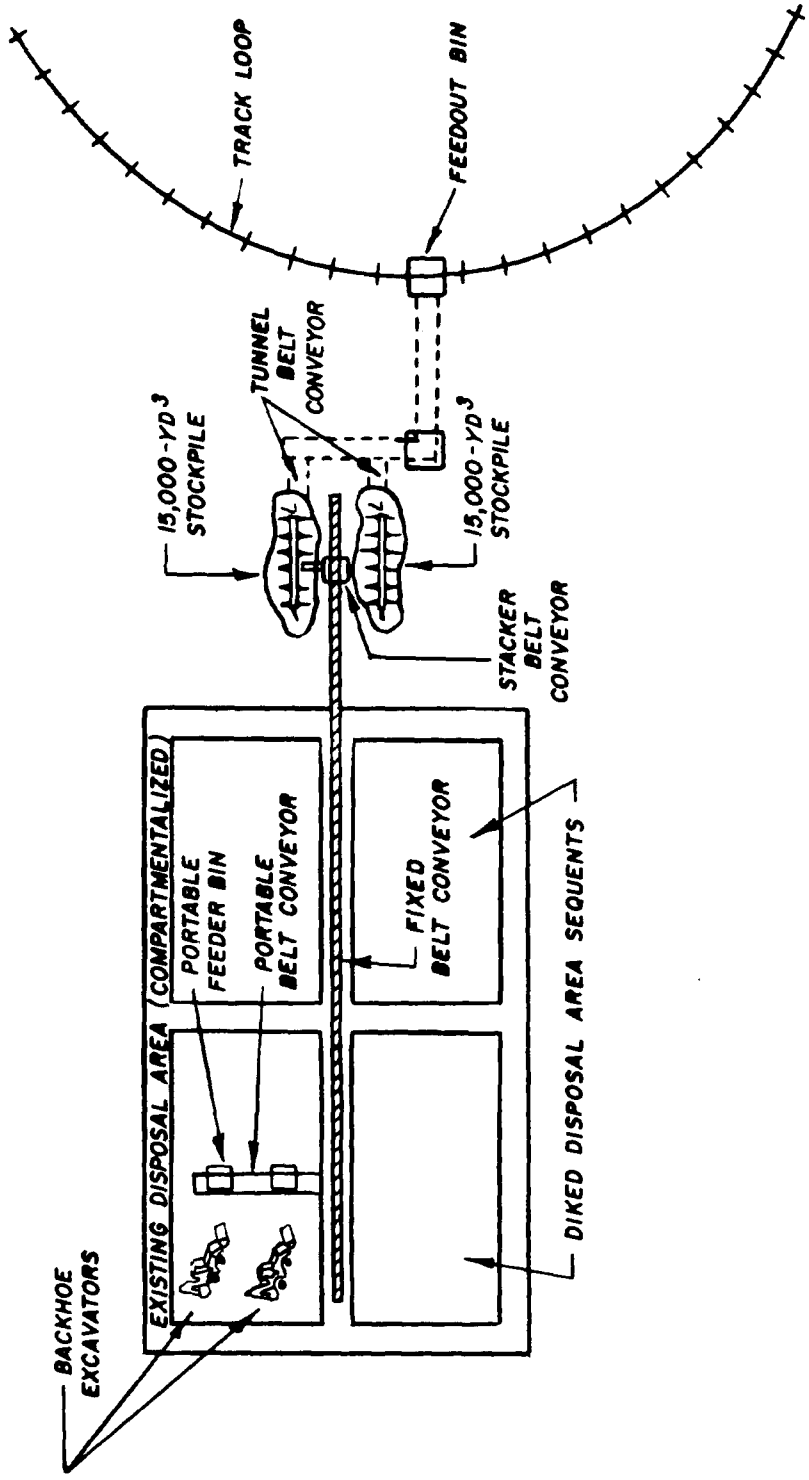


Figure 3-6. Unit train rail loading facility

upon disposal area size, equipment selected, type of access available, and frequency of trenching operations. A preliminary trenching program is developed from crust formation estimates, equipment operational characteristics (from Table 3-1), and trenching cycle intervals (from Table 3-2). Total cost may be estimated from computing equipment operating hours plus factors for nonproductive activities (30 percent is a good estimate), mobilization/demobilization, and administrative costs.

b. Transport costs. Transport cost can account for 90 percent or more of total land improvement and beneficial use budget costs. The cost figures presented in this section are meant to serve as examples for planning and do not represent definitive cost estimates. Table 3-3 is included to provide insight into the cost relationships for various modes of transport. The table provides total system costs for all five transport modes. Transport costs are reported in dollars per cubic yard of dredged material moved. This breakdown shows that economic feasibility is limited by distance for most transport modes. This table also shows the economies of scale for larger annual volumes of material shipped. Real estate and right-of-way costs for the hydraulic pipeline system are not included in the cost-estimating procedure.

Table 3-1

Operational Characteristics of Trenching Equipment

Equipment	Crust Thickness, in., for Effective Operation		Maximum Trench Depth, in.	Approximate Trenching Rate, lin ft/hour	Approximate Rental Cost* \$/hour
	Minimum	Maximum			
RUC	0	12	18	2,000+	75-100
Low-ground-pressure tracked vehicle + rotary trenchers	4	24	24	2,000+	35-45
Small dredge	4	10	30	25	50-75
Amphibious dragline	6	18**	Crust + 18	40	50-70
Small dragline on double mats	12	18	Crust + 18	30	35-50
Medium dragline on double mats	12	18	Crust + 18	40	40-50
Small dragline on single mats	18	24 <sup>+</sup>	Crust + 18-24	50	35-45
Medium dragline on single mats	18	30 <sup>+</sup>	Crust + 18-24	60	40-50
Large dragline on single mats	24	36	Crust + 24	80	45-55

Note: a. Vehicle or mat ground pressure must also satisfy critical layer RCI mobility criteria.

b. Low-ground-pressure tracked vehicle assumed to pull drag plow with point set only 1 or 2 in. below existing crust.

c. More exact definitions of dragline equipment given in text.

\* Southeastern United States, 1977.

\*\* Above this crust thickness, conventional dragline is usually more efficient.

+ Between 24- and 30-in, crust thickness, use single mats.

Increase rates 10 lin ft/hour if dragline is working from perimeter dike.

Table 3-2

Estimated Interval Between Trenching Cycles for Various Equipment  
Items in Fine-Grained Dredged Material

<u>Equipment Item</u>	<u>Equipment Location in Disposal Area</u>	<u>Initial Condition of Disposal Area Surface</u>	<u>Estimated Trenching Interval</u>
RUC	Interior	Decant point	Each 2 weeks for first month, monthly thereafter
RUC	Interior	Crust $\geq$ 2 in.	Monthly
Low-ground-pressure tracked vehicle + rotary trencher	Interior	Crust $\geq$ 4 in.	Monthly
Small dredge	Interior	4 in. < crust - 10 in.	4 months
Amphibious dragline	Interior	Crust $\geq$ 6 in.	4 months
Conventional dragline	Interior	Crust $\geq$ 12 in.	4 months
Conventional dragline	Perimeter	Decant point	Monthly for first 3 months, bimonthly for next 3 months, 4 months thereafter
Conventional dragline	Perimeter	2 in. < crust < 6 in.	Bimonthly for first 4 months, 4 months thereafter
Conventional dragline	Perimeter	Crust $\geq$ 6 in.	4 months

Table 3-3

Comparison of Costs of Various Transport Systems,  
Quantities, and Distances\*\*

Annual Quantity yd <sup>3</sup>	Transport Distance miles	Cost, \$/yd <sup>3</sup> , for Cited Transport System				
		Pipeline	Rail	Barge	Belt	Truck
500,000	10	2.47	*	2.47	8.98	4.57
	20	3.14	*	3.14	15.15	6.61
	100	9.54	7.18	4.71	*	13.69
	250	*	9.32	7.41	*	*
1,000,000	10	1.46	*	2.92	5.39	3.73
	20	1.91	*	3.14	13.47	4.19
	100	6.45	5.39	4.49	*	12.91
	250	*	7.58	7.18	*	*
3,000,000	10	0.79	*	2.70	2.25	3.17
	20	1.12	*	2.92	3.93	3.56
	100	4.10	4.21	4.49	*	12.35
	250	*	5.34	7.35	*	*
5,000,000	10	0.67	*	2.81	1.68	3.05
	20	0.90	*	2.92	3.14	3.42
	100	3.48	4.04	4.38	13.58	12.07
	250	*	6.06	7.07	*	*

\* Indicates not competitive economically.

\*\* These costs were taken from item 57 and are adjusted to March 1978 dollars.

CHAPTER 4

HABITAT DEVELOPMENT

4-1. Definition and Application. Habitat development refers to the establishment and management of relatively permanent and biologically productive plant and animal habitats. The use of dredged material for habitat development offers a disposal technique that is an attractive and feasible alternative to more conventional disposal options. Various habitat development alternatives and their applicability to disposal operations and sites will be discussed in this section. Within any habitat, several distinct biological communities may occur. For example, the development of a dredged material island may involve a wide variety of habitats (Figure 4-1). Four general habitats are suitable for establishment on dredged material:

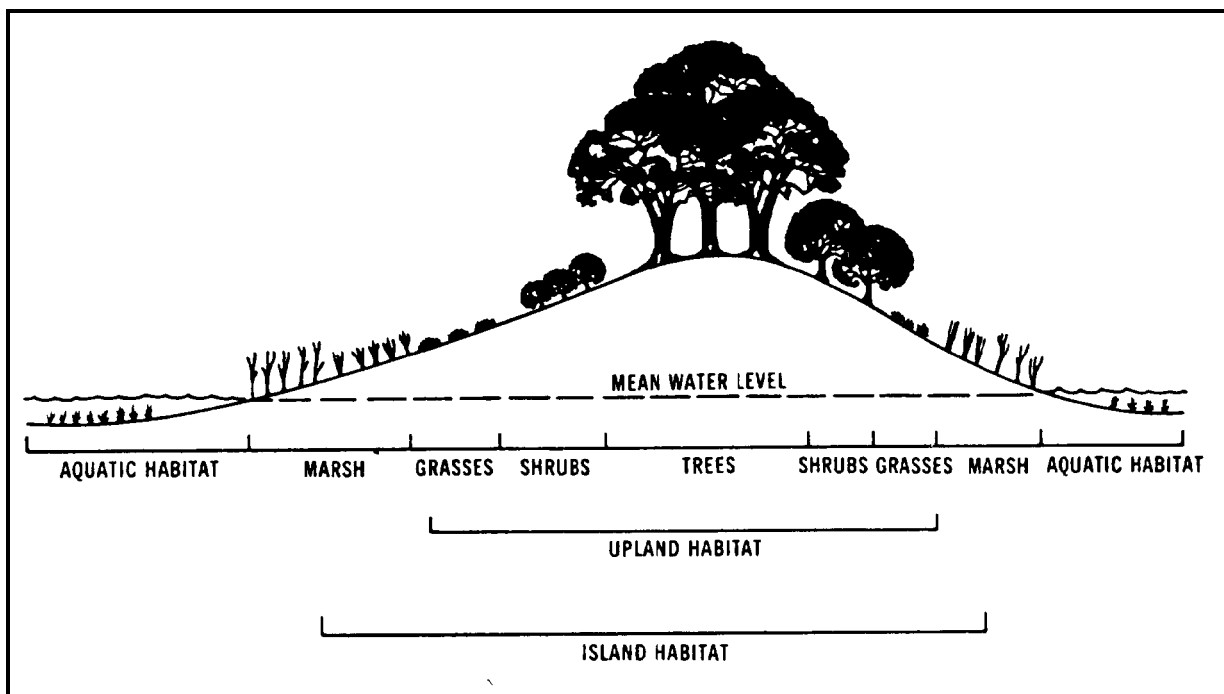


Figure 4-1. Hypothetical site illustrating the diversity of habitat types that may be developed at a disposal site

a. Wetland. Wetland habitat is a very broad category of periodically inundated communities, characterized by vegetation which survives in wet soils. These are most commonly tidal freshwater and saltwater marshes, relatively permanently inundated freshwater marshes, bottomland hardwoods, freshwater swamps, and freshwater riverine and lake habitats.

EM 1110-2-5026  
30 Jun 87

b. Upland. Upland habitat includes a very broad category of terrestrial communities, characterized by vegetation which is not normally subject to inundation. Types may range from bare ground to mature forest.

c. Aquatic. Aquatic habitats are typical submerged habitats extending from near sea, river, or lake level down several feet. Examples are tidal flats, oyster beds, seagrass meadows, fishing reefs, clam flats, and fresh-water aquatic plant beds.

d. Island. Islands are upland and/or high zone wetland habitats distinguished by their isolation and particular uses, and completely surrounded by water or wetlands.

These concepts and their implementation are discussed in detail in items 19, 32, 51, and 72 and in Chapters 5-8 of item 73.

4-2. Case Studies of Selected Habitat Development Sites. Numerous examples of habitat development using dredged material substrates exist; nearly 1,000 are listed in Appendix C and four are presented here to show the diversity of such sites.

a. Buttermilk Sound Salt Marsh.

(1) Buttermilk Sound, a 5-acre intertidal island marsh located in the Altamaha River, Georgia, was created by plantings during 1975-76 on a sandy, infertile dredged material island which had not revegetated since deposition of material a number of years ago. Success of the original plantings was related to the period of tidal inundation and type of propagule. Sprigs were more successful than seeds, and smooth cordgrass was the most successful species planted (item 19).

(2) From the outset, this marsh site has been very successful (Figure 4-2). Since 1979 it has been visually indistinguishable from natural reference marshes. Although tidal scouring initially washed out plantings and eroded the lower part of the intertidal zone, the site quickly stabilized. The established plant community has trapped large amounts of fine material, resulting in a thick layer of silt that now covers the original substrate. Smooth cordgrass dominates the entire lower two-thirds of the intertidal zone. Swards of big cordgrass and saltmeadow cordgrass remain at the middle elevations where they had been planted. The Buttermilk Sound site differs from nearby natural marshes by possessing greater plant species diversity at lower elevations. This is probably due to plant species that were introduced in zones lower than those at which they would naturally occur. Aboveground biomass is similar to natural marshes, but belowground biomass is less. Wildlife use of the marsh is greater than in the natural marshes in all respects, including white-tailed deer, alligators, clapper rails, tern nesting, and migratory shorebird and waterbird use (item 59).



Figure 4-2. Buttermilk Sound habitat development field site, Altamaha River, Georgia, after 6 years of development



Figure 4-3. Salt Pond 3 habitat development field site, South San Francisco Bay, California, after 5 years of development



(3) In 1985, the Buttermilk Sound site continues to represent one of the most successful marshes built by the CE. It appears to be very stable and the marsh area, especially in the upper marsh zone, continues to increase coverage and density to the extent that only one bare sandy spot remains on the entire island. This spot was not shaved down from the original elevation to an intertidal zone, and therefore has been very slow to vegetate.

b. Salt Pond 3 Salt Marsh.

(1) Salt Pond 3, a marsh site is South San Francisco Bay, California, was established on a portion of a 100 acre saltwater evaporation pond that was partially filled hydraulically with clayey dredged material in 1974. It is the only nonisland habitat development site that has been built by the CE. Plantings of Pacific cordgrass and pickleweeds were established during 1976-77. Cordgrass sprigs successfully colonized the lower two thirds of the intertidal zone, and pickleweeds rapidly and naturally colonized the upper one-third (item 59) (Figure 4-3).

(2) The plantings maintained themselves and have spread slowly into adjacent unvegetated areas. Production is somewhat less than in nearby natural marshes, perhaps due to the relatively early stage of site succession. The lower cordgrass zone appears visually equivalent to natural marshes, and the entire 100 acres with the exception of an occasional small mudflat and the tidal channel have become densely vegetated (item 59).

(3) Wildlife use is predominantly by birds, especially shorebirds which feed along the channel, and terns and other waterbirds. Peregrine falcons and other raptors frequent the area and feed on songbirds and rodents in the upper marsh zone. This site appears to be stable and has survived the excessive rainfall and severe storms that pounded the west coast in 1983 without apparent damage. The rainfall actually seemed to improve appearance of the marsh by increasing growth in the upper marsh zone.

c. Gaillard Island Confined Disposal Facility.

(1) Gaillard Island, a new diked disposal island in lower Mobile Bay, Alabama, was built in 1981 by the Mobile District (Figure 4-4). The large, triangular-shaped island is being filled with material from the main shipping channel, and its gently sloped dike is primarily silty clay. Waves come into the island dike from all three sides, and erosion is a continuing problem. In 1981, smooth cordgrass was planted on the northwest dike behind temporary breakwaters made of floating and fixed tire breakwaters. Surviving plantings from 1981 grew and spread behind the breakwater, and more plants were set in 1982 with more breakwater designs and tests. Many of these were thriving in 1983 in spite of severe storms in the area over 1982-83 (item 2). Plantings in 1983 and 1984 were primarily coupled with tests of several filter materials and tire configurations, as well as burlap rolls, different size propagules, and various placements in the intertidal zone.



Figure 4-4. Gaillard Island habitat development field site, Lower Mobile Bay, Alabama, after 3 years of development



Figure 4-5. Bolivar Peninsula habitat development field site, Galveston Bay, Texas, after 6 years of development

(2) On the upland portion of the dike, aerially seeded Bermuda grass now dominates, and it has effectively stabilized large portions of the dike. Diversity of invading plant species is increasing, and this colonization process is expected to accelerate over time. Plant succession is already progressing, as areas that were weedy annuals in 1982 are now perennial grasses. Species diversity and populations of both plants and animals increase with each seasonal data collection period; these have been documented since 1981 and will continue to be noted, at least through 1987 (item 2).

(3) Twenty bird species are now nesting on the island; in 1984, 1985, and 1986 the birds numbered approximately 16,000 each year. Laughing gulls dominated the nesting areas; however, large numbers of seven tern species, black-necked stilts, and black skimmers nested with apparent success. Muskrats colonized the island in late 1985; land birds nested there for the first time in 1984. Brown pelicans are nesting on Gaillard Island, and 1983 marked the first recorded nesting for the species in Alabama in this century. In 1983, two chicks fledged from a single successful nest. In the 1984 summer survey, nests had increased to eight; 133 active nests were observed in 1985. In 1986, there were over 200 active nests by May, with more being built. In addition, large numbers of nonbreeding white and brown pelicans are living year-round at Gaillard Island (item 42).

d. Bolivar Peninsula Upland and Marsh Site.

(1) The Bolivar Peninsula field site is located on Goat Island in eastern Galveston Bay, Texas, and includes both marsh and upland planted areas. The original site is 20 acres of sandy dredged material, protected by a sandbag dike and a fence. It was built by the CE and planted in 1976-77. Both smooth and saltmeadow cordgrasses established well on this site (Figure 4-5). In the upland area, shrubs, trees, and upland grasses initially established well, but invasion by other species eventually crowded them out (item 2). Since initial establishment, smooth cordgrass has spread throughout the lower tidal zone and dominates the site. The saltmeadow cordgrass has spread throughout the upper intertidal zone, and has also spread into the upland section of the site. Saltgrass and pickleweeds have invaded the same zone (item 2).

(2) Oysters had densely colonized the dike area by 1982 and now help serve as a breakwater for the marsh. The site has also been heavily colonized by fiddler and blue crabs and has much fish use during high tide. Wildlife use is quite good; large numbers of sea and wading birds use the site. Small mammals live inside the fence that was once built to exclude them, and a number of ground nesting birds use the site. By 1983, conversion of the upland zone from prairie grasses and woody plants to high marsh plants was complete. Cover on the site is dense, and unless it becomes heavily grazed by ranging feral goats on the island, should remain in that condition (item 59). Clapper rail use is also quite heavy (item 42).

(3) Four adjacent dredged material sites are now being compared on Goat Island: the old site planted in 1976-77; a new deposit (1982) to the west of the old site being planted to test two breakwater designs built of low-cost materials; a second new deposit (1982) on the east side of the old site that is serving as a control; and a part of the old site that was covered with a new application of sandy dredged material in January 1986. Part of the original planting was deliberately covered with dredged material to determine the impacts of smothering, and to determine how rapidly a salt marsh could recover from such disturbance. It will also be compared to a site in East Matagorda Bay where silty dredged material was placed in August 1986 over existing high marsh. Data will be collected on these four areas at least through 1987 (item 42).

(4) The Bolivar Peninsula site survived a direct hit by two hurricanes in 1983 and 1986. The only noticeable change was the washing away of the protective fence in the bay in front of the site. All of the natural marshes with which it was compared were changed by washouts of pockets of marsh that created open-water pockets. These types of washouts did not occur on the field site (item 42).

4-3. Habitat Development Selection Process. The diversity of biological communities indicates the potential diversity of alternatives available under habitat development. This wide range of options will usually make using quantitative measures for selecting specific alternatives impractical, and consequently, selecting a given habitat development alternative is likely to be highly judgmental. The best determination will be made by a combination of local biological and engineering expertise and public opinion. Guidelines for the evaluation of individual habitat development situations are summarized below.

a. Conditions Favoring Habitat Development.

(1) The selection of habitat development as a disposal alternative will be competitive with other disposal options and types of beneficial uses when one or more of the following conditions exists:

- (a) Public/agency opinion strongly opposes other alternatives.
- (b) Recognized habitat needs exist.
- (c) Enhancement measures on existing disposal sites are identified.
- (d) Feasibility has been demonstrated locally.
- (e) Stability of dredged material deposits is desired.
- (f) Habitat development is economically feasible.
- (g) Extensive quantities of dredged material are available.

Since disposal alternatives are often severely limited and constrained by public opinion and/or agency regulations, with constraints on open-water and other sites, disposal habitat development will be an attractive alternative, and in many cases will have strong public appeal. The need for restoration or mitigation or the need for additional habitat may strongly influence the selection of the habitat development alternative. This is particularly applicable in areas where similar habitat of considerable value or of public concern has been lost through natural processes or construction activities, such as at Pointe Mouillee in Lake Erie. Habitat development may be used as an enhancement measure to improve the acceptance of a disposal technique. For example, seagrass may be planted on submerged dredged material, or wildlife food plant established on upland confined disposal sites. Habitat development has considerable potential as a low-cost mitigation procedure and may be used to offset environmental impacts incurred in disposal.

(2) The concept of habitat development is more apt to be viewed as a feasible alternative if it has been successfully demonstrated locally. Even the existence of a pilot-scale project in a given locale will offset the uncertainties often present in the public and in resource agencies' perception of an experimental or unproven technique. The vegetation cover provided by most undiked habitat alternatives will generally stabilize dredged material and prevent its return to the waterway. In many instances this aspect will reduce the amount of future maintenance dredging necessary at a given site and result in a positive environmental and economic impact.

(3) The economic feasibility of habitat development should be considered in the context of long-term benefits. Biologically productive habitats have varied but unquestionable value (i.e., sport and commercial fisheries) and are relatively permanent features. Consequently, habitat development may be considered a disposal option with long-term economic benefits that can be applied against additional costs that may be incurred in its implementation. Habitat development may be particularly economically competitive in situations where it is possible to take advantage of natural conditions or where minor modifications to existing methods would produce desirable biological communities. For example, the existence of a low-energy, shallow-water site adjacent to an area to be dredged may provide an ideal marsh development site and require almost no expenditure beyond that associated with open-water disposal. Actual dollar values assigned to habitat development has been a controversial topic of discussion among scientists for a number of years. All agree that it has to be done, and that such sites are highly valuable; none agree on valuation estimates.

b. Guidelines. Habitat development presents several options ranging from establishment of upland communities to the development of seagrass meadows. A broad procedural guide to the selection of the habitat development alternative is given in Figure 4-6. The beneficial use planner should ignore categories unrelated to the particular problem, and may wish to add key site specifications.

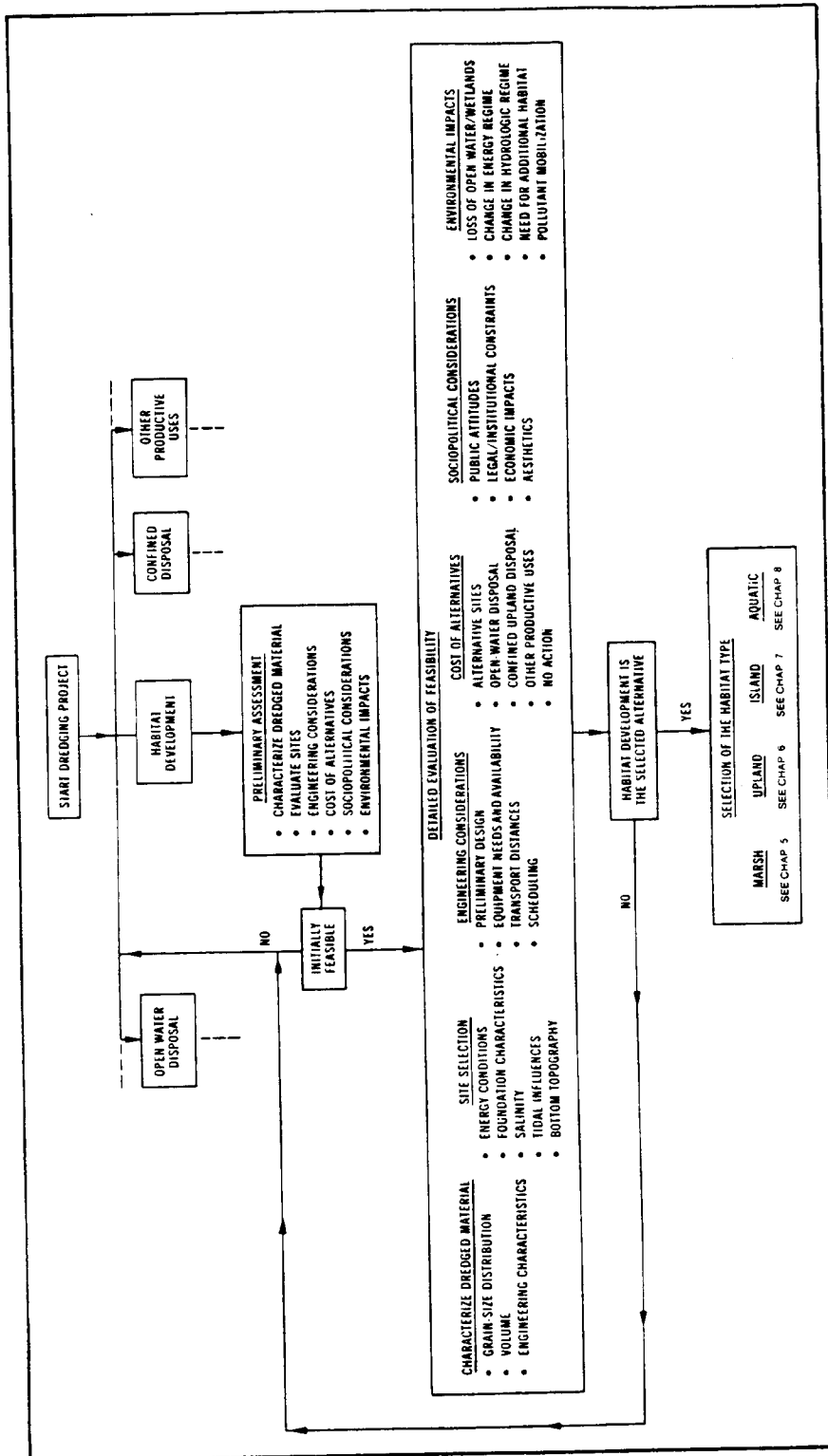


Figure 4-6. Procedural guidelines for selection of habitat development alternatives

(1) Preliminary assessment. The initial consideration of habitat development as a disposal alternative should include a preliminary assessment of feasibility, which involves judgment based on available data. A determination that habitat development is not initially feasible should be based on compelling negative evidence and not merely on a lack of information or specific precedents. In the absence of such negative evidence, one should proceed to the detailed evaluation of feasibility. Factors may arise at several stages in the evaluation that would lead to a determination of infeasibility. Should that occur, other disposal alternatives would be reconsidered.

(a) The detailed evaluation of feasibility includes six major categories beginning with a characterization of the dredged material and arranged generally in the order of need for acquisition of information. In characterizing the dredged material, the physical, chemical, and engineering characteristics of the material to be dredged should be determined. These properties will help define the general considerations of site selection.

(b) Site selection should be based on an adequate knowledge of energy conditions, foundation characteristics, salinity, tidal influences, and bottom topography. Energy conditions will largely influence the feasibility of establishing a stable substrate, or the necessity of protection structures. Foundation characteristics will determine the ability of a given site to support construction activities or structures. Salinity and tidal influences will dictate the plant species composition. A more detailed analysis of these factors will be necessary later for detailed design purposes if the habitat development alternative is selected, but even in this early phase, some field sampling may be necessary if general information is not available.

(c) Engineering considerations at this stage are largely confined to preliminary designs and an assessment of equipment needs and availability. Details such as scheduling to meet critical environmental dates (e.g., spring or summer planting times) and the identification of dredged material transport distances will provide useful planning data. In many projects, the pivotal determination of engineering feasibility or infeasibility can be made at this stage.

(d) Evaluation of the cost of alternative disposal methods is the next essential step. In a number of CE Districts, this is the first step in assessment. Detailed economic analyses must await the further development of design criteria; however, a general cost comparison of the various alternative sites should be possible at the completion of the preliminary assessment of feasibility. This is another critical step because considerable time and effort can be spared by defining the economic limits that the project must satisfy to remain competitive with other alternatives.

(e) Of the sociopolitical considerations, public attitudes and legal and institutional constraints are most likely to prove limiting. Negative public attitudes generally occur when the community views the proposed habitat as a threat to established values. Legal and institutional constraints

frequently arise when there are unanswered questions of ownership and access or when local interests have designated the site for an alternative future use. Direct economic impacts may be identified if the habitat to be developed may alter important shellfishing or recreational areas or block a water view.

(f) The environmental impact of most habitat development projects may be expressed as a loss of open-water habitat or wetland systems and changes in hydraulic and energy regimes. The impacts of these factors tend to be cumulative and are directly related to the perceived need for additional habitat. In general, the need for more habitat is considered more critical in areas that have lost or are losing considerable habitat of that type. Pollutant mobilization by plants growing on contaminated dredged material might be of concern, and its potential should be determined prior to habitat development.

(2) Selection of habitat development as an alternative. Upon completion of the preliminary assessment of feasibility, a determination can be made whether habitat development is applicable. If habitat development is a selected alternative, a decision regarding the type or types of habitats to be developed must be made. This decision will be largely judgmental, but in general, site peculiarities will not present more than one or two logical options. Specific advantages and disadvantages likely to be encountered are evaluated, and items of particular concern during early feasibility determinations are highlighted in Chapters 5, 6, 7, and 8.



## CHAPTER 5

### WETLAND HABITATS

5-1. Marshes. Marshes are considered to be any community of grasses or herbs that experience periodic or permanent inundation. Typically, these are intertidal freshwater or saltwater marshes and periodically inundated freshwater marshes. Marshes are recognized as extremely valuable natural systems and are accorded importance in food and detrital production, fish and wildlife cover, nutrient cycling, erosion control, floodwater retention, ground-water recharge, and aesthetics. Marsh values are highly site-specific and must be examined in terms of such variables as species composition, location, and extent, which in turn influence their impact upon a given ecosystem.

5-2. Marsh Development Considerations. Accurate techniques have been developed to estimate costs and to design, construct, and maintain man-made marsh systems (items 2, 19, 42, and 59). Methods are available to predict the impact of the alternatives on the environment and to describe the value of the proposed resource prior to its selection.

a. Advantages. Several advantages have been found in marsh development as a disposal alternative:

- (1) Considerable public appeal.
- (2) Creation of desirable biological communities.
- (3) Considerable potential for enhancement or mitigation.
- (4) Frequently a low-cost option.
- (5) Useful for erosion control.

Marsh development is a disposal alternative that can generate strong public appeal and has the potential of gaining wide acceptance when some other techniques cannot. The created habitat has biological values that are readily identified and accepted by many in the academic, governmental, and private sectors. However, application requires an understanding of local needs and perceptions and the effective limits of the value of these ecosystems. The potential of this alternative to replace or improve marsh habitats lost through dredged material disposal or other activities is frequently overlooked. Marsh development techniques are sufficiently advanced to design and construct productive systems with a high degree of confidence, even in moderate wave energy environments. For example, salt marshes have been established at Bolivar Peninsula, Texas, and Gaillard Island, Alabama, behind temporary breakwaters in moderate energy areas. These habitats can often be developed with very little increase in cost above normal project operation, a fact attested to by hundreds of marshes that have been inadvertently established on

dredged material and by the more than 130 marshes that have been purposely created using dredged material substrates in U. S. waterways.

b. Disadvantages. Several problems are likely to be encountered in marsh development:

- (1) Unavailability of appropriate sites.
- (2) Loss of other habitats.
- (3) Release of contaminants.
- (4) Loss of site for subsequent disposal.

By far the most difficult aspect of the application of marsh development is the location of suitable sites. Low energy, shallow-water sites are most attractive; however, cost factors will become significant if long transport distances are necessary to reach low energy sites. Temporary protective structures may be required if low energy sites cannot be located and have been successful at several Gulf coast sites where moderate wave energy occurs (items 1 and 2). Marsh development frequently means the replacement of one desirable habitat with another, and this will likely be the source of most opposition to this alternative. There are few reliable methods for comparing the various losses and gains associated with this habitat conversion; consequently, determining the relative impact may best be made on the basis of the professional opinion of local authorities. Although studies have shown that contaminant uptake from soil in marsh environments is minimal, the planner should remain alert that the potential exists with highly contaminated sediment use. Development of a marsh at a given site can prevent the subsequent use of that area as a disposal site. In many instances, additional development on that site would be prevented by state and Federal resource agencies. Exceptions may occur in areas of severe erosion or subsidence, or where previous disposal created a low marsh and subsequent disposal would create a higher marsh.

c. Maintenance. Dredged material marshes should be designed to be relatively maintenance free. The degree of maintenance will largely depend on the energy conditions at the site, a factor that should be included in the cost analysis of the project. No maintenance may be required to protect the new marsh in low energy situations. In areas of somewhat higher energy conditions, protection may be required only until the marsh has a chance to mature. In those areas, protective structures may be designed for a relatively short life with no additional maintenance required. In high energy situations, perpetuation of the marsh may require planned periodic maintenance of protective structures and possibly periodic replanting.

5-3. Guidelines for Marsh Development.

a. Selection of Wetland Type. If marsh development is the beneficial use alternative selected, it is necessary to select the most appropriate wetland type (Figure 5-1). In most situations, the selection of a wetland type will be largely predetermined by overriding environmental conditions such as tidal range salinity or flood conditions. Most marsh development projects, simply because of the nature of dredged material disposal and the formation of drainage patterns, will contain elements of shallow and deep marsh (freshwater) or high and low marsh (saltwater).

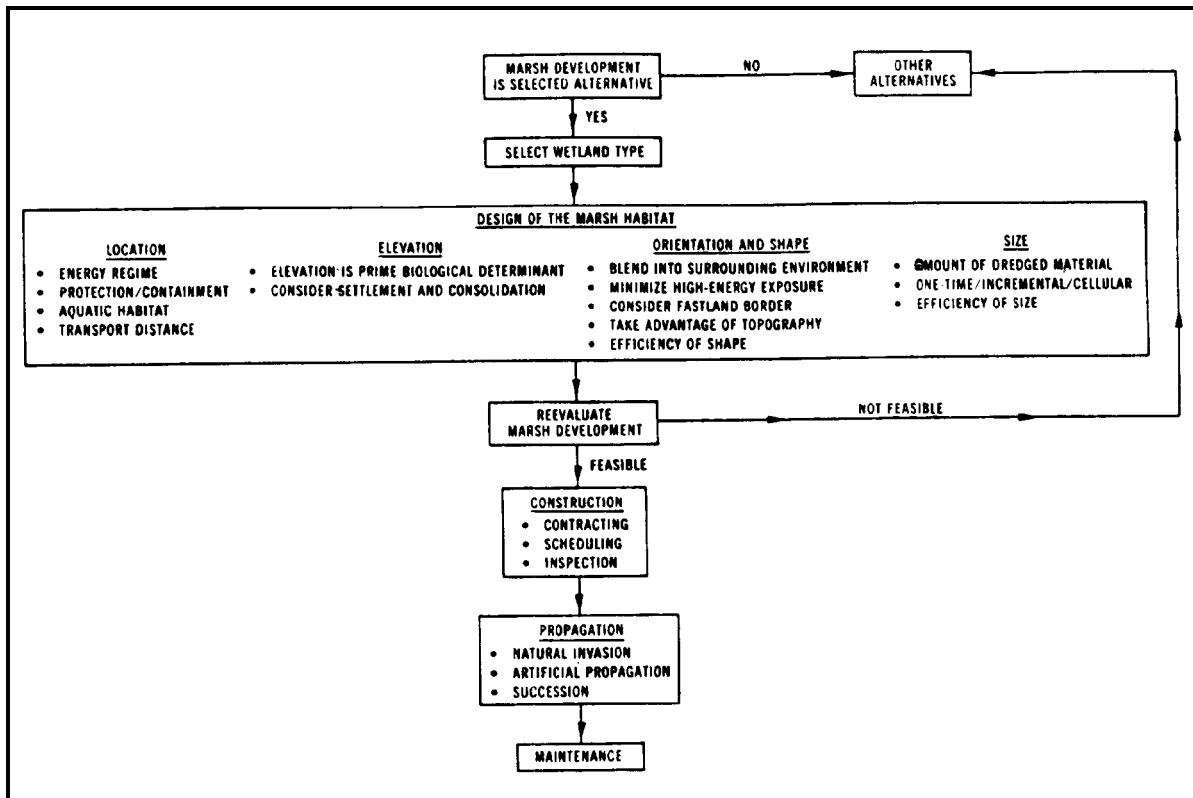


Figure 5-1. Procedural guidelines for selection of marsh habitat development

b. Design of Marsh Habitat. The detailed design of the marsh habitat is separated into four parts: location, elevation, orientation and shape, and size. The design should maintain the goals of disposal of dredged material through the development of a desirable biological community, using the most cost-efficient methods and causing a minimum of environmental perturbation. Engineering and biological designs of marshes have been researched and field tested by WES (items 19 and 59) in a number of locations.

(1) Location. The location of the new marsh may be the most important decision in marsh development. Low energy areas are best suited for marsh development, and sandy dredged material has been found to be the ideal substrate. Departure from these conditions will require a careful evaluation of the need for structural protection and containment. High wave or current energies may prevent the formation of a stable substrate and the establishment of vegetation, making various forms of protective structures or mechanisms necessary (item 2). Another major consideration in the protection/containment equation is the grain-size distribution. Hydraulically placed clay will usually require temporary or permanent containment, regardless of wave or current conditions. Containment is generally required to hold fine-grained type material within a prescribed area. Silt under very low energy situations may require no containment or protection; however, in moderate energies it is essential. Sand that would require no protection under low energy situations may require some protection under moderate wave energy. Obviously, a wide range of conditions exists. It should be remembered that those areas best suited for marsh development (shallow, low energy) are also likely to be biologically productive. Particular efforts should be made to avoid unusually productive areas such as seagrass meadows, clam flats, and oyster beds. In general, the further dredged material must be moved, the greater the cost in marsh development. The availability of suitable equipment may also influence the feasibility of distant disposal. Therefore, attention should be given to locating the disposal site as near the dredging operation as possible.

(2) Elevation. Final elevation of the marsh substrate is largely determined by settlement and consolidation and is the most critical of the operational considerations, as it dictates both the amount of material disposed and the biological productivity of the habitat established. Techniques are available to predict the final stable elevation of a given volume of dredged material placed in a confined intertidal situation (item 19). Salt marshes are generally most productive within the upper third of the tidal range, while freshwater marshes should generally be flooded to a depth of not more than 2 feet. Determination of final elevation is critical and should be based on precise knowledge of the elevational requirements of the plant community. Variation in topography will produce habitat diversity and should be encouraged, provided that the majority of the area is within the desired elevation range. If the possibility of not being able to achieve a desired elevation appears likely, incremental filling may be possible, with a conservative estimate of the amount of material necessary to attain a given elevation. Should the final elevation still be too low, the difference can be made up in subsequent disposal. If one-time disposal is anticipated, it may be

possible to overfill and rework the area to a lower elevation with earth-moving equipment,

(3) Orientation and shape. The orientation and shape of the new marsh will largely determine its total cost, its efficiency as a disposal site, and its effectiveness as a biological addition to the natural environment. The shape should minimize impact on drainage or current patterns in the area surrounding the disposal site and allow it to blend into the surrounding environment. If high energy forces are anticipated, the marsh should be shaped to minimize high-energy exposure. Such design will reduce the threat of failure and reduce the cost involved in providing protection. If available, a fast-land border, such as a cove, island, or breakwater, can serve as low cost protection and minimize the length of otherwise necessary and costly containing or protective structures. An effort should be made to take advantage of bottom topography during the design of the new marsh. Disposal sites are often not uniform in depth; if possible, protective structures should be located in shallow water and the fill area in deep water to maximize the containment efficiency. If dikes are built from local material, it may be possible to deepen the disposal area by locating borrow material within the dike area. Shape may also be a major cost determinant when diking is required. For a given area of protected marsh, a circle requires the minimum dike length. A rectangle increases dike length in proportion to its length-width ratio. For example, a rectangle ten times longer than wide requires a perimeter nearly twice that of a circle to contain the same area.

(4) Size. The size of the disposal area will be a function of the amount of the material to be dredged and the volume of the disposal area. There are several filling options that might affect size, including one-time, incremental, and cellular. One-time filling implies that a site will be filled and marsh established within that operation, and that the area will not be used again for disposal. In incremental filling it is recognized that the site will be used during the course of more than one dredging operation or season and the disposal area will be considered full when a predetermined marsh elevation is attained. In cellular filling, a compartment of a prescribed disposal area is filled to the desired elevation during each disposal project. Both incremental and cellular filling offer the efficiency of establishing a large disposal site and utilizing it over a period of years, thus avoiding repetitive construction, design, and testing operations. A major difference between these two methods is that the cellular method provides a marsh substrate at the end of each season, whereas many years may be required before incremental filling attains this goal. Cellular or incremental disposal sites would generally be larger than one-time disposal sites, and this increase in size may offer a more cost-effective disposal site.

c. Reevaluation and construction. A final reevaluation of the marsh development alternative should take place prior to construction. Marsh development contracting procedures may sometimes prove to be difficult because neither the contractors nor the CE may have had previous experience with marsh contracts. Prebid conferences to explain the intricacies of the project as

well as carefully detailed contract specifications are strongly advised. Scheduling the dredging can prove to be particularly important. To obtain maximum vegetative cover within the first year, it is necessary to have the dredged material in place and with a relatively stable surface elevation by the beginning of the growing season. Delays will affect the initial success of the project and may result in loss of nursery or seed stock, replanting costs, adverse public reaction, and unwanted erosion at the site. It cannot be overemphasized that careful inspection of the disposal operation is essential, as the attainment of the prescribed elevation is critical, an aspect that may not be appreciated by the dredging crew.

d. Vegetation establishment. Propagation of marsh plants can be attained by natural invasion or artificial propagation. Natural establishment of plants can be expected if the environmental requirements for a marsh community, including a source of propagules, are present at a site. In some cases, especially in freshwater marshes, natural invasion will occur on a site within a few months; in others, especially saltwater coastal areas, many years may be required. The process of marsh establishment will be accelerated on most sites by seeding or sprigging. In the selection of species for artificial propagation, every effort should be made to ensure that the selected species represent a natural assemblage for a given area. Exotic or offsite species will not generally be able to compete with natural invaders. An exception may be an instance in which a species is selected for temporary cover or erosion control until natural invasion has colonized the site. For example, smooth cordgrass is planted in tropical Florida, with mangrove seed pods interspersed. The smooth cordgrass provides protection for the mangrove seedlings until they become firmly established. The advantage of propagation by natural invasion is the low cost, and this may be a pivotal consideration in borderline projects. The advantages of artificial propagation are more rapid surface stabilization and an immediate vegetation cover. Seven types of propagules are available for marsh vegetation establishment: seeds, rootstocks, rhizomes, tubers, cuttings, seedlings, and transplants (sprigs). By far the most commonly used in marsh establishment is transplanted sprigs.

(1) Factors influencing design. The successful establishment of a planned marsh requires careful project design and implementation. Each site will exhibit its own peculiarities and must be approached individually. In any marsh design, a number of factors are significant; the most important are salinity, tidal range, flood stages, soil texture, wave and wind action, contaminant tolerance, outside influences, and cost.

(2) Protection. The new substrate must be protected either by virtue of its location in a low energy area or by placement of a protective structure such as a permanent or temporary dike or breakwater (Figure 5-2). Low energy areas are most commonly found in the lee of beaches, islands, and shoals; in shallow water where wave energies are dissipated; on the inside downstream side of riverbends; in embayments where marshes presently exist; within zones of active deposition; and away from long fetch exposure, tidal channels, uncontrolled inlets, and headlands. Plants themselves may be used as a



Figure 5-2. A floating tire breakwater installed at Gaillard Island, Alabama, to protect newly planted marsh from moderate wave energies



Figure 5-3. Transplants at Miller Sands habitat development site, planted on 3-foot centers, at the end of the first growing season

protection barrier by planting more erosion-resistant large transplants on the outer fringes of the marsh, with more susceptible but less expensive propagules such as rootstocks, tubers, and seeds in the interior and high marsh areas of the site. Young plants are particularly vulnerable to wildlife feeding and browsing. Herbivores such as Canada geese, muskrats, nutria, rabbits, goats, sheep, and cattle can rapidly destroy a newly established marsh. Heavy grazing may even destroy mature marsh communities. Potential animal depredation should be evaluated for each site and, in extreme cases, should be controlled by trapping or fencing.

(3) Plant spacing. Plant spacing is highly site specific and is governed by the quality of the substrate, type of propagule, length of the growing season, and desired rapidity of plant cover. Generally, when transplants are used, parallel rows and spacings of 1 to 3 feet are recommended to achieve relatively uniform cover by the end of the second growing season (Figure 5-3). Planting at about 3-foot intervals is usually a good compromise between high costs and full cover. If the cost of transplants is a limiting factor, or there is no compelling reason to attain full cover within a short time, then spacing may be greater than 3 feet. If the site is extremely unstable, subject to heavy wildlife pressures or physical stresses, or if aesthetics are an immediate concern, more dense plantings may be desirable. For example, if Canada geese are known to use the area heavily, the plants should be spaced closely to encourage the geese to limit their feeding to the edges of the new marsh. Transplants may be evenly or randomly spaced; even spacing is more efficient in use of machinery and labor. Other vegetative propagule types such as rootstocks, rhizomes, and smaller sprigs are handled similarly to transplants. However, since they grow much slower initially, these propagules should be spaced more closely. Intervals of 1 foot are recommended for rootstocks and rhizomes, and 1 to 1.5 feet for smaller sprigs.

(4) Diversity. In general, a site planted in a variety of species over a topographic range, from deepwater to upland areas, is preferred. Exceptions to this are sites where physical stresses are particularly harsh or stabilization is critical (as on dike slopes), where only one species can tolerate the conditions, or where quick cover by a vigorous monoplanting, such as smooth cordgrass at low intertidal elevations, is needed. More typically, variation in site elevation with respect to water regime will necessitate planting the dredged material with at least two species to obtain both high and low marsh. Species diversity can be used to achieve greater appeal to a more diverse group of wildlife, to enhance habitat for a target wildlife species, to control animal depredation by planting a high-value wildlife food species as a sacrifice, to better ensure site success, and to provide for long-range plant succession at the site by making available sources of several desirable species. Generally, marshes of about 20 percent mudflats, 30 percent vegetation cover, and 50 percent open, shallow water are most productive from an ecological standpoint and in overall wildlife use. It may be necessary to first establish the marsh, then do any clearing that may be required for a wildlife enhancement objective.



(5) Plant species selection. The selection of plant species appropriate to the region, to the site, and to the project objectives is the first step toward vegetation establishment. Success of the project may hinge upon the species being planted, propagule types used, and the use of the plant material by wildlife. The site planner should familiarize himself with nearby marsh plant communities that occur on similar sites, noting the distribution and relative abundance of species within the stands. All species should be considered. Smooth cordgrass, because of its large areal extent, has been considered the major marsh species in the eastern and gulf coasts of the United States, but other species such as black needlerush, saltgrass, saltmeadow cordgrass, big cordgrass, saltmarsh bulrush, river bulrush, cattails, and nutsedges are also easily established and highly productive. Figures 5-4, 5-5, 5-6, and 5-7 show generalized profiles of major marsh plant associations for east and west coast salt marshes, brackish marshes, and fresh lake, pond, and river marshes. Selection of a species or mixed group of species for planting at a particular site should be based upon: project goals, location, climate and microclimate, tolerance, soil, plant growth habits, plant availability, maintenance requirements, and costs. If a project goal is to establish habitat for target wildlife species, any plant species known or suspected to be of use for cover, food, resting, or nesting for those species should be considered. If soil stabilization is a goal, species selection will be influenced. Marsh plant species have varied capacities for stabilization. Their underground root structure, rate of growth, and season of growth are important, and species with a longer growth cycle, such as smooth cordgrass and saltmeadow cordgrass, probably are more effective at erosion control than ones such as big cordgrass with a seasonal cycle.

(6) Propagule selection. Once species selection has been completed, more detailed consideration must be given to the type and availability of plant propagules, the amount of plant material needed to propagate a site, and the costs. The criteria for selection of propagule types are similar to the considerations used for selection of plant species: availability and costs, collection and handling ease, storage ease, planting ease, disease, urgency of need for vegetative cover, and site elevation.

(7) Handling plant material and planting the site. These techniques are generally those that will be applied by a CE contractor. Specific handling and planting details for marsh vegetation are discussed in items 19 and 39 for seeds and vegetative propagules such as transplant and rootstock. Appendix B provides information on 359 upland and 105 wetland plant species that may be planted on dredged material beneficial use sites.

(8) Pilot propagation study. In a marsh development project where there are unknown factors such as seed or sprig collection and planting techniques, effects of animal depredation, rate of plant spread, heavy metal uptake, or lack of experience in similar projects, it is prudent to conduct a pilot study. A pilot project is particularly advisable if the project is a large and costly one. A pilot study's main purpose is to determine whether or not the selection plant species and propagules will grow under conditions

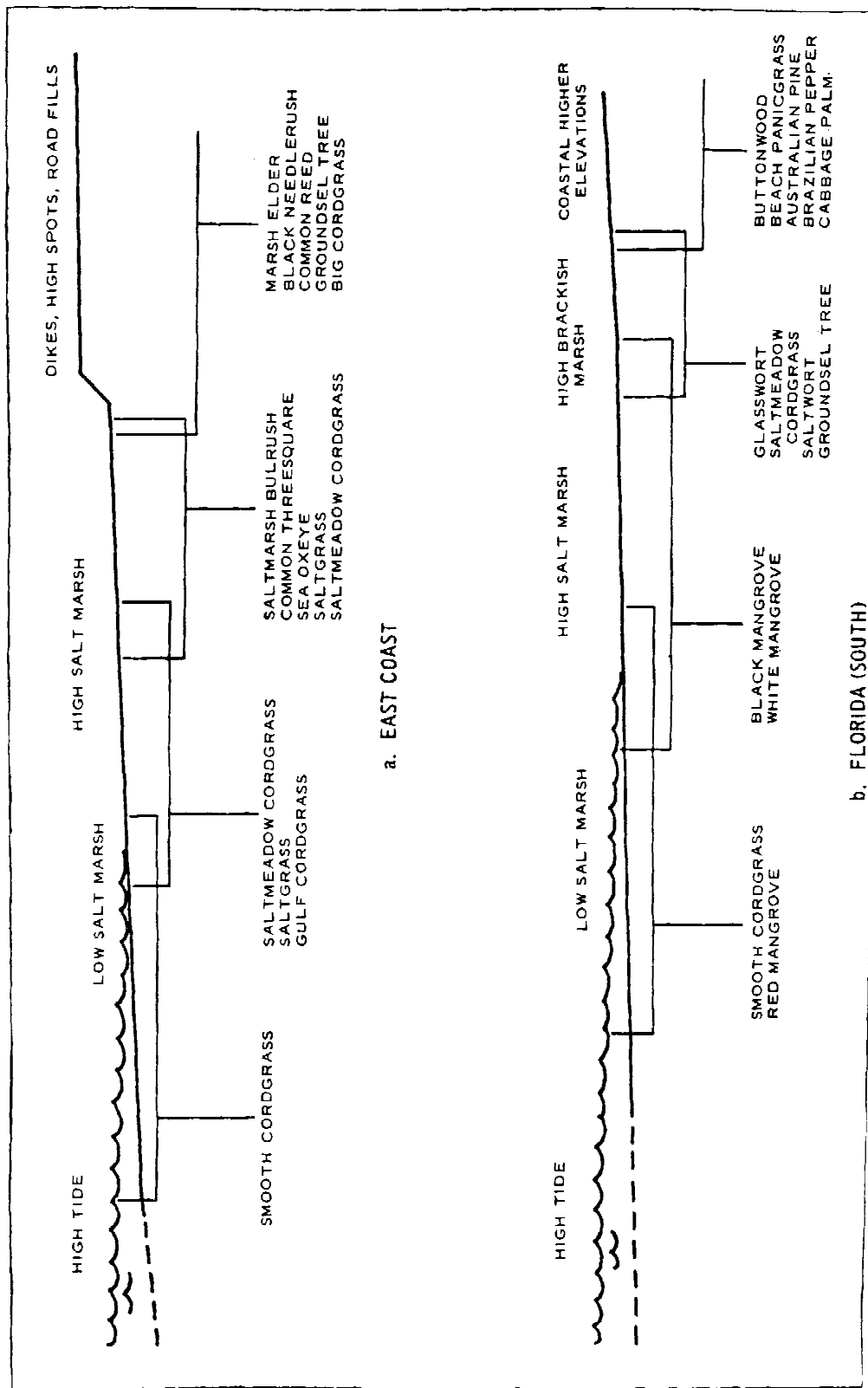


Figure 5-4. Sketches of typical east coast and Florida tidal marshes showing plant associations and usual occurrence in the marshes

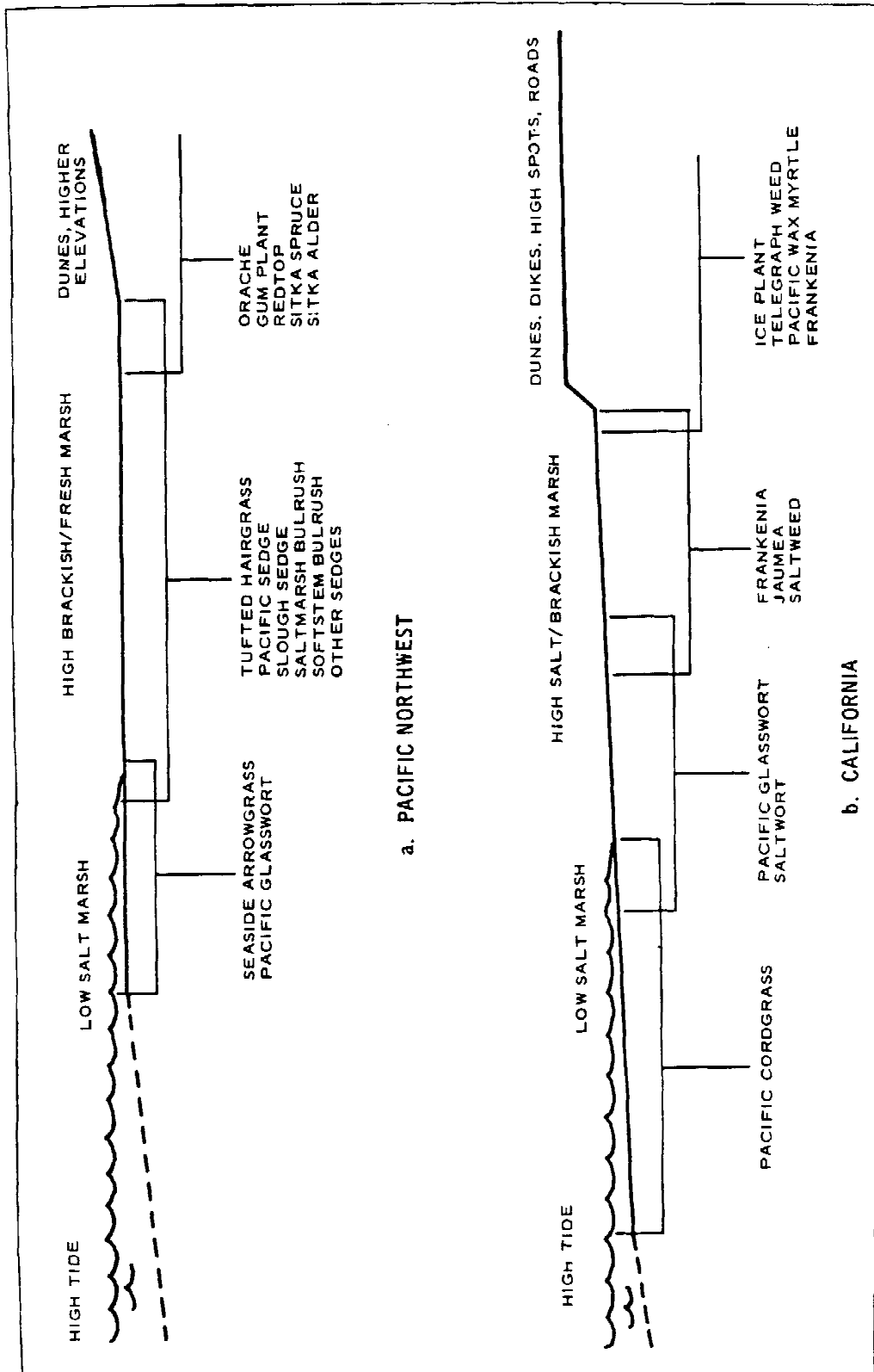


Figure 5-5. Sketches of typical Pacific Northwest and California Coast tidal marshes showing plant associations and usual occurrence in the marshes

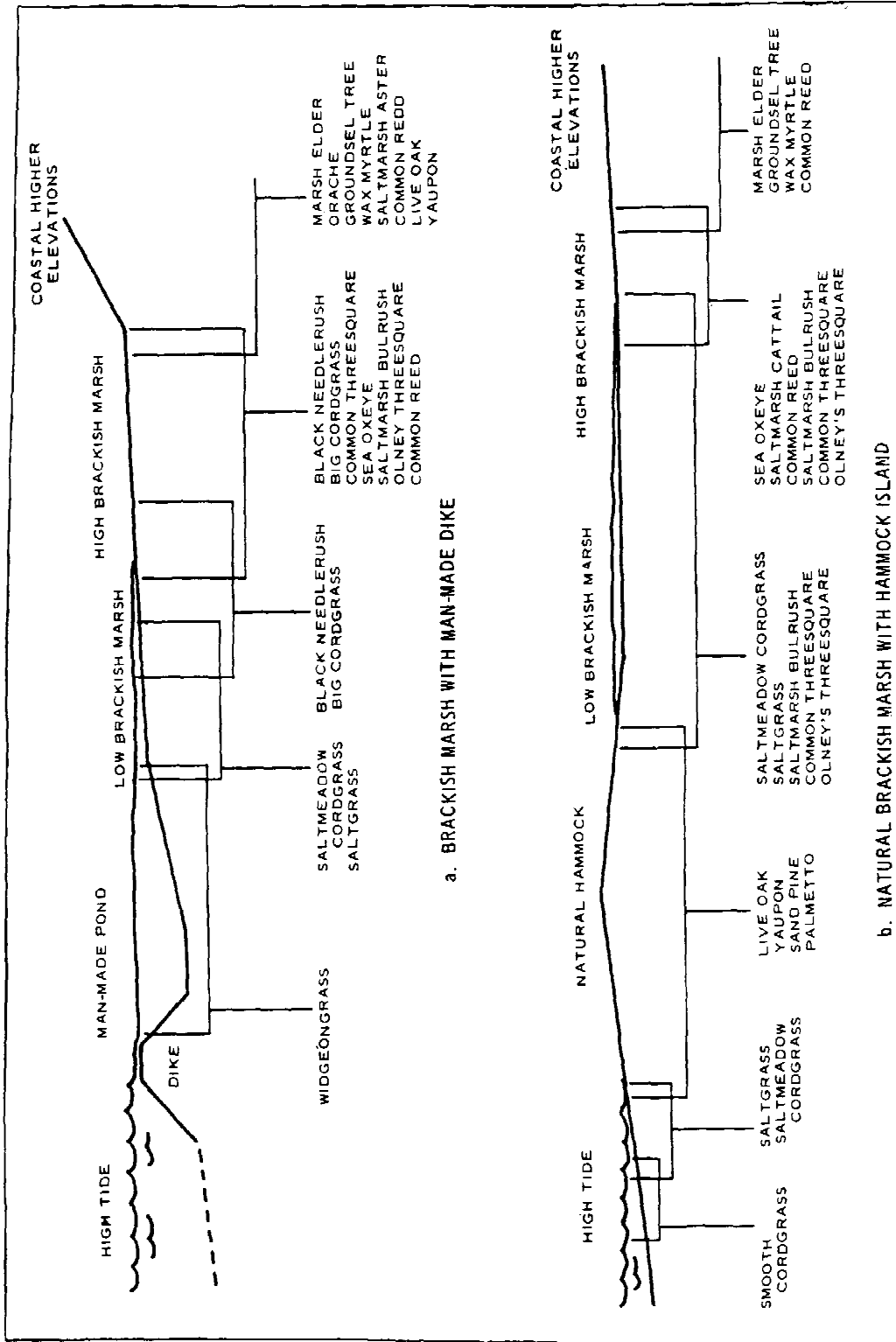


Figure 5-6. Sketches of typical brackish marshes showing plant associations and usual occurrence in the marshes

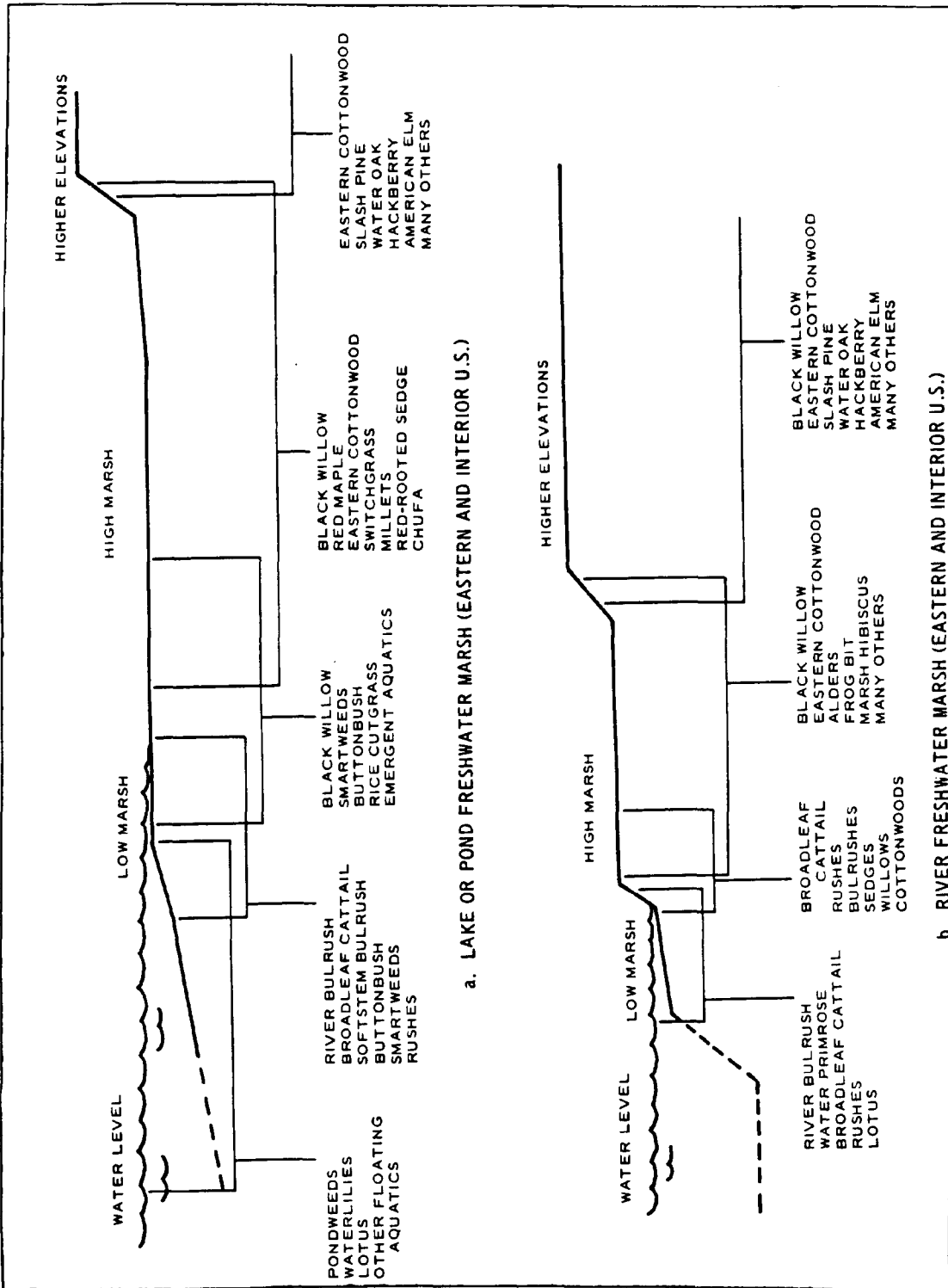


Figure 5-7. Sketches of typical lake or pond and river freshwater marshes showing plant associations and usual occurrence in the marshes

found on the site. The study can be conducted in less than a year, but the test species should be allowed to grow for one full season before conclusions are drawn. Such a project should be of sufficient size that it will accurately reflect future operational difficulties. Each selected species should be tested against all site conditions, and it may be advisable to test more than one propagule type, propagation method, planting time, and plant spacing for each species. The size of the pilot study is limited only by the desired tests, the time available for such testing, and funding. A simple statistical design will permit quantitative evaluation of the study where prediction of degree of success or failure can be made. The success of these plants can generally be evaluated by observation of survival. Test plots established should be evaluated on a regular basis to determine survival and growth, natural plant invasion, erosion, and animal depredation. Same-position photography on a regular basis is also valuable in obtaining a good record of plant success, growth, or dieback.

(9) Time of planting. Time of planting is very important regardless of the propagule type used. For example, seeds planted before the last frost in the spring may suffer heavy damage, and planting in midsummer may result in heat and drought stress of the seedlings as they sprout. Vegetative propagules may be planted when the ground is not frozen, and when the day temperatures average less than 68°F. With provisions for local climatic extremes and periods of severe storm or tide activity, propagules are best planted in early to midspring. Along the gulf and south Atlantic coasts, planting is recommended in all but the summer months. Fall planting, although a horticulturally acceptable practice, is not recommended for marshes as severe loss of propagules may result from erosion of sediments away from the root systems before regrowth begins the following spring. To lessen shock, propagules held in storage inside a nursery or greenhouse should not be planted until temperatures at the field site are at least as warm as the storage area. Propagules held in shady areas should be gradually acclimated to sunny conditions to prevent blistering and death of leaves. Propagules should also be acclimated to the salinity that exists at the site. For example, if saltmeadow cordgrass propagules are dug from a donor marsh of five parts per thousand (ppt) salinity to be planted in a marsh of higher salinity, they could be maintained at 5 ppt until about 2 weeks before planting when they should be moved to a solution of the same salinity as the accepting marsh. If there is a large difference of at least 10 ppt, gradual acclimation is necessary.

(10) Dredged material (soil) bed preparation and treatment. Initial dredged material assessment should have revealed certain characteristics of the substrate: texture, salinity, nutrient level, and potentially toxic levels of metals, pesticides, petroleum products, etc. These characteristics were considerations used to select species and propagules and now must be considered in the preparation of the soil bed and any treatments needed for planting such as liming and fertilizing. Actual plot preparation should take place just prior to planting of the site. Sandy dredged material disposal sites often can be graded to achieve desired slope and elevations. Fine-textured material cannot be easily modified once placed. Dewatered and

potentially acidic material may be encountered at higher elevations within the marsh development site. Modification of the pH of this dewatered material using some form of lime may be necessary if the pH is less than 5.5. Fine-textured dredged material seldom needs fertilizer, as it tends to be rich in nutrients. A positive short-term plant response generally can be obtained by fertilizing sandy material and it is usually recommended on highly erosive sites. However, long-term survival of the site may not be affected by fertilizer applications. In general, under marsh conditions of periodic inundation, fertilization is not recommended.

(11) Plants for dikes. Temporary or permanent dikes must often be erected to contain fine-textured dredged material. It may be advantageous to stabilize these with plants to reduce erosion. Representative plants that may be used successfully on dikes in coastal areas are saltmeadow cordgrass, saltgrass, groundsel tree, marsh elder, common reed, seaside goldenrod, beach panic grass, and coastal bermuda grass. These are established using agronomic upland practices discussed in Chapters 6 and 12 and in items 30 and 32. Dikes in interior and freshwater areas may be planted with species such as tall fescue, reed canary grass, giant reed, common reed, common Bermuda grass, and switchgrass. All these species may be seeded, and most are commercially available.

e. Potential Problems.

(1) Project timing. Dredging and biological calendars frequently do not match. There are two key items regarding biological scheduling: predictable lead time is necessary to prepare some propagule types, and planting is usually best in the spring. Transplants grown in a greenhouse cannot be held beyond a certain point without greatly increasing costs and weakening the propagules. Similarly, seeds must be collected when they mature in the field and often will not remain viable for extended periods of time. Dredging schedules are often variable, particularly so when new disposal techniques are being employed. In almost all situations the dredging schedule will predominate; therefore, it is best not to initiate all planting preparations until dredging times are assured. In most situations a delay of 4 to 6 months between completion of dredging and propagation will be acceptable. If this is not acceptable, the dredging schedule should be adjusted if possible. Late summer dredging will usually result in a site being ready for propagation in the spring of the following year. It will often not be possible to dredge and plant in the same calendar year as both procedures are subject to time constraints and delays.

(2) Contaminant uptake by plants. Metals and chlorinated hydrocarbon compounds commonly associated with industrial, agricultural, and urban areas may be transferred to marsh plants from the air, water, or marsh substrate. When contaminated dredged material is used for marsh development, the potential for contaminant transfer should be considered. This potential problem has been discussed in Chapter 2.

(3) Invasion of nonpreferred plant species. In brackish or freshwater marshes, invasion of unwanted plant species such as purple loosestrife or common reed can occur readily if propagules of those species are already present nearby. The most frequent invader in the east and gulf coast areas with the exception of south Florida and Texas is common reed; in freshwater areas, broadleaf cattails may create dense stands. Although these two species have value for soil stabilization and wildlife use, they may grow in too dense a stand for maximum wildlife diversity and therefore require control. If the final elevation of a salt marsh substrate is higher than planned and relatively free of tidal inundation, common reed and more upland species may invade. In northern U. S. fresh marshes, purple loosestrife is developing into a major pest species. If it is at a higher elevation but tidal inundation still occurs, a high marsh may result when a low marsh was planned.

(4) Pests and diseases. Wildlife and feral animals of domestic breeds can destroy newly planted vegetation or retard succession by grazing or trampling. Grazing pressure varies among regions and situations. Potential control methods include fencing the site to exclude pests, trapping and removing pests, locating the site at a sufficient distance from pest sources, and planning the project to avoid a known pest problem. Infestations of harmful pests such as chewing insects and snails will cause occasional problems and should be dealt with, if necessary, as they occur. Pest prevention techniques should be tailored to the site. While plant diseases do occur among marsh species, healthy stands will generally not become heavily infected. Only in cases of severe infections should control measures be undertaken.

f. Postpropagation Maintenance and Monitoring. Monitoring of beneficial use sites is discussed in detail in Chapter 16. There are two major considerations in postpropagation phases of any marsh project: to maintain or not to maintain the site. Nonmaintenance has advantages of allowing natural succession to take place once the initial establishment is ensured and involves no additional expenditures. Disadvantages that could result from lack of maintenance include plant invasion by unwanted species, colonization by undesirable wildlife species, and major changes in site topography from climatic forces. Monitoring can determine the need for further soil treatment, to control for pests, to remove debris accumulations smothering plants, to make additional plantings, and to determine site progress and success.

