

TA7  
W34  
no.  
D-90-3  
c.2

US Army Corps  
of Engineers

# ENVIRONMENTAL EFFECTS OF DREDGING PROGRAMS

TECHNICAL REPORT D-90-3

## BENEFICIAL USES OF DREDGED MATERIAL

PROCEEDINGS OF THE GULF COAST  
REGIONAL WORKSHOP

26-28 APRIL 1988, GALVESTON, TEXAS

Robert L. Lazor, Editor

Environmental Laboratory

DEPARTMENT OF THE ARMY

Waterways Experiment Station, Corps of Engineers  
3909 Halls Ferry Road, Vicksburg, Mississippi 39180-6199

and

Richard Medina, Editor

DEPARTMENT OF THE ARMY

US Army Engineer District, Galveston  
PO Box 1229, Galveston, Texas 77553-1229



February 1990

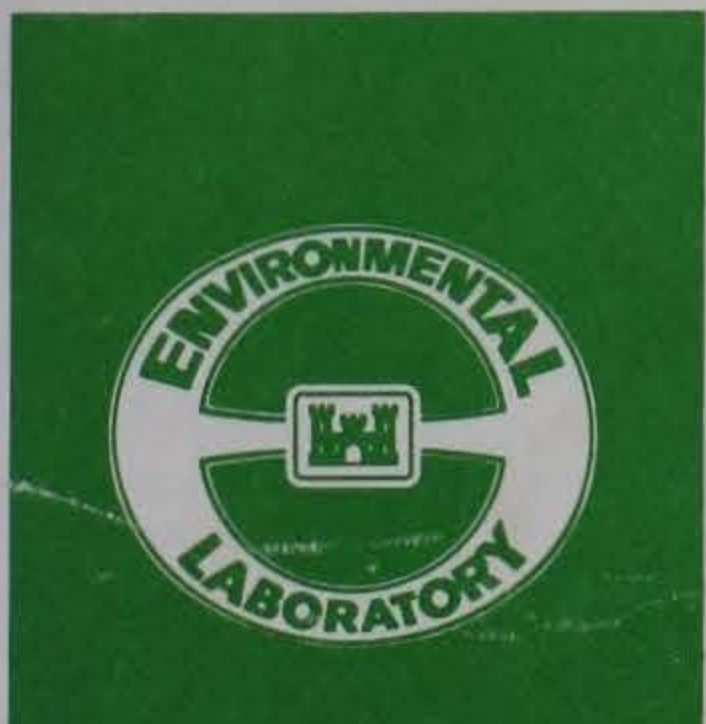
Final Report

Approved For Public Release; Distribution Unlimited

Prepared for DEPARTMENT OF THE ARMY  
US Army Corps of Engineers  
Washington, DC 20314-1000

and

US Army Engineer District, Galveston  
Galveston, Texas 77553-1229



US-CE-C Property of the  
United States Government

RESEARCH LIBRARY  
US ARMY ENGINEER WATERWAYS  
EXPERIMENT STATION  
VICKSBURG, MISSISSIPPI

21268761

TAT  
W34  
no. 12-90-3  
c. 2

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE

REPORT DOCUMENTATION PAGE				Form Approved OMB No. 0704-0188	
1a. REPORT SECURITY CLASSIFICATION Unclassified		1b. RESTRICTIVE MARKINGS			
2a. SECURITY CLASSIFICATION AUTHORITY		3. DISTRIBUTION / AVAILABILITY OF REPORT Approved for public release; distribution unlimited.			
2b. DECLASSIFICATION / DOWNGRADING SCHEDULE					
4. PERFORMING ORGANIZATION REPORT NUMBER(S) Technical Report D-90-3		5. MONITORING ORGANIZATION REPORT NUMBER(S)			
6a. NAME OF PERFORMING ORGANIZATION See reverse.	6b. OFFICE SYMBOL (If applicable)	7a. NAME OF MONITORING ORGANIZATION			
6c. ADDRESS (City, State, and ZIP Code) See reverse.		7b. ADDRESS (City, State, and ZIP Code)			
8a. NAME OF FUNDING / SPONSORING ORGANIZATION US Army Corps of Engineers; USAED, Galveston	8b. OFFICE SYMBOL (If applicable)	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER			
8c. ADDRESS (City, State, and ZIP Code) Washington, DC 20314-1000; PO Box 1229, Galveston, TX 77553-1229		10. SOURCE OF FUNDING NUMBERS			
		PROGRAM ELEMENT NO.	PROJECT NO.	TASK NO.	WORK UNIT ACCESSION NO.
11. TITLE (Include Security Classification) Beneficial Uses of Dredged Material; Proceedings of the Gulf Coast Regional Workshop, 26-28 April 1988, Galveston, Texas					
12. PERSONAL AUTHOR(S) Lazor, Robert L.; Medina, Richard; Editors					
13a. TYPE OF REPORT Final report	13b. TIME COVERED FROM _____ TO _____	14. DATE OF REPORT (Year, Month, Day) February 1990	15. PAGE COUNT 297		
16. SUPPLEMENTARY NOTATION Available from National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161.					
17. COSATI CODES		18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number) Dredged material management Dredging 12			
FIELD	GROUP				
19. ABSTRACT (Continue on reverse if necessary and identify by block number) <p>The Gulf Coast Regional Workshop on the Beneficial Uses of Dredged Material was held in Galveston, TX, on 26-28 April 1988. The workshop was sponsored by the US Army Engineer District, Galveston, in cooperation with the following organizations: US Environmental Protection Agency; US Fish and Wildlife Service; National Marine Fisheries Service; US Department of Agriculture; and State, local, and private interests.</p> <p>The primary objective of the workshop was to focus attention on the wide range of beneficial uses of dredged material along the gulf coast, with special emphasis placed on agency viewpoints, beach nourishment, land stabilization, habitat development case studies, and innovative uses and concepts. Increased cooperation among the diverse number of Federal, State, local, university, and private interests involved with dredged material management was a high-priority goal.</p> <p style="text-align: right;">(Continued)</p>					
20. DISTRIBUTION / AVAILABILITY OF ABSTRACT <input checked="" type="checkbox"/> UNCLASSIFIED/UNLIMITED <input type="checkbox"/> SAME AS RPT. <input type="checkbox"/> DTIC USERS		21. ABSTRACT SECURITY CLASSIFICATION Unclassified			
22a. NAME OF RESPONSIBLE INDIVIDUAL		22b. TELEPHONE (Include Area Code)	22c. OFFICE SYMBOL		

6a. NAME OF PERFORMING ORGANIZATION (Continued).

USAEWES, Environmental Laboratory;  
USAED, Galveston

6c. ADDRESS (Continued).

3909 Halls Ferry Road, Vicksburg, MS 39180-6199; PO Box 1229, Galveston,  
TX 77553-1229

19. ABSTRACT (Continued).

The 3-day workshop opened with a keynote address by MG Henry J. Hatch, Director of Civil Works, US Army Corps of Engineers, Washington, DC. First-day activities focused on a Federal agency viewpoints panel; a State and local agency viewpoints panel; and Technical Session I, Beach Nourishment and Land Stabilization. The second-day agenda featured Technical Session II, Habitat Development: Case Studies; Technical Session III, Innovative Uses and Concepts; Federal, State, and industry panel: Conclusions and Observations; and a keynote luncheon presentation by Dean Gerald J. McLindon, Dean Emeritus, Louisiana State University. A boat tour of the Houston Ship Channel, Port of Houston, on the third day provided a highly informative view of the navigation maintenance requirements.

Conclusions and observations of the workshop focused on the following: the need for communication and cooperation among all those involved in public interest determinations concerning dredged material placement; the wide variety of beneficial uses of dredged material available for consideration; and the rapidly developing technical status of beach nourishment, land stabilization, habitat development, and innovative concepts. Renewed efforts should be undertaken to identify feasible, cost-effective, and environmentally sound beneficial use options in cooperation with all interests involved.

## PREFACE

The Gulf Coast Regional Workshop on the Beneficial Uses of Dredged Material was sponsored and funded by the US Army Engineer (USAE) District, Galveston, under the general sponsorship by the Dredging Division, Headquarters, US Army Corps of Engineers (HQUSACE), and the USAE Division, Southwestern. This was the fourth workshop on the subject and represents an important continuing contribution to engineering, technical, and scientific communities. Work was conducted under the Environmental Effects of Dredging Programs (EEDP) of the US Army Engineer Waterways Experiment Station (WES). Cooperating agencies were the US Environmental Protection Agency, US Fish and Wildlife Service, US Department of Agriculture, National Marine Fisheries Service (NMFS), and numerous State and local agencies and private interests.

Editors of the proceedings were Messrs. Robert L. Lazor, Wetlands and Terrestrial Habitat Group (WTHG), Environmental Laboratory (EL), WES, and Richard Medina, Construction-Operations Division, USAE District, Galveston, who also provided overall coordination for the workshop. Ms. Lee T. Byrne of the WES Information Technology Laboratory provided editorial review.

Members of the workshop coordinating and planning committee were Messrs. Medina, George R. Rothen, Sidney Tanner, and Robert Harbaugh, USAE District, Galveston; Messrs. George W. Johnson, Jr., and William T. Pearson, USAE Division, Southwestern; Mr. Jesse A. Pfeiffer, Jr., HQUSACE; and Mr. Lazor and Ms. Joan Pope, WES. Dr. Sammy M. Ray, Texas A&M University at Galveston, was workshop facilitator.

BG Robert C. Lee, Commander, USAE Division, Southwestern, served as moderator of the Federal agency viewpoints panel. COL John A. Tudela, Commander, USAE District, Galveston, was moderator of the State and local agency viewpoints panel. Technical session moderators were Mr. Pearson (Session I); Dr. Edward Klima, NMFS, and Mr. Leland Roberts, Texas Parks and Wildlife Department (Session II); and Mr. Johnson (Session III). Dr. Ray served as panel moderator for the panel entitled "Federal, State, and Industry: Conclusions and Observations."

Dr. Gerald J. McLindon, Dean Emeritus, Louisiana State University, provided the keynote luncheon address.

Conduct of the workshop and compilation of the proceedings were accomplished under the general supervision of Dr. Hanley K. Smith, Chief, WTHG, and Mr. Hollis H. Allen, Acting Chief, WTHG; Dr. Conrad J. Kirby, Chief, Environmental Resources Division, EL; and Dr. Robert M. Engler, Program Manager, EEDP. Dr. John Harrison was Chief of EL. Ms. Pope, Coastal Engineering Research Center, WES; Mr. Thomas R. Patin, EEDP, and Dr. James Wakeley, WTHG, provided reviews of the proceedings.

MG Henry J. Hatch was the Director of Civil Works, HQUSACE. Commander and Director of WES was COL Larry B. Fulton, EN. Dr. Robert W. Whalin was Technical Director.

This report should be cited as follows:

Lazor, Robert L., and Medina, Richard, editors. 1990. "Beneficial Uses of Dredged Material; Proceedings of the Gulf Coast Regional Workshop, 26-28 April 1988, Galveston, Texas," Technical Report D-90-3 , US Army Engineer Waterways Experiment Station, Vicksburg, MS.

## CONTENTS

	<u>Page</u>
PREFACE.....	1
ATTENDEES.....	5
AGENDA.....	14
CONVERSION FACTORS, NON-SI TO SI (METRIC) UNITS OF MEASUREMENT.....	17
INTRODUCTION.....	18
Call to Order <i>Sammy M. Ray</i> .....	18
Opening Remarks <i>COL John A. Tudela</i> .....	20
Welcome <i>BG Robert C. Lee</i> .....	21
KEYNOTE ADDRESS <i>MG Henry J. Hatch</i> .....	24
FEDERAL AGENCY VIEWPOINTS ON THE BENEFICIAL USES OF DREDGED MATERIAL <i>BG Robert C. Lee, Moderator</i> .....	30
Viewpoints of the US Department of Agriculture <i>Frank Wheeler</i> ....	30
Viewpoints of the US Environmental Protection Agency <i>Norm Thomas</i> .....	33
Viewpoints of the National Marine Fisheries Service <i>William B. Jackson</i> .....	38
Viewpoints of the US Fish and Wildlife Service <i>Michael J. Spear</i> .....	42
Viewpoints of the US Army Corps of Engineers <i>Charles Hummer</i> .....	47
Questions and Responses--Federal Agency Viewpoints Panel.....	53
STATE, LOCAL, AND PRIVATE INTERESTS VIEWPOINTS ON THE BENEFICIAL USES OF DREDGED MATERIAL <i>COL John A. Tudela, Moderator</i> .....	58
Texas Parks and Wildlife Department <i>Susan Rieff</i> .....	58
Texas Department of Highways and Public Transportation <i>Robert Cuellar</i> .....	63
Texas General Land Office <i>Sally S. Davenport</i> .....	68
Louisiana Department of Natural Resources <i>Charles Groat</i> .....	72
Barge Industry <i>Berdon Lawrence</i> .....	77
Port of Houston Authority <i>James D. Pugh</i> .....	81
Questions and Responses--State, Local, and Private Interests Viewpoints Panel.....	84
INVITED PAPERS	
SESSION I: BEACH NOURISHMENT AND LAND STABILIZATION	
<i>William T. Pearson, Moderator</i> .....	88
Overview of Beneficial Uses of Berms <i>Thomas W. Richardson</i> .....	88
Low Wave Energy Stabilization of Shorelines <i>John Lesnick</i> .....	93
Stabilization and Development of Marsh Lands <i>Hollis H. Allen, Robert L. Lazor, and James W. Webb</i> .....	101
Environmental Considerations in Using Beach Nourishment for Dredged Material Placement <i>David A. Nelson and</i> <i>Edward J. Pullen</i> .....	113

	<u>Page</u>
Beach Nourishment and Overview of Sand Bypassing <i>James E. Clausner and Michael Kieslich</i> .....	129
Questions and Responses--Beach Nourishment and Land Stabilization.....	141
SESSION II: HABITAT DEVELOPMENT: CASE STUDIES <i>Edward Klima and Leland Roberts, Moderators</i> .....	143
Habitat Development on Dredged Material (Video Presentation) <i>Hanley K. Smith</i> .....	143
Environmental Assessment of Dredged Material Disposal on Grazing Lands at East Matagorda Bay, Texas <i>James W. Webb and Mary C. Landin</i> .....	144
Creation of Salt Marshes for Fishery Organisms <i>Thomas J. Minello and Roger J. Zimmerman</i> .....	159
Use of Dredged Material Islands by Colonial Nesting Waterbirds in the Northern Gulf Coast <i>Mary C. Landin</i> .....	160
Beneficial Uses of Dredged Material Within the New Orleans District <i>Suzanne Hawes</i> .....	174
Using New Work and Maintenance Material for Marsh Creation in the Galveston District <i>Thomas H. Rennie</i> .....	184
Overview of Dredged Material Management in the Vicksburg District <i>Harold Lee and E. Gaylan MacGregor</i> .....	188
Seagrass Transplantation--Is It a Viable Habitat Mitigation Option? <i>Gordon W. Thayer, Mark S. Fonseca, and W. Judson Kenworthy</i> .....	194
Questions and Responses--Habitat Development.....	205
KEYNOTE LUNCHEON ADDRESS	
Dredged Material Disposal--What Is in the Future? <i>Gerald J. McLindon</i> .....	207
SESSION III: INNOVATIVE USES AND CONCEPTS <i>George W. Johnson, Jr., Moderator</i> .....	230
Development and Operations of the Containment Area Aquaculture Program Demonstration Shrimp Farm <i>Richard Coleman, Jurij Homziak, and Durwood Dugger</i> .....	230
Thin-Layer Placement of Dredged Material: A Method for Reduced Environmental Impacts <i>Susan Ivester Rees</i> .....	247
The Dredging Research Program <i>Lim Vallianos</i> .....	258
The Corps/EPA Field Verification Program <i>Robert L. Lazor</i> .....	268
New Federal Regulations on Dredging <i>Joseph R. Wilson</i> .....	275
FEDERAL, STATE, AND INDUSTRY PANEL: CONCLUSIONS AND OBSERVATIONS	
Introduction <i>Sammy M. Ray, Moderator</i> .....	282
<i>Charles Groat, William Kruczynski, George R. Rothen, William G. Wooley, Rollin MacRae, Richard Gorini, Hanley K. Smith</i> .....	282
CLOSING REMARKS <i>COL John A. Tudela</i> .....	293

ATTENDEES

ACOSTA, Ivan, USAED, Galveston, PO Box 1229, Galveston, TX 77553  
(409-766-3991)

ALLEN, Don, USAED, Galveston, PO Box 1229, Galveston, TX 77553  
(409-766-3051)

ARCIDIACONO, Sal, USAED, Galveston, PO Box 1229, Galveston, TX 77553  
(409-766-3803)

ARRINGTON, John, 7025 Kopman, Houston, TX 77061 (713-649-4795)

BAKER, Bill, Houston Lighting & Power Co., PO Box 1700, Houston, TX 77001  
(713-922-2209)

BARRERA, Art, USAED, Brownsville Area Office, 3505 Boca Chica Boulevard,  
Suite 341, Brownsville, TX 78521-4065 (512-546-2456)

BASS, Robert, USAED, Galveston, PO Box 1229, Galveston, TX 77553  
(409-766-3037)

BEGGS, Robert, USAED, Corpus Christi Area Office, PO Box 2948, Corpus  
Christi, TX 78403-2948 (512-888-3354)

BENNETT, Bruce, USAED, Galveston, PO Box 1229, Galveston, TX 77553  
(409-766-3934)

BERISTAIN, Melissa, EPA Marine & Wetlands Protection, 26 Federal Plaza, New  
York, NY 10278 (212-264-5170)

BISHOP, David, USAED, Conemaugh Lake, Rt 1, Box 702, Saltsburg, PA 15681

BONHAM, Kenneth, USAED, Galveston, PO Box 1229, Galveston, TX 77553  
(409-766-3004)

BORISKIE, Michael, Phillips 66, PO Box 866, Swenny, TX 77480  
(409-491-2357)

BOUDREAUX, DeyAnn, Texas Environmental Coalition, PO Box 2859, South Padre  
Island, TX 78597 (512-761-4635)

BRADLEY, Paul, USAED, Mobile District, 109 St. Joseph St., Rm 7013, Mobile, AL  
36628-0001 (205-690-2570)

BRANDON, Don, Chambers County, PO Box 1206, Anahuac, TX 77514  
(409-267-3571)

BRINKLEY, Ron, Texas General Land Office, 105 San Jacinto, LaPorte, TX 77571  
(713-470-1191)

BRYAN, Joe, Brown & Root, Inc., PO Box 3, Houston, TX 77001-003  
(713-954-2220)

BURKE, Dock, Texas Transportation Institute, Texas A&M University System,  
College Station, TX 77843 (409-345-5815)

BUXTON, David, Harris County Flood Control District, 9900 N.W. Freeway,  
Houston, TX 77092 (713-684-4050)

CALDWELL, Patton, Gulf Coast Portland Cement, PO Box 262, Houston, TX 77001  
(713-926-3181)



CAMPBELL, Marylou, LRGV Sierra, Lone Star Chapter, PO Box 2189, South Padre Island, TX 78597 (512-943-5571)

CARANGELO, Paul D., Island Botanics, Inc., 714 Don Patricio, Corpus Christi, TX 78418 (512-937-4873)

CASTELLINE, Mike, USAED, Galveston, PO Box 1229, Galveston, TX 77553 (409-766-3970)

CHATRY, Steve, Gulf Coast Trailing Co., PO Box 10, Kenner, LA 70063 (504-467-6000)

CHEESMAN, John B., Jr., Galveston Bay Foundation, PO Box 897, Anahuac, TX 77514 (713-721-7975)

CLARK, Roy, USAED, New England, 424 Trapelo Road, Waltham, MA 02254-9149 (617-647-8328)

CLAUSNER, James E., Waterways Experiment Station, PO Box 631, Vicksburg, MS 39181-0631 (601-634-2009)

COFRANCESCO, Al, Waterways Experiment Station, PO Box 631, Vicksburg, MS 39181-0631 (601-634-3182)

COLEMAN, Richard, Waterways Experiment Station, PO Box 631, Vicksburg, MS 39181-0631 (601-634-2569)

CUDE, Junias, USAED, Port Arthur Area Office, PO Box 157, Port Arthur, TX 77640 (409-985-4383)

CUELLAR, Robert, State Department of Highways & Public Transportation, PO Box 5051, Austin, TX 78753-5051 (512-465-7412)

CUTLER, Casey, USAED, Galveston, PO Box 1229, Galveston, TX 77553 (409-766-3963)

DANIEL, Tom, 22 Lincoln St., Hampton, VA 23669 (804-727-6347)

DAVENPORT, Sally S., General Land Office, Stephen F. Austin Building, 1700 West Congress, Austin, TX 78701 (512-463-5055)

DELL, David A., US Fish & Wildlife Service, PO Box 4305, Lafayette, LA 70502 (318-264-6630)

DODSON, Bill, Dodson Investments, 2206 Hazard St. #3, Houston, TX 77019 (713-520-0000)

DUARTE, Rene, USAED, Galveston, PO Box 1229, Galveston, TX 77553 (409-766-3093)

EARLS, Gary, USAED, Southwestern, 1114 Commerce Street, Dallas, TX 75242 (214-767-4522)

EDISON, Douglas, Port of Olympia, PO Box 827, Olympia, WA 98507 (206-586-1084)

ELLER, Jim, Gulf Coast Waste Disposal Authority, 910 Bay Area Boulevard, Houston, TX 77058 (713-488-4115)

FISHER, Frank M., Rice University, Biology Dept., PO Box 1892, Houston, TX 77251 (713-527-4917)

FISHER, King, King Fisher Marine Svc., Inc., PO Box 108, Port Lavaca, TX 77979-0108 (512-552-6751)

GALCERAN, Earl L., Permit Section, Harris County Engineer Dept., 301 Main,  
Houston, TX 77002 (713-221-5374)

GANZE, Charles, Gulf Coast Waste Disposal Authority, 910 Bay Area Blvd.,  
Houston, TX 77058 (713-488-4115)

GERSCH, B. C., State Department of Highways & Public Transportation,  
PO Box 5051, Austin, TX 78723 (512-465-7412)

GIAMMONA, Charles P., Texas A&M University, Civil Engineering Dept., College  
Station, TX 77843 (409-845-3507)

GILLETTE, Mary, League of Women Voters of Houston, 5027 Longmont, Houston, TX  
77056 (713-529-3171)

GILMORE, James, USAED, Galveston, PO Box 1229, Galveston, TX 77553  
(409-766-3034)

GLAIBER, Paul, Great Lakes Dredge & Dock Co., PO Box 18585, Tampa, FL 33679  
(813-874-6998)

GLENBOSKI, Linda, USAED, New Orleans, PO Box 60267, ATTN: (CELMNOD-ON),  
New Orleans, LA 70160-0267 (504-862-2318)

GORINI, Richard, Port of Houston Authority, PO Box 2562, Houston, TX 77252  
(713-226-2100)

GROAT, Charles, Assistant to the Secretary, Louisiana Department of Natural  
Resources, Region VI, PO Box 44487, Baton Rouge, LA 70804-4487

GUNN, Robert L., USAED, New Orleans, PO Box 60267 (CELMNED-DW), New Orleans,  
LA 70160 (504-862-2406)

HAGWOOD, Derle, Virginia Port Authority, 600 World Trade Center, Norfolk, VA  
23510 (804-623-8251)

HANN, Roy W., Jr., Texas A&M University, Civil Engr. Dept., Env. Engr.  
Program, College Station, TX 77843

HARBAUGH, Bob, USAED, Galveston, PO Box 1229, Galveston, TX 77553  
(409-766-3044)

HARRINGTON, Richard, Texas Parks & Wildlife Dept., 9729-D S. Padre Island  
Drive, Corpus Christi, TX 78418 (512-937-6323)

HASSELER, Jim, USAED, Buffalo, 1776 Niagara St., Buffalo, NY 14207

HATCH, MG Henry J., Department of the Army, Washington, DC 20314-1000

HAUCH, Robert G., USAED, Galveston, PO Box 1229, Galveston, TX 77553  
(409-766-3964)

HAWES, Suzanne, USAED, New Orleans, PO Box 60267, New Orleans, LA  
70160-0267 (504-862-2518)

HEARNSBERGER, Roy, Carter & Burgess, Inc., 6001 Savoy, #300, Houston, TX  
77036 (713-974-7090)

HEATHERLY, Terry, USAED, Galveston, PO Box 1229, Galveston, TX 77553  
(409-766-3979)

HERBERT, Homer J., Port of Iberia, PO Box 9986, New Iberia, LA 70562-9986  
(318-364-1065)

HERRING, Warren, King Fisher Marine Svc., Inc., PO Box 108, Port Lavaca, TX  
77979-0108 (512-552-6751)

HERSHEY, Terry, Bayou Preservation Assoc., 1 Longbow Lane, Houston, TX 77024  
(713-681-1816)

HIGHTOWER, Mike, Texas A&M University, Sea Grant College Program, College  
Station, TX 77843-4115 (409-845-3854)

HOLMES, Dwain, Aluminum Company of America, State Highway 35, Point Comfort,  
TX 77978 (512-987-6506)

HORN, Jack, Port of Houston Authority, PO Box 2562, Houston, TX 77252-2562  
(713-226-2144)

HOUSEMAN, Tony, 14425 Interstate 10 East, Orange, TX 77630

HRAMETZ, Joe, USAED, Galveston, PO Box 1229, Galveston, TX 77553  
(409-766-6311)

HUMMEL, Ed, USAED, Galveston, PO Box 1229, Galveston, TX 77553  
(409-766-3933)

HUMMER, Charles, USACE, ATTN: CECW-D, 20 Massachusetts Ave., NW, Washington,  
DC 20314-1000 (202-272-8843)

JACKSON, Butch, State Dept. of Highways & Public Transportation,  
PO Box 9907, Corpus Christi, TX 78469 (512-855-8281)

JACKSON, William (Bill) B., National Marine Fisheries Svc., 4700 Avenue U,  
Galveston, TX 77550 (409-766-3500)

JANSKY, Michael, US EPA Region VI, 1445 Ross Avenue, Dallas, TX 75202  
(214-655-2260)

JEAN, C. L., Jr., Houston Fuel Oil Terminal Co., PO Box 969, Channelview, TX  
77530-0969 (713-452-3390)

JOHNSON, George W., Jr., USAED, Southwestern, 1114 Commerce Street, Dallas, TX  
75242-0216 (214-767-2430)

JOHNSON, Lynne, Buffalo Bayou Coalition, 710 Marchmont, Houston, TX 77024  
(713-465-8529)

KATZ, Aaron, USAED, Galveston, PO Box 1229, Galveston, TX 77553  
(409-766-3136)

KENNEDY, David, IP Farms Inc., PO Box 550, Alvin, TX 77511 (713-581-9920)

KIESLICH, Michael, USAED, Galveston, PO Box 1229, Galveston, TX 77553  
(409-766-3071)

KLIMA, Edward, National Marine Fisheries Svc., Galveston Laboratory,  
Galveston, TX 77550 (409-766-3500)

KNAPP, Mary, USFWS - Corpus Christi, c/o CCSU, PO Box 338, Corpus Christi, TX  
78412 (512-888-3346)

KNIPPA, John D., Gulf States Utilities, PO Box 2951, Beaumont, TX 77704  
(409-839-5762)

KRUCZYNSKI, William, Environmental Protection Agency, Environmental Research  
Lab, Sabine Island, Gulf Breeze, FL 32560 (904-932-5311)

LANDIN, Mary C., Waterways Experiment Station, PO Box 631, Vicksburg, MS  
39181-0631 (601-634-2942)

LANGAN, Pat, USAED, Mobile, 109 St. Joseph St., Rm 7013, Mobile, AL  
36628-0001 (205-690-3730)

LaQUAY, Timothy, King Fisher Marine Svc., Inc., PO Box 108, Port Lavaca, TX  
77979-0108 (512-552-6751)

LARD, Claude F., US Fish & Wildlife Svc., PO Box 1445, Victoria, TX 77901  
(512-573-7821)

LAWRENCE, Berdon, President, Hollywood Marine, Inc., PO Box 1343, Houston,  
TX 77251

LAZOR, Robert L., Waterways Experiment Station, PO Box 631, Vicksburg, MS  
39181-0631 (601-634-2935)

LeBLANC, Fred, Texas Parks & Wildlife Dept., PO Box 8, Seabrook, TX 77586  
(409-474-2811)

LEE, Harold, USAED, Vicksburg, PO Box 60, Vicksburg, MS 39181-0060

LEE, BG Robert C., USAED, Southwestern, 1114 Commerce Street, Dallas, TX  
75242-0216 (214-767-2502)

LEGROTTE, Jim, FEMA Region VI, 800 North Loop 288, Denton, TX 76201  
(817-898-9162)

LESNICK, John, Moffatt and Nichol Engineers, 3717 National Drive, #107,  
Raleigh, NC 27612

LEVEILLE, Thomas P., US Coast Guard, 601 Rosenberg, Galveston, TX 77843-3115  
(409-766-3691)

LEWIS, James, US Fish and Wildlife Svc., PO Box 1306, Albuquerque, NM 87103  
(505-766-8064)

MacGREGOR, Robert, Espey, Huston & Assoc., 1509 31st, Galveston, TX 77550  
(409-762-5959)

MacRAE, Rollin, Texas Parks & Wildlife Dept., 4200 Smith School Road, Austin,  
TX 78744 (512-389-4725)

MALIN, Dick, Port of Olympia, PO Box 827, Olympia, WA 98507 (206-586-6159)

MANNCHEN, Brandt, 629 Euclid, Houston, TX 77009 (713-640-4311)

MATHEWSON, Christopher, Center for Engineering Geosciences, Texas A&M  
University, College Station, TX 77843-3115 (409-845-2488)

MAURER, Herbie A., USAED, Galveston, PO Box 1229, Galveston, TX 77553  
(409-766-3966)

MAYFIELD, John, ALCOA, State Hwy 35, Point Comfort, TX 77978 (512-987-6172)

McCANN, John M., Jr., Board of Engineers for Rivers and Harbors, 2593 Lead  
Road, Kingman Bldg., Port Belvoir, VA 22060-5576 (202-355-2454)

McCARTNEY, Paul D., Texas Department of Health, PO Box 218, LaMarque, TX  
77568 (409-938-8421)

McLINDON, Gerald J., 635 Riveroaks Place, Baton Rouge, LA 70815

MEDINA, Rick, USAED, Galveston, PO Box 1229, Galveston, TX 77553  
(409-766-3962)

MEYERS, Steve, USAED, Galveston, PO Box 1229, Galveston, TX 77553  
(409-766-3992)

MINELLO, Thomas J., National Marine Fisheries Svc., Galveston Laboratory, 4700  
Avenue U, Galveston, TX 77551 (409-766-3500)

MOORE, Donald, National Marine Fisheries Svc., Habitat Conservation Division,  
4700 Avenue U, Galveston, TX 77551-5997 (409-766-3699)

MORGAN, Kevin, USAED, Galveston, PO Box 1229, Galveston, TX 77553  
(409-766-3947)

MOSELEY, Joe E., Shiner, Moseley & Associates, 2820 SPID, Suite 210, Corpus  
Christi, TX 78415 (512-857-2211)

MURPHY, Dan, USAED, Galveston, PO Box 1229, Galveston, TX 77553  
(409-766-3946)

NAILON, Robert, Texas A&M, Sea Grant Program, PO Box 699, Anahuac, TX 77514  
(409-267-3185)

NELSON, David, Waterways Experiment Station, PO Box 631, Vicksburg, MS  
39181-0631 (601-634-3816)

NEW, Noah, USAED, Southwestern, 1114 Commerce Street, Dallas, TX 75242-0216  
(214-767-2433)

OUBRE, John, Port of Iberia, PO Box 9986, New Iberia, LA 70562  
(318-364-1065)

PARKER, Bob, Parker Bros. & Co., Inc., PO Box 107, Houston, TX 77001

PEARSON, William T., USAED, Southwestern, 1114 Commerce Street, Dallas, TX  
75242-0216 (214-767-2302)

PFEIFFER, Jesse A., Jr. Office, Chief of Engineers, ATTN: CERD-C, Washington,  
DC 20314-1000

PIEHLER, Chris M., Louisiana Dept. of Natural Resources, Coastal Management  
Division, Rt. 8, PO Box 169, Lake Charles, LA 70605 (318-474-6318)

PILGRAM, Walter, Jr., West Side Calhoun County Navigation, PO Box 49, Long  
Mott, TX 77972 (512-785-6492)

PITTMAN, L. Phil, Louisiana Dept. of Natural Resources, Coastal Management  
Division, Rt. 8, Box 169, Lake Charles, LA 70605 (504-342-7591)

PLASEK, Louise, USAED, Galveston, PO Box 1229, Galveston, TX 77553  
(409-766-3939)

POPE, Joan, Waterways Experiment Station, PO Box 631, Vicksburg, MS  
39181-0631 (601-634-3034)

PRESLAN, Bill, Fugro-McClelland, PO Box 740010, Houston, TX 77274  
(713-778-5538)

PROCTOR, Ray, USAED, Galveston, PO Box 1229, Galveston, TX 77553  
(409-766-3036)

PRUETT, Albert, USAED, Mobile, 109 St. Joseph St., Rm. 7013, Mobile, AL  
36628-0001 (205-694-3702)

PUGH, James D., Executive Director, Port of Houston Authority, PO Box 2562,  
Houston, TX 77252-2562

PULLEN, Jack, Waterways Experiment Station, PO Box 631, Vicksburg, MS  
39181-0631 (601-634-3650)

QUARLES, Jack, FEMA, Region VI, Federal Center, 800 N. Loop 288, Denton, TX  
76201

RANKIN, Paula, USAED, Galveston, PO Box 1229, Galveston, TX 77553  
(409-766-3948)

RAY, Sammy M., Texas A&M University, PO Box 1675, Galveston, TX 77553

REES, Susan Ivester, USAED, Mobile, PO Box 2288, Mobile, AL 36628-0001

RENNIE, Thomas, H., USAED, Galveston, PO Box 1229, Galveston, TX 77553  
(409-766-6303)

RICHARDSON, Steve, City of Galveston, PO Box 779, Galveston, TX 77553  
(409-766-2106)

RICHARDSON, Tom, Waterways Experiment Station, PO Box 631, Vicksburg, MS  
39181-0631 (601-634-2019)

RIEFF, Susan, Resource Protection Division, Texas Parks and Wildlife Dept.,  
4200 Smith School Road, Austin, TX 78744 (512-389-4632)

RIVAS, Elaine, USAED, Galveston, PO Box 1229, Galveston, TX 77553  
(409-766-3928)

ROBERTS, Leland, Resource Protection Division, Texas Parks and Wildlife Dept.,  
4200 Smith School Road, Austin, TX 78744 (512-389-4632)

ROCHEN, George R., USAED, Galveston, PO Box 1229, Galveston, TX 77553  
(409-766-3959)

RODRIGUEZ, Julio, Panama Canal Commission, Dredging Division, APO Miami, FL  
34011-5000

ROOF, Ellyn H., Galveston Bay Conservation & Preservation Association,  
1111 Pine Circle, Seabrook, TX 77586 (713-474-2358)

ROZSYPAL, Johnny, USAED, Fort Point Area Office, PO Box 1229, Galveston, TX  
77553 (409-766-6311)

ROWE, Oscar, USAED, New Orleans, ATTN: CELMN-PD-FC, PO Box 60267, New  
Orleans, LA 70160 (504-862-2512)

RUDENBERG, F. Hermann, Sierra Club, 3327 Avenue Q 1/2, Galveston, TX 77550  
(409-761-4707)

SANTANACH, Luis, Panama Canal Commission, Dredging Division, APO Miami, FL  
34011-5000

SCHILLING, Fred, USAED, New Orleans, PO Box 60267, New Orleans, LA  
70160-0267 (504-862-2321)

SMITH, C. Bruce, Texas General Land Office, 1700 N. Congress, Austin, TX  
78701 (512-463-5055)

SMITH, Darrell, USAED, Galveston, PO Box 1229, Galveston, TX 77553  
(409-766-3949)

SMITH, Frank C., Jr., Galveston Bay Foundation, 3330 Bering Dr., Houston, TX  
77057 (713-780-2514)

SMITH, Hanley K., Waterways Experiment Station, PO Box 631, Vicksburg, MS  
39181-0631

SPEAR, Michael J., Regional Director, US Fish & Wildlife Svc., PO Box 1306,  
Albuquerque, NM 87103 (505-766-2321)

STEPHENS, W. A., Warren Petroleum, PO Box 485, Galena Park, TX 77547  
(713-453-7173)

STEWART, Sharon, Texas Environmental Coalition, PO Box 701, Lake Jackson, TX  
77566 (409-297-6360)

STEWART, Tim, State Dept. of Highways & Public Transportation, PO Box 9907,  
Corpus Christi, TX 78469 (512-855-8281)

TANNER, Sidney, USAED, Galveston, PO Box 1229, Galveston, TX 77553  
(409-766-3063)

TAPP, Ronnie Lee, USAED, Jacksonville, PO Box 4970 (CESAJ-PD-ES),  
Jacksonville, FL 32232-0019 (904-791-1690)

TEMPLETON, W. H., (Bill), Box 4184, Sargent, TX 77414 (409-244-9020)

THAYER, Gordon W., National Marine Fisheries Service, Beaufort Laboratory,  
Beaufort, NC 28516 (919-728-8747)

THOMAS, Norm, Chief, Federal Activities Br., Environmental Protection Agency,  
1445 Ross Avenue, Dallas, TX 75202

TILLMAN, Richard E., Texas A&M Marine Advisory Svc., 1202 Navigation Circle,  
Rockport, TX 78382 (512-729-7252)

TILLMAN, Russ, Waterways Experiment Station, PO Box 631, Vicksburg, MS  
39181-0631 (601-634-2016)

TUDELA, COL John A., USAED, Galveston, PO Box 1229, Galveston, TX 77553  
(409-766-3002)

VALENTINE, LTC Kit, Chief, Environmental Oversight Branch, US Army Corps of  
Engineers, Department of the Army, Washington, DC 20314-1000

VALLIANOS, Lim, Waterways Experiment Station, PO Box 631, Vicksburg, MS  
39181-0631 (601-634-2070)