5-4. Engineering Aspects of Wetland Habitat Development. Field investigations and laboratory tests required for sediment characterization and substrate design in marsh habitat development are similar to those required for design of conventional dredged material disposal areas. The term "substrate" here refers to the dredged material upon which a marsh will be developed. The elements of substrate design include configuration, elevation, protection, and retention. Required field investigations and laboratory tests as they pertain to habitat development in salt water or fresh water sites include channel investigations, site investigations, bottom topography, evaluation of wave and water energy, and substrate foundation investigations including consolidation and sedimentation. More detailed descriptions of certain procedures are



contained in Palermo et al. (item 62). Engineering design of substrate for marsh habitat development consists of defining elevation, slope, shape and orientation, and size (area and volume). The design must provide for placement of the dredged material within the desired limits and required elevations, allowing for settlement due to consolidation of dredged material and foundation soils. Adequate surface area or detention time must be provided for fine-grained sediments to allow settling of suspended solids in order to meet effluent criteria during construction. Various aspects of substrate design are discussed in items 19 and 62. Procedures are equally applicable to both saltwater and freshwater sites.

a. Elevation Control Requirements. The most critical aspect of a marsh development project is usually attainment of a precisely defined stable elevation. Unconfined substrates, normally developed with coarse-grained dredged material, will not undergo significant settlement due to self-weight consolidation. They may, however, require considerable shaving down to reach an intertidal level (Figure 5-8). However, settlements due to consolidation of compressible foundation soils may occur. Confined substrates are normally developed with fine-grained dredged material, and significant settlements of confined substrates may occur due to self-weight consolidation.. One-time construction of confined substrates presents the most critical requirement of prediction of settlements since the initial placement of dredged material must be such that a final elevation within acceptable limits is achieved (Figure 5-9). Since the substrate surface cannot be raised by later placement of additional material, the design must include predictions of settlement to be expected. In incremental construction, the substrate surface elevation is raised by supplemental placement of dredged material, and an exact prediction of settlement for initial layers is not required. Field experience gained by observation of settlement behavior of the initial dredged material layer may be used to aid in prediction of settlement of subsequent layers.

b. Design. for Sedimentation. Confined substrates composed of fine-grained dredged material must be designed for retention of the solids by gravity sedimentation during the dredging operation. Design for sedimentation is directly affected by size of the containment (area and volume), inflow rate (a function of the dredge size), operational conditions, physical properties of the sediment, and salinity of the dredging environment. Design procedures are available that provide for determination of the respective surface area or detention time required to accommodate continuous dredged material placement. Factors influencing hydraulic efficiency of the substrate containment must also be evaluated to include effects of short-circuiting, ponding depth, weir placement, and shape of the containment. If the substrate containment does not provide for adequate sedimentation within the project constraints, it may be possible to increase the substrate containment size, decrease the disposal rate by using a smaller dredge, or increase settling time by using intermittent operations.

c. Weir Design. Retention structures used for confined substrates must provide a means to release carrier water from the disposal site. This is best



Figure 5-8. Heavy equipment was required to shave down sandy dredged material deposits to intertidal levels at Bolivar Peninsula, Texas, and at other man-made wetland sites

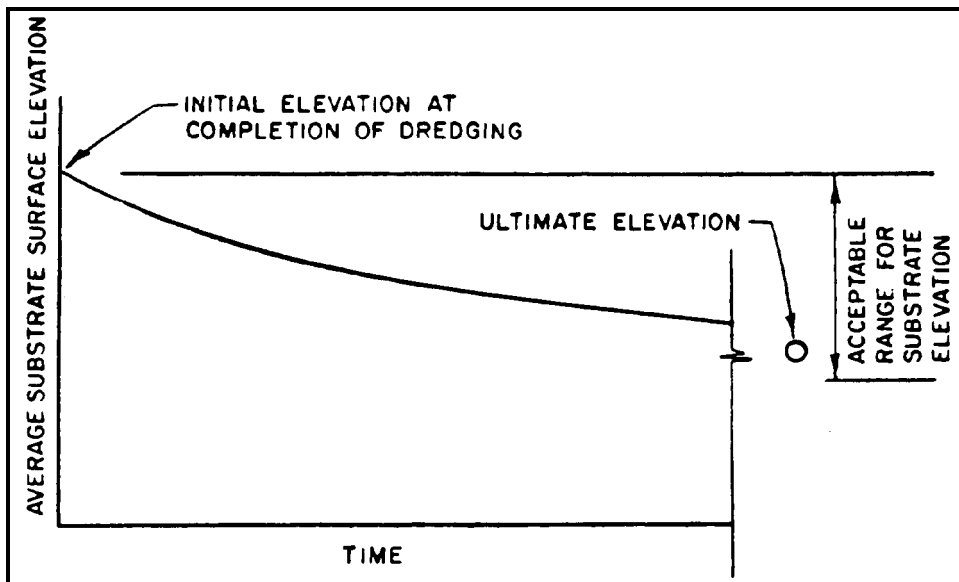


Figure 5-9. Dredged material substrate surface elevations versus time

accomplished by placing a weir structure within the substrate containment. The weir structure must be designed to provide the capability of selective withdrawal of the clarified upper layer of ponded water within the containment without excessive resuspension and withdrawal of the settled solids. Weir design is based on the assumption that sufficient surface area or detention time has been provided for sedimentation and that short-circuiting is not excessive. Weir design procedures are described in Walski and Schroeder (item 82).

d. Requirements for Retention and Protection. Site hydraulics and sediment properties determine the need for retention and protective structures at marsh development sites. These sites may require structural protection from erosion caused by currents, waves, or tidal action. A retaining structure may also be required to retain the dredged material until it consolidates and to control the migration of suspended fines. The first step in the selection of a retention or protective structure is to validate the requirement for such a structure. Particular concern should be given to the effects of any proposed structure on current or wave patterns. Structures which may constrict water flow and increase local current velocities or reflect wave energy may increase erosion. Much of the engineering discussion in this part is detailed in item 17. The relationships between erosion, transportation, and deposition velocities and the sediment grain size are summarized in Figure 5-10. Values are based on velocities measured 6 inches above the bottom of a sediment.

e. Structure Selection Considerations. Considerations in containment structure selection include the dredged material to be retained or protected, maximum height of dredged material above firm bottom, required degree of protection from waves and currents, permanence of the structure, foundation conditions at the site, and availability of structure material. These considerations will determine feasibility of a structure in relation to the project goal, the likelihood that the structure can be maintained over its useful life, and the structure's total cost. These factors are site-critical and require engineering site data. Several retention and protective structure types are considered technically feasible for use in marsh habitat development and are illustrated in Figure 5-11. Two types of structures are likely to be used in habitat development projects: sand dikes and fabric bags.

f. Design Considerations.

(1) Final elevation of the substrate must be considered in the site design. The first step is to establish the desired elevation of the proposed marsh. Anticipated foundation and fill consolidation to obtain maximum fill level, maximum ponding level, and theoretical maximum dike height of structure include any additional freeboard that may be necessary to prevent overtopping. Allowances for retention structure settlement must also be considered. In the design of containment structures, all the water and earth pressure forces acting on the structure must be considered, as well as any surcharge that is anticipated during construction or in later use. New substrate which requires

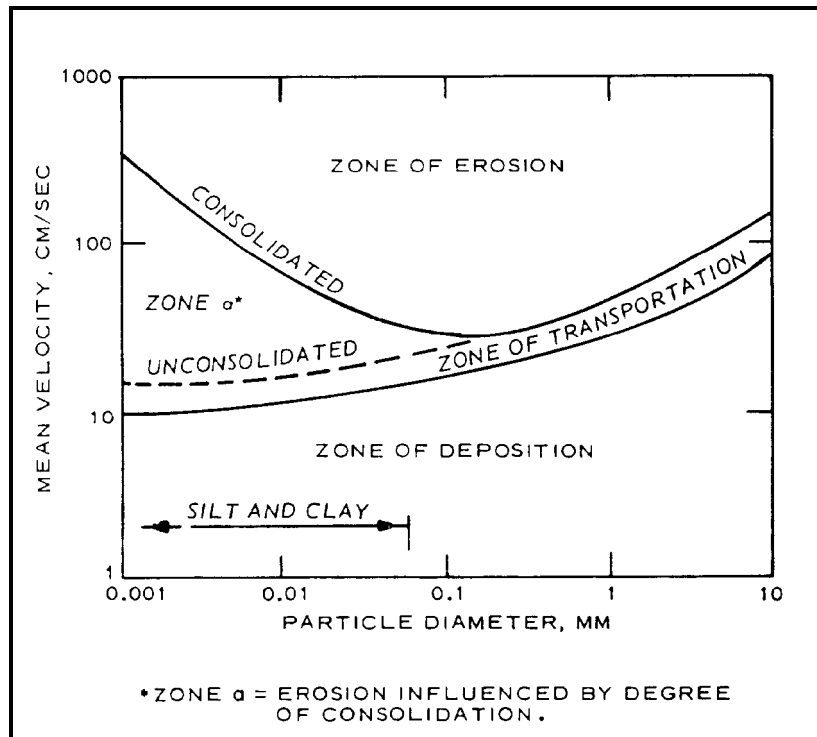


Figure 5-10. Erosion-deposition criteria for different grain sizes

a retaining structure generally will be composed of soft clays and silts, which remain in a slurry state for a significant period after placement. A fluid pressure loading may be exerted on the retaining structure until the substrate begins to consolidate and develop shear strength.

(2) Wind wave characteristics such as height, period, direction, and the probability of occurrence can be found using locally collected data and hindcasting methods. At sites where wind waves appear to be a major consideration, early recognition of that fact may permit relocation or shifting of the site to reduce the open-water fetch in the predominant wind direction, thus limiting the maximum wind-generated wave. In shallow back bays and estuaries, water depth will frequently limit the growth of wind waves (item 17).

(3) Ship-generated waves may also be a major cause of erosion along the edges of marshes. Wave measurements properly timed to ship traffic at the dike site will allow establishment of a design value. Erosion and scour cause the removal of soil particles by water action above and below normal water surfaces; they can cause structural failure and must be guarded against by properly designed protective structures. The erosive ability of water waves

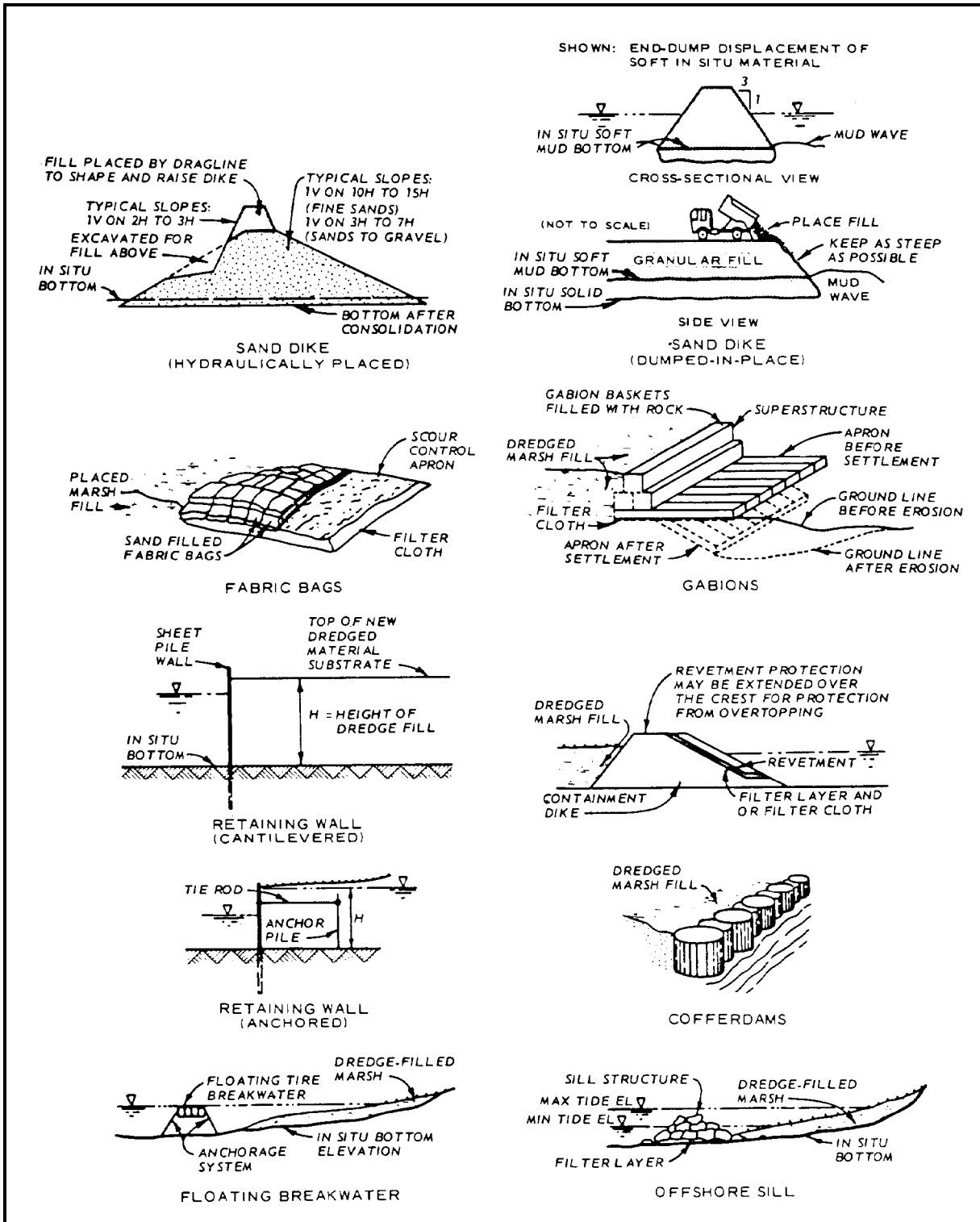


Figure 5-11. Retention and protective structures (item 17)

and currents at a potential disposal site must be considered in the selection and design of a retaining structure and its foundation. Erosion can be minimized by proper location and orientation of the retention/protective structure. Locating the site in a low energy environment is the ideal solution, and a must in many areas. Flattening the outer slopes of the fill or dike will reduce turbulence and scour. Streamlining the upstream face of the fill will also lessen erosion. Vegetation may be used to stabilize the dike and reduce erosion. Protection of inner and outer surfaces by the use of filter cloth, revetment, or antiscour blankets of rubble may be required in higher energy situations. Protection created by breakwaters or floating wave attenuating devices is also possible but may not be economically feasible (item 17).

(4) In riverine environments, an important consideration in determining water velocity must be the effect the fill placement will have on altering the flow conditions. When the fill decreases the cross-sectional area of a channel, there will be resulting increases in flow velocities and/or water surface elevations. These should be estimated and used to evaluate the erosion and scour potential. Foundation stability, stress, settlement, and seepage forces and piping are also important considerations in site design (items 17 and 62) (Figure 5-12).

g. Construction Considerations for Retention/Protective Structures. Characteristics of the site will determine which construction techniques are feasible and greatly influence construction costs. Among the location factors that influence costs are: equipment accessibility, wave and current conditions, tidal range, water depth, bottom conditions, and distance from the dredging site (item 17). Construction techniques and control of these structures are discussed at length in items 17 and 62.

h. Weir Structures. Weir structures are required for release of water during and after the filling operations and should be considered an integral part of the retention/protective structure. Weirs should be well-anchored and collared. Two basic types of weirs are the drop inlet and the box. The drop inlet weir is most commonly used in CE confined disposal operations. The structure consists of a half-cylinder corrugated metal pipe riser equipped with a gate of several stop-logs or flashboards that serve as a variable height weir. They can be added or removed as necessary to control flow into and out of the containment area. A discharge pipe leads from the base of the riser through the dike to the exterior. The box weir consists of an open cut through the entire dike section. The cut is usually lined with timber but could be lined with concrete or steel. Box sluices also use stop-logs for controlling drainage. Box sluices are not often employed. However, box sluices are capable of rapidly discharging large volumes of water. This feature could prove advantageous in marsh establishment since natural water level fluctuations throughout the containment area may be necessary during construction and are essential to the natural operation of the new marsh. Additional information regarding weir design, construction, and operation can be found in items 30, 62, and 82.

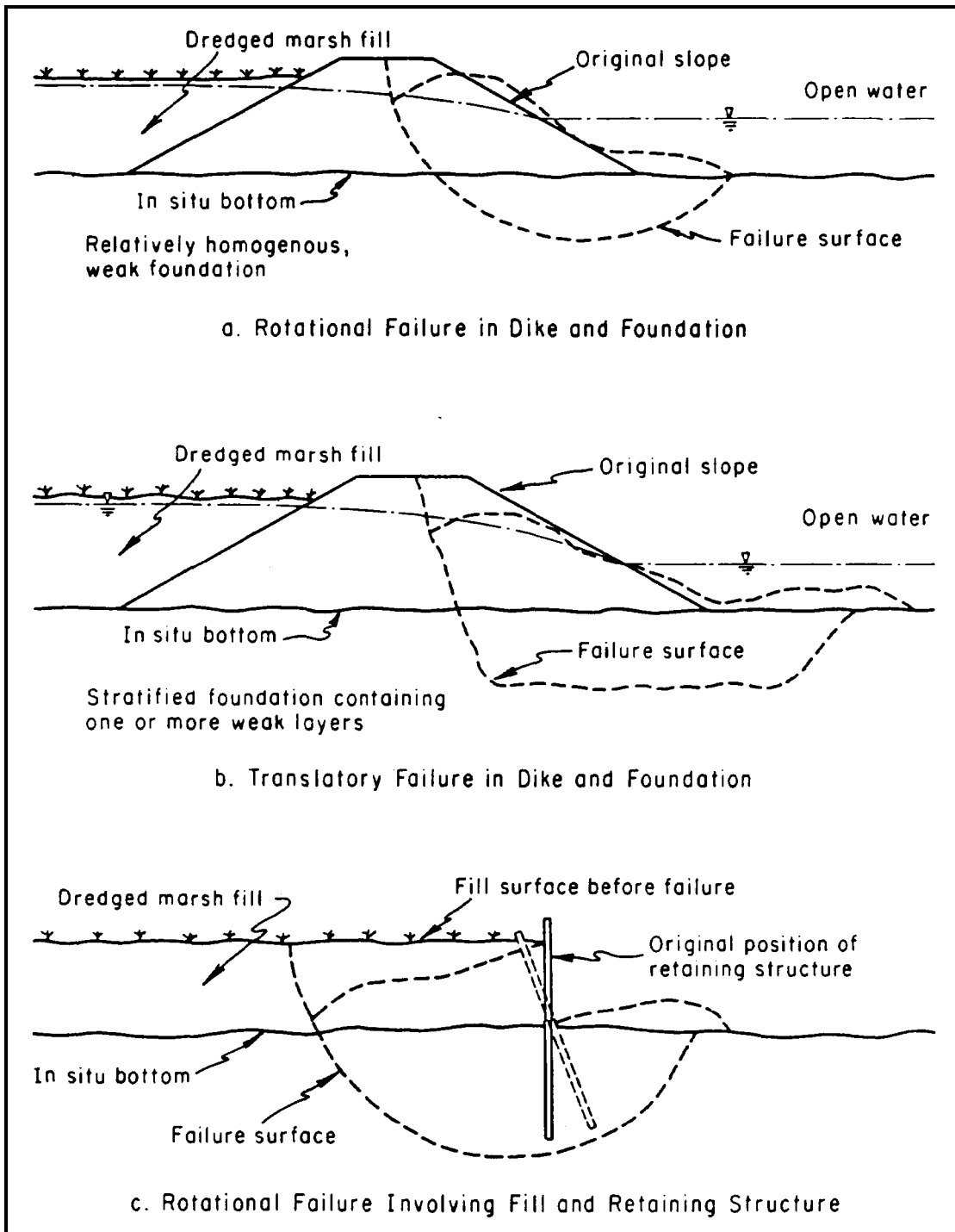


Figure 5-12. Examples of typical slope failures (item 17)

i. Dredged Material Placement Operations. Material may be placed within the disposal site using either hydraulic or mechanical methods. The hydraulic pipeline dredge is by far the most commonly used method and will provide the major source of material to be used for marsh establishment. Pipeline length can be extended to several miles with the addition of intermediate booster pumps, but at a substantial additional cost (item 19). Hydraulic transport of material assumes additional prominence when one considers that the newer concepts for dredged material handling systems involving direct pumpout of bucket-loaded scows usually involve final disposition via pipeline. The pipeline dredge can dispose of material in shallow-water areas through the use of shore lines or shallow-draft floating pipelines. Detailed information on obtaining selected dredged material for dike construction, operations for placement of the material, movement of pipelines in shallow-water areas and on the shoreline, energy dissipators, operational guidelines, and the influence of dredged material placement on structures is presented in item 19.

j. Management Activities for Confined Substrate Placement. Placement of dredged material within a confined area is identical with placement in any other containment area. Certain management activities are therefore necessary to ensure that suspended solids are retained within the area and that effluent quality is maintained (items 4 and 62). The management of surface water can be accomplished by controlling the elevation of the outlet weir(s) throughout the operation to regulate the depth of water ponded within the containment area. Proper management of surface water is required to ensure containment area efficiency and can provide a means for access by boat or barge to the containment area interior. At the beginning of the placement operation, the outlet weir is set at a predetermined elevation that will ensure that the ponded water will be deep enough for settling as the containment area is being filled. As the operation begins, slurry is pumped into the area; no effluent is released until the water level reaches the weir crest elevation. Effluent is then released from the area at about the same rate as slurry is pumped into the area. Thereafter, the ponding depth decreases as the thickness of the dredged material deposit increases. After completion of the placement operation and of the activities requiring ponded water, the water is allowed to fluctuate with the tides through the existing weir structure. Use of the ponded water for floating the pipeline within the containment area can be of benefit to general containment area management by greatly facilitating the movement of the inlet point without disruption of the dredging operation. The floating inlet allows selective placement of coarse-grained material behind the retention structure or at desired mounding locations within the substrate. Once the substrate has achieved the desired degree of stability and after careful consideration of the erosion potential of such an action, the weirs or retention structure may be breached to allow natural water circulation throughout the substrate area.

5-5. Wooded Wetland Habitats. In contrast to marsh development, almost no development of wet woodlands on dredged material has been researched or field implemented. Item 41 developed guidelines and drew restoration plans for



bottomland hardwood sites and floodplain islands. Guidelines are not available for cypress/tupelo swamps nor for northern woody bogs, types of wooded wetlands commonly encountered by the CE. Since dredging operations and disposal sites are generally carefully steered away from wooded wetlands and wooded wetland habitat development has been very infrequent, this EM will not address these types of habitats.

## CHAPTER 6

### UPLAND HABITATS

6-1. General. Upland habitats encompass a variety of terrestrial communities ranging from bare soil to dense forest. In the broadest interpretation, upland habitat occurs on all but the most disturbed disposal sites. For example, a gravelly and bare disposal site may provide nest sites for killdeer or tern species; weedy growth may provide cover for raccoons or a food source for seed-eating birds; and water collected in desiccation cracks may provide breeding habitat for mosquitoes. The essential fact is that man-made habitats will develop regardless of their management; however, the application of sound management techniques will greatly improve the quality of those habitats (item 72)

6-2. Upland Habitat Development Considerations. Upland habitat development has potential at hundreds of disposal sites throughout the United States. Its implementation is largely a matter of the application of well-established agricultural and wildlife management techniques.

a. Advantages. Upland habitat development as a disposal alternative has several distinct advantages:

- (1) Adaptability.
- (2) Improved public acceptance.
- (3) Creation of biologically desirable habitats.
- (4) Elimination of problem areas.
- (5) Low-cost enhancement or mitigation.
- (6) Compatibility with subsequent disposal.

The principles and applications of this alternative are adaptable to virtually any upland disposal situation. Regardless of the condition or location of a disposal area, considerable potential exists to convert it into a more productive habitat. Small sites in densely populated areas may be keyed to small animals adapted to urban life, such as seed-eating birds and squirrels. Larger tracts may be managed for a variety of wildlife including waterfowl, game mammals, and rare or endangered species. The knowledge that a site will ultimately be developed into a useful area, be it a residential area, a park, or wildlife habitat, improves public acceptance. Many idle and undeveloped disposal areas that are now sources of local irritation or neglect would directly benefit from upland development, and such development may well result in more ready acceptance of future disposal projects. Upland habitat development will usually add little to the cost of disposal operations. Standard

procedures may involve liming, fertilizing, seeding, and mowing. A typical level of effort would be similar to that applied for erosion control at most construction sites and considerably less than that encountered in levee maintenance. Unless the target habitat is forest, this type of habitat will generally be compatible with subsequent disposal operations. In most situations, a desirable vegetative cover can be produced in one growing season. Subsequent disposal would simply require recovery of the lost habitat. Indeed, the maintenance of a particular vegetation stage may require periodic disposal to retard or set back succession (item 73).

b. Disadvantages. The disadvantages of upland habitat development are potential public opposition to subsequent disposal and possible necessity of long-term management. The development of a biologically productive area at a given site may discourage subsequent disposal or modification of land use at that site. This problem could be avoided by the clear identification of future plans prior to habitat development, or by the establishment and maintenance of biological communities recognized as being most productive in the earlier stages of succession. In the latter case, subsequent disposal may be a necessary management tool. Some habitat types will require management. For example, if annual plants such as corn are selected for establishment, then yearly planting will be necessary. If the intent is to maintain a grassland or open-field habitat, it may be necessary to mow the area every 2 to 5 years to retard woody vegetation. In most cases, it will be possible to establish very low maintenance habitats, but if the intent is to establish and perpetuate a given habitat type, long-term management will be essential and may be expensive.

### 6-3. Guidelines for Upland Development.

a. Upland Habitat Needs and Assessments. Those upland habitats in limited supply should be identified and the opportunity for additional habitat assessed. Public attitudes are of particular consequence in the implementation of this alternative, and public opinion should be actively sought. Site selection should be made with a particular target habitat in mind as the importance of other habitats will be greatly influenced by the needs and attributes of the surrounding area. The chemical and physical properties and the relative quantities of different types of dredged material should be evaluated to determine the characteristics of the soil to be used in the habitat development. Several remedial treatments are possible. For example, it may be possible to improve the agricultural characteristics of the surface layer by top dressing the site with material selected for its agronomic characteristics. It may also be possible to bury a problem soil by capping it with a layer of clean material.

#### b. Planning and Design.

(1) Assuming that upland habitat development has been selected as a disposal alternative or as an enhancement measure, habitat planning and design guidelines are indicated in Figure 6-1. The criteria discussed under site

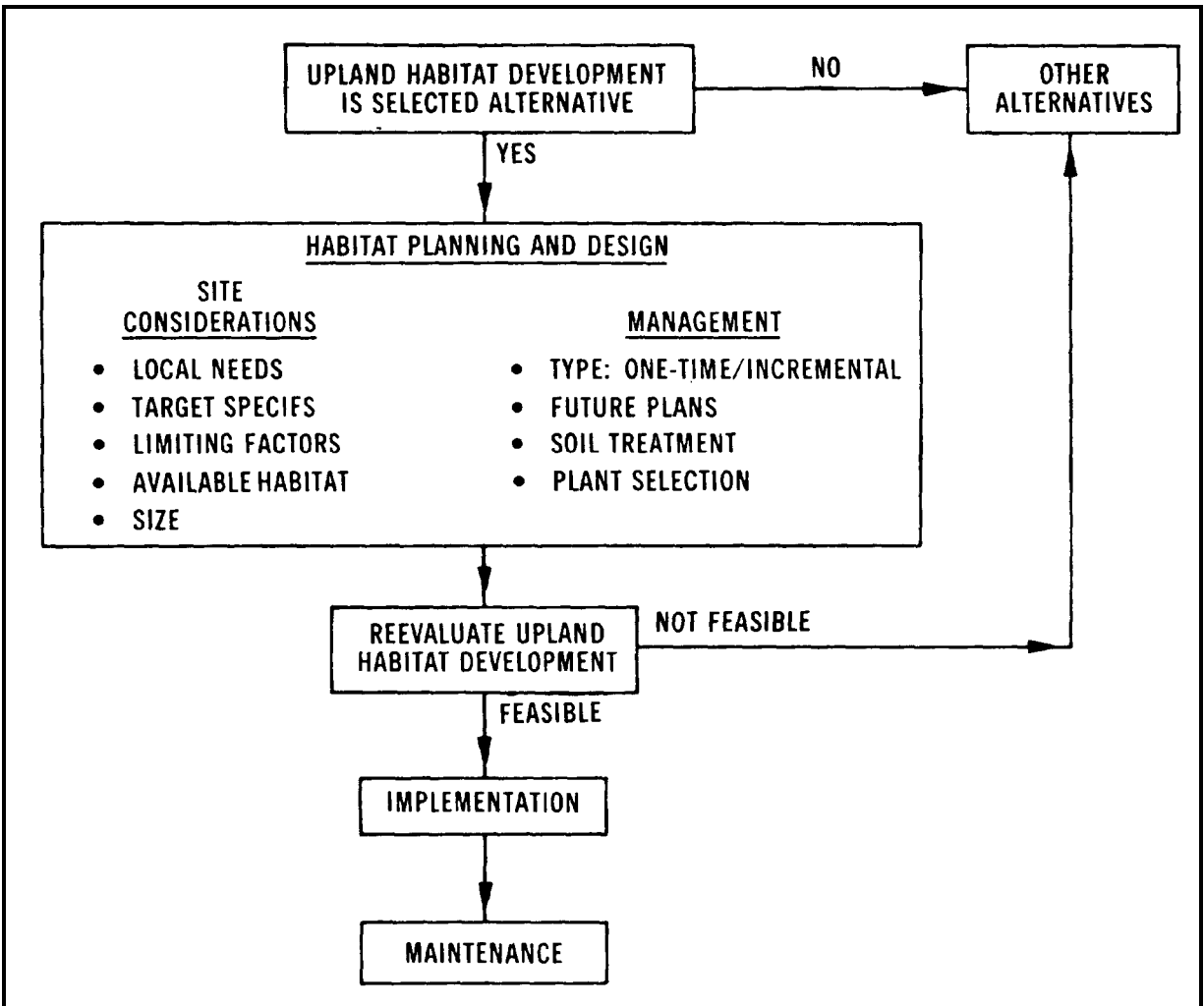


Figure 6-1. Procedural guidelines for selection of upland habitat development

considerations are applicable regardless of whether the site is a new or previously used disposal area. Local needs and thereby target wildlife species will be determined primarily by the desires of state wildlife agencies and those of the public. These needs are likely to reflect local perception of the value of wildlife. If the area has a strong hunting tradition, the emphasis may be on game animals. If there is strong agency concern for an endangered species, that may be the emphasis. In many cases, a target species per se will not be identified. Rather, a grouping such as "songbirds" or "small game" will be designated. The list of target species must be evaluated in light of the available habitat surrounding the site and the size of the disposal site. The size of a disposal area will seldom be large enough to exert a significant impact on regional animal populations if it only duplicates existing habitat types. Therefore, the success of the site will usually be determined by its ability to enhance surrounding habitats or remedy limiting environmental factors.

(2) Basic management decisions will depend on the type of disposal and future plans at the site. If one-time disposal with periodic maintenance is planned, the management plan may be quite flexible. One-time disposal without management indicates the need to establish a plant community that is relatively self-sustaining. If periodic disposal is planned, plant communities that are rapidly functional are advised. Properly planned, periodic disposal could be considered a wildlife management option used to control succession or diversify the habitat and avoid confrontation regarding subsequent activities. Future plans for any habitat development site should be well documented and understood by interested agencies and the public prior to implementation.

(3) Soil treatment and plant selection are closely related and can proceed after determination of the type of disposal, identification of the characteristics of the dredged material, and determination of target species have been completed. Soil treatment may include a variety of activities such as burying problem materials, dewatering, mixing materials to obtain improved soil characteristics, leaching, fertilization, and liming (Figure 6-2). Plant selection will be dictated by soil conditions and habitat preferences. In many situations it will be possible to identify highly desirable natural plant communities near the disposal area. Development of site conditions (soil, elevation, diversity) on dredged material that are similar to those of desirable plant communities will encourage natural invasion and natural development of similar communities. When this is possible, a considerable savings in planting and maintenance costs may be realized.

c. Reevaluation and Implementation. If, upon reevaluation, the upland habitat development alternative remains feasible, the project may be implemented and subsequently maintained. Implementation will be highly site specific but should present few difficulties beyond the problems typically encountered in contracting new or unusual work. Advice from local wildlife biologists and soil scientists may prove invaluable in this stage.

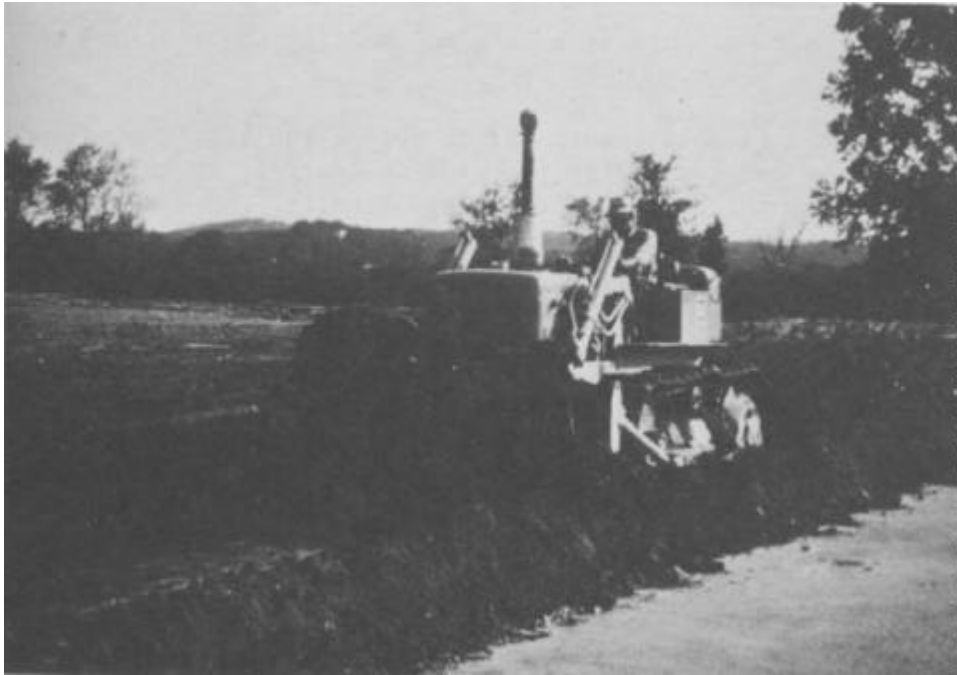


Figure 6-2. Mixing layers of silty and sandy dredged material at Nott Island upland site, Connecticut River, Connecticut

6-4. Upland Site Development.

a. Site selection. Two types of upland habitat development sites have potential beneficial use: older, existing sites where habitat development and enhancement occurred, and planned sites where upland habitat development is part of the project goal. In both cases, several factors determine selection of the best possible site: availability, disposal need capacity, proximity to dredging area, physical and engineering characteristics, environmental and social acceptability, tidal and current considerations, and habitat development feasibility.

b. Site characterization. After the upland disposal site has been selected for development, field and laboratory investigations of the site and related areas should be initiated. If the site is an older disposal area to be reclaimed, it and the surrounding area should be evaluated physically and biologically to assess its potential for habitat development and determine necessary action. If dredging and disposal operations are involved, it will be necessary to add information related to the site's capacity, need for and design of a protective or retention structure, and construction details. This information should be collected in conjunction with characterization of the sediments to be dredged. Physical, biological, socioeconomic, and engineering tests should be made to determine site suitability (items 32 and 62) and acceptance. Target wildlife species should be identified, and other potential

upland objectives such as site stability and multiple habitat use should be considered.

c. Vegetation establishment. Since upland habitat is developed primarily for wildlife and less often for erosion control, it is important to key in on target species that will use the disposal site. An excellent example is the Nott Island site in the Connecticut River, Connecticut, where a mixture of grasses and legumes was planted as a nesting and grazing meadow for waterfowl, deer, and small mammals (Figure 6-3). Although an animal's habitat consists of a wide variety of components, vegetation is by far the most important. Vegetation growth form, height, density, placement, diversity or uniformity, seasonal changes, biomass, and hardiness strongly influence species composition, abundance, and well-being of wildlife. Secondary objectives of recreation, aesthetics, erosion control, and soil quality also depend in part on



Figure 6-3. Nott Island habitat development site, showing the planted nesting and grazing meadow after 5 years of development

vegetation. These relationships make it necessary to begin consideration of the ultimate vegetation of the site early in the planning process. Three methods of upland vegetation establishment exist: allowing natural plant invasion and establishment, planting selected species, and combining natural establishment with planned propagation.

(1) Natural invasion and establishment. The ability of propagules to reach the upland site is the most important factor in describing the potential for natural colonization on dredged material. This ability increases as the distance from a propagule source decreases and as the size of the site and ease with which the propagule can be transported increase. Propagules may be transported over a distance by wind or water; by attaching themselves to an animal's fur, feathers, or feet; by being ingested and excreted by an animal; or by attaching to a human. Secondary factors in the potential for natural colonization include physical and biological features of the site itself. Plants growing and reproducing on the site will reestablish after deposition of dredged material if the deposit was not too thick and if new substrate conditions are not prohibitive. Plants growing and reproducing near the area will establish only if seeds blow or are carried onto the site, if rhizomes or other vegetative reproduction forms extend onto the site, and if the new substrate conditions are not prohibitive.

(2) Planting selected species. Standard practices in agronomy are usually sufficient to handle plant propagation on upland sites. With appropriate planning and management, any site can be vegetated within a few years and most sites within a year. Planting upland sites ensures that desirable vegetation grows there, that substrates stabilize rapidly, and that aesthetic appearances of disposal sites improve faster. The chief disadvantage over natural invasion is the cost involved with site preparation and plant propagation and establishment.

(3) Combining natural establishment and planting. A combination of the two methods of vegetation establishment may be beneficial. Allow invasion to stabilize the substrate and start modifying the sediments, then plant a different type of vegetation when the season or timing or soil conditions are more suitable. The reverse also is possible: to get immediate benefits of selected plantings, plant the site, then allow the site to proceed in natural successional stages. Also, use subsequent deposits of dredged material to set back vegetation succession to a more desirable stage.

d. Selecting Plant Species and Propagule Type.

(1) Selecting plant species.

(a) If the site is to be planted, advance consideration must be given to the plant species that will create the desired habitat for the target wildlife species. An initial selection of species should be made during the planning phase, even though once the site is established, alternate species may prove to be more acceptable and be substituted for those originally selected (item 32). Numerous species are suitable for planting upland dredged material sites (item 39). Item 13 identifies, by state, 250 species or species groups that are of benefit to wildlife and adapted to grow on dredged material and presents species growth characteristics, habitat requirements, ranges, and tolerances of 100 of these. Item 45 identifies 50 species generally useful for dewatering and decontaminating dredged material. Item 54



gives growth characteristics of many tree and shrub species suitable for confined upland disposal areas. Items 12, 39, and 73 summarize data on plants known to grow on dredged material sites.

(b) Other species of more local character are available, and many species with unknown tolerances and adaptability may prove useful after field testing. Local soil conservation service personnel and agronomists will be able to provide updated information on species and new varieties. Selection of species or species mixtures to be planted at a particular disposal site must include consideration of project goals, climate, substrate characteristics, plant species characteristics, plant species availability, ease of propagation, management requirements, and costs. Certain species mixtures are commonly planted, such as a clover and a grass species, to take advantage of the different properties of each. Occasionally the mixture will not be successful because of interactions among the species and because the soil is too acidic, infertile, or compacted.

(2) Selecting propagule type. Items 32 and 39 give the best propagule types for selected plant species, based on criteria of availability and cost, ease of collection and handling, ease of storage, ease of planting, occurrence of disease, and need for rapid vegetation establishment. In general, seeds are cheaper and easier to work with than vegetative propagules such as cuttings, sprigs, or seeding in upland habitats. However, some plant species and planting situations require vegetative propagules, e.g., to rapidly stabilize the exterior of a sand dike.

(3) Handling plant material. If commercial seed sources are not available, collection and storage of wild seeds should follow the guidelines in item 32. Some desirable species are available as transplants (potted, balled and burlapped, or bare-rooted nursery stock). However, many upland plants that are desirable as long-term cover and food sources, such as trees and shrubs, are not commercially available.

e. Preparing and Planting the Site.

(1) Substrate modification. Once the dredged material has been placed and dewatered sufficiently to allow equipment access, it can be modified as necessary. Modifications will usually be directed toward preparing the substrate for vegetation establishment, and will depend on the condition of the substrate and the exact design of the project. In upland habitats, these activities are largely agronomic.

(a) Mechanical modification. The site may require grading to change the topography that resulted from disposal, e.g., to make the slope uniform by removing depressions or mounds, increase relief by making depressions or mounds or altering the slope, make islands, or raise low spots. Variation in texture of the sediments results either intentionally by disposal of more than one type of material or naturally through hydraulic sorting during disposal. This variation may need to be reduced to a more uniform soil for ease of

seedbed preparation. This can be done by repeated passes with a blade or deep plowing followed by disking. If possible, grading should be done at the time of year when precipitation is lowest to reduce erosion of the bare soil. Seedbed preparation includes plowing or disking one or more times to break up clumps and aerate the soil, fill or cover desiccation cracks, even out moisture content, destroy unwanted vegetation that may have invaded, turn under green manure, incorporate soil amendments, and in general improve the quality of the substrate. Preparation is best done several months prior to planting and again just before planting, if labor and equipment are available. Success of the site may depend especially on this process.

(b) Chemical modification. Prior to final mechanical seedbed preparation (preferably several weeks to months ahead), the substrate at the site should be sampled and the soils analyzed chemically in the same fashion as for site characterization. Their properties may have been altered by dredging and dewatering from what they were in the initial tests. Some of the common problems that may be found include high salinity levels, soil acidity or alkalinity, or lack of one or more of the essential plant nutrients at levels sufficient to support good plant growth. These can be corrected with soil amendments, leaching, or other techniques (item 32).

(c) Biological modification. Biological modification of the substrate may also aid in the success of the project. This could include such things as removal of existing and competitive vegetation by cutting, short-lived herbicide application, or cultivation; growth of a preliminary green fertilizer crop; or addition of farmyard manure, sewage sludge, etc., on light-textured sands to improve their nutrient- and moisture-holding capacity. If legumes are to be grown on the site, the seed should be inoculated with the proper strain of Rhizobium bacterium to improve chances of fixing adequate amounts of atmospheric nitrogen.

(2) Timing. Timing of all factors related to plant establishment is an important consideration in habitat development. Adequate planning will have allowed lead time to locate, obtain, and prepare sufficient amounts of viable seeds or vegetative propagules, including any period of seed dormancy. Timing of planting will strongly influence plant success. For example, seeding warm weather annuals before the last cool period in spring will result in heavy crop damage, and seeding the same seeds in midsummer will result in heat and drought stress during sprouting. Seeding of cold weather species too early in the autumn will result in sporadic germination, increased chances of insect infestations such as army worms, and heat and drought stress. Optimum seeding times vary with climatic regions and photoperiods, and local agronomic authorities should be consulted before planting. Refer to items 32 and 39 for species-specific details on timing.

(3) Planting.

(a) Temperature. Vegetative propagules may be planted any time the ground is not frozen and any time the day temperatures average less than 68°F.

In general, March to May is best for warm weather plants and September to November for cold weather plants over most of the United States. In the Deep South, transplanting is usually done successfully from October through May, with June through September being too hot. Dormant propagules may be more readily transplanted in winter months. Propagules held in storage inside a nursery or greenhouse should not be planted until temperatures at the field site are at least as warm as the storage area, to lessen shock. Propagules held in a shady area should be gradually acclimated to sunny conditions if the site is in the sun, to prevent blistering and death of leaves and plant shock. General planting methods are given in Items 32 and 39; specific recommendations for local conditions can be obtained from the Soil Conservation Service or county extension service agents.

(b) Methods. Methods of planting vary with the propagule type. Seeds should be sowed in a well-prepared seedbed that has been plowed and/or disked to a depth of at least 6 inches. It is important to consider planting techniques and equipment, seeding rates and depths, and seed and soil treatments when using seed propagules. For transplants, types of propagules, planting techniques and equipment, transplant spacings, timing of planting, plant growth habits, and long-range project goals are all important factors in determining site success (item 32).

6-5. Engineering Design of Upland Sites. Guidelines for substrate design and sediment protection and retention apply to both a new disposal area or one that may already have a retention structure and some material placed. Design should be based on information gathered during the site description, on results of field and laboratory tests, and on the requirements for the planned habitat development. The majority of the information in this section was compiled from items 17, 32, and 62. Dredged material may be placed by either hydraulic or mechanical methods. The hydraulic pipeline dredge is the most commonly used and will continue to be the major source of dredged material to be used for upland habitat development. Hydraulic transport of material assumes additional prominence when one considers that the newer concepts for dredged material handling systems, involving direct pumpout of hopper dredges, temporary containment basins, or bucket-loaded scows, usually involve final disposition by pipeline. The pipeline dredge can dispose of material in upland areas through the use of shore lines or shallow-draft floating pipelines.

a. Substrate Design.

(1) Elevation. Substrate design for upland habitat development includes determination of site elevations, slope, orientation, configuration, and size (area and volume). The design must provide for placement of dredged material to a stable elevation within the desired elevation limits, allowing for settlement due to consolidation of both the sediments and foundation material. For fine-grained sediments, the substrate must be designed to provide adequate surface area and retention time for sedimentation of suspended solids. Procedures for substrate design generally follow those established by

items 56 and 62 for the design of conventional containment areas. The determination of substrate elevation is governed by two limitations: the project requires placement of a given channel sediment volume, and the size to handle this volume within elevation limits must be determined; or the project requires a substrate to be constructed within given size limits, and the volume of channel sediment to construct this substrate must be determined. In either of these cases, a correlation between in situ sediment volumes and volumes occupied by the dredged material must be determined. The first step is to calculate void ratios by determining water content of samples of the sediments to be dredged. The second is to compute the void ratio of the dredged material after dredging and deposition (items 56 and 62).

(2) Sedimentation of solids. Confined disposal areas with primarily fine-grained dredged material should be designed to retain solids by gravity sedimentation during the dredging operation. Solids retention is directly affected by the size of the confinement area (particularly length and depth), inflow rate (dependent on dredge size and operation), physical properties of the sediment, and salinity of the water and sediments. Items 56 and 62 detailed separate design procedures for determining sediment retention time requirements for fresh and saline sediments with continuous disposal. In addition, these procedures include factors influencing efficiency of the substrate containment, effects of short-circuiting, ponding depth, weir placement, and shapes of containment. In the event that substrate containment does not provide an adequate gravity sedimentation basin, then one of the following alternatives must be exercised:

- (a) The size of the site must be increased.
- (b) A smaller dredge must be used.
- (c) Intermittent dredging and/or disposal operations must be initiated.

(3) Weir design. Retention structures used to confine dredged material must provide a means of releasing carrier water back into the waterway, which is best accomplished by placing a weir within the containment area. Effluent quality can be strongly affected by the design and operation of the discharge weir, with the weir length and ponding depth having the greatest control on this quality. Item 82 developed a design procedure for defining weir length and ponding depth to minimize the discharge of solid particles into the waterway.

(4) Dredged material settlement. Settlement will occur following completion of the dredging operation because of the self-weight consolidation of the dredged material layer and/or the consolidation of compressible foundation soils. Estimated settlements may be determined by procedures presented by item 62. Once loading conditions are determined, ultimate settlements that occur after the completion of 100-percent primary consolidation can be estimated from laboratory consolidation data. This settlement is not as critical as for wetland habitats, but is important because of the ponding effect it

causes. Time rates of consolidation for both the dredged material and foundation soils are required to determine the relationship between the desired final substrate elevation and time. If the data from the laboratory tests reveal that settlement will not meet desired elevation requirements, an adjustment to the substrate configuration must be made to raise or lower the initial substrate elevation as required.

b. Substrate Protection and Retention.

(1) Requirements for a structure. Data gathered for the site description should be used to determine if a protective or retention structure will be needed for the upland site. Engineering data collected at a specific site should determine: amount and character of material to be protected or retained, maximum height of dredged material retained above the firm bottom, degree of protection from waves and currents required, duration of the structure, foundation conditions at the site, and availability of construction material. All habitat development sites may require a structure for protection of the perimeter from erosion caused by currents, waves, or tidal action. Particular concern should be given to the effects of any proposed structure on existing current or wave patterns. A structure positioned so that it constricts the water flow will increase local current velocities or reflect wave energies, and thus may encourage erosion. All habitat development sites may require structures for retention of the dredged material to allow it to consolidate, to control the suspended solids content of the effluent, or to protect surrounding habitat or adjacent structures. Site hydraulics, the properties of the sediment to be dredged, the time over which disposal will occur, and the existing site characteristics are closely interrelated in determining the need for such structures.

(2) Selection of structure. The protective or retention structure should meet four conditions:

(a) Suitability to the project goals of dredged material disposal and habitat development.

(b) Practicality and ease of construction.

(c) Ease of maintenance.

(d) Reasonableness of cost.

Item 17 evaluates several protective and retention structures considered technically feasible for use in terrestrial habitat development and presents information on structure selection, applicability to specific site conditions, and conceptual procedures for design and construction. The most feasible structures are often dikes constructed from filled fabric bags or from sand in moderate to low wave-energies in temperate climates (item 17). The term "fabric bag" covers products from several producers of sacklike containers that can be filled with sand, sand-cement, or concrete and used as building

blocks for breakwaters, groins, revetments, or containment dikes. Rock and rubble from new work dredging can also be used.

(3) Design of structure. EM 1110-2-1902 and EM 1110-2-2300 provide proven methods for design and construction of earth- and rock-filled structures. Those procedures should be used to supplement engineering considerations of elevation requirements and earth and water pressure forces. Internal structures may be advisable. Cross and spur dikes are used to control circulation within a disposal area, with the cross dike commonly employed to divide large disposal areas into smaller cells, and spur dikes employed to interrupt direct slurry routes between the inlet and outlet. The cross dike is the more significant of the two structures for habitat development purposes, since use of a cross dike allows flexibility in disposal including incremental filling and separation of dredged material by grain size. (See Figure 15-2, Chapter 15, for riprapped structures and cross dikes used at an upland habitat site.)

(4) Construction of structure. Site-specific factors affecting construction techniques are: equipment accessibility, wave and current conditions, tidal range, water depth, bottom conditions, and distance from the dredging site (item 17). The construction material used and method of construction are significant factors. In addition to the fabric bags previously discussed, three basic types of retention structure construction exist: hauled dikes, cast dikes, and hydraulically placed dikes (item 30). Construction techniques for retaining walls, sills, breakwaters, gabions, and other structures are highly site specific and should be determined on a case-by-case basis (item 30).

6-6. Ecological Design of the Upland Sites. Planning for a habitat development site should be based on sound ecological principles and should attempt to make efficient use of available resources in reaching the goal. The two major resources that can be manipulated for habitat development are substrate (in this case, dredged material) and vegetation. All previous aspects of planning should be united in the ecological design of the site for proper placement of dredged material and vegetation.

a. Placement of Dredged Material. Many aspects of the engineering design of an upland disposal site are directly related to the site's potential biological characteristics. Physical appearance of the site is particularly important, and structures, configuration, size, elevation, topography, timing, and site interaction with surrounding habitats must be considered for ecological integrity of the upland site.

b. Placement of Vegetation. Presence or absence and patterns of vegetation are critical factors in habitat development. Such ecological concepts as structural diversity, community size, species patterns of abundance, and biotic succession are pertinent. Specific concepts that should be applied to upland habitat design are diversity, ecological succession, habitat patterning, and vegetation structure and function.

6-7. Dredging and Disposal Operations.

a. Construction. The first step in construction of an upland habitat development site is to build a protective or retention structure, if called for in the project design, or to modify an existing structure or site (e.g., raise a dike or add drainage). Some site preparation may be necessary, perhaps construction of an access route or removal of vegetation. Access for equipment and pipes should be built to minimize damage, especially to wetlands. Unless the project calls for shallow disposal and recovery of plants present on the site, vegetation to be covered should be mowed or cut to prevent recovery after disposal or to prevent dead branches and shrubs from protruding. Clearing and grading are required along the dike alignment to allow construction.

b. Dredged Material Placement. A significant amount of material rehandling is sometimes required in developing upland habitat because the final distribution of material at the site is important. This handling can be reduced if the initial location and distribution of the coarse- and fine-grained fractions of the dredged material are controlled. One means of control is to take advantage of the differential settling characteristics of the various sized particles in the dredged slurry. Another means is to operate the dredging plant and peripheral equipment in a manner that will produce the desired substrate (item 4). For the majority of disposal operations, the criteria for locating the discharge pipeline in the disposal area have been to maintain an adequate flow distance relative to the weir, keep the discharge end of the pipeline a safe distance away from the interior slope of the dike, and minimize the pumping distance from the dredge. The criteria are directed at preventing short-circuiting or channelization of the flow through the containment area, avoiding scouring damage to dikes, and minimizing pumping costs. Some modifications of these pipe location criteria may be required if advantage is to be taken of particle size differential settling characteristics for habitat development. Coarse-grained material encountered during dredging operations can be taken advantage of with end-of-pipe operations. If the character of the sediment-water slurry being transported is known beforehand or can be determined by monitoring at the dredge or at the end of the pipe, then the coarse material can be diverted by use of a wye connection without interrupting the dredging operations or the dredging sequence. The diverted material can be placed directly in the desired location hydraulically or stockpiled for later use in habitat development. Stockpiling and subsequent rehandling of the material are roughly equivalent to obtaining the material from a source outside the disposal area and involve the use of additional or supplementary equipment.

c. Containment Area Operation. Activities during substrate material placement are aimed at the retention of solids and production of an effluent that will meet criteria for release into the waterway. Operational difficulties, such as channelization of the dredged slurry and insufficient ponding depth, may result in excessive amounts of solids leaving the disposal area through the weir. This is counterproductive and usually violates laws and

regulations. Therefore, it is recommended that during and after the disposal operation a well-planned monitoring program be implemented to ensure that suspended solids in the effluent remain within acceptable environmental limits. Suspended solids retention can sometimes be increased by increasing ponding depths through efficient operation of the weir. Concepts of containment area management instituted immediately following the completion of a disposal operation are also important to successful implementation of a habitat project. The most important aspect of dredged material disposal area management was to remove all surface water as fast as possible to enhance surface drying (item 4). This conclusion can be extended to include terrestrial habitat development since extensive site activity must usually wait until the substrate is trafficable. In addition, working the area to a gentle slope toward the effluent point allows efficient drainage of surface water, and evaporative dewatering can be supplemented by transpiration by vegetation.

d. Quality Control. Specifications for all phases of construction should be detailed and clear. Thorough inspection of all operations will ensure that the work is in compliance with plans and specifications for upland habitat development and any mitigation requirements, and will mean fewer post-dredging operations and lower project cost.



## CHAPTER 7

### ISLAND HABITATS

#### 7-1. General.

a. One hundred years of active dredging operations by the CE, state agencies, and private industry has resulted in the creation, by placement of dredged material, of over 2,000 man-made islands throughout U.S. coastal, Great Lakes, and riverine waterways (item 40) (Figure 7-1). These islands are of varying sizes and characteristics and presently range in age from newly formed ones to those estimated to be 50 years old. Although the majority of the islands were made by the CE, many are owned or managed by other Federal agencies, state governments, conservation organizations, or private citizens. The CE continues to maintain an interest in these man-made islands because of its responsibility in using environmentally acceptable disposal methods and sites, the continuing need for disposal sites, the need for wildlife habitats in waterway areas, and the islands' recreation potential (item 51). The rapid increase in the U.S. population and the corresponding demand on natural resources have helped to cause a gradual change in the use of the islands by wildlife and a need for reassessment of their role as habitats. Natural sites have been altered and occupied by man through industrial, housing, and recreational development to such a large extent that some areas of the United States no longer have coastal islands that are still suitable wildlife habitat. Dredged material islands have provided this vital habitat in many areas.

b. The primary wildlife species needing dredged material islands as part of their life requirements are 37 species of colonial-nesting waterbirds: pelicans, cormorants, anhingas, herons, egrets, ibises, spoonbills, gulls, terns, and skimmers. Several of these species are rare, threatened, or endangered throughout large parts of their ranges (Figure 7-2). An estimated 2 million are nesting on over 700 of these dredged material islands in U.S. waterways, especially along the Atlantic and Gulf coasts from Long Island to Mexico. Islands can offer these birds protection from ground predators, seclusion from man, and nesting substrates similar to those found in traditional nesting sites. The birds are especially vulnerable during the nesting season when they concentrate for several months in colonies and remain in them until their chicks have fledged. These waterbirds are protected by Federal laws since they are migratory species. These laws make destruction, harassment, or disruption of nesting colonies of birds illegal, including those on dredged material sites. State laws often back up these Federal regulations in offering protection to nongame species.

c. In general, the correlation between increases in human populations and decreases in waterbird populations holds true. The only exceptions exist when alternate habitats such as dredged material islands become available. Huge declines in waterbird numbers have stabilized somewhat, partly as a result of the creation of islands, and without which waterbird populations

EM 1110-2-5026  
30 Jun 87



Figure 7-1. A dredged material island in Florida typical of those built in the U.S. Intracoastal Waterway



Figure 7-2. Endangered brown pelicans nesting on Gaillard Island CDF, their first nesting in Alabama in over 80 years

would be 50 percent or less of present levels (item 73). Detailed research and discussion on islands built of dredged material are presented in items 40 and 73. Guidance for selection of island development as a disposal alternative is presented in Figure 7-3, and details for the selection process are presented in item 72.

7-2. Island Development and Management. Although many colonies of birds presently are nesting on dredged material islands, there are numerous characteristics of these islands that could be improved by management to enhance the available habitat, and there are several ways dredging operations can be altered to benefit the numerous sea and wading birds and other wildlife on dredged material islands. Development and management of dredged material islands for avian wildlife will also usually provide essential habitat for smaller mammals and rodents that use the islands, and covers a broad spectrum of techniques. In some cases, small mammals may act as bird predators, so their colonization should not be encouraged.

a. Habitat Changes.

(1) Basically, development/management of an island for colonial sea and wading birds is concerned with habitat manipulation, habitat establishment, and habitat protection. Manipulation of habitats, by far the most likely technique to be used by engineers, would include proper placement of dredged material to maintain or reestablish habitats, increase the size of existing islands, and/or change configuration, elevation, vegetation, and other features for more desirable habitats. Manipulation of habitats would include, for the biologist, establishment of new vegetation and management of existing vegetation on islands through various agronomic and horticultural techniques.

(2) Establishment of new habitats is desirable when nesting habitat is lacking and new islands must be created, with the resulting need for vegetation establishment; when nesting habitat is expanded by an addition to an existing island which must be established with vegetation; or when undesirable nesting habitats (vegetation) occurring on islands must be cleared out and desirable habitats established in their place.

(3) Habitat protection may be accomplished by island posting or fencing for isolation. Most bird species are already protected by law, but their habitats are not protected except during the time they are occupied by the nesting birds. Year-round protection to prevent destruction of habitat from year to year and seasonal protection to prevent nesting colony disruption by humans and predators are necessary.

(4) Management of existing islands has been demonstrated to be an effective disposal technique and wildlife management practice. Considerable potential exists for the disposal of dredged material and the creation or improvement of avian habitat. Management of existing dredged material islands is most desirable because the potential environmental impacts of disposing on an existing site are less than those of developing new islands.

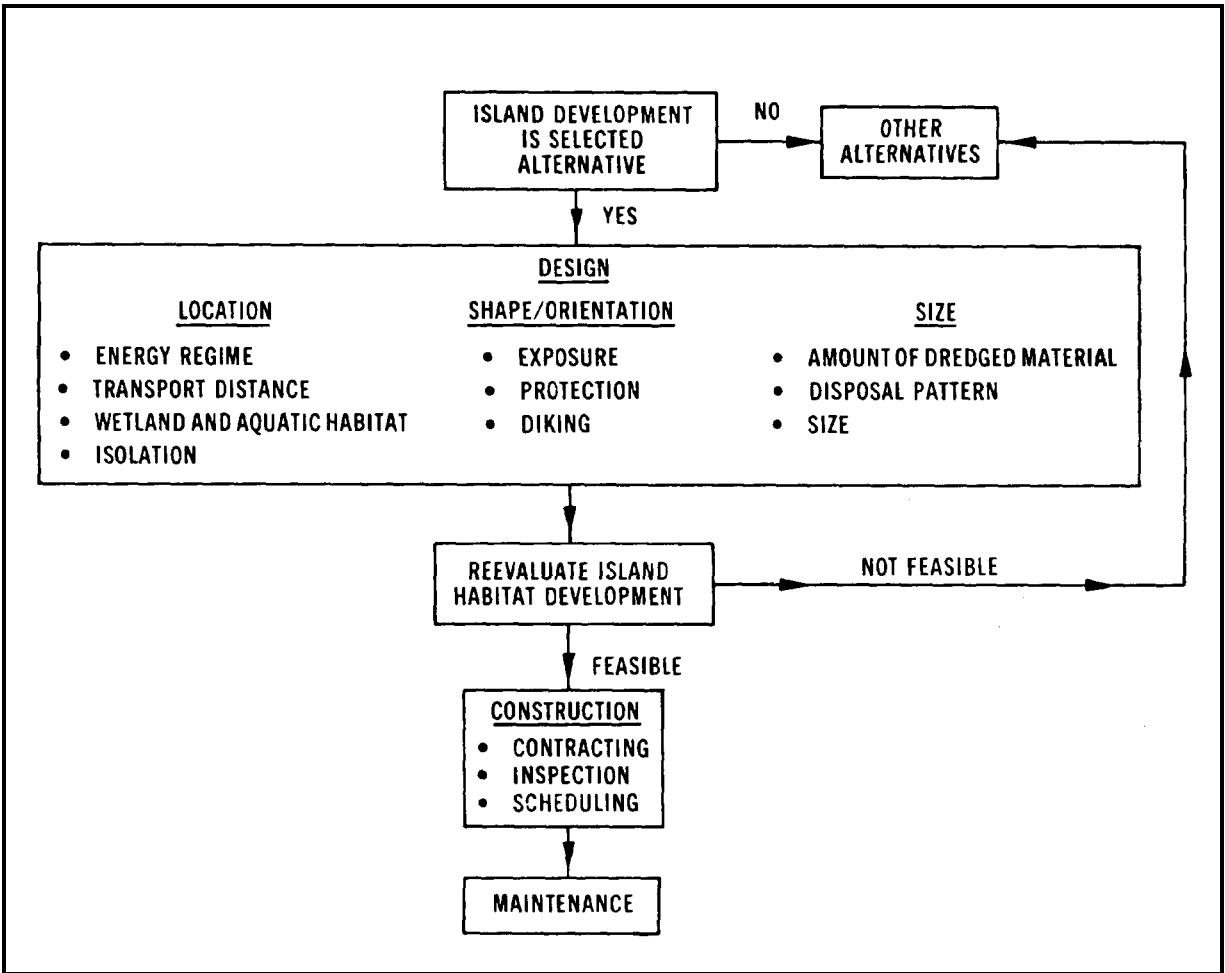


Figure 7-3. Procedural guidelines for selection of island habitat development

b. Use of Dredging Operations on Existing Islands.

(1) The CE has provided habitat incidental to project purpose since the agency first created dredged material islands. Since that time, islands have been kept in various stages of plant succession through dredged material deposition from channel maintenance operations. These operations can have a significant positive impact on waterbird breeding populations (Figure 7-4). Through proper planning the positive impact of regular maintenance dredging could be increased. Since past dredging operations have been carried out with little or no regard for nesting birds, many areas do not have adequate diversity of nesting habitats. Some areas lack ground nesting habitats while others lack woody habitats. Item 73 reports habitat needs that could be satisfied by dredging operations in all the regions studied. Needs for bare ground nesting areas and more tree/shrub habitats exist on almost every part of the U.S. coast. The rate at which various habitats appear on an island after receiving dredged material and an estimate of their longevity have been determined (items 40 and 73).

(2) Once site-specific needs are known, nesting habitat management can easily become a part of the regular maintenance dredging process. To maintain target habitat diversity for certain bird species, islands in any given area would have to be selected to receive periodic depositions of dredged material. Restrictions against dredged material deposition on all or parts of some islands may be necessary in order to allow habitats for tree nesting birds to develop or to preserve existing tree habitats (Figure 7-5). The feasibility of these management recommendations has already been demonstrated by the Wilmington District. They have been practicing such management on a local, annual basis for several years and have developed a long-range colonial sea and wading bird management plan for the lower Cape Fear River estuary which includes maintenance dredging and placement and timing of dredged material depositions on existing islands.

c. Building New Islands.

(1) Construction of new islands would be desirable under some conditions. If it has been demonstrated that there is a need for nesting habitat in an area lacking suitable islands, and if the benefits for the birds will exceed any negative effects of construction of an island to benthic organisms and current flow, then an island could be built. However, islands should not be placed in areas where they would be used for recreational purposes during the breeding season, thus eliminating or severely reducing their wildlife value.

(2) In most areas there is no need for more islands for colonial nesting birds or other forms of wildlife. Management of existing islands should be given first priority. There are areas, however, where additional nesting habitats would be beneficial and existing dredged material and natural islands are not available to fulfill that need. Establishment of need should be

EM 1110-2-5026  
30 Jun 87



Figure 7-4. Royal and sandwich terns nesting on dredged material islands in North Carolina, where successional vegetation stages are deliberately set back with disposal operations to maintain tern nesting habitat



Figure 7-5. Woody habitat on Little Pelican Island, a dredged material island in Galveston Bay, Texas, which is not often disturbed by disposal, and continues as a heron, egret, spoonbill and ibis nesting colony

determined by consultation with knowledgeable wildlife biologists or by field studies. Generally, construction of new islands for wildlife will not be feasible unless it can be demonstrated that the anticipated positive impacts on the target species will outweigh any negative impacts on the environment. However, it would be desirable to construct a limited number of new islands in various regions of the United States for study purposes and to obtain baseline data. As more natural sites are taken over by man, strategic placement of new sites may become more valuable as a management tool. The present knowledge of bird utilization is based primarily on empirical observations of existing dredged material islands, and more baseline data are needed.

(3) In addition to establishment of need, the feasibility of new island construction will be dependent on the concerns of Federal and state agencies and the private sector. These concerns vary considerably among the regions of the country. However, it has been proven that construction of new islands for birds and other forms of wildlife is feasible. The Wilmington District constructed two islands in Core Sound, North Carolina (Figure 7-6), and the US Army Engineer Waterways Experiment Station (WES) has built or modified several islands for habitat development. The two North Carolina islands were unique in that they were the first to be constructed and placed in a manner to deliberately create habitat for colonial sea birds and aquatic life, and they were retained by the use of large nylon sand-filled bags. The sites were designed so that during future maintenance dredging of the nearby navigation channel, material could be added to them within the existing sandbag retainers, and more sandbags may be added to create higher retention dikes. The kidney shape of the islands formed a small cove where it is expected that a marsh will develop and benthic organisms will thrive. Marsh around the island was given a boost by the planting of smooth cordgrass and saltmeadow cordgrass around the perimeter. The islands were placed in an area with adequate shallow water and food resources but with a scarcity of bare ground nesting habitat. Gull-billed terns, common terns, least terns, and black skimmers nested on the islands during the first breeding season after construction. A number of islands have now been built in Florida, Alabama, Texas, Louisiana, and the Great Lakes with waterbird habitat development as a secondary project goal.

(4) Site location of an island should be worked out with knowledgeable wildlife biologists and concerned agencies to establish the best location. Building an island in an area that does not conform to the biological and engineering specifications outlined herein would fail to produce the desired wildlife habitat. The islands must be placed where the birds will be isolated from predators and human disturbances, unless the islands are going to be actively protected by wardens. With active protection, colonies of sea and wading birds have been successful close to human activities and have provided tourist attractions that could be observed from outside the colony (item 40).

(5) Timing of island development is important. Ideally, an island should be built during the fall or winter preceding the initiation of the next breeding season. The birds generally do not use a site until after the

EM 1110-2-5026  
30 Jun 87

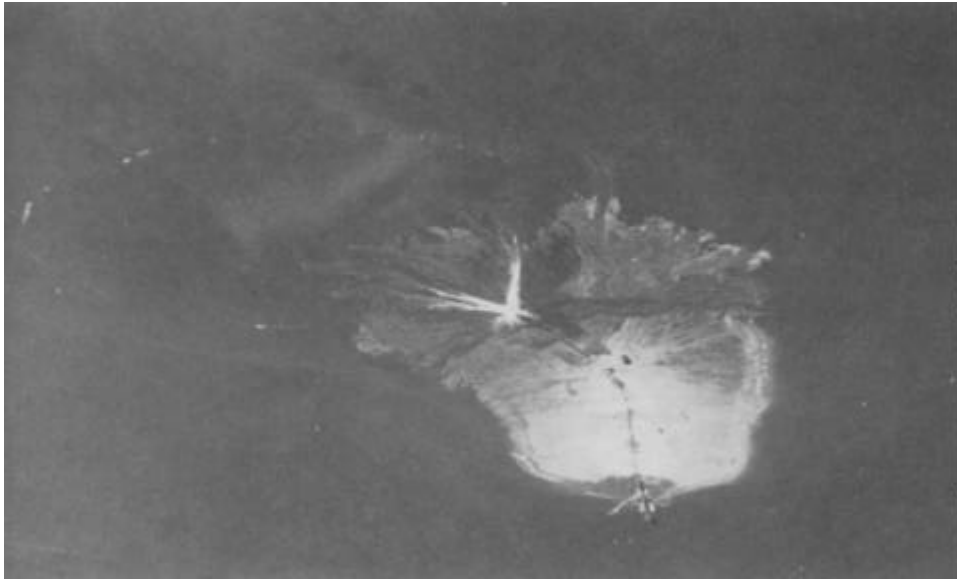


Figure 7-6. A new dredged material island built by Wilmington District in Core Sound in 1977 for seabird nesting habitat. The island is still being used for disposal, and is also a very successful nesting site.

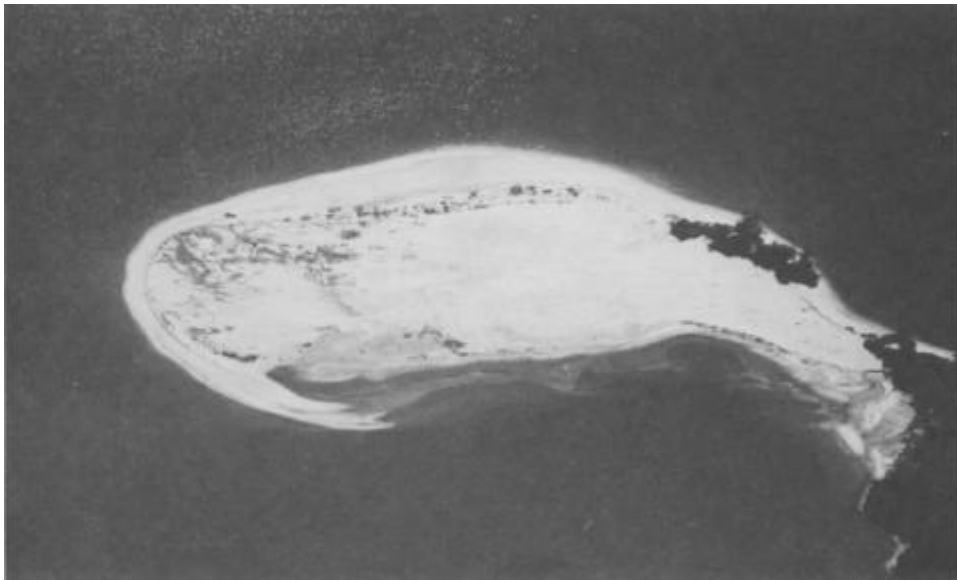


Figure 7-7. An addition built by Jacksonville District to Sunken Island in Hillsborough Bay, Florida, during maintenance dredging operations. It was built as seabird nesting habitat in cooperation with the National Audubon Society.



initial sorting of fine materials by wind and water. If it is built in the spring, this sorting will not have had time to take place, and any colony of birds trying to nest there may not be successful. Their eggs may be covered by drifting fine material. In addition, they cannot use a site until it has had adequate time to dewater.

(6) The physical design of an island is important. In general, islands must be permanently emergent at high water levels; birds have been found nesting on all sizes and shapes of islands as long as they met this crucial breeding requirement. However, observations of hundreds of bird colonies on dredged material islands and the kinds of islands they select has led to four categories of recommendations: size, configuration, substrate, and elevation (item 40). Whether an island is diked or undiked can make a significant difference in bird use.

(a) Ideally, new islands should be no smaller than 5 acres and no larger than 50 acres; however, birds have been found nesting on both smaller and larger islands, and this is a highly site- and species-specific feature. Islands larger than 50 acres would generally be difficult to manage and would also be more likely to support predator populations such as coyotes, snakes, foxes, feral cats and dogs, rats, and raccoons. Islands between the two extremes can be more easily managed, and considerable habitat diversity could be achieved on them. Generally, the greater the amount of habitat diversity to be maintained for wildlife populations, the larger the island should be.

(b) The configuration of an island will depend on the target wildlife species. Steep slopes such as those found on dikes should be avoided for all species. A slope no greater than a 3-foot rise per 100 feet has been recommended (item 73). Substrate configurations for the ground nesting species are given in item 73. Many bare ground nesters must have gentle slopes to prevent their eggs from rolling from nest scrapes. There is also evidence that the formation of a bay or pond with the island makes it more attractive to nesting birds (item 40).

(c) The general nesting substrate requirements of colonial bird species are given in item 73. Generally, coarser materials such as sand or cobble make better nesting substrates due to greater stability. Fine materials such as silts and clays are subject to wind and rain erosion, and usually have desiccation cracks, settling, and ponding. A mixture of sand and shell material makes good nesting substrate for most of the ground nesting birds which prefer sandy beach areas. These bird species historically nested on sandy beaches before being forced off by human use. Fine, unstable dredged material may be stabilized to form suitable nesting substrate by adding coarse materials such as shells over its surface or by planting a ground cover on the material to provide vegetation for those species which prefer that kind of habitat, such as the Forster's tern or laughing gull. Tree nesting species obviously prefer woody vegetation, and these trees and shrubs often colonize best on silty, more fertile substrates. Selected plant species of shrubs and trees which are discussed in item 73 may be planted on the sites since there

are several plant species which seem to be preferred over others by tree nesting birds. If plant propagation is to be a part of a management scheme, these species should be given first consideration.

(d) Elevations of constructed islands should be high enough to prevent flooding of the areas that could be used by waterbirds for nesting. However, elevations do not need to be so high that the substrate will not become stabilized due to wind erosion. Generally, the optimal elevation for an island is between 3 and 10 feet above mean high water. The desirable elevation to be achieved will depend on texture of the exposed dredged material, wind exposure, and the habitat objectives or target species. Coarser materials may stabilize at higher elevations than finer materials. If islands could be constructed of coarser material for ground nesting birds, then it would be acceptable in some cases to exceed the recommended elevation. In general, the higher the elevation, the slower the island will be colonized by plants. Therefore, lower elevations to achieve plant cover for some ground nesting species and all tree nesting species should be considered where those are the target wildlife species and where substrates are of fine-textured material. It should be remembered that given the proper substrates and vegetation for nesting, none of the species using dredged material islands for nesting choose one elevation over another as long as they are above the tide or flood lines.

d. Dredged Material Island Additions, Additions to islands may be a useful management tool if valuable nesting sites are altered by erosion until they have to be eventually abandoned. Additions to such islands will prolong their usefulness as nesting habitats. Additions to islands which are covered with vegetation will increase habitat diversity by providing some bare ground habitat, at least temporarily, for those forms of wildlife requiring bare ground (Figure 7-7). In south Florida, additions may be done in such a manner that encourages growth of mangroves, an excellent nesting substrate for tree nesting birds. Colonies have responded favorably to island additions, especially bare ground nesting species along the gulf and Atlantic coasts.

e. Confined Disposal Facilities (CDFs). In the Great Lakes and a number of ports along the eastern and gulf coasts, CE Districts have constructed large, permanent, diked islands for maintenance dredging. These islands are sometimes over 1,000 acres in size, often well-armored, and in most cases designed for permanent containment of contaminated sediments, especially along the mid-Atlantic to New York coast and in the Great Lakes. These islands are located up to 3 miles from shorelines and are relatively isolated. From the time of their construction, they have been used more and more by nesting and loafing seabirds. Jacksonville, Mobile, Detroit, Wilmington, and other CE Districts considered seabird use in design and management on newer CDFs, and the seabird colonization has been spectacular in several cases. Management on CDFs generally consists of continued protective isolation, wildlife monitoring, and posting. Vegetation management has not yet become a problem on any of these relatively new islands.

f. Protection of Bird Colonies.

(1) Since the primary users of dredged material islands are the sea and wading birds which nest in colonies, and the lack of isolation and protection is one of the primary problems these birds face, this species group would be greatly benefited by the provision of protection of colonies and nesting areas. They are already protected by Federal law and regulation as migratory species. Since this does not protect habitat unless the migratory animal is present, it can sometimes be detrimental for long-term protection purposes. In addition, some states have laws and regulations designed to give protection. A number of endangered or threatened species nest in colonies on dredged material islands. It has been shown repeatedly throughout North America that, in general, protected colonies are successful and unprotected colonies are not. Every Federal and state agency and individual has the responsibility to see that its actions are not in violation of laws which protect wildlife. To ensure compliance with the law, maintenance operations involving placement of dredged material should be conducted in a manner which will not disturb the bird colonies. Management should include proper care during placement of dredged material, surveying, and dike construction.

(2) Public education concerning the vulnerability of colonial-nesting birds has the potential of being a valuable management tool. Through various public affairs channels, the general public could be made aware of the value of dredged material islands to colonial birds. At the same time they could be informed that the continued disposal of dredged material may be a viable management option.

(3) Other protective measures for colonies which are valuable management tools include posting of colonies with signs such as those used by Mobile and Portland Districts, fencing, designation of certain colonies as sanctuaries, limiting of scientific study (and thus disturbance of the birds by constant observation and measurements), and control of wildlife predators such as raccoons, foxes, and feral animals.

g. Vegetation on Dredged Material Islands.

(1) A number of suitable plant species could be planted on islands that would increase the islands' attractiveness to wildlife and especially to colonies of nesting sea and wading birds (items 39 and 73). Depending upon the wildlife species specific requirements, a variety of suitable plants could be used in a management plan for islands. No plantings would be necessary for ground nesting species in most cases, although some of these species use sparse herbs and grasses for nesting. Since tree nesting species require tree/shrub habitat, planting of this vegetation type on islands would hasten wildlife use by more quickly providing suitable habitat. Woody habitat will require 5 to 30 years to develop, depending upon the region and climatic conditions.

(2) Another aspect of vegetation on islands is that sometimes it must be controlled in order to provide the proper or desired habitat for target wildlife species. Vegetation control would be necessary if habitat for ground nesting species was scarce and there was an abundance of other habitats or if the wrong species of trees were growing on an island that precluded nesting or other wildlife use. Some of the control methods that have been successfully tried on dredged material islands are mechanical removal (tractors, tillers, chain saws, axes), hand removal (pulling up plants by their roots), controlled burning, and applications of herbicides. Controlled burning is not very successful because new growth will begin immediately. Herbicides should be carefully applied according to directions; they have been found to be extremely effective on islands in North Carolina.

### 7-3. Development and Management Problems.

a. Numerous potential problems may be encountered in building and/or managing dredged material islands. A key to success in the early planning stages is cooperation and coordination with Federal, state, and local agencies with regulatory authorities. Many obstacles to project success could be removed by correct planning and public awareness efforts before the project actually begins.

b. The development of specifications for dredged material disposal to develop islands for habitat and simultaneously satisfy the need to dispose of a given amount of dredged material requires considerable care. Specifications should include: exact locations, time of disposal, size of deposit, elevation of deposit, and movement of disposal pipes to ensure that habitat plans are carried out. Onsite monitoring is highly desirable and is necessary when disposal is onto an island with an existing bird colony or population of vulnerable wildlife.

c. Silt curtains (effective only in certain parts of United States under certain soil conditions) or temporary dikes sometimes may be required in disposal activities, and if a dike is built on an existing island and filled, the dike should usually be at least partially removed or breached to allow ground access to water by young birds. This will require return to the site by earth-moving equipment. Dikes do not need to be erected until just prior to disposal use for best use by wildlife. Periodic monitoring to determine aftereffects of disposal will provide useful information for future disposal efforts.

d. The public is seldom aware of wildlife needs. Severe damage can be inflicted on a colony by simply fishing or boating adjacent to an island during the nesting season through disturbance of young and adults. Surveying and dike construction activities could also disrupt nesting birds. Education of both the general public and dredging personnel is needed. An information program should be a part of every ongoing or planned dredging operation. Positive public opinion regarding disposal operations of dredged material in North America may improve public acceptance and understanding of dredged

EM 1110-2-5026  
30 Jun 87

material disposal operations, and allow more of this resource to be developed for the benefit of North American wildlife.

## CHAPTER 8

### AQUATIC HABITATS

#### 8-1. General.

a. Aquatic habitat development is the establishment of biological communities on dredged material at or below mean tide in coastal areas, and in permanent water in lakes and rivers. Potential developments include such communities as tidal flats, seagrass meadows, oyster beds, clam flats, fishing reefs, and freshwater aquatic plant establishment. This habitat development alternative has great potential that is just now beginning to be realized through various District projects. The bottom of many water bodies potentially could be altered using dredged material; this could simultaneously improve the characteristics of the site for selected aquatic species and permit the disposal of significant quantities of material (item 72).

b. A number of applications of this alternative have been made by CE Districts in recent years, including development of razorshell clam sites in Portland District, creation of gravel riffles in the Tennessee-Tombigbee Waterway in Mobile and Nashville Districts, razor clam and mussel habitat in St. Paul District, and establishment of artificial fishing reefs in a number of Districts. Unsuccessful attempts to establish seagrasses on dredged material have been made, and is a concept to be reattempted using the newest techniques and very careful site selection.

c. The recent creation of an underwater berm using coarse-grained dredged material has been tested at Virginia Beach, Virginia, in Norfolk District. This will not only provide aquatic habitat, but will serve to protect the shoreline through storm wave dissipation, sand stockpiling for beach nourishment, and allowing a reduction in maintenance dredging in some tidal inlets. Three smaller sites have also been developed as underwater berms for aquatic habitat: Thimble Shoal, Virginia, in Norfolk District; Kings Bay, Georgia, in Jacksonville District; and Charleston Harbor, South Carolina, in Charleston District.

8-2. Aquatic Habitat Development. Limited aquatic habitat development has been tested in Florida (items 72 and 77), the Great Lakes, and several west, east, and Gulf coast Districts. It is a still-developing concept, with much still unknown about what is likely to be encountered or considered at any site. Each aquatic habitat site should be approached as a unique situation until further guidelines are made available.

a. Advantages. Several advantages to aquatic habitat development are recognized. It provides high biological production, has a potential for wide application, complements other habitats, and provides habitat where none previously existed or had been destroyed. Aquatic habitats may be highly productive biological units. Seagrass beds are recognized as exceptionally valuable

habitat features providing both food and cover for many fish and shellfish. Oyster beds and clam flats have high recreational and commercial importance. Fishing reefs built on flat, relatively sterile lake, river, or bay bottoms provide habitat diversity, food, and cover, as well as recreation for fishermen. Dredging material disposal projects impacting aquatic communities predictably incur strong criticism, and in these cases reestablishment of similar communities may be feasible as a mitigation or enhancement technique. In many instances it may be possible to establish aquatic habitats as part of a wetland habitat development project. This concept potentially has very wide application, as most dredging projects are flanked by open water. Often, the selective subaquatic placement of material will both enhance the disposal site and accommodate large amounts of dredged material. In the case of fishing reefs built of dredged material, the material is usually bedrock or rubble from new work dredging operations suitable for reef formation. This kind of dredged material is also well suited for oyster and clam bed development since it gives oysters and clams places to attach.

b. Disadvantages. The primary and overriding disadvantage of aquatic habitat development is an inadequate understanding of techniques for applying this alternative. Careful site-by-site determination combined with local biological and engineering expertise is necessary. Seagrass establishment to date has largely been on disturbed sites that did not involve dredging (items 76 and 77), and its application to disposal sites thus far has been very limited. Development of freshwater aquatic habitat has been limited to providing protective structures via barge-transported coarse-grained material to allow natural plant development, in the case studies listed in para 8-1b.

8-3. Guidelines for Aquatic Habitat Development. The lack of more specific engineering and environmental guidance on aquatic habitat development should not eliminate the consideration of this alternative. References which provide guidance by experts in coastal areas include items 64 and 76-78. Most aspects of habitat development presented in the preliminary assessment and the detailed evaluation of feasibility (Figure 4-6) will be applicable to aquatic habitat development. Of particular significance will be hydraulic energies along the bottom and circulation patterns. The interaction of the texture of the material with the hydraulic energies of the site will be significant, as the material must provide a stable surface substrate. The possibility that alteration of the bottom configuration of a waterway could adversely affect current patterns should be carefully considered, especially with fishing reefs and protective structures for freshwater aquatic plants. In large projects or in those projects where some question exists regarding the impact, it may be advisable to develop physical, chemical, and biological models of the aquatic system prior to project implementation.

8-4. Design of Seagrass Habitat. There are few well-documented examples of seagrass habitat development on dredged material, though a few successful transplants have been made in southern California and on one site in Florida. Revegetation of reclaimed subtidal bottom has been successfully accomplished (item 76), and results from these projects can be applied to dredged material.

Transplanting techniques are described in item 76. Figures 8-1 and 8-2 show the coring method of transplanting plugs, in this case, of shoal grass at Port St. Joe, Florida. Figure 8-3 shows a bareroot propagule of eel grass. Figure 8-4 shows turtle grass being transplanted into sand. Seagrass development will help stabilize dredged material through the binding action of roots and rhizomes, and in the dissipation of wave and current energy, thereby reducing erosion processes.

a. Location. Seagrasses normally occur along shorelines with low wave and current energies. Development of seagrass habitat in higher energy areas will require permanent protection with breakwaters or planting within lagoons created within dredged material islands.

b. Depth. Bottom elevations within seagrass beds extend from mean low water to -2 m in estuaries and -10 m in coastal environments.

c. Water Quality. Surveys to predict expected annual fluctuations in water quality at a site will be needed to assess suitability. Data should be collected as frequently as possible so that the site can be adequately characterized. Presence of natural seagrass beds in the vicinity of a proposed site will also be a strong indicator of general water quality suitability.

(1) Light. The foremost need of seagrasses is sufficient light penetration through the water column to support growth. High water column turbidity is an indication that a site is not suitable for habitat development.

(2) Salinity. Most of the common species of seagrasses require salinities greater than 20 ppt, though some local variations may exist where plants tolerate salinities as low as 10 to 15 ppt.

(3) Temperature. Though seagrasses require relatively low-energy environments, the area needs to be well flushed and currents must circulate to prevent lethal temperature extremes from occurring.

d. Sediment Type. Sediment grain size is not usually a limiting factor, as most seagrasses can tolerate a wide range in sediment from coarse sand to mud.

e. Vegetative Establishment.

(1) Plant selection. In most geographic regions, species selection will be based on salinity, though along the southeast Atlantic and Gulf coasts where two or three seagrass species occur, other considerations need to be made. In this area, environmental tolerances or species growth rate may be a prime factor in species selection (item 48).

(2) Propagule selection. Seagrass habitat development is almost exclusively restricted to transplanting mature plants from a donor bed, as nursery



EM 1110-2-5026  
30 Jun 87



Figure 8-1. Removing plugs of shoal grass from an existing bed near Port St. Joe, Florida. They were transplanted on a nearby dredged material site.



Figure 8-2. Temporary storage for the shoal grass plugs was provided by containers of seawater, which were transported to the dredged material site by skiff.

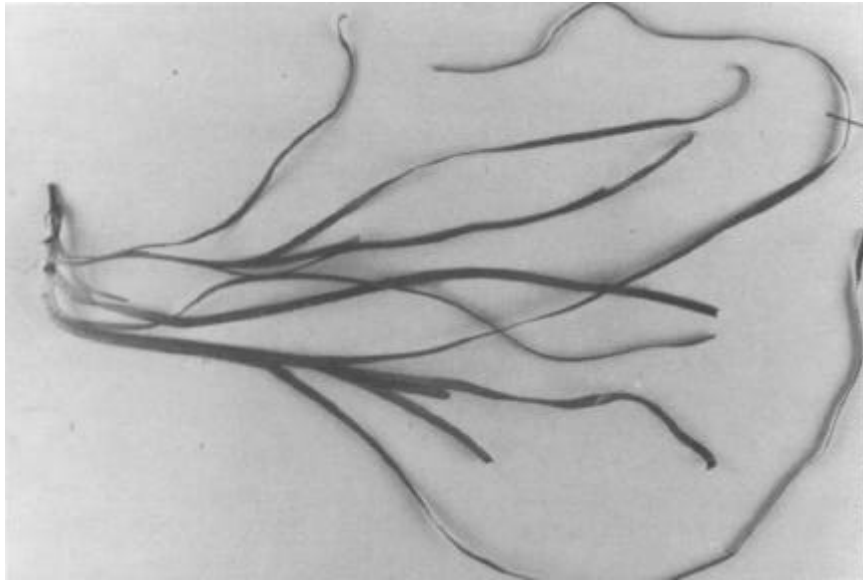


Figure 8-3. A bareroot propagule of eel grass ready for transplantation. This is the most efficiently handled and cost effective type of propagule.

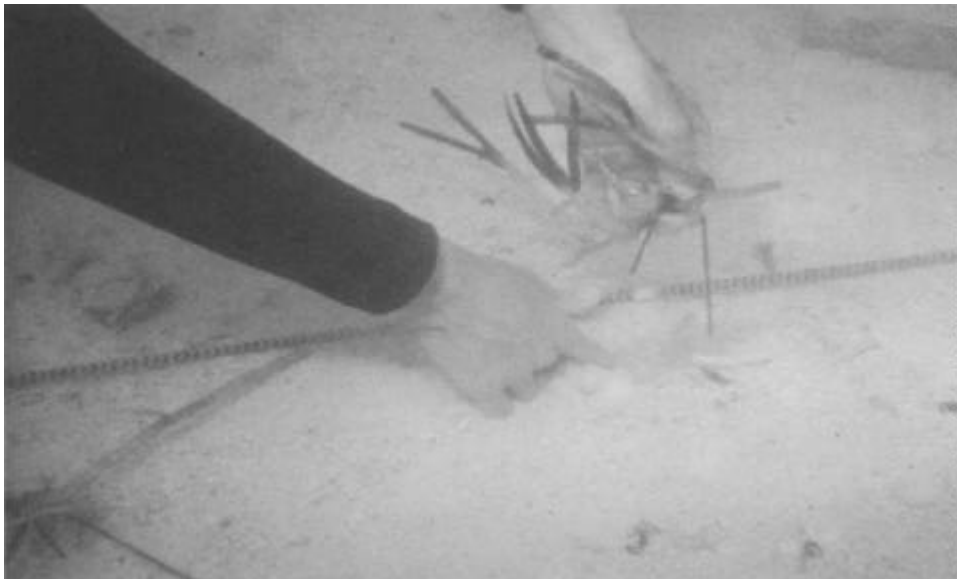


Figure 8-4. Transplanting a bareroot propagule of turtle grass on a sandy site. The transplant is held in place with a long staple, which prevents waves and currents from washing it out.

EM 1110-2-5026  
30 Jun 87

stock is currently unavailable. Mature plants reproduce by branching. Methods using seeds or seedlings have not been adequately developed.

(3) Plant spacing. The rate at which seagrass will cover the bottom is dependent on species growth rate and spacing of transplants. Some species are much faster growing than others. Spacing guidelines can be found in item 76.

(4) Handling plant material. Plants need to be handled as carefully as possible to avoid damage to roots and shoots. Turtle grass meristematic tissue protection is critical for that species' reproduction. Short-term plant storage (hours) can be in well-aerated containers, while longer term storage (days, weeks) should be in floating pens or flowing seawater tables. Plants should never be directly exposed to sun and air for more than a minute or two.

(5) Pilot propagation study. In a seagrass development project where there are unknown factors such as water quality, rate of plant spread, or lack of experience in similar projects, it is prudent to conduct a pilot study. A pilot project is particularly advisable if the project is a large and costly one. A pilot study's main purpose is to determine whether or not the propagules will grow under conditions found on the site. The study can be conducted in less than a year, but the test species should be allowed to grow for one full season before conclusions are drawn. Such a project should be of sufficient size that it will accurately reflect future operational difficulties. The size of the pilot study is limited only by the desired tests, the time available for such testing, and funding. A simple statistical design will permit quantitative evaluation of the study where prediction of degree of success or failure can be made. The success of these plants can generally be evaluated by observation of survival. Test plots established should be evaluated on a regular basis to determine survival and growth.

(6) Time of planting. Almost without exception, spring is the best time for planting seagrasses. Transplanting can be successful in other seasons, but with less overall survival.

## CHAPTER 9

### BEACHES AND BEACH NOURISHMENT

9-1. General. Shore erosion is a major problem along many ocean beaches and the shoreline of the Great Lakes. One of the most desirable, cost-effective shore protection alternatives is beach nourishment (Figure 9-1). Beach nourishment is usually accomplished by borrowing sand from inshore or offshore locations and transporting the sand by truck, by split-hull hopper dredge, or by hydraulic pipeline to an eroding beach. These operations result in massive displacement of the substrate, changes in the topography or bathymetry of the borrow and replenishment areas, and destruction of nonmotile benthic communities. However, a well-planned beach nourishment operation can minimize these effects by taking advantage of the resiliency of the beach and nearshore environment and its associated biota, and by avoiding sensitive resources (item 67).

9-2. Types of Beach Nourishment. Four major types of beach nourishment occur along U.S. shorelines: new borrow material not connected with maintenance dredging, maintenance dredging of an existing channel, dumping in the littoral zone to allow beach nourishment, and rehandling of stockpiled material.

a. Borrow Dredging. This type of dredging entails removal specifically for beach nourishment. The major physical impact of dredging borrow material is the mechanical disturbance of the substrate and the subsequent redistribution of suspended sediments and turbidity. Suspension of sediments and turbidities is usually a short-term impact. Once dredging ceases, heavier sediments rapidly settle, and fine sediments are dissipated by waves and currents. Sea bottom borrow pits remain intact for long periods of time unless currents transport sediments into the pits and fill them. If the borrow pits are in an area of low wave energy and the surrounding bottom sediments contain high levels of organic materials, the pits are likely to slowly fill with the organic-laden sediments. Decomposition of the organic material in these pits may result in anaerobic conditions and generally poor water quality.

b. Maintenance Dredging. The use of maintenance dredged material for beach restoration can serve two beneficial purposes: disposal of the material, and restoration of an eroding beach. If such material is selected, it should closely match the sediment composition of the eroding beach and be low in fine sediments, organic material, and pollutants. Sediments containing large quantities of fine materials result in high turbidities and may introduce trace metals and other contaminants into the water. High turbidities and sedimentation may inhibit reestablishment of beach animals that have a specific habitat requirement or may prevent recruitment to the beach by pelagic larvae, particularly if beach restoration occurs during the peak spawning season in spring and early summer. The disposal may interfere with the selection of a nesting beach by sea turtles if beach sediments are significantly changed, and the appearance of such sediments is aesthetically displeasing.

EM 1110-2-5026  
30 Jun 87



Figure 9-1. A beach nourishment operation under way at Mayport, Florida



Figure 9-2. A sea turtle hatchling moving toward open water on  
a Florida dredged material beach

c. Dumping in the Littoral Zone. Disposal of dredged material can be by deliberate placement on the sea bottom, where it will be carried by currents and waves to the beach. The dredged material will replenish the eroding beach in a natural manner as it is carried by wave energy. Material can be placed in the littoral zone by hydraulic pipeline or by split-hull hopper dredge.

d. Rehandling Stockpiled Material. Coarse-grained dredged material can be pumped into a holding area, where it is allowed to dewater. Then it can be moved by truck or heavy equipment onto the eroding beach. This technique is commonly applied in small restoration projects.

### 9-3. Environmental Considerations.

#### a. Impacts on Beach Organisms.

(1) Animals on high-energy beaches are subject to the effects of seasonal sediment erosion and accretion and major physical changes related to storms. In the Pacific Northwest, animals may be stressed to the 60-foot contour. Beach animals are adapted to survival under these stressful conditions, whereas those animals offshore are generally in a more stable environment and are less adapted to a high level of sediment movement. Burial of nonmotile benthic animals by replenishment material placed on the beach, or material being transported offshore from the beach, is usually lethal unless the animals are able to migrate through the sediment overburden and escape. Laboratory studies have shown that some benthic animals (especially bivalves) can migrate vertically through more than 1 foot of deposited sediment. The ability of benthic animals to survive burial by dredged material will depend not only upon the depth of the sediment, but also upon the length of time the animals are buried, time of year, sediment grain size, quality of the sediment, and other specific requirements of the animals. Therefore, rate of survival will vary from location to location.

(2) Beach nourishment creates new habitat that is uninhabited by benthic animals, except for those that may have survived being pumped to the beach with the dredged material or those that survived by vertical migration through deposited sediments. A beach nourishment operation is generally followed by rapid establishment of new benthic populations. Many of these are opportunistic species that develop large population densities, then decline as other species are recruited which are more adaptable to the new habitat. The time for the resident species to become established is referred to as the recovery time of the nourished area (the time required to approach a stable animal population level). Recovery time varies, depending upon type of recruitment of benthic animals. Those animals that have planktonic larvae or can migrate from nearby areas into the nourished area will establish rapidly, whereas those that spend their entire life cycle within the sediments may be slow in recovering. Once beach restoration ceases, recovery of benthic animals is generally rapid, and complete recovery usually occurs within one or two seasons.

(3) The sediment type used for nourishment and the season of year the nourishment takes place are critical to the recovery rate. If the dredged material is different from the natural beach sediment or contains large quantities of fine material, there may be a major change in beach biota, and it may require a long period of time before local resident populations can be reestablished.

b. Impacts on Offshore Organisms. Potentially, the most serious impact of offshore dredging is the loss or damage to major commercial species of benthic shellfish, seagrass beds, corals, and sea turtles. Damage can be minimized by proper selection of borrow areas, by precisely positioning the dredge to avoid these sensitive resources, and by using dredging equipment that minimizes sedimentation and turbidity, such as a suction dredge.

(1) Benthos.

(a) Repopulation of a dredged area by benthic animals will depend upon the magnitude of the disturbance, the new sediment interface, and the water quality in the borrow pit. Borrow pits will be recolonized by migration of animals from adjacent areas and by larval transport. Stability of the environment and bottom sediment type after dredging are major factors in determining the level and rate of species recolonization. It is extremely important to remember that if bottom sediments are significantly changed from the natural sediments, the reestablished populations may not be of the same magnitude or species composition as those prior to dredging.

(b) Offshore borrow pits that accumulate organic material and acquire high concentrations of hydrogen sulfide and low concentrations of dissolved oxygen in the water are generally very poor quality aquatic habitats. They also usually take a long time to recolonize by benthic animals, or may never recolonize.

(2) Corals.

(a) The ability of corals to recover from beach nourishment is related to the extent of reef damage. If a reef is heavily damaged by equipment being dragged across the reef, by being covered with sediments, or by all corals being killed, the reef can take a long time to recover, or it may never recover. It has been shown that corals may recover if the damage is not too extensive. Corals along the Florida Atlantic coast damaged during beach nourishment apparently recovered by 7 years after the dredging operation.

(b) Corals along Florida and Hawaii coasts are susceptible to direct physical damage by dredging and to sedimentation and reduced light unless dredging operations are carefully planned and executed. With proper planning and control, dredging impacts on corals can be minimized. One of the most significant impacts on corals results from dragging of anchors and cables, which collapse the reef and destroy benthic animals. Erosion and scour at the base of the corals in the dredged area also may damage corals. This can

result in the corals slumping or tilting, or forming overhangs that tend to break off. Reef coral recovery is very slow.

(3) Fish and motile invertebrates.

(a) The mobility of fish and some invertebrates renders them less vulnerable to the adverse effects of beach nourishment than the nonmotile benthic communities. When disturbed by beach nourishment, motile animals will generally leave the area. Those animals that do not leave or are susceptible to suspended sediments in the water can be killed by coating of their gills, leading to anoxia, or if they spawn in the area the sediments may cover their eggs or delay hatching time of their eggs. Feeding habits also may vary according to length of exposure to suspended sediments. Filter-feeding fish are more vulnerable to siltation than bottom feeders.

(b) Destruction of habitat rather than suspended sediment seems to be a greater potential problem to fish. Those fish which are either closely associated with the beach for some part of their life cycle for spawning (i.e., California grunion) or some burrowing and reef-dwelling species with limited mobility (i.e., the dusky jawfish on the Florida Atlantic coast) are more likely to be adversely affected. Beach nourishment operations at Imperial Beach, California, did not prevent subsequent spawning of the grunion; however, on the Florida Atlantic coast it may have displaced the dusky jawfish.

(c) Loss of benthic animals due to sediment burial may indirectly affect motile animals that prey on them. This was suspected to have occurred following a nourishment project on the North Carolina coast. Nourishment occurring during the peak season of beach animal recruitment delayed population reestablishment for several months. During this period, fish and shellfish that usually feed in the surf zone were not observed. Nourishment may also have had short-term benefits to some fish by suspending additional food materials, and the associated turbidities may have provided protection from predators to some motile animals. Studies have shown that moderate to complete recovery of motile animals will usually occur within less than a year unless a required habitat or food source is permanently lost. Fish have been observed moving into an area within the first day after a disturbance.

(d) Mobile animals will be least affected by borrowing operations because of their ability to avoid a disturbed area. Studies have shown that fish will leave an area of active dredging and return when dredging ceases. Whether fish will continue to use a borrow pit as habitat depends upon water quality in the pit. If the pit accumulates anaerobic sediment that results in poor water quality, fish will avoid the pit. However, fish may be attracted to a dredged area as a result of suspended food and as a haven from the cold surface water during the winter. The sediment plume from the dredge may also provide protection to some motile animals. Total recovery at a dredged site, therefore, is variable and ranges from immediate for some species to a year or more for others, depending upon the nature of the habitat modification.



(4) Sea turtles.

(a) Sea turtles are one of the animals most vulnerable to the effects of beach nourishment on the South Atlantic and Gulf coasts (Figure 9-2). Turtle nesting on the beaches and replenishment operations occasionally conflict in these areas. There is concern that turtle nesting and hatching success may be adversely affected by beach nourishment.

(b) Sand particle size and sand compaction have been found to influence nest site selection by some sea turtles. Aborted nesting attempts (false crawls) have occurred on rebuilt beaches in Florida. The precise effects of beach nourishment on nesting sea turtles have not been documented because of insufficient studies. The present limited data indicate caution should be taken in rebuilding beaches that are known to be major turtle nesting sites. It would be best to avoid turtle nesting beaches from April through November, the period which encompasses all of the sea turtles' nesting and incubation season. Such operations must be closely coordinated with U.S. Fish and Wildlife Service (FWS), National Marine Fisheries Service, and state agencies.

(c) Hibernating or aestivating sea turtles have been captured and killed by trawls and dredges. Turtles that are not hibernating or aestivating should be able to avoid a dredge and move back into an area when dredging ceases. If hibernating sea turtles are located, dredging should cease until the operation can be coordinated with FWS.

(5) Seagrass beds. As with corals, caution should be taken to avoid these highly productive areas. Both the actual dredging operation and turbidity caused by adjacent dredging will destroy seagrasses. Seagrasses are usually very slow to recover, if they ever recover. To date, seagrass transplantation has not been refined to a point where a high-percentage survival of transplants and economic feasibility justify efforts to restore large areas of destroyed seagrasses (See Chapter 8). Dredging cautions for corals should also apply for seagrasses.

c. Timing. Timing of the nourishment operation may also be a critical factor in reestablishment of benthic animals. If nourishment occurs during spring and early summer, recruitment of planktonic larvae may be inhibited. High turbidities and unstable substrate are known to preclude larval settlement, thus delaying recovery time of benthic animals. The best time ecologically for beach nourishment and borrowing is during the period of lowest biological activity. This is usually during the winter when there would be minimal effect on the adult and developmental stages of most nearshore and beach animals. Adults have usually migrated out of the area and would be less concentrated in the shallow beach zone, and the nesting and spawning season of beach animals would have passed. Nevertheless, it is still necessary to ensure that no sensitive nonmotile animals are in the area.

d. Dredged Material Substrates. Sediments to be used as material should match the natural beach sediments and should be low in pollutants.

This recommendation is particularly important when maintenance dredged material is used for beach nourishment. Minimum damage to beach animals will occur when clean sand is placed on a sandy substrate, whereas damage to the benthic animals would be great if fine sediments high in organic material are used. Changes in the sand particle size on ocean beaches, should they occur, may also influence site selection and nesting of the threatened and endangered sea turtles.

e. Equipment in Sensitive Areas.

(1) If it can be avoided, the cutterhead on a suction dredge should not be used in the vicinity of live coral reefs or other light-sensitive resources, unless barriers are established to separate the dredging site from them. The suction dredge without a cutterhead is a better choice because siltation is minimized and there is less potential for physical damage to the reef. The dredge should be positioned within the designated borrow area and should not cross a live coral reef, commercial clam bed, or other valuable resources. Cables, anchors, and discharge pipes of a dredge should be positioned in sand or another nonsensitive habitat. Local directions in tidal flow and current should be determined prior to dredging, and the operation adjusted to prevent sediments from crossing live coral reefs or other sensitive resources.

(2) Consideration should be given to shallow dredging over a large area in a low wave energy environment rather than deep dredging which may create a stagnant borrow pit which will require a long time to recover or may never recover. Although ecological damage from dredging the shallow pit would initially be greater, recovery should be faster in the shallow dredged area.

f. Monitoring. Biotic surveys should be made at beach restoration and borrow sites. As an absolute minimum, a preproject baseline survey should be made to identify and locate natural resources, i.e., corals, commercial clam beds, sea turtle nesting beaches, fish spawning areas, and seagrass beds, to aid the planner in avoiding potential damage to these resources.

CHAPTER 10

AQUACULTURE

10-1. General.

a. The CE interest in aquaculture stems from its basic mission in construction and operation of navigable waterways. Due to the increasing difficulty and expense of obtaining dredged material containment acreage for use as single purpose areas, the development of a multiple-use strategy such as aquaculture is desirable. It is possible that future site availability would be improved by increased value of acreage leased to dredging project sponsors because landowners could enter separate and profitable lease agreements with aquaculturists. Aquaculture is attractive because of the potential for: (1) producing nutritious low-cost protein; (2) partially satisfying increased demand for seafood in the United States; (3) increasing employment in fish farms, feed mills, processing plants, and other supporting industries; and (4) providing larval stock for commercially and recreationally important natural populations currently stressed due to pollution and habitat loss. Aquaculture activities would also generate a more positive public image of the CE and its activities.

b. Aquaculture in a dredged material containment area was first explored by the CE during the Dredged Material Research Program. In 1976, Dow Chemical Company, under contract to the CE, successfully cultured a crop of white shrimp in an active containment area near Freeport, Texas (Figure 10-1). This project demonstrated that dredged material containment site environments are compatible with aquaculture in the sense that animals will grow, survive, reach marketable size, and be of marketable quality. No attempt was made to justify the project's production economics; the cost of postlarval white shrimp stock, the limited acreage, and the small size of the unfed white shrimp at the time they were harvested all contributed to high production costs (item 52).

10-2. Aquaculture Concept.

a. Advances in Technology. Many of the technology problems which affected production economics during the 1976 dredged material demonstration at Freeport, Texas, have been reduced through continuing research on the biology and culture requirements of desirable plant and animal species. It is now possible, for example, under laboratory conditions, to duplicate the life cycle of the white shrimp species used in that study. One advantage of this technology is a reduced cost of obtaining juvenile shrimp compared with the cost of field excursions for capturing egg-carrying and recently mated female shrimp in the wild, and returning them to a laboratory for spawning. Another very significant advantage is that artificial control over the natural reproductive cycle permits production of juvenile shrimp whenever they are needed and allows production of multiple crops in a single growing season.

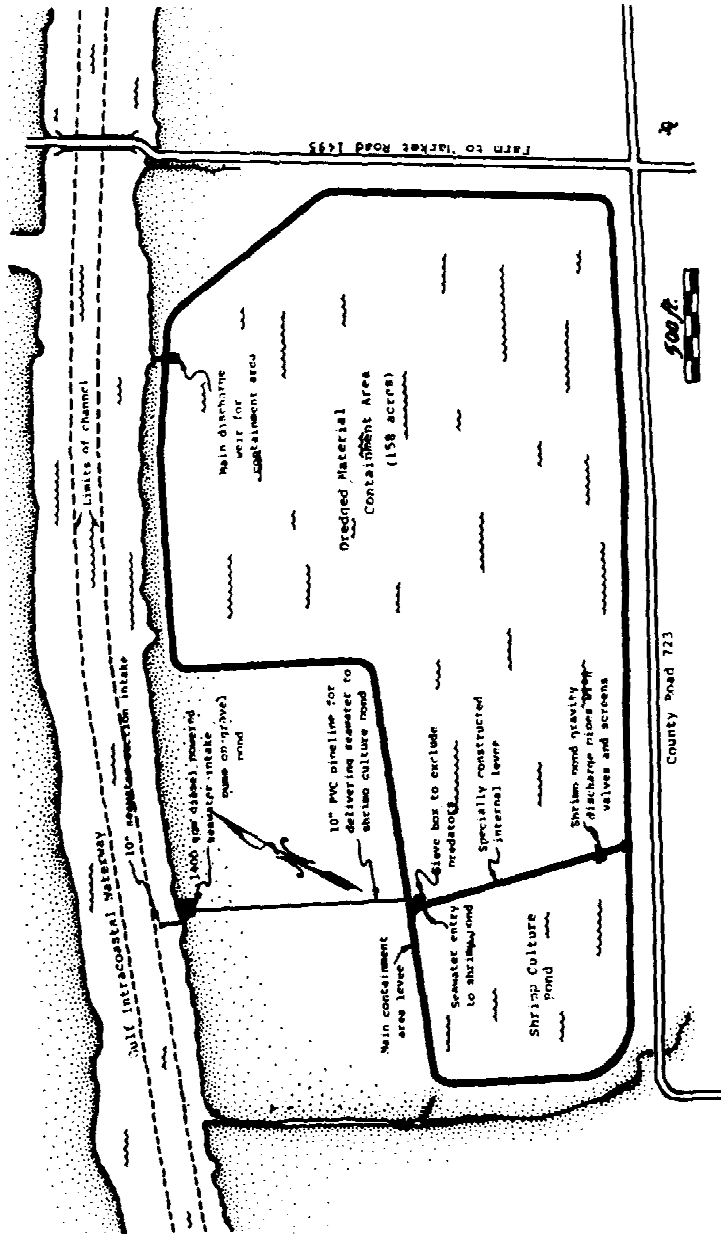


Figure 10-1. Galveston District dredged material Containment Area No. 85, showing the shrimp pond, internal levee, and associated structures

The result is more efficient use of the cultivation area, higher annual production, and lower net production costs.

b. Favorable Economics.

(1) Dredged material containment sites commonly possess structural features such as dikes and water control devices that may enhance their suitability as aquaculture areas. In some instances, land acquisition costs (purchase or lease) and dike and water control structure costs are absorbed wholly or in part by the Federal government or a local cooperator on the dredging project, such as the city government or port authority. In cases where a Federal or local subsidy exists, the aquaculturist could be the beneficiary. The lack of available coastal sites has been one of the principal restraints on the application of commercial aquaculture techniques. This is due both to the cost of real estate and to the Government's regulatory permitting process which affects consideration of aquaculture in coastal lowlands, particularly wetlands. Freshwater and coastal dredged material containment areas have several benefits related to desirable location: (a) proximity to favorable water sources, (b) waterfront property use that may otherwise be unavailable to the aquaculturist, and (c) nearness to large market areas and established transportation routes.

(2) Dikes that would serve to contain the dredged material would also serve to impound the water necessary for aquaculture. However, dikes of an existing containment site that is under consideration for aquaculture may have to be modified to increase their height, adjust their slopes, or improve their water-retaining capabilities. At a new containment site, the dikes could be designed to permit both the containment of dredged material and the retention of water for the aquaculture operation. Water control structures that are used to regulate water quality at containment areas could also serve to regulate water exchange rates and levels in an aquaculture pond, and could be used to drain the pond or concentrate the crop for harvesting.

10-3. Aquaculture Considerations.

a. Compatibility Between Aquaculture and Dredged Material Management.

(1) There are at least two general containment site management techniques that could be compatible with aquaculture. Figure 10-2 depicts the placement of dredged material into a containment area surrounded by a single primary dike system. Distribution of the dredged material would be dependent on the size (surface area) of the containment, the relative volume and physical characteristics of the dredged material, and the use of controlled disposal operation conditions such as pipeline placement and movement. It is unlikely, though not impossible, that culture operations could be sustained within the site during active disposal. A small volume of dredged material disposed into a large disposal site containing a species tolerant of suspended sediments is one workable scenario. Figure 10-2 also depicts a containment site divided into multiple compartments or cells which would be filled

sequentially over the life of the disposal site. Construction of secondary, internal cross dikes produces a configuration with numerous operational advantages over an undivided one. The most obvious benefit would be related to the separation of one or more cells from dredged material disposal operations. The second configuration has an additional benefit in a new site because it also separates the aquaculture operation from potentially contaminated dredged material. This is a source of perceived, if not actual, production or marketing problems.

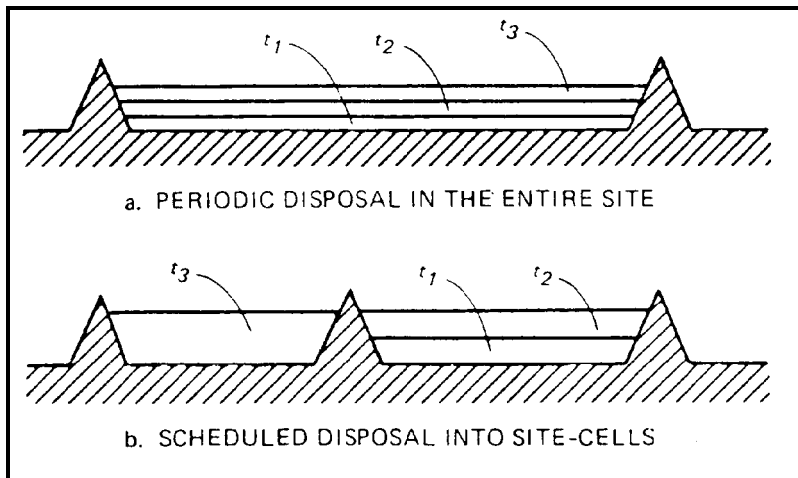


Figure 10-2. Two concepts for combining dredged material containment and aquaculture operations ( $t$  = time in years and may vary between 1 and 15 from site to site)

(2) The length of time following a disposal event before aquaculture activities could begin would be a site-specific variable depending on the site's size and configuration, the volume and character of the dredged material, and the possible use of dredged material dewatering and other volume-reducing techniques for efficient containment site management. A site without cross dikes will not be available to aquaculture during the active dewatering period. Otherwise, aquaculture and dewatering objectives are totally compatible.

b. Aquaculture Products. Aquaculture in containment sites could be designed to produce crops for commercial harvest or could be directed toward producing fish and shellfish stocks for release to augment depressed natural populations. Current aquaculture-for-release programs in California, Texas, the Pacific Northwest, Japan, and the Middle East use natural and artificial coastal ponds, lagoons, and embayments for their propagation programs. Similar programs could easily be undertaken in containment areas.

c. Site Characteristics. Containment sites exhibit a wide range of variability: location, size, construction, compatibility of aquaculture with disposal requirements, and a myriad of other site-specific physical and chemical features which make each containment area unique. Not all containment sites will be suitable for aquaculture, but a significant number have the proper combination of features to support aquaculture. Crucial to developing aquaculture as a secondary use of containment sites is the fact that aquaculture will be possible only if it is compatible with the disposal requirements and schedules imposed by the intended primary use of the site, i.e. dredged material disposal. Only when both the aquaculturist's and the disposal agency's requirements are met can the site be developed for aquaculture.

d. Site Acquisition and Permitting. Site development and pond management practices are expected to be similar to those presently used in commercial aquaculture operations. Major exceptions lie in the areas of site acquisition by entrepreneurs and permit-granting procedures. Existing easement agreements would have to be amended, requiring prospective aquaculturists to reach separate agreements with both the property owner and the CE. Representatives of commercial aquaculture enterprises claim that the current permitting process is so involved and complex that the growth of aquaculture in the United States is effectively thwarted. Having the CE involved in promoting aquaculture in addition to retaining its traditional role in the permitting process could possibly expedite the process in the future.

e. Use of Contaminated Sediment.

(1) Waterway and harbor sediments placed into containment sites are sometimes contaminated with elevated concentrations of heavy metals, pesticides, petroleum hydrocarbons, and PCBs. Inorganic contaminants such as metals are generally incorporated in sediment particles while organic contaminants such as petroleum hydrocarbons and PCBs are generally associated with organic material present in the sediments. Because of the way contaminants are retained within sediments, they are relatively unavailable to aquatic animals; those that are available are generally not concentrated by aquatic animals to levels much in excess of those found in the sediments.

(2) Laboratory experiments in which aquatic animals were exposed to sediments contaminated with various metals and organic contaminants have shown that the organics are more likely to be transferred from sediments to animals. Animals, such as certain marine worms that live and feed below the surface of the sediment, are more likely to accumulate organic compounds like PCBs than most shrimp or clams, which live or feed at or above the surface of the sediment. Higher levels of organic material in the sediment appear to reduce the biological availability of PCBs and other organic chemicals in sediments. There are some data to indicate that animals can accumulate lead and petroleum hydrocarbons from contaminated sediments, but the levels of these contaminants found in these animals are low in comparison to sediment levels, and there is no evidence that they are harmed by these low levels of contamination.

(3) Most studies generally focused on highly contaminated sediments and should be viewed as representing the "worst case." Containment sites used for the disposal of dredged material with "some contaminants" need not be viewed as a major constraint to their use for aquaculture. Test procedures for determining whether a particular sediment will be a problem to a specific aquacultured species are available, fast, and inexpensive. Contaminant status is something to be aware of and considered during the planning process.

f. Economics. The economic and marketing requirements of commercial finfish and shrimp culture operations and those operations conceived for containment areas are very similar. The capital investment requirements of containment area aquaculture could be significantly less. Simplified land acquisition, reduced real estate costs, shared costs of dike construction and maintenance, and the possibilities of an expedited permitting process would all contribute to reducing capital requirements. Operating costs will depend on site- and species-specific characteristics and are difficult to describe in general terms, but no extraordinary additional costs have been identified.

g. Pond Construction and Management.

(1) Pond construction and modification for aquaculture would be site and species specific. If a containment site satisfied initial geotechnical and engineering requirements, constructing additional dikes, installing water control equipment, and other necessary modifications should follow the procedures employed in conventional operations. Cooperative efforts involving aquaculturists, U.S. Soil Conservation Service (SCS), and the CE are recommended for developing designs and specifying any modifications necessary for using containment areas for aquaculture.

(2) Health considerations, water quality, and species management techniques for containment site culture should be identical to current practices, although the effects of large amounts of fine sediment in the containment area ponds and the lack of experience in managing large-scale aquaculture operations pose questions that still need to be answered. Management procedures for large ponds have not been developed for many species simply because large ponds have not been generally available. With increased availability afforded by the widespread use of containment site acreage, appropriate techniques should evolve. Similarly, adequate water exchange, aeration, and harvest techniques should overcome many difficulties created by the presence of large amounts of fine sediments.

10-4. Feasibility.

a. Aquaculture in active dredged material containment areas appears to be a feasible, cost-effective, and compatible multiple use of containment sites. Existing technology can be directly applied to the concept, making it practical with little additional research and development investment required. The needs of the local areas, interests of the involved parties, and technical constraints will determine which type of culture operation (commercial or



stock augmentation) and which species will be most suitable for a given site. Aquaculture is generally perceived to be only applicable in the U.S. in warmer climates. However, aquaculture is practiced commercially in the Pacific Northwest, California, New England, Chesapeake Bay, and the Carolinas, as well as in Florida and in the Gulf Coast states. Although growth rates are generally slower in colder waters, the concept is still highly applicable.

b. The large successful industries centered on crayfish, salmon, catfish, trout, and bait minnows can provide both the technical expertise and the sources of stock needed for developing a profitable operation. The technology involved in freshwater fish culture is both well defined and compatible with culture plans envisioned for containment areas. Redfish, exotic and native shrimp, hybrid striped bass, bait shrimp, and minnows are the most promising species for marine/brackish water culture.

CHAPTER 11

PARKS AND RECREATION

11-1. General.

a. Potential recreational uses of dredged material disposal sites are practically unlimited. They range from projects as simplistic as fill for a recreation access road to projects as complex as the 4,500-acre Mission Bay development in San Diego, California, supporting both public and private commercial and noncommercial recreation facilities.

b. Of all types of beneficial uses, recreation on dredged material containment sites is one of the most prevalent land uses in actual acres. It is not surprising to find many examples of such use since there is such a demand for recreational sites in urban areas where much dredging occurs. It requires sound, careful planning to accomplish; financial investments will vary from project to project and could be quite expensive on large complex sites. The nature of recreation sites with requirements of a lot of open space and light-weight structures is especially suited to the weak foundation conditions associated with fine-grained dredged material. Recreational land also is generally for public use, and high demand for public water-oriented recreation encourages the development of recreational land use projects on dredged material. Finally, legislation relating to wetlands, coastal zone management, and flood control is biased in favor of this type of use. The recreational land use of dredged material containment sites is one of the more promising and implementable beneficial uses of dredged material, but is heavily dependent on financial backing at the local level.

c. There are many factors that influence the potential use of dredged material disposal sites for recreational purposes. Important ones that must be considered include the local or regional demand and need for recreational facilities, the interest and capability of local sponsors to participate in development and operation, and available access. Local and regional planners, State Comprehensive Outdoor Recreation Plans, and public participation programs are all sources of information about public demands and needs. Local and regional planners are also good sources of information on potential project sponsors.

11-2. Case Studies.

a. East Potomac Park. A non-commercial recreational development at East Potomac Park in southwest Washington, D.C., is located astride the confluence of the Anacostia and Potomac Rivers. Disposal operations completed in 1912 created 329 acres from fine-grained clays and organic materials dredged from the Potomac main channel. By 1925 the park reached full recreational development, and since 1939 ownership and operation of the facility have been in the hands of the National Park Service. The site currently offers four

nine-hole golf courses and a snack bar, driving range, and clubhouse. Other recreational facilities include a swimming pool, indoor and outdoor tennis courts, eight baseball fields, and fields for field hockey, football, and polo. Buildings on the site include the National Park Service offices, a maintenance building, a comfort station, and several other minor structures. Use of the park open space for recreation has increased to the extent that the conversion of a portion of golf course land to open space is being considered. The park serves a regional need for recreation of residents of the District of Columbia, Arlington County, and the City of Alexandria, Virginia, as well as for area commuters. In 1975, the North Atlantic Division placed the value of the park at \$94 million.

b. Patriots Point. The Patriots Point Project, a 450-acre commercially oriented recreational site immediately across the Cooper River, 1 mile east of Charleston, South Carolina, was built on an old disposal site. The site, formerly known as Hog Island, was used for disposal of maintenance and new channel dredged material--primarily mixed sandy silt and clay--from 1956 to 1970; dikes were constructed of heavy clay. In the early 1970's, a quasi-state agency, designated the Patriots Point Development Authority, was established to plan and develop a recreational complex. The focal point of the development is a Naval and Maritime Museum with the aircraft carrier Yorktown, moored at the site in early 1976, as the principal attraction. The Authority's master plan includes an 18-hole golf course, a 150-room motor inn with convention facilities, a 375-slip marina, and a 300-space recreational vehicle park. Long-range plans include construction of an oceanarium, aquatic theatre, amphitheater, restaurant, man-made lakes, and permanent mooring for at least three more classes of decommissioned naval ships as the vessels become available. A dike-top tour route around the site has been constructed. The project will ultimately attract 1.5 million visitors annually. Structures at the site will be supported on pilings due to the compressible nature of the fine-grained dredged sediments and underlying organic material. An overburden of sand will be added to provide suitable drainage and foundation conditions for light structures and parking areas. Topsoil, including some dredged material, will also be placed in portions of the site to encourage vegetative growth, particularly in designated buffer zones. Figure 11-1 depicts the master plan for Patriots Point.

c. Kalawa Recreational Area. A large marina, fishing pier, and water sports complex was built on sandy dredged material in the Columbia River at Kalawa, Washington (Figure 11-2). The area was armored with riprap to prevent current erosion. It also contains park areas, a heliport, a recreational center, and baseball fields.

d. North Central United States. Numerous recreation sites such as riverside picnic areas, water parks, marinas, and other river-related sites have been built on dredged material, both by the CE and by private sponsors along the Upper Mississippi River and its tributaries. In the Great Lakes, parks, marinas, fishing piers, and other recreation facilities have been built

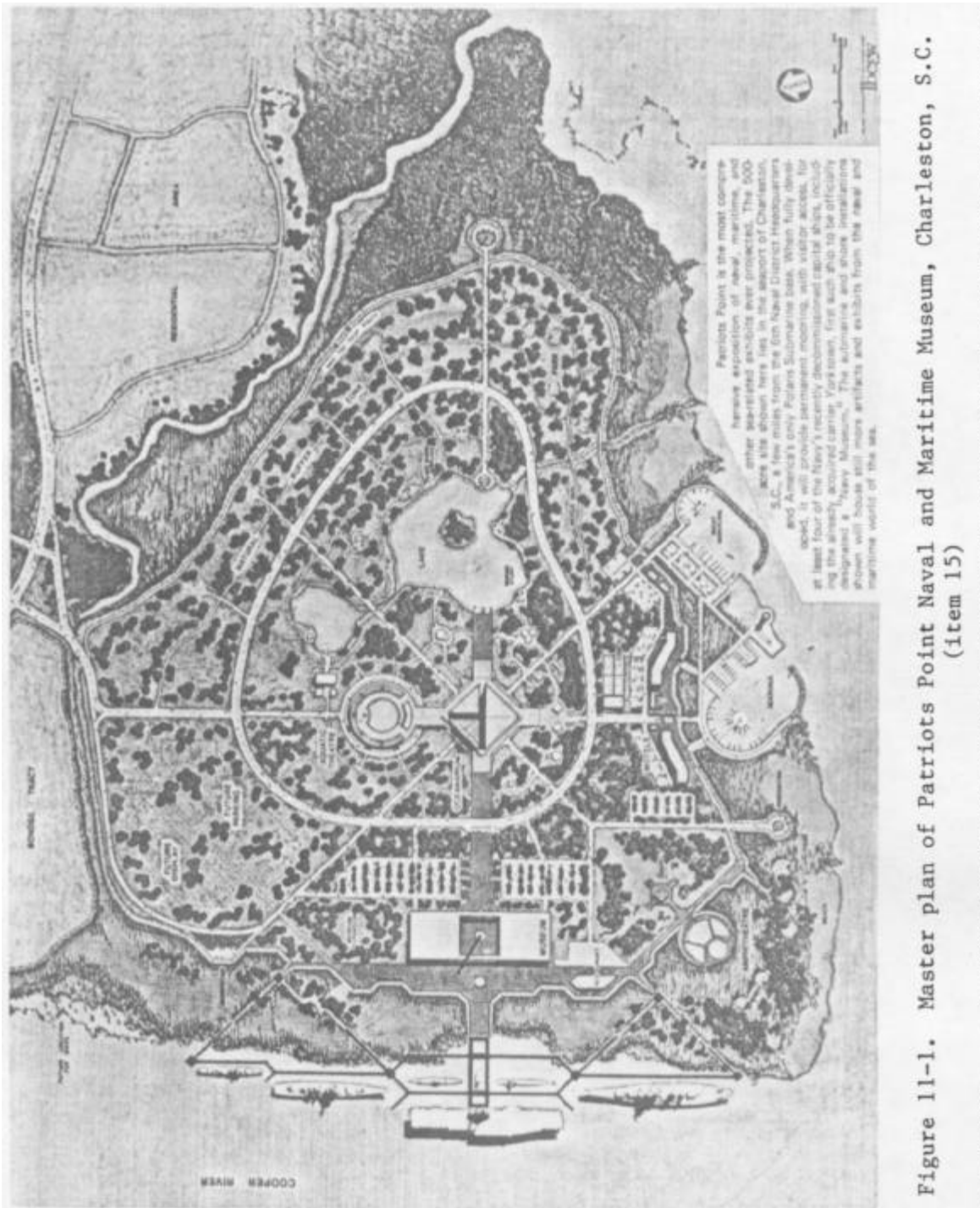


Figure 11-1. Master plan of Patriots Point Naval and Maritime Museum, Charleston, S.C.  
(item 15)

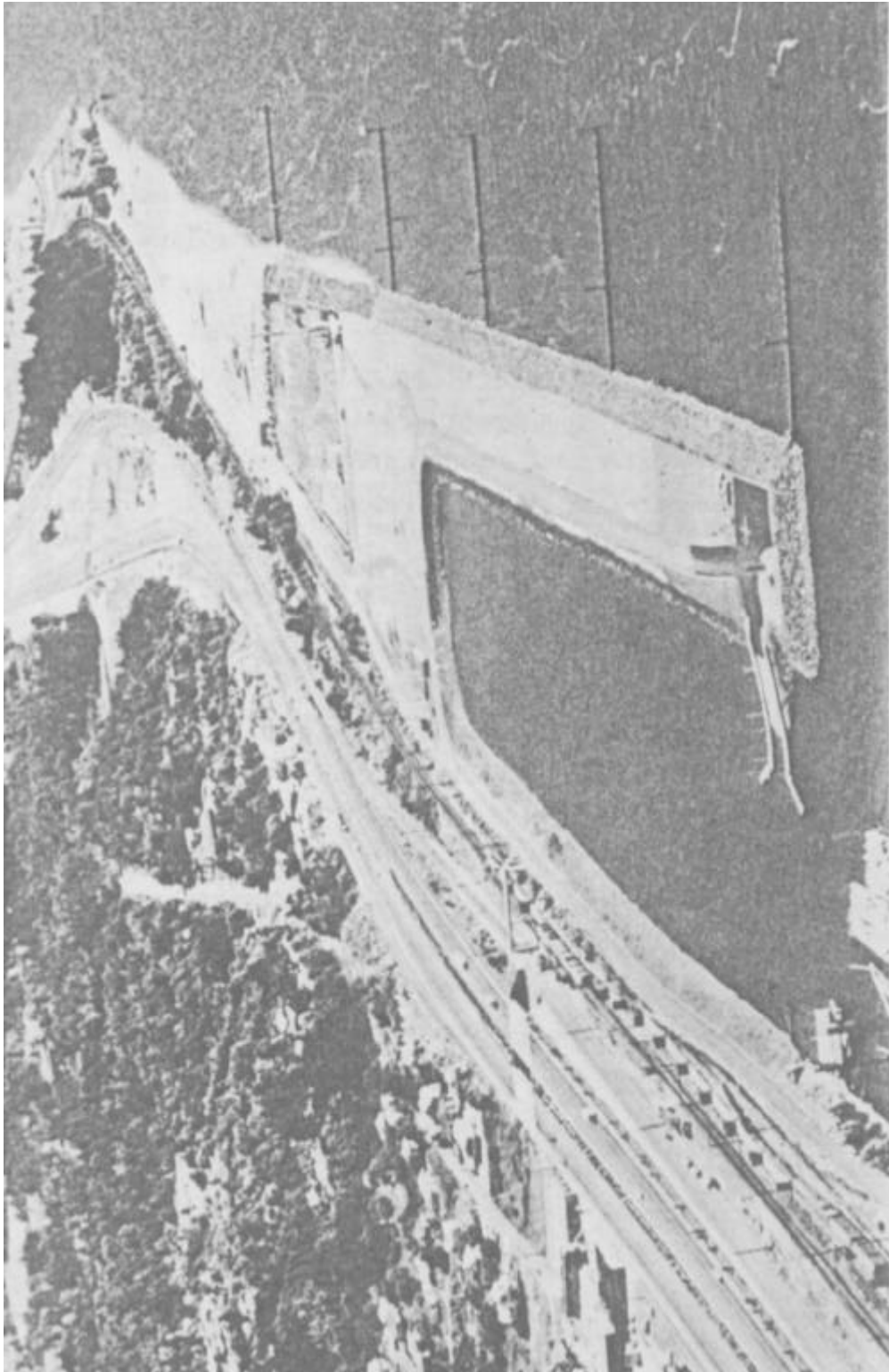


Figure 11-2. This riverside recreational area at Kalawa, Wash., was built on material dredged from the Columbia River

on dredged material in western Lake Erie, Lake St. Clair, Duluth Harbor, and a number of other urban areas.

e. Others. A total of 136 examples of recreational use of dredged material are listed in Appendix C.

### 11-3. Recreation Activities and Facilities.

a. Certain types of private recreation facilities, while they are on dredged material disposal sites, are normally provided by private enterprise. Although the CE does not participate in the provision of these types of facilities, they should be regarded as potential beneficial uses since they occur on disposal sites. These sites often provide cost-feasible and socially acceptable disposal alternatives. There are also many opportunities for providing recreation opportunities at disposal sites. Disposal sites in coastal and riverine areas have highly diverse recreation potential, especially for water-oriented activities. These sites are especially attractive for shoreline recreation development such as swimming beaches, boat launching ramps, and fishing piers. When areas are of sufficient size, campgrounds, marinas, outdoor sport facilities, and hiking and nature trail systems may be constructed. Recreation development potential of these areas is quite high when authority, funds, and land area are all of sufficient amounts, and the public interest is best served by such development. The types of activities and facilities that can be provided on dredged material sites are included in Table 11-1. Recreation planning and design criteria for specific recreation facilities are provided in EM 1110-2-400. While high site recreational use is generally dependent on facilities development, undeveloped disposal lands also attract a segment of the public for activities appropriate for those areas, such as nature study, primitive camping, hiking, hunting, and beach-combing. Provision for access to these areas is one of the minimal requirements. These undeveloped sites are also used as trails for off-road vehicular recreation.

b. Dredged material disposal islands are also used extensively for recreational purposes. They provide a base for such water-based activities as hunting, fishing, boating, waterskiing, swimming, and camping. In many river and estuarine systems, dredged material islands and beaches are the only available sandy beaches, and there is often danger of site use conflict between wildlife, especially nesting colonial birds and turtles, and humans. The recreation experience and enjoyment of the users can be affected by the development and design of the disposal sites and by the timing of disposal operations. Variations in size, proximity, and level of development of camping sites can provide a diversity of recreation experiences.

c. Development of facilities and vegetation on these islands should preserve the more primitive conditions of naturally occurring point or island bars. A study of recreation users on the Upper Mississippi River noted preferences for undeveloped islands composed of mostly open sand with some trees and grass; islands with riverine vegetation were not favored. Extensive vegetation of disposal islands is therefore not required nor desired for

Table 11-1

Types of Recreational Activities and Facilities Found on Dredged  
Material Disposal Sites

<u>Activities</u>	<u>Required Facilities</u>
Beach-combing	Beach
Bicycling	Trails or roads
Bird watching	Undeveloped natural areas
Boat launching	Ramps, parking area, marina
Camping	Campground
Dining	Restaurants and snack shops
Fishing	Water access
Hiking	Trails
Hunting	Undeveloped natural areas
Motorcross and dirt biking	Trails
Nature study	Undeveloped natural areas
Outdoor games	Athletic fields and playgrounds
Picnicking	Tables, trash receptacles
Sunbathing	Beach
Swimming	Beach
Viewing	Scenic overlook or observation tower

recreational use. The use of a given dredged material island or sandbar was influenced by the presence of sandy beach areas, adequate water depth for boats, and uncrowded conditions which gave users relative isolation from other campers.

d. Proper location of dredged material islands and access points can also reduce boating congestion in locks and navigation channels. Many boaters in the Upper Mississippi River survey noted that they used the locks only to reach their favorite disposal sites. Development of multiple launching points and/or the location of specifically designed disposal sites near population centers could eliminate some of the recreation blockages and the traffic congestion in navigation channels.

e. The recreation potential of both shoreline and island disposal areas can be enhanced by management of fish and wildlife habitat. Fish and wildlife habitat development can be an authorized purpose and secondary goal of navigation projects involving dredging. Wildlife enhancement and mitigation may also be required to offset habitat losses due to project construction. In such cases, lands are generally purchased or long-term easements obtained, and detailed habitat management plans developed and implemented. However, in a number of areas where dredging occurs, disposal sites are limited, and a well-developed long-range management plan is usually lacking for disposal sites. In these instances it may be more practical to manage for nongame species and nonconsumptive recreational use rather than the more traditional game management for sport hunting. A variety of songbirds and other small animals are appreciated by the public, and with proper habitat management (nest boxes, food and cover plantings, etc.), these species can be encouraged around picnic, camping, and other recreation areas.

f. When fishing is a recreational goal at a disposal site, some basic management techniques to maintain high populations and harvests of game fishes may be required by developing and maintaining ponded areas in disposal sites. Spawning beds and water level manipulation to enhance reproduction, reefs, and piers to attract and concentrate fish, and a sound plan for dredged material disposal will contribute to a healthy sports fishery in a given area.

#### 11-4. Recreation Carrying Capacity.

a. Proper design of recreation developments on dredged material disposal sites can ensure that recreation use does not exceed the recreation carrying capacity of the resource. Carrying capacity is the maximum potential level of use which avoids social overcrowding and resource overuse. A number of methods are available to estimate recreation carrying capacity of projects (item 79). Proper project design of structures, facilities, and access points decreases the likelihood of overuse or underuse. Overuse of recreational resources results in overcrowding of recreation users and degradation of the dredged material resource.



b. Sandbars, beaches, and other disposal sites can be strategically located to further disburse recreation use to areas able to support the use. Barriers and screens such as ditches, fences, and berms can be placed adjacent to environmentally sensitive areas and hazardous locations at disposal sites such as those where incremental dredging is still occurring and where recreation use is not desired. On such sites still in active use, serious consideration must be given to liability from accidental or purposeful human intrusion onto the active disposal portion of the site. The density concentrations of boating, boat fishing, and waterskiing can be affected in part by the number, location, and distribution of boat launching, docking, and servicing facilities built throughout an area. Providing multiple launching and docking facilities at disposal sites tends to reduce density concentrations and distribute recreation use more evenly.

## CHAPTER 12

### AGRICULTURE, HORTICULTURE, AND FORESTRY

12-1. General. Broad use of dredged material disposal sites has been made by the agriculture, forestry, and horticulture industries. Some disposal sites, especially in river systems, have provided livestock pastures. These pastures have not been developed in any way except by allowing natural grass colonization or by planting pasture grasses on them. Other uses involve actively incorporating dredged material into marginal soils (item 25). An attractive alternative for disposing of dredged sediments is to use these rich materials to amend marginal soils for agriculture, forestry, and horticulture purposes. Marginal soils are not intensively farmed because of inherent limitations such as poor drainage, unsuitable grain size, and poor physical and chemical conditions. They may also be of low productivity because of high water tables or frequency of flooding. Millions of acres of these marginal soils are located near waterways.

12-2. Agriculture. Item 81 notes several areas where there is currently extensive interest in the agricultural use of dredged material. For example, about 500 acres of the Old Daniel Island Disposal Site in South Carolina have been successfully truck farmed for the past 8 years, and other parts of the site are planted in soybeans, an agronomic crop. The Tulsa District has approximately 2,600 acres of dredged material containment sites leased for use as grazing land. When dredged material is free of nuisance weeds and has the proper balance of nutrients, it is similar to productive agricultural soils and can be beneficial for increasing crop production when incorporated or mixed. By the addition of dredged material, the physical and chemical characteristics of a marginal soil can be altered to such an extent that water and nutrients become more available for crop growth. In some cases, raising the elevation of the soil surface with a cover of dredged material may improve surface drainage and reduce flooding and therefore lengthen the growing season. Dredged material characteristics which influence plant growth and guidance for dredged material incorporation and cover use are discussed in this section.

a. Planning Considerations. Chemical and physical analyses of the dredged material, site locations, weed infestation potential, and possible salinity problems must be considered before deciding upon the suitability of a specific dredged material as a medium for agricultural purposes. Figure 12-1 demonstrates priority listing of these factors to be used when considering the feasibility of an agricultural use for dredged material at the containment site (item 75).

(1) Chemical analyses. Since dredging operations may take place in waterways containing industrial wastes and sediment runoff from agricultural areas, dredged material can contain heavy metals, oil and grease, high nutrient concentrations from fertilizer runoff, and other contaminants.

(a) Heavy metals. Heavy metal uptake by plants is dependent on a number of factors, primarily the form and concentration of metals in the rooting media, and the type and variety of plant. Research has shown that the heavy metal uptake by plants is normally much less than the heavy metal content of the rooting media (items 25 and 44). Table 12-1 shows the range in the concentration of heavy metal uptake by agronomic and common vegetable food crops grown under normal conditions and the suggested plant tolerance levels (item 25). The question as to whether or not to produce food or nonfood crops depends upon the chemical contaminants present in the dredged material. Agricultural service agencies and extension offices can assist with guidelines and answers to specific questions. While research has shown that relationships exist between the extractable heavy metals in the soil and the heavy metal uptake by certain plants (item 46), these data are important to dredged material applications upon soils if a food crop is to be grown, but are less

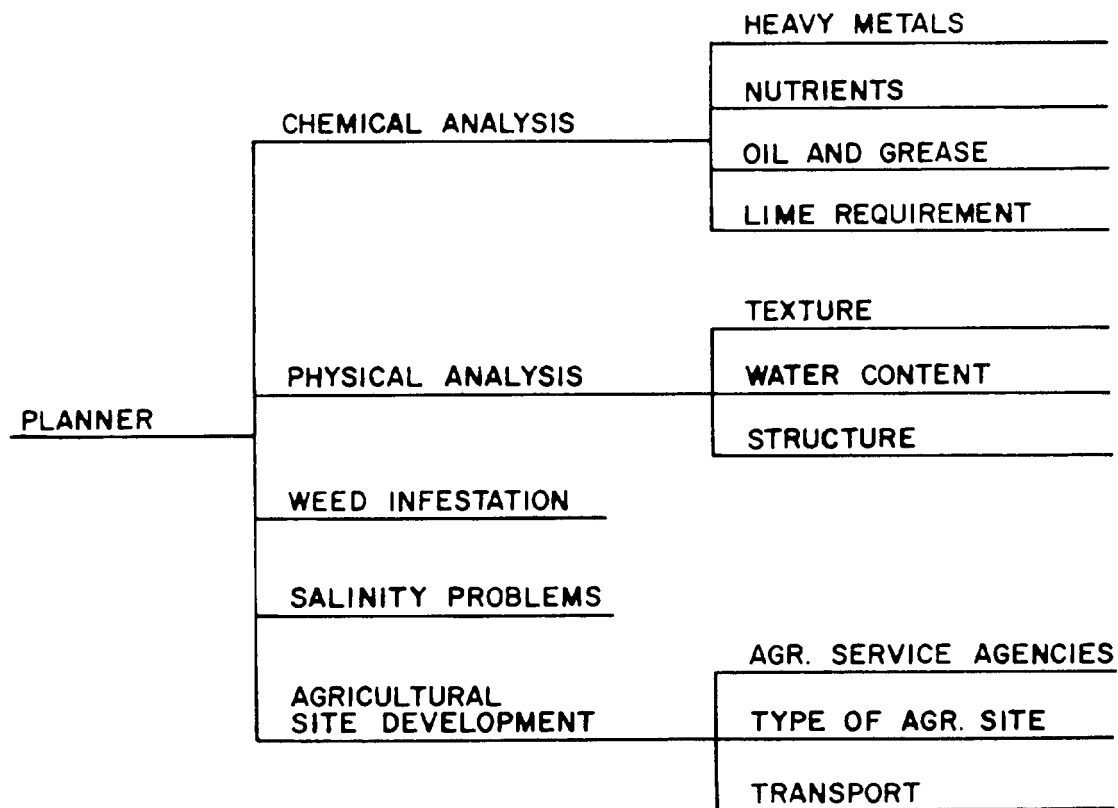


Figure 12-1. Decisional factors to be considered at the dredged material containment area before applying dredged material for agricultural purposes

important when nonfood crops are to be produced. An example of a nonfood crop is the growing of Christmas trees or pulpwood on dredged material containing concentrations of heavy metals too high for human or wildlife consumption (item 49). Another example is the uptake of minimal amounts of heavy metals in the heads of grain plants, making them a good food crop selection even if larger amounts of heavy metals are present; however, the heavy metals may concentrate in the leaves, making these grain crops less desirable when harvested as a forage.

(b) Nutrients. Nutrient analyses of dredged material should provide data to determine nutrient availability and to establish recommended fertilizer applications for vegetative production. The nutrient constituents of dredged material which require greatest attention are nitrogen, phosphorus, potassium, metallic metals, and organic compounds. Although medium- and fine-grained dredged material is normally high in nutrients available for plant uptake, the levels of these nutrients are usually not high enough to limit plant growth. However, nitrogen, which is usually in the ammonium form, will undergo nitrification rapidly in an aerobic soil. Nitrate is the readily available form of nitrogen for plant uptake or loss by surface runoff and leaching into ground water. Specific recommendations on rates of fertilizers can be obtained from the state Soil Testing Service or local agricultural extension agent, after soil tests have been conducted. A considerable portion of dredged material, especially in the Upper Mississippi River and some

Table 12-1

Average Range of Heavy Metal Uptake by Plants for Selected Food Crops\* and Suggested Plant Tolerance Levels (item 25)

<u>Element</u>	<u>Average Range ppm</u>	<u>Suggested Tolerance Level, ppm</u>
Cadmium	0.05-0.20	4
Copper	3-40	150
Iron	20-300	850
Manganese	15-150	325
Nickel	0.01-1.0	4
Lead	0.1-5.0	10
Zinc	15-150	350
Boron	7-75	200
Chromium	0.1-0.5	2

\* Corn, soybeans, tomatoes, beets, lettuce, peas, potatoes, melons, squash, alfalfa, clover, wheat, oat, barley, and pasture grasses.

coastal areas, is sterile, clean sand. In these cases, sites may never be suitable for agriculture, and will need major nutrient and soil amendment incorporation.

(c) Oil and grease. Research has shown that the oil and grease content of some dredged material is considerably higher than that of soil. However, depressed agricultural yields attributable to high oil and grease content have not been studied. Possible effects of high oil and grease content on soil properties or plant growth are an apparent slower wetting of the soil materials, a smothering effect on plant parts, and a tendency to restrict water uptake by the plants.

(d) Lime requirements. Lime requirements for dredged material vary, but if the pH of the material is below 6.5, it should be amended with ground agricultural limestone before being applied to marginal soil for agricultural production. Large amounts of sulfur in the dredged material will require heavy initial applications of lime to neutralize the acidity, as well as succeeding applications to maintain neutral conditions. A soil pH below 4.0 indicates the presence of free acids resulting from the accumulation of sulfate and nitrate ions; a pH below 5.5 suggests the presence of toxic quantities of exchangeable aluminum, iron, and manganese; and a pH from 7.8 to 8.2 may indicate an accumulation of the bicarbonate ion, and the uptake of elements will be detrimental to plant growth. Gupta et al (item 25) provides specific recommendations on rates of both fertilizer and lime to apply at various soil (dredged material) deficiency levels. A rule of thumb for lime requirements of high sulfur dredged material is to double the usual lime requirement.

(2) Physical analyses. The physical characteristics of dredged material can assist the CE in making critical judgments of the best use of dredged material to ensure against adverse impacts on agricultural lands. The texture and water content are essential tests to aid in characterization of dredged material deposits within a containment site.

(a) Texture. Textural classification helps to determine not only the nutrient-supplying ability of soil materials, but also the supply and exchange of water and air that are so important to plant life. Therefore, an important criterion is to adjust the texture of the final mixture of dredged material and marginal soil to approximate a loam soil (USDA classification). Using the USCS classification system, a dredged material of loam texture contains silts and clays whose liquid limit is less than 50. Mixing a fine-textured dredged material (silt and clay) with a coarse-textured marginal soil (sand) to the proportions of a loam would improve its physical and chemical characteristics for crop production. Sandy, coarse-grained dredged material is generally low in organic matter content, available nutrients, and heavy metal concentrations. Dredged material of this type may have potential as an amendment to heavy impermeable clay soils, improving structure and permeability. For beneficial surface applications without incorporation with existing soils, it would be preferable to apply dredged material of loam textures only. Sandy

loams are generally preferred for vegetable root crops such as carrots, beets, potatoes, and peanuts, whereas loam to silt-loam soils are preferred for row crops, orchards, and small grains.

(b) Water content. When placing dredged material on agricultural lands, it is desirable to have the water content of the material within the plastic limit range. This will present fewer problems in handling, placing, and mixing. If dredged material is to be placed in slurry form, the lift thickness should be limited to 18 inches. This thickness of dredged material will usually dry within a 6-month period, depending upon dredged material texture, to the point where soil mixing and farming operations can begin.