WEBB, James W., Texas A&M University, Marine Biology Department, PO Box 1675,  
Galveston, TX 77553 (409-740-4525)

WERMUND, E. G., Texas Bureau of Economic Geology, Box X, University Station,  
Austin, TX 78750 (512-471-1534)

WERNER, Frederick T., US Fish & Wildlife Svc., 17629 El Camino Real, #211,  
Houston, TX 77058 (713-229-3681)

WHEELER, Frank, Soil Conservation Service, 101 S. Main, Temple, TX 76501  
(817-774-1261)

WHITEHEAD, Dawn, US Fish and Wildlife Svc., 17629 El Camino Real, #211,  
Houston, TX 77058 (713-229-3681)

WHITMIRE, Richard, USAED, Galveston, PO Box 1229, Galveston, TX 77553  
(409-766-3969)

WILES, Kirk, Texas Department of Health, 1100 W. 49th Street, Austin, TX  
78756 (512-458-7510)

WILLEY, Barry, USAED, Galveston, PO Box 1229, Galveston, TX 77553  
(409-766-3954)

WILSON, Joe, USACE, ATTN: CECW-D, 20 Massachusetts Ave., NW, Washington, DC  
20314-1000 (202-272-0397)

WOODS, Cynthia, USAED, Norfolk, 803 Front Street, Norfolk, VA 23510

WOOLEY, William G., USAED, Galveston, PO Box 1229, Galveston, TX 77553  
(409-766-3059)

WOOTERS, Kelly, PO Box 5504, College Station, TX 77844

YOUNGER, William, Texas A&M Marine Advisory Service, Room 326, Courthouse  
Bldg., Bay City, TX 77414 (409-244-7650)

YUILL, Richard, Rice University, Biology Dept., PO Box 1892, Houston, TX  
77251 (713-527-8101)



## AGENDA

Monday, April 25, 1988

3:00-6:00 REGISTRATION DESK OPEN

Tuesday, April 26, 1988

7:00-8:30 REGISTRATION

8:30-9:00 Call to Order-Dr. Sammy M. Ray, Texas A&M University at Galveston, Workshop Moderator  
Opening Remarks-COL John A. Tudela, Commander, Galveston District, CE, Galveston, TX  
Welcome-BG Robert C. Lee, Commander, Southwestern Division, CE, Dallas, TX

9:00-9:30 KEYNOTE ADDRESS: MG Henry J. Hatch, Director of Civil Works, US Army Corps of Engineers, Washington, DC

9:30-9:50 BREAK

9:50-11:30 FEDERAL AGENCY VIEWPOINTS PANEL  
Moderator: BG Robert C. Lee, Commander, Southwestern Division, CE, Dallas, TX  
Mr. Frank Wheeler, Soil Conservation Service, Temple, TX  
Mr. Norm Thomas, Chief, Federal Activities Branch, Region VI, Environmental Protection Agency, Dallas, TX  
Mr. William B. Jackson, Southeast Regional Liaison Officer, National Marine Fisheries Service, Galveston, TX  
Mr. Michael J. Spear, Regional Director, Region II, US Fish and Wildlife Service, Albuquerque, NM  
Mr. Charles Hummer, Acting Chief, Dredging Division, US Army Corps of Engineers, Washington, DC

11:30-1:00 LUNCH

1:00-2:30 STATE AND LOCAL AGENCY VIEWPOINTS PANEL  
Moderator: COL John A. Tudela, Commander, Galveston District, CE, Galveston, TX  
Ms. Susan Rieff, Director, Resource Protection Division, Texas Parks and Wildlife Department, Austin, TX  
Mr. Robert Cuellar, Transportation Systems Planning, State Department of Highways and Public Transportation, Austin, TX  
Mrs. Sally S. Davenport, Acting Deputy Commissioner, General Land Office, Austin, TX  
Dr. Charles Groat, Assistant to the Secretary, Louisiana Department of Natural Resources, Baton Rouge, LA  
Mr. Berdon Lawrence, President, Hollywood Marine Inc., Houston, TX  
Mr. James D. Pugh, Executive Director, Port of Houston Authority, Houston, TX

2:30-2:50 BREAK

2:50-5:00 SESSION I--BEACH NOURISHMENT AND LAND STABILIZATION  
Moderator: Mr. William T. Pearson, Southwestern Division, CE,  
Dallas, TX  
Overview of Beneficial Uses of Berms, Mr. Tom Richardson,  
Waterways Experiment Station, Vicksburg, MS  
Low Wave Energy Stabilization of Shorelines, Mr. John Lesnick,  
Moffatt and Nichol Engineers, Raleigh, NC  
Stabilization and Creation of Marsh Lands, Mr. Robert L. Lazor  
and Mr. Hollis H. Allen, Waterways Experiment Station,  
Vicksburg, MS  
Environmental Issues of Beach Nourishment, Mr. David Nelson,  
Waterways Experiment Station, Vicksburg, MS  
Overview of Beach Nourishment and Sand By-Passing, Mr. Michael  
Kieslich, Galveston District, Galveston, TX, and Mr. James  
Clausner, Waterways Experiment Station, Vicksburg, MS

Wednesday, April 27, 1988

8:00-9:30 SESSION II--HABITAT DEVELOPMENT: CASE STUDIES

Co-Moderators:

Dr. Edward Klima, National Marine Fisheries Service,  
Galveston, TX, and Mr. Leland Roberts, Resource Protection  
Division, Texas Parks and Wildlife Department, Austin, TX

A National Overview of Habitat Development, Dr. Hanley K. Smith,  
Waterways Experiment Station, Vicksburg, MS

Monitoring of Dredged Material Disposal on Grazing Lands,  
Dr. James W. Webb, Texas A&M University, Galveston, TX

Creation of Fisheries Habitat in Estuaries, Dr. Thomas J.  
Minello, National Marine Fisheries Service, Galveston, TX

Use of Dredged Material Islands by Colonial Nesting Waterbirds  
in the Northern Gulf Coast, Dr. Mary C. Landin, Waterways  
Experiment Station, Vicksburg, MS

9:30-9:50 BREAK

9:50-11:30 Wetland Creation in New Orleans District, Ms. Suzanne Hawes, New  
Orleans District, New Orleans, LA

Using New Work Material for Marsh Creation, Dr. Thomas H.  
Rennie, Galveston District, Galveston, TX

An Overview of Dredged Material Management in the Vicksburg  
District, Mr. Harold Lee and Mr. Galen MacGregor, Vicksburg  
District, Vicksburg, MS

Seagrass Transplantation, Is It a Viable Habitat Replacement  
Option?, Dr. Gordon W. Thayer and Dr. M. S. Fonseca, National  
Marine Fisheries Service, Beaufort, NC

11:30-1:30 KEYNOTE LUNCHEON

Introduction by COL John A. Tudela

Guest: Dr. Gerald J. McLindon, Dean Emeritus, School of  
Environmental Design, Louisiana State University, Baton Rouge,  
LA

1:30-3:15 SESSION III--INNOVATIVE USES AND CONCEPTS  
Moderator: Mr. George W. Johnson, Jr., Southwestern Division,  
CE, Dallas, TX  
Aquaculture in Dredged Material Containment Areas,  
Mr. Richard Coleman, Waterways Experiment Station, Vicksburg,  
MS, and Mr. Durwood Dugger, Director of Aquaculture,  
Mariquest, Inc., Port Isabel, TX  
Thin Layer Placement: A Method for Reduced Environmental  
Impacts, Dr. Susan Ivester Rees, Mobile District, Mobile, AL  
Advances in Dredge Technology, Dr. Lim Vallianos, Waterways  
Experiment Station, Vicksburg, MS  
The Corps/EPA Field Verification Program, Mr. Robert L. Lazor,  
Waterways Experiment Station, Vicksburg, MS  
The Corps' New Maintenance Dredging Regulation, Mr. Joe Wilson,  
US Army Corps of Engineers, Washington, DC

3:15-3:30 BREAK

3:30-5:00 FEDERAL, STATE, AND INDUSTRY PANEL: CONCLUSIONS AND  
OBSERVATIONS  
Panel Moderator: Dr. Sammy M. Ray  
Panel Members:  
Dr. Charles Groat, Louisiana Department of Natural Resources,  
Baton Rouge, LA  
Dr. William Kruczynski, Environmental Protection Agency, Gulf  
Breeze, FL  
Mr. George R. Rothen, Chief, Construction-Operations Division,  
Galveston District, Galveston, TX  
Mr. William G. Wooley, Chief, Planning Division, Galveston  
District, Galveston, TX  
Mr. Rollin MacRae, Texas Parks and Wildlife Department, Austin,  
TX  
Mr. Richard Gorini, Port of Houston Authority, Houston, TX  
Dr. Hanley K. Smith, Waterways Experiment Station, Vicksburg, MS

CLOSING REMARKS--COL John A. Tudela

CONVERSION FACTORS, NON-SI TO SI (METRIC)  
UNITS OF MEASUREMENT

Non-SI units of measurement used in this report can be converted to SI (metric) units as follows:

<u>Multiply</u>	<u>By</u>	<u>To Obtain</u>
acres	4,046.873	square metres
cubic yards	0.7645549	cubic metres
degrees (angle)	0.01745329	radians
feet	0.3048	metres
gallons (US liquid)	3.785412	cubic decimetres
inches	25.4	millimetres
miles (US statute)	1.609347	kilometres
pounds (mass)	0.4535924	kilograms
square miles	2.589998	square kilometres
tons (2,000 pounds, mass)	907.1847	kilograms
yards	0.9144	metres

BENEFICIAL USES OF DREDGED MATERIAL  
PROCEEDINGS OF THE GULF COAST REGIONAL WORKSHOP  
26-28 APRIL 1988, GALVESTON, TEXAS

INTRODUCTION

CALL TO ORDER

Sammy M. Ray  
Workshop Facilitator  
Texas A&M University  
Galveston, Texas

I would like to welcome you to the fourth workshop on the beneficial uses of dredged material. The disposal of dredged material is a long continuing problem, but a problem that has a solution. What we do with this material is often a very controversial matter. To arrive at solutions, meetings such as this are required so that individuals may look at the problem of disposal of dredged material from different points of view. These solutions must be viewed from the standpoint of protecting the environment and providing navigation by the Corps, whose primary mission is to find better ways of disposing of the dredged material. So in previous meetings such as this, groups have discussed different placement methods that are environmentally sound.

In many cases, dredged material that used to be treated as a waste can be utilized as a resource. After hearing both sides of the question, people will have a more detailed understanding of the work being done, and proposals for handling dredged material can be accomplished. As I look out into the audience, I see many individuals representing Federal agencies, private, state, and other interests. I think that we will have an opportunity to discuss the problem. In many situations surrounding discussion of the problem, the issues are often handled in a confrontational or adversary manner. I have been working in the environment for over 40 years, and that work started in controversy and continues in controversy. By sitting down together, we see one another's perspective or view regarding a subject. By looking to the future, we may come to a more beneficial way of doing business. By doing this, we can not only view our own solution to a problem but also understand other people's views or what they espouse in a more beneficial manner. I am

hopeful that as a result of this meeting we come away with a better understanding of the different points of view and also a better understanding of how we seek solutions for an ongoing problem. Also, and this is not original from me as I have not worked closely with dredging and dredged material disposal, but looking down the road, how do we handle dredged material disposal and methods for use of dredged material generated from farming and so forth? How do we deal with the amount of dredged material that comes down our waters each year from upland areas? By dealing with this problem at the source, then we can reduce the problem in our harbors, etc.

It gives me great pleasure to introduce COL John Tudela, Commander of the Galveston District, US Army Corps of Engineers. As a former Pharmacist Mate, third class in the US Marine Corps, I have not had many opportunities to introduce a colonel. I introduce to you COL John A. Tudela.

## OPENING REMARKS

COL John A. Tudela  
Commander, US Army Engineer District, Galveston  
Galveston, Texas

Thank you, Dr. Ray, and welcome to Galveston, welcome to the Gulf Coast Regional Workshop on the Beneficial Uses of Dredged Material, and welcome to the home of the US Army Corps of Engineers, Galveston District. I am very pleased to see the widespread interest that the subject at hand has generated, and I am also very pleased to see that we have had a tremendous turnout. We look forward in the next 3 days to hear the experts in the field, and we certainly have a host of experts with appropriate backgrounds to tell us how we may use dredged material in a beneficial manner.

We have prepared a good program. For your information we sit (at the site of this hotel) on dredged material, which is no doubt a very beneficial use of dredged material. Next to us is a monument of engineering feat, the Galveston Seawall, and if I am not mistaken, we will be blessed with tremendous weather for the next 3 days. I thank you for coming, and I wish you a good stay. The experts here have brought information on better ways to deal with dredged material that can provide engineers with environmentally sound dredged material disposal options. We look forward to seeing the results of the workshop and how we can improve ourselves both in the environmental and in the social sense. I would like to introduce you to the Division Engineer and Commander of the Southwestern Division located in Dallas, TX--BG Robert C. Lee.

## WELCOME

BG Robert C. Lee  
Commander, US Army Engineer Division, Southwestern  
Dallas, Texas

Ladies and gentlemen, it gives me a great deal of pleasure to welcome you to this, the fourth workshop on the beneficial uses of dredged material.

That pleasure is increased by the number and variety of involved interests we have represented here. I know I am talking to the choir when I say this conference is extremely important and timely. For that reason, I am going to keep my remarks brief. We need time to address the problems we have come here to discuss. What do we do with the dredged material we remove to keep our navigable waterways open?

Navigable waterways are the key to both our economic good health and our national defense. Although keeping those waterways open is a Corps responsibility, the disposal of dredged material is not just a Corps problem. It is a problem that concerns government, private industry, and the public. It is a problem that will be solved only if there is a concerted and cooperative effort by all interested parties. I see these workshops as a big step in the right direction toward solving this problem.

Although the Corps of Engineers is well represented at this workshop, this is not a Corps meeting. It is not being held for the Corps to impart knowledge or impose our will in this very sensitive area.

It is a gathering to share knowledge, a chance for different viewpoints to be brought together, a place for us to work out a best solution to our mutual problems.

If you have looked at the agenda for this meeting, you will notice that we have sessions to consider technical problems and opportunities such as the use of underwater berms to nourish beaches, protect shorelines, and preserve nearshore environments and the use of structural and nonstructural means of preserving and restoring beaches.

We will be looking at wave energy and the environmental issues related to beach nourishment and land stabilization. Also among the topics on the agenda for discussion are the technical aspects of dredged materials and



grazing lands, creation of fisheries and fish habitats in estuaries, and creation or enlargement of bird-nesting islands.

We will hear both the researchers' and the contractors' points of view of an aquaculture project that has an international flavor. I do not want to steal the presenter's thunder by going into detail about this project, but it has very interesting possibilities for the future.

In addition to the technical session, we will hear viewpoints from distinguished representatives of government and industrial associations.

There are many more important sessions scheduled for this workshop, but I think you are probably getting the idea just how penetrating these workshops will be.

Frankly, Galveston is a very appropriate place to hold this workshop. If it were not for putting dredged material to a beneficial use, we would not be meeting here.

This hotel sits atop 5 or more ft\* of dredged material. In fact, the entire Galveston Island has been raised about 5 ft by recycling dredged material from the local waterways and channels.

Our Galveston District has one of the Corps' largest dredging missions. My informants in COL Tudela's office tell me they dredge more than 40 million cu yd of material each year. If you put all of the dredged material on a square block of Galveston, it would stack up to more than 14,000 ft high. That is higher than Pike's Peak.

By the way, how many of you took off from Washington National to get here? Washington National Airport is an excellent example of putting dredged material to beneficial use.

It is a sobering thought to realize that we are meeting here to consider ways of beneficially using that 3-mile-high stack of dredged material.

Dredged material and its reuse is not limited to coastal areas. Much work on inland waterways, such as in the upper Mississippi, has been done. However, since this is a gulf coast regional workshop, the majority of what we discuss over the next couple of days will relate to this region.

---

\* A table of factors for converting non-SI units of measurement to SI (metric) units is presented on page 17.

The agenda is exciting, the list of participants is impressive, and the wealth of expertise, knowledge, and experience in this room is unmatched for this kind of workshop.

The challenge for this workshop is to look for solutions to our problems and take advantage of our opportunities.

I regret that I cannot be with you for the entire workshop, but I will be here as long as I can. I am looking forward to acting as the moderator of the Federal panel beginning in just a few minutes.

Thank you for inviting me and asking me to participate. I will see you in a few minutes at our first panel session.

## KEYNOTE ADDRESS

MG Henry J. Hatch  
Director of Civil Works  
US Army Corps of Engineers  
Washington, DC

We have long held the idea that there is no single placement option for dredged material as a panacea. In some cases, ocean placement is the option of choice, and as most of you know, the Corps and US Environmental Protection Agency (EPA) are now finalizing action on the designation of a number of ocean sites. Getting them to agree that dredged material is not sludge and treated under those regulations has been a major breakthrough. The London Dumping Convention (LDC), which most of you realize, is our international agreement concerning ocean placement of dredged material. The view of the LDC is that the ocean should be considered on equal terms with other options. A number of people campaigned in the United States, practically none internationally, with the view that ocean placement be considered the option of last resort. This was internationally rejected by the LDC.

I have not seen and the staff has not been able to convince me that there are, in fact, adverse effects of putting dredged material in the ocean, generally referring to the clean material which represents the vast majority of dredged material. We are still doing a lot of missionary work, and you can see that part of the purpose of this meeting will be considered part of that work so that we can draw our different opinions about dredged material closer together. Beach nourishment is certainly another viable option in many, many cases and perhaps in the great many cases has been the most popular use. Our previous policy allowed us to place this material on the beaches of states and required the state to pay for the added cost. However, the Water Resources Development Act of 1986 allows the Federal government to pay for one-half of the added cost when the state requests placement, and we are implementing this change this year. That is terrific, and we expect a lot of states to have an interest. On the other hand, we have on the other extreme a law in Florida that requires the Federal government to put material from all projects in Florida on beaches at Federal expense. We have not agreed to that, but you can see the opinions on how to use that dredged material vary from a state

that mandates beach use to others that would just like to see the dredged material go away.

A lot of other options are available, diked containment areas, upland placement with a lot of uses with proper management. I think that we will talk about site management during this workshop. Every project, and certainly the placement of the dredged material as a component of the project and a very important component of our projects, has to take into account our three E's, i.e. engineering feasibility, economic sense, and environmental sensitivity. We talk about the three E's, and we refer to the relative health or viability of any proposal we are about to undertake; or I might add that in the permitting process of any proposal when we are looking at other people's planned or proposed activities.

The beneficial uses, as the name implies, can in fact show up on the benefit side of the benefit cost calculation. So those of you who pictured the Corps of Engineers as the "Colonel Blimp" with the pith helmet and the "keep busy button" could say that they are here to find additional benefits for placement of dredged material so that they can inflate the benefit to cost ratios. Well, I would simply argue that if we have a bona fide benefit that accrues to the Federal Government and the public because of the dredged material placement and subsequent use, then fine, so be it. I might add that those benefits are not solely economic but also environmental. Bird, fish, and shellfish habitat development, artificial islands, and wetlands all can be created. We still have a number of disbelievers who say that you cannot create a wetland. Evidence continues to grow to demonstrate that we in fact can, we have, and we will. I might add that our own regulations require the Corps to consider beneficial uses in every dredging project. We have had a lot of innovation in the last 10 years. We have proceeded with the classic uses, the addition of land for airports, parks, parking lots, industrial developments, and so forth. They are all over the world and in the United States, such as fill for highways, railways, construction aggregate; sand for roads in the winter are probably used more in St. Paul, where the last workshop was held, than in Galveston, but it is used up north.