(3) Weeds. Weed infestation is generally a serious problem in many dewatered, inactive, fine-grained dredged material containment areas. Prior to the transport of dewatered dredged material to an agricultural site, an extensive weed control effort may have to be initiated to avoid serious weed problems to the agricultural producer. For example, an application of herbicide or removal of the top 6-inch vegetation layer of the containment area with a bulldozer before the transport of dredged material to the agricultural site would temporarily control the weed problem. Transport of such material, unless it was only to the advantage of the CE to do so, would be at the expense of the agricultural producer.

(4) Salinity. If the dredged material is from a coastal or tidal region, special attention must be given to salinity because crops will not grow on highly saline soils, and few agronomic crops will grow in brackish soils. The electrical conductivity of a soil water extract gives an indication of the total concentration of soluble salts in the soil. The term "soluble salts" refers to the inorganic soil constituents that are soluble in water. Excess soluble salts not only limit the availability of water to plants but also restrict growth. Salt-tolerant plant species are available and research on salt-tolerant agriculture crops is under way, but none have been found to be economically productive to date. Techniques for treating dredged material with high salinity problems are available and should be completed before the material is transported to an agricultural site.

(5) Agricultural site selection. The distance and mode of transportation utilized for the movement of dredged material will determine the major costs of its application to agricultural lands. Thus, the agricultural site selected should be in reasonable proximity to the dredged material disposal site and adaptable to the long-range disposal needs of the CE.

(a) Agricultural service agencies. In most areas of the country, a variety of suitable locations of marginal soils can be found by contacting the local offices of the SCS and U.S. Forest Service, as well as the local Agricultural Extension Service. Soil classification and land use maps are available from these agencies, as is direct assistance in locating marginal soils suitable for amendment with dredged material.

(b) Type of agricultural site. The type of site determines whether it can be used for agriculture, i.e., a short-term or long-term disposal area. Short-term usage means 1 to 3 months' time for the transfer of dredged material from a containment site, and for the transport, spread, mix, and cultivation of the dredged material for seedbed preparation at the agricultural site. Long-term usage implies that the agricultural site can be used as an active disposal area over a long period of time (5 or 10 years). This would involve only a few acres of the agricultural site at any one time in applications of dredged material, so that the rest of the field could be planted in crops. A schematic of a long-term disposal area is shown in Figure 12-2, where various levels of dredged material are being used for different activities. Shallow-rooted crops such as grasses, small grains, soybeans, and vegetables can be cultivated in designated areas when dredged material is first applied (6- to 12-inch depth). However, as the application of dredged material is continued in specific areas of the field (3 feet or more in depth), deep-rooted crops such as corn, sorghum, cotton, alfalfa, and trees can be successfully cultivated.

(c) Transport. The accessibility to the dredged material containment site and the agricultural site determines project viability and mode of transport. The agricultural site may have limited access due to field roads, drainage ditches, and fence locations; therefore, access routes on a farm may require design and construction to facilitate the disposal and spreading of dredged material. If the application of dredged material is to be efficient and effective, scheduling of application should not interfere with normal farm operations. Access roads to the disposal site should circumvent the farmstead and avoid the location of poultry and livestock.

b. Agricultural Site Considerations. With an understanding of the characteristics of the dredged material at the various disposal sites, consideration should be given to the potential problems at the agricultural site. Factors which must be considered at the agricultural site are properties of the marginal soil, application depth of dredged material, land preparation needs, compaction, erosion potential, flood/drainage area, and seedbed preparation (item 75).

(1) Incorporation. The beneficial effects of incorporating dredged material into marginal soils are increased available water capacity, increased nutrient supply when fine-grained dredged material is mixed with coarse-grained marginal soils, and improved drainage when coarse-grained dredged material is mixed with fine-grained marginal soils (item 52).

(a) Marginal soil. Marginal soils are not used for production of crops due to low economic return. These soils can be unproductive pastures, abandoned fields, fields requiring excessive irrigation or drainage, or areas in various stages of degradation. These soils can be made productive for a variety of economic crops by incorporating dredged material of desirable grain sizes to bring these marginal soils to a loam soil classification.

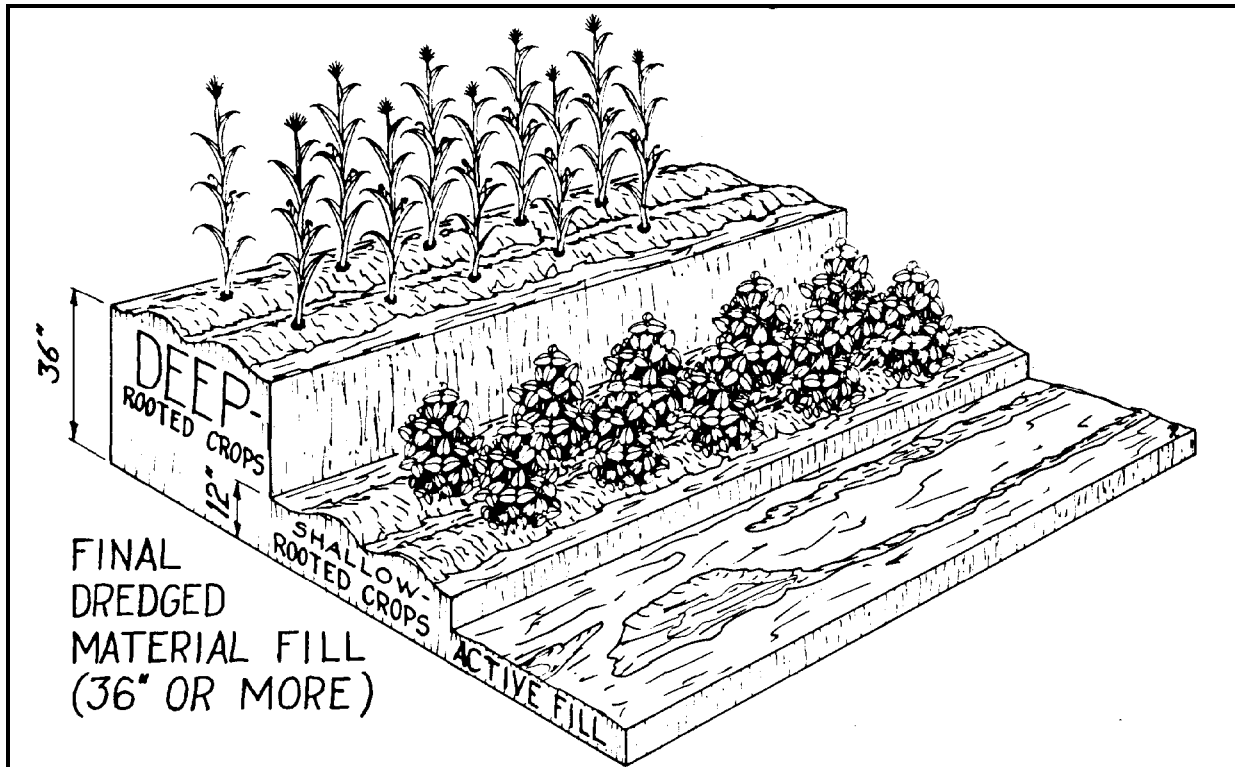


Figure 2-12. Long-term agricultural dredged material disposal site (item 75)

(b) Depth. Plant growth can be limited by root development; therefore, it is important to increase the depth of rooting media on marginal soils with applications of dredged material. To obtain an optimal mixture under normal field conditions, the depth of dredged material to be incorporated is limited to a 6-inch cover. At this depth, a 16-inch moldboard plow can furrow the 6 inches of dredged material to a depth of 12 inches using a tractor-plow combination. If incorporation of greater depths of dredged material is required, then special types of plows not common to normal farm operations must be used.

(c) Land preparation. Tillage operations prior to the application of dredged material may be useful to speed surface drying and eradicate weeds. The application of dry dredged material to level soil surfaces presents few problems when the soil surfaces are dry. If the agricultural site has poor drainage, the application of dredged material should be done after the area has had an opportunity to dry. Row drains can be constructed with a plow that cuts through low areas to provide drainage into field laterals. The addition of dredged material to slopes ranging from 5 to 10 percent may increase operational problems and the potential for erosion, as well as the sediment content in runoff water. If steep slopes (greater than 10 percent) are to be used,



standard conservation practices should apply, possibly including terraces, grassed waterways, diversion channels, and supplemental practices such as contour farming, strip-cropping, and crop rotation (item 75).

(d) Compaction. The purpose of using dredged material is to improve the agricultural site; therefore, the application and spreading of the dredged material should not impair agricultural production by severely compacting the marginal soil. For example, soil compaction problems associated with the weight per axle load of large (25-ton) dump trucks may necessitate using smaller (9-ton) dump trucks which would reduce soil compaction but increase transportation costs by 25 percent.

(e) Seedbed preparation. The use of various types of tillage equipment is, to some extent, dependent on the type of crop to be produced. However, tillage operations such as plowing and harrowing are common to all types of seedbed preparation. Cultivation and planting of the newly incorporated mixtures should be accomplished as soon as possible because tillage will increase the infiltration of water and reduce surface runoff, therefore lowering the potential for erosion.

(2) Cover. When the area to be covered is too rocky, gravelly, or otherwise unsuitable for cultivation, additions or capping with dry dredged material to depths of 1 foot or more without incorporation into the existing site may be required to improve the area for agronomic production. When dredged material is to be used as a surface cover or cap, it is best that the texture approximate a loam soil for crop production (item 25).

(a) Depth. The depth of dry dredged material to be applied in increments as a surface cover or cap should be at least 3 feet to ensure good drainage and an adequate rooting medium. This depth of 3 feet or more can be achieved by additions of 6-inch layers if the agricultural site can be used as an active dredged material disposal site over a period of years.

(b) Drainage/flood. When the soil depth is increased by additions of dredged material, the depth to the water table increases and reduces wet spots in the field, thus extending the period available for farming operations. If the area is only briefly and intermittently flooded, additions of 3 feet or more of dredged material may completely eliminate the flooding problem. If it is flooded enough to have reduced soil conditions, it is a wetland and should not be farmed.

(c) Erosion. Slopes greater than 10 percent are not generally used for the application of dredged material because the establishment of a vegetative ground cover is more difficult. When the dredged material is to be placed on erodible slopes, it should be planted in grass cover immediately until the dredged material has stabilized. If the agricultural site is a terraced area, the terraces should be seeded in a permanent vegetation cover to prevent accelerated erosion. Flat or nearly level agricultural fields are the most satisfactory for dredged material application and farming operations.

(d) Seedbed preparation. When the marginal soil is to be buried with over 2-foot depths of dredged material, it should be leveled with a bulldozer and other tractor-plow or disk combinations used for seedbed preparation. Any application of dredged material will require standard seedbed preparations to level and till the site.

c. Crop selection. There are a number of agricultural, or food, crops which have been or may be grown on dredged material. These include pasture grasses; food grains such as rice, corn, wheat, oats, rye, barley, and millet; soybeans; sunflowers; truck crops; and cotton. Crop selection for food and forage use is dependent upon climate, culture, and regional markets. The varieties of agricultural crops typically selected for production in any given area can be obtained from county and local Agricultural Extension Services and the county Soil Conservation District offices.

12-3. Horticulture. Horticulture crops are generally considered vegetable, fruit, nut, and ornamental varieties of commercially grown plants. Dredged material applications on soils for vegetable production, orchards, and nurseries will not differ from the guidelines discussed under agricultural planning and site considerations. Discussion will be limited to special horticultural crops.

a. Vegetable Production. All commercially grown vegetable truck crops can be produced on dredged material amended soils. Vegetables grow best on sandy loam soils of good texture, drainage, and aeration. The best types of dredged material mixtures for such crops would be sandy silts or silty dredged material which can be incorporated into an existing sandy site, or sandy dredged material which can be incorporated into an existing silt or clay site. Clays in general are too heavy for good vegetable production, but they could be improved by applications of sandy material.

b. Orchards. Few fruit and nut crops are produced close to waterways and dredging sites, with the exception of pecan orchards. In general, pear/peach/apple orchards and other pome fruits grow best on hillsides and out of low bottomlands, and citrus orchards generally grow best away from the influence of salt-spray. Although no disposal sites have been planted as orchards, such application is probably feasible. However, additional applications of dredged material once trees are established would have to be limited to not more than 6 inches to prevent damage to root systems due to soil aeration changes.

c. Ornamental Plant Nurseries. Ornamental liner shrubs in nurseries are grown two ways: potted or set in the ground in a high-quality soil mixture. Either type requires horticultural soil mixes of loamy soil, sand, peat, and vermiculite. Dewatered dredged material could be applied as a part of the soil mix in areas where soil must be trucked into nursery sites at considerable expense. Most commercial nurseries make their own soil mixes, and may be amenable to use of good quality dredged material. The major disadvantage would be the limited quantities of material a nursery would require.

d. Sod Farms. Urban and suburban areas require large quantities of readily available grass sod for such uses as residential lawns, parks, golf courses, and rights-of-way. Unless sites are available near these high-population areas for sod production, sod must be trucked into the area for sale by retail nurseries and shops. Marginal soils near urban centers could be brought into grass sod production through applications of dredged material. Since grass sod is less exacting in its growth requirements than most food crops, the type of dredged material used is not as critical. However, the material should be a loamy or silty sand substrate, if possible, to ensure best grass growth.

e. Christmas Tree Farms. Another specialized use of dredged material is the cultivation of Christmas trees on disposal sites (item 75). This has already been carried out successfully in the Baltimore District. Since Christmas trees require 5 to 8 years to reach marketable size, the disposal site or compartment on larger disposal sites is generally unavailable for such beneficial use. This will limit the feasibility of this option in most waterways where dredging occurs. If dewatered material is trucked (at sponsor expense) to a marginal soil site, then planted with trees, this beneficial use option would be more acceptable.

#### 12-4. Forestry.

a. For a number of years, the timber industry has been working with tree genetics to produce faster growing, stronger trees, and with reclamation of disturbed eroding sites using trees, primarily pines. However, some hardwoods and black walnut have been tested in the northcentral United States, and numerous cottonwood, sycamore, and eucalyptus plantations for paper production have been planted in the southern United States. The improvement of marginal timber land with applications of dredged material would be received with interest and enthusiasm from foresters who have the problem of trying to produce timber on poor soil. There are several rapidly growing pulpwood species that may be grown in large disposal sites with several compartments once the compartments are nearing completion. Dewatered dredged material trucked to marginal land or abandoned disposal sites would be the sites most appropriate for timber production.

b. The same physical and chemical soil properties discussed under agricultural considerations would apply to forestry, except that trees could be grown safely on dredged material with higher contaminant levels than could food crops. The tolerance level of each timber crop for heavy metals and other contaminants and the physical characteristics of the material would be forestry limiting factors.

c. Since land would be tied up in tree production after planting for 10 to 30 years, the primary disadvantage of this beneficial use would be loss of disposal sites. An advantage would be use of moderately contaminated dredged material not suitable for many other beneficial uses. Dredged material trucked into a site could be spread with heavy equipment as deeply as

desired by the forester since tree roots penetrate several feet into the substrate. Large quantities of dredged material could be disposed of on marginal sites in this manner, and made productive.

d. Commercial tree species that would be suitable for timber production on dredged material would be eastern cottonwood, American sycamore, eucalyptus, green ash, water oak, and sweet gum on periodically flooded (limited flooding) sites. These species would also have a shorter rotational requirement of 5 to 15 years. Long-leaf pine, slash pine, loblolly pine, black walnut, white ash, pecan, and several oak and hickory species would grow best on upland sites amended by dredged material applications.

CHAPTER 13

STRIP MINE RECLAMATION AND SOLID WASTE LANDFILL

13-1. General. Two beneficial uses of dredged material that are still fairly new concepts have proven to be feasible in laboratory, field, and District tests (items 4 and 75). These are the reclamation of abandoned strip mine sites that are too acidic for standard reclamation practices, and the capping of solid waste landfills (item 75). Both uses would require large quantities of dewatered dredged material that could be moderately contaminated and still be acceptable. Both uses would ultimately provide nonconsumptive vegetative cover to unsightly areas, and the areas could be further reclaimed for minimal-use recreation sites and/or wildlife habitat. Item 75 provides excellent discussion of both types of beneficial uses. The techniques discussed in this chapter also apply to pyrite soil reclamation, gravel pits, and rock quarries. St. Paul District has reclaimed an abandoned gravel pit, and Portland District has reclaimed a rock quarry using these techniques.

13-2. Strip Mine Reclamation. Various techniques have been developed to control acid mine drainage from surface mine spoils. The primary purpose of these techniques is to reduce air and water contact with the acid-generating mine spoils. Methods which accomplish this are reducing slopes, thereby lowering runoff velocities and erosion, and establishing plants on the mine spoils. A balance must be struck between slope reduction and increased infiltration capacity. Attempts to establish vegetative cover on highly acidic mine spoils have usually resulted in low survival rates. The lack of a vegetative cover on mine spoils will result in erosion and further exposure of acid-generating pyrites to air and water (item 75). In order to reduce adverse effects of mine spoils, placement of a topsoil or topsoil substitute suitable for vegetative growth such as dredged material is recommended. Application of dredged material to surface mine spoils will provide a cover that will reduce the infiltration of water and the diffusion of air to the pyrite material, and provide a suitable growing medium for vegetation. Planning must be coordinated with the landowner and, if the mine is an active surface mine, the mining operator. Before reclamation activities can commence, State reclamation laws which include the final grade of the area, cover requirements, and vegetation requirements must be assessed. Assistance for various aspects of surface mine reclamation can be obtained from state reclamation departments, county agricultural extension offices, the SCS, and the U.S. Office of Surface Mining.

a. Dredged Material Requirements. Dewatered dredged material can be used for surface mine reclamation in much the same way as topsoil or agricultural soil. If construction on the site is considered as the final land use for the reclaimed mining area, tests for consolidation, shear strength, and permeability should be performed on the dredged material as well as the mine spoil. Fractions of dredged material having different grain sizes can be mixed to provide a surface with desirable physical and engineering properties.

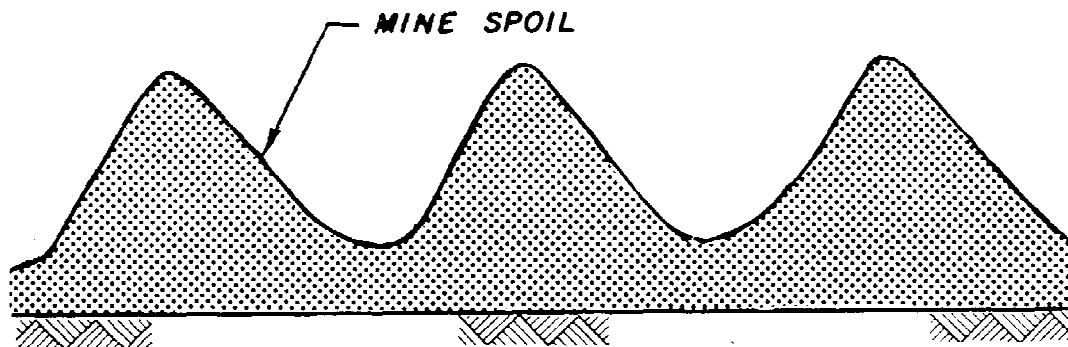
Almost any desired soil property can be obtained by dewatering, mixing, and compacting dredged material (item 4). Fine-grained or sandy silt dredged material can be used as a cover on mine spoils for the establishment of vegetation. Dewatered dredged material having a loam texture is the most desirable for best vegetation growth. The dredged material should be tested for pH, organic content, and soluble salts. It should have a nearly neutral (6.0 to 7.5) pH, a minimum organic content of 1.5 percent by weight, and a low amount of soluble salts (500 ppm or less) to allow optimum plant growth.

b. Site Preparation and Dredged Material Placement. The amount and method of site preparation needed at surface mines are dependent on the topography, the method of mining performed (area, contour, open pit, etc.), and the final land use. Site preparation consists chiefly of regrading the surface mine to a configuration that will accommodate a dredged material cover at a desired thickness and slope to support vegetation. The two principal surface mining techniques are area and contour mining. The potential for ground water percolation and contamination should be determined for both the mine spoil and the dredged material.

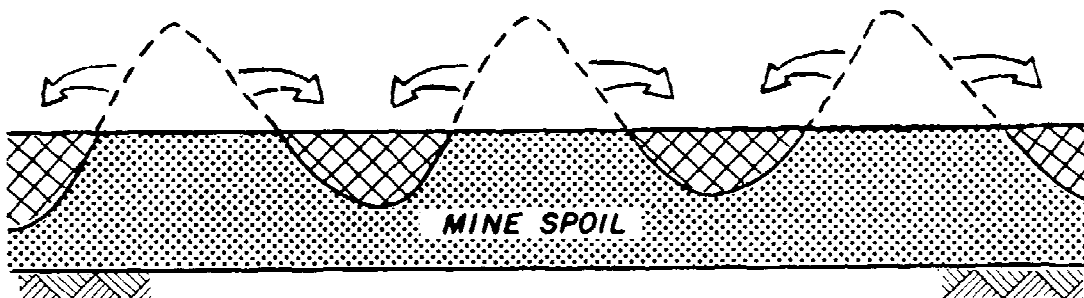
(1) Area mining reclamation.

(a) The area mining method produces the characteristic topography of a series of parallel ridges or piles of mine spoil. Site preparation consists of leveling mine spoil ridges or piles to a width specified by law and/or final land use. Leveling or "striking off" mine spoil ridges is accomplished by bulldozing the ridges into the valleys between ridges. The mine spoil piles should be leveled to a topography where conventional earthmoving equipment can spread dewatered dredged material to a desired thickness (Figure 13-1). This method of leveling was field tested by the Chicago District at Ottawa, Illinois. The mining site was leveled, capped with dewatered material, mixed, soil amendments added, and planted in a grass mixture. The site established vegetative cover rapidly, and is a very successful site (item 63). It has still maintained good vegetation cover 8 years after planting.

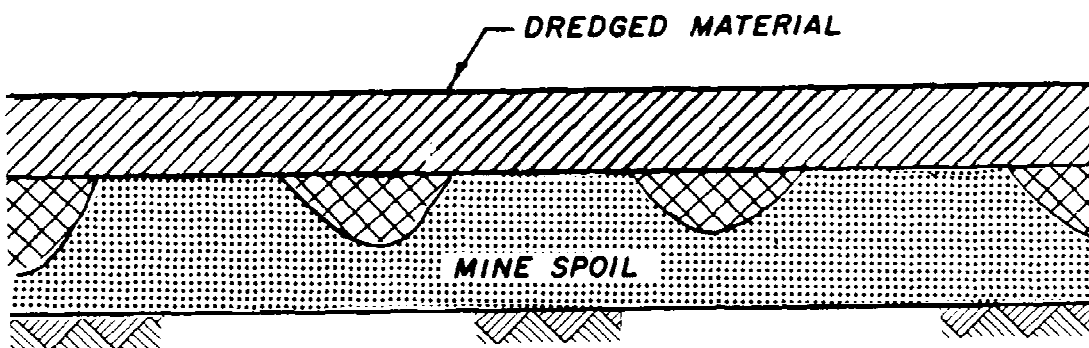
(b) An alternate concept of reclaiming area mines is the use of slurried dredged material. This method to date has not been field tested, but appears promising. It consists of hydraulically pumping dredged material in a pipeline onto a prepared area mine. This form of reclamation is only feasible for area mines located within pumping distance of an active dredging operation or rehandling basin. Preparation of the site consists of grading mine spoils to a fairly uniform level and constructing dikes around the area to contain the slurried dredged material. Because of the slurry's high water content, it must be pumped in lifts and allowed to dewater before adding the next lift. The depth of each lift is dependent upon the final land use and time constraints (item 57). If the area is to be used for foundation material to support lightweight structures, the lifts of slurried dredged material should be limited to about 36 inches so that drying will be enhanced (item 52). The dredged material should be allowed to dry to a moisture content near its



a. Prereclamation



b. Grading the mine spoil



c. Application of dredged material

Figure 13-1. Schematic diagram showing operational techniques used to reclaim a surface mine spoil with dredged material

plastic limit before adding the next lift (item 57). If the area being reclaimed is not planned to support structures and is mainly being reclaimed for recreation or vegetation establishment, the depth of each lift can be increased and the amount of time between lifts can be shortened.

(2) Contour mined land reclamation.

(a) The reclamation of contour mines is more difficult due to the hilly terrain in areas where this type of mining occurs. This technique of mining requires removal of the overburden by starting at the outcrop of the coal seam and proceeding along the contour around the hillside. The highwall is located on the uphill side, while a rim and steep downslope are covered by the spoil material cast down the hillside. Being above the grade of local drainage, water from the pits flows directly into natural waterways. Reclamation of contour mines involves backfilling and terracing the disturbed land to the approximate original contour or to a contour compatible with the surrounding terrain. This requires placing dredged material into strip pits and over the mine spoil which was cast downhill (Figure 13-2).

(b) The choice of which regrading technique to use for reclamation depends on many variables, including final land use, terrain, amount of dredged material, and state and Federal reclamation requirements. Concepts for using dredged material on contour mine backfill are shown in Figures 13-2, 13-3, and 13-4. The use of dredged material to reclaim the mine to the original ground surface level and contour is demonstrated in Figure 13-2. The mine spoil on the downslope is also covered with dredged material to provide a vegetative media. Figure 13-3 shows the use of the Georgia V-ditch technique which does not fill to the original soil surface but leaves a highwall and fill section to be leveled to support vegetative as well as agronomic production. The slope reduction technique, as shown in Figure 13-4, permits stockpiling of dewatered dredged material before final grading to original slopes and contours.

c. Vegetation Establishment.

(1) Establishment of a quick vegetative cover is important at reclamation sites for it is one of the most effective erosion control methods (item 63). It must be known whether the area is ultimately to be used for farming, grazing, construction, temporary soil stabilization, restoration for aesthetics, or other purposes. When selecting vegetation, plant species should be chosen that will be able to adapt to dredged material conditions, such as low pH, high moisture, grain-size distribution, and fertility level. The species selected should be adaptable to the climatic conditions (sunlight exposure, temperature, wind exposure, rainfall) found at the site. It is best to choose vegetation native to the area which can be easily propagated. A species mixture should be planted to ensure successful establishment of a vegetative cover (item 63).



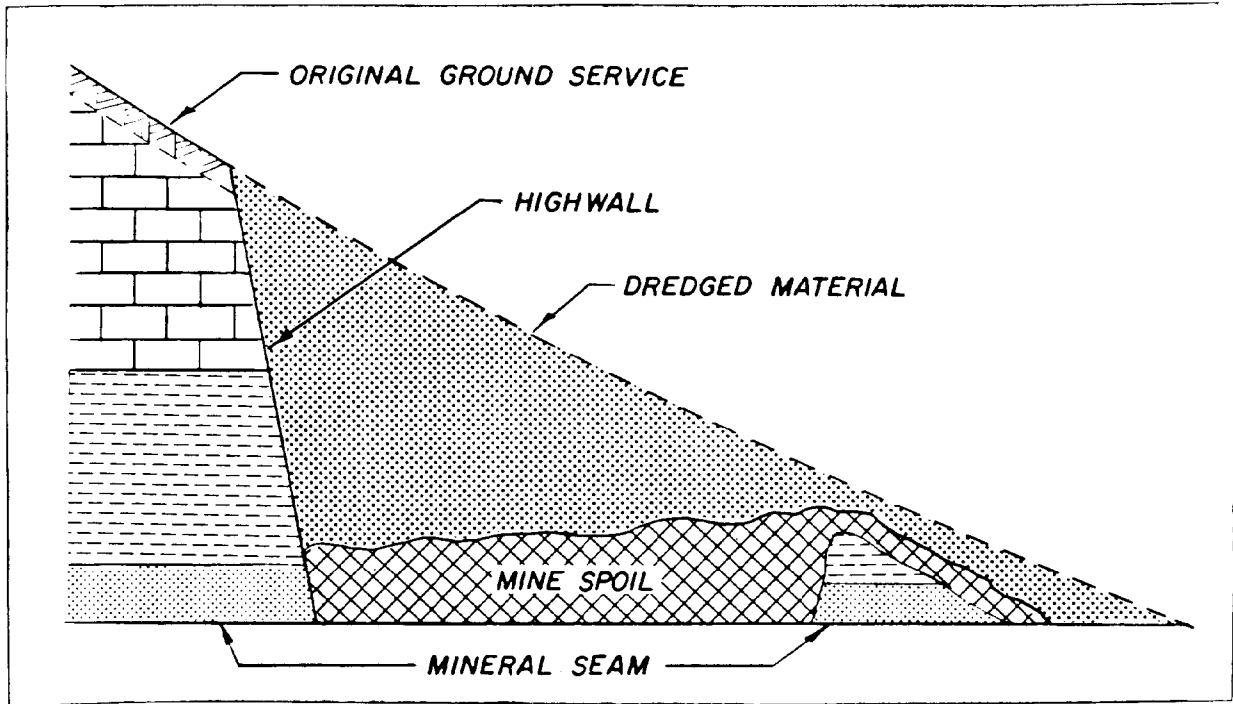


Figure 13-2. Gross-sectional view of contour backfill technique  
(item 75)

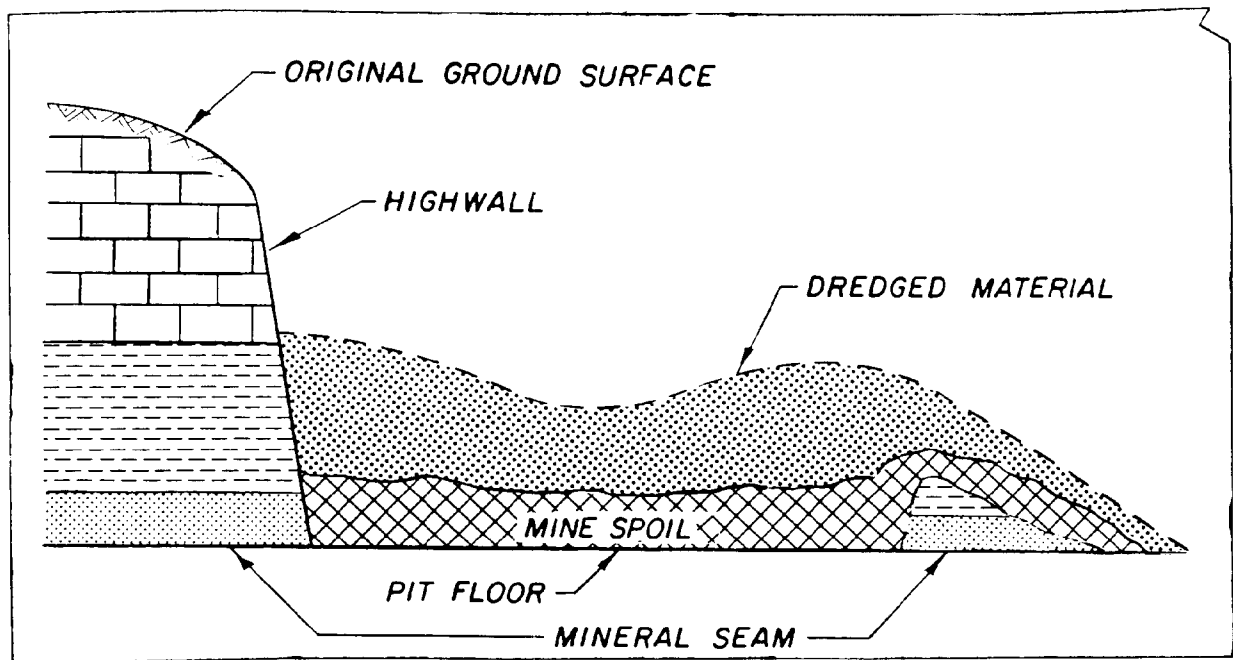


Figure 13-3. Gross-sectional view of the Georgia  
V-ditch backfill technique (item 75)

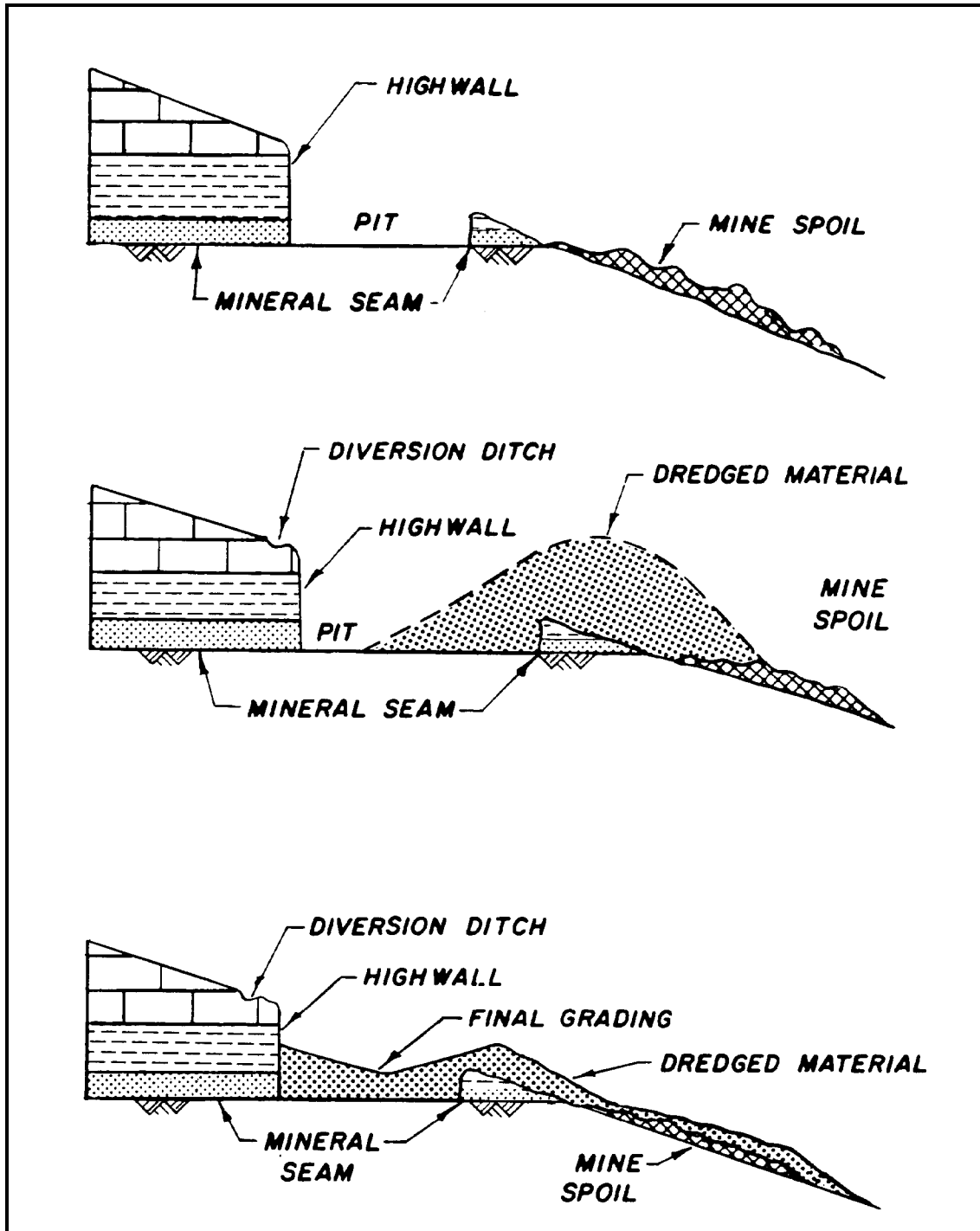


Figure 13-4. Schematic of slope reduction technique (item 75)

(2) It is desirable to roughen or cultivate the dredged material surface before seeding in order to reduce the velocity of rainfall runoff and increase water infiltration to seedbed depth. The surface of the dredged material should not be compacted because this impedes seedling emergence. Common methods for preparing the surface of the dredged material are scarification, tracking, and contour benching or plowing using disks, harrows, and tractors. Tracking grooves made by the cleats of a tractor should run parallel to the contour. Contour benching is performed on long slopes to build terraces to reduce the velocity of rainfall runoff (item 75). Terracing is performed with a bulldozer running parallel to the contour and allowing the soil to dribble off the edge of the blade. Furrowing of a terrace is performed by repeated plowing parallel to the contour. Other methods for planting such sites are available in items 16 and 32. Dredged material should not be placed on a slope that is in a frozen or muddy condition or when the subgrade is excessively wet or in a condition that may be detrimental to proper grading and the proposed seeding. Hydromulching or mechanical mulching on new cuts, revetments, dikes, and terraces is also usually required to prevent erosion.

d. Site Selection. Mining sites that would be suitable for dredged material disposal for reclamation purposes must meet certain criteria. The mined areas should be assessed for transportation capabilities as well as qualitative considerations such as social and environmental concerns. Field investigations of potential sites should include such general factors of the site as geology, ground water, effluent standards, ambient water quality, land costs, drainage, surrounding land use, and vegetation of adjacent lands. Permission for site use must also be obtained. Transportation costs are a major consideration, and are generally at sponsor expense. For this reason, mines that are near disposal sites and/or suitable transportation systems are probably the only ones feasible for consideration.

13-3. Solid Waste Landfills. Governmental agencies responsible for the management of solid waste are experiencing difficulties in obtaining suitable sites on which to operate environmentally sound solid waste disposal operations. A major portion of the solid waste generated in this country is ultimately placed on land in sanitary landfills. The location of a sanitary landfill is often constrained by the cover material requirements and availability and the site characteristics related to potential adverse environmental impact. Item 3 reports that dredged material can satisfactorily perform the functions of a cover material, thereby making it possible to locate sanitary landfills at sites previously considered unsuitable due to a lack of native cover soil. St. Paul and Mobile Districts have both used clean dredged material as caps for urban landfills. This section is intended to aid planners in determining the suitability of dredged material for productive use in solid waste management schemes and to provide guidance for development of possible landfill projects (items 3 and 75).

a. Dredged Material Characteristics. The potential uses for dewatered dredged material in a sanitary landfilling operation are as a material for

covers, liners, gas vents, leachate drains, and gas barriers. Chapter 2 presented a discussion of physical and chemical characteristics to be considered when using dredged material in a land improvement project. Some dredged material grain-size distributions are generally more suitable than others.

(1) Cover. The solid waste in a sanitary landfill is covered daily with at least 6 inches of material to prevent an unsightly appearance, control vectors at the site, prevent internal fires, and control surface water infiltration. Landfills with two or more lifts must have intermediate covers 12 inches deep between lifts. The intermediate cover must fulfill all functions of a daily cover for up to 12 months and must be trafficable to assist vehicle support and movement. Dredged material characteristics of a desirable cover material are easy workability, moderate cohesion, and significant strength. A mixture of sand, silt, and clay has been shown to be a suitable cover material; if a gravel is fairly well graded with 10 to 15 percent sand and 5 percent or more fines, it can make an excellent cover. The only types of dredged material eliminated for use as cover are highly organic materials and peat. Due to the difficulty in handling, dredged material should not be used in the slurry state. On the other hand, the use of dewatered dredged material as cover is operationally feasible because the material can be easily hauled, spread, and compacted by conventional earth-moving equipment.

(2) Liners and barriers. Barriers and liners serve the same purpose, i.e., to prevent the migration (lateral and vertical) of leachate water or decomposition gases. The suitability of the dredged material for this use is determined by the permeability of the material. Dredged material with classifications of CL or CH is likely to be suitable for use in constructing a liner or barrier. Attempts should be made to keep these barriers and liners saturated to prevent cracking and to keep pore spaces filled with water to prevent gas leaks.

(3) Gas vents and leachate drains. Gas vents are used to direct the flow of gas to the atmosphere where it is harmlessly dissipated, and leachate drainage layers are used to intercept leachate and drain it to an area where it can be collected for treatment or recirculation (item 3). The controlled ventilation of gas requires that the vent be more pervious than the surrounding soil, and a leachate drain must also be very pervious so that leachate will be drained quickly away from the solid waste. To be suitable for venting gas or draining leachate, the dredged material must consist of sand or gravel with little or no fines and must be much more pervious than the soils at the site.

b. Site Considerations.

(1) Site selection. The selection of the solid waste disposal site will be the decision of the governing sanitary district. Site suitability and site management options will be evaluated by the sanitary district. The offer of dredged material to these districts allows them to consider sites initially screened out due to the lack of natural soil cover. It should be remembered

that in this beneficial use, the CE is simply providing a useful material to a sanitary district; therefore, site selection and construction and operation of the landfill are not the responsibility of the CE.

(2) Preliminary dredged material data collection. The dredged material source (dredging operation or containment area) should be defined in terms of location and quantity. Critical dredged material characteristics should be determined by examining physical and engineering characteristics and settling properties and by noting any evidence of contaminants. The available dredged material should be viewed in terms of suitability for sanitary landfill use, i.e., as covers, liners, barriers, vents, and drains. The dredging area should be assessed for available transport modes.

(3) Transport systems. For dredged material uses in solid waste management to be economically attractive, the landfill site must be within a reasonable distance of the dredged material supply. Not more than 50 miles is recommended in order to keep the unit cost of shipment down. Truck haul is the only mode of transport recommended because of its convenience, feasibility of operation, and ease of fitting into landfilling schemes (item 40).

(4) Economics. The success of any attempt to use dredged material in solid waste management will be dependent upon the economic feasibility of the project for each of the agencies concerned. Since each operation involving the use of dredged material in solid waste management is unique, economic feasibility is evaluated on a case-by-case basis. There should be a net benefit to all agencies involved.

## CHAPTER 14

### MULTIPURPOSE USES AND OTHER LAND USE CONCEPTS

14-1. General. With careful engineering design, construction, long-term coordination and planning, and proper implementation of operational and maintenance procedures, a disposal site having combinations of uses may be developed. This multipurpose use of disposal sites is strongly encouraged. A park and recreational development built over an existing solid waste landfill using dredged material as a cap is an example of how several of the beneficial uses discussed in the preceding sections can be lumped into a multipurpose project. There are a number of actual and planned examples of multipurpose sites. Often, multipurpose objectives do not involve substantial cost increases to the dredging project when plans are made in the initial phases of design and construction. Frequently, recreational use and wildlife and fish habitat can be developed simultaneously on a disposal site. Potential problems with development of multipurpose projects are usually related to conflicting user groups of the proposed disposal/development site. Careful selection of compatible potential users can avoid situations where the projected uses conflict.

#### 14-2. Case Studies.

a. One example which demonstrates what can be accomplished when poor-grade dredged material is placed in conjunction with higher quality material to produce a multipurpose site is Aquatic Park in Toronto, Ontario, Canada. Along the shoreline, numerous commercial, transportation, and recreational sites have been created by the combined use of landfill and dredged material. Aquatic Park, under development by the Toronto Harbour Commissioners, is an excellent example of how the form of the land created can enhance the number and quality of productive uses. Construction rubble was used to create an approximately 3-mile-long headland running at an oblique angle to the natural shoreline. The headland is essentially linear but has numerous indentations in its shoreline dike. Dredged material was placed in the water behind the rubble dike where protection is afforded from wave and tidal action and associated erosion. The dredged material was placed to form contours for the development of lagoons and lakes along and behind the shoreline. The resultant configuration of the headland resembles natural landforms in the area. The length of shoreline- is many times the length that would have resulted from a conventionally shaped disposal area; thus, opportunity for shoreline utilization has been increased. Figure 14-1 shows Aquatic Park during dredged material placement in early stages of development.

b. Another very interesting and highly successful case study is Pointe Mouillee in western Lake Erie, Michigan (item 42) (Figure 14-2). Pointe Mouillee has been under development by the Detroit District for over 10 years. All engineering operations on the island portion and dikes were completed in 1983. The marsh phase of site development, including construction of

EM 1110-2-5026  
30 Jun 87

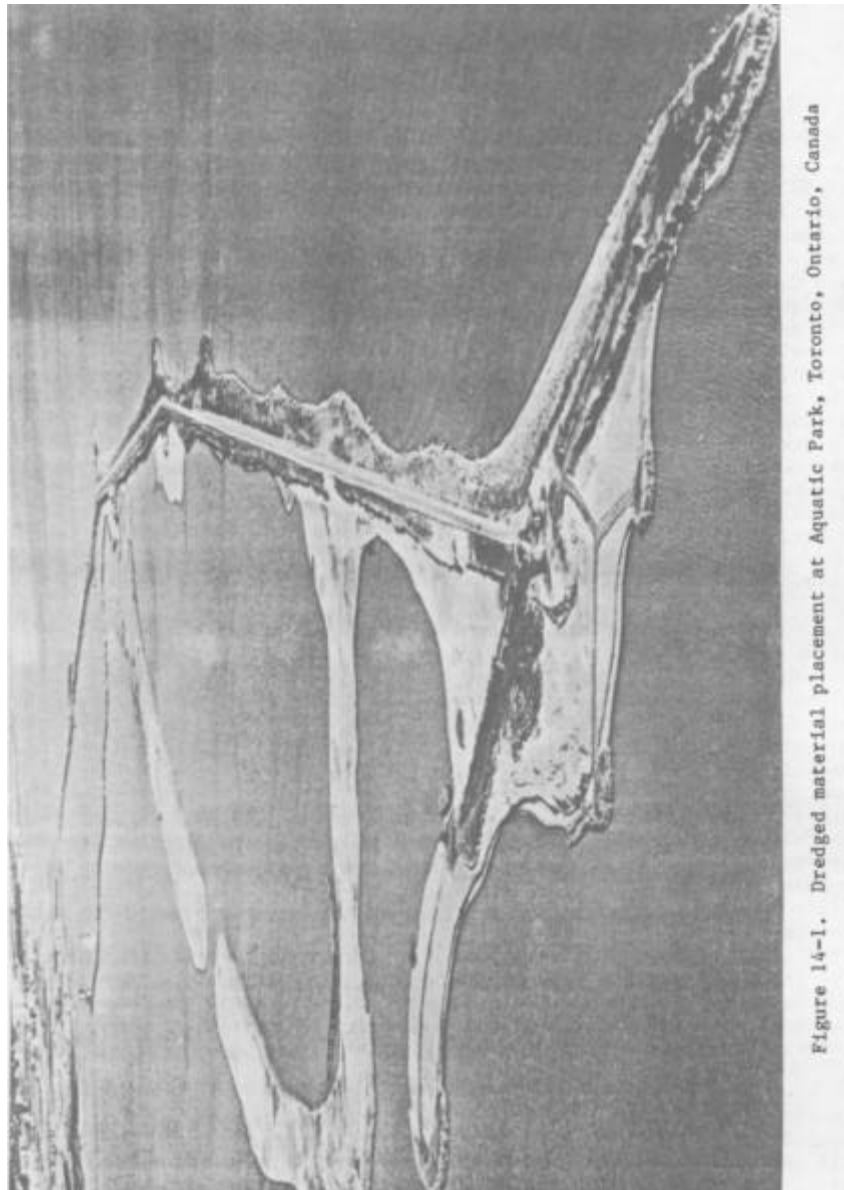


Figure 14-1. Dredged material placement at Aquatic Park, Toronto, Ontario, Canada



Figure 14-2. Pointe Mouillee, in western Lake Erie, is a CDF for contaminated dredged material that also serves as a multipurpose beneficial use site



freshwater marshes, marinas, visitor center, public walks and areas, and fishing facilities, has just begun. The existing marsh inside the installed floodgates is progressing naturally, nourished by sediments trapped by channeling part of the Rouge and Detroit Rivers through the marsh. The nesting islands built of dredged material are covered with tall vegetation, and the fringes are being used by nesting waterfowl. Portions of the shoreline have been planted in grain fields for wildlife. Many of the barrier island dike compartments have been filled with dredged material to capacity, and they are colonizing naturally with locally occurring plant species. The island is scheduled to be planted with perennial grasses and forbs to create nesting and grazing meadows. Capping the dredged material with clean soil is also being considered (item 42). The dikes of the island have had waterbird use for loafing and feeding since construction began, primarily by gull species. This follows the expected pattern for construction in Lake Erie noted in the 1970s in which virtually every new dredged material site was colonized by nesting seabirds if the site consisted of suitable habitat (item 73). A management plan for the site was drafted in 1980-81 and is being followed carefully. This site is only one of two in the United States in which a CE District has applied and received permission to use Section 150 funds of the Water Resources Development Act (P.L. 94-587) for wetlands development, and up to \$400,000 per dredging project has been earmarked for habitat development of Pointe Mouillee (item 59). This site is multipurpose, providing wetlands, upland, island, and aquatic habitat development; fishing, hunting, boating, recreation; ice fishing; nature trails; marina; visitor center; bird watching; and jogging and hiking.

c. A third example of a multipurpose disposal site is being developed in Coss Bay, Oregon, where a large containment site with eight compartments and extensive cross dikes is being filled and dewatered incrementally. The site will ultimately be developed for port, industrial, residential, and urban uses by the local sponsor, and parts of the site are scheduled for agricultural crops (Figure 14-3).

d. Some of the beneficial use examples given in other chapters of this EM that have actual multipurpose use include Gaillard Island at Mobile, Alabama; the aquaculture project at Freeport, Texas; all of the examples in Chapters 11 and 15; and a number of island habitat development sites where recreation and boating are also prime uses.

14-3. Other Land Use Concepts. Dredged material beneficial uses described and discussed in this EM are all highly productive, environmentally and economically acceptable alternatives to standard disposal practices. Dredged material has been shown in numerous cases to be a valuable resource with comparable properties of any saturated (or dewatered) soil. A few uses that may be considered beneficial did not merit separate chapters, but will be discussed here for completeness of this manual.

a. Erosion Gully Fill. Large quantities of dredged material could be disposed of within the numerous gullies formed from poor soil conservation

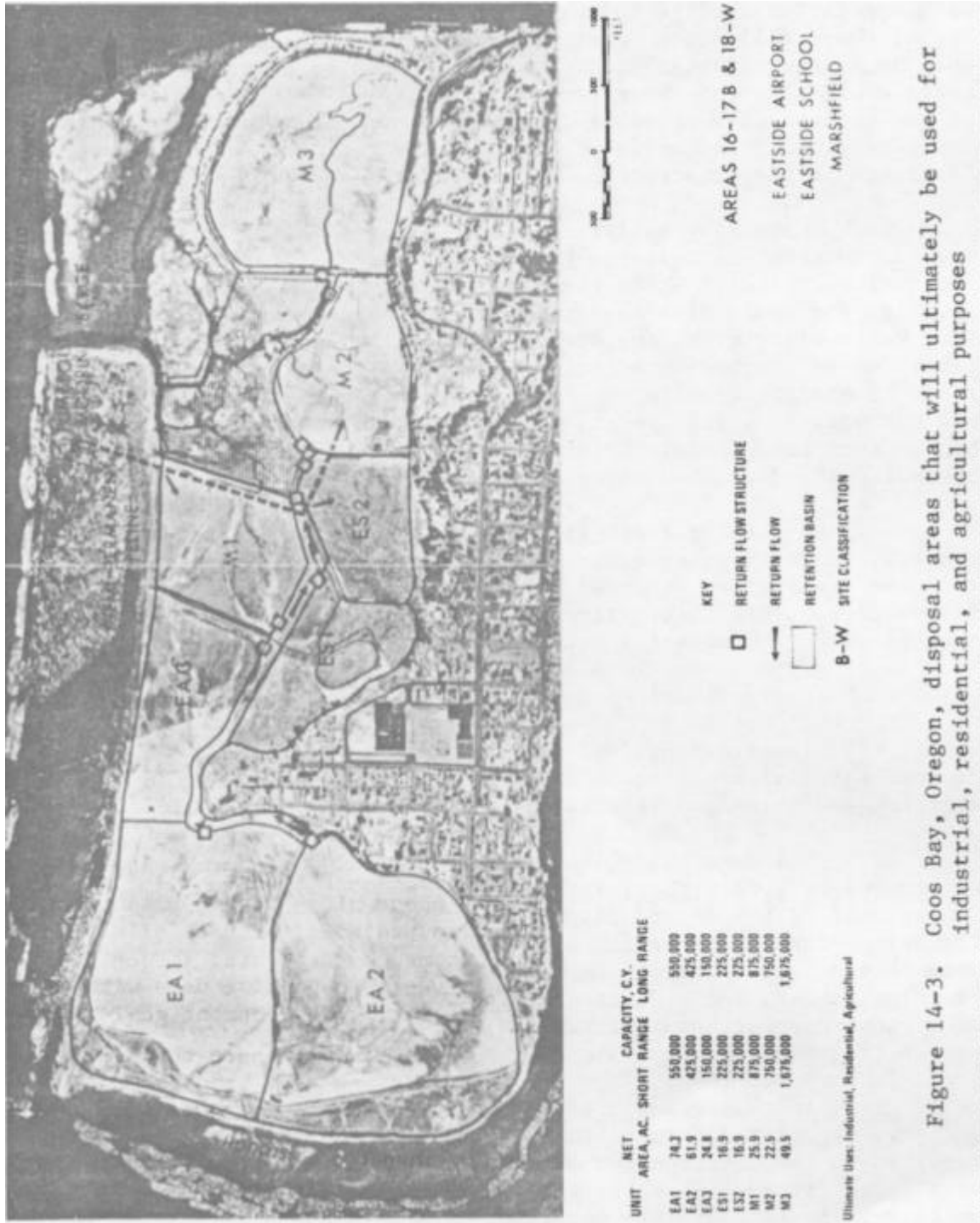


Figure 14-3. Coos Bay, Oregon, disposal areas that will ultimately be used for industrial, residential, and agricultural purposes

practices in both rural agricultural and urban construction areas. Such gullies are unsightly and unproductive and, generally, attempts to cover them with vegetation such as kudzu, rather than to reclaim them, are made. Since few of these hill sites occur within reach of hydraulically pumped material, only dewatered and transported material could be used. Transport and handling costs would make this an expensive alternative that probably will find little if any economically feasible justification. An example where this beneficial use was actually accomplished is the gully fill done by Mobile and Nashville Districts in the construction of the Tennessee-Tombigbee Waterway.

b. Topography Relief. Another means of using large quantities of dredged material is building hills for landscape diversity on large, level recreational sites. While this also usually would apply only to dewatered material and would also be costly, it has been considered in planning by the Fort Worth District in the special case of new work dredging in the Trinity River due to the huge quantities of material to be moved. It is being practiced in modification in the Red River Navigation Project in Louisiana, where new cut work is being used to build up island sites in the river to a level higher than the floodplain for recreation. These Red River sites employ hydraulically deposited material.

c. Earthen or Earth-filled Dams. In areas where reservoirs for flood control, recreation, or other purposes are planned, dewatered dredged material could be transported and used for construction of either earthen or earth-filled dams. This alternative would only be feasible in locales where other sources of borrow material are more costly or unavailable.

d. Institutional Use.

(1) Institutional use includes all public service/municipal uses of dredged material containment areas such as electric utilities, transportation systems, and water and wastewater facilities.

(2) One case study is Pleasure Island, bordering the Intracoastal Waterway near Port Arthur, Texas, a 3,500-acre land area formed from over 50 years of silt and sand disposal. A rock dike protects a small portion of the island that is presently developed. Among the diverse facilities developed thereon are a university campus (Lamar University), an Army Reserve Training Center, and a CE Area Office. Two recently constructed rock dikes will encourage further institutional facilities including an already planned sewage treatment plant.

(3) Another example is in Salem County, New Jersey, where a 1967 land exchange negotiated between the CE and the local public utility company has resulted in the construction of a nuclear power plant on a 200-acre disposal site. The first of four units commenced operation in 1976; the remaining units were on-line by 1979 and 1980. The site was originally a sandbar upon which fine-grained material from Delaware River dredging over the past

EM 1110-2-5026  
30 Jun 87

70 years had been placed to form a peninsula; it is now called Artificial Island.

CHAPTER 15

CONSTRUCTION AND INDUSTRIAL/COMMERCIAL USE

15-1. Harbor and Port Facilities.

a. The economic potential and social productivity of industrial/commercial activities provide a strong incentive for urban growth and development. These activities have flourished in natural harbors and along urban waterways where raw materials can be received and finished products shipped most economically. Industrial/commercial development near waterways has been aided by the availability of hydraulic fill material from nearby dredging activities. The use of dredged material to expand or enhance port-related facilities has generally received local support because of the readily apparent potential benefits to the local economy. Approval of the disposal operation is generally predicated on the advancement of the port development project and not on the incidental need for proper disposal of the dredged sediments. Traditionally, where disposal has been to advance the industrial development goal, attempts were made to use the dredged material beneficially; where it would not, the material was disposed of by the most economical means available. The key for the beneficial use planner is to identify how, when, and where dredged material from a navigation project can fulfill an economic need, while not overlooking biological beneficial uses and environmental considerations and limitations. Identification of economic or social benefits may help overcome some environmental opposition to disposal sites. Job-producing planned uses in cities with depressed employment are much more likely to gain approval than projects that appear to conflict with basic community needs.

b. There are numerous examples of dredged material sites that were used in harbor/port development. One such facility constructed on dredged material is the Presidents Island-Memphis Harbor Project located approximately 5 miles southwest of Memphis, Tennessee (Figure 15-1). It is a 960-acre site on the southeast side of the island (now a peninsula) filled with sandy dredged material. A slack-water area was created by diking, and an 800-foot-wide by 12-foot-deep channel was dredged and the sediments placed along 3.5 miles of the channel's north bank. Filling was completed in 1957, and within 20 years most industrial development was completed. By 1973 over 70 separate industrial concerns had bought or leased acreage on the site. A feasibility study of proposed harbor expansion alternatives prepared by the Memphis District recommended that a second harbor channel be dredged at Presidents Island and the material placed on the island along the new channel's south bank. This proposal would create an additional 1,000 acres above the floodplain for port and related industrial/commercial facilities. When the first facility was completed, there was little concern for the wetlands that were covered up. Expansion plans must take these wetlands into careful consideration.

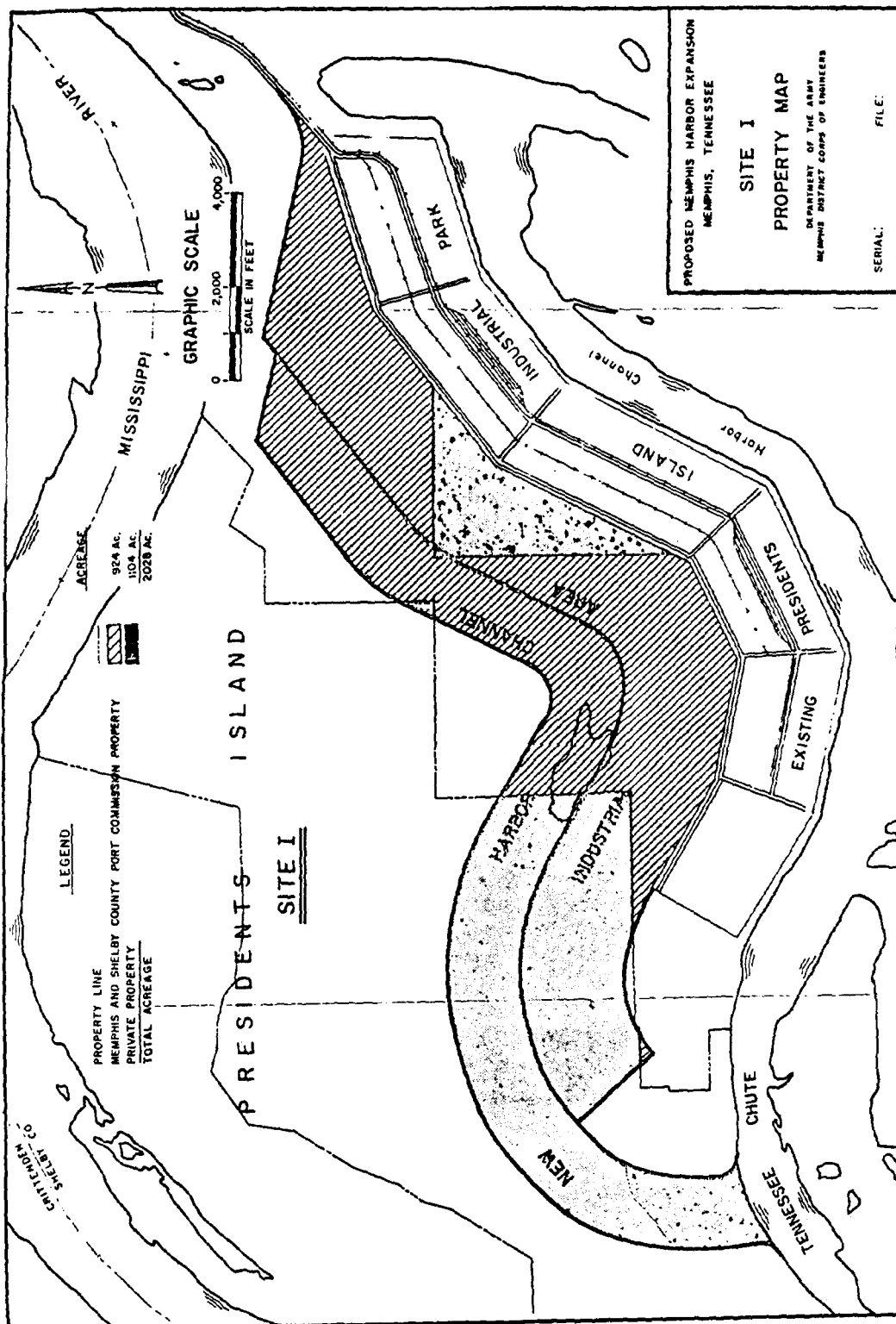


Figure 15-1. Presidents Island-Memphis Harbor Project

c. In dozens of locations in U.S. rivers, dredged material is used for such benefits and for creating foundation above the floodplain for grain elevators, shipping terminals of all types, barge-fleeting areas, and storage facilities for U.S. products waiting to be moved to market (coal, timber, agricultural products). Two examples at Portland, Oregon, a container facility and a grain elevator located at convenient shipping points, were both built on dredged material (Figure 15-2). Another example is the harbor at Vicksburg, Mississippi, on the lower Mississippi. A large industrial site providing facilities to over 50 industries was built on dredged material from the Yazoo River (Figure 15-3). Other examples include port and shipping facilities at Texas City, Galveston, and Houston, Texas, in Galveston Bay; port facilities in the Duwamish River in Seattle, Washington; and facilities at Blakely and Brookley Island complexes in upper Mobile Bay, Alabama.

15-2. Residential and Urban Use. In spite of the sometimes poor foundation qualities, dredged material containment areas have become sites of multiple-building high- and low-rise residential and business complexes. Success has been attained where the properties of the dredged material have been properly accounted for in the residential design. A few examples of residences and businesses built on dredged material include:

a. Almost the entire City of Galveston, Texas, where dredged material has been used for fill, erosion control, hurricane protection, foundation material, and other beneficial uses for at least the past 70 years.

b. Thousands of residences and businesses have been built on sandy dredged material in Tampa, St. Petersburg, Clearwater, Sarasota, Miami, Jacksonville, and numerous other locations in Florida. (Most of these were built in wetlands, and therefore much of this type of development in Florida has decreased significantly in the past 10 years.)

c. Residential areas in the Burrough of Bronx in New York City.

d. Residential and business areas throughout the City of New Orleans, both on the riverfront and on Lake Ponchartrain.

e. A combined use of sandy dredged material over the past 60 years on the Mississippi Gulf Coast for residences and businesses, highway fill, sea wall protection, and beach nourishment (for both recreation and nesting habitat for the least tern).

f. Businesses at Jackson, Mississippi, where borrow material was dredged from inside the Pearl River levee and pumped into place outside the levee for foundation material.

g. A huge industrial/residential/commercial complex, including a marine park, was built on sandy dredged material at San Diego, California (Figure 15-4).

EM 1110-2-5026  
30 Jun 87



Figure 15-2. Two port facilities built on dredged material at Portland, Oregon, at the confluence of the Columbia and Willamette Rivers. A container port is located on the Columbia (left) and a grain terminal is located on the Willamette (right)



Figure 15-3. The port and industrial park at Vicksburg, Mississippi, which were built from dredged material from the Yazoo River



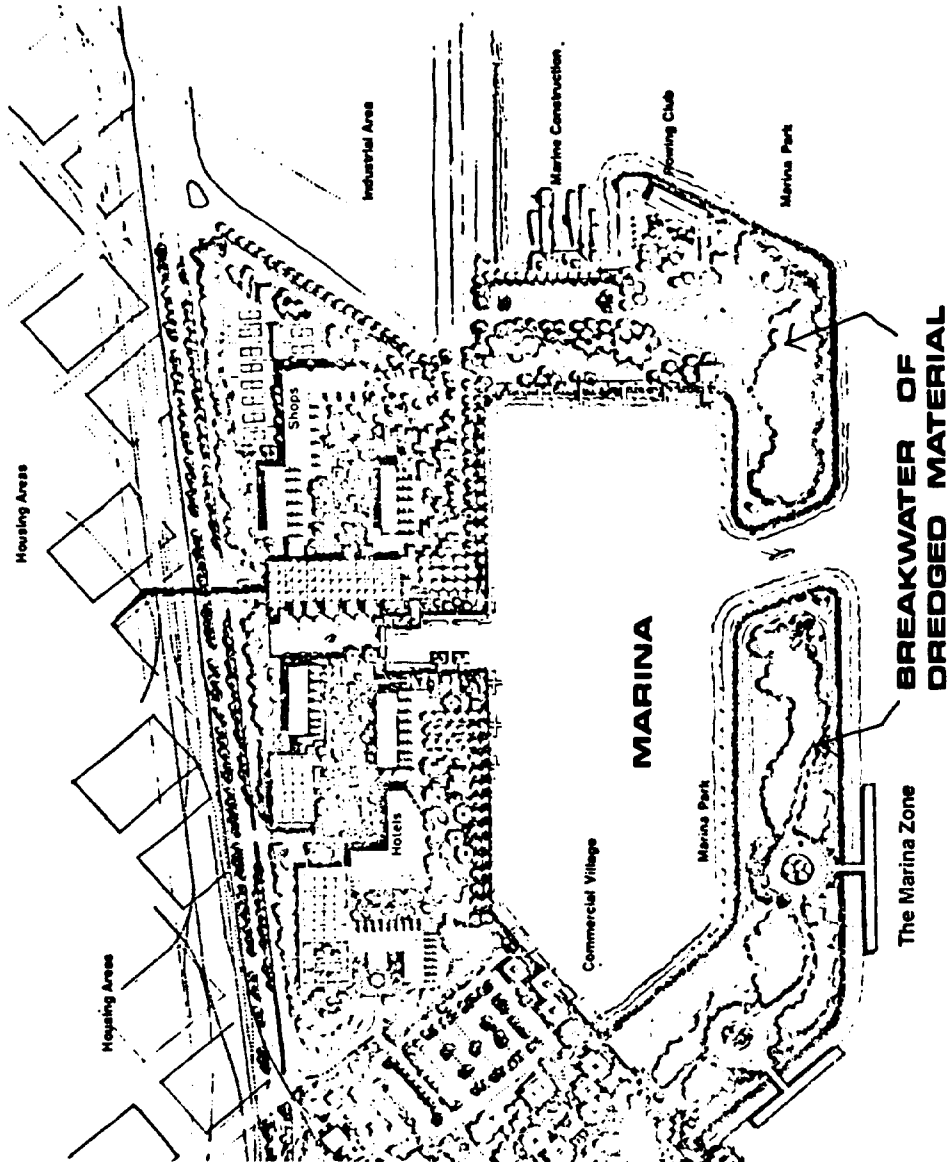


Figure 15-4. The master plan used for construction on sandy dredged material of an industrial/residential/commercial complex, including a marine park, at San Diego, California

h. A large, shopping center complex was built on dredged material at Swan Island on the Columbia River in Portland, Oregon. It included shopping and commercial areas and low-rise office buildings (Figure 15-5).

15-3. Airports. Airport runways and facilities in New York City, New York; Washington, D.C.; Grays Harbor, Washington; Minneapolis, Minnesota; New Orleans, Louisiana; Portland, Oregon; San Francisco, California; Brookley Air Force Base; and a number of other coastal areas have been built on dredged material foundations. These were built in areas where insufficient land was available for a commercial airport, and use of dredged material was easily justified both economically and socially. Such uses of dredged material will undoubtedly continue as harbors and cities increase in congestion and population.

15-4. Dikes, Levees, and Containment Facilities. The CE makes almost constant use of dredged material for dikes, levees, and confined disposal facilities (CDFs). Dredged material, pumped onsite and dewatered, readily lends itself to these uses. By using dredged material to build or increase capacity in CDFs, or for dikes and levees, overall project costs can be reduced while not having to use fastland soil for these projects and by expanding the life of existing containment sites. Some local and state agency and private use is made of dredged material for dikes and levees in certain situations such as for erosion and flood protection, or for private industrial dredged material containment facilities.

15-5. Fill Material and Roads. Thousands of cubic yards of dredged material have been dewatered in holding areas, then given or sold to public or private interests for fill material. This material has been used for a variety of building and parking lot foundation and site capping uses, primarily in urban areas. It has also been used for road construction as foundation material, especially in coastal counties. Often, such material is given away without charge in order to make room in disposal sites for subsequent disposal. In St. Paul District, dewatered sandy material was used to fill in an abandoned gravel quarry that was a dangerous eyesore. These beneficial uses, coupled with minimal handling requirements, make these disposal alternatives inexpensive and attractive.

15-6. Islands and Historic Preservation. On the Mississippi, Louisiana, Alabama, and Florida coasts, historic sites on barrier islands and beaches have been protected from wave erosion and subsidence by sandy dredged material being pumped around and near such sites. Excellent examples are found in Mississippi where the beach front, with its historic colonial and antebellum landmarks, and Ship Island, where historic Fort Massachusetts is located, were restored with sandy dredged material after both were almost totally demolished by Hurricane Camille.



Figure 15-5. A large shopping mall, Port Center, was built on dredged material at Swan Island on the Columbia River at Portland, Oregon. It included shopping and commercial areas, as well as low-rise office buildings.

15-7. Considerations.

a. The use of dredged material as industrial/commercial and construction material requires almost no additional work on the part of project engineers, unless it involves a CE work project, once material has been placed inside a containment facility and dewatered. Users and sponsors of the dredged material site at that point are responsible for moving and handling the material, developing the site, management and maintenance, and all other aspects of industrial/commercial site use. If the dewatered material is to be used for dike and levee construction, normal earth-moving and handling procedures by the CE would apply, and generally would not involve use of a dredge. Techniques outlined in items 17, 30, 62, and 82 are referenced for dike and CDF engineering design and construction. Industrial/commercial use of dredged material is probably one of the most inexpensive beneficial uses. Its primary advantage other than low cost is that it allows greater use of disposal sites when dredged material is removed. Its primary disadvantage is that on sites that become industrial areas, port facilities, airports, and other such commercial ventures, the sites are no longer available for disposal, and other disposal sites must be located and obtained.

EM 1110-2-5026  
30 Jun 87

b. While there are a number of obvious economic advantages to these types of beneficial uses, the environmental aspects may be so disadvantageous that a project is not feasible. For example, most of these sites already built displaced wetlands and other critical habitats. This can no longer be done without mitigation and stringent permit requirements.

## CHAPTER 16

### BASELINE AND MONITORING STUDIES

#### 16-1. General.

a. Potential beneficial uses of dredged material should be thoroughly examined as part of preproject planning studies. Preliminary surveys of existing and candidate sites should be made during the reconnaissance phase of new studies, and detailed aerial and ground surveillance should be conducted for feasibility studies. Results should be displayed in the appropriate format in feasibility reports, including pre-authorization survey reports. Project environmental assessments and environmental impact statements must include a detailed comparison of alternative sites, including adverse and beneficial impacts.

b. Modern tools such as remote sensing, visual data management systems, and automatic data processing should be employed to help determine the most appropriate locations and best uses for dredged material. High resolution aircraft-collected scanner imagery and color infrared photography can provide detailed land-use information that can be directly analyzed by computer. Information obtained through remote sensing not only provides a valuable database, but can be used to monitor changes in existing conditions with or without the project. A variety of computer systems and software programs are available for analyzing data.

c. Coordination with other Federal and state agencies is essential for projects that include dredging activities. Scoping meetings should be held at regular intervals throughout all phases of project planning. Agencies and organizations that should be involved in scoping activities include the EPA, FWS, NMFS (when operating in coastal waters), state coastal zone management agencies, state fish and wildlife agencies, and state and Federal cultural resource agencies. Other state and local organizations, both public and private, should be included as appropriate. Adequate review time must be provided for agencies to comment on proposed actions.