Some new ideas have focused on Murden's Mounds, named in honor of Bill Murden, recently retired division chief of our dredging division in the Civil Works Directorate. We put mounds not really directly on the beach, but out shortly offshore in the nearshore zone, and they serve as a feeder to bring

material onto the coastline. They also reduce wave energy on the beach. A number of our current initiatives include working with the National Marine Fisheries Service (NMFS) on an effort to restore coastal habitat resources. That program is in its third year, and we have pilot projects with them under way in several areas. These show promise. We are using Murden's mounds, creating artificial reefs, breeding grounds, and other things. That idea was first briefed to Army and Congressional leaders, and Mr. Bill Gordon, the NMFS leader, presented some alarming statistics on coastal habitat losses and the resultant losses on fisheries production. It was suggested that rather than viewing habitat loss and placement of dredged material as two separate issues, we try to consider them collectively. The National Oceanic and Atmospheric Administration (NOAA) research on delineation and ecological characterization of the critical coast and offshore habitats is another effort. Many of you have heard debate over wetland versus shallow habitat. We can design and construct a wide variety of habitat with dredged material, but we still need to develop definitive habitat guidance on the physical habitat requirements for each body of water and region where we dredge. Data from the US Fish and Wildlife Service (USFWS) wetland inventory will be useful. Within the Corps, we are developing guidance for dredged material and for long-term placement strategies. In fact, we have encouraged all of our port Districts, for example those who have major ports, to develop with the local interest, who in many cases are required to provide the dredged material placement sites, a long-range plan and stop trying to do this year by year by year. Development of that plan is, of course, in coordination with all the State and Federal agencies that are interested.

The Congressional Office of Technology Assessment recently released a report that indicates that 95 percent of the material that we dredge could be put to beneficial use; and in fact, that only 15 percent actually is. We can do better. Indeed, judging by the letters that we get now from the public and Congress concerning dredged material, the public has clearly come to look for and accept beneficial uses. Now you will notice that I did not use some traditional words in my remarks. I did not say "spoil," and I referred to "sludge" only once. I did not say "disposal." It began at our first workshop with a little mind game. Let me share with you some of my thoughts on what is in a word. I believe that when we get into a discussion of the beneficial

uses of dredged material, it is difficult to use terms with absolutely no value at best or disgusting at the other end of the spectrum or harmful.

I think that dredging has received a bad rap at least linguistically. When someone asks, "Where did you 'dredge up' that suit you have on?" chances are they are considering something like the Salvation Army rather than Nieman Marcus or Brooks Brothers. Now, we are not going to banish the word "dredge"; I think that is too much a part of us. Dredging is simply a mechanism for subaqueous excavation. I suggested this at one time, and the eyes kind of "rolled back," and I got a blank stare; so let us just stay with "dredging." But anyway, I think that we have a bunch of words that my mother used to say "simply do not belong in polite society."

Especially now that our dredging activity and the interest in it is really up, I do not use the terms "disposal" or "dumping"; those are two. What do you dispose of, and what do you dump? Something that across the board is 90 plus percent available for use beneficially, no. Both of those imply something that we are trying to get rid of, whereas we should be looking for ways to put that material to use. It is not just a Corps problem as I indicated before; local sponsors under the Water Resources Development Act must find those relocation sites. Anyway, even the Act says "disposal" sites; so we will probably keep using that word. Naturally, when someone is looking for a "disposal" site or a "dumping" ground that is a good one, then, the first response is "not in my back yard." However, when we talk about placing material that is clean, you say, "Wait a minute; I am looking for some fill. That is good; put it here; I can use it."

The Chief of Engineers has an Environmental Advisory Board formed several years ago, roughly about the time of the passage of the National Environmental Policy Act or shortly thereafter, to provide the Corps of Engineers with a more direct insight into its environmental challenges and responsibilities from outside the Corps. That board still exists and meets twice a year. Last month at a subsequent periodic meeting, one of the members suggested that we substitute "placement" for "disposal" and "dumping." So you see that I even tried to do that in the opening comments, and it is difficult even for me. But I had to smile when he said that, as I had just approved a directive to the Corps to begin trying to do just that. We even used that suggested word. There are some other words; "spoil" is one of them. What is spoiled or putrid about dredged material? I had an opportunity to appear before Congress

when they were considering the disposal of sludge, among other things, from the sewage treatment systems from New York, and they wanted me to talk about dredged material reflation. I had the opportunity to distinguish between the largely organic and our largely mineral stuff that does not have a direct impact on the water column and then settles to the bottom, as does sludge, which has a rather extensive horizontal dispersal and hence adverse impacts.

When the construction industry excavates for a building, do they produce construction "spoil"? Do we call that "sludge"? The only difference between materials is that ours has been below water and there is a lot more of it to move in our projects. Another word is "sludge," and I have already talked about that one, and it is a problem. Well, just think about that. I engaged in a conversation with a lady from the Sierra Club at our meeting in Baltimore, and we had a great time. We were speaking two completely different languages. I was doing my absolute best not to use those terms, and she was using every one after I had given this talk, and she was speaking through gritted teeth, which is nice.

Anyway, the public is changing its general attitude about the material. I mentioned the cards and letters we are getting for the "Hey, come get it here." We are getting more of these letters than we ever have before. Perhaps those cards and letters far outnumber those letters that say, "Do not do this in my backyard."

Now, the rest of the seminar is going to focus on practical, economic, sensible ways to bring that about. I wish all the participants all the success, and I will be able to stay with you all day today. We still have an awful lot to learn; we have a lot to learn. If we have something new to share with you, these meetings provide an opportunity. I wish you well over the next few days, and again a lot of thanks to the Galveston District for hosting this meeting. To Dr. Ray from Aggieland, I appreciate your role in this workshop. I wish you the very best.

QUESTION: What is the overall current status of Murden's Mounds? These mounds are offshore deposits of dredged material that can provide a source for beach nourishment or reduce wave energies.

RESPONSE: These mounds are being used off Hampton Roads, Norfolk District, and other areas. In the gulf, these mounds are being considered for Mobile District in Mobile, AL. If you are interested, then contact either the

US Army Engineer Waterways Experiment Station (WES) or the Mobile District, US Army Corps of Engineers (CE). In the Galveston District, a mound is proposed for Brownsville, TX, and should be initiated this summer.

QUESTION: I agree that words such as "spoil," "dumping," etc., do con-  
note a negative meaning, but you also used the word "fill." I think this is a  
good word without negative meaning.

RESPONSE: Thank you, I knew that I was on shaky ground when I added  
that word to my script.

QUESTION: What is the consistency and length of term of the Corps'  
Environmental Advisory Board?

RESPONSE: They serve staggered terms, and COL Kit Valentine is an  
informed point of contact on this subject. The EAB members are appointed by  
the Chief of Engineers. More detailed information can be obtained by contact-  
ing COL Valentine in my office. What we try to do with that group is not to  
pick people from the choir, but their purpose is to tell the "king he has no  
clothes on." All their meetings are public, and all are announced in the  
Federal Register. Please call COL Valentine in my office, and he would be  
delighted to respond.



FEDERAL AGENCY VIEWPOINTS ON THE BENEFICIAL  
USES OF DREDGED MATERIAL

Moderator: BG Robert C. Lee

VIEWPOINTS OF THE US DEPARTMENT OF AGRICULTURE

Frank Wheeler  
Soil Conservation Service  
US Department of Agriculture  
Temple, Texas

I appreciate the opportunity to address the participants of this very important workshop. First, I would like to extend the regrets that our new State Conservationist, Wes Onoth, who has come to us by way of Ohio, could not be present to attend this meeting. He had a previous obligation, but he sends his regards. As most of you are probably aware, the Soil Conservation Service (SCS) or those of us that work for the SCS consider the SCS to be the technical arm of the US Department of Agriculture (USDA). A little more simply put, we provide technical assistance to the landowners to help them conserve their soil and water resources. Working through local soil and water conservation districts, we help the landowner to develop conservation plans that include such practices as grasses, waterways, terraces, diversions, contour farming, minimum tillage, conservation tillage, and uses of crop residues on the land. The SCS's role, then, is to keep the soil on the land, and this has already been addressed by some of the earlier speakers.

If a soil does not enter the waterways, it does not become dredged material. In other words, as an agency we are in the business of putting the Corps out of the business of dredging. This workshop is evidence that we have fallen somewhat short of that goal. From a more positive view, what would dredging activities be like today if we had made no effort as an SCS service agency and the local landowners have made over the last few years? The role of the SCS as an agency is to reduce the amount of sediment and materials which enter our Nation's waterways. I would like to speak to you from a soil scientist perspective, and that is my background as I am not directly involved in conservation planning. I am more of a resource gathering person in that I obtain soils data and natural resource data; but from a soils scientist

perspective, I would like to take just a minute to discuss this material we call "dredged material." Prior to 1969, some 19 years ago, those clay sediments dredged or pumped from the floors of rivers and bays were all identified by soil classifiers as "land type" or "made land," as the Corps was out there "making land" that we all could see. In areas where no islands existed, there was suddenly an island formed. So we called this "made land" and labeled it a miscellaneous land type because we did not know what this feature was. We had not taken the time or effort to identify this material.

In 1969, we were in the process of taking a soils survey in Chambers County, Texas, and as young soil scientists, we were trying to master a new publication called SOIL TAXONOMY. Some of you may be familiar with this publication. In an effort to place all soils or soil-like materials into the new classification system, we had to make a close examination of all miscellaneous land types and other systems that we called alluvial lands, etc., and this made land was another of the miscellaneous land types. So we drew lines around this land, or dredged material, which had been placed on the landscape. We ran lines of transects across this material and studied it. We classified several of the sites in Chambers County. We came to the conclusion that we could identify this soil or this material, which we called "dredge." So we named this material, and we called it the I-jam series, which was named for a small community in Chambers County. Now, the person that named this (and I noticed one or two persons cracking a smile and I was not the one that did this) but we accused the person who came up with this name that he could not really figure out what this material was and I am going to "jam it" right here in the classification system. Which worked out very nicely, and it was named after a small community in Chambers County.

If you want to review some of the ranges of the characteristics of the I-jam series, then you need to refer to the recent edition of the Galveston County soil survey. It was published 3 weeks ago, and I have brought two boxes of the publication with me; that is all the copies that I had. Both boxes are situated at the registration table. Please sign the report-wanted sheet if you would like us to send you a copy. You can read about the I-jam soil and these soils that have a wide range of soil type, such as shells, clay, etc. We do not call it "sludge." We do not call soil "dirt" in the SCS. Dirt is that stuff your mother used to sweep under the carpet. We do not call dredged material "sludge."

Now for the beneficial uses of dredged material, I am sure that many individuals in this room have a better idea of the types of problems that dredged material can help as a beneficial use. My personal experiences are rather limited. I was the party leader for the Harris County soils survey, and I recognize a few people in the audience who have had an impact on the environmental aspects. One is Ms. Terry Hershey. There are several persons here I recognize from Texas A&M University. But my personal experiences with materials that have been dredged are those that were hydraulically pumped from the Houston Ship Channel and placed in these leveed areas, the soil particles settled out, and the water drained back into the bay. These areas were barren and stayed barren for several years. The dredged material is a medium in which plants can grow. Maybe we do not always want to grow plants, and perhaps we would like to build wetlands as we have said. Back in the 1970's, dredged material was used for cattle walks out into the marsh, wildlife habitat, building sites; where vegetation was established, it was used for livestock grazing. Those are some personal observations that I made out in the field.

From an environmental standpoint, the SCS is concerned that dredged material is placed in areas that have the least impacts on wetlands and our prime farmland resources. The SCS can be of assistance in identifying these important resources. We have expertise in the fields of critical area treatment, plant materials development, wildlife habitat management, and shoreline erosion control. I feel confident that the SCS, of course within its personnel limits, can carry out these tasks. The SCS is willing to work with groups such as Federal, State, local, etc., to achieve the beneficial use of dredged material. Thank you.

VIEWPOINTS OF THE US ENVIRONMENTAL PROTECTION AGENCY

Norm Thomas  
Region VI, Federal Activities Branch  
US Environmental Protection Agency  
Dallas, Texas

On behalf of Mr. Robert Layton, EPA, Region VI, Administrator, I thank you for the invitation to this fourth workshop on beneficial uses of dredged material. It certainly is timely and appropriate for Galveston, along the gulf coast, to host this meeting. The problems in the Gulf of Mexico are gaining national attention.

Let me say right up front that we are concerned about wetland loss and coastal erosion. Everywhere that dredged material can be utilized to benefit wetlands through creation or enhancement, it should be strongly considered. Everywhere it is economically feasible and environmentally acceptable to use dredged material to protect or restore coastal areas, it should be done.

We have all heard the story about "The sky is falling, the sky is falling." Well, I am beginning to believe it with regard to the loss of wetlands and increased coastal erosion. Maybe we should be yelling, "The sea is coming, the sea is coming." The Corps of Engineers and some other select few have been working on this problem for years. Now these concerns are getting greater attention; many more people are talking about coastal erosion and wetland loss; more people now understand and fear what the losses could mean to the economic prosperity of the gulf coast.

The EPA, and particularly Region VI, has in recent years become more aware of and concerned about the loss of coastal lands, marshes, and wetlands. The number of square miles reported as lost is hard to imagine, but the loss is observable and certainly believable. Since Region VI encompasses five states, which include Texas and Louisiana, the stretch of coastal area is extensive.

The statistics are repeated often but deserve to be repeated again.

- a. More than half the wetlands in the lower 48 states have been lost.
- b. Every year, 50 square miles of coastal Louisiana are lost.

The areas experiencing the greatest wetland loss during the last 20 years are the lower Mississippi River Valley and the gulf coast and plains of Louisiana, Florida, and eastern Texas. Recognizing the importance of the

gulf, the EPA has recently initiated what it calls the Gulf Initiative. A video recording explaining the effort is available in the foyer for anyone to view.

If you stop and think of it, the Gulf of Mexico is extremely valuable and deserves a special initiative.

- a. Two-thirds of the contiguous United States drains into the gulf.
- b. The gulf produces approximately 40 percent of the Nation's commercial fish yield.
- c. Gulf shrimp fishing is most valuable in the United States.
- d. The gulf provides critical habitat for 75 percent of migratory waterfowl traversing the United States.
- e. Gulf coastal wetlands comprise about half of the national total.
- f. One-sixth of the US population now lives in gulf coastal states.
- g. Ninety percent of all US offshore oil and gas comes from the gulf area.
- h. Approximately 45 percent of US shipping tonnage passes through gulf ports.
- i. The Navy has proposed eight strategic homeporting sites in the gulf.

The Gulf Initiative seems to be a logical effort to voice the awareness of the problems and potential solutions in the gulf coastal area.

I do not have the statistics, but it stands to reason that most of the dredging operations occur along the gulf. Since we are losing the most area and have the most dredged materials, it stands to reason we should strive to obtain the most benefit from the disposal of dredged material.

This panel is asked to express our respective agency's views relating to the beneficial uses of dredged materials. A short answer would be that EPA supports any use or method of disposal for dredged material that would provide for creations of marsh and wetland habitats, or provide for reduction of loss in coastal lands or provide protection against hurricane or floods.

The agency's role in managing the disposal of dredged material is regulated under two laws--the Marine Protection, Research and Sanctuaries Act (MPRSA) of 1971 and Section 404 of the Clean Water Act (CWA). Regulatory authority under both laws is shared jointly by EPA and the CE. The CWA program primarily seeks to protect US waters, wetlands, estuaries, lakes, rivers, and streams, whereas MPRSA is concerned with protection of the oceans. Consideration of the beneficial uses of dredged material is a common issue shared in both programs.

Under MPRSA, the control of ocean dumping of dredged material is primarily exercised by means of two activities: EPA's designation of sites for ocean dumping and the CE's issuance of permits for ocean disposal of dredged material. Since receiving delegation of the ocean dredged material disposal site designation program from EPA headquarters, seven sites have been designated by our Region--four off the Texas coast and three off the Louisiana coast. We have another 18 sites pending designation. Except for the Navy homeporting facility, the ocean dumping sites being designated have been used by the Corps for 20 or more years. The EPA's primary responsibility under the law is to determine if the continued use of these sites by the CE will result in unacceptable adverse impacts. If not, the disposal site is designated, and a site-specific management and monitoring plan is developed.

The EPA, Region VI, has a standing Memorandum of Understanding (MOU) with both the Galveston CE District and the New Orleans CE District. These MOUs identify each agency's responsibilities regarding preparation of site designation environmental impact statements (EISs), preparation of rule-making packages, and development of site-management plans. We are proud to say that we have an excellent working relationship with both the CE District offices.

During the preparation of site designation EISs, the issue of beneficial use of dredged materials has been raised. Our response has been that, although this issue may be highly relevant to determining the need for ocean dumping in relation to a specific dredging project, it is not directly related to the EPA's proposed action; that is, we are evaluating the "acceptability" of an ocean disposal site. The EPA believes that beneficial uses of dredged material should be addressed during the Corps project review process. Also, the EPA encourages and supports the Corps' continued research of beneficial uses of dredged material while we work toward the designation of existing ocean disposal sites.

The EPA has been involved in wetlands protection since the passage in 1972 of Section 404 of the CWA, which regulates the discharge of dredged and fill material. The primary purpose of Section 404 is to restore and maintain the chemical, physical, and biological integrity of the waters of the United States through control of discharges of dredged or fill material. This, as you know, is a shared program with the CE.

In our region, we review between 1,500 and 2,000 projects per year. One of the basic tools for review is the 404(b)(1) guidelines. These guidelines

require alternative analysis and incorporation of mitigation for impacts on wetlands. We often ask for mitigation, which makes use of the dredged material for enhancement of the area. Another tool is the CE public interest review; it is in the national public interest to provide protection and to restore and maintain the Nation's coastal waters and wetlands.

The growing awareness of the problem is encouraging. I am particularly proud of the mass effort going on in Louisiana. Legislators, State agencies, Federal agencies, city groups all are joining the effort. The CE New Orleans District has recently initiated a Louisiana comprehensive coastal plan study. The reconnaissance phase was kicked off by Colonel Brown in February. It is designed to have full participation of State and Federal agencies. This study along with several others ongoing in Louisiana will be looking at wetland creation and preservation alternatives that would include beneficial uses of dredged material. The CE has published an informational booklet describing the problem, causes, and potential actions available.

Back several years ago, we all appeared to agree that the loss of wetlands and coastal lands were caused by: (a) man-made activities such as leveeing and channel work; (b) loss of new sediments and materials; (c) subsidence; (d) saltwater intrusion; and (e) relative sea level rise.

Given this, and recognizing the need for large amounts of dredging for navigation and flood-control purposes, we need to think about dispersing it for the benefit of a wetlands enhancement and creation program. Building marsh, diversions for marsh management purposes, plugs and placement in old canals, and beach nourishment, all should be considered. Take credit as a mitigation effort.

While it appears that the problem is gaining interest on a national level and the general public is expressing concerns, it still disturbs me when I hear some things from old timers as I did a couple of weeks ago. This remark I heard from a person from another agency, "The problem in Louisiana can be stated in three words: drainage, drainage, drainage." That to me means only one thing: There are still those who believe that wetlands are in the way of progress. We still have a selling job to do. If we can put the dredged material to a beneficial use, let us put a dollar value on it that is realistic, let us make allowance and give credits for mitigation; and if the B/C ratio is anywhere reasonable, then let us put the dredged material to work for us.

I do not pretend to have the answers. Therefore, I look forward to the papers to be presented. But I can say this--while EPA views dredging as essential, it also views the material as valuable and believes it can be of beneficial use if properly applied.



## VIEWPOINTS OF THE NATIONAL MARINE FISHERIES SERVICE

William B. Jackson  
Southeast Region Liaison Officer  
Southeast Regional Office  
National Marine Fisheries Service  
Galveston, Texas

It is a pleasure to be here today. On behalf of Dr. Joseph Angelovic, Acting Regional Director of the Southeast Region, NMFS, I wish to thank the Corps of Engineers for putting this workshop on the beneficial uses of dredged material together. Since 1986, the conferences and workshops held concerning this important topic have certainly led to many valuable and important research efforts at the state, Federal and university levels, with quite a diversity of findings, to say the least. All of the different opinions as to the way to use dredged material in the most beneficial way reminds me of five Aggies who were trying to measure a telephone pole. One was on the bottom, and the others were on his shoulders with yardsticks. A friend came by and suggested that, since the pole was not tight in the ground, they lay it down and measure it. The Aggie on the top said, "We do not want to know how long it is. . . . We want to know how tall it is." Well, it seems that how we measure the beneficial uses of dredged material is at this stage of just who is looking at the way the measurements are made. Perhaps it is now time for a more focused approach.

The NMFS in 1983 adopted a far-reaching policy on habitat conservation. This policy ensured that habitat, from the ocean to coastal wetlands and estuaries, is fully considered in all NMFS programs and activities. It laid the foundation to increase attention to habitat conservation on species for which the NMFS has management or protection responsibilities; for management and research cooperation; and for strengthening working relations with NMFS constituents and partners. The goals of the Habitat Conservation Policy were specified in 12 implementation strategies.

Implementation Strategy Eight has direct relevance to the topic of this conference, "The Beneficial Uses of Dredged Material." This strategy calls for NMFS to become more actively involved with agencies such as the Corps of Engineers during early stages of project development. This is intended to reduce conflicts and introduce practical alternatives, mitigation planning,

and habitat enhancement measures. Based on this strategy, the NOAA and Department of the Army in 1985 entered into a cooperative agreement for NMFS and the CE to conduct a pilot study to determine the feasibility of establishing a nationwide fisheries habitat restoration and creation program. Two study sites have been selected in the Southeast Region on existing dredged material disposal sites. One study is located in North Carolina and the second in Galveston Bay, Texas. These pilot studies will be discussed later in this conference by our Beaufort and Galveston Laboratory researchers; so I will not go into any more detail here.

The pilot studies provide an excellent avenue for determining beneficial uses of dredged material. Past disposal practices have been implemented, based primarily on availability of disposal areas and economics. As such, the impacts to fishery resources have not always been controllable and frequently turned out to be damaging. For example, while maintenance dredging the Gulf Intracoastal Waterway (GIWW) along East Matagorda Bay Texas in 1983, large areas of the shallow bay, which provided excellent habitat for marine fishery resources, were covered with disposal material.

The consideration of fish and wildlife as a primary focus of any dredged material disposal plan is necessary to direct disposal alternatives. This may often dictate disposal on upland areas or at offshore sites away from estuaries, but a review may also present important opportunities to enhance near-shore and estuarine fish and wildlife resources. Examples include the rapidly subsiding and eroding substrate in coastal Louisiana, which is resulting in the conversion of about 50 square miles of marsh into open water annually. In that area, we have encouraged the spreading of material dredged by the New Orleans District into the recently formed open water to reestablish the substrate to elevations that support marsh. I believe that the success of such marsh reestablishment is being discussed later in this conference. We also have been in recent consultation with the Galveston District concerning marsh establishment to be attempted on material to be dredged from deepening the Texas City Ship Channel.

We would like to see the coordination mechanisms established by the NMFS/CE/Cooperative Agreement expanded to not only establish new beneficial uses of dredged material to enhance fish and wildlife, but to mitigate for past practices. Both NMFS and the CE are conducting the existing pilot study

using current authorities, resources, and funds to implement selected habitat restoration and creation proposals. Clearly, the determination of beneficial uses of dredged material warrants the expansion of at least the current funding structure, since within NMFS, existing funds are insufficient to carry this program beyond a minimal effort. Based on the reports you will hear later on the existing pilot studies, I believe you will see their importance and the need for increased financial support.

I would also like to take this opportunity to alert you to an important new partner in your deliberations on activities that affect fishery habitat. The Gulf of Mexico Fishery Management Council (GMFMC), as well as the other seven fishery management councils, have been given comment and recommendation authority over any habitat alteration activity undertaken within its jurisdiction by the 1986 Amendment to the Magnuson Fishery Conservation and Management Act. The Gulf Council has established a habitat policy that is supported by three objectives, as follows:

- a. Maintain the current quantity and productive capacity of habitats supporting important commercial and recreational fisheries, including their food base (this objective may be accomplished through the recommendation of no loss and minimization of environmental degradation of existing habitat).
- b. Restore and rehabilitate the productive capacity of habitats that have already been degraded.
- c. Create and develop productive habitats where increased fishery productivity will benefit society.

To achieve these goals, the Gulf Council has formed a Habitat Committee and Advisory Panels for the gulf states. The purpose of the Committee is to bring to the Council's attention activities that may affect the habitat of the fisheries under its management authority. The Council, pursuant to the Magnuson Act, will use its authorities to support State and Federal environmental agencies in their habitat conservation efforts, to ensure that habitat losses are kept to the minimum, and that efforts for appropriate mitigation strategies and applicable research are supported.

The NMFS supports the search for beneficial uses of dredged material that have the potential to benefit the production of marine, estuarine, and anadromous fishery resources. Since past studies of newly created or reestablished marsh are inconclusive as to its ability to support the recreational and commercial fishery resources that our society needs and depends upon, refurbishment of existing marsh may be preferable to reestablishment

methodology. We therefore encourage the development of techniques that renourish sinking marshes and enable the existing vegetation to grow through the new layer of substrate.

We also encourage efforts directed at enhancing past disposal areas that have adversely affected fishery production. With regard to other possible beneficial uses, the useful life of confined disposal sites could be greatly extended if the confined dredged material could be made more available and attractive for commercial use, such as for raising the grade elevations of low coastal emergent lands, in need of higher elevations for subsequently constructed buildings to meet Federal flood insurance requirements. We thank you for inviting us to present these NMFS viewpoints on the beneficial uses of dredged material. I wish all of you success in meeting the objectives of the conference.

## VIEWPOINTS OF THE US FISH AND WILDLIFE SERVICE

Michael J. Spear,  
Regional Director, Region II  
US Fish and Wildlife Service  
Albuquerque, New Mexico

I am Mike Spear, Regional Director for the US Fish and Wildlife Service (USFWS), Region II, which includes the Texas coast. I am pleased to be on this panel to address the potential beneficial uses of dredged material.

The subject of the workshop, "The Beneficial Uses of Dredged Material," is particularly timely for dredging activities along the Texas coast. While many of our navigation channels have existed for a number of years, they are continually evolving to meet the changing needs of the waterborne transportation industry. Channels are being deepened to accommodate deeper draft vessels; larger turning basins and wider channels are needed to satisfy and accommodate larger vessels. Such project modifications lead to greatly increased amounts of initial and maintenance dredge spoil.

Through the years, there have been many changes in the maintenance of navigation channels, both deep and shallow draft. New disposal areas for these channels have been created while others have been reconfigured or subdivided. Some confined disposal areas are now approaching capacity, thereby, creating a problem with future disposal in locales where only open water or wetlands remain near the waterway.

In meeting our responsibilities under the Fish and Wildlife Coordination Act and the National Environmental Policy Act, the USFWS participates with the CE and other agencies in the planning of dredging projects and selection of spoil disposal areas. We maintain that wise resource management would eliminate the use of shallow open-water disposal areas; however, progress toward this goal has been slow. Also, sediment and water analyses have revealed that certain channel sediments are very likely to have long-term contaminant impacts on fish and wildlife.

The service supports the uses of dredged materials in the least environmentally damaging manner. Such activities include recycling programs, use as construction materials, and wetland creation and protection. These activities facilitate wetland management and protection and enhance existing disposal capacity management.

There is no way to accurately determine the extent of wetland habitat loss from historical maintenance of the GIWW, because there were no environmental requirements to monitor such impacts until the early 1970's, after approximately 85 years of work had been completed. Any disposal area confinement and change in surface elevation are usually devastating to wetland habitat. Even if the elevation remains stable, the drying of dredged material often forms a hard crust that is not readily penetrable by plant roots. There are remnants of wetlands within many of the confined disposal areas, but these areas are usually slated for further deposition of maintenance material in the near future. Normally, the maximum useful life of a confined disposal area is 50 years.

The benthic community in and adjacent to a disposal area is frequently covered by dredged material as it spreads out from the point of disposal. Recovery is possible by upward migration of buried organisms; however, it is generally accepted that the benthos are smothered by the deoxygenated sediments, and recovery results primarily from recolonization.

Recovery time for a disturbed bay bottom community depends upon many factors. Primary among these is the character of the deposited material compared with the original bottom. Recovery is least rapid when fine-grained clays and silts are deposited on a sandy substrate. Recovery times have been documented to range from a few weeks to more than a year and a half, depending upon the interplay of sediments, currents, and weather.

The biochemical impact of dredged material is a subject that generates many questions but few answers, because dredged material contaminants are not known to have acute impacts such as fish kills. There are, however, a variety of sublethal impacts that can be demonstrated and are highly suspect in reducing potential productivity in the bays and estuaries. Most estuarine communities live in the suspended sediment immediately above the bay bottom, which is well documented in literature to contain the highest level of contaminants and where most benthic feeding occurs.

Currently there are in excess of 64,000 chemicals manufactured or used as new materials in petrochemical and pesticide manufacturing. Waste products from these industries enter navigation channels through spills, air emissions, waste storage area runoff, waste discharge, urban runoff, and agricultural runoff. These contaminants are usually bound to suspended sediment and settle in channels where they are redistributed during maintenance dredging

operations. Only a few of these contaminants are monitored as part of the present dredging program. Many contaminants are not very water soluble so the elutriate test currently used by the Corps often indicates low contaminant levels. These pollutants are usually strongly bound to fine sediments. In the elutriate test, these sediments and their associated contaminants are filtered and separated from the water before chemical analysis, thereby, making it virtually impossible for these contaminants to be detected.

These sediment-bound contaminants are filtered by molluscs in the estuary and ingested by most fish and shellfish species. Strong digestive enzymes metabolize these contaminants from the sediment, which reduces hatching of eggs, causes death of larval stages, and reduces growth of young. This results in a reproductive and recruitment loss to the estuarine community, which at present is unquantifiable.

Mitigation for the adverse impacts of contaminated dredged material must begin with an identification of the problem. Stretches of navigation channels that have a high likelihood of contamination should be identified and sampled for most of the EPA's priority contaminants. Analysis should include concurrent sampling of the sediment, overlying water, and the benthic community in the sediment to establish the presence of contaminants and the partitioning among the three components. This information could then be used to establish sediment criteria for dredged material and to determine which, if any, contaminants should be monitored on a long-term basis at each disposal site. Obviously, contaminated dredged material is limited in its uses in beneficial applications.

The task of establishing sediment criteria is a difficult one that would require the participation of the Corps, the EPA, the Service, the Texas Parks and Wildlife Department, and the Texas Water Commission operating as a working group. An acceptable level of contamination in the sediments must be decided upon using the relationship between contaminant levels in the sediments, in the benthic community, and the known toxicological data. Once the criteria are established, we will have a scientific base from which to decide if dredged material is acceptable for continued use outside contained disposal areas.

On 13 December 1983, the Corps formally requested that the Texas Department of Highways and Public Transportation, local sponsor for maintenance of the Gulf Intracoastal Waterway, obtain additional disposal areas for selected

reaches of the Waterway where disposal capacity is anticipated to be lacking in the very near future. The long-term goal of the Service on the Texas coast is to see the bulk of all dredged material safely contained on uplands or appropriately disposed offshore in the Gulf of Mexico, if other beneficial uses or less environmentally damaging alternatives cannot be identified.

As is obvious from the theme of this conference, not all experiences with dredged material disposal have been bad. Some of the best seabird rookery sites on the Texas coast, including the only nesting site for the endangered eastern brown pelican, are dredged material islands. Nesting of certain species of birds are to a great degree dependent upon a steady supply of fresh dredged material to retard vegetative succession on their nest sites, and many rookeries would disappear altogether if constant spoil deposition did not keep pace with erosion. Nevertheless, this beneficial aspect of the disposal should not be viewed as a constant demand for more islands. In fact, we suspect that most colonial-nesting waterbirds along the Texas coast are not limited by the availability of nesting areas and that in some places the presence of too many disposal islands located too close together leads to predator problems.

What may be needed is not more rookery islands, but better management of the ones we already have. For example, because ponded water can sustain coyotes and raccoons on an island, they then can destroy bird eggs and nestlings and will eventually frighten away the adult birds. Existing water-holding depressions on islands should be filled with spoil, and containment areas should be designed so that all rainwater drains off between dredging cycles. In this and other ways, uncontaminated dredged material can certainly be put to good use for the sake of the migratory birds.

There are other beneficial uses of dredged material for which further evaluation is needed, especially in the area of marsh creation. Marsh creation is best attempted in low energy areas where marsh once existed but has been lost to subsidence, fill, or erosion. Marsh creation goals include viable nursery areas for estuarine species that continue to thrive over the long term with little or no maintenance. These marshes may also provide habitat for wintering waterfowl and contribute to waterfowl population restoration and maintenance goals described in the North American Waterfowl Management



Plan. Implementation of this plan developed jointly between the United States and Canada is a top priority within the Service.

Disposal area reuse management or "recycling" is a technique to extend the life of existing disposal areas. This technology has been extensively researched by the Corps and has the beneficial use of material already in disposal areas as its central feature. There are many disposal areas that are easily accessible where this technology could be applied. If existing disposal areas could have their useful life extended, it would greatly reduce the need for new disposal areas and ease the abandonment of problem sites. The Service is presently pursuing implementation of this technique in association with the Texas City Channel enlargement project in Galveston Bay.

One little explored area is the use of uncontaminated dredged material for top soil refurbishment. What might appear at first to be a high-cost disposal practice could well turn out to be very feasible when weighted against costs to prevent top soil erosion. Much additional work and a pilot study are needed in this area.

In summary, the Service supports beneficial uses of dredged material that protect and enhance the wetlands and shallow open waters of the gulf coast. Principal concerns center on open bay disposal, confined spoil area location, and adequate identification, evaluation, and disposal of contaminated spoil material. The potential exists for disposal area reuse management (recycling) and for marsh creation and maintenance.

Thank you for the opportunity to attend this workshop and present the views of the Service. The Service recognizes that the proper handling and disposition of dredged material is a challenge that will extend into the future. It is our sincere hope that workshops such as these will help identify both the long-term problems and opportunities associated with this issue.

## VIEWPOINTS OF THE US ARMY CORPS OF ENGINEERS

Charles Hummer  
Dredging Division  
US Army Corps of Engineers  
Washington, DC

Thank you very much, GEN Lee. I was a little concerned at some of the remarks that Mike Spears made because in trying to correct the record I might be falling on someone's sword. We have joined with EPA in a rather extensive set of testing procedures where we looked at the disposal of dredged material, and I might add rather highly contaminated material in the EPA Field Verification Program. The Field Verification Program (FVP) was a \$7 million program where we were able to dispose of the same material in a marshland creation area, open-water bay bottom situation, and finally upland. Comparisons could be made of the impact of each disposal environment. One of the primary objectives of the effort was to test and quantify the sublethal, long-term effects of contaminated dredged material. Unfortunately, we did learn a lot about sublethal effects but did not obtain a final answer as this is a difficult, ongoing research area. This is good news.

As GEN Lee mentioned, I did go to Notre Dame with those two nuns that he mentioned earlier. I graduated out of sequence with 200 nuns, and 4 Baptist missionaries, and I was the only chemical engineer who was noncleric in the class. That was many years ago. I also might point out Mike Spears was not a Texas A&M University graduate, but that I am. I actually graduated from a dredging short course in 1978 from Texas A&M. I shall never forget that experience because when Dr. John Herbich gave me the certificate that I could not read, he said that you are now one.

I think GEN Hatch clearly conveyed to you this morning the Corps' views and perspectives on the concepts of the beneficial uses of dredged material and the opportunities that it offers. I would like to use my time to overview our national views, policies, and constraints and how we handle dredged material. Some of these constraints relate to how, when, and where we can use beneficial uses as a viable alternative. Certainly, these are alternatives that we should and must use, under regulations and the law, in planning our dredging projects. I hope that this overview will be helpful in light of the following technical views and discussions.

The Corps' basic Civil Works mission is water resources management. In our evaluations, we are always required to look at the balanced use and conservation of all our resources. MG Hatch stated as our position that dredged sediments must be viewed as one of the many resources we should and must manage. In specific regard to our navigation mission, the Corps is probably unique in the world or in the sense that Congress has tasked us with dredged material regulatory activities and on the other hand with construction-operations with attendant disposal of dredged material. On the surface, and some of you will agree with this, this may appear to be a conflict and appear to be the fox guarding the hen house routine. I think, however, that the Congress routinely weaves an intricate and often complex web of checks and balances into authorities which it assigns to the executive branch agencies, and certainly the Corps with its dredging mission is no exception to that.

The common denominator between our construction and regulatory missions is that our decision be based in the general best interest of the public. It is an understatement that this is a really difficult task. On the environmental side of the balance, there are presently over 30 Federal environmental laws and executive orders that may on a case-by-case basis apply to dredging and dredging material disposal activities. At the Federal level, EPA is assigned the major environmental oversight for our programs and region EPA at the regional level. The NMFS and USFWS are also assigned major environmental consultation and coordination roles and in some cases also have the equivalent of an environmental veto under some very necessary acts. The 41 individual states that are served by the Federal navigation system also have major environmental oversight roles under Section 401 of the CWA, which requires us to seek state water quality certifications for individual projects. This in essence is also veto power for projects with limited regional scope. In specific regard to beneficial use applications, the individual environmental laws themselves and the specific resource management authorities assigned to the Federal resource agencies can create and direct in some cases insurmountable roadblocks.

Some Federal resource agency objectives may also conflict with state resource goals and objectives. So you can see that the whole issue is indeed complex. On the development side of the balance, both the CWA (Section 404) and the Marine Protection Act (MPA) (Section 103) contain provisions for navigation or economic considerations which are in the national interest and can

override other compelling interests. The specific project authorizations themselves can often limit, either intentionally or unintentionally, our management options for specific projects. For example, pertinent to beneficial uses is authority to rehandle sediment for beneficial uses to upland sites for certain specific projects. In all cases, both during project planning and during project life, project benefits must outweigh project costs. This has implications both from an economic standpoint as well from an environmental perspective as environmental monitoring, testing, and mitigation are all identifiable project costs.