#### 16-2. Monitoring.

a. Background. This section describes the needs, considerations, and some methods for monitoring dredged material operations prior to, during, and after dredging in order to have a clear picture of the dredging and beneficial use impacts and values, as well as a source of pertinent references on monitoring. Monitoring within this section focuses only on those beneficial uses of dredged material that are derived from vegetation and/or animals.

b. Need for Monitoring. Monitoring of a proposed or existing dredged material site for the purpose of planning appropriate beneficial uses is an absolute necessity to ensure compatibility between or among the proposed uses and the dredged material disposal activities. Monitoring is important for

numerous reasons. It provides a framework or database from which logical beneficial use alternatives can be proposed. For example, if waterfowl habitat is desired for hunting use, but monitoring data indicate that marsh cannot be established because of too much wave energy, it makes little sense to consider duck hunting as a beneficial use. Monitoring also documents that appropriate planning of dredged material uses has been implemented and provides a basis from which defensible arguments can be made for selected beneficial uses. Monitoring is useful in obtaining an understanding of potential problems with alternative uses of dredged material, constraints, or possibilities related to dredged material management. It provides a clear picture over time whether the planned beneficial uses develop properly or at all and what changes are taking place that influence those uses or other potential beneficial uses. For example, Miller Sands Island planted as an upland goose resting/grazing pasture in the Columbia River has reverted to use primarily by nutria because the sandy pasture has not been maintained by soil amendments and by trapping of the nutria. The nutria eat the good grasses and herbs planted for goose pasture and leave only horsetail, an unpalatable plant. A monitoring program can indicate if these kinds of situations are developing so that remedial actions can be taken that will preserve the intended beneficial use.

c. Considerations of Monitoring. In planning and initiating a monitoring program of beneficial uses on dredged material, one must consider a variety of factors that are likely to impinge upon both dredging operations and the intended beneficial uses. These impingements may take place prior to, during, and after dredging and can influence decisions as to what beneficial uses should be planned and how they are likely to change over time. The level of attention needed will be greatest in the initial stages (i.e., monitoring the disposal process, overseeing propagule collection and planting, etc.), and will in most cases decrease with time (item 32). Influencing factors that should be monitored include such things as soil or substrate conditions; size and location of site; plants and animals presently on the site or in nearby areas; natural succession typical of the area; existing and future site use; flooding and/or wave energy conditions; tidal conditions; social and economic considerations; and the probability of future dredged material deposition. This section suggests a general monitoring approach to follow after the decision has been made to develop selected beneficial uses on a site. It assumes that legal restrictions, site availability, site capacity, and other legal, administrative, or engineering aspects are favorable.

d. Methods. Beneficial use monitoring may be planned for two kinds of sites: an established dredged material site where deposition has been completed, and a site where proposed or ongoing deposition of dredged material is taking place. In the first case, an established dredged material site may be many years old or relatively new, and may be vegetated or unvegetated. In the second case, the new substrate at any one or more topographic elevations will dictate whether the site will be aquatic or upland or a combination of the two. The approach should be tailored to the kind of deposition. Monitoring of a site involves numerous factors and therefore can be most effectively

accomplished by a multidisciplinary team, generally including a wildlife biologist, botanist, soil scientist, engineer, fisheries biologist, land use planner and, in some cases, a lawyer. The team needs to be structured according to the anticipated uses of the site. For example, it makes little sense to include a fisheries biologist if an upland site without any ponds or lakes is the site being considered for beneficial uses unless ponds or lakes are anticipated. Four steps for each item to be monitored should be followed: develop a statement of objectives, identify the population or unit to be sampled and data to be collected, specify the precision of data collection, and select an efficient sampling design.

(1) Physical factors. Physical factors considered important to monitor include such things as: climate; geographic location and size; topography and configuration; physical and chemical characteristics of the substrate to be deposited upon and material to be deposited; tides, currents, and other hydrological data; physical and chemical characteristics of the water in which material is deposited; and land use.

(a) Climate. Climatic data are important to monitor because they will dictate what kinds of plants and animals can ultimately grow and reproduce at the site. In a dredged material disposal project it is usually impractical to personally collect climatic data over a long enough time period to be meaningful. Therefore, resort to the literature and data sources that apply to the site area. First evaluate climate on a large scale because climate changes are relatively slow. Changes in such things as soils and vegetation will usually occur gradually. Soil and plant communities are relatively stable and mutually compatible over extensive land areas. Classification of climates over large areas requires development of parameters such as temperature and rainfall extremes on a macroscale. Maps available from the U.S. Department of Commerce enable determination of approximate limits of average minimum temperatures, rainfall distribution zones, major climatic zones, and other zones that influence types of vegetation that can be grown in an area. Determine climatic conditions on a microclimatic scale, or those climates within the first few feet of the soil. It is important to characterize these because they determine more accurately whether plants and animals will be able to survive drought, chilling, or frosts, or excess moisture. Those microclimates characterized by low precipitation during the growing season will have a deficit of moisture for plant growth, especially if temperatures are high. For example, St. Paul, Minnesota is in a semi-humid grassland-forest transition zone because it has a mean annual precipitation of 25 inches. However, San Antonio, Texas, with the same mean annual precipitation has semi-arid vegetation because of higher temperatures (70°F vs. 44°F). Soil-water losses are greater in Texas than Minnesota. To obtain these temperature and rainfall data at a local level, the planner should refer to local meteorological data furnished by the nearest National Weather Service station or establish an onsite weather station obtainable from scientific instrument supply distributors. If the latter option is selected, data should be collected in the area for as long as considered practical, preferably for at least 2 to 3 years.

(b) Geographic location and size. Geographic location will determine an area's macroclimate and microclimatic characteristics, which will in turn influence plants and animals. The potential or existing size of a disposal area should be considered in relation to its location; these interrelated factors determine an area's potential value for various beneficial uses. This is particularly true for the development of wildlife habitat. Small areas may offer no appreciable habitat development potential, whereas large areas may offer numerous management possibilities. Location of the site is extremely important, perhaps much more so than the size. Item 13 relates an example that illustrates this. A 2-acre upland site surrounded by marsh and located very close to the mainland may support a greater diversity of wildlife species than a 10-acre island site with similar habitat but isolated by open water from marsh and mainland populations. The smaller site may often be used by marsh inhabitants such as rails, herons, egrets, and raccoons; it may be visited by white-tailed deer and many small land birds; and it may support a high marsh rabbit population due mainly to the abundance of surrounding marsh vegetation. Natural plant succession and dispersal of animal species occur quickly and easily due to the area's proximity to plant and animal sources. The island site, although larger, may be used only by waterbird species. Natural succession and animal dispersal to the island are slower due to the island's isolation. Often dredged material islands are the only areas available for bird colonies, and the isolation keeps predators and human disturbance to a minimum.

(c) Topography, configuration, and land features. A site's topography and configuration must be examined because these factors greatly influence potential beneficial uses. The elevation of the dredged material in relation to mean water level will determine, for example, the kinds of vegetation and habitat that can be developed. Figure 4-1 in Chapter 4 illustrates this point. Configuration of the site plays a large role in determining what uses should be planned. Coves on a dredged material island, for example, can lead to successful marsh establishment (item 2) because protection from long wind fetches is provided. Topography and land configuration also relate to an area's erodibility, flooding potential, waterway traffic, and future deposition plans. Hills, bluffs, and man-made features will influence accessibility and ease of developing desired beneficial uses. Monitoring of these factors is best achieved with an aerial photograph, topographic map, and diagram as a base. Elevational and bathymetric data may be unavailable and will have to be established by standard survey and geodetic procedures. A map or diagram should show access routes, both land and water, as means of transporting equipment; these routes should be rated. The map or diagram should show dikes, mounds, or other evidence of previous disposal. Note areas of debris accumulation and indications of nearby human activity such as a boat dock, cabin, foot trail, or livestock. See references in item 19 for techniques on reconnaissance mapping.

(d) Soils or dredged material substrate. Analysis of core samples and soil sampling data should be made on existing soils to determine undesirable physical and/or chemical properties that may pose a hazard to potential site



use. If proper procedures are not taken, it is possible that buried undesirable materials could migrate upward through the water column. See item 47 for procedures to be used in sampling and analyzing soils, and for ways to handle any potentially hazardous soils. If the dredged material sediments already in place are to be used for beneficial uses, some physical and chemical tests must be conducted. Soil properties influence kinds of plant species that can be grown on the site or that will invade the site. These plants, in turn, will ultimately affect other beneficial uses to be planned. Similar physical and chemical soil tests will also be necessary for dredged material sediments, since these materials will be the growing medium for plants. See item 47 for the determination of soil or sediment properties. After soil properties are determined, soil scientists should be consulted to determine which soil treatments are required to ensure adequate plant development. Periodic monitoring of the site's soil properties should be carried out since fertilization and other soil amendments and physical treatments may be necessary to ensure site beneficial uses are not adversely affected by changing soil conditions. The frequency of monitoring will largely be determined by economic and time constraints.

(e) Tides, waves, currents, and other hydrologic data. These factors influence water and nutrient availability to plants and animals and cause erosion. For salt marsh development, vertical elevation of a substrate with respect to tidal fluctuations determines the number of times per year the substrate and plants will be flooded with saltwater. The average number of hours submerged per month and the average number of hours submerged during daylight are important in determining plant distribution (item 10). Because of the energy and potential erosion they exert upon a site, waves can influence plant establishment. Fetch, or the distance wind travels across water to reach land, and the depth of water are primary determinants of the degree of wave energies. Item 37 relates a method for evaluating wave climate based on observed relationships between fetch, shore configuration, grain size, and success in controlling erosion in 86 salt marsh plantings in 12 coastal states. Of course, direct measurements for characterizing tides and waves can be accomplished through electronic gauges or by physically reading tides and waves on staff rods. Currents are normally considered when dredged material is deposited in rivers and streams. Currents have a direct effect on whether plants can become established. Current meters should be installed on the site and monitored for several months throughout the year to obtain a knowledge of maximum and minimum current conditions. Other hydrologic factors such as water table and water levels or depths will directly influence planned beneficial uses due to their effect on plant establishment and zonation. Water table, levels, and depths will influence the ability of plants to carry out their physiological processes (e.g. photosynthesis, respiration). Some plants can tolerate more or less water than others, which will in turn dictate what vegetation can be grown on a dredged material site. The vegetation will largely dictate the kinds of animal habitat that can be developed or the kinds of animals that will use the site. A procedural guide for monitoring such things as depths to water table and other hydrologic factors can be found in Item 47.

(f) Water quality. Salinity, pH, turbidity, dissolved oxygen (DO), biological oxygen demand (BOD), chemical oxygen demand (COD), and mineral nutrients within the water column will largely influence the kinds of plants and aquatic fauna that will develop on or adjacent to a dredged material site. They should be monitored periodically prior to, during, and after dredging to obtain an idea of how water quality conditions might change over time, which in turn might affect plant and animal development. (See Section 2-4 of this manual for sampling and laboratory requirements and procedures regarding water quality factors.)

(2) Biological factors. Biological factors considered important to monitor include such things as: aquatic, semiaquatic, and upland plant species; all animals species including soil macroinvertebrates, microfauna, and benthos; and shellfish and finfish.

(a) Vegetation. Knowledge of existing plant species on or adjacent to the site will enable plant species selection. Indigenous plants may be desirable for various beneficial uses such as wildlife habitat development, agricultural, forestry, or horticultural purposes. Map the vegetation composition and distribution, either from visual estimation or sampling. Reconnaissance mapping and map use for various purposes, including wildlife and vegetation, and a guide to gaining natural resource information through remote sensing techniques are discussed in item 19. This guide includes vegetation and animal habitat inventory and assessment. Item 27 provides habitat analysis and evaluation methods suitable for vegetation description and other site attributes. Sampling methods are not standardized for vegetation but must be tailored to the type and areal extent of vegetation and the level of information required. Excellent general references for monitoring vegetation include items 10, 26, and 36. Item 61 provides a guide of sampling and summarizing data for plant community surveys and classification, including methods, data sheets, and computer summarization printouts. The specific location of any plants protected by law should be noted when sampling vegetation. A botanist familiar with the area should be consulted for species verification; regional botanical field guides such as items 65 and 70 will be helpful.

(b) Animals. Both aquatic and upland animals on and adjacent to the dredged material site should be monitored. Important economic species such as shrimp and other associated shellfish may be in adjacent waters and could be cultured and developed on the dredged material site. Furbearing animals such as beaver and otter may be in the area and could be attracted to the site for trapping pelts or other beneficial uses. Monitoring of smaller animals is important because they are part of the food web and can provide insight to use by larger predatory animals. Current and future animal use of a site, in general, should be determined through observation of signs such as tracks or browse marks, actual observations, or some form of sampling. For example, in sampling both aquatic and upland animals on dredged material in the intertidal zone of a Texas site near Galveston, monthly observations at exact locations were made. Aquatic invertebrates on the water bottom that may be covered

during the dredging process or during beneficial use development should be described by species composition, abundance, and distribution. For information on sampling techniques, consult item 22, which discusses sampling of salt marsh benthos and burrows; item 50, which describes a reconnaissance technique for oysters; and item 85, which describes sampling for fiddler crabs in salt marsh. Other aquatic animal sampling and monitoring methods for plankton, periphyton, macrophyton, macroinvertebrates, and fish are amply discussed in item 83. For purposes of definition, monitoring of upland animals will include in this manual those animal species, such as waterfowl and colonial nesting birds, that use unflooded land for any of their life requisites. Item 69 provide numerous methods of monitoring primarily upland animal species. Another general reference that applies primarily to upland animal monitoring is item 34. Item 27 provides an excellent discussion on estimation of density of primarily upland animals by use of the line transect method. For dredged material that will be or has been deposited in a floodplain, item 78 provides a sampling method for floodplain arthropods although they stated there is no single sampling method applicable to studies of arthropods, as these animals vary in mobility and microhabitat preferences. Additional literature on sampling methods of upland animal populations includes items 5, 8, 35, 55, and 58. A wildlife biologist familiar with the proposed or existing dredged material site can estimate wildlife use of the site and should be consulted about the presence of threatened, rare, or endangered species. Critical habitat and areas of concern for these species must be located, protected, and/or enhanced in every dredging project.

e. Conclusion. Monitoring methodology should be tailored to the nature of the element and the overall reason for monitoring. In this case, it is to ensure that dredged material operations eventually lead to some planned beneficial uses. Monitoring methodology can be as simple as a yearly recording of presence or absence or as intensive as necessary to establish and document a management program or provide statistically reproducible data to protect legal interests.

CHAPTER 17

SITE VALUATION

17-1. Evaluation.

a. Dredging in our Nation's waterways and harbors is necessary to maintain navigation. However, the costs of dredging can sometimes be justified by documenting the benefits that can be derived from a network of navigable waterways. Tangible dollar benefits are generally savings in shipping costs realized by shippers using the waterways. In addition to dredging costs, the costs of disposal of dredged material from waterways are substantial. In conventional disposal operations potential benefits are usually ignored, and the cost of the disposal operation is simply part of the total cost of the entire dredging-disposal project.

b. Dredged material can provide socioeconomic benefits if beneficial uses are implemented. Uses of either the material itself or the containment area in which it is placed are options. Land enhancement benefits from the placement of dredged material can be substantial, and highly productive habitat can be developed on disposal sites. The value of new or filled land or a wetland or other habitat created by disposal of material dredged from a project is a valid benefit that can be credited to the overall project. Both new and maintenance dredging projects should evaluate land enhancement and beneficial use alternatives. An analysis should also be made of the associated socioeconomic benefits and costs of the disposal of dredged material. This process should consider several alternatives for disposal including beneficial uses, and should consider all benefits and costs, tangible as well as intangible. A number of factors need to be considered in benefits, including attitudes and opinions of local citizens, resource agencies, and environmental groups, the general public good, and distinguishing or limiting historical or archaeological features.

c. To aid in the evaluation of the land enhancement value and associated benefits that can be derived by the beneficial use of dredged material containment areas, a land value methodology has been developed for certain types of beneficial uses. The methodology is basically designed to provide guidance for projects still in the early planning stages and produces estimates of the direct market value of the created land, the related community benefits, and adverse impacts from the land use. The use of this methodology can help highlight the many advantages of the beneficial land use of dredged material. Project sponsors and local officials may gain wider public support for beneficial use projects if they can effectively demonstrate to the community the full range of benefits from project implementation.

17-2. Methodology.

a. Basis of Appraisal. The basis for the land value portion of the methodology is the comparable sales approach often used in real estate

appraisal. This approach was considered the most appropriate for the value estimate of newly created land from dredged material. For the assessment of associated benefits and adverse impacts resulting from the land-use project, a matrix has been devised to categorize and describe all relevant effects. The methodology itself can be divided into: site description, establishment of use potential, estimate of value, and associated benefits and adverse impacts. The first three collectively estimate the site value changes; the fourth identifies the associated benefits and/or adverse impacts of the land-use project.

b. Site Description. Before an analysis of the value of a site can begin, the site must be described in terms of its physical features, environmental setting (including natural and man-made areas), and relationship to the economic structure of the area. This phase of the methodology is primarily a data base for subsequent analyses. Many of the items of importance to the value of the prepared site will emerge during the course of this data-gathering task. Taking the required time to develop the data needed for this section of the methodology, the final estimate of value can be made with more confidence.

c. Establishment of Use Potential. This section of the methodology establishes the most likely and the highest and best use of the containment area after the dredged material has been placed, dewatered, and consolidated. Normally, the highest and best potential use of a piece of land, within existing legal and institutional constraints, is used as the basis for the value assessment. Values of comparable land in the area determine the value of the new piece of land. The use potential is established by identifying current land uses surrounding the site, the need for certain land uses within the area, the zoning intensity of various levels of development, and other institutional and legal constraints. Also, the physical characteristics previously identified must be considered. For example, a disposal site made of fine-grained dredged material will not be suitable for high-rise developments despite other positive attributes, but it may have use as a recreation site where low-load structures may be safely erected, or as a wildlife habitat and nature area. Finally, the accessibility of the site to the existing infrastructure is an important determinant of practical use potential.

d. Estimate of Value.

(1) This is the final stage of the methodology in the actual site valuation process. For the successful accomplishment of a value estimate, an economist or real estate appraiser familiar with land values should be involved. Three key functions must be performed in the estimation process:

(a) Land parcels similar to the site to be created by the containment area and for which there are recent sale or assessment data must be identified.

(b) An estimate of demand or need for the new site must be made based on the information obtained in the estimate of use potential.

(c) The relative applicability of the comparable sites versus the new site for beneficial uses must be determined.

(2) Values of comparable parcels are the basis on which the market value estimate is made. Once the comparables have been identified and their value established, a utility estimate is made to determine how similar, with respect to "value-producing" factors, the comparables and the new site are. If the comparables and the new site are similar with respect to accessibility, zoning restrictions, proximity to public services, foundation constraints, etc., then the comparables can be considered to have equal utility to the new site and be used to establish site value. Using the relative utility measure and the demand for the new land use, an adjusted value for the new site can be estimated. By comparing this value estimate with the original value of the site before the dredged material was deposited, a land enhancement benefit can be estimated for whatever beneficial use that has been proposed.

(3) Before an estimated land valuation can be determined for other than upland human-use sites, values must be determined for such potential site uses as wetlands and other types of habitat development, nonconsumptive recreation, fish nursery areas, commercial and noncommercial shellfish and finfish industries, aquatic vegetation, endangered species critical habitat, water quality, and other difficult-to-estimate variables. These types of values are extremely controversial and hard to assess. None of the scientists working in their fields in the development of values agree on uniform estimates. Values often need to be assigned on a site-specific basis. WES has been coming to grips with this problem through the Dredging Operations Technical Support Program and Wetlands Research Program. WES often assists Districts in reaching estimated values of new or proposed dredged material or mitigated sites.

e. Associated Benefits and Adverse Impacts.

(1) The direct increase in market value of a site from the placement of dredged material is an important land enhancement benefit; however, the induced associated benefits and/or adverse impacts can also be substantial. These benefits and impacts may touch many different economic groups in a wide geographic range away from the site. The methodology can assist in identifying these benefits and impacts, describing their magnitude and significance, and displaying them for decisionmakers and the public.

(2) Two guides were developed by Conrad and Pack (item 15) to assist in identifying the significant benefits and impacts resulting from the beneficial use of dredged material containment areas. One guide graphically shows the relationships of various categories of effects which could result from a productive land use. The other lists specific types of social, economic, and environmental factors that might be affected by the beneficial use. These

guides are by no means all-encompassing but provide a framework for identification of the important benefits and adverse impacts.

(3) Once the benefits and adverse impacts are identified, a matrix can be used to describe and evaluate them. The matrix should have a simple structure, and the evaluation is based on the judgment involved in the process. No general weighting system was considered appropriate for the evaluation of these associated benefits and adverse impacts. However, a matrix should allow this subjective evaluation to be displayed so that other interested parties can review them. An important point should be remembered when using this methodology. The entire methodology is intended as a set of guidelines, and it involves the application of sound judgment in a multidisciplinary group. Deviation from the methodology may be warranted where sound judgment dictates that the situation being investigated does not lend itself to application of the methodology, such as when dealing with habitat applications of a site.

17-3. Case Studies. In developing the methodology, 15 case study sites were examined and the methodology tested on each (item 15). As developed, the methodology is to be used on undeveloped sites for planning purposes. Sites that were already developed were selected in the interest of getting a diverse group for testing. The results of the case studies indicated that the methodology is flexible and adaptable to a wide range of sites. Table 17-1 lists the case study sites along with their physical and dredged material characteristics. Table 17-2 shows the settings of the case study sites. Table 17-3 is a compilation of the estimated change in land values of the sites as a result of developing them for upland beneficial use. The values indicate that, through beneficial use application, dredged material containment areas can realize significant increases in value. The wide range of value increases shows that the value increase is a site-specific characteristic. The methodology, however, allows an estimation of this change before the site is developed. Table 17-4 is presented to show the types of associated benefits and adverse impacts that were encountered during the case studies. Details of the case studies are available in item 15.

17-4. Use of the Methodology. The large land enhancement benefits that can accrue from the beneficial use of dredged material make this alternative to conventional disposal particularly attractive. The methodology described in Chapter 17 is a tool that can be used in the planning stages to identify and evaluate both the tangible increase in market value and other benefits to be derived from beneficial upland land use. Use of this methodology can only serve to point out these benefits and/or adverse impacts so that appropriate disposal alternatives will not be overlooked. The methodology does not apply to sites not used as upland human-use sites such as wetlands. See para 17-2d(3) for a discussion of other site valuation.

Table 17-1

Case Study Site Physical and Dredged Material Characteristics (item 15)

Site	Location	Approximate Size		Soil Characteristics Type	Soil Characteristics			Depth to Foundation Strata	
		ha	acres		Grain Size	Bearing Capacity	Vegetative Support	m	ft
Anacortes	Anacortes, WA	11	26	Sand/ clay	Fine	Fair	Good	8	25
Artificial Island	Salem County, NJ	81	200	Silty clay loam	Fine	Fair	Good	21	70
Bay Port	Green Bay, WI	233	575	Sand/ clay	Fine	Poor	Good	5	15
E. Potomac Park	Washington, D.C.	133	329	Silt/ clay	Fine	Poor	Good	31	100
Fifth Avenue Marina	San Diego, CA	9	22	Fine sand	Fine	Fair	Good	NA	
Florida State Fairgrounds	Hillsborough Co., FL	112	276	Silt/ clay	Fine	Poor	Good	NA	
Hookers Point	Tampa, FL	162	400	Silt/ clay	Fine/ medium	Fair	Good	NA	
Hoquiam	Hoquiam, WA	18	45	Sand/ silt	Fine	Fair	Good	10	34
Patriots Point	Charleston, SC	182	450	Silty loam	Fine	Poor	Good	18	60
Vicksburg	Vicksburg, MS	142	350	Sand/ silt	Fine	Good	Good	12	40
Virginia Beach	Virginia Beach, VA	17	43	Sand & clay	Fine to medium	Fair	Poor	NA	
Pelican Island	Galveston, TX	1306	3225	Silt/ clay	Fine	Fair	Good	NA	
Port Jersey	Jersey City, NJ	172	430	Sand/ clay	Fine to medium	Fair	Poor	23	75
Blount Island	Jacksonville, FL	680	1700	Silt/ clay	Fine	Good	Good	25	80
Rivergate	Memphis, TN	172	425	Sand/ clay	Medium	Good	Good	NA	



Table 17-2  
Case Study Site Settings (Item 15)

Site Name	Productive Use	Water and Sewer	Urban Setting	Zoning	Access
Anacortes	Industrial/manufacturing	To site	Urban/port	Industrial/urban	Excellent
Artificial Island	Nuclear power plant	Home nearby; developed their own services	Rural	Industrial/urban	Poor
Bay Port	Industrial/port	Nearby	Urban	Industrial/urban	Good
E. Potomac Park	Park	Onsite	Urban	Open space	Excellent
Fifth Avenue Marina	Marine/park	Adjacent to site	Urban	Open space	Excellent
Florida State Fairgrounds	State fairgrounds	Onsite	Suburban	Urban transition	Good
Hookers Point	Industrial/port facility	Onsite	Urban/port	Industrial/urban	Excellent
Hoquiam	Industrial/manufacturing	0.2 km (0.13 mile) from site	Urban/port	Industrial/urban	Good
Patriots Point	Museum, marina, golf course, hotel	Water extended to site. Package sewage treatment plant installed.	Suburban	Commercial/agricultural/open space	Fair
Vicksburg	Industrial/manufacturing	Adjacent to site	Suburban	None	Good
Virginia Beach	Beachfront commercial	Adjacent to site	Urban	Residential/commercial	Excellent
Pelican Island	Industrial/residential/institutional/recreational	To site	Urban	Industrial/residential/open space	Excellent
Port Jersey	Industrial/commercial	Onsite	Urban	Industrial	Excellent
Blount Island	Industrial	To site	Suburban	Industrial	Excellent
Rivergate	Industrial	Onsite	Suburban	Manufacturing	Excellent

Table 17-3  
Case Study Site Valuation Study (item 15)

Site Name	Use Considered for Valuation	Raw Value Prior to Dredged Material Placement		Adjusted Present Value		Enhancement Value	
		per ha	per acre	per ha	per acre	per ha	per acre
Anacortes	Industrial/port	\$5,400/ha*	\$2,200/acre	\$43,200/ha	\$17,500/acre	\$37,800/ha	\$15,300/acre
Artificial Island	Nuclear power generation	\$12/ha	\$5/acre	\$3,200/ha	\$1,300/acre	\$3,200/ha	\$1,300/acre
Bay Port	Heavy Industrial	Nominal	Nominal	\$16,100/ha	\$6,500/acre	\$16,100/ha	\$6,500/acre
E. Potomac Park	Recreational	None	None	\$645,900/ha	\$261,500/acre	\$645,900/ha	\$261,500/acre
Fifth Avenue Marina	Recreational/open space	\$10,800 to \$26,900/ha	\$4,300 to \$10,900/acre	\$1.94 million to \$2.60 million/ha	\$784,000 to \$1.0 million/acre	\$1.92 million to \$2.60 million/ha	\$779,000 to \$1.0 million/acre
Florida State Fairgrounds	Commercial/retail	\$11,100/ha	\$4,500/acre	\$106,300/ha	\$43,000/acre	\$95,100/ha	\$38,500/acre
Hookers Point	Deepwater terminal facilities	Nominal	Nominal	\$160,600/ha	\$65,000/acre	\$160,600/ha	\$65,000/acre
Hoquiam	Industrial/port	\$2,000/ha	\$800/acre	\$13,100/ha	\$5,300/acre	\$11,100/ha	\$4,500/acre
Patriots Point	Commercial/recreational	\$5/ha	\$2/acre	\$43,000/ha	\$17,400/acre	\$43,000/ha	\$17,400/acre
Vicksburg	Industrial/port						
Virginia Beach	Commercial/retail	\$5,600/ front m	\$1,700/ front ft	\$5,600/ front m	\$1,700/ front ft	Maintenance value	Maintenance value
Pelican Island	Industrial/residential	\$1,725/ha	\$700/acre	\$19,266/ha	\$7,800/acre	\$17,540/ha	\$7,100/acre
Port Jersey	Industrial	\$35,000/ha	\$14,000/acre	\$198,000/ha	\$79,000/acre	\$163,200/ha	\$65,200/acre
Blount Island	Industrial	\$16,055/ha	\$6,500/acre	\$83,360/ha	\$33,750/acre	\$67,305/ha	\$27,250/acre
Rivergate	Manufacturing	\$11,100/ha	\$4,500/acre	\$134,500/ha	\$54,500/acre	\$123,400/ha	\$50,000/acre

\* 1977 dollars.

Table 17-4

Case Study Sites--Associated Benefits/Adverse Impacts (item 15)

<u>Associated Benefits/Adverse Impacts</u>	Anacortes	Artificial Island	Bay Port	E. Potomac Park	Fifth Ave. Marina	Florida State Fairg.	Hookers Point	Hoquiam	Patriots Point	Vicksburg	Virginia Beach	Pelican Island	Port Jersey	Blount Island	Rivergate
Adjusted value increase						X	X				X				
Increased business activity			X	X	X	X	X				X		X		X
New jobs	X	X	X			X	X	X	X	X	X	X	X	X	X
Increased taxes/revenues	X		X					X		X	X				
Sales	X					X	X	X	X		X	X			X
Real estate	X	X	X			X	X		X		X	X	X	X	X
Community attractiveness				X	X	X	X		X		X	X	X	X	X
General boost to economy	X		X			X	X		X			X		X	X
Operations revenue						X	X		X						
Provide needed community facilities				X	X	X	X						X		
Increased recreation opportunities				X	X	X			X		X	X			
Construction jobs		X					X					X	X		X
Utility taxes		X													X
Decrease in area taxes		X													
Public education (re: nuclear power plants)		X													
Increased congestion		X	X		X				X		X			X	
Higher property taxes												X			
Environmental degradation		X	X		X				X	X				X	
Increased municipal expenses															
Limits area development potential		X													
Community concern		X								X		X		X	
Detracts from adjacent vistas									X						
Improved medical care services		X													
Provide needed power		X													
Educational/cultural opportunities									X						
Expands area tourist potential									X						
Introduce alternative transportation mode							X		X		X		X	X	
Create site for administrative offices				X											X

APPENDIX A

BIBLIOGRAPHY

1. Allen, H. H., Clairain, E. J., Jr., Diaz, R. J., Ford, A. W., Hunt, L. J., and Wells, B. R., "Habitat Development Field Investigations, Bolivar Peninsula Marsh and Upland Habitat Development Site, Galveston Bay, TX: Summary Report," TR D-78-15, 1978, U. S. Army Engineer Waterways Experiment Station, Vicksburg, MS.
2. Allen, H. H., Webb, J. W., and Shirley, S. O., "Erosion Control with Saltmarsh Vegetation," Proc. 3rd Symposium on Coastal and Ocean Management, ASCE Conference, San Diego, CA, 1983, pp. 735-748.
3. Bartos, M. J., Jr., "Use of Dredged Material in Solid Waste Management," TR D-77-11, 1977, U. S. Army Engineer Waterways Experiment Station, Vicksburg, MS.
4. Bartos, M. J., Jr., "Classification and Engineering Properties of Dredged Material," TR D-77-18, 1977, U. S. Army Engineer Waterways Experiment Station, Vicksburg, MS.
5. Bond, R. R., "Ecological Distribution of Breeding Birds in the Upland Forests of Southern Wisconsin," Ecological Monograph, Vol. 27, No. 4, pp. 351-384, 1957.
6. Buckman, H. O. and Brady, N. G., The Nature and Properties of Soils, MacMillan Publishers, New York, NY, 1960.
7. Burks, S. L. and Engler, R. M., "Water Quality Impacts of Aquatic Dredged Material Disposal: Laboratory Investigations," TR DS-78-04, 1978, U. S. Army Engineer Waterways Experiment Station, Vicksburg, MS.
8. Caughley, G., Analysis of Vertebrate Populations, John Wiley and Sons, New York, NY, 1977, 234 pp.
9. Chaney, R. L., et al., "Recommendations for Management of Potentially Toxic Elements in Agriculture and Municipal Wastes," Tractors Involved in Land Applications of Agricultural and Municipal Wastes, 1974, National Program Staff, Soil, Water and Air Sciences, Beltsville, MD.
10. Chapman, S. B., Ed. Methods in Plant Ecology, John Wiley and Sons, New York, NY, 1976.
11. Chen, K. Y., Gupta, S. K., Sycip, A. Z., Lu, J. C. S., Knezevic, M., and Choi, W. W., "Research Study on the Effect of Dispersion, Settling, and Resedimentation on Migration of Chemical Constituents During Open-Water Disposal of Dredged Material," CR D-76-1, 1976, U. S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

EM 1110-2-5026  
30 Jun 87

12. Coastal Zone Resources Corporation, "Identification of Relevant Criteria and Survey of Potential Application Sites for Artificial Habitat Creation," CR D-76-02, Vols I and II, 1976, U. S. Army Engineer Waterways Experiment Station, Vicksburg, MS.
13. Coastal Zone Resources Division, "Handbook for Terrestrial Wildlife Habitat Development on Dredged Material," TR D-78-37, 1978, U. S. Army Engineer Waterways Experiment Station, Vicksburg, MS.
14. Cole, J. and Brainard, M., "Evaluation of Laws and Regulations Impacting the Land Use of Dredged Material Containment Areas," TR D-78-55, 1978, U. S. Army Engineer Waterways Experiment Station, Vicksburg, MS.
15. Conrad, E. T. and Pack, A. J., "A Methodology for Determining Land Value and Associated Benefits Created from Dredged Material Containment," TR D-78-19, 1978, U. S. Army Engineer Waterways Experiment Station, Vicksburg, MS.
16. Doerr, T. B. and Landin, M. C., "Vegetative Stabilization of Training Areas of Selected United States Military Reservations," Contract Report furnished to U. S. Army Engineer Construction Engineering Research Center, Vols I and II, 1983, Champaign, IL.
17. Eckert, J. W., Giles, M. L., and Smith, G. M., "Design Concepts for In-Water Containment Structures for Marsh Habitat Development," TR D-78-31, 1978, U. S. Army Engineer Waterways Experiment Station, Vicksburg, MS.
18. Environmental Laboratory, "Ecological Evaluation of Proposed Discharge of Dredged and Fill Material into Navigable Waters" (interim guidance for implementation of Section 404(b) (1) of PL 92-500), TR D-76-17, 1976, U. S. Army Engineer Waterways Experiment Station, Vicksburg, MS.
19. Environmental Laboratory, "Wetland Habitat Development with Dredged Material: Engineering and Plant Propagation," TR DS-78-16, 1978, U. S. Army Engineer Waterways Experiment Station, Vicksburg, MS.
20. EPA/CE Technical Committee on Criteria for Dredged and Fill Material, "Ecological Evaluation of Proposed Discharge of Dredged Material into Ocean Waters; Implementation Manual for Section 103 of PL 92-532," 1977, U. S. Army Engineer Waterways Experiment Station, Vicksburg, MS.
21. Francinques, N. R., Palermo, M. R., Lee, C. R., and Peddicord, R. K., "Management Strategy for Disposal of Dredged Material: Contaminant Testing and Controls," MP D-85-1, 1985, U. S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

22. Frey, R. W., Basan, P. B., and Scott, R. M., "Techniques for Sampling Salt Marsh Benthos and Burrows," American Midland Naturalist, Vol. 89, No. 1, pp. 228-234, 1973.
23. Gambrell, R. P., Kahlid, R. A., Patrick, W. H., Jr., "Disposal Alternatives for Contaminated Dredged Material as a Management Tool to Minimize Adverse Environmental Effects," TR DS-78-08, 1978, U. S. Army Engineer Waterways Experiment Station, Vicksburg, MS.
24. Green, C. E. and Rula, A. A., "Low-Ground-Pressure Construction Equipment for Use in Dredged Material Containment Area Operation and Maintenance: Equipment Inventory," TR D-77-1, Vol I, 1977, U. S. Army Engineer Waterways Experiment Station, Vicksburg, MS.
25. Gupta, S. C., Larson, W. E., Gast, R. G., Combs, S. M., and Dowdy, R. H., "The Agricultural Value of Dredged Material," TR D-78-36, 1978, U. S. Army Engineer Waterways Experiment Station, Vicksburg, MS.
26. Grieg-Smith, P., Quantitative Plant Ecology, Butterworth and Company, London, 1964.
27. Gysel, L. W. and Lyon, L. J., "Habitat Analysis and Evaluation," Wildlife Management Techniques Manual, The Wildlife Society, Washington, DC, pp. 305-328.
28. Halliburton, T. A., "Guidelines for Dewatering/Densifying Confined Dredged Material," TR DS-78-11, 1978, U. S. Army Engineer Waterways Experiment Station, Vicksburg, MS.
29. Halliburton, T. A., Durham, G. N., Brown, K. W., Peters, R. E., and Dulaney, T. B., Jr., "Effects of Mechanical Agitation on Drying Rate of Fine-Grained Dredged Material," TR D-77-10, 1977, U. S. Army Engineer Waterways Experiment Station, Vicksburg, MS.
30. Hammer, D. P. and Blackburn, E. D., "Design and Construction of Retaining Dikes for Containment of Dredged Material," TR D-77-09, 1977, U. S. Army Engineer Waterways Experiment Station, Vicksburg, MS.
31. Hayden, M. L., "Prediction of Volumetric Requirements for Dredged Material Containment Areas," TR D-78-41, 1978, U. S. Army Engineer Waterways Experiment Station, Vicksburg, MS.
32. Hunt, L. J., Landin, M. C., Ford, A. W., and Wells, B. R., "Upland Habitat Development with Dredged Material: Engineering and Plant Propagation," TR DS-78-17, 1978, U. S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

EM 1110-2-5026  
30 Jun 87

33. Johnson, S. J., Cunny, R. W., Perry, E. B., and Devay, L., "State-of-the-Art Applicability of Conventional Densification Techniques to Increase Disposal Area Storage Capacity," TR D-77-4, 1977, U. S. Army Engineer Waterways Experiment Station, Vicksburg, MS.
34. Johnson, J. L., Franklin, J. F., and Krebill, R. G., Ed., Research Natural Areas: Baseline Monitoring and Management, Proc. Symposium in Missoula, MT, 1984, USDA Forest Service General Technical Report INT-173, Ogden, UT, 84 pp.
35. Kendeigh, S. C., "Measurements of Bird Populations," Ecological Monographs, Vol. 14, No. 1, pp. 68-106, 1944.
36. Kershaw, K. A., Quantitative and Dynamic Plant Ecology, American Elsevier Publishing Company, New York, NY, 1973.
37. Knutson, P. L. and Inskeep, M. R., "Shore Erosion Control with Salt Marsh Vegetation," CETA 83-4, U. S. Army Engineer Coastal Engineering Research Center, Fort Belvoir, VA.
38. Lambe, T. W., Soil Testing for Engineers, John Wiley and Sons, New York, NY, 1962.
39. Landin, N. C., "Annotated Tables of Dredged Material Island Vegetation Throughout the United States," MP D-78-07, 1978, U. S. Army Engineer Waterways Experiment Station, Vicksburg, MS.
40. Landin, M. C. "Building and Management of Dredged Material Islands for North American Wildlife," Proc. 9th World Dredging Conference, Vancouver, BC, Canada, 28 pp., 1980.
41. Landin, M. C., "Habitat Development at Eight Corps of Engineer Sites: Feasibility and Assessment," MP D-82-1, 1982, U. S. Army Engineer Waterways Experiment Station, Vicksburg, MS.
42. Landin, M. C., "Habitat Development Using Dredged Material," Proc. Dredging and Dredged Material Disposal, ASCE Conference, Tampa, FL, 1984, pp. 907-918.
43. Lang, P., et al., "Guidance for Contracting Biological and Chemical Evaluations of Dredged Material," Report to U. S. Army Engineer District, New York, 1981, U. S. Army Engineer Waterways Experiment Station, Vicksburg, MS.
44. Lee, C. R., Engler, R. N., and Mahloch, J. L., "Land Application of Waste Materials from Dredging, Construction, and Demolition Processes," MP D-76-5, 1976, U. S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

45. Lee, C. R., Sturgis, T. C., and Landin, M. C., "A Hydroponic Study of Heavy Metal Uptake by Selected Marsh Plant Species," TR D-76-05, 1976, U. S. Army Engineer Waterways Experiment Station, Vicksburg, MS.
46. Lee, C. R., Smart, R. M., Sturgis, T. C., Gordon, R. N., and Landin, M. C., "Prediction of Heavy Metal Uptake by Marsh Plants Based on Chemical Extraction of Heavy Metals from Dredged Material," TR D-78-06, 1978, U. S. Army Engineer Waterways Experiment Station, Vicksburg, MS.
47. Lee, C. R., et al., "Restoration of Problem Soil Materials at Corps of Engineers Construction Sites," Instruction Report in preparation, 1985, U. S. Army Engineer Waterways Experiment Station, Vicksburg, MS.
48. Lewis, R. R. and Phillips, R., "Experimental Seagrass Mitigation in the Florida Keys," Proc. U. S. Fish and Wildlife Service Workshop on Coastal Ecosystems of the Southeastern United States, pp. 143-152, 1981.
49. Little, A. D., Inc., "A Feasibility Study of Lawn Sod Production and/or Related Activities on Dredged Material Disposal Sites," CR D-75-1, 1975, U. S. Army Engineer Waterways Experiment Station, Vicksburg, MS.
50. Little, E. J. and Quick, J. A., Jr., "Ecology, Resource Rehabilitation, and Fungal Parasitology of Commercial Oysters in Pensacola Estuary, FL," Florida Marine Research Publication No. 21, 1976, 89 pp.
51. Lunz, J. D., Diaz, R. J., and Cole, R. A., "Upland and Wetland Habitat Development with Dredged Material: Ecological Considerations," TR DS-78-15, 1978, U. S. Army Engineer Waterways Experiment Station, Vicksburg, MS.
52. Lunz, J. D., Nelson, D. A., and Tatem, H. E., "Aquaculture in Dredged Material Containment Areas," Proc. Dredging and Dredged Material Disposal, ASCE Conference, Tampa, FL, 1984, pp. 811-819.
53. Mang, J. L., Lu, S., Lofy, R. J., and Stearns, R. P., "A Study of Leachate from Dredged Material in Upland Areas and/or in Productive Uses," TR D-78-20, 1978, U. S. Army Engineer Waterways Experiment Station, Vicksburg, MS.
54. Mann, R., Niering, W. A., Sabbatina, R., and Wells, P., "Landscape Concept Development for Confined Dredged Material Sites," CR D-75-05, 1975, U. S. Army Engineer Waterways Experiment Station, Vicksburg, MS.
55. Marion, W. R. and Shamis, J. D., "An Annotated Bibliography of Bird Marking Techniques," Bird-Banding, Vol. 48, No. 1, pp. 42-61, 1977.



EM 1110-2-5026  
30 Jun 87

56. Montgomery, R. L., "Methodology for Design of Fine-Grained Dredged Material Containment Areas," TR D-78-56, 1978, U. S. Army Engineer Waterways Experiment Station, Vicksburg, MS.
57. Montgomery, R. L., Ford, A. L., Poindexter, M. E., and Bartos, M. J., "Guidelines for Disposal Area Reuse," TR DS-78-12, 1978, U. S. Army Engineer Waterways Experiment Station, Vicksburg, MS.
58. Neff, D. J., "The Pellet-Group Count Technique for Big Game Trend, Census, and Distribution: A Review," Journal of Wildlife Management, Vol. 32, No. 3, pp. 597-614, 1968.
59. Newling, C. J., and Landin, M. C., "Long-Term Monitoring of Habitat Development at Upland and Wetland Dredged Material Disposal Sites: 1974-1982," TR D-85-5, 1985, U. S. Army Engineer Waterways Experiment Station, Vicksburg, MS.
60. Office, Chief of Engineers, Department of the Army, "The Unified Soil Classification System," Standard 619, 1960, Washington, DC.
61. Ohman, L. F. and Ream, R. R., "Wilderness Ecology: A Method of Sampling and Summarizing Data for Plant Community Classification," USDA Forest Research Paper NC-49, North Central Forest Experiment Station, St. Paul, MN, 1971, 14 pp.
62. Palermo, M. R., Montgomery, R. L., and Poindexter, M. E., "Guidelines for Designing, Operating, and Managing Dredged Material Containment Areas," TR DS-78-10, 1978, U. S. Army Engineer Waterways Experiment Station, Vicksburg, MS.
63. Perrier, E. R., Llopis, J. L., and Spaine, P. A., "Area Strip Mine Reclamation Using Dredged Material: A Field Demonstration," TR EL-80-4, 1980, U. S. Army Engineer Waterways Experiment Station, Vicksburg, MS.
64. Phillips, R., "Planting Guideline for Seagrasses," EA 80-2, 1980, U. S. Army Engineer Coastal Engineering Resources Center, Fort Belvoir, VA.
65. Pierce, R. J., Wetland Plants of the Eastern United States, U. S. Army Engineer Division, North Atlantic, New York, NY, 1977, 50 pp.
66. Plumb, R. H., Jr., "Procedure for Handling and Chemical Analysis of Sediment and Water Samples," TR EPA/CE-81-1, 1981, U. S. Army Engineer Waterways Experiment Station, Vicksburg, MS.
67. Pullen, E. J. and Naqui, S. M., "Biological Impacts on Beach Replenishment and Borrowing," Shore and Beach, Vol. 51, 1983 (Apr), pp. 27-31.

68. SCS Engineers, "Feasibility of Inland Disposal of Dewatered Dredged Material: A Literature Review," TR D-77-33, 1977, U. S. Army Engineer Waterways Experiment Station, Vicksburg, MS.
69. Schemnitz, S. D., Ed., Wildlife Management Techniques Manual, The Wildlife Society, Washington, DC, 1980, 686 pp.
70. Silberhorn, G. M., Tidal Wetland Plants of Virginia, VIMS Science Education Series No. 19, Virginia Institute of Marine Science, Gloucester Point, VA, 86 pp., 1976.
71. Skjei, S. S., "Socioeconomic Aspects of Dredged Material Disposal: The Creation of Recreation Land in Urban Areas," CR D-76-06, 1976, U. S. Army Engineer Waterways Experiment Station, Vicksburg, MS.
72. Smith, H. K., "Introduction to Habitat Development on Dredged Material," TR DS-78-19, 1978, U. S. Army Engineer Waterways Experiment Station, Vicksburg, MS.
73. Soots, R. F., Jr., and Landin, M. C., "Development and Management of Avian Habitat on Dredged Material Islands," TR DS-78-18, 1978, U. S. Army Engineer Waterways Experiment Station, Vicksburg, MS.
74. Souder, P. S., Jr., Tobias, L., Imperial, J. F., and Mushal, F. C., "Dredged Material Transport Systems for Inland Disposal and/or Productive Use Concepts," TR D-78-28, 1978, U. S. Army Engineer Waterways Experiment Station, Vicksburg, MS.
75. Spaine, P. A., Llopis, J. L., and Perrier, E. R., "Guidance for Land Improvement Using Dredged Material," TR DS-78-21, 1978, U. S. Army Engineer Waterways Experiment Station, Vicksburg, MS.
76. Thorhaug, A., "Seagrasses in the Gulf of Mexico, Florida, and Caribbean Including Restoration and Mitigation of Seagrasses," Proc. U. S. Fish and Wildlife Service Workshop on Coastal Ecosystems of the Southeastern United States, pp. 161-178, 1981.
77. Thorhaug, A., "Large Scale Seagrass Restoration in a Damaged Estuary," Marine Pollution Bulletin, Vol. 16, No. 2, pp. 55-62, 1985.
78. Uetz, G. W., Van Der Laan, K. L., Summers, G. F., Gibson, P. A. K., and Getz, L. L., "The Effects of Flooding on Floodplain Arthropod Distribution, Abundance and Community Structure," American Midland Naturalist, Vol. 101, No. 2, pp. 286-299, 1979.

EM 1110-2-5026  
30 Jun 87

79. Urban Research and Development Corporation, "Recreation Carrying Capacity Handbook: Methods and Techniques for Planning, Design, and Management," IR R-80-1, 1980, U. S. Army Engineer Waterways Experiment Station, Vicksburg, MS.
80. U. S. Environmental Protection Agency, "Methods for Chemical Analysis of Water and Wastes," EPA Monitoring and Support Laboratory, 1979, Cincinnati, OH.
81. Walsh, M. R. and Malkasian, M. D., "Productive Land Use of Dredged Material Containment Areas: Planning and Implementation Considerations," TR DS-78-20, 1978, U. S. Army Engineer Waterways Experiment Station, Vicksburg, MS.
82. Walski, T. M. and Schroeder, P. R., "Weir Design to Maintain Effluent Quality from Dredged Material Containment Areas," TR D-78-18, 1978, U. S. Army Engineer Waterways Experiment Station, Vicksburg, MS.
83. Weber, C., I., Ed., "Biological Field and Laboratory Methods for Measuring the Quality of Surface Waters and Effluents," EPA-670/4-73-001, EPA Office of Research and Development, Cincinnati, OH, 1973.
84. Willoughby, W. E., "Low-Ground-Pressure Construction Equipment for Use in Dredged Material Containment Area Operation and Maintenance: Performance Predictions," TR D-77-1, Vol II, 1977, U. S. Army Engineer Waterways Experiment Station, Vicksburg, MS.
85. Wolf, P. L., Shanholtzer, S. F., and Reimold, R. J., "Population Estimates for Uca pugnax (Smith, 1970) on the Duplin Estuary Marsh, GA, U. S. A.," Crustaceana, Vol. 29, No. 1, pp. 79-91.

APPENDIX B

PLANT MATERIALS FOR BENEFICIAL USE SITES

B-1. General.

a. This appendix contains two tables of plant species recommended for planting on dredged material beneficial use sites. The upland plant species table (Table B-1) is 32 pages long and contains detailed information on propagation and planting of 359 native and cultivated species. These upland plants are suitable for habitat development (the listing was developed for that purpose), parks and recreational sites, livestock pastures, natural areas, rights-of-way, confined disposal dikes and levees, reservoir projects, land-fill sites, strip mine reclamation, and other beneficial use sites in need of vegetative cover. The marsh plant species table (Table B-2) is 10 pages long and contains detailed information on propagation and planting of 105 individual species and groups of species suitable for use in marshes and habitat development wetland sites. No distinction has been made in salinity of pH tolerances or soil requirements of the plants. Both of these tables were taken from item 39, and that paper should be referred to for more specific information on these plant materials.

b. There are numerous Federal, state, and private sources of native plant materials, including the following:

- U.S. Soil Conservation Service Plant Material Centers
- U.S. Forest Service Tree Nurseries
- U.S. Forest Service National Forests
- State Agriculture Experiment Station at Land Grant Colleges in each state
- State Forests
- State Departments of Natural Resources
- State Game and Fish Commissions
- State Departments of Agriculture

Soil Conservation Service and Forest Service information and reports may be obtained by writing to the U.S. Department of Agriculture, Washington, DC 20250.

Table B-1  
Selected Upland Plant Species for Habitat Development on Dredged Material Sites (Item 39)

Species* (Alphabetized by Common Name)	Best Propagule Type	Collection Periods**	Temporary Storage Requirements	Planting Periods**	Range†	Mature Height	Growth Habits	Remarks
<b>Grasses</b>								
American beachgrass <sup>1,2,3</sup>	Transplants	Oct-Mar	In wet sand beds or in pots of sand	Feb-May	MA, NE, GL	To 5 ft	Perennial cool season grass with stiff stems, full sun	Tolerates saline conditions, beach and dune areas, excellent for sandy beach and dune areas
American dunegrass <sup>1,3</sup>	Transplants	Sep-Mar	In wet sand beds or in pots of sand	Mar-Jun	NE, RMW	To 5 ft	Strong, erect fast growing, full sun	Prefers sand areas, good soil stabilizer
Bahia grass <sup>1,3</sup>	Seeds	Jul-Sep	Dry, cool area	Mar-Jun	SE, MA, FL, MS	To 6 in.	Summer perennial, creeping base with upright stems, full sun	Cultivated for pasture, good cover, wide range of soils
Barley <sup>1,2,3</sup>	Seeds	May-Jul	Dry, cool area	Oct-Nov	Entire U.S.	To 4 ft	Annual winter cover crop grass, full sun	Extensively cultivated for cover and grain, requires good soil bed
Barnyard grass <sup>1,3</sup>	Seeds	Jun-Sep	Dry, cool area	May-Sep	Entire U.S. except FL	To 6 ft	Annual grass, arching heads, full sun	Prefers moist soils, cultivated for waterfowl food
Beach panic grass <sup>1</sup>	Transplants	Sep-Mar	In wet sand beds or pots of sand	Mar-Jun	MA, SE, FL, MS	To 4 ft	Perennial, few flowered, full sun	Prefers sandy soils
Beaked panic grass <sup>1</sup>	Seeds	Jul-Sep	Dry, cool area	Apr-Jun	MA, SE, FL, MS, MKV, SP, MP	To 6 ft	Perennial, hardy, fast growing, full sun	Prefers moist sandy soil
Big bluestem <sup>1,3</sup>	Seeds	Jul-Sep	Dry, cool area	Apr-Jun	Entire U.S. except PNW, CA	To 6 ft	Perennial, robust, tufted, dense sod, full sun	Important forage grass, prefers well-drained soils
Bromegrass <sup>1,3</sup>	Seeds	Jul-Sep	Dry, cool area	Apr-Jun	Entire U.S. except SE, FL, MS, SP	To 6 ft	Perennial, creeping rhizomes, erect stems, dense sod, full sun	Important forage grass, prefers well-drained soils
Bromesedge <sup>1</sup>	Seeds	Sep-Oct	Dry, cool area	May-Sep	Entire eastern U.S. and CA	To 3 ft	Perennial, dense culms, upright stems, full sun	Pest plant in pastures and crops, grows under most soil conditions

(Continued)

\* Numbers given after species names indicate the following information:  
 1-Known to occur on dredged material.  
 2-Planted on dredged material sites.  
 3-Known to be available commercially or from state and Federal nurseries.  
 \*\* Collection periods, storage requirements and planting periods are only for best propagules. Many of these species may be handled in other ways for other propagule types not portrayed in this table.  
 † SE = southeast; MS = mid-south; SP = south plains; MP = mid plains; NP = north plains; NE = northeast; MA = mid Atlantic; PNW = Pacific northwest; SW = southwest; FL = Florida; GL = Great Lakes; MKV = Mississippi River Valley; CA = California; MW = Midwest

Table B-1 (Continued)

Species (Alphabetized by Common Name) Grasses (Continued)	Best Propagule Type	Collection Periods	Temporary Storage Requirements	Planting Periods	Range	Mature Height	Growth Habits	Remarks
Browntop millet <sup>3</sup>	Seeds	Sep-Nov	Dry, cool area	Mar-Jul	SE, MA, MS, FL	To 9 in.	Summer annual, erect stems, good seed producer, full sun	Prefers wet soils, excellent waterfowl food, no soil preparation necessary in many cases
Bull paspalum <sup>1</sup>	Seeds	Jul-Oct	Dry, cold room	Mar-Jun	MA, SE, FL, MS	To 6 ft	Stout summer annual, fast growing, spreading, full sun	Prefers moist soils, good seed producer
Buehy beardgrass <sup>1</sup>	Seeds	Aug-Oct	Dry, cool area	Apr-Jun	NE, MA, SE, FL, MS, SP, SW, CA	To 6 ft	Erect dense, fast growing, full sun	Prefers moist soils
Calley Bermuda grass <sup>3</sup>	Transplants, rootstock	Year-round	In soil beds	Mar-Jun	SE, MS, SP, FL	To 6 in.	Perennial, fast growing, sterile, full sun	Vigorous new hybrid Bermuda, pasture use
Coastal Bermuda grass <sup>3</sup>	Transplants, rootstock	Year-round	In soil beds	Mar-Jun	SE, MA, FL, SP, MS	To 6 in.	Perennial, fast growing, sterile, full sun	Planted extensively in southern pastures for grazing and hay, tolerates salt spray
Common Bermuda grass <sup>1,3</sup>	Seeds	Jun-Sep	Dry, cool area	Apr-Jun	Entire U.S. except NM, PNM, NP, NE	To 2-4 in.	Perennial, fast growing, abundant seeds, full sun	Pasture crop, lawns, peat in cultivated areas, tolerates wide range of conditions
Common reed <sup>1</sup>	Rootstock, rhizomes	Sep-Mar	In sand beds or pots of sand	Feb-Jun	GL, NE, MA, SE, FL, MS, SP	To 12 ft	Perennial, fast growing persistent, full sun	Peat plant in many areas; not recommended for any use other than soil stabilization
Corn <sup>1,2,3</sup>	Seeds	Jul-Oct	Dry, cool area	Mar-Jun	Entire U.S.	To 9-10 ft	Summer annual, upright heavy seed producer, full sun	Cultivated extensively for grain, silage, and human consumption
Dallis grass <sup>1,3</sup>	Seeds	Jun-Sep	Dry, cool area	Year-round (MS, FL) Apr-May (north)	SE, MS, FL, MA, SP, SW	To 5 ft	Dense perennial, full sun	Cultivated pasture grass
Deertongue <sup>1</sup>	Seeds	Aug-Oct	Dry, cool area	Oct-Nov; Mar-Apr	NE, MA, SE, MS, MP, NP, HRV	To 5 ft	Warm season, full sun, dense clumps	Tolerates acid soils, seeds have strong dormancy
European beachgrass <sup>1,3</sup>	Transplants	Oct-Mar	Hold in wet sand beds or in sand pots	Feb-May	PNM, CA	To 5 ft	Perennial, cool season grass, rigid stems, full sun	Tolerates saline conditions, excellent for sand beach and dune areas

(Continued)

(Sheet 2 of 32)

Table B-1 (Continued)

Species (Alphabetized by Common Name)	Best Propagate Type	Collection Periods	Temporary Storage Requirements	Planting Periods	Range	Mature Height	Growth Habits	Remarks
<u>Grasses (Continued)</u> Fall panic grass <sup>1</sup>	Seeds	Sep-Nov	Dry, cool area	Feb-Jun	Entire U.S. NP, PNW	To 3 ft	Coarse, summer annual, fast growing, good seed producer, full sun	Tolerates wide range of soil conditions, including wet areas, considered crop pest plant
Foxtail millet <sup>3</sup>	Seeds	Jun-Sep	Dry, cool area	Apr-Jul	Entire U.S. except MW, FL, SP	To 6 ft	Summer annual, upright, fast growth, full sun	Cultivated exten- sively for grain and silage, prefers moist soils
Goose grass <sup>1</sup>	Seeds	Jun-Sep	Dry, cool area	Apr-Jul	Entire U.S. except NP, PNW	To 6 in.	Small culmed perennial, heavy seed producer, full sun	Pest plant in culti- vated areas, grows in most soil conditions
Green bristlegrass <sup>1</sup>	Seeds	Jul-Oct	Dry, cool area	Apr-Jul	Entire U.S.	To 3 ft	Vigorous summer annual, clumped, full sun	Occurs in many soils, pest in crops, not palatable to browsers
Italian ryegrass <sup>1</sup>	Seeds	May-Jul	Dry, cool area	Oct-Nov	Eastern U.S. and SP, NP, PNW, CA	To 3 ft	Perennial in south, in north, hardy, forms dense root system, full sun	Cultivated for winter grazing, quick winter cover, and lawns
Japanese millet <sup>3</sup>	Seeds	Jun-Sep	Dry, cool area	Apr-Sep	Entire U.S. except FL	To 5 ft	Tall heavy annual, abundant seeds, full sun	Occurs in all soils, grown for waterfowl and cattle feed, is salt tolerant to some extent
Johnson grass <sup>1,3</sup>	Seeds	Jul-Oct	Dry, cool area	Apr-Sep	Entire U.S. except NP, MW, PNW	To 5 ft	Hardy, fast growing, erect, strong seed pro- ducer, full sun	Planted for pastures and hay, pest plant in cultivated areas
Jungle rice <sup>1</sup>	Seeds	Jun-Sep	Dry, cool area	May-Sep	Entire U.S. except NP, MW	To 3-4 in.	Perennial, prostrate to erect, full sun	Good seed producer, prefers wet to moist soils
Large crabgrass <sup>1</sup>	Seeds	Jun-Sep	Dry, cool area	Apr-Sep	Entire U.S. except NP	To 1 ft	Creeping annual fast growing, full sun	Occurs in all soils, pest in cultivated areas, immune to herbicides
Little hairgrass <sup>1</sup>	Seeds	Jun-Aug	Dry, cool area	Apr-Jun	MA, PNW, CA	To 10 in.	Annual, tufted culms, full sun	Prefers sand, dry coastal soils
Oats <sup>3</sup>	Seeds	May-Jun	Dry, cool area	Sep-Oct	Entire U.S.	To 3 ft	Cool season annual, agronomic cereal crop, full sun	Occurs in almost all soil conditions, needs well-prepared seed bed

(Continued)

(Sheet 3 of 32)

Table B-1 (Continued)

Species (Alphabetized by Common Name)	Best Propagate		Temporary Storage Requirements	Planting Periods	Range	Mature Height	Growth Habits	Remarks
	Type	Collection Periods						
Orchardgrass <sup>1,3</sup>	Seeds	Jun-Aug	Dry, cool area	Mar-Sep	Entire U.S.	To 4 ft	Clumped, perennial hardy, full sun to shade	Prefers well-drained soils and does well in many soils, culti- vated for grazing, hay, and silage
Panic grass <sup>1</sup>	Seeds	Jun-Aug	Dry, cool area	Mar-Jun	Eastern and mid-U.S.	To 4 ft	Dense clumped perenni- als, strong rhizomes, full sun	Prefers moist sandy soil
Pearl millet <sup>3</sup>	Seeds	Sep-Oct	Dry, cool area	Mar-Jun	MA, SE, SP, SW	To 6 ft	Robust, summer annual, heavy seed producer, full sun	Cultivated for grain and silage, prefers moist soil but toler- ates drought
Perennial ryegrass <sup>1,3</sup>	Seeds	May-Jul	Dry, cool area	Sep-Nov	SE, MS, SP, FL	To 3 ft	Hardy, dense root sys- tem, full sun	Good winter cover, good winter wildlife food and cattle for- age in the south
Prairie cordgrass <sup>1,2,3</sup>	Seeds	Jul-Oct	Dry, cool area	Apr-Jun	Entire U.S. except SE, FL, MS, CA	To 9 ft	Tall perennial, full sun	Occurs in wet, coastal areas
Proso millet <sup>3</sup>	Seeds	Sep-Oct	Dry, cool area	Mar-Jun	MW, SP	To 4 ft	Summer annual, erect stems, full sun	Produces seeds in 4 months after plant- ing, good food value, cultivated for grain
Quackgrass <sup>1</sup>	Rootstock	Sep-Mar	In sand beds or pots of sand	Mar-Jun	Entire U.S.	To 4 ft	Perennial, long running root stock, hardy, full sun	Pest plant, exotic
Red fescue <sup>1,3</sup>	Seeds	May-Aug (north)	Dry, cool area	Mar-May (north)	Entire U.S. except FL, SP MS, SE	To 3 ft	Hardy robust creeping grass forms a dense sod, sheds, to full sun	Cultivated exten- sively in mixed stands for pastures, lawns, and rights-of-ways
Redtop <sup>1,3</sup>	Seeds	Aug-Oct	Dry, cool area	Apr-Jun	Entire U.S.	To 3 ft	Tall hardy, stolonifer- ous, full sun	Cultivated for silage, hay, and grazing
Red canary grass <sup>1,3</sup>	Seeds	Jun-Aug	Dry, cool area	Mar-Jun	Entire U.S.	To 6 ft	Summer perennial, robust, fast growth, full sun	Prefers moist soil, but grows anywhere, cultivated on sewage areas and for pas- tures, good seed producer

(Continued)

(Sheet 4 of 32)



Table B-1 (Continued)

Species (Alphabetized by Common Name)	Best Propagate Type	Collection Periods	Temporary Storage Requirements	Planting Periods	Range	Mature Height	Growth Habits	Remarks
Rescue grass <sup>1,3</sup>	Seeds	Jul-Oct	Dry, cool area	Apr-Jun	SE, MA, CA, SW	To 3 ft	Robust, summer perenn- ial, full sun	Cultivated in south as forage
Rice cutgrass <sup>1</sup>	Seeds	Aug-Oct	Dry, cool area	Apr-Jul	Entire U.S.	To 4 ft	Dense culms, perennial, much branched, shade to full sun	Prefers moist and wet soils
Rye <sup>3</sup>	Seeds	May-Jul	Dry, cool area	Sep-Nov (south) Apr-May (north)	Entire U.S.	To 3 ft	Hardy cool season an- nual, high speed pro- ducer, full sun	Cultivated exten- sively for grain, cover, and green forage crops, espe- cially in north
Saltgrass <sup>1,2,3</sup>	Transplants, seeds	Sep-May Jul-Sep	In wet sand beds or in pots of sand	Mar-Jun	Entire U.S. in saline areas except PNW, CA	To 1 ft	Dense perennial, hardy, many rhizomes, good seed producer, full sun	Prefers moist, coastal areas, occurs in salt marshes and on sand dunes
Saltmeadow cordgrass <sup>1,2,3</sup>	Transplants, seedlings	Year-round (south) Mar-Oct (north)	In wet sand beds or in sand pots	Feb-Jun	NE, MA, SE, FL, MS, SP	To 3 ft	Densely rooted, summer perennial, spreads best from tillers	Occurs in flooded saline areas to dry sand dunes, and is successfully planted on dredged material
Sand dropseed <sup>1</sup>	Seeds	Sep-Oct	Dry, cool area	Apr-Jul	Entire U.S.	To 3 ft	Erect perennial, hardy, slow growing, full sun	Prefers sandy soils, grows on prairie areas
Sea oats <sup>1,2,3</sup>	Transplants, seeds	Sep-Mar (trans) Aug-Oct (seeds)	In wet sand beds	Mar-Jun	MA, SE, FL MS	To 6 ft	Robust perennial, dense roots, full sun	Prefers sandy, coastal areas, excel- lent dune stabilizer, tolerates salt spray
Seashore bluegrass <sup>1</sup>	Transplants	Sep-Mar	In wet sand beds or pots of sand	Mar-Jun	PNW, CA	To 1 ft	Creeping rhizomous per- ennial with upright culms, full sun	Prefers coastal sand dunes
Seashore paspalum <sup>1</sup>	Transplants	Sep-Mar	In wet sand beds or in sand pots	Sep-Jun	SE, FL, MS	To 1 ft	Dense perennial, fast growing, full sun	Tolerates flooding and salt spray, occurs on dredged material islands in dense stands
Shoredune panic grass <sup>1</sup>	Seeds	Sep-Oct	Dry, cool area	Mar-May	NE, MA, FL, MS, SP	To 6 ft	Upright, coarse, peren- nial, fast growing, full sun	Prefers sandy beach soils, tolerates salt sprays, occurs on dredged material islands

(Continued)

Table B-1 (Continued)

Species (Alphabetized by Common Name)	Best Propagule Type		Collection Periods	Temporary Storage Requirements	Planting Periods	Range	Mature Height	Growth Habits	Remarks
	Type	Periods							
Grasses (Continued)									
Sixweeks fescue <sup>3</sup>	Seeds	May-Jun	Dry, cool area	Mar-May	Entire U.S.	To 1 ft	Annual, fast seed producer, full sun or shade	Cultivated as forage and hay crops	
Smooth crabgrass <sup>1</sup>	Seeds	Jun-Sep	Dry, cool area	Apr-Sep	Entire U.S. except SW	To 1 ft	Creeping, fast growing, annual, full sun	Occurs in many soil types, a pest in cultivated fields and gardens	
Sorghum <sup>3</sup>	Seeds	Jul-Oct	Dry, cool area	Apr-Sep	Entire U.S.	To 6 ft	Upright, summer annual, heavy seed producer, full sun	Cultivated extensively as grain and silage crop, tolerant area wide range of soils	
Sudan grass <sup>3</sup>	Seeds	Jul-Oct	Dry, cool area	Apr-Jul	Entire U.S. except NE, PNW	To 9 ft	Wandering, upright annual, hardy, fast growing, full sun	Cultivated for hay and silage, tolerates wide range of soils	
Switchgrass <sup>1,3</sup>	Seeds	Jun-Sep	Dry, cool area	Apr-Sep	Entire U.S. except NP, PNW, CA	To 6 ft	Summer perennial, fast growing, hardy, full sun	Prefers moist soils, grows at water's edge, tolerant of salt spray	
Tall fescue <sup>1,2,3</sup>	Seeds	Apr-Jun (south) May-Aug (north)	Dry, cool area	Oct-Nov (S) Mar-May (N)	Eastern U.S. except FL, NP, PNW	To 5 ft	Cool weather grass in south, summer grass in north, full sun	Cultivated for pastures	
Texas millet	Seeds	Jul-Oct	Dry, cool area	Mar-Aug	MA, SE, FL, MS, SP	To 6 ft	Summer annual with spreading stems, full sun	Fast growing, considered crop weed, grows well on sand dunes	
Timothy <sup>1,2,3</sup>	Seeds	Jul-Sep	Dry, cool area	Apr-Jun	Entire U.S. except SP, FL, MS	To 3 ft	Summer perennial, fast growing, erect, full sun	Cultivated extensively in North America for hay	
Torpedo grass <sup>1</sup>	Transplants	Sep-Mar	In wet soil beds or pots of sand	Sep-Jun	FL, MS, SP	To 4 in.	Stout perennials, many rhizomes, dense cover, full sun	Sea beaches, prefers sandy moist soils, tolerates salt spray	
Vasey grass <sup>1</sup>	Seeds	Jul-Sep	Dry, cool area	Apr-Jun	FL, SE, MA, MS, SP, CA	To 6 ft	Clumped, stout perennial, erect, hardy, full sun	Prefers moist soil, pasture grass, roadside cover	
Virginia dropseed <sup>1</sup>	Seeds	Jun-Sep	Dry, cool area	Apr-Jun	MA, FL, MS	To 1 ft	Perennial, branching rhizomes, erect, culms, full sun	Occurs on sandy and muddy seashores, tolerates salt spray	

(Continued)

(Sheet 6 of 32)

Table B-1 (Continued)

Species (Alphabetized by Common Name)	Best Propagule Type	Collection Periods	Temporary Storage Requirements	Planting Periods	Range	Mature Height	Growth Habits	Remarks
<u>Grasses (Continued)</u> Walter's millet <sup>1,3</sup>	Seeds	Jul-Sep	Dry, cool area	Apr-Sep	SP, MS, FL, SE, MA, NE, CA	To 9 ft	Stiff stems, abundant seeds, annual, full sun	Occurs in all soils, cultivated for waterfowl food, prefers wet soils
Wheat <sup>3</sup>	Seeds	May-Jul	Dry, cool area	Oct-Nov (winter) Mar-May (spring)	Entire U.S.	To 3 ft	Winter annual, good seed producer, hardy, full sun	Cultivated extensively, tolerates cold, good cover and food crop
Wild rye <sup>1</sup>	Seeds	May-Jul	Dry, cool area	Sep-Jun	Entire U.S. except CA	To 4 ft	Perennial, tufted, erect culms, heavy seeds, full sun	Prefers moist soils, good seed producer, tolerates salt spray somewhat
Woolly panic grass <sup>1</sup>	Seeds	Jul-Sep	Dry, cool area	Apr-Jun	MA, SE, FL, MS	To 2 ft	Perennial, clumped spreading shade and sun	Prefers moist soils, grows in woods and open areas, occurs on sea coast
Yellow bristlegrass	Seeds	Jul-Oct	Dry, cool area	Apr-Jul	Entire U.S. except SW, CA	To 3 ft	Summer annual, good seed producer, full sun	Occurs in many soil con- ditions, pest in crops, not palatable to browsers
<u>Herbs</u> Alfalfa <sup>3</sup>	Seeds (innoculated)	Jul-Sep	Dry, cool area	Aug-Sep or Feb-Apr	Entire U.S.	To 2 ft	Perennial, much-branched legume, full sun	Requires good seedbed preparation, occurs on moist soils, prefers rich, moist areas
Alsike clover	Seeds (innoculated)	Mar-Apr (south) Jun-Sep (north)	Dry, cool area	Nov-Feb (south) Mar-Jun (north)	Entire U.S.	To 2 ft	Perennial, ascending branches, full sun	Prefers moist, acidic soils, cultivated in areas where clovers won't grow
Arrow-leaved tearthumb <sup>1</sup>	Transplants, seeds	Jul-Sep	Dry, cool area	Mar-Jun	Eastern and mid-U.S.	To 2 ft	Viney, annual, weak stemmed, spiny, full sun	Prefers moist soils
Beach pea <sup>1</sup>	Seeds (innoculated)	May-Sep	Dry, cool area	Feb-Jun	Entire coastal U.S.	To 1 ft	Perennial, viney plant, hardy, full sun	Prefers sandy moist soils, occurs on coastal beaches dunes, and islands
Beach strawberry	Transplants	Sep-Mar	In sand beds or in pots of sand	Mar-Jun	PNW, SW	To 8 in.	Perennial plants with runners, full sun to shade	Prefers moist sandy soils
Big filaree	Seeds	Apr-Jul	Dry, cool area	Sep-Nov	CA	To 8 in.	Winter annual, full sun	Pest plant, occurs in most well-drained soils

(Continued)

Table B-1 (Continued)

Species (Alphabetized by Common Name)	Best Propagate Type	Collection Periods	Temporary Storage Requirements	Planting Periods	Range	Mature Height	Growth Habits	Remarks
<b>Herbs (Continued)</b>								
Bird's foot trefoil <sup>1</sup>	Seeds (innoculated)	Jun-Sep	Dry, cool area	Mar-Jun	NE, MA	To 2 ft	Long rooted perennial, full sun	Pest plant, occurs in most soils, common coasts
Bittersweet nightshade <sup>1</sup>	Seeds	May-Sep	Dry, cool area	Apr-May	NE, MA, NP	To 8 ft	Perennial, climbing stem, full sun to shade	Prefers moist soils and in woods, but grows in open areas
Black medic <sup>1,3</sup>	Seeds (innoculated)	Mar-Jun (south) Jun-Aug (north)	Dry, cool area	Nov-Feb (south) Mar-Jun (north)	Entire U.S.	To 1 ft	Annual, shallow taproot, full sun	Prefers well-drained or dry soils, dormant in south in the summer
Black nightshade <sup>1</sup>	Seeds	Jul-Oct	Dry, cool area	Apr-Jun	Eastern U.S.	To 3 ft	Erect, annual, hairy, hardy, full sun	Pest in cultivated areas, occurs in most soils
Blackseed plantain <sup>1</sup>	Seeds	Jun-Sep	Dry, cool area	Apr-Jun	Eastern and mid U.S.	To 3 ft	Perennial, rootstock, stout, thick, erect, hardy, full sun or shade	Pest plant, occurs in woods, fields, and waste areas
Bottlebrush <sup>1</sup>	Seeds	May-Oct	Dry, cool area	Apr-Jun	Eastern U.S.	To 3 ft	Annual, many branched stem, full sun	Prefers well-drained open areas
Bracted plantain <sup>1</sup>	Seeds	Jun-Oct	Dry, cool area	Apr-Jun	Entire U.S. To 2 ft except, NM, NM, CA, SW	To 2 ft	Perennial, stout root- stock, erect, full sun	Prefers dry open areas
Broadleaf plantain <sup>1</sup>	Seeds	May-Sep	Dry, cool area	Apr-Jun	Entire U.S.	To 8 in.	Perennial, rootstock short, thick, erect, full sun	Occurs in most soils, in waste places
Buckthorn plantain <sup>1</sup>	Seeds	Apr-Nov	Dry, cool area	Mar-Jun	Eastern U.S.	To 1 ft	Perennial, pubescent, short rootstock, full sun	In fields and waste places
Bush lupine	Seeds	Jun-Sep	Dry, cool area soak in hot water before planting	Apr-Jun	PNW, CA	To 2 ft	Perennial, many branched, shrubby, full sun	In dry, open areas
Calandrinia	Seeds	Jul-Sep	Dry, cool area	Mar-Jun	CA	--	--	In dry scrub areas, sandy coastal beaches
Camphorweed <sup>1</sup>	Seeds	Jul-Sep	Dry, cool area	Apr-Jun	MA, SE, FL, MS, SW, SP, MP	To 3 ft	Biennial, many branched many flowered, full sun	Prefers dry, sandy soils, sea beaches, occurs com- monly on dredged mate- rial islands
Chufa <sup>1,2,3</sup>	Tubers, seeds	Jul-Oct	Moist cold room (tubers) Dry, cool area (seeds)	Mar-Jun	Entire U.S.	To 2 ft	Perennial sedge, robust, fast growing, numerous edible tubers, full sun	Prefers wet to moist soils, prime wildlife food, extremely prolific

(Continued)

(Sheet 8 of 32)

Table B-1 (Continued)

Species (Alphabetized by Common Name)	Best Propagule Type	Collection Periods	Temporary Storage Requirements	Planting Periods	Range	Mature Height	Growth Habits	Remarks
<u>Herbs (Continued)</u>								
Coast deervetch	Seeds (innoculated)	Jun-Sep	Dry, cool area	Apr-Jun	PW, CA	To 2 ft	Perennial, long roots, slender stems, full sun	Prefers dry, well- drained soils
Common chickweed <sup>1</sup>	Seeds	Dec-Feb	Dry, cool area	Oct-Dec	Entire U.S.	To 2 ft	Weak, tufted annual, much branched, full sun	Pest plant in all agro- nomic situations
Common filaree <sup>1</sup>	Seeds	Apr-Jul	Dry, cool area	Sep-Nov	NE, MA, SF, SP, GL, PW, CA	To 6 in.	Winter annual, taproots, many branched, full sun	Pest plant, occurs in moist soils, prefers well-drained soils
Common lambsquarters <sup>1</sup>	Seeds	Jul-Oct	Dry, cool area	Apr-Jun	Entire U.S.	To 4 ft	Annual erect, bushy com- mon, shade to full sun	Pest plant, occurs in moist soils, occurs on dredged material islands
Common mullein <sup>1</sup>	Seeds	Jun-Sep	Dry, cool area	Apr-Jun	Entire U.S.	To 7 ft	Erect, stout, biennial, full sun	Pest plant, occurs in open well-drained areas
Common purplelane <sup>1</sup>	Seeds	Jun-Sep	Dry, cool area	Apr-Jun	Entire U.S.	To 6 in.	Annual, prostrate, free branching, deep roots, full sun	Prefers dry sandy areas
Common ragweed <sup>1</sup>	Seeds	Sep-Nov	Dry, cool area	Apr-Jun	Entire U.S.	To 2 ft	Annual, shallow roots, robust, common full sun	Pest plant, occurs in moist soils, tolerates salt spray, occurs on dredged material islands
Common epikerueh <sup>1</sup>	Transplants, seeds	Apr-Sep	In sand beds (trans.) moist, cool area	Apr-Sep	Entire U.S.	To 2 ft	Perennial, upright, slender stems, full sun	Occurs in moist soils in interior areas
Common threesquare <sup>1</sup>	Transplants, seeds	Sep-Mar (trans) Jul-Oct (seeds)	In sand beds (trans.) moist cool area	Mar-Jun	Entire U.S. except SW	To 6 ft	Perennial, upright, tri- angular stems, full sun	Occurs in moist soils in fresh and brackish areas, good wildlife food
Cow pea <sup>1</sup>	Seeds (innoculated)	Jun-Sep	Dry, cool area	Mar-Sep	Entire U.S.	To 2 ft	Summer annual, viney, fast growing, good seed producer, full sun	Cultivated in most soils for human food, hay and forage, especially in the south
Crimson clover <sup>3</sup>	Seeds (innoculated)	Mar-Apr (south) Jun-Sep (north)	Dry, cool area	Dec-Feb (south) Mar-Jul (north)	Entire U.S.	To 2 ft	Strong perennial in south, annual in north, procumbent stems, fast growing	Cultivated on moist soils for hay and grazing and on rights-of-ways
Croton	Seeds	Aug-Oct	Dry, cool area	Apr-Jun	CA, SW	To 3 ft	Many branched, stout an- nual, robust, full sun	Occurs in waste areas and dry soils, pest plant

(Continued)

Table B-1 (Continued)

Species (Alphabetized by Common Name)	Best Propagule Type		Collection Periods	Temporary Storage Requirements	Planting Periods	Range	Mature Height	Growth Habits	Remarks
	Type	Storage							
Herbs (Continued)									
Curly dock <sup>1</sup>	Seeds		Apr-Jul	Dry, cool area	Apr-Jun	Entire U.S.	To 4 ft	Perennial, stout, deep tap root, erect, persistent, full sun	Pest plant, occurs in waste areas and crops and in most soils
Deerweed	Seeds		Jun-Sep	Dry, cool area	Apr-Jun	CA	To 2 ft	Perennial, long tap roots, full sun	Occurs waste areas, dry soils
Dwarf spikerush <sup>1</sup>	Transplants, seeds		Mar-Nov (trans) Jun-Sep (seeds)	In sand beds dry, cool area	Mar-Jun	Entire U.S. except SW	To 3 ft	Perennial, tiny stems, turf-like, full sun	Occurs in moist soils in fresh, brackish areas
Pilaree	Seeds		Apr-Sep	Dry, cool area	Nov-May	PNW, CA	To 1 ft	Annual, tufted, ascending stems, full sun	Occurs in most soils, waste places and fields, prefers well-drained areas
Flat pea <sup>1,3</sup>	Seeds (innoculated)		May-Sep	Dry, cool area	Feb-Jun	NE, MA, NY, GL, PNW	To 2 ft	Perennial, viney plant, forms mats, full sun to shade	Occurs in most soils, very slow growing
Flowering spurge <sup>1</sup>	Seeds		Apr-Oct	Dry, cool area	Mar-Jun	Eastern and mid U.S.	To 3 ft	Perennial, long stout rootstock, erect, full sun	Prefers dry soils
Giant ragweed <sup>1</sup>	Seeds		Jul-Oct	Dry, cool area	Apr-Jun	Entire U.S. except PNW, CA	To 15 ft	Annual, stout, erect, persistent, full sun	Pest plant, prefers soil, tolerates salt spray, common on coasts
Goosefoot <sup>1</sup>	Seeds		Jun-Sep	Dry, cool area	Mar-Jun	Entire U.S.	To 3 ft	Annual, scruffy, erect, branched, full sun	Pest plant, occurs in most soils, in waste places
Hairy vetch <sup>3</sup>	Seeds (innoculated)		Mar-Apr (south) Apr-Jul (north)	Dry, cool area	Nov-Feb (south) Mar-May (north)	Entire U.S.	To 3 ft	Annual or biennial, viney, weak, stemmed, fast growing, full sun	Cultivated for forage, occurs in most soils, excellent erosion control
Hardstem bulrush <sup>1,2</sup>	Rhizomes, transplants		Jun-Sep	Dry, cool area	Mar-Jun	Entire U.S.	To 6 ft	Perennial, stout, sharp stemtips, persistent, full sun	Prefers moist soils, pest in low ground pastures, extremely hardy
Ramp sesbania <sup>1</sup>	Seeds		Aug-Nov	Dry, cool area	Mar-Jun	SW, MA, SE, FL, MS, SP	To 12 ft	Annual legume, widely branched, robust, full sun	Occurs in most soils, in soybean fields
Hop clover <sup>3</sup>	Seeds (innoculated)		Jan-Mar (south) Mar-Jun (north)	Dry, cool area	Oct-Feb (south) Jan-Apr (north)	Entire U.S.	To 1 ft	Winter annual, low, forms carpet, procumbent, full sun	Occurs on poor dry soils, excellent nitrogen fixing legume, crowds out grasses

(Continued)

(Sheet 10 of 32)

Table B-1 (Continued)

Species (Alphabetized by Common Name)	Best Propagule Type	Collection Periods	Temporary Storage Requirements	Planting Periods	Range	Mature Height	Growth Habits	Remarks
Herbs (Continued)								
Horse nettle <sup>1</sup>	Seeds	May-Sep	Remove pulpy coat dry, cool area	Apr-Jun	Eastern U.S. and SP	To 2 ft	Perennial, erect, spiny, branched, full sun	Occurs in most dry soils, pest plant in agricultural situations
Horseweed <sup>1</sup>	Seeds	Jun-Nov	Dry, cool area	Apr-Jun	Entire U.S.	To 10 ft	Annual, stout, erect, fast growing, full sun	Pest plant, occurs on most soils, tolerates salt spray, common on dredged material islands
Japanese clover <sup>3</sup>	Seeds (innoculated)	May-Sep	Dry, cool area	Feb-Apr	Entire U.S.	To 3 ft	Annual, erect, many branched, full sun	Cultivated for forage, and silage, excellent on poor, well-drained soils
Jerusalem artichoke	Seeds	Sep-Oct	Dry, cool area	Apr-Jun	Eastern U.S. mid-U.S.	To 12 ft	Perennial, fleshy, root- stock, tubers, stout, erect	Prefers moist soil, tubers are edible
Korean clover <sup>1</sup>	Seeds (innoculated)	May-Sep	Dry, cool area	Feb-Apr	Entire U.S.	To 3 ft	Annual, erect, many branched, full sun	Cultivated for forage, hay, and silage, excel- lent on poor, well- drained soils
Ladino clover <sup>3</sup>	Seeds (innoculated)	Mar-Apr (south) Apr-Jul (north)	Dry, cool area	Nov-Jan (south) Feb-Mar (north)	Entire U.S.	To 3 ft	Perennial, fast growing, fleshy stems, creeping, full sun	Cultivated for forage, hay, and silage, excel- lent on poor, well- drained soils
Ladysthumb <sup>1</sup>	Seeds	Jun-Oct	Dry, cool area	Apr-Jun	Entire U.S.	To 2 ft	Annual, ascending stems, variable branching, full sun	Prefers moist soils, in waste places, pest plant in some areas
Leopedeza <sup>3</sup>	Seeds (innoculated)	May-Sep	Dry, cool area	Feb-May	Entire U.S.	To 2 ft	Perennial, shrubby, full sun	Cultivated for forage, hay, and silage, highway rights-of-ways, well- drained soils
Lupine	Seeds	May-Sep	Dry, cool area soak with hot water prior to planting	Apr-Jun	PNW, CA, SW	To 2 ft	Perennial, shrubby, full sun	Prefers dry, sandy soils
Malta scarthistle <sup>1</sup>	Seeds	Apr-Sep	Dry, cool area	Feb-Apr	Entire U.S.	To 4 ft	Annual, much branched, spiny yellow flowers, full sun	Occurs in most soils, waste and cultivated areas, pest plant
Mapleleaf goosefoot <sup>1</sup>	Seeds	Jul-Sep	Dry, cool area	Apr-Jun	Entire U.S. except PNW, CA	To 8 ft	Annual, erect, bright green, branched, shade to full sun	Occurs in woods and thickets or in open, moist soil types
Marsh pea <sup>1</sup>	Seeds (innoculated)	May-Sep	Dry, cool area	Feb-Jun	Entire U.S.	To 4 ft	Perennial, viney shrub, very persistent, full sun	Prefers moist areas

(Continued)

Table B-1 (Continued)

Species (Alphabetized by Common Name)	Best Propagate Type	Collection Periods	Temporary Storage Requirements	Planting Periods	Range	Mature Height	Growth Habits	Remarks
Herbs (Continued)								
Marsh pepper <sup>1</sup>	Seeds	Jul-Sep	Dry, cool area	Mar-Jun	Entire U.S.	To 2 ft	Annual, erect, reddish green, may be branched full sun	Occurs in moist waste places, sometimes in standing water
Maximilian's sunflower	Seeds	Aug-Nov	Dry, cool area	Apr-Jul	MA, SE, MS SP, MP, NP PNW	To 6 ft	Upright, coarse, stout, annual, full sun	Occurs in moist soils, attractive flowers
Mexican tea <sup>1</sup>	Transplants, seeds	Aug-Oct	Dry, cool area	Apr-Jun	Entire U.S.	To 3 ft	Annual in north, perennial in south, much branched, erect, full sun	Pest plant, occurs in most soils, in cultivated and waste areas
Musk filaree	Seeds	Feb-Jul	Dry, cool area	Nov-Apr	CA	To 2 ft	Winter annual, semierect, full sun	Prefers dry, well-drained soils
Narrowleaf vetch <sup>1,3</sup>	Seeds	Feb-Apr (south) Apr-Jun (north)	Dry, cool area	Oct-Dec Feb-May (north)	Entire U.S.	To 3 ft	Perennial, viney, trailing, spreading, full sun	Cultivated for pastures, hay, and silage
Nodding smartweed <sup>1</sup>	Seeds	Jun-Sep	Dry, cool area	Mar-Jun	Entire U.S.	To 3 ft	Annual, much branched, nodes, swollen, good seed producer, full sun	Occurs in moist soils and in waste and cultivated areas
Nutsedge <sup>1</sup>	Corms, seeds	Jun-Aug	Dry, cool area	Mar-Jun	NP, MP, SP, FL	To 2 ft	Perennial, hard oblong corms, ascending, full sun	Occurs in dry fields and on hills
Olney threesquare <sup>1</sup>	Transplants, seeds	Sep-Mar	In sand beds or in sand pots	Apr-Jun	Entire U.S. coastline	To 7 ft	Perennial, upright, stems three-winged, full sun	Occurs in coastal and fresh moist areas, tolerates salinity
Orache <sup>1</sup>	Seeds	Aug-Oct	Dry, cool area	Apr-Jun	Entire U.S. coastline	To 3 ft	Annual, widely branched fruiting bracts, fleshy, full sun	Occurs in saltmeadows, along coasts, and inland areas
Partridge pea <sup>1,3</sup>	Seeds (immolated)	Jul-Oct	Dry, cool area, soak seeds in water before planting	Apr-Jun	Eastern U.S.	To 3 ft	Annual, widely branched, erect, spreading, full sun	In dry soils, common in south in cultivated fields and disturbed areas
Pennsylvania smartweed <sup>1</sup>	Seeds	Jul-Sep	Dry, cool area	Mar-Jun	Eastern and mid U.S.	To 4 ft	Annual, ascending, branched stems, full sun	Occurs on moist soils, prefers moist soil, a sometimes pest plant
Pickleweed <sup>1</sup>	Seeds	May-Aug	Dry, cool area	Apr-Jun	CA, PNW, NE, SW	To 3 ft	Perennial, stout stem, erect, unbranched, full sun	Prefers wet places

(Continued)

(Sheet 12 of 32)



Table B-1 (Continued)

Species (Alphabetized by Common Name)	Best Propagate Type	Collection Periods	Temporary Storage Requirements	Planting Periods	Range	Mature Height	Growth Habits	Remarks
Herbs (Continued)								
Pokeberry <sup>1</sup>	Seeds	Sep-Oct	Dry, cool area	Mar-Jun	Entire U.S. except NP, PW, MW, SW	To 9 ft	Robust perennial, with several purple stems, full sun to shade	Occurs in moist soil types, and waste places
Prostrate knotweed <sup>1</sup>	Seeds	Jun-Oct	Dry, cool area	Apr-Jun	Entire U.S.	To 2 ft	Annual, prostrate or ascending stems, creeping full sun	Best plant in many areas, occurs in moist soils
Prostrate pigweed	Seeds	Jun-Oct	Dry, cool area	Apr-Jun	NE, CL, MRV, NP	To 2 ft	Annual, many branched, prostrate, spreading, full sun	Prefers well-drained soils, occurs in waste areas, best plant
Prostrate spurge	Seeds	May-Sep	Dry, cool area	Mar-Jun	Entire U.S.	To 2 ft	Perennial, procumbent branches, stout at rootstock, full sun	Prefers well-drained soils
Purple nutsedge <sup>1</sup>	Tubers, seeds	Jul-Sep	Moist, cool area (tubers) dry, cool area (seeds)	Mar-Jul	Entire U.S.	To 2 ft	Perennial, extremely hardy and persistent, full sun	Best plant in lawns, gardens, fields, pastures
Purple vetch <sup>1</sup>	Seeds (innoculated)	Mar-May (south) May-Jul (north)	Dry, cool area	Nov-Feb (south) Mar-May (north)	Entire U.S.	To 3 ft	Perennial, viney, trailing, spreading, full sun	Cultivated for pastures, hay, and silage
Red clover <sup>1,3</sup>	Seeds (innoculated)	Mar-Apr (south) Apr-Sep (north)	Dry, cool area	Jan-Mar (south) Mar-Jun (north)	Entire U.S. except MW	To 2 ft	Perennial, ascending stems, many branched, full sun	Cultivated as forage and hay crops, soil conservation areas
Redroot pigweed <sup>1</sup>	Seeds	Jun-Oct	Dry, cool area	Mar-Jun	Entire U.S.	To 3 ft	Coarse, summer annual, deep red taproot, very hardy, persistent, shade to full sun	Occurs on moist soil types, best plant in agronomic and feedlot situations
Reseeding soybean <sup>3</sup>	Seeds	Sep-Nov	Dry, cool area	Mar-Jul	SE, MS	To 12 ft	Annual legume, viney stems, full sun	Cultivated as waterfowl food, occurs in moist soils
River bulrush <sup>1</sup>	Rootstock	Sep-Apr	In sand beds or pots of sand	Apr-Jun	NE, MA, SE, CA	To 6 ft	Perennial, erect, widely spreading, seed head, full sun	Occurs in moist areas and interior U.S.
Saltmarsh bulrush <sup>1,2</sup>	Rootstock	Sep-Mar	In sand beds or pots of sand	Mar-Jun	MS, SP, CA, PNW	To 6 ft	Perennial, spiny seed, triangular stems, full sun	Prefers marshes, occurs on dredged material islands
Saltwort <sup>1</sup>	Transplants	Sep-Mar	In sand beds or in pots of sand	Mar-Jun	NE, MA, SE, FL	To 2 ft	Annual, spiny, much branched, gray leaves, full sun	Prefers coastal moist areas, tolerates brackish soils

(Continued)

(Sheet 13 of 32)

Table B-1 (Continued)

Species (Alphabetized by Common Name) Herbs (Continued)	Best Propagule Type	Collection Periods	Temporary Storage Requirements	Planting Periods	Range	Mature Height	Growth Habits	Remarks
Schweinitz's nutsedge <sup>1</sup>	Seeds	Aug-Oct	Dry, cool area	Apr-Jun	NE, GL, MRV, NP, MP	To 3 ft	Perennial, thickened stems, slender stems, full sun	Prefers sandy soils, and moist areas
Sea blite <sup>1</sup>	Seeds	Jul-Sep	Dry, cool area	Mar-Jun	Entire U.S. in salt marshes	To 3 ft	Annual, much branched, full sun	Prefers coastal moist areas, tolerates salt spray
Sea ox-eye <sup>3</sup>	Seeds, transplants	Jul-Sep (seeds) Sep-Mar (trans.)	Dry, cool area (seeds) B&P* or potted (trans.)	Feb-May	Eastern and southern U.S. coasts	To 2 ft	Shrubby, fleshy, gray foliage, full sun	Occurs in sandy, coastal areas, tolerates salinity
Seashore lupine <sup>1</sup>	Seeds	May-Sep	Dry, cool area, soak in water before planting	Mar-Jun	PNW, CA	To 2 ft	Perennial, scrubby, full sun	Prefers sandy beaches and marshes
Seaside dock <sup>1</sup>	Seeds	Jul-Oct	Dry, cool area	Apr-Jun	Entire U.S. except SE, FL, MS	To 4 in.	Perennial, deep roots, erect, fast growing, full sun	Prefers moist sand areas, tolerates salt spray
Seaside goldenrod <sup>1</sup>	Seeds	Aug-Dec	Dry, cool area	Apr-Jun	Eastern and southern U.S. coasts	To 8 ft	Perennial, stout, erect, very leafy, large flower, full sun	Occurs on coasts and dredged material islands
Seaside plantain <sup>1</sup>	Transplants, seeds	Mar-Oct (trans) Jun-Sep (seeds)	In sand beds or pots, dry, cool area	Mar-Jun	Entire coastal U.S.	To 8 in.	Annual and perennial, fleshy rootstock and stems, full sun	Prefers salt marshes and seashores, tolerates salinity
Seaside leavedza <sup>3</sup>	Seeds	Sep-Dec	Dry, cool area	Mar-Jun	FL, MP, MA, SE, MRV, SP, MS	To 3 ft	Woody perennial, dense fine foliage, good seed produc- tion, full sun	Occurs in moist soils, used on rights-of-ways, in pastures, hay fields, and conservation projects
Sheep sorrel <sup>1</sup>	Seeds	May-Jun	Dry, cool area	Feb-Apr	Entire U.S.	To 1 ft	Perennial, basal rosette, full sun	Grows in infertile acid soils, will die in fer- tile soils
Shiny tick-trefoil <sup>1</sup>	Seeds (inoculated)	Jul-Sep	Dry, cool area	Apr-Jun	Eastern U.S.	To 5 ft	Perennial, erect, much branched, pubescent, shade or sun	Prefers rich soils, grows in woods or open areas
Silverleaf croton <sup>1</sup>	Seeds	Aug-Oct	Dry, cool area	Apr-Jun	FL, SE, MS	To 3 ft	Annual, many branched, silver leaves, full sun	Occurs in coastal soils, tolerates salt spray, tolerates drought
Southern bulrush <sup>1</sup>	Rootstock	Sep-Mar	In sand beds or pots of sand	Mar-Jun	SE, MS, FL, CA	To 12 ft	Perennial, triangular stems, upright, droopy spikelets, full sun	Occurs in coastal moist areas, tolerates brack- ish soils

(Continued)

\* Balled and burlapped.

Table B-1 (Continued)

Species (Alphabetized by Common Name)	Best Propagule Type	Collection Periods	Temporary Storage Requirements	Planting Periods	Range	Mature Height	Growth Habits	Remarks
<u>Herbs (Continued)</u>								
Southern ragweed <sup>1</sup>	Seeds	Jul-Oct	Dry, cool area	Apr-Jun	SE, MS, SP	To 3 ft	Annual, hirsute, many branched, full sun	Occurs in dry upland soils, pest plant, occurs in waste areas
Soybean <sup>1,2,3</sup>	Seeds (innoculated)	Sep-Oct	Dry, cool area	Apr-Jul	Entire U.S.	To 2 ft	Annual, fast growing, high seed production, full sun	Cultivated extensively for beans, excellent wildlife food
Spotted burclover	Seeds (innoculated)	Feb-Apr (south) Apr-Jul (north)	Dry, cool area	Nov-Jan (south) Feb-May (north)	Entire U.S.	To 2 ft	Annual, spreading, stout, spiny seeds, full sun	In poor, dry soils
Spotted spurge <sup>1</sup>	Seeds	Jun-Nov	Dry, cool area	Apr-Jul	Entire U.S.	To 1 ft	Annual, branched stem, prostrate, spreading, full sun	Prefers dry soils
Squarestem spikerush	Transplants, seeds	Apr-Jul (trans.), Jun-Aug (seeds)	In sand beds or pots (trans.), dry, cool area (seeds)	Mar-Jul	Entire U.S.	To 3 ft	Perennial, slender stems, square stems, full sun	Prefers moist areas, occurs on coasts in fresh water
Sunflower <sup>1</sup>	Seeds	Jul-Oct	Dry, cool area	Apr-Jun	Eastern and mid U.S.	To 12 ft	Perennial, fleshy roots, creeping rootstock, branch-inch, full sun	Prefers moist areas, stems often purple, showy flowers
Tansy mustard <sup>1</sup>	Seeds	May-Jul	Dry, cool area	Mar-May	Entire U.S. except SW	To 2 ft	Annual, erect, branched, slender ascending branches, full sun	Prefers dry soils
Tropic croton <sup>1</sup>	Seeds	Aug-Oct	Dry, cool area	Apr-Jun	SE, FL, MS, SP, MA, MRV	To 6 ft	Annual, rough, hardy, full sun	Pest in pasture areas, occurs in moist soils
Tumble-weed <sup>1</sup>	Seeds	Jun-Sep	Dry, cool area	Mar-Jun	Entire U.S.	To 3 ft	Annual, pale green, erect, bushy branched	Occurs in moist soils, prefers dry
Virginia pepperweed <sup>1</sup>	Seeds	May-Nov	Dry, cool area	Mar-Jun	Entire U.S. except CA, PNW	To 2 ft	Many branched, hardy, full sun	In dry soils, pest plant in fields, on many dredged material islands
Western ragweed <sup>1</sup>	Seeds	Sep-Nov	Dry, cool area	Apr-Jun	WA, CA, SW, NE, CL, NP, MP, SP	To 6 ft	Perennial, creeping rootstock, hardy, full sun	Prefers well-drained soils, a pest plant
White clover <sup>1,2,3</sup>	Seeds (innoculated)	Mar-May (south) May-Sep (north)	Dry, cool area	Jan-Mar (south) Mar-Jun (north)	Entire U.S. except MW	To 1 ft	Shallow rooted perennial with creeping branches, full sun	Cultivated as pasture and hay crops, occurs on moist soils

(Continued)

Table B-1 (Continued)

Species (Alphabetized by Common Name)	Best Propagate Type	Collection Periods	Temporary Storage Requirements	Planting Periods	Range	Mature Height	Growth Habits	Remarks
<u>Herbs (Continued)</u>								
White sweetclover <sup>1</sup>	Seeds (innoculated)	Apr-May (south) Jun-Nov (north)	Dry, cool area	Nov-Feb (south) Mar-May (north)	Eastern U.S.	To 10 ft	Annual, erect or ascending, branching, full sun	Roadsides, pastures, lawns, occurs in moist soils
Wild bean <sup>1</sup>	Seeds (innoculated)	Sep-Oct	Dry, cool area	Mar-Jun	Eastern and mid-U.S.	To 9 ft	Summer annual legume, viney, full sun	Occurs on beaches, tol- erates salt spray
Wild buckwheat <sup>1</sup>	Seeds	Jun-Nov	Dry, cool area	Mar-Jun	Entire U.S.	To 3 ft	Annual, viney plant, rapid growth, full sun	Occurs in most soils, a pest plant in crops
Wild sensitive pea	Seeds (innoculated)	Jun-Nov	Dry, cool area	Mar-Jun	Entire U.S.	To 1 ft	Annual, erect, branching, full sun	Prefers dry soil
Wild strawberry	Seeds, transplants	Mar-May (south) May-Jul (north)	In sand beds (trans.) dry, cool area (seeds)	Sep-Feb	Eastern and mid U.S.	To 4 in.	Perennial, stout, slender stalks, shade or sun	Prefers dry, rich soil, edible berries
Woolly croton <sup>1,3</sup>	Seeds	Aug-Oct	Dry, cool area	Apr-Jun	MA, SE, MS, SP, MP, HRV	To 7 ft	Robust, branching annual, good seed production, full sun	Pest in pastures, grows in most soils, prefers sandy areas
Woolly Indianwheat <sup>1</sup>	Seeds	May-Aug	Dry, cool area	Mar-Jun	MM, SP, NP, MP	To 1 ft	Annual, ascending leaves, slender stems, full sun	Prefers dry plains and prairies, other dry areas
Yellow starthistle <sup>1</sup>	Seeds	Jul-Sep	Dry, cool area	Apr-Jun	NE, MA, HRV MM, CA	To 2 ft	Annual, branched, winged stems, full sun	Pest plant in cultivated areas
Yellow sweetclover <sup>1</sup>	Seeds (innoculated)	May-Jun (south) Jul-Nov (north)	Dry, cool area	Nov-Feb (south) Apr-Jun (north)	Eastern U.S.	To 1 ft	Annual, erect or ascending, branching, full sun	Occurs in waste areas and fields, most soils
<u>Vines</u>								
American bitterweet	Seeds	Sep-Nov	Dry, cool area	Mar-Jun	NE, MA, SP, SW, CL, HRV	To over 24 ft	Twining, woody vine, ascending trees or trail- ing on ground	Prefers rich, moist soil
Bamboo vine	Tuber, seeds	Sep-Mar (tubers) Jun-Sep (seeds)	In soil beds, dry, cool area	Feb-Jun	MA, SE, FL, MS, SP	Long trailing stems	Tuber rootstocks, stout, hardy, evergreen, spines, shade	Prefers moist areas in woods and thickets
Beach morning glory <sup>1</sup>	Stems, seeds	Sep-Apr	In sand beds, dry, cool area	Mar-Jun	Eastern U.S. and SP	To 12 ft	Perennial, twining, large roots	Prefers sandy beaches and dunes

(Continued)

(Sheet 16 of 32)

Table B-1 (Continued)

Species (Alphabetized by Common Name)	Best Propagule Type	Collection Periods	Temporary Storage Requirements	Planting Periods	Range	Mature Height	Growth Habits	Remarks
Vines (Continued)								
Common greenbrier <sup>1</sup>	Seeds	May-Aug	Dry, cool area	Mar-Jun	Eastern and mid-U.S.	Long trailing stems	Woody, four-angled shoots, spiny, shade to sun	Prefers moist areas in woods and thickets, occurs in dry areas
Crossvine	Seeds	May-Aug	Dry, cool area	Mar-Jun	SE, MS, FL, MRV	To 60 ft	Woody, cross visible in cross section, shade or sun	Prefers moist woods, occurs in moist open areas
Fox grape <sup>1</sup>	Seeds	Aug-Sep	Remove pulpy coat dry, cool area	Mar-Jun	MA, NE, MRV SE	To 90 ft	Climbing, large stem, shade	Prefers thickets, native stock for cultivated grape hybrids
Fringed catbrier <sup>1</sup>	Tuber, seeds	Sep-Mar (tubers) Apr-Jul (seeds)	In soil beds (tubers) dry, cool area (seeds)	Apr-Jun	Eastern and mid-U.S.	Long trailing stems	Woody, four-angled, large tubers, spiny leaves and stems, shade or sun	Prefers thickets, moist areas, occurs in dry habitats
Frost grape <sup>1</sup>	Transplants	Jun-Oct	Remove pulpy coat dry, cool area	Mar-Jun	NE, MA, SE, MW	Long trailing stems	Climbing, pubescent, thin shining leaves, shade or sun	Prefers moist rocky areas, occurs in open moist areas
Japanese honeysuckle <sup>1</sup>	Rootstock, transplants	Jun-Sep	Dry, cool area	Feb-Jun	Entire U.S.	Long climbing stems	Pubescent, fragrant, persistent, shade or sun	Pest plant in unkept areas, excellent forage plant
Kudzu <sup>3</sup>	Rootstock, transplants	Sep-Mar	In soil beds or pots of soil	Feb-Jun	Entire U.S.	Long climbing stems	Hairy, three-foliate leaves, sun or shade	Pest plant in unkept areas, excellent cover vine, ornamental
Lanceleaf greenbrier	Seeds	Apr-Aug	Dry, cool areas	Mar-Jun	SE, FL, SP, MS	Long trailing stems	Woody, slender, no tubers or spines, shade or sun	Prefer dry thickets
Muscadine grape <sup>1,3</sup>	Seeds, transplants	Aug-Oct	Remove pulpy coat dry, cool areas	Mar-Jun	SE, MA, FL, SP, MP, MS	Long trailing stems	Woody, slender stems, large leaves, shade or sun	Prefers moist sand soil in thickets, occurs in silt and clay in open
Peppervine <sup>1</sup>	Seeds	Sep-Oct	Dry, cool area	Mar-Jun	Entire U.S.	Long climbing stems	Numerous tendrils, aerial roots, fast growing, dense cover, sun or shade	Prefers wood and thickets, dry soil, but occurs in open areas
Sawbrier	Seeds	Sep-Mar (tubers) Jun-Aug (seeds)	In soil beds (trans.) dry, cool area (seeds)	Mar-May	Eastern U.S. and SP	Long trailing stems	Deep, tuberous rootstock, stout spines, shade or sun	Prefers dry sandy soil, also called asaparilla
Summer grape <sup>1</sup>	Seeds	Sep-Oct	Remove pulpy coat, dry cool area	Mar-Jun	SE, MS, FL	Long trailing vine	Evergreen, coarse stemmed, persistent, sun or shade	Prefers dry soil in woods, it occurs in open

(Continued)

Table B-1 (Continued)

Species (Alphabetized by Common Name)	Best Propagule Type	Collection Periods	Temporary Storage Requirements	Planting Periods	Range	Mature Height	Growth Habits	Remarks
<u>Vines (Continued)</u>								
Supplejack <sup>1</sup>	Seeds, transplants	May-Aug	Dry, cool area	Mar-Jun	ME, SE, FL, SP	High climbing stems	Shrub, rough, stout leaves and stems	Prefers moist woods, but occurs in open areas
Virginia creeper <sup>1</sup>	Seeds	Aug-Oct	Remove pulpy coat dry, cool areas	Mar-Jun	NE, MA, HRV, MS, SP, MP, NP	High climbing stems	Large leaves, bark loose and shreddy, tendrils, shade or sun	Prefers dry soils in thickets, occurs in the open
Wild bamboo <sup>1</sup>	Seeds	Oct-Nov	Remove pulpy coat dry, cool area	Mar-Jun	SE, MS, FL	Long trailing vine	Evergreen, coarse stemmed, persistent, sun or shade	Forms low thickets in the open or wood areas
<u>Shrubs and Small Trees</u>								
American elderberry <sup>1</sup>	Transplants, seeds	Sep-Mar Jul-Sep	In nursery, dry cool place	Feb-Jun	Eastern and mid-U.S.	To 30 ft	Deciduous, many stemmed, large flowers, full sun	Prefers moist soils, but occurs over wide soil ranges
American hornbeam	Transplants	Sep-Mar	B&B or potted in nursery	Feb-Jun	Eastern and mid-U.S.	To 30 ft	Deciduous, round crown, partial or full shade	Prefers dry soils, often is understory in open woods
American plum <sup>1</sup>	Transplants, seeds	Sep-Mar Jul-Sep (seeds)	B&B or potted in nursery, dry, cool place	Feb-Jun	Eastern and mid-U.S.	To 30 ft	Deciduous, spreading crown, full to partial sun	Prefers moist soils, occurs in dense thickets, edible fruit
Arrowwood viburnum	Transplants	Sep-Mar	B&B or potted in nursery	Feb-May	MS, SE	To 9 ft	Deciduous, shrubby, large flowers, partial sun	Prefers moist soils, common as understory
Autumn olive <sup>1,2,3</sup>	Transplants	Sep-Mar	B&B or potted in nursery	Mar-Jun	MA, SE, MS, FL, SP	To 15 ft	Evergreen in south, deciduous in north, full sun, shrub, full to partial sun	Prefers dry soils, drought resistant, very hardy
Bayberry <sup>1</sup>	Transplants	Sep-Mar	B&B or potted in nursery	Feb-Jun	NE, MA	To 9 ft	Evergreen, very dense, full sun, shrub	Prefers sandy soils, occurs in coastal areas, common on dredged material, important habitat plant
Beach plum <sup>1</sup>	Transplants, seeds	Oct-Mar	B&B or potted in nursery	Feb-May	MA, NE	To 6 ft	Deciduous, low growing, many branched, full sun	Prefers sandy, coastal soils, edible fruit
Bearberry	Transplants, seedlings	Sep-Mar	B&B or potted in nursery, cleaned and stratified (seeds)	Feb-Jun	NE, MA, GL, HRV, NP, MW, CA, PNN	to 8 in.	Evergreen, spreading shrubby, slow growth, shade to full sun	Occurs in dry, sandy, and rocky soils
Beautyberry <sup>1</sup>	Transplants, seeds	Sep-Mar	B&B or potted in nursery	Feb-Jun	SE, MS, FL, MA	To 8 ft	Deciduous, shrubby abundant fruit, full sun to partial shade	Grows in variety of soil conditions, does best as understory plant

(Continued)

Table B-1 (Continued)

Species (Alphabetized by Common Name) Shrubs and Small Trees	Best Propagule Type		Collection Periods	Temporary Storage Requirements	Planting Periods	Range	Mature Height		Growth Habits	Remarks
	Type	Source					Height	Width		
(Continued)										
Bicolor lespedeza	Transplants	Sep-Nov Mar-Jun	B&B or potted in nursery	Mar-Jun	MA, SE, FL, SP	To 9 ft	Deciduous legume, irregular shrub, full sun	Tolerates poor soils and drought conditions, prefers well-drained, dry areas		
Black raspberry <sup>1</sup>	Transplants	Sep-Mar	Potted in nursery or soil bed	Feb-Jun	NE, MA, SE, SP, MP	To 12 ft	Deciduous, spiny, glaucous, roots from stem tips, full sun	Occurs in most soils, persistent, pest plant in pastures		
Blue brush	Seeds	Jun-Aug	Dry, cool area	Feb-Jun	PNW, CA	To 3 ft	Deciduous, shrubby, shade to sun	Occurs in dry, rocky, sandy areas, used for tea substitute by pioneers		
Blue elderberry	Seeds	Jul-Oct	Cleaned and stratified seeds	Feb-Jun	SW, CA, PNW	To 25 ft	Deciduous, many stemmed, showy flowers, full sun	Occurs in most soils in open or in edges of woods		
Brazilian peppertree <sup>1</sup>	Cuttings, transplants	Oct-Apr	In rooting medium (cuttings), B&B or potted (trans.)	Oct-Jun	FL	To 30 ft	Evergreen, many branched, tropical, showy flowers, full sun	Occurs in most soils below freeze line in Florida, common on dredged material islands		
Brewer saltbush	Seeds	Jun-Sep	Dry, cool area	Feb-Jun	CA, SW	To 2 ft	Shrubby, dense, full sun	Occurs in dry, saline soil, also known as sage brush		
Buffaloberry <sup>1</sup>	Seeds	Jul-Sep	Cleaned and stratified	Mar-Jun	NE, MA, GL, NP, SW	To 8 ft	Deciduous, shrubby, shade to sun	Occurs in moist soils		
Bush lupine	Seeds	Jul-Sep	Dry, cool area	Mar-Jun	PNW, CA	To 2 ft	Perennial, shrubby, many seed pods, full sun to part shade	Occurs in dry and well-drained soils, both in open and in edges of woods		
California blackberry <sup>1</sup>	Seeds, transplants	Sep-Apr (trans.) Jun-Jul (seeds)	B&B or potted in nursery (trans.) cleaned and stratified (seeds)	Feb-May	PNW, CA	To 3 ft	Perennial, woody, many branched, arching, full sun	Occurs in dry, well-drained areas in most soils, very dense wood		
California buckthorn	Transplants	Sep-Mar	B&B or potted in nursery	Feb-May	PNW, CA	To 6 ft	Deciduous, shrubby, thorny, full sun	Occurs in dry soils		
Canadian serviceberry <sup>1</sup>	Seeds, transplants	Sep-Apr (trans.) May-Jun (seeds)	B&B or potted in nursery (trans.) cleaned and stratified (seeds)	Mar-Jun	SE, NE, MA	To 21 ft	Deciduous, upright, shrubby, pubescent young twigs, full to partial sun	Prefers moist areas, occurs in most soils		

(Continued)

Table B-1 (Continued)

Species (Alphabetized by Common Name) Shrubs and Small Trees (Continued)	Best Propagate Type			Temporary Storage Requirements	Planting Periods	Range	Mature Height	Growth Habits	Remarks
	Type	Collection Periods	Planting Periods						
Carolina ash	Transplants	Sep-Mar	Mar-Jun	B&B or potted in nursery	MA, SE, FL, MP, MS, SP	To 45 ft	Deciduous, pubescent, five to seven leaflets, shade or sun	Occurs in moist or wet soils, in woods or in open	
Carolina rose <sup>1</sup>	Hips, cuttings	Jul-Oct (hips) Apr-Oct (cuttings)	Feb-Jun	Cleaned and stratified (hips), in rooting medium (cuttings)	Eastern and mid U.S.	To 5 ft	Deciduous, thorny, arching, fast growing, full sun	Occurs in moist soils, well-drained to dry, open areas	
Cascara buckthorn <sup>1</sup>	Seeds	Jul-Sep	Apr-Jun	Cleaned and stratified	PNW, CA	To 21 ft	Deciduous, shrubby, shade to full sun	Occurs in moist soils, open areas or in woods	
Cherry laurel <sup>1,3</sup>	Transplants, cuttings	Sep-Mar	Mar-Jun	B&B or potted in nursery	SE, MS, MA	To 30 ft	Evergreen, shrubby, ascending branches, full sun to partial shade	Occurs in moist soils, cultivated as an ornamental	
Chickasaw plum <sup>1</sup>	Seeds	Jun-Jul	Feb-May	Cleaned and stratified	SE, MS, MA SP	To 6 ft	Deciduous, shrubby, thorny, large fruit, full sun	Ferns, thickets, occurs in most dry and well-drained soils	
Common buckthorn	Transplants	Sep-Mar	Feb-Jun	B&B or potted in nursery	SE, FL, MS, SP	To 30 ft	Deciduous, shrub or tree, few seeds, shade or sun	Prefers moist soils, in open or edges of woods	
Common chokecherry <sup>1</sup>	Seeds	Aug-Sep	Mar-Jun	Cleaned and stratified	MS, MV, MP, SW, PNW, CA	To 30 ft	Deciduous, shrubby underground stems, forms thickets, shade or sun	Occurs in moist soils including sand dunes and rocky areas	
Common deerberry	Transplants, seeds	Sep-Mar (trans.) Apr-Jun (seeds)	Feb-May	B&B or potted, cleaned and stratified	Eastern U.S.	To 6 ft	Deciduous, much branched, irregular, shade or sun	Occurs in dry soils in woody, thickets, and edges of woods	
Common juniper <sup>1</sup>	Seeds, seedlings	Sep-Mar (seedlings) Sep-Nov (seeds)	Mar-Jun	B&B or potted in nursery, stratified at 5°C	GL, MS, SE	To 12 ft	Spreading, narrowleaf evergreen shrub, full sun	Used as an ornamental shrub over a large range, quite hardy, tolerates alkaline soils	
Common sweetleaf	Transplants	Sep-Mar	Feb-May	B&B or potted in nursery	MA, SE, MS	To 9 ft	Deciduous, large waxy leaves, sweet taste, shade or sun	Occurs in woody areas and thickets, mostly in shade, sometimes in open areas	
Crabapple <sup>1</sup>	Transplants, seeds	Sep-Mar (trans.) May-Jul (seeds)	Feb-May	B&B or potted (trans.) cleaned and stratified (seeds)	MA, SE, FA, MS	To 21 ft	Deciduous, thorny, bitter fruit, showy flowers, full sun	Occurs in most dry soils, in open thickets	

(Continued)

(Sheet 20 of 32)



Table B-1 (Continued)

Species (Alphabetized by Common Name) Shrubs and Small Trees	Best Propagule Type	Collection Periods	Temporary Storage Requirements	Planting Periods	Range	Mature Height	Growth Habits	Remarks
(Continued)								
Dahoon <sup>1</sup>	Transplants	Oct-Mar	B&B or potted in nursery	Feb-May	SE, FL, MS	To 25 ft	Evergreen, thorny, slow growing, full sun	Prefers sandy moist areas, in woods or open, in coastal areas
Downy serviceberry	Transplants	Sep-Mar	B&B or potted in nursery	Feb-Jun	SE, MS	To 45 ft	Deciduous, large leaves, pubescent, shade or sun	Prefers dry soils, in woods or open areas
Eastern hophornbeam <sup>1</sup>	Transplants	Sep-Mar	B&B or potted in nursery	Feb-Jun	NE, GI, MP, SP, HRV, SE, MA, FL, MS	To 10 m	Deciduous, hardwood, leaves yellow-green, shade or sun	Prefers dry soils, in woods or in open areas
Elderberry <sup>1</sup>	Seeds	Jun-Aug	Cleaned and stratified	Feb-Jun	MW, PNW, CA, SW	To 7 m	Deciduous, large seedheads, few branches	Occurs in dry soils
Elderberry <sup>1</sup>	Seeds	Jun-Aug	Cleaned and stratified	Feb-Jun	PNW, CA	To 7 m	Deciduous, shrubby	Occurs in dry soils
Evergreen blackberry <sup>1</sup>	Seeds	Jun-Jul	Cleaned and replanted	Aug-Sep	Eastern U.S.	To 4 m	Stout, deciduous, arching branches, persistent	Best plant in pastures, cultivated for fruit
Firethorn <sup>3</sup>	Seeds, transplants	Sep-Jan (seeds) Sep-Mar (trans.)	Cleaned and stratified (seeds), B&B or potted	Feb-May	MA, SE, SP, FL, MS	To 4 m	Evergreen, irregular, hardy, showy flowers and fruit, full sun	Occurs in moist soils, grows well in wet or dry areas, cultivated as ornamental
Flowering dogwood <sup>1</sup>	Transplants	Oct-Feb	B&B or potted in nursery	Feb-Apr	Eastern U.S. and SP	To 15 m	Deciduous, bushy crown, showy flowers, shade or sun	Occurs in dry soils, cultivated as ornamental, in woods or in open areas
Gallberry <sup>1</sup>	Transplants	Oct-Mar	B&B or potted in nursery	Feb-May	NE, MA, SE, FL, MS	To 2 m	Evergreen, shrubby, dotted underside of leaves, shade or sun	Prefers sandy soil, occurs on coasts
Gray dogwood <sup>1</sup>	Transplants	Sep-Mar	B&B or potted in nursery	Feb-May	Eastern and mid-U.S.	To 2 m	Dense deciduous, shrubby, gray bark, shade or sun	Prefers moist soils, occurs in thickets, woods, open areas
Ground blueberry <sup>1</sup>	Seeds	May-Jun	Cleaned and stratified	Jan-Mar	SE, MS, MA	To 2 m	Evergreen, pubescent, few branches, shade or sun	Prefers moist areas, in woods or in open areas
Groundsel tree <sup>1</sup>	Seeds, transplants	Sep-Nov	B&B or potted (trans.) dry, cool area (seeds)	Jan-May	SE, MA, MS, SP, NE	To 3.5 m	Many branched, deciduous, shrubby, full sun	Prefers moist areas, occurs on sea coasts, tolerates salinity

(Continued)

Table B-1 (Continued)

Species (Alphabetized by Common Name) Shrubs and Small Trees	Best Propagate Type	Collection Periods	Temporary Storage Requirements	Planting Periods	Range	Mature Height	Growth Habits	Remarks
(Continued)								
Halberd-leaved willow <sup>1,3</sup>	Transplants	Sep-Mar	B&B or potted	Feb-Jun	Entire U.S.	To 10 m	Many branched, deciduous, full sun	Cultivated as ornamental
Hibiscus <sup>1</sup>	Seeds, transplants	Sep-Mar (trans.) Jun-Aug (seeds)	B&B or potted (trans.) dry, cool area (seeds)	Feb-Jun	NE, SE, MA, FL, MS, SP	To 2.3 m	Deciduous, many branched, erect, large seed pods, full sun	Prefers moist soils, tolerates some salinity, occurs on coasts and inland
Highbush blueberry <sup>1,3</sup>	Seeds, cuttings	Jan-Feb (trans.) Jun-Aug (seeds)	Cooled, cleaned, and planted (seeds) layered in rooting medium (trans.)	Feb-Jun	NE, SE, MA, FL, MS	To 4 m	Deciduous, erect, hardy, many branched, shade to full sun	Occurs in moist soils
Hollyleaf cherry	Seeds, transplants	Jul-Sep	Cleaned and stratified	Nov-May	CA	To 8 m	Evergreen, serrated holly- like leaves, full sun	Prefers dry soils
Honey mesquite <sup>1</sup>	Seeds	Aug-Sep	Dry, cool area	Feb-May	SP, SW	To 14 m	Deciduous, shrubby, thorny, irregular crown, full sun	Prefers dry, sandy, or loam soils, pest plant in western pastures
Hooker's willow <sup>1</sup>	Cuttings	Year-round	Layered in rooting medium	Feb-Jun	PNW, CA	To 10 m	deciduous, shrubby pubes- cent, full sun	Prefers moist areas, tolerates shifting sand and flooding
Japanese lespedeza	Seeds, inoculated	May-Sep	Dry, cool area	Feb-Jun	Entire U.S.	To 1 m	Shrubby, woody perennial, full sun	Cultivated for grazing
Low blueberry	Seeds	Jun-Jul	Cleaned and stratified	Oct-May	SE, MA, MS	To 0.6 m	Shrubby, erect, rhizomous, stout, shade or sun	Prefers dry areas, thickets or woods
Mapleleaf viburnum	Seeds	Jul-Oct	Cleaned and stratified	Feb-May	SE, MS, MA	To 3 ft	Deciduous, shrubby, maple shape leaf, shade or sun	Thickets or open areas
Marsh elder <sup>1</sup>	Transplants	Oct-Apr	B&B or potted in nursery	Feb-May	NE, MA, SE, FL, MS, SP	To 12 ft	Deciduous, many branched, serrated leaves, full sun	Prefers sandy, moist areas, occurs on coastal islands, dunes, and marshes
Mountain blackberry	Seeds, rootstock	Jun-Jul (seeds) Year-round (rootstock)	Cleaned and re- planted (seeds), in soil beds (root (rootstock) stock)	Sep-Nov (seeds) Feb-May (rootstock)	NE, MA, GL, HRV	To 10 ft	Deciduous, hardy, very robust, prolific fruiting, full sun, spiny	Pest plant in pastures, occurs and thrives almost anywhere
Multiflora rose <sup>1,3</sup>	Transplants	Sep-Mar	B&B or potted in nursery	Feb-Jun	Entire U.S. except NP	To 12 ft	Deciduous, arching, thorny, showy flowers, full sun	Pest plant in unkept pastures and fields, cultivated for wind- breaks and cover

(Continued)

(Sheet 22 of 32)

Table B-1 (Continued)

Species (Alphabetized by Common Name)	Best Propagule Type	Collection Periods	Temporary Storage Requirements	Planting Periods	Range	Mature Height	Growth Habits	Remarks
<u>Shrubs and Small Trees</u> (Continued)								
Myrtle oak	Transplants	Oct-Mar	B&B or potted in nursery	Oct-Mar	FL	To 45 ft	Evergreen, leathery, full sun	Prefers sandy coastal soils, tolerates salt spray
Northern bayberry <sup>1</sup>	Transplants	Oct-Mar	B&B or potted in nursery	Feb-Jun	NE, MA	To 45 ft	Evergreen, pubescent, dense, dark green, full sun	Prefers sandy coastal soils, tolerates salt spray
Oleander <sup>1,2,3</sup>	Transplants	Oct-Mar	B&B or potted in nursery	Feb-Apr	SV, FL, MS	To 30 ft	Evergreen, dense, upright stems, showy flowers, full sun	Prefers dry sand soils, tolerates salt spray and drought, not freeze tolerant
Pacific bayberry	Transplants	Sep-Mar	B&B or potted in nursery	Mar-Jun	PNW, CA	To 27 ft	Evergreen, shrubby, dense foliage, full sun	Prefers sand sites, occurs in coastal areas, tolerates salt spray
Pacific dogwood <sup>1</sup>	Transplants	Sep-Mar	B&B or potted in nursery	Feb-Jun	PNW, CA	To 9 ft	Deciduous, shrubby, erect, bushy, full sun and shade	Prefers well-drained areas
Pacific wax myrtle	Transplants	Oct-Feb	B&B or potted in nursery	Feb-May	PNW, CA, coasts	To 35 ft	Evergreen, thick shrubs, ascending branches, full sun	Prefers moist areas, occurs in marshes, gullies, sand dunes, islands
Pacific willow <sup>1</sup>	Cuttings, transplants	Year-round (cut.) Sep-Mar (trans.)	In rooting medium (cut.), B&B or in pots (trans.)	Feb-May	PNW, CA	To 12 ft	Deciduous, shrubby, fast growing, full sun	Prefers moist areas
Poison ivy <sup>1</sup>	Transplants	Sep-Mar	B&B or in pots in nursery	Feb-Jun	Entire U.S.	To 15 ft	Deciduous, fast growing, full sun	Prefers moist areas, vine form not recom- mended for planting
Possumhaw <sup>1,3</sup>	Seeds	Sep-Dec	Cleaned and stratified	Mar-Jun	CL, SP, MP, MRV, SE, MS, MA, FL	To 30 ft	Deciduous, red berries, very showy, shade or sun	Prefers moist areas, cultivated as ornamental
Possumhaw viburnum	Seeds	Aug-Oct	Cleaned and stratified	Mar-Jun	SE, MS, MA, FL	To 25 ft	Deciduous, large leaves, shade or sun	Occurs in moist soils, in woods or in open
Purple osier willow	Transplants, cuttings	Sep-Mar	In rooting medium, or potted	Mar-Jun	MA, MRV, NE	To 12 ft	Deciduous, purple stems, slender, full sun	Cultivated as an orna- mental, prefers moist places, used in bank stabilization

(Continued)

Table B-1 (Continued)

Species (Alphabetized by Common Name)	Best Propagule Type	Collection Periods	Temporary Storage Requirements	Planting Periods	Range	Mature Height	Growth Habits	Remarks
<u>Shrubs and Small Trees</u>								
(Continued)								
Pussy willow <sup>3</sup>	Transplants, cuttings	Sep-Mar	B&B or potted in nursery	Mar-Jun	NE, NP, GL	To 24 ft	Deciduous, shrubby, full sun	Prefers moist soils, widely used as an ornamental
Quail brush	Seeds	Jul-Oct	Dry, cool area	Mar-May	SW	To 3 ft	Deciduous, shrubby, pale green, full sun	Prefers dry, sandy soils tolerates salinity
Red alder <sup>1</sup>	Transplants, cuttings	Year-round (cut.) Sep-Mar (trans.)	In rooting medium (cut.) B&B or in pots (trans.)	Feb-May	PNH, CA	To 4.5 ft	Deciduous, shrubby, up- right branches, full sun	Occurs on moist soils, on cutover forest land, beaches, streams
Red buckeye	Transplants, seeds	Aug-Oct (seeds) Sep-Mar (trans.)	Stratified (seeds), B&B or in pots	Feb-May	SE, NS, SP	To 24 ft	Deciduous, shrubby, shade or sun	Large fruit is inedible, occurs in moist soils
Red osier dogwood <sup>1,3</sup>	Cuttings, transplants	Aug-Apr (cut.) Sep-Apr (trans.)	In rooting medium B&B or potted	Apr-Jun	NE, HRV, GL, NP, SW, PNW, MW	To 8 ft	Deciduous, shrubby stolonif- ferous, full to partial sun	Occurs in moist soils, prefers moist poorly drained areas
Riverflat hawthorn	Seeds	Apr-Jun	Cleaned and stratified	Mar-May	SE, MA, MS	To 15 ft	Deciduous, leathery, thorny, shade or sun	Prefers dry soils, in woods or in open, red fruit
Rough-leaved dogwood <sup>1</sup>	Transplants	Sep-Mar	B&B or potted	Feb-May	SE, MA, MS, SP, NP, MP	To 15 ft	Deciduous, showy flowers, fast growing, sun or shade	Prefers moist areas, occurs in moist soils
Russian olive <sup>1,2,3</sup>	Seeds, transplants	Sep-Oct (seeds) Sep-Mar (trans.)	Cleaned and strati- fied (seeds), B&B or potted (trans.)	Mar-Jun	Entire U.S.	To 21 ft	Evergreen, shrubby, spiny, irregular crown, full sun	Occurs in moist soils, cultivated for wind break, roadside, ornamental
Rusty blackhaw	Seeds	Jul-Oct	Cleaned and stratified	Feb-Apr	SE, MS, MA, FL	To 9 ft	Deciduous, leathery, shiny green, shade	Prefers dry areas, in woods, but occurs in thickets and open areas
Salal <sup>1,3</sup>	Transplants, root stock	Sep-Mar	B&B or potted in nursery	Feb-Jun	PNW, CA	To 6 ft	Evergreen, dark shiny leaves, shade	Prefers moist areas, cultivated for florist industry
Salmonberry <sup>1</sup>	Seeds	Jun-Aug	Cleaned and in dry cool area	Mar-Jun	PNW	To 15 ft	Deciduous, branching, leafy, shrubby, showy flowers, large fruit, shade	Occurs in moist areas, in woods and thickets

(Continued)

(Sheet 24 of 32)

Table B-1 (Continued)

Species (Alphabetized by Common Name) Shrubs and Small Trees	Best Propagate Type	Collection Periods	Temporary Storage Requirements	Planting Periods	Range	Mature Height	Growth Habits	Remarks
(Continued)								
Saltbush <sup>1</sup>	Seeds	Jul-Oct	Dry, cool area	Feb-May	SW	To 3 ft	Deciduous, shrubby, pale green, full sun	Prefers dry, sandy soils, tolerates drought and salinity
Saltcedar <sup>1,3</sup>	Transplants	Oct-Mar	B&B or potted in nursery	Feb-May	MA, SW, SP, MS, FL	To 15 ft	Evergreen, small foliage, irregular crown, full sun	Prefers dry, sandy soils, tolerates drought and salinity
Sandbar willow <sup>1,3</sup>	Transplants cuttings	Sep-Mar	B&B or potted in nursery	Mar-Jun	NE, MV, GL, ME, SP, MW	To 27 ft	Deciduous, shrubby, dense, full sun	Prefers moist soils, riverbanks
Sand blackberry <sup>1</sup>	Seeds	May-Jul	Cleaned and stratified	Feb-Jun	MA, SE, FL	To 3 ft	Deciduous, arching, erect, spiny, robust, full sun	Prefers dry, sandy areas
Sand pine <sup>1,2,3</sup>	Transplants, seedlings	Oct-Mar	B&B or potted in nursery	Feb-May	FL, MS	To 18 ft	Narrowleaf evergreen, shrubby, full sun	Grows in poor soils, tolerates drought, sandy conditions, occurs on coasts
Sawtooth oak <sup>1,2,3</sup>	Transplants	Sep-Mar	B&B or potted in nursery	Feb-May	SE, MS, FL, SP	To 30 ft	Deciduous, irregular growth, full sun	Cultivated for wildlife food, occurs on moist soils
Scotch broom <sup>1,3</sup>	Transplants	Sep-Mar	B&B or potted in nursery	Feb-May	PNW	To 7 ft	Evergreen showy flowers, dense growth, full sun	Best plant in some areas, cultivated as ornamental elsewhere
Sharp-toothed blackberry <sup>1</sup>	Rootstock, seeds	Year-round (root.) Jun-Jul (seeds)	In soil beds (root.) cleaned and stratified (seeds)	Sep-Nov (seeds) Feb-May (rootstock)	SE, ME, FL, MS, MV	To 6 ft	Deciduous, hardy, very robust, prolific fruiting, full sun, spiny	Best plant in pastures, occurs and thrives almost anywhere
Shining sumac <sup>1</sup>	Seeds, rootstock	Sep-Nov Sep-Mar	Cleaned and stratified (seeds), in soil beds (rootstock)	Feb-Jun	Eastern and mid-U.S.	To 12 ft	Deciduous, little branching, lateral spreading roots, forms thickets, full sun	Occurs in moist soils, in open areas
Shore pine <sup>1,3</sup>	Transplants, cuttings	Sep-Mar	B&B or potted in nursery	Feb-May	PNW, CA	To 36 ft	Narrowleaf evergreen, spreading, full sun	Coastal dunes plant, very hardy, can be grown from seeds
Shrub verbena <sup>1,3</sup>	Seeds, transplants	May-Sep (seeds) Sep-Mar (trans.)	Dry, cool area (seeds) B&B or potted (trans.)	Jan-Apr	FL, SE, MS, SP	To 3 ft	Deciduous, tropical, showy flowers, full sun	Cultivated as ornamental, prefers moist, sandy soils
Silky dogwood <sup>1</sup>	Transplants	Sep-Mar	B&B or potted	Feb-Jun	Eastern and mid-U.S.	To 10 ft	Deciduous, purplish stems, full sun	Prefers moist soils, in woods and in open areas

(Continued)

(Sheet 25 of 32)

Table B-1 (Continued)

Species (Alphabetized by Common Name) Shrubs and Small Trees	Best Propagule Type	Collection Periods	Temporary Storage Requirements	Planting Periods	Range	Mature Height	Growth Habits	Remarks
(Continued) Silky willow <sup>1</sup>	Transplants, cuttings	Year-round (cut.) Sep-Mar (trans.)	In rooting medium, B&B or potted (trans.)	Mar-Jun	NE, MA, GI, MRV	To 12 ft	Deciduous, purplish stems, pubescent, full sun	Prefers wet to moist soils, in open areas
Sitka alder <sup>1</sup>	Transplants, cuttings	Year-round (cut.) Sep-Mar (trans.)	In rooting medium, B&B or potted (trans.)	Feb-May	PNW	To 30 ft	Deciduous, shrubby, multi- stemmed, full sun	Prefers moist soils, in open areas
Smooth sumac <sup>1</sup>	Seeds	Sep-Feb	Cleaned and stratified	Feb-Jun	Entire U.S.	To 6 ft	Deciduous, shrubby, few branches, forms thickets from roots, full sun	Occurs in moist soils, in open areas
Southern bayberry <sup>1</sup>	Transplants	Sep-Mar	B&B or potted	Feb-May	SE, MA, FL, MS, SP	To 15 ft	Evergreen, dense, upright branches, full sun	Prefers moist, sandy areas, occurs on sea- coasts and islands
Southern dewberry <sup>1</sup>	Seeds, transplants	Apr-May (seeds) Year-round (trans.)	Cleaned and strati- fied (seeds), B&B or potted (trans.)	Jan-Mar	SE, MS, FL, SP	To 3 ft	Deciduous, persistent, large fruit, full sun	Occurs in moist soils, excellent wildlife food
Sparkleberry	Seeds	May-Jul	Cleaned and stratified	Jan-May	SE, MA, SP, MS	To 30 ft	Deciduous in north, ever- green in south, sprawling, shrubby, shade or full sun	Occurs in dry soils, in woods or open thickets
Squaw huckleberry	Seeds	May-Jun	Cleaned and stratified	Feb-Jun	Eastern and mid-U.S.	To 15 ft	Deciduous, leathery, shrubby shade or sun	Occurs in dry woods or open thickets, edges of woods
Staghorn sumac <sup>1</sup>	Seeds	Oct-Dec	Cleaned and stratified	Feb-May	Eastern and mid-U.S.	To 12 ft	Deciduous, few branches, showy fruit, full sun	Forms thicket, occurs in dry soils
Summersweet	Seeds	Sep-Nov	Cleaned and stratified	Feb-May	SE, MS	To 5 ft	Deciduous, ascending stems, pubescent, shade or sun	Occurs in moist soils, in woods and open areas, cultivated as ornamental
Swamp privet <sup>1</sup>	Transplants	Sep-Mar	B&B or potted	Feb-May	SE, MS	To 24 ft	Deciduous, many branches, shrubby, shade or sun	Prefers moist, bottom- land type soils (silt, clay)
Swamp rose <sup>1</sup>	Transplants	Sep-Mar	B&B or potted	Feb-Jun	MA, SE, MS	To 3 ft	Deciduous, arching branches, full sun	Prefers moist soils

(Continued)

(Sheet 26 of 32)

Table B-1 (Continued)

Species (Alphabetized by Common Name)	Best Propagule Type	Collection Periods	Temporary Storage Requirements	Planting Periods	Range	Mature Height	Growth Habits	Remarks
<b>Shrubs and Small Trees</b>								
<i>(Continued)</i>								
Tag alder <sup>1</sup>	Transplants, cuttings	Year-round (cut.) Sept-Mar (trans.)	In rooting medium, B6B or potted	Feb-May	NE, MA, MS, SP, MRV	To 15 ft	Deciduous, rusty, pubes- cent, shade or sun	Occurs in moist soils, in woods or in open areas
Tartarian honeysuckle <sup>1</sup>	Transplants, rootstock	Sep-Mar	B6B, potted or in soil beds	Feb-Jun	Entire U.S.	To 6 ft	Deciduous, showy flowers, full sun	Cultivated as ornamental shrub
Texas huisache <sup>1</sup>	Seeds	Aug-Oct	Dry, cool area	Jan-Apr	SP, MS, SW	To 15 ft	Deciduous, large seed pods, full sun	Prefers dry, sandy soils, tolerates drought and salinity
Thorny eleagnus <sup>1,3</sup>	Transplants, cuttings	Sep-Apr	B6B or potted in nursery	Mar-Jun	Entire U.S.	To 12 ft	Evergreen, robust, thorny, spreading, arching, full sun	Cultivated as ornamen- tal, tolerates poor soil and salt spray
Toothache tree <sup>1</sup>	Transplants	Sep-Mar	B6B or potted in nursery	Feb-May	SE, FL, MS, SP	To 36 ft	Deciduous, fast growing, spiny, full or partial sun	Prefers well-drained soils, occurs on dredged material in Texas and North Carolina
Turkey oak <sup>1</sup>	Transplants, cuttings	Sep-Mar	B6B or potted in nursery	Feb-May	SE, MA, FL	To 30 ft	Deciduous, large leathery leaves, full sun	Prefers sandy coastal areas
Wax myrtle <sup>1,3</sup>	Transplants	Oct-Mar	B6B or potted in nursery	Mar-Jun	SE, FL, MS, MA, SP	To 10 ft	Evergreen, dense, shrubby, ascending branches, full sun	Prefers moist areas, does well on poor, sandy coastal sites
Western blackberry <sup>1</sup>	Transplants	Sep-Mar	B6B or potted	Feb-Jun	PNW, CA	To 3 ft	Arching, deciduous, full sun	Occurs in dry soils, pest plant in pastures
Western chokecherry	Seeds	Aug-Sep	Cleaned and stratified	Feb-May	CA, PNW	To 24 ft	Deciduous, bushy, full sun	Occurs in most soils, smells bad
Western dogwood	Transplants	Sep-Mar	B6B or potted	Feb-May	PNW, CA	To 15 ft	Deciduous, irregular branches, shade or sun	Occurs most soils, in woods or in open areas
Western huckleberry	Transplants	Sep-Mar	B6B or potted in nursery	Feb-Jun	PNW, CA	To 8 ft	Evergreen, erect, slow growth, shade to sun	Occurs in dry woods
Wild apple <sup>1</sup>	Seeds, transplants	Aug-Oct (seeds) Sep-Mar (trans.)	Cleaned and stratified B6B or potted	Feb-May	Entire U.S.	To 21 ft	Deciduous, thorny, showy flowers, large fruit, full sun	Occurs in most soils, parent stock of all commercial apple trees
Wild black currant <sup>1</sup>	Transplants	Sep-Mar	B6B or potted	Feb-Jun	Northern U.S.	To 3 ft	Deciduous, arching erect branches	Occurs in most soils

(Continued)

Table B-1 (Continued)

Species (Alphabetized by Common Name)	Best Propagule Type	Collection Periods	Temporary Storage Requirements	Planting Periods	Range	Mature Height	Growth Habits	Remarks
<u>Shrubs and Small Trees</u>								
<u>(Continued)</u>								
Wild cherry <sup>1</sup>	Seeds	Aug-Sep	Cleaned and stratified	Feb-Jun	PNW, CA, SW	To 30 ft	Deciduous, bitter fruit, full sun	Occurs in moist soils
Wild indigo <sup>1</sup>	Seeds, transplants	Sep-Oct	Dry, cool area (seeds) B&B or potted (trans.)	Jan-Mar	SP, MS, SE	To 3 ft	Deciduous, tumblers, seed-pods rattle, full sun	Occurs in dry soils, prefers sand or silt, tolerant of salt spray
Wild rose <sup>1,3</sup>	Transplants, cuttings	Sep-Mar	B&B or potted in nursery (trans.) in rooting medium (cuttings)	Feb-Jun	MA, SE, MS, SP, FL	To 15 ft	Deciduous, arching branches, thorns, profuse flowers, full sun	Prefers moist soils, fast growing, tolerant of wide range of soil conditions
Wingscale	Seeds	Nov-Dec	Dry, cool place	Jan-May	MI, SW, CA	To 8 ft	Evergreen, shrubby, much branched, full sun	Tolerates drought and wide range of soil conditions, prefers dry sandy soil
Winterberry <sup>3</sup>	Transplants	Sep-Mar	B&B or potted in nursery	Mar-Jun	SE, MS	To 15 ft	Deciduous, arching, rounded crown, full sun or shade	Wide range of soil conditions, prefers moist soils
Witch hazel	Transplants	Sep-Mar	B&B or potted in nursery	Feb-May	NE, MA, SE, MS, MP, GL, HRV	To 30 ft	Deciduous, shrubby, partial sun to full shade	Prefers moist soils
Yaupon <sup>1,3</sup>	Transplants	Oct-Mar	B&B or potted in nursery	Jan-Apr	SE, MA, MS, SP, FL	To 18 ft	Evergreen, forms dense thickets, has ornamental dwarf form, full sun	Prefers sandy soils, grows on coast, tolerates salt spray
Yellow paloverde <sup>3</sup>	Transplants	Oct-Mar	B&B or potted in nursery	Jan-Apr	SW, CA	To 21 ft	Deciduous, legume, shrubby, full sun	Tolerates extreme drought and some salinity, prefers sandy soil
<u>Large Trees</u>								
American beech <sup>1,3</sup>	Transplants	Sep-Mar	B&B or potted in nursery	Mar-Jun	NE, MA, SE, MS, GL, HRV, SP	To 90 ft	Deciduous, with shallow root system, full sun	Best in moist conditions, poorly drained soils
American sycamore <sup>1,3</sup>	Transplants	Sep-Mar	B&B or potted in nursery	Mar-Jun	NE, MA, SE, MS, SP, MP, NP, GL, HRV	To 90 ft	Deciduous, wide spreading crown, full sun	Best in moist soils, but grows under a variety of conditions
Australian pine <sup>1,3</sup>	Transplants	Oct-Feb	B&B or potted in nursery	Dec-Apr	FL, CA	To 135 ft	Narrowleaf evergreen, drooping branches, full sun	Grows well in sandy soils, exotic naturalized in U.S.