Unless specifically identified by Congress, in all cases all benefits must be predominately navigation related. We have no general authority for waterway cleanup or in the context of this workshop where the predominant benefits may be for habitat development or restoration. Those authorities are in the purview of our sister agencies from whom you have heard this morning. I think this underlines a very important message, and that is the need for cooperation between these diverse but often coincidental requirements that these agencies may have. Finally, in the days of Federal deficits and diminishing agency budgets, we have many more active Federal navigation projects to maintain (about 250 of them) than we have funds to maintain them. So as managers of the Federal navigation program, we must do so in a logical, consistent and equitable manner without prejudice if you will. While Congress can and often does rearrange our priorities, and it is certainly their right to do so, our mission is to maintain navigation in the public interest. This means that our priorities must be based in large part on the relative public benefit derived from the individual projects. Over the years and most recently in the Water Resources Development Act (WRDA) of 1986, Congress has given us some very clear direction on how we should manage our program.

First and foremost, except for overriding national interests, the Corps is not a project proponent. While most of our projects are assigned a local sponsor, the actual project sponsor is a state or some local authority in which the project lies. Thus the individual states, in many cases, have a major role in establishing our national priorities. Second, and closely related, is that we must ensure consistency in how we evaluate and manage our projects both environmentally and also in terms of project costs. This is embodied in the fact that each of our budget proposals must represent the least costly environmentally acceptable dredged material disposal alternative

or alternatives. In terms of this conference, if a beneficial use is the least costly and environmentally acceptable alternative, then everybody wins and is happy. If not, then we have no authority to recommend another alternative unless the benefactor is willing to pay the difference in cost, unless the Congress ultimately decides that such should be the preferred approach. I think that MG Hatch mentioned that in the WRDA of 1986 in terms of beach nourishment, the Federal government has been given the latitude to absorb at least 50 percent of those added costs. I guess the bottom line is that the taxpayers in Utah would be unhappy if we unilaterally used funds to benefit the State of Florida with Federal dollars by nourishing Florida's beaches. This is simply not our decision but Congress'.

This is clearly reflected in the fact that Congress has over the years fully encouraged and supported a very strong research and development (R&D) program by the Corps as it relates to dredged material disposal. Some \$100 million over the last 15 years has been spent looking at the environmental impacts of dredging activities and, in specific, dredged material disposal. To summarize in the perspective of this workshop, on the one hand the checks and balances that Congress has placed on our dredging program apply equally across the board be it with beneficial uses of dredged sediments or dredging highly contaminated bottom sediments. These constraints can be either environmental or economic or both. Some of these constraints are well defined, and others are not so well defined. A close analogy is the EPA Superfund program, as this program is also required to weigh benefits against costs and is subjected to the many checks and balances that our program is. The EPA has only recently been able to clearly define and in turn communicate the most difficult constraints on their program to Congress to obtain the necessary legislative relief to get on with their Superfund job.

On the other hand, dredged sediments are a valuable resource of limited supply and must be managed in that manner. An early finding with our joint project with NMFS habitat initiative has been that the beneficial uses alternative is not given proper consideration in our planning process. We are finding, however, that through the specific focus of this initiative on coastal habitat considerations, our respective field offices have identified some rather innovative and practical beneficial use applications that have resulted in some rather significant cost reductions as well as project efficiency and management. I think that many of those will be discussed in the

various panels over the next day and one-half. Over the short term, we plan to implement those lessons learned into practice into our final revisions to the environmental compliance regulations for Federal dredging projects by incurring full and equal consideration of beneficial uses alternatives in the project planning process. We will also continue to encourage new and innovative applications. We have a foot in the door, so to speak, in this effort through the numerous provisions in the WRDA of 1986, indicating increasing Congressional recognition and awareness of the beneficial uses alternatives.

As part of this Act, Congress has also sent up a trial balloon on future implementation of this concept within our program. That is, unless Congress is convinced otherwise, any additional costs associated with beneficial use applications that in the public interest can be justified will in all probability be cost-shared, and the overall project benefits must continue to be predominately related to navigation. Over the longer term, we must take a page from lessons learned from EPA's Superfund program and get a much better handle on our system of checks and balances to effectively communicate to all concerned and all those many interests what we can do to achieve successes or be failures. Our focal point for this effort is the ongoing coastal habitat initiative with NMFS with its major objective to identify what actions can be effected within our existing authorities. Hopefully, we can go jointly forward to propose funding to expand this initiative.

I think this workshop is specifically aimed at providing a forum for sharing technology and practices including successes and failures. Its value is truly enhanced by the participation of all players in this complex process. The program reflects the need to understand and to share the many alternatives available to meld the navigation, environmental, and shore protection objectives. It is encouraging to have seen the strong interest in this initiative from the three previous workshops; this is the fourth. In fact, I would say that the scope, interest, and variety of this workshop exceeds the previous three, and I say that is encouraging. I look forward to seeing the results of this workshop and the next workshop in the planning phase for the west coast within the next year.

I would like to say that I was rather encouraged by the remarks from my colleagues from the other Federal agencies because I think this presented the very complex and interrelated roles that our agencies play. I think that this workshop focuses on the common feature of optimism which we view when using

dredged sediments beneficially. I think that this is a common thread throughout all the remarks, not surprisingly, and I think that this is also encouraging. This points out the need to continue those cooperative efforts that we have under way and expand those efforts to address those very complex problems as it relates to dredged sediments. I thank you very much.

QUESTIONS AND RESPONSES--FEDERAL AGENCY VIEWPOINTS PANEL

Panel Moderator: BG Robert C. Lee

QUESTION (John Oubre): Addressed to Norm Thomas and Mike Spear regarding a statement that offshore disposal looks good if not outstanding. I would like a response from Mike Spear as to why he feels this way, and secondly does the same conclusion pertain to channel construction in the Gulf of Mexico itself?

RESPONSE (Mike Spear): I did not understand the second part about the channel construction, but I made the statement about offshore disposal, and I think I also commented that this was relative to the alternatives and this is where you have to look at alternatives. When you look at the alternatives in which dredged material is being looked at on the GIWW and in which some of the ship channels are being examined, offshore disposal appears to have almost no impacts when compared with those other methods. I think that if you look hard enough, there are places offshore we will not want to put it. But I think there are lots of places where it would not be a major problem--in estuaries, in wetlands, or in the cases of upland disposal, which look very promising. As I stated earlier, we still do not have those upland sites identified along the GIWW that I think the Corps and USFWS and other agencies would like to have. I did not understand the second part of the other question dealing with channel construction?

QUESTION (John Oubre): In considering a project that would start inshore and continue to offshore, then the channel project would continue on into the Gulf of Mexico to a certain reach. Would the same conclusions pertain as to the disposal of the channel project in the gulf itself having relatively no impact on the offshore channel project?

RESPONSE (Mike Spear): I am still having trouble with your question, but the same conclusions apply to the dredging that you are looking at. We would like the offshore disposal alternative examined vigorously, regardless of where you get the material--inshore or near-offshore. I may be missing your point.

QUESTION (John Oubre): The dredging of the channel in the gulf itself would require some dredged material to be disposed. Now in disposing of that material in the Gulf of Mexico, am I hopefully to assume that disposing of



that material from the channel project in the gulf looks outstanding as you have indicated?

RESPONSE (Mike Spear): I would say yes when compared with the alternatives that are often presented.

RESPONSE (Norm Thomas): I have sympathy for the Corps, and I do not know how they keep their sanity. A sponsor for a project is pulling on one side as hard as possible; then the National Wildlife Federation is pulling on another side; the NMFS and EPA are pulling some place else; and the Corps is trying to filter through all of this to come up with a project that is beneficial for the Nation. At the same time, the Corps is trying to satisfy every one of us, and that becomes a very difficult task, and I do not know how you keep your sanity. The project that John Oubre has is a project in Vermillion Bay to service a port facility in New Iberia, LA. The question that he was asking pertains to the fact that once you get out into the gulf with your dredging operation to deepen the channel to 12 ft to pass barges, his proposed project is to dispose of material alongside the channel. Our responsibility in the whole effort is that a policy decision has been made to write an EIS for any dredged material disposal in the gulf. The EPA's responsibility is to write an EIS. The Corps' responsibility is to evaluate those alternatives that are available to Mr. Oubre, such as a confined area, a designated ocean disposal or gulf area, an upland area; but it is the Corps' responsibility under Section 102 under the MPA to look at those alternatives. They must look at those alternatives in making a public interest determination. Mr. Spear with the USFWS and the NMFS would have the responsibility to respond to any placement of any material in the gulf. We would probably not have much of a problem with dredging a particular channel in the gulf and placing the material alongside the channel in the gulf. Did I confuse anything, John Oubre? John Oubre answered no.

QUESTION FOR MR. HUMMER (Charles Groat): I am Chip Groat from the Louisiana Department of Natural Resources. You mentioned that the Corps had funds available for cost sharing in beneficial uses of dredged material to match with the state under the WRDA of 1986. How much is available for FYs 1988 and 1989?

RESPONSE (Charles Hummer): I am glad that you mentioned this. Let me clarify what was said earlier that Congress gave us the authority to share 50 percent of the added costs for beach nourishment. We still have to go

back in and run the economic analysis the same as we would for any dredging project to determine if it is in the project's interest to do that, and then we have to go in and get the appropriation. Therefore, no monies are set aside in our program to accomplish that authority and that is not surprising. We generally get authority and must wait until appropriations are approved.

QUESTION (Bill Templeton): Question for Mr. Jackson and also for Mr. Spear. Mr. Jackson commented on the fact that dredged material was placed in East Matagorda Bay in 1983. It was also placed there in 1986. The material is still there. How would you recommend that this material be removed from the bay, as it is still severely impacting the bay complex?

RESPONSE (Bill Jackson): Your question is how we would remove the dredged material from the bay bottom. Yes, sir. I do not believe, since it is already spread on the bay bottom, that it will be feasible biologically or economically to remove the material. The point that we tried to make in 1983 and 1986, and I will refer to Don Moore in the back, is that NMFS is not inclined to go along with open bay bottom disposal of dredged material. You either have a specific point disposal or upland area; otherwise we get into marsh management. Don, can you respond to this?

QUESTION (Bill Templeton): The reason I asked this is that a permit is now pending to open a cut from East Matagorda Bay to the gulf. Is this a viable solution?

RESPONSE (Bill Jackson): I think that Don Moore can best answer this.

RESPONSE (Don Moore): As Mr. Jackson just brought up, by removing the material that is already in the bay, we have damaged the habitat; how much it would recover would be a case-by-case situation. The other situation that the gentlemen just brought up of a new opening into the bay is under current review. One of the things that we are currently looking at is how much additional habitat marsh, wetland, etc., is involved in physically creating the channel and the disposal areas.

RESPONSE (Mike Spear): I concur.

QUESTION (Gordon Thayer): For MG Hatch or Mr. Hummer, we have heard a number of statements about the NMFS and Corps' Memorandum of Agreement (MOA) on beneficial uses. That is a 3-year MOA and within the funding authorities of the individual organizations, which I think was unknown when signed at Headquarters level. These have cost the entities in the field an inordinate amount of resources. Question one, Galveston and Wilmington NMFS have asked

that the 3-year effort be extended, and question two, at Headquarters level will funding be available for both groups?

RESPONSE (Charles Hummer): First I would like to point out that while we have two projects under the MOA at the current time which are officially part of the MOA, a number of others have been done informally. Several are in Chesapeake Bay and have produced very good results; we view this as being very encouraging for the future. I am not aware that there would be any objection from our Headquarters to extend, but I am also aware that no request has been made to do so.

RESPONSE (MG Hatch): Everything that Mr. Hummer said was right. Now as far as I am concerned, we can continue that type of process; whether it is under an MOA or not does not make much difference to me. But what I would like to do is to see what is now a pilot program graduate, and graduate as early as possible, so that this type of activity can become a normal part of the process whether it is associated with Operations and Maintenance (O&M) dredging or is associated with new construction. I might also add that the discussions by the EPA and USFWS this morning have reminded me of something that NMFS suggested to me sometime ago: that the Corps use the model, that is our experience with NMFS, and enter into similar types of agreements for perhaps slightly different purposes with our sister resource agencies so that we can, in fact, pursue to some logical conclusion their concerns whether it is marsh degradation or reestablishment or various types of habitat or that type of thing that we have all kinds of room to enter into agreements. I am not suggesting that we draft one this afternoon and sign it, but I would like to have a similar agreement with EPA and USFWS, and yes, extend these things as long as necessary, but I do not like to be engaged in "paralysis by analysis" either. Once we can reach some reasonable conclusions, then let us get on with it and integrate what we have learned into our regular program.

QUESTION (Chris Mathewson): One of the comments that Mr. Norm Thomas made about placement of usable material obtained during the deepening of excavated waste, i.e. dredged material, ocean dumping, and approval of clean sites, has there been any consideration in evaluating the open-gulf or open-water sites so that the nearshore processes gradually bring this material back onto the beach? Or is this just the licensing of sites that are out of sight and out of mind?

RESPONSE (Norm Thomas): GEN Lee, I think that we will be able to close early because I think that I can give you a really short answer. All the sites that we are working on at the present time have been in historical use by the Corps for a number of years and are dispersal sites in which the material is placed in a confined area and the monitoring portion is to make sure that the right site is there. But all of the sites have been in existence for a number of years. What we are trying to do is to get an official determination and site designation of those. We have two, with one being the homeporting, and I think that Tom Rennie from Galveston District can address site selection much better than I can. However, site selection for the homeporting facility happened to be close to one that was available for Corpus Christi and proved to be the most feasible alternative. The other one is one that we are working on with Mr. Oubre and that is the only one that we have had a request for in the past. I think that you are correct; we should be looking in the future for those sites which possibly can create these mounds, for example, and replenish beaches, but I do not have the expertise to do this and therefore rely on the Corps of Engineers.

RESPONSE (Charles Hummer): Norm, in the case of Mobile Harbor, we did have a designated site, one that EPA designated under the MPA. In view of the other objective to test these berms, the Mobile District requested, in cooperation with EPA, that the site be modified or extended somewhat to use these offshore berms. This was the same process that we used in the Norfolk District with the Dam Neck Site, which was a designated O&M site that was extended inward/shoreward so that we could construct berms there to study the impacts both on the shore and the berm itself. So we have used traditional sites and modified them to the extent that we could modify them to the berm concept.

RESPONSE (Don Moore): To a previous question by John Oubre, which was directed to Mike Spear, and that is the example of site-specific anomalies. That part of the coast of Louisiana is brackish in the gulf just west of the Atchafalaya. It is shallow, and because of that the open ocean gulf reach and the proposed channel and disposal form an area of shell reefs and oysters throughout. Each site is specific, and generalities do not always apply in most cases, thank you.

STATE, LOCAL, AND PRIVATE INTERESTS VIEWPOINTS ON  
THE BENEFICIAL USES OF DREDGED MATERIAL

Moderator: COL John A. Tudela

TEXAS PARKS AND WILDLIFE DEPARTMENT

Susan Rieff  
Director, Resource Protection Division  
Texas Parks and Wildlife Department  
Austin, Texas

Thank you very much, Colonel. Let me begin by saying that like everyone else assembled on this panel, the Texas Parks and Wildlife Department very strongly supports the purpose of this conference and the concepts to which it is dedicated, that is, finding new, alternative, and innovative beneficial uses for dredged material. Rather than repeat a lot of what has been said by NMFS and USFWS representatives this morning, I am going to give you some background on the Parks and Wildlife Department, its previous involvement and interest in this issue, and some of the things that we would like to see. The title of this panel is State Viewpoints, and I will try to give you a perspective from Texas.

I have had many areas of disagreement with the CE since coming to the Department several years ago, but there is one area where I am very sympathetic towards the Corps--trying to make sense out of the number of State agencies that are involved in issues that the Corps has to deal with. It is confusing even within State government. I believe that when I counted at one time there were 12 separate State agencies with natural resources responsibilities.

The Texas Parks and Wildlife Department's activities are very diverse, but our responsibilities are fairly clear-cut: our agency has the primary responsibility for protecting the state's fish and wildlife resources. For those of you not familiar with the Department, it is governed by a nine-member Commission. The members of the Commission are appointed by the Governor, and they set policy for the Department.

Our activities relating to dredging and disposal of dredged material really fall into two major groups. First, we perform an environmental assessment of all projects having the potential to negatively affect the fish

and wildlife habitat of Texas. Perhaps most importantly for the purposes of this conference, we look at all navigation and dredging projects, focusing on major port development projects and the Gulf Intracoastal Waterway. The Department is also the only State agency which reviews all Section 404 permit applications and provides comments to the CE.

In all these activities, the Department's concern is maintaining the health and productivity of important estuarine resources. The NMFS representative and Mike Spear of the USFWS earlier discussed the concerns of those agencies relative to the disposal of dredged material. To save some time here, I will just say that we generally concur with their positions regarding spoil disposal, we specifically share their concerns about open-bay disposal, and we object to it in almost all cases. Data collected by the Department over the last few years indicate that shellfish and finfish in Texas bays and also in the gulf are overfished. This is of great concern to us, and the Department has exercised its regulatory authority to impose stricter harvesting limits with some success. That is the only regulatory option that is available to us, but it does not go far enough in terms of solving problems.

The other determinant of fish and shellfish populations is habitat. Any loss of fish or wildlife habitat is of interest to the Department and the Commission, and the unfortunate fact is that dredging activities, and disposal of dredged material, often eliminate important fish and wildlife habitat or reduce its quality. So obviously we are very interested in the purpose of this conference and are anxious to help reduce harmful disposal activities in Texas. The Texas Parks and Wildlife Department has for many years now been active in dredging projects. In 1974 the Commission adopted a formal policy opposing open-bay disposal of spoil material. That action was followed in the following year by the publication of an EIS on maintenance dredging of the intracoastal waterway. The Department expressed several concerns about that document, and in 1983, the Commission joined with some local fishermen in litigation in an effort to stop dredged spoil disposal in East Matagorda Bay. A lot of discussion followed that action which I am sure many of you are familiar with, and it appears to have led to greater dialogue between the State, the Corps, and the other Federal resource agencies about dredged spoil disposal in Texas.

However, all the problems are not solved, as evidenced by the recent action taken by the Parks and Wildlife Commission to adopt a resolution pertinent to the proposed Houston-Galveston Ship Channel project. In that resolution, the Commission specifically opposed the open-bay disposal of spoil which is planned as part of that project. What this demonstrates is a continuing commitment from the Texas Parks and Wildlife Department to find better ways of dealing with the problems associated with dredged material disposal. And this is not just limited to one agency. Statewide, there is growing concern about the health and productivity of our bays and estuaries. Two years ago, the State legislature mandated a new comprehensive study of Texas bays and estuaries and funded it generously. Other State agencies have also been more active and involved in these activities. But what it comes down to in 1988 is that the Department and Commission are unwilling to continue to accept indiscriminate disposal of spoil material in shallow estuarine waters of the state.

Let me emphasize here that the Department recognizes that dredge spoil disposal is not a simple problem. We also recognize how inappropriate it would be for us to stand aside and say this is a terrible problem and we object to it and you guys go fix it. We are not doing that. We recognize that it is very difficult.