(Continued)

(Sheet 28 of 32)



Table B-1 (Continued)

Species (Alphabetized by Common Name)	Best Propagate Type	Collection Periods	Temporary Storage Requirements	Planting Periods	Range	Mature Height	Growth Habits	Remarks
<b>Large Trees</b> (Continued)								
Black cherry <sup>1,3</sup>	Transplants	Aug-Oct	B&B or potted in nursery	Mar-Jun	NE, MA, SE, FL, MS, SP, MP, NP, GL	To 55 ft	Deciduous, upright crown, full sun	Can be grown from seed, wood highly prized for furniture
Black cottonwood <sup>1,3</sup>	Transplants, cuttings	Sep-Mar	B&B or potted in nursery (trans.) layered in rooting medium (cuttings)	Mar-Jun	PNW, SW, CA	To 115 ft	Deciduous, fast growing, large, full sun	Used for paper products, prefers moist soils, used for windbreaks and shade
Black gum <sup>1,3</sup>	Transplants	Sep-Mar	B&B or potted in nursery	Mar-Jun	NE, MA, SE, FL, MS, SP, MP, NP, MRV, GL	To 80 ft	Deciduous, upright crown, slow growing, full sun	Prefers moist soil
Black locust <sup>1,3</sup>	Transplants	Sep-Mar	B&B or potted in nursery	Mar-Jun	MS, MA, MP	To 75 ft	Deciduous, fragrant flowers, spiny, full sun	Tolerates drought and poor soil conditions, a legume
Black walnut <sup>1,3</sup>	Seeds, seedlings	Sep-Nov (seeds) Sep-Mar (seedlings)	Stratified (seeds), B&B or potted (trans.)	Mar-Jun	MA, SE, MS, SP, NP, MRV	To 90 ft	Deciduous, edible, upright crown, sun to shade	Varied soil conditions, good plant food, excellent furniture wood, grows slowly
Black willow <sup>1</sup>	Transplants, cuttings	Oct-Mar	B&B or potted in nursery (trans.) layered in rooting medium	Feb-Jul	SE, MS, MA, SP, FL	To 36 ft	Deciduous, shrubby, full sun	Very fast growing, prefers moist and flooded soils
Cow oak <sup>3</sup>	Seeds, transplants	Sep-Nov (seeds) Oct-Mar (trans.)	Stratified at 5°C, B&B or potted in nursery	Mar-Jun	MA, SE, FL, MS, SP	To 72 ft	Deciduous, large edible seeds, full sun to part shade	Prefers moist soils, fast growing
Eastern cottonwood <sup>1,3</sup>	Transplants, cuttings	Sep-Mar	B&B or potted in nursery (trans.) layered in rooting medium (cut.)	Mar-Jun	MA, SE, GL, MRV, NP, MP, SP, MS	To 90 ft	Deciduous, very fast growing, full sun	Used for paper products, shade, prefers moist soil
Eastern red cedar <sup>1,3</sup>	Transplants, seeds	Sep-Mar (trans.) Sep-Nov (seeds)	B&B, potted in nursery (trans.), stratified at 5°C (seeds)	Feb-Jun	SE, MS, SP, MRV	To 36 ft	Narrowleaf evergreen, drought tolerant, full sun	Produced commercially by tree nurseries, tolerates alkaline soil, has shrub form under stressed conditions
Eastern white pine <sup>3</sup>	Transplants	Sep-Mar	B&B or potted in nursery	Mar-Jun	NE, GL, MA	To 90 ft	Narrowleaf evergreen, pyramidal crown, full sun	Prefers moist sandy soil

(Continued)

Table B-1 (Continued)

Species (Alphabetized by Common Name)	Best Propagule Type	Collection Periods	Temporary Storage Requirements	Planting Periods	Range	Mature Height	Growth Habits	Remarks
<u>Large Trees</u> (Continued)								
Green ash <sup>1</sup>	Transplants	Sep-Mar	B&B or potted in nursery	Mar-Jun	Eastern and mid U.S.	To 72 ft	Deciduous, full or partial shade	Prefers moist soils, tolerates poor soil conditions
Hackberry <sup>1,3</sup>	Transplants	Sep-Mar	B&B or potted in nursery	Feb-Jun	SE, MS, SP, MRV, MP	To 90 ft	Deciduous, large spreading crown, full sun	Tolerates alkaline and sandy soils
Honeylocust <sup>1,3</sup>	Transplants	Sep-Mar	B&B or potted in nursery	Mar-Jun	SE, MA, GL, MP, MS	To 72 ft	Deciduous legume, spiny, full or partial sun	Prefers moist fertile soils
Laurel oak <sup>1,3</sup>	Transplants	Sep-Mar	B&B or potted in nursery	Jan-Mar	SE, SP, MS	To 90 ft	Flar topped crown, broad-leaf evergreen, full sun	Prefers moist soils, occurs on coasts
Live oak <sup>1,3</sup>	Transplants	Sep-Mar	B&B or potted in nursery	Jan-May	SE, SP, MS, MA	To 45 ft	Evergreen, large spreading crown, full sun	Prefers sandy moist soils, and occurs on coasts, tolerates salt spray
Loblolly pine <sup>1,3</sup>	Transplants, seedlings	Sep-Mar	B&B or potted in nursery	Feb-Jun	SE, SP, MS, MA	To 65 ft	Narrowleaf evergreen, large crown, full sun	Coastal and interior plant, on sandy and silty soils (poorly drained)
Longleaf pine <sup>1,3</sup>	Transplants, seedlings	Sep-Mar	B&B or potted in nursery	Feb-May	MA, SE, MS, FL, SP	To 110 ft	Narrowleaf evergreen, tall open crown, full sun	Prefers sandy conditions, but occurs in other soils, occurs on coasts
Mockernut hickory <sup>3</sup>	Transplants, seedlings	Sep-Mar	B&B or potted in nursery	Feb-May	NE, MA, SE, FL, MS, MRV, SP, MP	To 75 ft	Deciduous, arching branches, full or partial sun	Prefers drier soils, edible nuts, hardy, common
Paper mulberry	Transplants	Sep-Mar	B&B or potted in nursery	Mar-Jun	Eastern U.S.	To 45 ft	Deciduous, arching branches, full or partial sun	Exotic, naturalized in U.S., fast growing, forms thickets
Peachleaf willow <sup>1</sup>	Transplants, cuttings	Sep-Mar	B&B or potted in nursery (trans.), layered in rooting medium (cuttings)	Mar-Jun	GL, NP, MP, MW	To 55 ft	Deciduous, drooping branches, full sun	Prefers moist soils, grows on dredged material islands
Pecan <sup>3</sup>	Transplants, seedlings	Sep-Mar	B&B or potted in nursery	Feb-May	SE, MS, SP, MP	To 130 ft	Deciduous, irregular crown, full sun	Prefers moist soils, but grows in wide range of soil conditions, edible nuts

(Continued)

(Sheet 30 of 32)

Table B-1 (Continued)

Species (Alphabetized by Common Name)	Best Propagule Type	Collection Periods	Temporary Storage Requirements	Planting Periods	Range	Mature Height	Growth Habits	Remarks
<b>Large Trees</b> (Continued)								
Perseimon <sup>1</sup>	Rootstock	Sep-Mar	In soil beds in nursery	Feb-Jun	MA, SE, FL, MS, SP, MP, MRV	To 55 ft	Deciduous, drooping branches, full sun	Prefers moist, rich soils, but tolerates wide range of soil conditions, edible fruit
Pignut hickory	Transplants, seedlings	Sep-Mar	B&B or potted in nursery	Feb-May	NE, MA, SE, FL, MS, MRV, SP, MP	To 70 ft	Deciduous, open crown, full sun	Prefers drier soils than other hickories
Redbay <sup>1</sup>	Transplants	Oct-Mar	B&B or potted in nursery	Feb-May	MA, FL, SE, MS, SP	To 55 ft	Evergreen, upright branches, full or partial sun	Often occurs in dense woods, prefers moist soils
Red maple <sup>1,3</sup>	Transplants	Sep-Mar	B&B or potted in nursery	Feb-Jun	Entire eastern U.S.	To 75 ft	Deciduous, upright branches, full or partial sun	Prefers moist soils, widely used as an ornamental
Red mulberry <sup>1,3</sup>	Transplants	Sep-Mar	B&B or potted in nursery	Mar-Jun	Entire eastern U.S.	To 66 ft	Deciduous, rounded dense crown, full or partial shade	Prefers moist, fertile soils, edible fruit
River birch <sup>1,3</sup>	Transplants	Sep-Mar	B&B or potted in nursery	Feb-Jun	MA, SE, MS, SP, MP, MRV	To 75 ft	Deciduous, irregular multi-stemmed, full or partial sun	Prefers moist soils, used as ornamental, common in South
Sassafras <sup>1,3</sup>	Transplants	Oct-Mar	B&B or potted in nursery	Feb-May	NE, MA, SE, MS, SP, MP, MRV, GL	To 80 ft	Deciduous, spreading branches, full or partial sun	Prefers upland soils but occurs over wide range of soil conditions, forms dense thicket
Slash pine <sup>1,3</sup>	Transplants, seedlings	Oct-Mar	B&B or potted in nursery	Feb-May	SE, FL, MS	To 90 ft	Narrowleaf evergreen, dense, rounded crown, full sun	Grows rapidly, commercial forest tree, occurs on coast
Southern red oak <sup>3</sup>	Transplants, seedlings	Oct-Mar	B&B or potted in nursery	Feb-May	MA, SE, MS, SP	To 75 ft	Deciduous, rounded crown, full sun	Prefers poor upland soil, used as an ornamental
Sugarberry <sup>1,3</sup>	Transplants	Oct-Mar	B&B or potted in nursery	Mar-Jun	SE, FL, MS, SP, MP	To 36 ft	Deciduous, spiny, irregular crown, full sun	Prefers alkaline, well-drained soils
Sugar maple <sup>1,3</sup>	Transplants	Sep-Mar	B&B or potted in nursery	Mar-Jun	GL, NE, MRV, NP, MP, MA	To 90 ft	Deciduous, rounded crown, full sun	Prefers moist soils, used for wood, furniture, as an ornamental, and for syrup

(Continued)

Table B-1 (Concluded)

Species (Alphabetized by Common Name)	Best Propagule Type	Collection Periods	Temporary Storage Requirements	Planting Periods	Range	Mature Height	Growth Habits	Remarks
<u>Large Trees</u>								
(Continued)								
Sweetbay <sup>1</sup>	Transplants	Oct-Mar	B&B or potted in nursery	Feb-May	MA, SE, FL, MS	To 55 ft	Evergreen, shrub in north, tree in south, full sun to partial shade	Prefers moist soils, deciduous in north
Sweetgum <sup>1</sup>	Transplants, seedlings	Sep-Mar	B&B or potted in nursery	Feb-Jun	MA, SE, FL, MS, SP, HRV	To 110 ft	Deciduous, spreading crown, fast growing, full sun	Prefers well-drained soil, tolerates many soil conditions, used for furniture
Tulip poplar <sup>1,3</sup>	Transplants	Sep-Mar	B&B or potted in nursery	Feb-Jun	NE, MA, SE, MS, HRV, GL	To 140 ft	Deciduous, fast growing, full sun	Prefers moist soil
Water oak <sup>1,3</sup>	Transplants, seedlings	Oct-Mar	B&B or potted in nursery	Feb-May	SE, MA, FL, MS, SP	To 65 ft	Deciduous, rounded crown, full sun	Prefers moist soil, fast growing, produces abundant, small, bitter acorns
White ash <sup>1,3</sup>	Transplants	Sep-Mar	B&B or potted in nursery	Mar-Jun	Eastern and mid-U.S.	To 72 ft	Deciduous, upright crown, full sun	Prefers upland well-drained areas, fast growing
White oak <sup>3</sup>	Transplants, seedlings	Sept-March	B&B or potted in nursery	Feb-June	NE, MA, SE, MS, GL, HRV, SP, MP, NP	To 90 ft	Deciduous, spreading rounded crown, full sun	Tolerates wide range of soil and climatic conditions, edible acorns
White poplar <sup>3</sup>	Transplants, cuttings	Sept-March	B&B or potted in nursery	Feb-June	Entire U.S.	To 72 ft	Deciduous, multi-trunked, full sun	Fast growing, exotic naturalized over much of U.S.

Table B-2  
Recommended Propagules and Techniques for Selected Marsh Species (item 39)

Species	Recommended Propagules	General Collection, Handling, and Planting Techniques	Remarks
Alkali bulrush	Transplants, tubers	Dig plants; divide; replant on site at same depth, or pot for holding in nursery or greenhouse.	Seeds frequently eaten by waterfowl and other birds; used for soil stabilization; prefers fine-textured soils. Fresh/brackish.
Arrow arum <sup>2</sup>	Transplants, seeds	Dig plants; separate; replant at same depth on the site or pot for holding. Gather seeds when mature; store in fresh water at 33-37°F; broadcast on site and rake into soil.	Primarily a good soil stabilizer, although seeds are infrequently eaten by waterfowl, and muskrats use it for lodge material. Potential pest plant. Fresh water.
Beak rush <sup>2</sup>	Seeds	Gather seeds when mature (July to September); store in fresh water at 41°F; broadcast on site and rake into soil.	Seeds eaten primarily by waterfowl. Fresh water.
Beggar's ticks <sup>2</sup>	Seeds	Store dry at 41°F; broadcast on site and rake into soil.	Good food source for songbirds, game birds, and chicks. Potential pest plant. Fresh water.
Big cordgrass <sup>2</sup>	Transplants, seedlings	Dig young plants from natural stands; separate; replant on site at same depth or pot for holding. Germinate seeds and grow seedling until ready for planting (three to six months).	Excellent soil stabilizer in low, brackish marshes. Salinity prevents this species from competing with smooth cordgrass. Seeds eaten by many birds; rodents eat young, tender foliage. Potential pest plant. Fresh/brackish.
Bigelow's glasswort <sup>2</sup>	Cuttings, rootstock	Collect two to six inches cuttings of top shoots and broadcast in wet area on the site. If cuttings must be stored, they must remain moist. Dig rootstock; replant on site at same depth.	Low tidal area soil stabilizer away from shorelines. Tolerates fairly high salinities. Easily propagated. Poor source of wildlife foods. Occasionally used by nesting colonial seabirds. Brackish/saline.
Black mangrove <sup>2</sup>	Seed, seedlings	Collect seed pods when mature (summer and fall); plant whole pod upright in soil with stem end up and out of the soil. Dig seedlings from natural stand or grow from seed pods.	Excellent soil stabilizer in south Florida. Frequently occurs on dredged material islands and is used by colonial nesting wading bird species. Tolerates to 40 ppt salinity. Saline.
Black needlerush <sup>2</sup>	Transplants	Dig clumps; divide into sections with a cutting device; replant on site at same depth or pot for holding.	Good high marsh soil stabilizer. Will not tolerate extended inundation and naturally occurs on tidal creek banks and high spots in the marsh. Seeds eaten by birds and small animals. Fresh/brackish.
Bladderworts	Cuttings	Collect quantities of cuttings in buckets of water by scooping plants out of natural stands (in water); transfer to standing water on site.	Good waterfowl food source, especially for dabbling ducks. Potential pest plant in reservoirs. Fresh water.

(Continued)

<sup>1</sup> Transplants include plugs, sprigs, groups of individuals, very large seedlings, and large whole plants.

<sup>2</sup> Known to occur on dredged material.

<sup>3</sup> Commercially available

Table B-2 (Continued)

Species	Recommended Propagules	General Collection, Handling, and Planting Techniques	Remarks
Broadleaf arrowhead <sup>2</sup>	Transplants	Dig clumps; separate individuals; replant on site or pot for holding.	Good waterfowl food source; good cover for wildlife; muskrat food. Fresh water.
Buirushes <sup>2</sup>	Transplants, tubers	Dig plants; divide; replant on site or pot for holding. Dig tubers; separate; cut off top shoots to six inches if present; replant on site or pot for holding.	Excellent waterfowl and songbird food (seeds); foliage eaten by muskrats; used for cover, breeding, and nesting by many species. Fresh/brackish.
Burreed <sup>2</sup>	Transplants	Dig plants; divide; replant on site or pot for holding.	Seeds infrequent source of wildlife food. Fresh/brackish.
Buttercups	Cuttings	Collect quantities of cuttings in buckets of water by scooping plants out of natural stand (in water); transfer to standing water on site.	Good waterfowl food source. Potential pest plant in reservoirs. Fresh water.
Buttonbush <sup>2</sup>	Transplants, seeds	Dig small plants (large seedlings); transplant to site or pot for holding. Collect seeds in August-September; store seeds in fresh water at 41°F.	Seeds good source of food for waterfowl and other birds, insects, beavers, and muskrats. Provides cover and nesting habitat for birds. Fresh water.
Chufa <sup>2,3</sup>	Tubers	Dig tubers when mature (July-Sept.); separate from other plant material; store moist but not wet at 41°F; broadcast on site and rake into soil. Tubers are very small and may be treated as seeds.	Excellent food source for waterfowl, turkeys, deer, wild boar, songbirds; highly productive plants may produce hundreds of tubers per plant. Seeds, tubers, foliage all relished. Fresh water.
Common reed <sup>2</sup>	Transplants, rootstock	Dig plants; divide; replant on site or pot for holding. Dig rootstock; separate into sections with at least one growth point; plant on site.	Used for nesting by songbirds, marsh birds, and waterbirds. Stabilizes soil; rapid growth with tall rank form. Definite pest plant on disposal sites. Fresh/brackish.
Common threesquare <sup>2</sup>	Transplants, tubers.	Dig plants, divide, replant on site at same depth or pot for holding. Dig tubers; divide; cut off top shoots if present; replant on site.	Good source of food for waterfowl, muskrats, and nutria. Used for soil stabilization. Fresh/brackish.
Delta duckpotato <sup>2,3</sup>	Transplants	Dig plants, separate individuals; replant on site at same depth or pot for holding.	Excellent waterfowl food source; good soil stabilizer; only grows well on fine-textured soils. Fresh water.
Dock <sup>2</sup>	Seeds	Collect seeds when mature (May to July); store dry at room temperature or less; plant broadcast on site and rake into soil.	Good food source for songbirds (seeds). Hardy species that is good soil stabilizer. Fresh water.
Dotted smartweed <sup>2</sup>	Seeds, cuttings	Collect seeds; store dry at room temperature or less; broadcast on site and rake into soil. Take cuttings from natural stand; broadcast on wet area on site (not standing water).	Good soil stabilizer; good cover of ducklings; seeds eaten by waterfowl, muskrats, and deer. Foliage not palatable to herbivores. Fresh water.

(Continued)

(Sheet 2 of 10)

Table B-2 (Continued)

Species	Recommended Propagules	General Collection, Handling, and Planting Techniques	Remarks
Duckpotato <sup>2</sup>	Transplants	Dig plants; separate individuals; replant on site or pot for holding.	Excellent food source for waterfowl. Fresh water.
Duckweeds <sup>2</sup>	Whole plants	Collect buckets of plant from natural stand in water; place whole plant in standing permanent water on site.	Excellent food source for waterfowl, especially wood ducks. Good cover. In deep south can be pest plant in standing water in reservoirs. Fresh water.
Eelgrass <sup>2</sup>	Transplants	Dig clumps with coring devices; replant in shallow seawater with a minimum of current and wave action.	Good soil stabilizer in bay bottoms; food source for diving ducks; provides cover for marine organisms. Saline.
European glasswort <sup>2</sup>	Cuttings, rootstock	Take two to six inch cuttings from top shoots; broadcast on wet area of site. Dig rootstock; divide into clumps; replant on site at same depth.	Used primarily for soil stabilization but not for shorelines. Poor wildlife food use; occasionally used by nesting colonial seabirds. Brackish/saline.
Fimbristylis <sup>2</sup>	Transplants, seeds	Dig plants; separate individuals; replant on site at same depth or pot for holding. Collect seeds when mature (July-Sept.); store dry; broadcast on site and rake into soil.	Fair food source for songbirds and occasionally for waterfowl. Fresh/brackish.
Foxtail grasses <sup>2</sup>	Sprigs, seeds	Dig young plants; replant as sprigs on site at same depth or pot for holding as transplants. Collect seeds when mature (June-Oct, depending upon species); store dry at 41°F; broadcast on site.	Good source of food for most birds, browsers and and grazers, rodents. Cover for many wildlife species. Fresh water.
Frankenia	Transplants	Dig plants; separate individuals; replant on site at same depth or pot for holding.	Soil stabilizer; poor source of food but some use as cover by wildlife. Fresh/brackish.
Frog bit <sup>2</sup>	Seeds	Collect seeds when mature (July-Sept); store dry at room temperatures or less; broadcast on site and rake into soil.	Good seed source for songbirds; cover for small animals and birds; some use for stabilization. Fresh water.
Giant reed <sup>2</sup>	Seeds, transplants	Collect seeds when mature; store dry at room temperatures or less; broadcast on site and rake into soil. Dig plants; divide; replant on site or pot for holding.	Hardy plant; good seed source for wildlife; used for soil stabilization. Fresh water.
Groundsleel tree <sup>2</sup>	Seedlings	Dig seedlings in natural stands; at least 12-18 inches is minimum height for best survival; replant on site at same depth or pot for holding.	Excellent cover and nesting/breeding species; used frequently by colonial nesting wading birds on dredged material islands. Poor food source. Fresh/brackish.
Hardstem bulrush <sup>2</sup>	Transplants, tubers	Dig plants; divide; replant on site or pot for holding. Dig tubers; divide from other plant material; cut off top shoots to six inches if present; plant on site at same depth.	Excellent seed source for birds; hardy species; used by muskrats and for soil stabilization. Fresh water.

(Continued)

(Sheet 3 of 10)

Table B-2 (Continued)

Species	Recommended Propagules	General Collection, Handling, and Planting Techniques	Remarks
Horned pondweed	Cuttings, rootstock	Gather plant material from standing water; place on site in permanent standing water areas. Dig rootstock from shallow water areas where possible; plant intact on site.	Fair food source for waterfowl, especially dabbling ducks; good sediment stabilizer. Fresh water.
Horsetails <sup>2</sup>	Transplants	Dig plants; separate individuals; replant on site or pot for holding.	Poor food source; only use is soil stabilization. Fresh water.
Japanese millet <sup>2,3</sup>	Seeds	Buy seeds from commercial seed source.	Excellent upland and marsh bird food; relished by waterfowl; eaten by turkeys, raccoons and other small animals, deer; Used in game management as food plot source. Fresh water.
Ladythumb <sup>2</sup>	Cuttings, seeds	Take cuttings two to six inches from top shoots; broadcast on wet area of site; rake into soil. Collect seeds when mature; store in fresh water; broadcast on site and rake into soil.	Excellent source of food for waterfowl and upland game and songbirds. Fresh water.
Lizard's tail <sup>2</sup>	Transplants, seeds	Dig plants; separate individuals; replant on site or pot for holding. Collect seeds when mature (June-Aug); store in fresh water; broadcast on site and rake into soil.	Fair food source; used for soil stabilization in intermittent ponded areas. Fresh water.
Lobelia	Transplants	Dig plants; separate individuals; replant on site or pot for holding.	Fair food source; possibly used for soil stabilization. Fresh water.
Lotus	Seeds, rootstock	Collect seeds when mature (Aug-Oct); remove from pods; store in fresh water at 41°F; broadcast in shallow water on site. Dig rootstock when water is very low (late summer, fall); plant in shallow water on site.	Fair food source for waterfowl; relished by wild boars (roots); excellent cover for ducklings; potential pest plant in standing water and shallow reservoirs. Fresh water.
Lynghye's sedge <sup>2</sup>	Transplants, seeds	Dig plants, separate individuals; replant on site or pot for holding. Collect seeds when mature (July-Sept); store dry at room temperature; broadcast on site.	Good food source for waterfowl and other birds; good cover for many species. Fresh water.
Manna grass <sup>2</sup> ( <i>G. acutiflora</i> )	Seeds, sprigs	Collect seeds when mature; store dry at room temperature or less; broadcast on site. Dig young plants for sprigs; replant on site or pot for holding as transplants.	Excellent seed source for many bird species; foliage eaten by small and large animals; good cover. Fresh water.
Manna grass <sup>2</sup> ( <i>G. fluitans</i> )	Seeds, sprigs	Same procedures as above.	Excellent seed source for many bird species and other wildlife. Good cover. Grows in wetter areas than above species. Fresh water.

(Continued)

(Sheet 4 of 10)



Table B-2 (Continued)

Species	Recommended Propagules	General Collection, Handling, and Planting Techniques	Remarks
Marsh elder <sup>2</sup>	Seedlings	Dig seedlings in natural stands near parent plants; separate individuals; replant on site or pot for holding. Seedlings should be 12 inches tall minimum.	Excellent cover species for birds and small animals; used by colonial nesting wading birds for nesting substrate. Potential pest plant. Fresh/brackish.
Marsh hibiscus <sup>2</sup>	Seeds, transplants	Collect seeds when mature (Aug-Oct); store dry at 41°F; plant on site at least two to three inches deep. Dig plants, replant on site or pot for holding.	Good cover for birds, sunning turtles; grows on banks of streams and ponds, in ditches; good soil stabilizer. Fresh water.
Marsh pepper <sup>2</sup>	Cuttings, rootstock	Take 2-6 in. cuttings from top shoots; broadcast on wet area of site; rake into soil. Dig rootstock; divide into sections; plant in wet area of site.	Excellent seed source for waterfowl and other birds; foliage bitter to browsers; good cover and soil stabilizer. Fresh water.
Marsh smartweed <sup>2</sup>	Cuttings, seeds	Cuttings: same as above. Collect seeds when mature (June-Sept); store or plant immediately on site; rake in soil.	Excellent seed source for waterfowl and other birds; good cover for many wildlife species. Not palatable to herbivores. Fresh water.
Mud plantain <sup>2</sup>	Cuttings	Take two to six inch sections from top shoots; replant in mud and wet areas on site, taking care to bury portions of cuttings in soil.	Good soil stabilizer in intermittent ponds and streams. Fresh water.
Nodding smartweed <sup>2</sup>	Seeds	Collect seeds when mature (June-Sept); store in fresh water at 41°F; broadcast on site; rake into soil.	Abundant seed source for upland and waterfowl birds; grows in drier soils than most smartweeds. Potential pest plant. Not palatable to herbivores. Fresh water.
Nutsedges <sup>2</sup>	Tubers, rootstock	Dig tubers in late summer and fall; divide; plant on site or pot for using as transplants. Dig rootstock; divide into sections; plant on site, same depth.	Excellent food source for most wildlife, especially chufa and red-rooted sedge. Some species are commercially available; potential pest plant in agronomic areas. Fresh water.
Olney's threesquare <sup>2</sup>	Transplants, tubers	Dig plants; separate individuals; plant on site or pot for holding. Dig tubers; separate; plant on site at same depth.	Excellent food source for waterfowl, muskrats, nutria, small animals. Good soil stabilizer. Fresh water.
Orache <sup>2</sup>	Seeds	Collect seeds when mature; store dry at room temperature or less. Broadcast on site; rake into soil.	Good source of seeds for birds and rodents; good soil stabilizer. Fresh/brackish.
Pacific cordgrass <sup>2</sup>	Transplants, springs	Dig young plants from edge of marsh; plant at same depth immediately as sprigs, or grow in pots and transplant into site as larger plants. Growing from seeds not recommended as seeds have very low viability rate.	Only low marsh soil stabilizer on west coast that tolerates both high salinities and strong tidal action. Good soil stabilizer; good cover; very slow growth. Saline.

(Continued)

(Sheet 5 of 10)

Table B-2 (Continued)

Species	Recommended Propagules	General Collection, Handling, and Planting Techniques	Remarks
Red mangrove <sup>2</sup>	Seeds, seedlings	Collect seed pods when mature; plant whole pod upright in soil with stem end up and out of the soil. Dig seedlings from natural stand or grow from seed pods.	Excellent soil stabilizer in south Florida. Frequently occurs on dredged material islands and used by colonial nesting wading birds for nesting. Saline.
Reed canary grass <sup>2,3</sup>	Seeds	Buy seeds from commercial seed source.	Excellent soil stabilizer; seeds good wildlife food source; used to dewater and filter wastewater. Fresh water.
Reed grass <sup>2</sup>	Seeds, sprigs	Collect seeds when mature (July-Sept); store dry at 41°F; broadcast on site. Dig young plants to use for sprigs; separate individuals; plant on site or pot for growing as transplants.	Excellent seed source for birds; grazed heavily by mammals and rodents. Good soil stabilizer. Fresh water.
Reed manna grass <sup>2</sup>	Seeds, sprigs	Same procedures as above.	Same value as shown above. Fresh water.
Rice cutgrass <sup>2</sup>	Seeds, sprigs	Collect seeds when mature (May-July); store in fresh water at 41°F; broadcast on site and rake into soil (in wet areas). Dig young plants; separate individuals; plant on site at same depth in wet areas.	Good seed and foliage food source for many wildlife species, especially waterfowl and marsh birds. Good soil stabilizer of banks. Fresh water.
River bulrush <sup>2</sup>	Transplants, rootstock	Dig rootstock, divide into sections; plant at same depth on site. Dig plants; separate individuals; transplant to site or pot for holding.	Used frequently by nesting waterfowl and marsh birds; seeds good food source for many wildlife species. Good soil stabilizer. Fresh water.
Rushes <sup>2</sup>	Transplants, rootstock	Dig plants; separate individuals; transplant to site or pot for holding. Dig rootstock; divide into sections; plant at same depth on site. Collect seeds when mature (July-Oct); store in fresh water at 41°F; broadcast on site; rake into soil.	This group of plant species excellent for waterfowl, small animal, other birds' food; used as nesting substrate by waterfowl and marsh birds; good soil stabilizers; hardy plants. Fresh water.
Saltgrass <sup>2</sup>	Sprigs, rhizomes	Dig young plants; divide into sections; plant on site or pot for holding. Dig roots; divide rhizomes into small sections; plant on site; rake into soil.	Excellent soil stabilizer; grows well in high brackish marshes; used as lodge material by muskrats; seeds fair food source, but foliage poor source. Brackish/saline.
Saltmarsh aster <sup>2</sup>	Seeds	Collect seeds when mature (July-Sept); store dry at room temperature or less; broadcast on site; rake into soil.	Good soil stabilizer in high coastal marshes. Fresh/brackish.
Saltmarsh bulrush <sup>2</sup>	Transplants, tubers	Dig plants; divide; plant on site at same depth or pot for holding; Dig tubers; separate tubers; cut off top shoots if present; plant on site at same depth.	Excellent food source for waterfowl and muskrats, nutria, other small animals. Good cover; good soil stabilizer; used by muskrats for lodge material. Brackish.

(Concluded)

(Sheet 6 of 10)

Table B-2 (Continued)

Species	Recommended Propagules	General Collection, Handling, and Planting Techniques	Remarks
Saltmarsh cattail <sup>2</sup>	Transplants, rootstock	Dig plants; separate individuals; plant on site at same depth. Dig roots; separate; cut off top shoots if present; plant on site.	Good soil stabilizer. Occurs in ditches, intermittent ponds, primarily on coasts. Low food value; fair cover. Fresh/brackish.
Saltmarsh jaumea <sup>2</sup>	Transplants	Dig plants, separate individuals; plant on site at same depth or pot for holding.	Fair soil stabilizer on west coast in high brackish marshes. Brackish/saline.
Saltmeadow cordgrass <sup>2</sup>	Transplants, sprigs	Dig plants; divide into clumps; plant on site at same depth or pot for holding. Dig young plants; separate; plant on site at same depth.	Excellent soil stabilizer in brackish marshes; also used in dune stabilization on Atlantic coast. Seed production often poor; low food value; some cover value. Brackish.
Saw grass <sup>2</sup>	Sprigs, seeds	Dig young plants; separate individuals; plant on site or pot for holding. Collect seeds when mature (July-Sept); store in fresh water at 41°F; broadcast on site; rake into soil.	Species very site specific; occurs only in Florida and in isolated spots along the Gulf coast. Will not tolerate high nutrient levels. Good soil stabilizer; good cover; seeds eaten by some wildlife. Fresh water.
Sea lavender <sup>2</sup> ( <i>L. carolinianum</i> )	Seeds	Collect seeds when mature (July-Aug); store dry at 41°F; broadcast on site; rake into soil.	Fair soil stabilizer; cover. Low food value. Some nesting substrate value. Fresh/brackish.
Sea lavender <sup>2</sup> ( <i>L. vulgare</i> )	Seeds	Same procedures as above.	Same values as above. Fresh/brackish.
Sea ox-eye <sup>2</sup>	Transplants, seeds	Dig plants; separate individuals; plant on site at same depth or pot for holding. Collect seed heads when mature (July-Oct); store seeds in fresh water at 41°F; plant on site; rake into soil.	Excellent soil stabilizer; grows in high marshes and on shores. Low food value; some cover and nesting value. Brackish.
Sea purslane <sup>2</sup>	Seeds	Collect seeds when mature; store dry at room temperature or less; plant on site; rake into soil.	Fair soil stabilization value; low food value; some seed value as food. Some cover use. Fresh/brackish.
Seaside arrowgrass <sup>2</sup>	Transplants	Dig plants; divide into individuals or clumps; plant on site at same depth or pot for holding.	Excellent soil stabilizer in brackish tidal marshes in Pacific northwest; some cover value; low food value. Fresh water.
Sedges <sup>2</sup>	Transplants, seeds	Dig plants; separate into clumps or individuals; plant on site or pot for holding. Collect seeds when mature (June-Sept); store dry at 41°F; broadcast on site; rake into soil.	This group of species far-ranging and widely varied. Usually excellent seed value for wildlife; also good cover. Prolific plants. Fresh water.
Shoal grass <sup>2</sup>	Transplants	Dig plugs with coring device in water at low tide; plant at site immediately at same depth.	Propagules must be stabilized to prevent tidal scour. Good cover value for marine organisms; good sediment stabilizer. Saline.

(Concluded)

(Sheet 7 of 10)

Table B-2 (Continued)

Species	Recommended Propagules	General Collection, Handling, and Planting Techniques	Remarks
Slough grass <sup>2</sup>	Transplants, seeds	Dig plants; divide into clumps or individuals; plant at same depth on site or pot for holding. Collect seeds when mature (July-Sept); store in fresh water at 41°F; broadcast on wet site area.	Good food value for waterfowl and other seed-eating birds; foliage eaten by small animals. Good soil stabilizer. Fresh water.
Slough sedge <sup>2</sup>	Transplants, seeds	Dig plants; separate into clumps; plant on site at same depth or pot for holding; collect seeds when mature (July-Oct); store in fresh water at 41°F; broadcast on wet site; rake into soil if necessary.	Excellent wildlife seed source; foliage also eaten. Good soil stabilizer. Fresh water.
Smartweeds <sup>2</sup>	Cuttings, seeds	Take two to six inch cuttings from top shoots; broadcast on site; rake into soil taking care to cover parts of cuttings (site should be wet). Collect seeds, store in fresh water 04 dry depending on species; broadcast on site; rake into soil.	Excellent group of plants for wildlife value; seeds readily consumed by waterfowl and many other birds and small animals. Good soil stabilizers. Not palatable to herbivores.
Smooth cordgrass <sup>2,3</sup>	Sprigs, transplants	Dig young plants, separate individuals; plant as sprigs on site or pot to hold as transplant. Dig transplants from natural marsh or grow from seeds; plant on site taking care to cover all roots.	Best soil stabilizer of low salt marshes on east and gulf coasts. Used extensively for stabilization and marsh creation projects. Good cover value; good food value. Tolerant of tidal inundation for long periods. Saline.
Soft rush <sup>2</sup>	Transplants	Dig clumps; divide into sections with cutting device; plant on site at same depth or pot for holding.	Persistent high marsh species; good cover value. Some seed value, but foliage inedible. Known pest in pastoral areas. Fresh water.
Softstem bulrush <sup>2</sup>	Rhizomes, transplants	Dig roots; divide rhizomes leaving at least one growth point on each; plant on site one to three inches deep. Dig plants; divide into sections; plant on site or pot for holding.	Excellent soil stabilizer of fresh water coastal and interior marshes. Good seed value for wildlife. Used as cover and nesting material by waterfowl and other wildlife. Fresh water.
Southern bulrush	Rhizomes, transplants	Same procedures as above.	Same values as above, except that this species does not occur as extensively as softstem bulrush, and grows much larger and robust. Fresh water.
Southern cutgrass <sup>2</sup>	Seeds, sprigs	Collect seeds when mature (May-July); store in fresh water at 41°F; broadcast on wet site, rake into soil if necessary.	Excellent seed value for waterfowl and other birds; foliage eaten by small animals and grazers when tender and young. Good soil stabilizer. Fresh water.
Southern smartweed <sup>2</sup>	Cuttings, seeds	Take two to six inch cuttings from top shoots; broadcast in wet area on site; rake or place cuttings into soil. Collect seeds when mature (July-Oct); store in fresh water at 41°F; broadcast on site; rake into soil.	Excellent food source for waterfowl and marsh birds. Prolific growth habits; forms dense tall stands. Good cover value. Not palatable to herbivores. Fresh water.

(Continued)

(Sheet 8 of 10)

Table B-2 (Continued)

Species	Recommended Propagules	General Collection, Handling, and Planting Techniques	Remarks
Spatterdock <sup>2</sup>	Transplants	Dig plants; separate individuals; plant on site at same depth or pot for holding.	Good waterfowl food; good soil stabilizer. Fresh water.
Spikerushes <sup>2</sup>	Transplants	Dig plants; divide into clumps; plant on site at same depth or pot for holding.	Excellent soil stabilizer; fair waterfowl food. Fresh water.
Spirodella <sup>2</sup>	Whole plants	Scoop buckets of plants from standing water; transfer to standing water on site.	Good waterfowl food, especially wood ducks. Fresh water.
Sprangletop <sup>2</sup>	Seeds, sprigs	Collect seeds when mature (summer, fall); store dry at room temperature or less; broadcast on site; rake into soil. Dig young plants; plant on site as sprigs.	Excellent seed source for wildlife; good soil stabilizer; used for cover. Fresh water.
Sweet flag	Transplants	Dig plants; divide individuals; plant on site in high marsh at same depth.	Good soil stabilizer; fair wildlife value; potential pest plant. Fresh water.
Tufted hairgrass <sup>2</sup>	Transplants, sprigs	Dig plants; divide individuals; plant on site or pot for holding. Dig young plants; plant as sprigs on site.	Excellent low marsh species for Pacific northwest; prolific growth; good cover and fair food wildlife value. Good soil stabilizer. Fresh/brackish.
Turtle grass <sup>2</sup>	Transplants	Dig clumps with coring device from water at low tide; take care to be sure that at least one growth point is in each clump or it will not reproduce: plant on site in the water.	Excellent cover and wildlife value; good cover for marine organisms. Species susceptible to environmental changes by man; rare in some areas. Saline.
Walter's millet <sup>2,3</sup>	Seeds	Buy from commercial seed source.	Excellent food value for waterfowl and other wildlife such as raccoons, turkey, deer, muskrats. Good temporary soil stabilizer. Fresh water.
Water hemp <sup>2</sup>	Seeds	Collect seeds when mature; store in fresh water at 41°F; broadcast in wet area on site; rake into soil if necessary.	Good seed source for wildlife; fair soil stabilizer. Fresh water.
Water hyacinth	Cuttings, sprigs	Take two to six inch cuttings from top shoots; plant in mud on site. Dig young plants; divide; plant on site in wet area.	Good soil stabilizer; fair wildlife food. Fresh water.
Water lilies <sup>2,3</sup>	Rootstock	Dig rootstock in late summer and fall when water levels are low; transplant to shallow water on site.	Good cover for ducklings; some food value. Excellent sediment stabilizer; potential pest. Fresh water.
Watermilfoils	Cuttings	Gather containers of plant segments from standing water on site.	Excellent dabbling duck food; good cover. Potential pest plant in standing water and reservoirs. Fresh water.
Water nymphs	Cuttings	Same procedures as above.	Same value as above. Fresh water.

(Continued)

(Sheet 9 of 10)

Table B-2 (Concluded)

Species	Recommended Propagules	General Collection, Handling, and Planting Techniques	Remarks
Water plantain <sup>2</sup>	Transplants	Dig plants; divide individuals; plant on site at same depth.	Good food source for wildlife; fair soil stabilizer. Fresh water.
Water shield	Rootstock	Dig roots in shallow water in late summer and fall; transfer to standing shallow water on site.	Good cover value, good sediment stabilizer. Fresh water.
Water smartweed <sup>2</sup>	Cuttings, seeds	Take two to six inch cuttings from top shoots; plant on site in wet area taking care to bury part of cutting. Collect seeds when mature (July-Sept); store in fresh water at 41°F; broadcast on wet site.	Excellent waterfowl food; good cover. Excellent sediment and soil stabilizer. Fresh water.
Water willow	Transplants	Dig plants; divide individuals; plant on site at same depth.	Fair soil stabilizer; low wildlife value. Fresh water.
White mangrove <sup>2</sup>	Seeds, seedlings	Collect seeds when mature; plant immediately on site. Dig seedlings from natural stand; plant on site.	Excellent soil stabilizer; good cover; low food value; used by nesting birds. Saline.
Widgeongrass <sup>2</sup>	Cuttings	Remove buckets of segments of plants from standing water; transfer to standing water on site.	Excellent waterfowl food; grown by waterfowl managers for attracting waterfowl. Brackish.
Wild celery	Whole plants	Remove whole plants from standing water; transfer to standing water on site.	Excellent cover value; harbors many invertebrates fed on by wildlife. Shades out aquatic plants; pest in Florida and deep south in isolated locations. Fresh water.
Wild rice <sup>2</sup>	Sprigs, seeds	Dig young plants, divide individuals; plant in shallow water on site. Collect seeds when mature; plant on wet site.	Low tolerance for pollution; must have fine-textured soils in slow-moving water. Excellent wildlife food, good soil stabilizer. Fresh water.
Willows <sup>2</sup>	Cuttings	Take four to twelve inch cuttings from dormant trees (winter months, early spring); plant cuttings on site with butt end two thirds in soil.	Excellent soil stabilizer of stream and pond banks. Good cover and food value for songbirds. Very fast growing, potential peat plant. Fresh water.
Wolffias	Whole plants	Remove buckets of plants from standing water; transfer to standing water on site.	Excellent waterfowl food; good cover value. Fresh water.
Yellow flag	Transplants, rhizomes	Dig plants; divide individuals; plant in high marsh on site. Dig rhizomes; divide keeping one growth point on each rhizome; plant shallowly on site.	Good soil stabilizer, low wildlife value: showy flowers. Fresh water.

Sources of information used in the preparation of this table came from unpublished data by the author (Landin) and the following references: Adams (1963), Barbour and Davis (1970), Britton and Brown (1970), Brockman (1968), Broome et al. (1973), Burkhalter et al. (1974), Chabreck (1970), Correll and Johnston (1970), Duncan (1974), Eyles and Robertson (1963), Fassett (1960), Harris and Marshall (1960), Hitchcock (1950), Hotchkiss (1967), Hotchkiss (1970), Kadlec and Wentz (1974), Long and Lakela (1971), Martin et al. (1951), Mason (1965), Palmisano (1972), Radford et al. (1968), Salyer (1949), Seneca (1972), and Woodhouse et al. (1972).

(Sheet 10 of 10)

APPENDIX C

EXAMPLES OF BENEFICIAL USE DEVELOPMENT ON DREDGED MATERIAL  
SITES IN NORTH AMERICAN WATERWAYS\*

Project or Site Name	Location	Beneficial Use	Size
<u>North and Mid-Atlantic Coasts</u>			
<u>Connecticut</u>			
Black Rock Harbor marsh	Bridgeport, CN	Wetland	5 acres
Long Island Sound marshes (4)	Greenwich, CN	Wetland	1-3 acres each
New Britain marsh	New Britain Expressway, CN	Wetland	25 acres
Nott Island	Connecticut River, CN	Habitat development	25 acres
Saugatuck marsh	Saugatuck River, CN	Wetland	0.2 acre
7 colony island & coastal sites	State of Connecticut	Waterbird nesting	--
<u>District of Columbia</u>			
East Potomac Park	Washington, DC	Recreation fill	329 acres
National Airport	Washington, DC	Industrial/urban fill	
Washington Heliport	Washington, DC	Industrial/urban fill	
<u>Delaware</u>			
Chesapeake & Delaware Canal	State of Delaware	Recreation, wetland	
Indian River Bay marsh	Indian River, DE	Wetland	0.5 acre
New Castle County Park	New Castle County, DE	Recreation	
Port Mahon Highway	Port Mahon, DE	Industrial/urban fill	
6 colony island & coastal sites	State of Delaware	Waterbird nesting	—
<u>Massachusetts</u>			
Buzzard*s Bay marsh	Buzzard*s Bay, MA	Wetland	1-3 acres
Cochato River marsh	Randolph, MA	Wetland	0.6 acre
(Continued)			

\* Wetlands and other habitats built as mitigation, but that were not built on dredged material are not included in this listing. Several hundred wetland and aquatic habitats are in this non-dredged material category.

EM 1110-2-5026  
30 Jun 87

Project or Site Name	Location	Beneficial Use	Size
York River marsh	York River, ME	Wetland	1-3 acres
4 colony island & coastal sites	State of Maine	Waterbird nesting	--
<u>Maryland</u>			
Assateague beach	Assateague Beach, MD	Beach nourishment	
South Baltimore	Baltimore, MD	Residential fill	30 sites
Barren Island	Dorchester County, MD	Term nesting, wetland	35 acres
Bethlehem Steel Co.	Baltimore, MD	Industrial fill	500 acres
Bivalve reclamation	Bivalve, MD	Industrial fill	
Broad Creek marsh	Chesapeake Bay, MD	Wetland	1-3 acres
Charity Point	Chesapeake Bay, MD	Wetland	4 acres
Chester beach	Chester River, MD	Recreation fill	
Colgate Creek marsh	Patapsco River, MD	Wetland	5-6 acres
Eastern Shore	State of Maryland	Residential/commercial fill	
Fishing Creek beach	Chesapeake Bay, MD	Recreation fill	
Fort McHenry marsh	Baltimore, MD	Wetland	10 acres
Hambleton marsh (2)	Hambleton Island, MD	Wetland	1-3 acres
Harris Creek marsh	Chesapeake Bay, MD	Wetland	1-3 acres
Hart-Miller Island	Baltimore, MD	Recreation/wetland! habitat development	
Hawkins Point marsh	Baltimore, MD	Wetland	16 acres
Hawkins Point	Baltimore, MD	Industrial fill	
Honga River marsh	Chesapeake Bay, MD	Wetland	10 acres
Knapps Narrows marsh	Chesapeake Bay, MD	Wetland	1-3 acres
Knapps Narrows	Chesapeake Bay, MD	Dewatered landfill	
Little Wicomico beach	Little Wicomico River, MD	Beach nourishment	
Maryland Part Authority	Baltimore, MD	Marine terminal fill	
Middle Branch marsh	Patapsco River, MD	Wetland	1-3 acres
Northeast marsh	Northeast, MD	Wetland	1-3 acres

(Continued)



Project or Site Name	Location	Beneficial Use	Size
Ocean City beach	Ocean City, MD	Beach nourishment	
Ray Point marsh	Ray Point, MD	Wetland	1-3 acres
Ridge marsh	Ridge, MD	Wetland	1-3 acres
San Domingo marsh	St. Michaels, MD	Wetland	1-3 acres
Sinepuxent Wildlife Area	Sinepuxent Bay, MD	Habitat development	
Slaughter Creek	Chesapeake Bay, MD	Wetland	6 acres
Smith Island Park & Beach	Smith Island, MD	Recreation, sports	
Tar Bay marsh	Chesapeake Bay, MD	Wetland	1-3 acres
Tred Avon marsh	Chesapeake Bay, MD	Wetland	1-3 acres
7 colony island & coastal sites	State of Maryland	Waterbird nesting	—
<u>New Jersey</u>			
Artificial Island	Salem County, NJ	Industrial fill	200 acres
Barnegat marsh	Barnegat Bay, NJ	Wetland	1-3 acres
Delaware and Raritan Canal	Central New Jersey	Multipurpose (agriculture, capping, fill)	75,000 cu yd
Forked River marsh	Forked River, NJ	Wetland	1-3 acres
Hackensack River	Hackensack, NJ	Bulkhead fill	
Port Jersey	Jersey City, NJ	Industrial fill	430 acres
Sandy Hook	Sandy Hook, NJ	Beach nourishment	15 miles
49 colony island & coastal sites	State of New Jersey	Waterbird nesting	--
<u>New York</u>			
Brooklyn	New York, NY	Ship berthing facilities fill	
Bronx	New York, NY	Urban use	
Buffalo Port Authority	Buffalo, NY	Industrial fill	
Centerport marsh	Centerport, NY	Wetland	1-3 acres
Centerport Pond	Centerport, NY	Wetland	1-3 acres
East Islip Marina	Islip, NY	Wetland	1-3 acres
Fire Island Beach	Fire Island, NY	Beach nourishment	
Huntington marsh	Huntington Harbor, NY	Wetland	1-3 acres

(Continued)

EM 1110-2-5026  
30 Jun 87

Project or Site Name	Location	Beneficial Use	Size
Hoffman Island	Gateway Nat*1 Park, NY	Recreation fill	
LaGuardia International Airport	New York, NY	Industrial/urban fill	
Long Island Beach	Long Island, NY	Beach nourishment	
Long Island	Long Island, NY	Sanitary landfill	2.5 mi cu yd
Linden marsh	Linden, NY	Wetland	3 acres
Newtown Creek	New York, NY	Bulkhead fill	
North Lime marshes (3)	Hempstead, NY	Wetland	1-3 acres each
Rockaway Beach	Rockaway, NY	Beach nourishment	
Sand Island marsh	Islip, NY	Wetland	1-3 acres
Sandy Hook Beach	Sandy Hook, NY	Beach nourishment	
Seaford marsh	Seaford, NY	Wetland	1-3 acres
Shooters Island	New York, NY	Wetland & habitat development	10 acres
Smith Point Park	Suffolk County, NY	Recreation fill	512 acres
Swinburne Island	Gateways Nat*1 Park, NY	Recreation fill	
29 colony island & coastal sites	State of New York	Waterbird nesting	--
<u>Pennsylvania</u>			
Philadelphia Airport	Philadelphia, PA	Commercial fill	
Pea Island	Near Philadelphia, PA	Waterbird nesting	5 acres
<u>Rhode Island</u>			
52 colony island & coastal sites	State of Rhode Island	Waterbird nesting	--
<u>Virginia</u>			
Burton Bay marsh	Quimby, VA	Wetland	1-3 acres
Cober marsh	Chesapeake Bay, VA	Wetland	1-3 acres
Craddock marsh	Craddock Creek, VA	Wetland	1-3 acres
Craney Island CDF	Craney Island, VA	Industrial fill	
Deep Creek marsh	Deep Creek, VA	Wetland	1-3 acres
Dyke Marsh	Alexandria, VA	Wetland	17 acres
Eastville Marsh	Eastville, VA	Wetland	1-3 acres

(Continued)

Project or Site Name	Location	Beneficial Use	Size
Elizabeth River marsh	Elizabeth River, VA	Wetland	1-3 acres
Goose Creek marsh	Goose Creek, VA	Wetland	1-3 acres
Lambs Creek marsh	Lambs Creek, VA	Wetland	1-3 acres
Mobjack Bay CDF	Mobjack Bay, VA	Recreation fill	
Newport News dock facilities	Newport News, VA	Industrial fill	
Onancock marsh	Onancock Creek, VA	Wetland	1-3 acres
Rappahannock marsh	Rappahannock River, VA	Wetland	1-3 acres
Richmond Port	Richmond, VA	Industrial commercial fill	
Sarah Creek marsh	Sarah Creek, VA	Wetland	1-3 acres
Sloop marsh	Quimby, VA	Wetland	1-3 acres
Stutts Creek marsh	Stutts Creek, VA	Wetland	1-3 acres
Veocomico marsh	Veocomico River, VA	Wetland	1-3 acres
Virginia Beach	Virginia Beach, VA	Beach nourishment	43 acres
Windmill Point marsh	James River, VA	Wetland	20 acres
Woldsnare marsh	Woldsnare, VA	Wetland	1-3 acres
Woodland Beach	Woodland, VA	Shoreline stabilization	
22 colony island & colony sites	State of Virginia	Waterbird nesting	--

Southeastern Coast

Florida

Apalachicola Bay marsh	Apalachicola Bay, FL	Wetland	6 acres
BAL Harbor	, FL	Beach nourishment	
Bird Island	Tampa Bay, FL	Waterbird nesting	20 acres
Biscayne Bay	Biscayne Bay, FL	Hurricane protection fill	
Blount Island	Jacksonville, FL	Industrial/recreation fill	1700 acres
Canaveral Harbor extension	Cape Canaveral, FL	Industrial fill	

(Continued)

EM 1110-2-5026  
30 Jun 87

Project or Site Name	Location	Beneficial Use	Size
Canaveral Lock	Cape Canaveral, FL	Industrial fill	
Cape Canaveral landfill	Cape Canaveral, FL	Sanitary landfill	
Charlotte Harbor beach	Charlotte Harbor, FL	Beach nourishment	2 miles
Clearwater landfill	Clearwater, FL commercial fill	Urban/residential!	
Dade County beaches	Dade County, FL	Beach nourishment	
Del Ray beach	Del Ray, FL	Beach nourishment	3 miles
Duval County beaches	Duval County, FL	Beach nourishment	
Duval County shore	St. John*s River, FL stabilization	Shoreline	
Dade County landfill	Dade County, FL fill	Sanitary/industrial	
Farm land	Port Manatee, FL	Agriculture fill	200 acres
Florida East Coast (12) Florida	Atlantic Beaches in	Beach nourishment	over 30 miles
Florida State Fair	Tampa, FL	Recreation fill	276 acres
Fort Lauderdale landfill	Fort Lauderdale, FL	Commercial/urban fill	
Frenchman*s Creek	Palm Beach County, FL	Wetland	
Hannah State Park	Hannah State Park, FL	Beach nourishment	
Hillsborough Bay CDF (2)	Tampa, FL	Wetland (mangrove)	25 acres
Hillsborough Bay	Tampa, FL fill	Hurricane protection	
Hookers Point	Tampa, FL fill	Industrial/recreation	400 acres
Sewage Treatment Plant	Jacksonville, FL	Industrial fill	
Jacksonville landfill	Jacksonville, FL	Bulkhead fill	
Jupiter Beach	Jupiter Beach, FL	Beach nourishment	5 miles
Jupiter marsh	Jupiter, FL	Wetland	1-3 acres
Key West beaches	Key West, FL	Beach nourishment	
Loxahatchee Slough	Palm Beach County, FL wetland	Habitat development/	190 acres
Marco Island marsh	Marco Island, FL	Wetland (mangrove)	1-3 acres

(Continued)

Project or Site Name	Location	Beneficial Use	Size
Miami Beach	Miami Beach, FL	Beach nourishment	5 miles
Miami landfill	Miami, FL	Urban/residential fill	
Miami Harbor	Miami, FL	Industrial fill	
Ocklockonee marsh	Ocklockonee Bay, FL	Wetland	1-3 acres
Palm Beach	Palm Beach, FL	Beach nourishment	12.2 miles
Palm Beach landfill	Palm Beach, FL	Commercial/urban fill	
Panacea marsh	Panacea, FL	Wetland	1-3 acres
Panama City Beach	Panama City, FL	Beach nourishment	
Panama City Island	Panama City, FL	Recreation fill	
Pensacola Bay	Escambia County, FL	Wetland	2 acres
Picnic Island	Tampa, FL	Recreation fill	
Pompano Beach	Pompano Beach, FL	Beach nourishment	5 miles
Port Everglades Harbor	Port Everglades, FL	Industrial fill	
Port St. Joe marine area	Port St. Joe, FL	Seagrass restoration	1 acre
Port St. Joe Harbor	Port St. Joe, FL	Industrial fill	
Quarantine Island	Jacksonville, FL	Recreation fill	
St. Lucie Inlet	St. Lucie, FL	Wetland	
St. Lucie beach	St. Lucie, FL	Beach nourishment	
Sailfish Point marsh	Martin County, FL	Wetland	
Sunken Island	Hillsborough Key, FL	Waterbird nesting	40 acres
Tampa Harbor	Tampa, FL	Wetland	10 acres
Tiger Point	Santa Rosa County, FL	Wetland	5 acres
39 colony island & coastal sites	State of Florida	Waterbird nesting	-
<u>Georgia</u>			
Brunswick marsh	Brunswick, GA	Wetland	2 acres
Brunswick Port	Brunswick, GA	Industrial fill	
Buttermilk Sound marsh	Altamaha River, GA	Wetland	5 acres
Hell Gate marsh	Ossabaw Sound, GA	Wetland	1-3 acres
Jekyll Island beaches	Jekyll Island, GA	Beach nourishment! hurricane protection	

(Continued)

EM 1110-2-5026  
30 Jun 87

Project or Site Name	Location	Beneficial Use	Size
Kings Bay Naval Base CDF	Brunswick, GA	Habitat development/ waterbird nesting/ recreation	500 acres
McIntosh County marsh	McIntosh County, GA	Wetland	4 acres
Kings Bay	Brunswick, GA	Underway berm; shore protection; habitat development	
Savannah marsh	Savannah, GA	Wetland	4 acres
Savannah Port and Harbor	Savannah, GA	Industrial fill	
Savannah Marine Facility	Savannah, GA	Industrial fill, commercial fill	
Savannah Industrial Park	Savannah, GA	Industrial fill	
14 colony islands & coastal sites	State of Georgia	Waterbird nesting	—
<u>North Carolina</u>			
Annadale Plantation	Annadale, NC	Aquaculture	
Beaufort Island Park	Morehead City, NC	Recreation fill	
Beaufort marsh	Beaufort, NC	Wetland	1-3 acres
Lake Rudee marsh	Lake Rudee, NC	Wetland	1-3 acres
Bogue Bay Marina	Bogue Sound, NC	Recreation	
Bogue Sound marsh	Bogue Sound, NC	Wetland	1-3 acres
Brunswick Beach	Brunswick Beach, NC	Hurricane protection	
Cape Lookout beach	Cape Lookout, NC	Beach nourishment	
Carolina Beach	Caroline Beach, NC	Beach nourishment	
Cherrystone marsh	Cherrystone Inlet, NC	Wetland	1-3 acres
Core Sound Island	Core Sound, NC	Waterbird nesting	25 acres
Core Sound marsh	Core Sound, NC	Wetland	1-3 acres
Currituck marsh	Currituck Sound, NC	Wetland	1-3 acres
Emerald Isle	Emerald Isle, NC	Residential fill	
Fort Macon State Park	Fort Macon, NC	Beach nourishment	
Moorehead Harbor	Moorehead City, NC	Industrial fill	

(Continued)

Project or Site Name	Location	Beneficial Use	Size
Neuse River marsh	Neuse River, NC	Wetland	1-3 acres
Neuse Marina	Neuse River, NC	Commercial fill	
Newport River marsh	Newport River, NC	Wetland	1-3 acres
North River landfill	North River, NC	Hurricane protection	
Pine Knolls marsh	Pine Knolls Shore, NC	Wetland	5 acres
Snow*s Cut marsh	Snow*s Cut, NC	Wetland	1-3 acres
South Island marsh	South Island, NC	Wetland	1-3 acres
Surf City landfill	Surf City, NC	Hurricane protection	
Topsoil Beach landfill	Topsoil Beach, NC	Hurricane protection	
Wilmington Harbor	Wilmington, NC	Industrial fill	
Wrightsville Beach	Wrightsville Beach, NC	Beach nourishment	
78 colony islands & coastal	State of North Carolina	Waterbird nesting sites	
<u>South Carolina</u>			
Belle Isle Marina	Belle Isle, SC	Commercial fill	
Drum Island	Charleston, SC	Habitat development/ waterbird nesting	640 acres
Georgetown Harbor	Georgetown, SC	Industrial fill	
Hog Island	Charleston, SC	Multipurpose! recreation! commercial	
Hunting Island Creek	Hunting Island, SC	Beach nourishment	
Intra Coastal Harbor wildlife areas	Charleston, SC	Habitat development	
Old Daniel Island I	Charleston, SC	Agriculture	700 acres
Old Daniel Island II	Charleston, SC	Agriculture	1,000 acres
Patriots Point Park	Charleston, SC	Recreation	450 acres
Peedee River	Charleston, SC	Industrial fill	
Waccamaw River	Charleston, SC	Industrial fill	
Wynah Bay marsh	Wynah Bay, SC	Wetland	
10 colony islands & coastal sites	State of South Carolina	Waterbird nesting	—

(Continued)

EM 1110-2-5026  
30 Jun 87

<u>Project or Site Name</u>	<u>Location</u>	<u>Beneficial Use</u>	<u>Size</u>
<u>Puerto Rico</u>			
Puerto Rico marine areas	Puerto Rico	Seagrass restoration	
<u>Deep South Coast</u>			
<u>Alabama</u>			
Alabama Ship Yards	Mobile, AL	Industrial fill	
Alabama State Docks	Mobile, AL	Industrial fill	
Alabama River levees	Montgomery, AL	Flood control	
Battleship State Park	Mobile, AL	Recreation/resort community	
Battleship Parkway	Mobile, AL	Highway fill	
Blakely Island	Mobile Bay, AL	Industrial fill	300 acres
Brookley Disposal Island	Mobile Bay, AL	Industrial fill	
Coast Guard Station	Mobile, AL	Institutional fill	
Coffee Island marsh	Miss. Sound, AL	Wetland	20 acres
Dauphin Island	Miss. Sound, AL	Beach nourishment	
Gaillard Island	Mobile Bay, AL	Waterbird nesting	1,200 acres
Gaillard Island	Mobile Bay, AL	Wetland	35 acres
Guntersville Lake	Scottsboro, AL	Wetland	2 acres
Hollingers Island	Mobile Bay, AL	Recreation/industrial fill	
Jacintoport	Mobile, AL	Industrial fill	7,100 acres
Little Sand Island	Mobile Bay, AL	Industrial fill! wetland	20 acres
McDuffie Island	Mobile, AL	Industrial fill	
Mobile Industrial Park	Mobile, AL	Industrial fill	
Mobile beaches	Mobile, AL	Recreation	
Mobile Bay	Mobile, AL	Oyster bed development	
Ono Island	Baldwin County, AL	Wetland	12 acres
Tennessee-Tombigbee Waterway	MS/AL	Habitat development	500 acres

(Continued)



Project or Site Name	Location	Beneficial Use	Size
Tennessee-Tombigbee Waterway	MS/AL	Recreation/boat ramps	
57 colony island & coastal sites	State of Alabama, Mississippi, & Louisiana	Waterbird nesting	--
<u>Louisiana</u>			
Atchafalaya Basin	Atchafalaya River, LA	Wetlands	1,000 acres
Centroport	New Orleans, LA	Industrial fill part facilities	
Chandeliers	Miss. Sound, LA	Waterbird nesting	
CE District Offices	New Orleans, LA	Institutional fill	
Interstate 10	State of Louisiana	Highway fill	
Intracoastal Waterway islands and marshes	Southern Louisiana	Waterbird nesting! wetlands	75+ acres
Lake Borgne Development	New Orleans, LA	Commercial/urban fill	
Lake Calcasieu Area	Atchafalaya Basin, LA	Recreation	
Lafayette levees	Lafayette, LA	Flood control	
Louisiana State University at New Orleans	New Orleans, LA	Institutional fill	
Mermentau and Calcasieu Rivers marshes	New Orleans, LA	Wetlands	150+ acres
Mississippi River levees	South Louisiana	Flood control	
New Orleans (city) levees	New Orleans, LA	Flood control	
New Orleans Airport	New Orleans, LA	Commercial fill	
New Orleans landfill residential/ industrial fill	New Orleans, LA	Extensive commercial!	
Pasture land	Southern Louisiana	Agriculture	
Pontchartrain Amusement Park	New Orleans, LA	Recreation fill	
Pontchartrain Beach	New Orleans, LA	Beach nourishment	
Pontchartrain Development	New Orleans, LA	Commercial/residential/ recreation/sports fields/parks/lakes	

(Continued)

EM 1110-2-5026  
30 Jun 87

Project or Site Name	Location	Beneficial Use	Size
Pontchartrain Town-in-Town	New Orleans, LA	Residential fill	
Southwest Pass marshes (2,725 acres have been built in LA; 21,200 acres are planned)	Mississippi River, LA	Wetlands	1,200+ acres
<u>Mississippi</u>			
Cat Island	Mississippi Sound, MS	Waterbird nesting	
East Beach marsh	Ocean Springs, MS	Wetland	1-3 acres
Gulf Coast levees/dikes	Mississippi Sound, MS	Hurricane protection! flood control	
Gulfport/Biloxi Beach	Hancock & Harrison Counties, MS	Beach nourishment	30+ miles
Gulfport landfill	Gulfport, MS	Residential/commercial fill	
Gulfport disposal islands (2)	Gulfport, MS	Waterbird nesting	
Gulfport Harbor	Gulfport, MS	Industrial fill	
Gulf Park Estates marsh	Ocean Springs, MS	Wetland	1-3 acres
Horn Island	Mississippi Sound, MS	Waterbird nesting	
Horn Island	Mississippi Sound, MS	Beach nourishment	2 miles
Horn Island marsh	Mississippi Sound, MS	Wetland	1-3 acres
Horn Island Pass marsh	Mississippi Sound, MS	Wetland	10 acres
Petit Bois marsh	Mississippi Sound, MS	Wetland	1-3 acres
Ship Island marsh	Mississippi Sound, MS	Wetland	1-3 acres
Ship Island	Mississippi Sound, MS	Island restoration	30 acres
Ship Island	Mississippi Sound, MS	Dune stabilization	4 acres
Simmons Bayou marsh	Mississippi Sound, MS	Wetland	1-3 acres
Singing River marsh	Pascagoula, MS	Wetland	4 acres
Tallahala Creek Dam	Pascagoula, MS	Recreation fill	
Term Beach	Gulfport, MS	Waterbird nesting	50 acres
<u>Texas</u>			
Army Reserve Center	Galveston, TX	Institutional fill	
Big Pelican Island	Galveston, TX	Industrial fill	3,225 acres
Big Pelican Island	Galveston, TX waterbird nesting	Industrial fill!	200 acres

(Continued)

Project or Site Name	Location	Beneficial Use	Size
Bolivar Peninsula I	Galveston Bay, TX	Wetland	20 acres
Bolivar Peninsula II	Galveston Bay, TX stabilization	Wetland/shore	15 acres
CDF pond	Freeport, TX	Aquaculture (shrimp)	20 acres
CE District offices	Galveston, TX	Institutional fill	
City Golf Course	Galveston, TX	Recreation fill	50 acres
East Bay marsh	East Bay, TX	Wetland	acres
East Galveston Bay	Galveston, TX	Wetland	acres
Galveston Port	Galveston, TX	Industrial fill	
Galveston landfill	Galveston, TX	Commercial/residential/ institutional fill	Many square miles
Galveston beaches	Galveston, TX	Beach nourishment	15 miles
Galveston Seawall	Galveston, TX	Hurricane protection	10 miles
Grazing land	Galveston County, TX	Agriculture fill	200 acres
Grazing land	Jefferson County, TX	Agriculture fill	200 acres
Grazing land	East Matagorda Bay, TX	Agriculture fill	500 acres
Houston Ship Channel and Port	Houston, TX	Industrial fill	
Jacintoport	Galveston, TX	Industrial fill	4,500 acres
Laguna Madre Islands (30) nesting	Corpus Christi, TX	Recreation/waterbird	--
Little Pelican Island	Galveston, TX	Waterbird nesting	100 acres
Padre Island Nat*1 Seashore	Corpus Christi, TX	Beach nourishment	3 miles
Pleasure Island	Port Arthur, TX	Recreation fill	3,500 acres
Port Arthur/Lake Sabine	Port Arthur, TX	Recreation	
Redfish Bay marsh	Redfish Bay, TX	Wetland	5-10 acres
Sabine Island	Port Arthur, TX	Waterbird nesting	
Seawolf State Park	Galveston, TX	Recreation fill	20 acres
Smith Point marsh	Galveston Bay, TX	Wetland	5 acres
Snake Island marsh	Texas City, TX	Wetland	50 acres
Snake Island levee	Texas City, TX	Industrial fill	3 miles

(Continued)

EM 1110-2-5026  
30 Jun 87

Project or Site Name	Location	Beneficial Use	Size
Snake Island CDF	Texas City, TX	Industrial fill	500 acres
Steadman marsh	Steadman Island, TX	Wetland	1-3 acres
Texas City Dike marsh	Texas City, TX	Wetland	3 acres
Texas City Port	Texas City, TX	Industrial fill	
Texas A&M University, Moody Campus	Galveston, TX	Institutional fill	
Texas highway system	Galveston and Jefferson Counties, TX	Embankment fill	
242 colony island & coastal sites	State of Texas	Waterbird nesting	--

West Coast

California

Alameda Creek marsh	Alameda Creek, CA	Wetland	5-10 acres
Alameda Naval Air Station	Alameda, CA	Institutional fill	1-3 acres
Anza Pacifica marsh	Burlingame, CA	Wetland	1-3 acres
Bay Bridge marsh	Oakland, CA	Wetland	1-3 acres
Berkeley Aquatic Park	Berkeley, CA	Recreation	
Brannan State Park	Brannan State Park, CA	Recreation fill	
Candlestick Park	San Francisco, CA	Recreation fill	
California Highway Patrol Academy	Yolo County, CA	Institutional fill	
Crescent City Park	Crescent City, CA	Recreation fill	
Donlin Island marsh	Stockton, CA	Wetland	60 acres
Faber Tract marsh	Palo Alto, CA	Wetland	1-3 acres
Fiesta Island	San Diego, CA	Beach nourishment	
Fifth Avenue Marina	San Diego, CA	Recreation	22 acres
Foster City landfill	Foster City, CA	Entire town built on fill	
Grand Island CDF	Grand Island, CA	Recreation	
Grazing land	Salano County, CA	Agriculture	11,000 acres

(Continued)

Project or Site Name	Location	Beneficial Use	Size
Harbor Island	San Diego, CA	Recreation	
Hunters Point Naval Shipyard	San Francisco, CA	Institutional fill	
Interstate 5	Stockton/Sacramento, CA	Highway fill	
Larkspur Park	Mann County, CA	Recreation	
Lindburgh Airport	San Diego, CA	Industrial/commercial fill	
Long Beach	San Pedro Bay, CA	Recreation fill	
Los Angeles beaches	Los Angeles, CA	Beach nourishment	
Los Angeles Harbor	Los Angeles, CA	Industrial/commercial/recreation	
Marion County Day School marsh	Corte Madera Bay, CA	Wetland	1-3 acres
Marina Del Rey	Culver City, CA	Recreation	
Mission Bay Park	San Diego, CA	Recreation	4,500 acres
New Castle County Park	New Castle County, CA	Recreation	
Newport Beach	Newport Beach, CA	Recreation/waterbird nesting	
Oakland International Airport	Oakland, CA	Industrial/commercial fill	
Port View Park	Port View, CA	Recreation	
Presidio Military Reservation	San Francisco, CA	Institutional fill	
Rio Vista Beach	Rio Vista, CA	Beach nourishment	
Salt Pond #3 marsh	San Francisco Bay, CA	Wetland	100 acres
Santa Ana marsh	Santa Ana, CA	Wetland	2 acres
San Rafael landfill	San Rafael, CA	Residential fill	
San Joaquin and Sacramento River	North Central, CA	Flood control/agriculture fill	
San Francisco International Airport	San Bruno, CA	Industrial/commercial fill	
San Francisco piers	San Francisco, CA	Industrial/commercial fill	

(Continued)

EM 1110-2-5026  
30 Jun 87

Project or Site Name	Location	Beneficial Use	Size
San Diego Marine Park	San Diego, CA	Recreation/commercial fill	200 acres
San Diego Naval Air Station	San Diego, CA	Institutional fill	
Shelter Island	San Diego, CA	Recreation	
Tern beach	Los Angeles, CA	Waterbird nesting	3 acres
U.S. Naval Amphibious Base	San Diego, CA	Institutional fill	
U.S. Flat Operating Base	San Pedro Bay, CA	Institutional fill	
U.S. Naval Repair Station	San Diego, CA	Institutional fill	
Venice Cut marsh	San Jouquin River, CA	Wetland	55 acres
21 colony island & coastal sites	State of California	Waterbird nesting	--
<u>Oregon</u>			
Bonneville Lock and Dam	Columbia River, OR	Institutional fill	
Columbia River shoreline	Columbia River, OR	Beach nourishment	
Columbia River	Columbia River, OR	Shoreline stabilization	
Columbia River dikes	Columbia River, OR	Flood control	
Coos Bay Development	Coos Bay, OR	Industrial/commercial/agricultural/residential fill	400 acres
Coos Bay beaches	Coos Bay, OR	Snowy plover nesting	
Coos Bay berms	Coos Bay, OR	Clam bed development	
Dibblee Point Park	Dibblee Point, OR	Recreation fill	
Eureka Bar	Columbia River, OR	Nesting island	
Hood River Industrial Park	Hood River, OR	Industrial fill/wetland	100 acres
Hedges Creek marsh	Hedges Creek, OR	Wetland	55 acres
Kalama Park	Kalama, OR	Recreation fill	
Kelley Point Park	Portland, OR	Recreation fill	
Lord Island	Columbia River, OR	Nesting island	

(Continued)

Project or Site Name	Location	Beneficial Use	Size
Miller Sands Island (3 sites)	Columbia River, OR	Wetland/habitat development/ waterbird nesting/ dune stabilization	400 acres
Mott Island	Columbia River, OR	Habitat development	265 acres
Portland Port Authority	Portland, OR	Industrial fill	2,700 acres
Pony Village	North Bend, OR	Commercial fill	200 acres
Portland International Airport	Portland, OR	Industrial fill	
Portland landfill	Portland, OR	Sanitary landfill	
Portland Waterfront/ Old City	Portland, OR	Commercial fill	
Port Center	Portland, OR	Commercial fill	
Puget Island	Columbia River, OR	Waterbird nesting	
Rice Island	Columbia River, OR	Wetland/habitat development	35 acres
Sand Island	Columbia River, OR	Habitat development	7 acres
Swan Island Center	Portland, OR	Commercial fill	50 acres
Swan Island Shipyard	Portland, OR	Industrial fill	25 acres
Swan Island Airport	Portland, OR	Industrial fill	50 acres
Umqua River	Winchester Bay, OR	Oyster farming/ shoreline stabilization	100 acres
Walker Island	Columbia River, OR	Waterbird nesting	
Wallace Island	Columbia River, OR	Waterbird nesting	
Willamette River site	Willamette River, OR	Industrial fill	
Yaquina Bay	Newport Bay, OR	Clam bed development	
18 colony island & coastal sites	States of Oregon & Washington	Waterbird nesting	--
<u>Washington</u>			
Aberdeen Boat Ramp	Aberdeen, WA	Recreation fill	
Anacortes Site	Anacortes, WA	Industrial fill	26 acres
Big White Boat Ramp	Salmon River, WA	Recreation fill	

(Continued)

EM 1110-2-5026  
30 Jun 87

Project or Site Name	Location	Beneficial Use	Size
Columbia River Dams (8)	Western Washington	Recreation/habitat development/ institutional fill	
Columbia River Islands	SE Washington	Waterbird nesting	
Drano Lake Boat Ramp	Drano Lake, WA	Recreation fill	
Duwamish River fill	Seattle, WA	Urban renewal	
Everette islands	Everette, WA	Waterbird nesting	
Grays Harbor Airport	Grays Harbor, WA	Industrial fill	50 acres
Grays Harbor sewage lagoon	Grays harbor, WA	Sanitary fill	10 acres
Grays Harbor sawmill	Grays Harbor, WA	Industrial fill	10 acres
Grays Harbor port	Grays Harbor, WA	Industrial fill	25 acres
Grazing land	Pacific County, WA	Agriculture	2,000 acres
Hoquiam site	Hoquiam, WA	Industrial/recreation	45 acres
Kingston Industrial Port	Kingston, WA	Industrial	265 acres
McNary Dan	Umadilla, WA	Recreation/habitat development	50 acres
Puget Sound marine areas	Puget Sound, WA	Seagrass restoration	
Reichold Chemical Co.	Columbia River, WA	Industrial	
Rock Creek Fair and Park Gardens	Rock Creek, WA	Recreation fill	
Seattle landfill	Seattle, WA	Commercial fill	
Seattle Port Facilities	Seattle, WA	Industrial fill	
Seattle City Light Utility Co.	Seattle, WA	Dewatered stockpiling	
Shelton Industrial Park	Shelton, WA	Industrial fill	
Snake River Dams (4)	SE Washington/Western Idaho	Recreation/habitat development	
Toutle River fill	Longview, WA	Recreation/ agriculture	
Washington highway system	Seattle area, WA	Highway fill	
Winchester Bay Boat Basin	Winchester, WA	Recreation/commercial fill	
Wind River Boat Ramp	Wind River, WA	Recreation fill	
Coeur d*Alene Dam	Western Idaho	Recreation/industrial	

(Continued)



<u>Project or Site Name</u>	<u>Location</u>	<u>Beneficial Use</u>	<u>Size</u>
<u>Great Lakes</u>			
<u>Illinois</u>			
Calumet River Harbor	Chicago, IL	Recreation/industrial fill	42 acres
Cook County Forest Preserve	Chicago, IL	Forestry	
Ottawa mine site	Ottawa, IL	Stripmine reclamation	
<u>Indiana</u>			
Michigan City Harbor	Michigan City, IN	Recreation	4 acres
<u>Michigan</u>			
Bolles Harbor	Bolles Harbor, MI	Recreation	25 acres
Clinton River Park	Clinton River, MI	Recreation/habitat development	
Detroit Park	Detroit, MI	Recreation	300 acres
Dickinson Island	St Clair River, MI	Recreation/habitat development	174 acres
Ecorse Park	Ecorse, MI	Recreation	
Frankfort Harbor	Frankfort, MI	Recreation	1 acre
Grand Haven Harbor	Grand Haven, MI	Recreation	36 acres
Grassy Island	Detroit, MI	Recreation/waterbird nesting	80 acres
Holland Harbor	Holland, MI	Recreation	28 acres
Inland Route	Inland Route, MI	Habitat development	9 acres
Monroe Harbor Port	Monroe, MI	Industrial fill	
Monroe Harbor	Monroe, MI	Recreation, habitat development	50 acres
Mud Island	Detroit, MI	Recreation/waterbird nesting	25 acres
Pointe Mouillee	Monroe, MI	Recreation/erosion control/wetland/habitat development/waterbird nesting	4,600 acres
Saginaw Bay	Saginaw, MI	Recreation/nesting	283 acres

(Continued)

EM 1110-2-5026  
30 Jun 87

Project or Site Name	Location	Beneficial Use	Size
Saginaw River Industrial Park	Saginaw, MI	Industrial fill	
Sault SainteMarie Locks	St. Ste Marie, MI	Recreation/habitat development	
Sterling State Park	Monroe, MI	Recreation, erosion control	250 acres
<u>Minnesota</u>			
Duluth Port Authority	Duluth, MN	Recreation/industrial fill	200 acres
<u>New York</u>			
Buffalo Harbor	Buffalo, NY	Habitat development	33 acres
Dike #4	Buffalo, NY	Habitat development	40 acres
Times Beach	Buffalo, NY	Wetland, recreation	45 acres
Niagara Frontier Authority	Buffalo, NY	Harbor development	
<u>Ohio</u>			
Cleveland Airport	Cleveland, OH	Commercial fill	
Conneaut Park	Conneaut, OH	Recreation	
Dike #12	Cleveland, OH	Habitat development	56 acres
Dike #14	Cleveland, OH	Habitat development	88 acres
Edgewater Park	Cleveland, OH	Recreation	
Fairport Harbor Park	Fairport, OH	Recreation	
Gordon Park	Cleveland, OH	Recreation	
Huron Harbor	Huron, OH	Habitat development, recreation	63 acres
Lorain Harbor	Lorain, OH	Habitat development	58 acres
Mud Island	Toledo, OH	Industrial fill	
Port Huron	Huron, OH	Industrial fill	
Reed Island	Reed Island, OH	Recreation	
Toledo Dike CDF I	Toledo, OH	Industrial/habitat development	150 acres
Toledo Disk CDF II	Toledo, OH	Waterbird nesting	242 acres
Toledo-Lucas County Port Authority	Toledo, OH	Industrial fill	

(Continued)

<u>Project or Site Name</u>	<u>Location</u>	<u>Beneficial Use</u>	<u>Size</u>
<u>Pennsylvania</u>			
Erie Harbor	Erie, PA	Habitat development	23 acres
<u>Wisconsin</u>			
Bayport	Green Bay, WI	Industrial fill	575 acres
Green Bay Harbor	Green Bay, WI	Recreation	60 acres
Kenosha Harbor	Kenosha, WI	Habitat development	25 acres
Kewannee Harbor	Kewannee, WI	Recreation	28 acres
Lakefront Park	Milwaukee, WI	Recreation	
Manitowoc Harbor	Manitowoc, WI	Urban use	24 acres
Milwaukee Harbor	Milwaukee, WI	Habitat development	44 acres
Sebewaing Harbor	Sebewaing, WI	Industrial fill	180 acres
50 colony islands & lake sites	States of Ohio, Wisconsin, Michigan, Illinois, and Minnesota	Waterbird nesting	--
<u>Interior United States</u>			
<u>Arkansas</u>			
Little Rock Park	Little Rock AR	Recreation	
Yell County river parks	Little Rock area, AR	Recreation	
<u>Illinois</u>			
Rock Island Arsenal	Rock Island, IL	Institutional fill	
<u>Iowa</u>			
Upper Lansing Light	Mississippi River, Iowa	Recreation	2 acres
Upper Mississippi River water parks	States of Iowa, Illinois, & Missouri	Recreation	
<u>Kentucky</u>			
Kentucky Lake	Grand Rivers, KY	Wetland	1 acre
<u>Louisiana</u>			
Red River river parks	Red River & Shreveport, LA	Recreation	

(Continued)

EM 1110-2-5026  
30 Jun 87

<u>Project or Site Name</u>	<u>Location</u>	<u>Beneficial Use</u>	<u>Size</u>
<u>Minnesota</u>			
Crats Island	Mississippi River, MN	Pit Reclamation	30 acres
Indian Camp Light	Mississippi River, MN	Recreation	2 acres
Kinnikinnic Bar	St. Croix River, MN	Recreation	10 acres
Lakes of the Woods	Warroad, MN	Wetland	4 acres
Minn.-St. Paul International Airport	Minneapolis, MN	Industrial/commercial fill	37 acres
Pt. Douglas	St. Croix River, MN	Recreation	3 acres
Reads Landing	Mississippi River, MN	Pit Reclamation	60 acres
St. Paul Barge Terminal	Mississippi, River, MN	Industrial fill	15 acres
Lake of the Woods	Warroad, MN	Wetland	5 acres
Weaver Bottoms	Mississippi River, MN	Wetland	4,000 acres
Wilds Bend	Mississippi River, MN	Industrial fill	17 acres
<u>Missouri</u>			
Lake of the Ozarks	Missouri River, MO	Wetland	3.5 acres
Kansas City International Airport	Kansas City, MO	Industrial/commercial fill	
<u>Mississippi</u>			
Herrin-Gear Chevrolet	Jackson, MS	Commercial use	25 acres
Jackson YMCA	Jackson, MS	Commercial use	10 acres
Tennessee-Tombigbee Waterway	States of Alabama and Mississippi	Recreation/forestry	12,000 acres
Tennessee-Tombigbee Waterway	Columbus, MS	Aquatic habitat	5 acres
Vicksburg Harbor	Vicksburg, MS	Industrial fill	350 acres
<u>Ohio</u>			
Higgins Port Park	Higgins, OH	Recreation	
<u>Oklahoma</u>			
Grazing land	Tulsa, OK	Agriculture fill	2,600 acres
<u>South Dakota</u>			
City Park	Pierre, SD	Recreation fill	
Eagles Roost	Pickstown, SD	Bank stabilization	

(Continued)

<u>Project or Site Name</u>	<u>Location</u>	<u>Beneficial Use</u>	<u>Size</u>
<u>Tennessee</u>			
Mud Island	Memphis, TN	Commercial/recreation fill	50 acres
Presidents Island Harbor	Memphis, TN	Industrial fill	960 acres
Rivergate Island	Memphis, TN	Recreation fill	425 acres
<u>West Virginia</u>			
Big Sandy Park	Kenora, WV	Recreation fill	
<u>Wisconsin</u>			
Alma Marina	Mississippi River, WI	Recreation fill	5 acres
Buffalo City	Mississippi River, WI	Highway fill	2 acres
Winters Landing	Mississippi River, WI	Shoreline restoration	1 acre
<u>Canada</u>			
Aquatic Park	Toronto, Ontario	Recreation, com- mercial, resort, airport, marina	1,500 acres Mitchell Bay Onta
Port of Vancouver	Vancouver, British Columbia	Industrial fill	5,800 acres
St. Lawrence islands (9)	St. Lawrence Seaway	Waterfowl nesting	--
19 colony island & lake sites	Canadian Great Lakes	Waterbird nesting	--

Beneficial Use Applications of Dredged Material\*

State	Wetlands	Waterbird Nesting	Other Habitat Develop.	Recreation (all types)	Agriculture Forestry	Beach Nourishment	Commercial+ Residential	Industrial Inert/functional	Stabilization (bank/shore)	Flood Control Hurricane Prot.	Sanitary Landfill	Total
Alabama	5	16	2	4		1		13		1		42
Arkansas				2								2
California	9	23	1	17	2	3	9	15		1		79
Connecticut	7	7										15
Delaware	2	6		2								11
Florida	14	39	2	6	1	26	3+	11	1	2	1	106
Georgia	5	15	2	1		1		4	1			30
Illinois		2	2	4				2		1		10
Indiana				1								1
Iowa				5								5
Kentucky	1		1									2
Louisiana	3#	31	3	8	1	1	6+	5+		3+		61
Maine	1	4										2
Maryland	19	8	2	5		3	2	5+				44
Massachusetts	2	11										13
Michigan	2	29	6	16				2+		2		57
Minnesota	3	2	2	4			1	4				18
Mississippi	8	23	3	2		2	3	2	2	1		46
Missouri	1			5			1	1				8
New Jersey	2	49			1	1		3+				56
New York	11	29	3	4		4	1	6+			1	59
North Carolina	10	81	1	2		4	2	2		4		106
Ohio		2	5	7				5+				19
Oklahoma					1							1
Oregon	5	18	8	3	2	1	3	8+	3	1	1	53
Pennsylvania	1	1	1					1+				3
Rhode Island		5										5
South Carolina	1	11	3	2	2	1	2	3	1			25
South Dakota				1								2
Tennessee				2					1			2
Texas	9	242	1	2	1	1	1					5
Virginia	17	22	13	5	3	1	1+	13+	1	1		277
Washington		7		1				3	1			45
Washington, DC				21	1		3	23+			1	69
West Virginia				1			2					3
Wisconsin	2	2	2	4		1	1	4	1			16
Canada		28	1				3+					33
<b>Total</b>	<b>139</b>	<b>713</b>	<b>65</b>	<b>136</b>	<b>14</b>	<b>52</b>	<b>44+</b>	<b>137+</b>	<b>11</b>	<b>17+</b>	<b>4</b>	<b>1,332</b>

\* Wetlands and other habitats built as mitigation, but that were not built on dredged material, are not included in this listing. Several hundred such beneficial use projects have already been built or are in planning.  
 + Some sites in these states were so numerous, especially in highly urban areas where dredged material has been used for many years for residential, commercial, and industrial fill, and for levee construction, that they were impossible to count.  
 # Louisiana has had over 15,000 acres of wetlands built of dredged material, and although only 3 sites are shown, these sites cover virtually the entire dredging area of south Louisiana, notable Southwest Pass, Atchafalaya Basin, and Mississippi Gulf Outlet.