We also recognize that we have to contribute the staff time with some funds to find some solutions to these problems. The bottom line that we do come down to is that we can and must do a better job in Texas of dealing with this so that we assure that our bays and estuaries are protected from unnecessary adverse impacts. Our belief that we can do a better job is really supported by the success of pilot projects, research, and specifically practices used in other parts of the country. We have participated in some previous conferences like this one, and what we have learned from conferences is that there are disposal alternatives which can be employed in Texas to give us some better results. Some of the activities going on in other states are very encouraging, and we do not understand why Texas bays and estuaries do not receive the same degree of consideration given to those resources in other states. That is the goal that we would like to be moving towards.

I want to emphasize that some very positive steps have been taken in the last few years. I would like to congratulate the Galveston District in this regard. We now have an annual dredging conference. The purpose of the

conference is to let all agencies and interested parties know well in advance what the dredging schedules are going to be, specifically along the Gulf Intracoastal Waterway. That gives the Department time to conduct site visits to look for appropriate disposal sites, which is a major step forward and has resulted in some beneficial actions. Credit must also go to the State Highway Department, which has established a Gulf Intracoastal Waterway Advisory Committee (GIWAC). That Committee includes all the affected agencies and provides a forum for periodic discussion of issues associated with maintenance dredging of the channel. Also encouraging are conferences like this, pilot projects such as the one initiated in East Matagorda Bay in the last couple of years, and research going on at universities and other agencies.

The second step is more difficult and involves seeing meaningful changes in dredging plans. The results here are a little less clear-cut than those we have realized in notification and communication. At the state level, I think our efforts have been positive and progressive but probably have not gone far enough. Certainly Parks and Wildlife has increased its involvement and commitment of resources in this area. The Department can contribute in three major ways in solving dredge disposal problems.

First, we have the staff expertise to identify biologically sensitive areas along the coast where spoil materials simply should not be placed, and the agency will commit to do that. The second area where we can help is in identifying disposal sites, especially upland disposal sites. We had some limited success there, and it is very encouraging. To the extent that our resources will allow it, we intend to devote some staff time to actually hitting the ground and finding appropriate upland disposal sites, particularly in biologically sensitive areas. The third way in which we can contribute is by helping evaluate other disposal sites that may be identified by other agencies. So I am really making an offer to the Corps, other agencies, and the Highway Department--that is, we will make available our biological expertise to help find the best possible disposal sites.

We very much appreciate the efforts made by the Corps in the last few years to improve notification of dredging activities, to participate in conferences like this, and to participate in the GIWAC (the advisory committee). But I am going to express a serious concern here. Parks and Wildlife is looking for that coordination to be carried one step further so that it is not just coordination in form, but coordination in substance. In many cases



we are confusing coordination with notification. We will make real progress only when coordination results in solutions that everyone is happier with than what we had previously.

The situation that we now have is one where we are still dissatisfied with the dredging and spoil disposal plans, but we have known what is going to happen a little sooner than before. Early warning is a good step, but I want to see us get past that for two reasons. The first is to get some better spoil disposal solutions, which is what we ultimately are after. Secondly, coordination that is only paper coordination is never going to solve any conflicts and will keep us in an adversarial situation longer than is necessary.

In closing, I want to commend and thank the Corps for holding this conference and allowing Parks and Wildlife to participate, and also for the great help and good faith effort which you have made in the last few years to improve our understanding of these processes and get us into the decision-making process. In keeping with the spirit and title of this conferences, let me suggest to this audience that the best way to change everyone's perception of dredging activities and the connotation of words used to describe those activities is to ensure that those activities do not cause significant environmental damage to our coasts. When dredged material continues to be placed in shallow, open-water situations where it is harmful to fish and wildlife habitat, I can assure you that the Texas Parks and Wildlife Department and Commission will continue to talk about the dumping of spoil material. Alternatively, I can assure you that the Department and Commission will champion and support and advocate the "placement of dredged material" and "putting that material to beneficial uses" when those terms adequately and usefully apply. Keeping that material out of sensitive fish and wildlife habitats and environments is the goal that the Department is committed to achieving. We are offering our services to the Corps and other agencies involved with this in meeting this goal, and hope that you will call upon us. Thank you very much.

TEXAS DEPARTMENT OF HIGHWAYS AND PUBLIC TRANSPORTATION

Robert Cuellar  
Transportation Systems Planning  
Texas Department of Highways and  
Public Transportation  
Austin, Texas

Thank you, COL Tudela. It is a pleasure for me to represent the Texas State Department of Highways and Public Transportation on this "State and Local Viewpoints" panel. Each of us as panelists was asked to describe our agency's role in managing dredged material disposal. I should first mention that our Department has disposal management responsibilities principally associated with the Gulf Intracoastal Waterway. This 400-mile inland waterway, as most of you know, is a 12- by 125-ft canal used primarily by barge traffic and pleasure craft.

I would like to briefly describe how we received our management responsibilities and then describe what role the Department is playing.

After the completion of the Intracoastal Waterway in Texas in the mid-1940's and prior to 1 September 1975, the Corps of Engineers operated and maintained the waterway without an official nonfederal sponsor. Needs for disposal areas were negotiated by the Corps directly with private landowners. Through the years, the original disposal sites obtained when the waterway was first constructed were having their reserve storage capacity rapidly depleted. Additionally, there were growing environmental concerns over the continued use of some disposal sites located in the open waters of the bay systems.

With these issues becoming more critical and the need for coordination more obvious, the 64th Session of the State Legislature proposed that the State accept the role of nonfederal sponsor for the main channel of the waterway. The passage of the Texas Coastal Waterway Act of 1975 pledged the support of the State for the continuance of the waterway in an economic and environmentally sound fashion and designated our State Highway and Public Transportation Commission to administer the provisions of the Act.

Our role and duties as the nonfederal sponsor are clearly spelled out in the Act. The Commission is directed to work with the Department of the Army, all Federal and State agencies, and other appropriate persons.

Principal duties include the authorization to acquire by gift, purchase, or condemnation any property deemed necessary for channel expansion, relocation, or alteration of the waterway. Up until now, our primary responsibility has been to acquire the property necessary for placement of dredged material obtained through routine maintenance dredging of the Gulf Intracoastal Waterway.

Additionally, the Commission is directed to evaluate the waterway as it relates to the State of Texas, to report the identification of principal problems, and to make specific recommendations for legislative actions. We perform these evaluations, and the results are published and submitted to each regular session of the legislature.

That sums up what responsibilities the 1975 Coastal Waterway Act gave the State Highway and Public Transportation Commission. We were pleased to be designated nonfederal sponsor and feel the Department was an appropriate choice. Annually there are over 67-million tons of goods moved on the waterway by barge. If these goods had to be moved by truck, it would require over 3-million additional trucks traveling our State highway and local street systems. Thus, the GIWW is obviously a vital link in the State's total transportation network.

After passage of the 1975 Act, the Corps of Engineers requested that our Department provide additional disposal sites at five areas along the Texas coast. In those five areas, existing disposal sites were identified as being critically low in storage capacity.

It became obvious to us that there also needed to be some vehicle whereby the State and Federal agencies could meet and coordinate their individual actions. At this time, the Department helped to organize the GIWAC to coordinate the needs of the waterway. This committee consists of seven State agencies that are concerned with the continuance of the waterway, protection of the State's natural resources, and the economic development of the waterway. Many other interested groups such as the Sierra Club, Corps of Engineers, National Audubon Society, USFWS, and various marine industries, are invited to participate in committee meetings and are regularly informed of committee activities. One highly successful undertaking occurred in late 1984 when members of this committee participated in a task force whose mission was to inspect and agree on the identification of areas where additional disposal sites could be located.

As you may know, from 1975 until recently, funds were not made available by the State legislature for our Department to fulfill the duties outlined by the Waterway Act. Therefore, in an attempt to provide needed disposal sites, a search along the coastline was made for lands that could be used without there being any monetary return assessed for its use. Port authorities and navigation districts were also canvassed for land that could be used. A program was inaugurated asking private landowners to donate the use of their land to the State, free of charge, to alleviate these critical situations.

Most often, donation requests were turned down by the landowner. Frequently, landowners commented on how they would have to continue to pay taxes to the State on the land even while the State would be using it for free. Thanks to work led by Berdon Lawrence and other waterway supporters, there is now a State tax law that removes all ad valorem taxes from land donated for use as a disposal site for materials dredged from the main channel of the waterway. Hopefully this will be an incentive for more land donations.

Other agencies represented on this panel provided much assistance to the program. For example, 355 acres of State park land at Bryan Beach was donated for a 30-year period by the Texas Parks and Wildlife Department after a three-way negotiation between Parks and Wildlife, the Corps of Engineers, and the State Department of Highways and Public Transportation was agreed upon. Navigation districts and port authorities continued to cooperate with the use of their private disposal areas for emergency situations, and a few private landowners generously offered the use of their land. Private lands were used usually on a one-time basis while some other offers had to be refused due to environmental restrictions.

One landowner in Matagorda County donated 255 acres of his land for a one-time use if the material would be distributed thinly over his pasture. That project was developed into a technical study program to determine the benefits accrued by sheet deposition of the materials on the land. This project will be discussed more fully in tomorrow morning's session. So far, test results are promising, and this certainly shows promise as one beneficial use of dredged material.

A question our Department often gets is whether the dredged disposal material can be used in our highway construction program. Unfortunately, the disposal material, being predominantly of fine silt and clay, eliminates

most of this possibility since highway construction usually requires sand materials or to a more critical level, coarse aggregates.

Despite the previously described hard-earned, small-scale successes, it became apparent that these types of programs could not fulfill the needs of the waterway and that legislative funding was a necessity. In 1987, the 70th Session of the State legislature responded to the needs of the waterway by allocating approximately \$1,000,000 for the purchase of new disposal sites. The State Highway and Public Transportation Commission, using the new site information provided by the task force of the Waterway Advisory Committee, has begun the process of acquiring properties.

Accordingly, a public hearing was held by the Commission in Austin, on 27 January 1988, with another hearing scheduled for tomorrow, April 27. Following the completion of tomorrow's hearing, it is anticipated authorization will be granted for our Engineer-Director to proceed with the acquisition of 12 disposal sites located in Brazoria, Matagorda, and Calhoun Counties.

In some areas, the environmental problems in locating additional disposal sites are highly complex. One such area near High Island and another near the West Bay area prompted our Department to fund and initiate a research study to determine the optimum method for material disposal. Some impacts to the area will be unavoidable, and the study is designed to determine the solution that will cause the least possible disturbance to the environment. The study period is for 1-year and is under contract to the Texas Transportation Institute at Texas A&M University.

In closing, we feel that with the appropriation of waterway funds by the recent legislature, our Department is at last fully able to perform the responsibilities set forth in the 1975 Texas Coastal Waterway Act.

However, the funds allocated by the 70th Legislative Session are available only during the 1988-1989 biennium. It is imperative that future legislatures be aware that to continue this funding is in the best economic interest of the State. Continued stable funding is essential so that a long-range plan for the continued proper maintenance of the waterway can be implemented to best protect our most precious coastal natural resources.

But even with a stable, adequate level of funding to do the job in the best possible manner requires the input of the users of the waterway as well as those who are concerned about the protection of our natural resources.

Input, such as will be gained over these next few days, will be invaluable in choosing future courses of action.

Thank you for your attention. If you have any questions, I will be happy to answer them for you.

TEXAS GENERAL LAND OFFICE

Sally S. Davenport  
Director, Coastal Division  
Texas General Land Office  
Austin, Texas

The State of Texas owns, and the General Land Office manages, most of the submerged land in the bays and estuaries of Texas, from Sabine Lake to South Bay. A major portion of the GIWW traverses this land. As an agency responsible for the protection of the public interest, the General Land Office recognizes the tremendous value of the waterway and its ancillary channels to the State, regional, and national economies and the need to maintain the navigability of these vital transportation arteries.

The General Land Office has statutory responsibility for overseeing dredging operations on coastal public lands in Texas. We review and comment on applications for Corps of Engineers 404 permits; we serve on the GIWAC; and we are a member of the informal Maintenance Dredging Working Group, composed of representatives from State and Federal natural resource agencies. Along with the School Land Board, the General Land Office issues easements for a variety of projects that involve dredging and dredged material disposal, including pipeline installation, excavation of channels and ship basins, spoil disposal operations, and construction of piers and other structures on submerged land.

General Land Office and School Land Board rules governing these activities are designed to minimize adverse environmental effects. They call for the avoidance of productive bay-bottom and wetland habitats and for the use of dredging methods that will minimize turbidity and dispersal of dredged sediment. To reduce the need for new dredging, the rules encourage the use of existing natural and man-made channels, the cooperative use of channels, and the placement of new pipelines in existing rights-of-way. Rules governing dredged material disposal discourage open-water disposal in favor of the use of sites above mean high water.

Our goal at the General Land Office is to ensure that dredging and dredged material disposal operations on state-owned land provide for protection of the health and productivity of our bays and estuaries for future generations while allowing for economic growth and development.

New channel construction, decades of maintenance dredging, and expanding urban development coastwide have increased pressure on our fragile aquatic ecosystems. Compounding the problem is an urgent need for new disposal sites. One option being considered is increased open-water disposal in bays--the cheapest alternative to upland disposal. Acceptable upland disposal sites are in short supply. Very little State-owned upland property on the coast is suitable for this use, and private landowners are reluctant to permit spoil disposal on their property. Many State-owned spoil islands have reached their capacity, and others soon will.

As a rule, the General Land Office considers open-water disposal in bays an unacceptable course of action. The penalty the State would pay in terms of lost fishery productivity far outweighs the advantages of convenient disposal to minimize project costs. Furthermore, Federal spoil disposal operations on coastal public lands often preclude or impede the use of these lands for revenue-generating activities such as oil and gas development. For these reasons, the General Land Office has a decided interest in finding uses for dredged material that will reduce the demand for conventional "dumping grounds," and particularly for open-water sites. Uses now under study may hold promise as solutions to the problems of diminishing upland disposal sites, habitat loss, and shoreline erosion as well as means of generating revenue both for the State and for the private sector.

At present, the Galveston District of the Corps of Engineers considers the cost of transporting dredged material to gulf disposal sites or to upland sites not immediately adjacent to waterways prohibitive, but we hope this view is changing. The Port of Brownsville deeded South Bay (now proposed for inclusion in the State's Coastal Preserve System) to the State in exchange for an 1,100-acre disposal site in the Gulf of Mexico. The GIWAC is currently exploring the feasibility of using an upland site on State-owned land in Brazoria County for future disposal. This would involve the pumping of dredged material approximately 1 mile to the site, with the water drained from the material being returned to the GIWW via an existing ditch.

The Maintenance Dredging Working Group, in which we participate, is investigating disposal options from a purely environmental standpoint. Though some of the proposals discussed by the group may prove unacceptable today for economic reasons, necessity may increase their acceptability in the future. One proposal under discussion is to regain disposal capacity at existing sites



by allowing the removal and sale of the spoil material once it has dried. The exploration of beneficial uses for this material elsewhere may make this a feasible option at some sites, depending of course on the nature of the material and transportation logistics.

The use of dredged material to counter erosion losses on important rookery islands along the Texas coast has begun to receive more serious consideration in recent years. The General Land Office has discussed, with the Audubon Society and the Corps of Engineers, the possible placement of dredged material on areas that the Society leases from the General Land Office. While this use may be a minor one in comparison with overall disposal site needs, its value may appreciate (perhaps in some bays more than others) as our understanding of the habitat needs of colonial waterbirds improves. Special considerations associated with this use of spoil include timing operations to avoid nesting seasons and the possibility that only small amounts of material will be needed at specific sites.

Habitat enhancement projects to increase natural productivity at disposal sites are another prospect of interest to the General Land Office, particularly since projects of this type can be used for offsite mitigation. We participated in a cooperative habitat enhancement project undertaken by the Corps of Engineers and the NMFS on State-owned land at Pelican Spit in Galveston Bay and at Alligator Point in Chocolate Bay. We supplied aerial photographs of the two experimental sites selected and made site inspections prior to the disposal operation. These projects will provide us with information on the feasibility of establishing new marsh areas by cutting small channels through spoil deposits and by using spoil material to form underwater berms for protection of shallow water habitats that support emergent aquatic vegetation.

The use of selected disposal sites for aquaculture operations may have economic significance for the Texas coast, both as a means of preventing depletion of natural finfish and shellfish supplies and as a productive and potentially profitable use of dredged material. We are monitoring the Corps of Engineers' project on Brownsville Navigation District lands in the hope that similar lands in the General Land Office inventory may become candidate sites for aquaculture projects. Public interest in this kind of venture has been increasing in recent years.

These uses and others--such as direct beach nourishment, offshore berm building, placement of dredged sand in the littoral drift system, and sheet disposal--deserve our foresighted attention. As the success of experimental projects is documented, incorporation of beneficial uses into overall planning of spoil operations should be pursued.

We believe that an update of the Corps of Engineers' 1975 maintenance dredging plan for the Texas section of the GIWW would be the appropriate mechanism for launching a comprehensive study of disposal-related problems and solutions, and we offer our assistance in the development of a long-range disposal plan. We hope that two sets of digitized maps recently completed by our staff will be of value in the review of dredged material disposal sites and options. One set accurately locates the main channel, accessory channels, and authorized disposal sites of the GIWW on 7.5-min US Geological Survey (USGS) topographic maps. This set of maps was prepared from location information in engineering drawings furnished by the O&M Branch of the Galveston District of the Corps of Engineers. Draft maps are being prepared for submission to the Corps for review and comment before final distribution. The second set of digitized maps illustrates information about important rookery islands along the Texas coast and was prepared using data recently developed by the Texas Colonial Waterbird Society.

We are encouraged by prospects for improved management of dredged material in Texas and by the growing interest nationwide in beneficial uses that can help alleviate the demand for new disposal sites. It is certain that more sophisticated and more complex disposal options will require not only technical innovations, but also investigation of funding structures. We believe that these challenges can be met by closer communication among all affected interests--chiefly government, science, and industry. New thinking, new technology, and increased cooperation can ensure that the productivity of our valuable coastal ecosystems is not diminished by the activities necessary to support navigation and waterborne commerce.

LOUISIANA DEPARTMENT OF NATURAL RESOURCES

Charles Groat  
Assistant to the Secretary  
Louisiana Department of Natural Resources  
Baton Rouge, Louisiana

The Louisiana Department of Natural Resources is responsible for the coastal zone management program in the State and also for the State's coastal protection program which is a State effort, in cooperation with Federal agencies, trying to reduce the rate of coastal land loss in Louisiana. During the past 2 to 3 years, every discussion of coastal topics, whether it be coastal management or whether it is the coastal protection program, begins with the dramatic numbers associated with Louisiana wetlands loss. Whether it is 30 miles, 50 miles, or 300 square miles per year, the loss is dramatic, so dramatic in fact that it has come to dominate our thinking when we think about our coastal resources. We have to face the land-loss issue in the coastal zone, whether it is in permitting decisions or whether it is in coastal protection projects. When we are considering dredging channels for oil and gas production, we think about what this loss will add to land-loss rates. In considering freshwater diversions in cooperation with the Corps, barrier-island restoration or marsh management, we keep focusing on their impact and relation to the land-loss situation.