EM 1110-2-5026  
30 Jun 87

APPENDIX D

COMMON AND SCIENTIFIC NAME OF PLANTS AND ANIMALS  
MENTIONED IN THIS MANUAL

E-1. Plants.

<u>Common Name</u>	<u>Scientific Name</u>
Aiders	<u>Alnus spp.</u>
Alfalfa	<u>Medicago sativa</u>
Alkali bulrush	<u>Scirpus sp.</u>
Alsike clover	<u>Trifolium hybridum</u>
American beachgrass	<u>Ammophila breviligulata</u>
American beech	<u>Fagus grandifolia</u>
American bittersweet	<u>Celastrus scandens</u>
American dunegrass	<u>Elymus mollis</u>
American elderberry	<u>Sambucus canadensis</u>
American elm	<u>Ulmus americana</u>
American hornbeam	<u>Carpinus caroliniana</u>
American plum	<u>Prunus americana</u>
American sycamore	<u>Platanus occidentalis</u>
Apples	<u>Malus spp.</u>
Arrow arum	<u>Peltandra virginica</u>
Arrow-leaved tearthumb	<u>Polygonum sagittatum</u>
Arrowwood viburnum	<u>Viburnum dentatum</u>
Australian pine	<u>Casuarina equisetifolia</u>
Autumn olive	<u>Eleagnus umbellata</u>
Bahia grass	<u>Paspalum notatum</u>
Bald cypress	<u>Taxodium distichum</u>
Bamboo vine	<u>Smilax laurifolia</u>
Barley	<u>Hordeum vulgare</u>
Barnyard grass	<u>Echinochloa crusgalli</u>
Bayberry	<u>Myrica pennsylvanica</u>
Beach morning glory	<u>Ipomoea stolonifera</u>
Beach panic grass	<u>Panicum ararum</u>
Beach pea	<u>Lathyrus japonicus</u>
Beach plum	<u>Prunus maritima</u>
Beach strawberry	<u>Fragaria chiloensis</u>
Beak rush	<u>Rynchospora tracyi</u>
Beaked panic grass	<u>Panicum anceps</u>
Bearberry	<u>Arctostaphylos uva-ursi</u>
Beautyberry	<u>Callicarpa americana</u>
Beet	<u>Beta vulgaris</u>
Beggar*s ticks	<u>Bidens spp.</u>
Bermuda grass	<u>Cynodon dactylon</u>
Bicolor lespedeza	<u>Lespedeza bicolor</u>
Big bluestem	<u>Andropogon gerardi</u>
Big cordgrass	<u>Spartina cynosuroides</u>
Big filaree	<u>Erodium botrys</u>



EM 1110-2-5026  
30 Jun 87

Bigelow*s glasswort	<u>Salicornia bigelowii</u>
Bird*s foot trefoil	<u>Lotus corniculatus</u>
Bittersweet nightshade	<u>Solanum dulcamera</u>
Black cherry	<u>Prunus serotina</u>
Black cottonwood	<u>Populus trichocarpa</u>
Black gum	<u>Nyssa sylvatica</u>
Black locust	<u>Robinia pseudoacacia</u>
Black mangrove	<u>Avicennia nitida</u>
Black medic	<u>Medicago lupulina</u>
Black needlerush	<u>Juncus roemerianus</u>
Black nightshade	<u>Solanum nigrum</u>
Black raspberry	<u>Rubus occidentalis</u>
Black walnut	<u>Juglans nigra</u>
Black willow	<u>Salix nigra</u>
Blackseed plantain	<u>Plantago rugeli</u>
Bladderworts	<u>Utricularia spp.</u>
Blue brush	<u>Ceanothus thryiflorus</u>
Blue elderberry	<u>Sambucus caerulea</u>
Bottlebrush	<u>Plantago arenaria</u>
Bracted plantain	<u>Plantago aristata</u>
Broadleaf arrowhead	<u>Sagittaria latifolia</u>
Broadleaf cattail	<u>Typha latifolia</u>
Broadleaf plantain	<u>Plantago major</u>
Brazilian peppertree	<u>Schinus terebinthifolius</u>
Brewer saltbush	<u>Atriplex breweri</u>
Bromegrass	<u>Bromus inermis</u>
Broomsedge	<u>Andropogon virginicus</u>
Browntop millet	<u>Panicum ramosum</u>
Buckthorn plantain	<u>Plantago lanceolata</u>
Buffaloberry	<u>Shepherdia canadensis</u>
Bull paspalum	<u>Paspalum boscianum</u>
Bulrushes	<u>Scirpus spp.</u>
Bur reed	<u>Sparganium americanum</u>
Bush lupine	<u>Lupinus albifrons</u>
Bushy beardgrass	<u>Andropogon glomeratus</u>
Buttercups	<u>Ranunculus spp.</u>
Buttonbush	<u>Cephalanthus occidentalis</u>
Buttonwood	<u>Conocarpus erecta</u>
Cabbage palm	<u>Sabal palmetto</u>
Calandrinia	<u>Calandrinia maritima</u>
California blackberry	<u>Rubus ursinus</u>
California buckthorn	<u>Rhamnus californica</u>
Calley Bermuda grass	<u>Cynodon dactylon var. Calleyi</u>
Camphorweed	<u>Heterotheca subaxillaris</u>
Canadian serviceberry	<u>Amelanchier canadensis</u>
Carolina ash	<u>Fraxinus caroliniana</u>
Carolina rose	<u>Rosa carolina</u>
Cascara buckthorn	<u>Rhamnus purshiana</u>
Cattails	<u>Typha spp.</u>

Chufa	<u>Cyperus esculentus</u>
Cherry laurel	<u>Prunus caroliniana</u>
Chickasaw plum	<u>Prunus angustifolia</u>
Coastal Bermuda grass	<u>Cynodon dactylon</u> hybrid
Coast deervetch	<u>Lotus formosissimus</u>
Common Bermuda grass	<u>Cynodon dactylon</u>
Common buckthorn	<u>Rhamnus caroliniana</u>
Common chickweed	<u>Stellaria media</u>
Common chokecherry	<u>Prunus virginiana</u>
Common deerberry	<u>Vaccinium stamineum</u>
Common filaree	<u>Erodium cicutarium</u>
Common greenbrier	<u>Smilax rotundifolia</u>
Common juniper	<u>Juniperus communis</u>
Common lambsquarters	<u>Chenopodium album</u>
Common mullein	<u>Verbascum thapsus</u>
Common purslane	<u>Portulaca oleracea</u>
Common ragweed	<u>Ambrosia artemisiifolia</u>
Common reed	<u>Phragmites australis</u>
Common spikerush	<u>Eleocharis palustris</u>
Common sweetleaf	<u>Symplocos tinctoria</u>
Common three-square	<u>Scirpus americanus</u>
Corn	<u>Zea mays</u>
Cotton	<u>Gossypium hirsutum</u>
Cow oak	<u>Quercus michauxii</u>
Cow pea	<u>Vigna sinensis</u>
Crabapple	<u>Malus angustifolia</u>
Crimson clover	<u>Trifolium incarnatum</u>
Crossvine	<u>Bignonia capreolata</u>
Croton	<u>Croton californicus</u>
Curly dock	<u>Rumex crispus</u>
Dahoon	<u>Ilex cassine</u>
Dallis grass	<u>Paspalum dilatatum</u>
Deertongue	<u>Muhlenbergia rigens</u>
Deerweed	<u>Lotus scoparius</u>
Delta duckpotato	<u>Sagittaria platyphylla</u>
Dock	<u>Rumex</u> spp.
Dotted smartweed	<u>Polygonum punctatum</u>
Downy serviceberry	<u>Amelanchier arborea</u>
Duckpotatoes	<u>Sagittaria</u> spp.
Duckweeds	<u>Lemna</u> spp.
Dwarf spikerush	<u>Eleocharis parvula</u>
Eastern cottonwood	<u>Populus deltoides</u>
Eastern hophornbeam	<u>Ostrya virginiana</u>
Eastern red cedar	<u>Juniperus virginiana</u>
Eastern white pine	<u>Pinus strobus</u>
Eel grass	<u>Zostera marina</u>
Elderberry	<u>Sambucus glauca</u>
Elderberry	<u>Sambucus callicarpa</u>
Eucalyptus	<u>Eucalyptus</u> spp.

EM 1110-2-5026  
30 Jun 87

European beach grass	<u>Ammophila arenaria</u>
European glasswort	<u>Salicornia europea</u>
Evergreen blackberry	<u>Rubus laciniatus</u>
Fall panic grass	<u>Panicum dichotomiflorum</u>
Filaree	<u>Erodium obtusifolium</u>
Fimbristylis	<u>Fimbristylis castanea</u>
Firethorn	<u>Pyracantha coccinea</u>
Flat pea	<u>Lathyrus sylvestris</u>
Flowering dogwood	<u>Cornus florida</u>
Flowering spurge	<u>Euphorbia corollata</u>
Fox grape	<u>Vitis labrusca</u>
Foxtail grasses	<u>Setaria spp.</u>
Foxtail millet	<u>Setaria italica</u>
Frankenia	<u>Frankenia grandifolia</u>
Fringed catbrier	<u>Smilax bona-nox</u>
Frog bit	<u>Limnobium spongia</u>
Frost grape	<u>Vitis vulpina</u>
Gallberry	<u>Ilex glabra</u>
Giant ragweed	<u>Ambrosia trifida</u>
Giant reed	<u>Arundo donax</u>
Glassworts	<u>Salicornia spp.</u>
Goose grass	<u>Eleusine indica</u>
Gray dogwood	<u>Cornus racemosa</u>
Green ash	<u>Fraxinus pennsylvanica</u>
Green bristlegrass	<u>Vaccinium myrsinites</u>
Groundsel tree	<u>Baccharis haminifolia</u>
Gulf cordgrass	<u>Spartina spartinae</u>
Gum plant	<u>Grindelia integrifolia</u>
Hackberry	<u>Celtis occidentalis</u>
Halberd-leaved willow	<u>Salix hastata</u>
Hairy vetch	<u>Vicia hirsuta</u>
Hardstem bulrush	<u>Scirpus acutus</u>
Hemp sesbania	<u>Sesbania exaltata</u>
Hibiscus	<u>Hibiscus mascheutos</u>
Hickories	<u>Carya spp.</u>
Highbush blueberry	<u>Vaccinium corymbosum</u>
Hollyleaf cherry	<u>Prunus ilicifolia</u>
Honeylocust	<u>Gleditsia triacanthos</u>
Honey mesquite	<u>Prosopis juliflora</u>
Hooker*s willow	<u>Salix hookeriana</u>
Hop clover	<u>Trifolium procumbens</u>
Horned pondweed	<u>Zannichellia palustris</u>
Horse nettle	<u>Solanum carolinense</u>
Horsetails	<u>Equisetum spp.</u>
Horseweed	<u>Erigeron canadensis</u>
Ice plant	<u>Mesembryanthemum crystallinum</u>
Italian ryegrass	<u>Lolium multiflorum</u>
Japanese clover	<u>Lespedeza striata</u>

Japanese honeysuckle	<u>Lonicera japonica</u>
Japanese lespedeza	<u>Lespedeza japonica</u>
Japanese millet	<u>Echinochloa crusgalli</u> hybrid
Jerusalem artichoke	<u>Helianthus tuberosus</u>
Johnson grass	<u>Sorghum halepense</u>
Jungle rice	<u>Echinochloa colonum</u>
Korean clover	<u>Lespedeza stipulacea</u>
Kudzu	<u>Pueraria lobata</u>
Ladino clover	<u>Trifolium repens latum</u>
Ladysthumb	<u>Polygonum persicaria</u>
Lanceleaf greenbrier	<u>Smilax smallii</u>
Large crabgrass	<u>Digitaria sanguinalis</u>
Laurel oak	<u>Quercus laurifolia</u>
Lespedeza	<u>Lespedeza spp.</u>
Lettuce	<u>Lactuca sativa</u>
Little hairgrass	<u>Aira praecox</u>
Live oak	<u>Quercus virginiana</u>
Lizard*s tail	<u>Saururus cernuus</u>
Lobelia	<u>Lobelia dartmanna</u>
Loblolly pine	<u>Pinus taeda</u>
Longleaf pine	<u>Pinus palustris</u>
Lotus	<u>Nelumbo lutea</u>
Low blueberry	<u>Vaccinium vacillans</u>
Lupine	<u>Lupinus polyphyllus</u>
Lyngbye*s sedge	<u>Carex lyngbyei</u>
Malta starthistle	<u>Centaurea melitensis</u>
Manna grass	<u>Glyceria acutiflora</u>
Manna grass	<u>Glyceria fluitans</u>
Mapleleaf goosefoot	<u>Chenopodium hybridum</u>
Mapleleaf viburnum	<u>Viburnum acerifolium</u>
Marsh elder	<u>Iva frutescens</u>
Marsh hibiscus	<u>Hibiscus moscheutos</u>
Marsh pea	<u>Lathyrus palustris</u>
Marsh pepper	<u>Polygonum hydropiper</u>
Marsh smartweed	<u>Polygonum hydropiperoides</u>
Maximillian*s sunflower	<u>Helianthus maximilliani</u>
Mexican tea	<u>Chenopodium ambrosioides</u>
Milletts	<u>Echinochloa spp.</u>
Mockernut hickory	<u>Carya tomentosa</u>
Mountain blackberry	<u>Rubus allegheniensis</u>
Mud plantain	<u>Plantago reniformis</u>
Multiflora rose	<u>Rosa multiflora</u>
Muscadine grape	<u>Vitis rotundifolia</u>
Musk filaree	<u>Erodium moschatum</u>
Myrtle oak	<u>Quercus myrtifolia</u>
Narrowleaf vetch	<u>Vicia angustifolia</u>
Nodding smartweed	<u>Polygonum lapathifolium</u>
Northern bayberry	<u>Myrica pennsylvanica</u>
Nutsedges	<u>Cyperus spp.</u>

EM 1110-2-5026  
30 Jun 87

Oaks	<u>Quercus</u> spp.
Oats	<u>Avena sativa</u>
Oleander	<u>Nerium oleander</u>
Olney*s three-square	<u>Scirpus olneyi</u>
Orache	<u>Atriplex patula</u>
Orchard grass	<u>Dactylis glomerata</u>
Pacific bayberry	<u>Myrica californica</u>
Pacific cordgrass	<u>Spartina pacifica</u>
Pacific dogwood	<u>Cornus nuttallii</u>
Pacific glasswort	<u>Salicornia pacifica</u>
Pacific sedge	<u>Carex obnupta</u>
Pacific wax myrtle	<u>Myrica californica</u>
Pacific willow	<u>Salix lasiandra</u>
Palmetto	<u>Serena repens</u>
Panic grasses	<u>Panicum</u> spp.
Paper mulberry	<u>Broussonetia papyrifera</u>
Partridge pea	<u>Cassia fasciculata</u>
Peach	<u>Persea</u> spp.
Peachleaf willow	<u>Salix amygdaloides</u>
Pear	<u>Persea</u> spp.
Pearl millet	<u>Pennisetum glaucum</u>
Peas	<u>Vigna</u> spp.
Pecan	<u>Carya illinoensis</u>
Pennsylvania smartweed	<u>Polygonum pensylvanicum</u>
Peppervine	<u>Ampelopsis arborea</u>
Perennial ryegrass	<u>Lolium perenne</u>
Persimmon	<u>Diospyros virginiana</u>
Pickleweeds	<u>Salicornia</u> spp.
Pignut hickory	<u>Carya glabra</u>
Poison ivy	<u>Rhus radicans</u>
Pokeberry	<u>Phytolacca americana</u>
Pondweeds	<u>Potamogeton</u> spp.
Possumhaw	<u>Ilex decidua</u>
Possumhaw viburnum	<u>Viburnum nudum</u>
Prairie cordgrass	<u>Spartina pectinata</u>
Proso millet	<u>Panicum miliaceum</u>
Prostrate knotweed	<u>Polygonum aviculare</u>
Prostrate spurge	<u>Euphorbia supina</u>
Purple loosestrife	<u>Lythrum salicaria</u>
Purple nutsedge	<u>Cyperus rotundus</u>
Purple osier willow	<u>Salix purpurea</u>
Purple vetch	<u>Vicia americanus</u>
Pussy willow	<u>Salix discolor</u>
Potatoes	<u>Solanum tuberosum</u>
Quack grass	<u>Agropyron repens</u>
Quail brush	<u>Atriplex lentiformis</u>
Red alder	<u>Alnus rubra</u>
Redbay	<u>Persea borbonia</u>
Red buckeye	<u>Aesculus parvia</u>

Red clover	<u>Trifolium pratense</u>
Red mangrove	<u>Rhizophora mangle</u>
Red maple	<u>Acer rubrum</u>
Red mulberry	<u>Morus rubra</u>
Red osier dogwood	<u>Festuca rubra</u>
Red-rooted sedge	<u>Cyperus erythrorhizos</u>
Redroot pigweed	<u>Amaranthus retroflexus</u>
Redtop	<u>Agrostis alba</u>
Reed canary grass	<u>Phalaris arundinacea</u>
Reed grass	<u>Calamagrostis canadensis</u>
Reed manna grass	<u>Glyceria grandis</u>
Rescue grass	<u>Bromus catharticus</u>
Reseeding soybean	<u>Glycine ussuriensis</u>
Rice	<u>Oryza sativa</u>
Rice cutgrass	<u>Leersia oryzoides</u>
River birch	<u>Betula nigra</u>
River bulrush	<u>Scirpus fluviatilis</u>
Riverflat hawthorn	<u>Crateagus opaca</u>
Rough-leaved dogwood	<u>Cornus drummondii</u>
Rushes	<u>Juncus spp.</u>
Russianolive	<u>Elaeagnus angustifolia</u>
Rusty blackhaw	<u>Viburnum rufidulum</u>
Rye	<u>Secale cereale</u>
Salal	<u>Gautheria shallon</u>
Salmonberry	<u>Rubus spectabilis</u>
Saltbush	<u>Atriplex polycarpa</u>
Saltcedar	<u>Tamarisk parviflora</u>
Saltgrass	<u>Distichlis spicata</u>
Saltmarsh aster	<u>Aster tenuifolius</u>
Saltmarsh bulrush	<u>Scirpus robustus</u>
Saltmarsh cattail	<u>Typha angustifolia</u>
Saltmarsh jaumea	<u>Jaumea carnosa</u>
Saltmeadow cordgrass	<u>Spartina patens</u>
Saltwort	<u>Salsola kali</u>
Sandbar willow	<u>Salix interior</u>
Sand blackberry	<u>Rubus cuneifolius</u>
Sand dropseed	<u>Sporobolus cryptandrus</u>
Sand pine	<u>Pinus clausa</u>
Sassafras	<u>Sassafras albidum</u>
Saw grass	<u>Cladium jamaicense</u>
Sawbrier	<u>Smilax glauca</u>
Sawtooth oak	<u>Quercus acutissima</u>
Schweinitz's nutsedge	<u>Cyperus schweinitzii</u>
Scotch broom	<u>Cytisus scoparius</u>
Sea blite	<u>Suaeda maritima</u>
Sea lavender	<u>Limonium carolinianum</u>
Sea lavender	<u>Limonium vulgare</u>
Sea oats	<u>Uniola paniculata</u>

EM 1110-2-5026  
30 Jun 87

Sea ox-eye	<u>Borrichia frutescens</u>
Seaside arrowgrass	<u>Triglochin maritima</u>
Seaside dock	<u>Rumex maritima</u>
Seaside goldenrod	<u>Solidago sempervirens</u>
Seaside plantain	<u>Plantago maritima</u>
Seashore bluegrass	<u>Poa macantha</u>
Seashore lupine	<u>Lupinus littoralis</u>
Seashore paspalum	<u>Paspalum vaginatum</u>
Sedges	<u>Carex spp.</u>
Sericea lespedeza	<u>Lespedeza sericea</u>
Sharp-toothed blackberry	<u>Rubus argutus</u>
Sheep sorrel	<u>Rumex acetosella</u>
Shining sumac	<u>Rhus copallina</u>
Shoal grass	<u>Halodule wrightii</u>
Shoredune panic grass	<u>Panicum amarulum</u>
Shore pine	<u>Pinus contorta</u>
Showy tick-trefoil	<u>Desmodium canadense</u>
Shrub verbena	<u>Lantana camera</u>
Silky dogwood	<u>Cornus amomum</u>
Silky willow	<u>Salix sericea</u>
Silverleaf croton	<u>Croton punctatus</u>
Sitka alder	<u>Alnus sinuata</u>
Sitka spruce	<u>Picea sitchensis</u>
Sixweeks fescue	<u>Festuca octoflora</u>
Slash pine	<u>Pinus elliottii</u>
Slough grass	<u>Beckmannia syzigachne</u>
Slough sedge	<u>Carex trichocarpa</u>
Smartweeds	<u>Polygonum spp.</u>
Smooth cordgrass	<u>Spartina alterniflora</u>
Smooth crabgrass	<u>Digitaria ischaemum</u>
Smooth sumac	<u>Rhus glabra</u>
Soft rush	<u>Juncus effusus</u>
Softstem bulrush	<u>Scirpus validus</u>
Sorghum	<u>Sorghum vulgare</u>
Southern bayberry	<u>Myrica cerifera</u>
Southern bulrush	<u>Scirpus californicus</u>
Southern cutgrass	<u>Zizaniopsis mileacea</u>
Southern dewberry	<u>Rubus trivialis</u>
Southern ragweed	<u>Ambrosia bidentata</u>
Southern red oak	<u>Quercus falcata</u>
Southern smartweed	<u>Polygonum densiflorum</u>
Soybean	<u>Glycine max</u>
Sparkleberry	<u>Vaccinium arboreum</u>
Spatterdock	<u>Nympha lutum</u>
Spikerushes	<u>Eleocharis spp.</u>
Spirodella	<u>Spirodella polyrhiza</u>
Spotted burclover	<u>Medicago arabica</u>
Spotted spurge	<u>Euphorbia maculata</u>
Sprangletop	<u>Leptochloa fascicularis</u>

Squarestem spikerush	<u>Eleocharis quadrangulata</u>
Squash	<u>Cucurbita spp.</u>
Squaw huckleberry	<u>Vaccinium stamineum</u>
Staghorn sumac	<u>Rhus typhina</u>
Sudan grass	<u>Sorghum sudanese</u>
Sugarberry	<u>Celtis laevigata</u>
Sugar maple	<u>Acer saccharum</u>
Summersweet	<u>Clethra alnifolia</u>
Sunflower	<u>Helianthus giganteus</u>
Supplejack	<u>Berchemia scandens</u>
Swamp privet	<u>Forestiera acuminata</u>
Swamp rose	<u>Rosa palustris</u>
Sweetbay	<u>Magnolia virginiana</u>
Sweet flag	<u>Acorns calamis</u>
Sweet gum	<u>Liquidambar styraciflua</u>
Switchgrass	<u>Panicum virgatum</u>
Tag alder	<u>Alnus serrulata</u>
Tall fescue	<u>Festuca arundinacea</u>
Tansy mustard	<u>Descurainia pinnata</u>
Tartarian honeysuckle	<u>Lonicera tatarica</u>
Telegraph weed	<u>Heterotheca graniflora</u>
Texas huisache	<u>Acacia smallii</u>
Texas millet	<u>Panicum texanum</u>
Thorny eleagnus	<u>Elaeagnus pungens</u>
Timothy	<u>Phleum pratense</u>
Tomato	<u>Lycopersicon esculentum</u>
Toothache tree	<u>Zanthoxylum clava-herculis</u>
Torpedo grass	<u>Panicum repens</u>
Tropic croton	<u>Croton glandulosus</u>
Tufted hairgrass	<u>Deschampsia cespitosa</u>
Tulip poplar	<u>Liriodendron tulipifera</u>
Tumbleweed	<u>Amaranthus albus</u>
Tupelo gum	<u>Nyssa aquatica</u>
Turkey oak	<u>Quercus laevis</u>
Turtle grass	<u>Thalassia testudinum</u>
Vasey grass	<u>Paspalum urvillei</u>
Virginia creeper	<u>Parthenocissus quinquefolia</u>
Virginia dropseed	<u>Sporobolus virginicus</u>
Virginia pepperweed	<u>Lepidium virginicum</u>
Walter*s millet	<u>Echinochloa walterii</u>
Water hemp	<u>Acnida cannabina</u>
Water hyssop	<u>Bacopa caroliniana</u>
Water lilies	<u>Nymphaea spp.</u>
Watermilfoils	<u>Myriophyllum spp.</u>
Water nymphs	<u>Najas spp.</u>
Water oak	<u>Quercus nigra</u>
Water plantain	<u>Plantago aquatica</u>
Water primrose	<u>Jussiaea leptocarpa</u>
Water shield	<u>Brasenia schriberi</u>



EM 1110-2-5026  
30 Jun 87

Water smartweed	<u>Polygonum amphibum</u>
Water willow	<u>Decodon verticillatus</u>
Wax myrtle	<u>Myrica cerifera</u>
Western blackberry	<u>Rubus vitifolia</u>
Western chokecherry	<u>Prunus virginiana dimissa</u>
Western dogwood	<u>Cornus occidentalis</u>
Western huckleberry	<u>Vaccinium ovatum</u>
Western ragweed	<u>Ambrosia psilostachya</u>
Wheat	<u>Triticum aestivum</u>
White ash	<u>Fraxinus americana</u>
White clover	<u>Trifolium repens</u>
White mangrove	<u>Laguncluaria racemosa</u>
White oak	<u>Quercus alba</u>
White poplar	<u>Populus alba</u>
White sweetclover	<u>Melilotus alba</u>
Widgeongrass	<u>Ruppia maritima</u>
Wild apple	<u>Malus pumila</u>
Wild bamboo	<u>Smilax auriculata</u>
Wild bean	<u>Strophostyles helvola</u>
Wild black currant	<u>Ribes americanum</u>
Wild buckwheat	<u>Polygonum convolvulus</u>
Wild celery	<u>Vallisneria americana</u>
Wild cherry	<u>Prunus emarginata</u>
Wild indigo	<u>Baptisia leucophaea</u>
Wild rice	<u>Zizania aguatica</u>
Wild rose	<u>Rosa rugosa</u>
Wild rye	<u>Elymus virginicus</u>
Wild sensitive pea	<u>Cassia nictitans</u>
Wild strawberry	<u>Fragaria virginiana</u>
Willows	<u>Salix spp.</u>
Wingscale	<u>Atriplex canescens</u>
Winterberry	<u>Ilex verticillata</u>
Witch hazel	<u>Hammamelis virginiana</u>
Wolffias	<u>Wolffia spp.</u>
Woolly croton	<u>Croton capitata</u>
Woolly indianwheat	<u>Plantago purshii</u>
Woolly panic grass	<u>Panicum lanuginosum</u>
Yaupon	<u>Ilex vomitoria</u>
Yellow bristlegrass	<u>Setaria lutescens</u>
Yellow flag	<u>Iris versicolor</u>
Yellow paloverde	<u>Centaurea solstitialis</u>
Yellow starthistle	<u>Cercidium microphyllum</u>
Yellow sweetclover	<u>Melilotus officinalis</u>

E-2. Animals.

<u>Common Name</u>	<u>Scientific Name</u>
Bait shrimp	<u>Penaeus spp.</u>
Black-necked stilt	<u>Himantopus mexicanus</u>

Black skimmer	<u>Rynchops niger</u>
Blue crab	<u>Callinectes sapidus</u>
Brown pelican	<u>Pelenacus occidentalis</u>
California grunion	<u>Leuresthes tenuis</u>
Canada goose	<u>Branta canadensis</u>
Cat (feral)	<u>Felis cattus</u>
Catfish	<u>Ictalurus spp.</u>
Cattle	<u>Bos taurus</u>
Clams	<u>Pelecypoda</u>
Clapper rail	<u>Rallus longirostris</u>
Common tern	<u>Sterna hirundo</u>
Cormorants	<u>Phalacrocorax spp.</u>
Coyote	<u>Canis latrans</u>
Crayfish	<u>Astacidae</u>
Dog (feral)	<u>Canis domesticus</u>
Dusky jawfish	<u>Opistognathus whitehursti</u>
Fiddler crab	<u>Uca pugnax</u>
Foxes	<u>Vulpes spp.</u>
Goats (feral)	<u>Capra hircus</u>
Gull-billed tern	<u>Gelochelidon nolotica</u>
Gulls	<u>Larus spp.</u>
Killdeer	<u>Charadrius vociferus</u>
Laughing gull	<u>Larus atricilla</u>
Least tern	<u>Sterna albifrons</u>
Marsh rabbit	<u>Sylvilagus spp.</u>
Minnows	<u>Cyprinidae</u>
Muskrat	<u>Ondatra zibethica</u>
Mussels	<u>Pelecypoda</u>
Nutria	<u>Myocastor coypus</u>
Oyster	<u>Crassostea virginica</u>
Peregrine falcon	<u>Falco peregrinus</u>
Prawns	<u>Palaemonidae</u>
Rabbits	<u>Syvalagus spp.</u>
Raccoon	<u>Procyon lotor</u>
Rails	<u>Rallus sp.</u>
Redfish	<u>Sebastes marinus</u>
Roseate spoonbill	<u>Ajaia ajaja</u>
Sheep	<u>Ovis aries</u>
Shrimp	<u>Penaeus spp.</u>
Striped bass	<u>Morone saxatilis</u>
Terns	<u>Sterna spp.</u>
Trout	<u>Salmo spp.</u>
White pelican	<u>Pelecanus erythrorhynchos</u>
White shrimp	<u>Penaeus setiferus</u>
White-tailed deer	<u>Odecoilus virginiana</u>

GLOSSARY

TERMS

Aesthetic improvement: Disposal site appearance improvement which makes it more pleasing and acceptable to the general public living and working around the site.

Agricultural use: The beneficial use of dredged material by the application of dewatered or slurry dredged material to farm land, for the purpose of improving the soil for farming.

Aquaculture: A term applied to any commercial aquatic farming operation for freshwater or saltwater organisms such as crayfish, shrimp, or catfish. See Mariculture.

Aquatic habitat: Typical submerged communities extending from near sea, river, or lake level down several feet, such as tidal flats, oyster beds, clam flats, seagrass beds, or fishing reefs.

Atterburg liquid limit: A standard measure used in the Unified Soil Classification System (USCS) soil classifications which must be made in order to determine plasticity, or weight-bearing ability, of soil or dredged material.

Avian habitat: Any area that meets all or part of the life requirements of birds, a very large and wide-ranging group of species with a variety of habitat requirements.

Beach: The open, sandy habitat occurring between a body of water and upland areas that is not colonized by marsh or woody vegetation.

Beach biota: All living organisms which occupy the intertidal and dune zones of sandy beaches.

Beach nourishment: The practice of hydraulically pumping clean, sandy sediment onto an eroded beach for the purpose of restoration.

Beneficial uses: All productive and positive uses of dredged material, which cover broad use categories ranging from fish and wildlife habitat development, to human recreation, to industrial/commercial uses.

Biological calendar: The life cycle of any living organism, especially pertaining to any critical area requirements where a species is more vulnerable than at other times during the life cycle.

Biochemical oxygen demand (BOD): The amount of oxygen required during the aerobic decomposition of organic matter in a body of water. High BOD usually indicates large amounts of organic material.

EM 1110-2-5026  
30 Jun 87

Borrow material: Soil or sediment taken from a site for use in structure construction, such as sandy sediment dredged and pumped to restore an eroded beach, or clay taken to build a levee or dike.

Borrow pit: The term used to describe the site remaining after borrow material has been removed. In upland areas, the site frequently becomes a body of water. In marine areas, the site becomes a deep hole in a bay or near-shore area.

Bottomland hardwoods: Deciduous forests of dominant tree species which occur on soils that are moisture-saturated or inundated during a portion of the growing season. These forests are in serious decline due primarily to agricultural land clearing and flood control.

Breeding season: The period of time used by a living organism for mating, nesting or denning, rearing of young, and other activities related to reproduction.

Bulk density: An indicator of size and arrangement of various soil particles, and the weight measurement by which the entire soil volume is considered.

Carrying capacity, ecological: The ability of a given habitat or ecosystem to perpetually sustain stable populations of living organisms.

Carrying capacity, recreational: The ability of a given recreational site to sustain planned levels of human recreational use without environmental damage.

Cation exchange capacity (CEC): The capacity of soil or dredged material particulates to adsorb nutrients which then become available for plant growth.

Chemical oxygen demand (COD): The amount of oxygen required to oxidize organic chemical compounds and oxidizable inorganic compounds in a body of water. These chemicals rapidly oxidize, requiring great quantities of oxygen.

Chlorinated hydrocarbons: Polychlorinated biphenyls (PCBs) and similar compounds which can be harmful to living organisms, and which can sometimes be found in certain dredged material substrates, especially in urban areas and especially in fine-grained material.

Clam flat: Any aquatic habitat, both natural and man-made, occupied by colonies of clams, including those occurring in shellfish farming operations.

Clay: That fraction of soil or dredged material whose grain size distribution is 0.002 mm or less, generally referred to as fine-grained material.

Colonial-nesting: A term used to describe the habit of numerous bird species, especially waterbirds, of nesting in large groups, often with nests only 1 to 2 feet apart.

Colonies: Large groups of breeding birds that habitually nest together for protection and sociability, either in single species groups, such as least terns, or in mixed species groups, such as herons, egrets, and ibises.

Confined disposal facility (CDF): A term used to describe a disposal site structure built to hold dredged material in a totally confined condition. Often CDFs are built to permanently hold contaminated sediments.

Consolidation: A term used to describe the effect caused by dewatering and desiccation of dredged material substrates, usually resulting in significant lessening of volume of the material.

Consumptive use: A term usually used in reference to hunting and fishing on a site, in which a product (fish or wildlife) is obtained by the site user.

Contaminants: Heavy metals, oil and grease, chlorinated compounds, excess nutrient loads, and other substances found in dredged material that can be toxic to living organisms under certain environmental conditions.

Containment area: Any site used for the temporary or permanent confinement of dredged material, and which may or may not have a permanent retaining structure.

Contour benching: The soil conservation practice of building soil benches or terraces along natural or man-made contour lines on erodible slopes.

Contour farming: The agronomic practice of planting erodible slopes along natural or man-made contour benches in alternating and rotating strips of grass cover and row crops.

Coral reef: A fragile, living, marine structure made up of a number of species of coral organisms that occurs in tropical waters of the earth. In the United States, coral reefs only occur off the coasts of Florida, Hawaii, and Puerto Rico.

Creche: The term used for groups of chicks of some seabird species that form when the chicks leave their nests at a few days of age and congregate.

Critical habitat: Any habitat officially designated or generally accepted as essential to any or all life requirements of an endangered or threatened plant or animal.

Crop rotation: The agronomic practice of rotating grass cover and row crops from year to year to improve soil fertility and prevent erosion.

Crops, food: Agricultural and horticultural crops planted as food sources for humans, domestic livestock, and wildlife, and which can sometimes be grown on dredged material substrates.

EM 1110-2-5026  
30 Jun 87

Crops, nonfood: Horticultural and forestry crops planted for use by humans but not as food, such as timber, paper products, sod, and Christmas trees, and which can sometimes be grown on dredged material substrates.

Cross dike: A dike structure built within and across a CDF, usually for the purpose of compartmentalizing the CDF for incremental dredging.

Desiccation cracks: The phenomenon which occurs on fine-grained dredged material or deposited river sediment in which large cracks form as the material dewateres and consolidates.

Dewatering: The practice of actively or passively removing water from dredged material inside disposal sites.

Dike: An engineering structure built for the purpose of retaining dredged material or training sediments.

Disposal alternative: Any method of disposal and dredged material use that is proposed by the CE, one of which will be found to be acceptable to the CE, sponsors, resource agencies, and the public.

Disposal site: Any area, confined or unconfined, that is used for the deposition of dredged material.

Dissolved oxygen (DO): Oxygen molecules dissolved into bodies of water that are necessary for the respiration of most aquatic organisms. High concentrations of DO are usually present in free-flowing, tumbling water, but can be provided artificially in fish farms by special aerator pumps.

Diversion channels: The practice of building ditches or channels to divert rainwater and snowmelt on erodible slopes and soils.

Dragline trenching: The practice of dewatering dredged material by making trenches inside disposal sites with dragline equipment.

Dredged material: Any sediment under a body of water which is dredged by any method and displaced or removed to a disposal location.

Dredging window: That period of time when it is environmentally safe to dredge and deposit dredged material in an area occupied by species of concern, such as in the nonbreeding season in areas with important waterbird colonies or nonspawning season for locally important fish species.

Ecological stage: A specific period of growth or development of an ecological community; i.e., grassland is an intermediate stage in the developmental process of a new disposal site that will ultimately become a forest. See Ecological Succession.

Ecological succession: The progression of a site from early growth stages to climax; i.e., on a new, coastal dredged material island the stages of succession over time are: bare ground, sparse herbaceous cover, dense herbaceous cover, shrub/grasses, shrub/trees, and finally, maritime forest.

Effluent quality: The measure of quality of water coming over the weir in a confined dredged material disposal site during and after a disposal operation.

Endangered species: Plant or animal species of such limited and declining populations that they have been legally placed on a Federal or state Endangered Species List. Federally listed species and their needs are published in the Federal Register. Species that decline to the endangered status usually do so as a result of degradation or destruction of habitat.

Environmental legislation: Federal and state laws enacted to reestablish and maintain environmental quality in the United States. Many apply directly and indirectly to dredging activities.

Equipment accessibility: On disposal sites, this term refers to the ability of heavy equipment to economically and efficiently travel to and work in disposal sites and handle dredged material.

Erodible slopes: Slopes of more than 3 feet per 100 feet that, when bare of vegetative cover are highly erosive, especially those primarily made of silt and silty clay soils.

Erosion: The removal of soil or rock (or dredged material) by precipitation, wind, or wave action, resulting in site degradation or destruction.

Feral animal: Any domestic animal such as a dog or cat that has gone wild or that was born to wild parents, survives by its own resources, and is no longer or has never been a pet or domesticated.

Fill material (construction): In this case, soil or dewatered dredged material used as foundation material in upland areas for any structure from roads to buildings to landfill.

Fill material (Section 404): Any material used to replace an aquatic area with upland, or for changing the bottom elevation of a water body.

Fish farm: The commercial production of several species of fish or shellfish (catfish, trout, red fish, shrimp, crayfish, and others) in carefully maintained, man-made ponds or in protected, maintained natural coastal bays.

Fishing reef: Any underwater structure, natural or man-made, which changes the bottom topography and offers cover, food, and protection to fish and other aquatic organisms.

EM 1110-2-5026  
30 Jun 87

Fish nursery areas: Natural or man-made shallow water and marshy areas where small fish and fry can feed and find cover from predators.

Floating pipeline: A dredged material discharge pipeline that is supported in water and in marsh by floats which prevent its sinking into the substrate during a dredging operation.

Floating tire breakwater: A temporary, floating structure made of foam-filled vehicle rubber tires. These form modules that are erected and anchored in moderate wave energy areas to protect the shoreline and marsh plants establishing behind the breakwater.

Floodplain islands: Natural or man-made islands occurring within the floodplain of a river or lake, including those within the body of water and those which only become islands at high water stages.

Forestry use: The beneficial use of dredged material sites for the production of timber and timber products such as cottonwood or eucalyptus tree plantations.

Foundation qualities: The physical, chemical, and biological condition of the dredged material substrate which makes it suitable or unsuitable for beneficial uses, whether for building structures or for nonstructural use.

Freshwater marsh: Periodically inundated herbaceous vegetation community occurring in streams, lakes, and perched wetlands (salinity is near 0 ppt).

Gabions: Wire baskets filled with coarse rock material which are used with filter cloths as temporary retention or breakwater structures.

Game mammal: Any mammal species hunted by gun, archery, or trapping, and that has a legal harvest season designated for the species.

Gas vents: Vents purposely placed in solid waste landfills to direct the flow of built-up gas from decaying garbage to the atmosphere where it can dissipate.

Grassed waterways: The practice of conserving soil on runoff ditches on slopes by gently sloping the ditch sides and perpetually maintaining them in mowed grass to trap sediment and stop erosion.

Grazing area: Any land used for domestic livestock pasture. In this case, dredged material disposal areas that have been developed into pastureland.

Green manure: Legume or grass crops which are grown solely for fertilizer and while still in active growth are turned into the topsoil layer with a plow or disk to provide texture and nutrients to the top soil.



Habitat development: The construction and maintenance of a habitat for wildlife, finfish, and/or shellfish. In this case, refers to the creation of fish and wildlife habitat on dredged material disposal sites.

Habitat diversity: The occurrence within one ecosystem of several types of wildlife or fisheries habitat; i.e., on large dredged material islands, maritime forest, shrub communities, grass/herbaceous areas, bare ground, and marsh may all occur on different parts of the island simultaneously.

Habitat management: Deliberate and wise actions taken on dredged material disposal sites for the purpose of managing for plant or animal populations or communities or for target wildlife or fish species.

Habitat manipulation: Deliberate use of dredged material deposition to maintain a particular stage of ecological succession. Generally, such manipulation is used to maintain bare ground or very early stages.

Habitat patterning: The natural or deliberate positioning of different habitats in an ecosystem to provide diversity for the target wildlife or fish species.

Habitat protection: Deliberate and prudent posting, patrolling, fencing, or guarding of dredged material disposal sites to protect a fish or wildlife population and habitat from predators and excessive human intrusion.

Heavy metals: Metals which have been proven to be hazardous to living organisms ingesting them in sufficient quantities; generally, cadmium, nickel, lead, zinc, copper, mercury, chromium, and others.

Herbaceous vegetation: Plants without woody stems such as grasses, most legumes, forbs, and wildflowers (annuals or perennials).

Herbicides: Chemical compounds developed and used for the control or destruction of undesirable vegetation. They are often highly selective and specifically developed for target plant species.

Historic preservation: The protection from destruction and the maintenance of historic sites, such as Indian mounds in the Mississippi River floodplain or colonial archaeological sites on coastal islands.

Horticulture use: The beneficial use of dredged material disposal sites as nursery or orchard sites, or of dewatered dredged material as an ingredient in potting or plant bed soil mixtures.

Hydraulic pipeline: A dredged material discharge pipeline that carries slurry material from the dredging site to the disposal site. It may be floating or positioned on land, and may be movable or stationary.

EM 1110-2-5026  
30 Jun 87

Incremental dredging: The deposition of dredged material in a disposal site in small lifts over an extended period of time.

Industrial/commercial use: The beneficial use of dredged material for port, harbor, airport, building, or other industrial and commercial enterprise construction.

Inoculated seeds or rootstock: Seeds or roots exposed to beneficial fungi or other soil organisms that enhance the growth and survival of the plants. These mycorrhizal organisms aid in nutrient uptake and in root protection from toxic and saline soils.

Intermittent dredging: The shutting on and off of a dredging operation on a scheduled basis (i.e., 1 hour on/1 hour off) to allow settling to occur and effluent water to move at a slower rate.

Intertidal zone: That land area between mean low water and mean high water that is inundated periodically by tides.

Island: An upland habitat distinguished by its isolation and use, and completely surrounded by water or wetlands. Often, islands are fringed with or include interior wetland habitats.

Land enhancement: The improvement in use, quality, and value of land through habitat management, manipulation, and/or protection.

Land use: The use, beneficial or otherwise, of a specific land parcel. In this case, the planned or actual land use of dredged material disposal sites.

Land use control: The legal jurisdiction and ownership or lessee rights to control the use of a specific land parcel. In this case, the CE's rights of control of disposal sites.

Leachate drain: Layers of pervious material such as sand or gravel placed to intercept leachate on a disposal site or solid waste landfill and drain it to an area for treatment or recirculation.

Leaching: The percolation of nutrients and other compounds such as salt within the top layers of soil into subsoil layers and ground-water zones.

Legume: Any member of the Legumaceae family, typically having the important ability to fix and use atmospheric nitrogen to enhance plant growth and survival. Clovers, lespedezas, and acacias are excellent examples.

Levees: Earthen structures built to contain periodic floodwater in river systems within specific areas of the floodplain.

Lifts: A term describing deposits of dredged material into containment facilities. Each lift generally is allowed to dewater before another lift is deposited.

Limiting factor: Any physical, chemical, or biological factor which is the critical limitation on growth and survival of an organism; i.e., smooth cord-grass is limited in its growth by the boundaries of the intertidal zone.

Liners and barriers (leachate control): Physical structures or cloths used to seal off disposal areas to prevent translocation of contaminants into lower level of adjacent soil and ground or surface water.

Liner shrubs: Small, potted and rooted shrub cuttings generally not more than 2 years of age that are developed for commercial and landscaping sales. (Larger, older shrubs are usually called container stock.) In this case, liner shrubs that can be grown in a soil/dredged material mix, or that can be planted on disposal sites for purposes of habitat or recreational use.

Long-range project goals: Project goals which extend over a period of not less than 10 and up to 50 years, especially as they pertain to ultimate land use of disposal sites.

Long-term management plans: Engineering and environmental management plans developed for disposal sites or dredging reaches that have at least a 10-year and not more than a 50-year life.

Low maintenance habitat: Habitat that requires almost no labor-intensive management activities such as mowing or protection and that, once developed, is generally allowed to progress at its own pace.

Low wave energy: Wave action with tidal ranges averaging not more than 1 to 2 feet, in areas naturally or artificially protected from wind fetches and ship traffic.

Maintenance dredging: The cyclic dredging of the same area over a period of time to remove accumulating sediments and to maintain ship and barge traffic.

Manmade habitat: Any habitat that was deliberately created by humans, i.e., a saltmarsh built of dredged material.

Manmade island: Any island that was deliberately created by humans, generally only referring to those built by the CE of hydraulically pumped dredged material.

Marginal soil: Any soil that by virtue of its physical and chemical characteristics is not suitable for development for crops or other beneficial uses. In actuality these soils are often developed by landowners anyway, and are further degraded, depleted, and eroded.

EM 1110-2-5026  
30 Jun 87

Mariculture: The practice of growing in commercial enterprises marine crops of shrimp, oysters, squid, clams, red fish, and other sea animals that are high-consumption species (by humans). Mariculture is practiced more in Japan and other Asian countries than in the United States.

Maritime forest: A coastal forest generally consisting of wax myrtle, groundsel tree, live oak, and other species tolerant of near-constant sea breezes and occasional salt spray.

Material rehandling: The requirement of handling dredged material more than one time, such as with booster pumps, hopper barges, or as dewatered and stockpiled material.

Mean high water (mhw): Mean high water is the highest level of inundation under normal conditions to which the tide flows over the land.

Mean low water (mlw): Mean low water is the lowest level under normal conditions to which the tide drops in the tidal cycle.

Migratory species: All bird species which make semiannual migrations and who are protected by the U.S. Migratory Bird Treaty Act and its amendments. Also, all fish species which migrate for spawning or other purposes into and out of waters of the United States. (No mammals within U.S. areas where dredging occurs are migratory.)

Mine spoils: The material removed and/or processed in the mining of a site that is left behind as the mining operation moves forward to unmined areas.

Mitigation: The replacement or substitution of a habitat in repayment for habitat that has been degraded or destroyed. Generally, mitigation is habitat replacement-in-kind, but this is not always the case.

Moderate wave energy: Wave action with tidal ranges of 2 or more feet in unprotected areas, but with waves that are not normally severe or extremely forceful upon impact.

Monitoring: The process of collecting (before, during, and after disposal) physical, chemical, and environmental data to determine impacts of a particular dredging and dredged material disposal operation.

Monoplanting: Plantings of only one species on a site, i.e., cottonwood tree plantations, smooth cordgrass saltmarshes, or agronomic crops in large fields.

Multiple-head discharge pipe: A discharge pipe with more than one head or more than one opening on the same head to allow better spreading and distribution of dredged material. This type of pipe is not used except in low-flow discharges.

Multipurpose use: More than one beneficial use of the same dredged material disposal site.

Natural colonization: The habitation by natural invasion of any site by generally highly adaptable and opportunistic species, i.e., smartweeds colonizing a newly exposed mudflat in a lake, river, or reservoir.

Nesting beaches: Sand beaches in tropical areas used by sea turtle females for digging nests and laying eggs. Increasing use by humans of nesting beaches makes these endangered species increasingly vulnerable to loss of eggs and young. Beaches are also used by certain seabird species for nesting, for example, the endangered California least tern.

Nesting island: Any island, natural or manmade, which is used by colonial-nesting birds as breeding habitat.

Nesting substrate: Any foundation used for supporting nests, i.e., trees for wading birds; bare sand for terns and skimmers; sparse grass for gulls; wet marshy mounds for rails, loons, grebes, and others; and grassy meadows for ducks, geese, and swans.

New work dredging: Dredging in an area that has not previously been dredged, and which often includes clay bottom or bedrock material.

Nonconsumptive use: Use activities of disposal sites which do not harvest or destroy animals or plants on the site, i.e., bird watching, hiking, jogging, or bike riding.

Nongame species: Any animal species that is not legally hunted or trapped.

Nonmotile benthos: Benthic organisms occurring both in the intertidal zone and in deeper water that cannot move out of the way of dredging operations and that are severely or fatally impacted by dredging.

Nutrient load: The level of nutrients, primarily nitrogen, phosphorus, and potassium, in soil or dredged material usually caused by agricultural runoff from fertilized fields. Excess nutrient loads can occasionally cause detrimental effects in disposal sites, especially in ponded areas.

Nylon fabric sandbags: Large-capacity (4 by 8 feet) bags made of woven nylon, which are hydraulically filled in place with sand, and which are used as temporary breakwaters in moderate wave energy environments.

Ocean dumping: The practice of dredged material disposal via oceangoing barge into a designated disposal site in deep, open water, often miles from shore.

One-time dredging: The placement of dredged material into a disposal site only once; then the site is converted to other use.

EM 1110-2-5026  
30 Jun 87

Open-water disposal: The practice of dredged material disposal anywhere into open water; i.e., in the Lower Mississippi River above Head of Passes almost all dredged material is sidecast into open water to allow it to remain in suspension and move downriver.

Oyster bed: Any foundation used by oysters as a place of attachment to grow and complete their life cycles, i.e., rocks, submerged boats, or old oyster shells in shallow water.

Permeability: The ease with which water can move or pass through a soil or dredged material.

pH: The standard measure of 0.0 to 14.0 of acidity and alkalinity of soil, water, and other liquids. A pH of 7.0 is neutral, and uncontaminated rainfall is generally 6.0 to 7.0. A pH of 5.5 to 7.5 is the range generally found best for plant and animal growth.

Planktonic larva: Floating or weakly swimming and often microscopic aquatic juvenile forms of organisms such as coral or shellfish.

Plant material: Any plant growing on a site or intended for growth on a site can be referred to as plant material.

Plant nursery: A commercial or public enterprise where plants are propagated and grown for sale or for public use sites. Public plant nurseries are generally those of the U.S. Forest Service and the U.S. Soil Conservation Service.

Plant propagation: The planting and growth of plants, which includes obtaining and maintaining propagules; preparing the site; planting, fertilizing and making soil amendments; and cultivating the site.

Plasticity: A measure, obtained by calculating the Atterburg liquid limit and the plasticity limit, which determines the use and load-bearing ability of a fine-grained soil or dredged material.

Ponding: The collection of water by gravity flow on any site. In this case, a disposal site which may hold ponded water due to consolidation or improper weir placement, or purposely for beneficial uses such as aquaculture.

Problem soil: Any soil (or dredged material) that is not suitable for beneficial use due to soil physical or chemical conditions or engineering properties.

Progressive trenching: The progressive deepening of surface drainage ditches lower than the base of crust desiccation cracks on fine-grained dredged material as the water table falls.

Propagules: Any piece of plant material that will form a new plant, i.e., seeds, tubers, transplant sprigs, rhizomes, corms, bulbs, and cuttings.

Rare or threatened species: Plant or animal species of declining populations that have not reached the threshold of being considered endangered to the point of extinction.

Reclamation: The process of restoring and revegetating a disturbed site to or near its previous habitat quality.

Recreation use: The beneficial use of a dredged material disposal site for recreation, including camping, boating, swimming, picnicking, hiking, and other recreational activities.

Remote sensing: In this case, the use of high-intensity, infrared aerial photography for habitat mapping, plant community identification, and broad-scale planning.

Retaining structure: A temporary or permanent structure used for holding dredged material on a limited basis, not to be confused with a CDF.

Revegetation: The process of reestablishing vegetation cover on any disturbed or newly formed site through a variety of methods.

Riverine environment: The river island, on-bank, and near-bank plant and animal community within a floodplain.

Riverine Utility Craft (RUC): A specially developed craft for use in water and soft mud whose flotation is provided by twin styrofoam-filled rotors which make trenches that are useful in dewatering fine-grained dredged material. The RUC does not work well in coarse-grained material.

Rotating disposal pipe: A disposal pipe that has a swinging discharge head to allow dredged material to be placed over a wider area. This pipe is only for low-flow discharge and can be used to help maintain an intertidal elevation for marsh creation.

Salinity: The measure of soluble salts in soil or water (or dredged material) which make it suitable or unsuitable for particular beneficial uses.

Saltmarsh: Herbaceous vegetation growing at a saline intertidal elevation. Primary U.S. saltmarsh species at mean low water are smooth cordgrass on the east and gulf coasts and Pacific cordgrass on the west coast.

Sanctuary: Any area totally and legally protecting designated plant or animal species, for example, dredged material islands which have been designated waterbird sanctuaries.

EM 1110-2-5026  
30 Jun 87

Sand: That fraction of soil or dredged material whose grain size distribution is 2.00 to 0.05 mm, generally referred to as coarse grained.

Sandbar: A natural or man-made bare sand area within the channel of a river, either attached to the bank or in midstream.

Sand dike: A temporary dike structure made chiefly of sand and often emplaced via hydraulic dredging of sandy underwater deposits.

Scour: Physical forces exerted by intense underwater currents which cause digging out of substrates around in-water structures and along shorelines.

Seabirds: A group of birds which live around and over large bodies of water. In the United States, they live primarily in coastal bays, oceans, estuaries, large rivers, the Great Lakes, and the Great Salt Lake, and include gull, tern, and skimmer species.

Seagrass bed: A fragile, shallow, underwater marine ecosystem colonized by eel grass, turtle grass, shoal grass, and other marine plant species. These species are very specific in their requirements for nonturbid, clean, open water and can be greatly impacted by dredging.

Sea turtles: Extremely vulnerable, endangered or threatened, motile vertebrate marine animals whose nesting seasons and movements can conflict with dredging operations.

Sediment: Any soil material that has washed or blown into a body of water and settled to the floor to become a part of the substrate.

Sedimentation: The process of deposition of sediment in water through settling out of heavier coarse-grained particles. This term also refers to the deposition of alluvial sediment in a floodplain at river flood stage.

Seedbed preparation: The clearing, plowing, disking, and cultivation of a soil or dredged material to prepare it for seeding.

Seed farm: A farm used for the commercial production of seeds, generally associated with agronomic crops such as food grains and soybeans, but also including flower and vegetable seed production.

Seed mixture: A general mixture of locally acclimated seeds of several grass and legume species (usually at least three but not more than eight to ten) for planting in sites to become natural areas and grazing meadows.

Self-weight consolidation: Consolidation caused by the actual weight of the dredged material placed inside the disposal site, which forces water out of the material and to the surface or into underdrainage systems.



Shear strength: That point and beyond at which a dredged material substrate begins to consolidate and develop strength as a soil material after leaving the slurry state.

Ship-generated waves: Waves that are a direct result of ship traffic rather than wind or tidally influenced, and that are often severe on shorelines for a short period after ship or barge passage.

Shoreline stabilization: The erosion protection of shorelines by engineering structures such as riprap or by biological features such as saltmarshes or willow banks.

Silt: The fraction of soil or dredged material whose grain size distribution is 0.05 to 0.002 mm, generally referred to as fine grained.

Silt curtain: A floating fabric curtain device suspended around a dredging operation or disposal site to prevent rapid movement of suspended sediment out of the area.

Site maintenance: The care and management of disposal sites to accomplish the planned project and site goals.

Site specific: Rigid environmental and physical conditions which pertain to development and management of a particular site.

Site suitability, biological: The biological conditions of soil, substrate, and surrounding area which limit or enhance a dredged material site for beneficial uses. Such factors are size, distance to point of disturbance, water depth, vegetation stage, existing biological resources, presence or absence of a dike, and others.

Site suitability, chemical: The chemical conditions of the substrate and soil which limit or enhance a dredged material site for beneficial uses. This includes nutrient levels, sulfur, heavy metals, pesticide compounds, salinity, oil and grease, and others.

Site suitability, physical: The physical conditions of soil, substrate, slope, wave action, climate, water, stages, etc., that limit or enhance a dredged material site for beneficial uses.

Site suitability, socioeconomic: The social and economic conditions which limit or enhance a dredged material site for beneficial uses.

Site topography: On disposal sites, the various elevations, hills and mounds, and ponded areas achieved by the position of the disposal pipe. Topography can be altered by mechanical means for beneficial uses.

Slurry: A term describing the mixture of soil or sediment and water hydraulically dredged and pumped to a disposal site.

EM 1110-2-5026  
30 Jun 87

Socioeconomic benefits: The positive benefits to a community where a disposal site is located in terms of dollars returned to the community in jobs, recreational use, and general improvement of public perception and well-being.

Socioeconomic considerations: Social and economic conditions and opinions which must be evaluated for any project to determine project feasibility and cost:benefit ratios, as well as the project good to the community.

Sod farm: The commercial production and sale of sod blocks, usually of lawn and golf course grasses such as Tifgreen and Zoysia. In this case, sod growing on dredged material as a beneficial use.

Soil amendment: Fertilizers, lime, mulches, and any material added to the soil or dredged material to improve its quality for beneficial uses.

Solid waste landfill: Any area, usually associated with urban communities, where disposal of human refuse and garbage takes place. The waste is capped daily with at least 6 inches of soil (or dewatered dredged material).

Soluble salts: The fraction of salts in a moist soil (or dredged material) which becomes available to plants for adsorption.

Spawning season: The particular biological time in which mating and egg-laying occurs in fish species.

Species: A taxonomic designation assigned to a distinct group of plants or animals which can only breed with another like organism, and which is usually characterized by individual differences from any other species.

Species specific: Rigid environmental and physical conditions which pertain to development and maintenance of habitat for a particular species.

Sport fishery: A term which applies to fishing areas with sustainable populations of certain species of game fish.

Spur dike: A partial dike built within a CDF for purposes of directing and slowing flow of the slurry within the site to allow more sedimentation to occur before the slurry reaches the weir outlet.

Stockpiling: The practice of placing dewatered dredged material in a holding area, where it is slated for future beneficial uses.

Striking off: The method used in strip mine reclamation or dewatered dredged material spreading in which the disposal ridges are knocked into the valleys between those ridges, thereby leveling the site.

Strip-cropping: The agronomic practice of alternating a row crop with a grass or legume cover crop or a fallow strip to conserve soil and improve soil texture.

Strip mine reclamation: The grading, shaping, and revegetating of strip-mined soil to regain lost habitat and to prevent erosion and downstream toxicity problems.

Subsidence: An elevational change caused by the inability of foundation material to hold up the load placed on it by dredged material or natural deposition, for example, the Louisiana coastal marshes where subsidence is occurring at a very rapid rate.

Substrate: The foundation upon which all things exist; for example, the soil is a substrate supporting plants, animals, buildings, and other structures; trees are the substrate in which birds build nests; the bay bottom is the substrate supporting benthic communities.

Suspended solids: Soil particles and organic matter which remain suspended in the water column after agitation from dredging, or during movement downstream in river systems.

Swamp: A periodically inundated wooded area occurring in the southern United States, generally dominated by forest trees such as bald cypress and/or tupelo gum.

Target species: A desired species or group of species toward which habitat development and management are directed.

Temporary breakwater: A structure with a design life of 1 to 5 years erected for the purposes of slowing down or preventing wave action and for protection of the area behind the breakwater.

Terraces: A low earth structure created on farms and erodible land where steep slopes exist to conserve soil and aid in rainfall adsorption.

Tidal flat: An intertidal area exposed at low tide on which no marsh grows, usually called a mudflat. Tidal flats are often colonized by high numbers of small benthic organisms which are fed upon by a variety of other species such as shorebirds.

Tidal range: The ebb and flow over land between mean low water and mean high water where tide water is periodically present.

Tolerance level: That point at which a living organism can no longer survive a chronic or short-term environmental, physical, or chemical condition, such as a toxicity of heavy metals or pesticide compounds or extreme turbidity.

Toxicity: A term describing the limit of intolerance of organisms to survive lethal chronic or short-term subjection to certain chemical and contaminating substances, or physical and environmental conditions.

EM 1110-2-5026  
30 Jun 87

Transplant: The most common type of propagule used in wetland habitat development and in landscaping work; this term applies to a well-rooted, vegetative propagule of several stems or a single strong stem.

Transport: Any method used for the transportation of dredged material, usually by hydraulic pipeline or barge, or if dewatered, by barge, truck, or railroad.

Tree farm: A farm used only to grow trees of economically important species, such as cottonwoods or pine plantations for timber and paper, or firs and spruces for Christmas trees.

Truck farm: A farm used for the production of vegetables, some types of cut flowers, and some types of vine products and fruits, which are commercially marketed.

Turbidity: A condition in bodies of water where high sediment loads cause clouding of the water to varying extents. In the case of feeding animals, turbidity limits visual feeding. It also will shade out or smother aquatic vegetation.

Unconfined disposal site: Any dredged material disposal site where the material is not placed behind a retaining structure but is allowed to flow freely out of the disposal site.

Underdrainage dewatering: A method of dewatering dredged material disposal areas, where drainage materials such as sand or gravel layers or tiles are permanently emplaced before any dredged material is deposited.

Uplands: Any terrestrial community characterized by vegetation not usually tolerant of inundation, ranging from bare ground to mature forest.

Value methodology: Determination of potential socioeconomic benefits of dredged material sites by use of a matrix which categorizes and describes the effects and impacts.

Vegetation: Plants of all species and families, rooted, attached, or floating, deciduous or evergreen, woody or herbaceous, commercial or noncommercial. In this case, referring to any plant growing on dredged material or affected by dredging and dredged material placement.

Vegetation control: The practice of managing vegetation to maintain certain stages of growth through mechanical, biological, or chemical methods.

Waterbirds: A diverse group of birds recognized by scientists according to their colonial-nesting habits and their feeding in water; the group can be further refined into wading birds, diving birds, and seabirds.

Waterfowl: A group of birds which includes ducks, geese, and swans. (No swan can be legally hunted in North America.)

Water retention: The moisture-storing capacity of a soil or dredged material that is strongly influenced by the arrangement and quantity of fine particles and organic matter.

Weir: One type of outfall structure built into the dike of a CDF at the farthest point from the discharge pipe.

Weir placement: The location of the weir in a CDF for the best possible drainage of ponded water and for the longest distance for slurry travel from the discharge pipe to allow more dropout of sediment.

Wetland: Periodically inundated communities characterized by vegetation which survives in wet soils, ranging from coastal intertidal marshes to freshwater swamps and bottomland hardwoods. These areas usually have quite distinctive vegetation communities.

Wildlife: Any animal species or group of animals that range free and are not normally commercially produced for human food or use; includes both game and nongame species.

Wind fetch: A term used to describe the open area and distance across a bay or body of water in which wind can exert energy on waves to cause them to be higher and more forceful upon impact with shorelines.

Wind waves: Waves caused by wind action, especially across shallow bays with long wind fetches.

Wooded wetland: A wetland that is dominated by trees and shrubs, and includes swamps, bottomland hardwoods, and wooded bogs.