The fact is, as was stated by EPA's Norm Thomas this morning, that the gulf coast area is tremendously productive in fisheries, fur bearers, waterfowl, and oil and gas production, and with deference to our neighbors, most of that productivity is in Louisiana. So when we talk about that loss of productivity, it is a rather personal thing which impacts our State's economy, our lifestyles, and our recreational patterns in the most dramatic way of any state in the gulf. So we are very interested in doing anything that we can to slow the land-loss rate down. The land that is being lost is the productive land, the wetlands, and management of dredged material is one tool for dealing with the loss. We have to realize that dredged material in Louisiana is not only a product of maintenance dredging of navigation channels, but that oil and gas exploration have produced a significant amount of dredged material. How to handle that material so that it does not interfere with normal circulation patterns, so that the canals themselves do not interfere with salinity

regimes, has become a major issue in the coastal area. Thus when we talk about dredged material, we have to talk about all sources of that material. Nonetheless, it is still dredged material, and we have to decide what to do with it.

Without going into a long explanation or repeating what you may have already heard, I just have to remind us all that the basic problem of land loss in Louisiana is a combination of nature and of what we have done to ourselves, generally to provide various benefits. The fact is that the process that built the land in south Louisiana depended on the Mississippi River carrying sediment and freshwater into the coastal area. We have altered that delivery system. We have prevented the river from building new lobes, leaving existing wetlands vulnerable to subsidence and wave attack. Nature both giveth and taketh away, if it is untampered with. The problem we have in Louisiana is that in the name of flood control, navigation, and development of the southern part of the state, we have interfered with the giving part of nature's balance and shut-off water and sediment from the coastal wetlands with our levees.

The wetlands are no longer nourished with sediment which they require to maintain their equilibrium in the face of subsidence. We are no longer building any major new delta lobes as would be happening in the Atchafalaya area, for example, if we were not concerned with flood control and navigation. The dominating forces acting today are those which destroy, such as subsidence, salt-water intrusion and wave attack. We are losing large chunks of real estate, principally productive wetland habitats, due to natural forces heightened by sediment supply problems. Part of our problem is that even if we found ways to get sediment out of the Mississippi River into our wetlands, there would not be enough sediment present to do the complete job due to our efficient activities in holding and conserving the soil through erosion control activities and in the Mississippi River drainage basin. We have kept a lot of sediment from getting into the rivers by building dams and by soil conservation measures.

So the Mississippi is carrying 30 to 40 percent less sediment than it used to carry. Efficiency in soil conservation helps agriculture and reduces maintenance dredging needs, but in terms of adding sediment to the wetlands, much of the needed supply is simply not there.

We have eliminated sediment from the wetlands, and the question is how do we get more sediment into the wetlands and reverse the process. There are more ideas on how to protect the coastal areas than anyone can shake a stick at. Some are good, some are crazy, and some are untempered by engineering reality. One of the ones that you hear commonly is to turn the river and let it divert down the Atchafalaya, as it would like to do, and build a major wetlands systems in that coastal basin. Most people in this audience would recognize some of the difficulties this would pose for the lower Mississippi Valley, where we have a large investment in navigation, water supply, etc., from Baton Rouge south. So it is a simple solution, fraught with consequences that no one is ready to handle.

As stated earlier, another solution is to get more sediment into the wetlands. Clearly that is an important goal and an important way to combat subsidence. Clearly it is important to add sediments, to nourish wetlands, to fill in those areas that are disappearing or that have already subsided below marsh level. Where do we get the sediments? Is enough sediment available? How do you get the sediment out of the river? This is not easy. We can build diversions and get water out of the river, but to get sediment out of the river, from that part of the water column which it resides in, and to get it beyond the edge of the levee and disperse it into distant marshes is another problem. Not that it cannot be done, but that right now it is not an easy option that we can jump right into and save the wetlands.

It is difficult to find ways to get more sediment into the wetland system. What we have to work with is the sediment that is already there, and that brings us to dredged material. We are dredging a significant amount of material for navigation maintenance in Louisiana. Is there any way that this material, which must be deposited somewhere, can be put to beneficial use? Considering the damage to habitat caused by putting the material into some open-water areas, can we put dredged material into wetlands that are disappearing, wetlands that could be nourished, wetlands that could be rebuilt? The answer is yes. It is no great trick to place sediments into these wetlands, and it is no great trick to predict, given a little bit of lead time, where those materials ought to be placed, and there are delivery systems that can do it. But what to do and how to do it is not the problem. Sue Hawes will speak tomorrow about some of the innovative things that are already being done in New Orleans District. The question is not how; rather it is who pays?

How do we come up with the resources to cover the increased costs? It is clearly the philosophy of the Federal government, and I am not going to argue that it is wrong, that if we are going to provide increased services and increased ability to deal with this problem that the State should share in this cost. Maintenance dredging budgets do not allow for extra material handling costs, and the Corps does not consider wetland enhancement with dredged material as an integral part of its program to the degree that major funds are requested for this purpose. Some mechanism for generating the funds is needed to do this, and in the present fiscal environment, both federally and in the State of Louisiana, it is more easily said than done. Costs and cost effectiveness are issues yet to be resolved.

We need innovative concepts and ideas as to how to put this material to use in a cost-effective way. Hopefully the joint State/Federal planning effort which the Corps has launched in Louisiana will deal with this topic. But most importantly, we need a way of financing the placement of dredged material in suitable locations. We have mechanisms for coordination, but no mechanisms for dollars. Until we can solve that problem, we do not have much latitude.

What can we do with dredged material in Louisiana, and how much latitude do we have? How much good will this do? Well, since we are taking fair liberties with numbers, I took a few to give you a feel for the magnitude of the problem and the role that dredged material could play in Louisiana. Sue Hawes, I am sure, will mention their work in the lower Mississippi, where about 35,200 acres of wetlands will be created over the life of the project, which is 50 years. That number is approximately 1 year's land loss in Louisiana--1 year. If we take a number from MG Hatch's talk last year, which was 400 million yards of dredged material nationally, to be disposed of and if 6,500 cu yd are needed to create an acre of wetlands, it takes 4.2 million cubic yards (MCY) to make a square mile and 210 MCY to create 50 square miles. If we have 400 MCY, then we could make about 100 square miles of marsh if we took this entire national supply and pumped it into Louisiana. This would help us considerably if we could just figure out how to do it. The practical role of dredged material in helping to solve the land-loss problem is not this major, but it can be significant, and this is where innovation and comprehensive planning are needed.

How do we take the beneficial use of dredged material, combine this with the potential for sediment diversions out of the river, and use effective marsh management techniques to benefit our wetlands? How do we combine and coordinate these things into a program that effectively deals with the land-loss situation in Louisiana? Not stop it, but slow it down. The State's participation in the comprehensive planning effort initiated by the Corps of Engineers is the forum in which this planning and coordination can take place during the next 2 to 3 years. Dredged material will not solve the problem; it can help with solving the problem, but it still comes down to, who pays? Does the State have the will to tax itself to find the resources to pay its share? Will the Federal government realize that wetland loss is both a national and State issue? Will the Congress come forth with its share of the money for marsh restoration in Louisiana and other coastal areas suffering wetland loss? We do not know the answer to those questions, but at least a planning process is taking place that can give us a product to go forward with.

The agency that I represent has a vested interest in managing coastal lands and in advocating activities that minimize land loss. Making use of dredged material to reestablish and nourish disintegrating marshes can be an important part of efforts to slow coastal land loss. This conference helps us and other participants understand the role that dredged material can play in these efforts and make our interest known to the Corps.

## BARGE INDUSTRY

Berdon Lawrence  
Hollywood Marine, Inc.  
Houston, Texas

### Introduction

The GIWW in Texas plays a vital role in the transportation infrastructure of Texas industry. It is a common fact that without the GIWW, most of the refining and petrochemical companies would not have located in Texas. Today, our Texas industries must compete in a "Global Economy," and the GIWW's providing of safe, efficient, low-cost transportation is a key factor in assisting Texas industry to be able to compete worldwide.

To be competitive, the key today is low cost. The commercial waterways of the United States move more than 13 percent of the Nation's freight. This is accomplished by a fleet of over 7,500 tow and tug boats and 32,000 barges of all dimensions. This 13 percent of our Nation's freight is moved for 2 percent of the Nation's total transportation costs.

Another remarkable fact is that 1 standard barge load equals the capacity of 15 railroad cars or 60 trucks, and on the Texas Intracoastal Waterway we normally move from 1 to 5 barges at a time. The energy consumed to move these cargoes is 2-1/2 times more efficient than barges' closest competition, the railroads. These efficiencies are the key to saving you, the consumer, money. A 1986 study by the Texas Highway Department estimated that alternative transportation of the same volume of goods would require the use of nearly 1-million railroad cars or 3.4-million trucks.

### Importance of the GIWW to Our Texas Ports

One statistic that strongly illustrates the importance of the canal is the relationship of barge-to-ship tonnage moved through our Texas ports. For instance, in Houston there are about 5,000 ships calling on the port per year. At the same time there are about 80,000 barges calling on the port with the barge tonnage being 41 percent of the total tonnage. On the Sabine/Neches and Ports of Brownsville waterways, barge tonnage as compared with ship tonnage is



60 percent or more. At all the Texas Ports, barge tonnage is a significant factor. If it were not for the Intracoastal Canal, these barge tonnages would disappear or be forced to less efficient modes of transportation.

When you combine the tonnages of all of our Texas ports, the State of Texas is the largest maritime state in the United States. The Intracoastal Canal has played a key role in this leadership. The GIWW is a critical factor in our statewide strategy of economic diversification.

#### Commerce on the Texas GIWW Today

The primary products moved on the GIWW are petroleum, petroleum products, and petrochemicals with nonmetallic minerals, building materials, and various ores making up the rest.

You may ask, "What is the state of the waterway that serves these Texas Industries today?"

As all of you know, here in Texas the depression in the oil industry has really hurt our state economically. Our economy continues to reel from the ripple effects that have devastated oil, oil service, real estate, and the banking industries.

One of the bright spots today in our state's economy is the petrochemical industry, which is served directly by barge. A few years ago, 1982-1985, our Texas petrochemical industry was awash in red ink, plants closings, and layoffs. There was overcapacity in the industry and a strong dollar that supported the economics of imports and hindered exports. The good news for Texas today is that conditions have changed due to the following reasons:

- a. First, the older, less-efficient plants have been closed leaving only the more modern plants operating that can compete in a global economy.
- b. Second, the value of the dollar has weakened significantly allowing products manufactured in Texas to be able to compete in the world marketplace.
- c. Third, nationally, but not in Texas, our economy has remained strong creating an underlying demand for these products.

The petrochemical industry contributed \$23 billion to the Houston area economy in 1986. This represents about 25 percent of the area's gross regional product. The US petrochemical industry had a positive balance of trade of over \$10 billion in 1987, and that is predicted to increase.

We in the barge business are told constantly by leaders of the petrochemical industry that one of the important factors in their being cost competitive with other parts of the world is our extremely efficient Gulf Intracoastal Canal. Our canal can, will, and must continue to play a key part in the future success of Texas industry.

### Environmental Concerns

In the tug and barge industry, "Safety is First" is a matter of record.

Even though nationally the barge industry is acknowledged as the safest form of transportation, the industry believes that efforts to assure safety of our crews, cargoes, and the environment can always be improved upon.

For example, the US Coast Guard annually inspects every tank barge to be sure they are in good, safe operating condition. Our crews must be well trained and licensed by the Coast Guard to do their job.

But "Safety" is like a three-legged stool with:

- a. One leg being good equipment.
- b. A second leg being qualified, well-trained personnel to operate that equipment.
- c. The third leg being a safe and navigable waterway.

I can assure you that if you do not have the third leg, "A Safe Navigable Waterway," you do not have true safety for crews, cargoes, and the environment.

Let me give you a few examples. Along the waterway, there are places that, due to winds, tides, and currents, sand up to form a shallow spot, or as we refer to it, a shoaling. When the canal is not properly maintained, these hidden shoals can cause a severe grounding of the barges, possibly puncturing the cargo tanks and causing a spill. You all know the damage that a spill can do to the environment; so we must support the efforts of the Corps of Engineers in their maintenance dredging to prevent these hazardous shoaling conditions.

Also, if the 125-ft width of the canal is not maintained, there is not room for tows to safely pass each other. Today many new barges are 54 ft wide; so two tows passing need 108 ft of the 125 ft. You can quickly see that only leaves 17 ft of clearance. When the width of the canal is not properly maintained, collisions are much more likely to occur.

There is no push today to deepen or widen the GIWW, but we must maintain what is presently constructed.

The industry and general public need and deserve a safe waterway. We must keep the canal at the proper widths to prevent collisions and at the proper depth to eliminate the shoalings that have the ability to rip open the bottoms of our barges.

### Closing

As you deliberate the issue of dredged disposal materials, I urge you to keep foremost in your minds how critical it is that we keep our canal properly dredged.

I applaud the Corps for having this workshop, for it is in sessions such as this, that practical people can exchange ideas and come up with practical solutions that will minimize environmental impact.

PORT OF HOUSTON AUTHORITY

James D. Pugh  
Executive Director  
Port of Houston Authority  
Houston, Texas

The title of this presentation requires that a frame of reference be established to fully understand our perspective on the disposal of dredged material.

The enabling legislation which created the Port of Houston Authority states its purpose as being "to bring the benefits of deep draft navigation to the citizens of Harris County." Functionally, the Port Authority is the local sponsor for the Houston Ship Channel and a specialized developer of marine facilities. The facilities we construct, maintain, and sometimes operate are here to make opportunities for private sector enterprises through the promotion of waterborne commerce.

In addition to providing a modern complex of maritime terminals, the Port Authority has several other responsibilities that relate to our primary purpose. The Port Authority owns the right-of-way for the Port Terminal Railroad Association, comprises the Pilot Board, provides marine fire protection, and has many other activities related to economic development for this region.

All of the Port Authority's efforts over the past 75 years have been focused on one goal--an improved standard of living for Texans. What the citizens of this area have built over the last century is now the third largest seaport in the United States.

Port activity annually generates \$3 billion in economic benefits to this State. There are about 30,000 people employed by channel industries, and port business affects some 160,000 jobs in our State. This port, and others in Texas, allow the State's agricultural interests to export 40 percent of their production, which allows them to survive as farmers and ranchers. Our ports are also crucial to the petroleum industry and allow our petrochemical exports to compete in world markets. The Port of Houston also serves as a primary trade gateway for the Midwestern and Rocky Mountain States and is Mexico's largest volume seaport.

As you can see from the foregoing, the Port of Houston affects the lives of many people in this part of the continent. It also affects the lives of people who live in the 80 foreign countries we trade with around the world.

This port competes regionally, nationally, and internationally for the movement of all types of cargo. We compete against many ports which receive State funding or direct taxation revenues which we do not get in Houston. The Port of Houston Authority is self-sustaining for operating funds, but must ask Harris County taxpayers to help us with part of our capital needs.

This financial structure means that we must always be conscious of costs to ensure we remain competitive. If we do not remain competitive, hundreds of millions of public dollars become a wasted investment. The jobs and economic benefits we were created to stimulate will vanish, and every Texan's standard of living will suffer.

With this background, let me state that the Port of Houston Authority's policy is to carry out our mission in an environmentally acceptable manner. We must, however, continually balance environmental and social concerns with our ability to financially compete and survive.

As we address the challenge of dredged material disposal, some dimensions are useful to gage the magnitude of the challenge. The Port of Houston Authority is local sponsor for a 52-mile-long channel. To fulfill our responsibility, we must provide for disposal capability that will last 50 years into the future. We currently own about 7,000 acres in Harris County. Almost 5,000 acres of this property is reserved for disposal of dredged material. This represents about \$50 million of land in a major metropolitan area that is not economically productive.

The type of material our maintenance dredging generates is primarily silt, with a high organic content. This type of material is not suitable for many uses in construction or new land creation through fills. We have, however, found some beneficial uses for this resource.

In upland disposal areas, we have enhanced food-chain development and created secure habitat for wildlife by limiting access to these sites. In tributary waterways, island disposal has also created wildlife habitat, and some sites provide mixed-use recreational capabilities. We also feel our submerged structure disposal in Galveston Bay has created additional and more productive oyster beds, with the added benefits of storm wave energy dissipation and reduced shoreline erosion.

From our perspective, the greatest facet of the dredged material disposal challenge is basic geography. The increasing urbanization of this area and the escalating land values present a continuing need to develop cost-effective uses and disposal methods. Properties near the channel, where still available, have acquisition values of almost \$50,000 per acre. Overland transport costs are prohibitive, and upland sites create aesthetic problems in urban environments.

The Port Authority's net revenue from operations amounts to 25 cents per ton of cargo. This represents a margin of only 6 percent. With current dredging expense of \$1 million per year, the financial impact of high-cost disposal methods has a dramatic effect on our ability to generate capital for the future.

We need assistance in this continuing challenge for the future of our community. We look to the Corps of Engineers, our universities, and the resource agencies for cooperation in finding more cost-effective uses for this resource. Through joint effort and reasoned approaches, the Port of Houston Authority will meet this challenge and continue as a major economic asset for Texas and the United States.

QUESTIONS AND RESPONSES--STATE, LOCAL, AND PRIVATE INTERESTS VIEWPOINTS PANEL

QUESTION (Bill Templeton): Question for Susan Rieff and Sally Davenport. What is the agencies' status now on beach nourishment of dredged material?

RESPONSE (Susan Rieff): We do not have an official position on that, Mr. Templeton. I think that we would say and have said in other public meetings that we support any situation where the nature of the material is such that it is appropriate for that use. Unfortunately, in the limited cases that we looked at in Texas, the material has not been appropriate because of the contaminants or because of the other composition of the material to be placed on beaches. In any case, if it can be shown that the material is suitable for that use, then we would support that (use).

RESPONSE (Sally Davenport): I think that I can second what Susan said. You are well aware that our land commissioner is very much in favor of reducing erosion wherever possible along our coastal areas. As I understand it, to get a regular deposition on our beaches, the Governor must request the Corps to do so, and the local interests must come up with the matching monies necessary. I would like to say that perhaps State and local agencies cooperating with the Corps can work together in the future and do this where it is appropriate and where the material is available and suitable. Of course, I know your area, and you have a major problem; if the material is available, then we would support it, I would think.

RESPONSE (Bill Templeton): Thank you both very much.

QUESTION (F. Hermann Rudenberg): I would like to ask this question of the ladies? or of the panel? of the Colonel? If the Federal and State biological agencies are so opposed to open bay disposal, then why is it still going on?

RESPONSE (Susan Rieff): The Parks and Wildlife Department has no regulatory authority in this area, and we are basically limited to reviewing and providing technical comments to proposed activities, which we do routinely and extensively. We adopt policies through whatever means of persuasion or pressure we have to bring to bear to advocate alternatives to open bay disposal. We have done that, and we have gone to court on one occasion, and we use what means are available to us, but we unfortunately or fortunately in other cases

are not the ultimate decisionmaker as to where that material goes. Does this answer your question from our perspective? (Response, yes)

RESPONSE (Sally Davenport): From the Texas General Land Office standpoint on dredging projects that create material which needs to be disposed of, but are private or commercial projects rather than Federal projects, we do have some say-so, and we do not allow open bay disposal of these materials. But on those projects that are Federally sponsored, the final decision comes from the Federal level, and they use their "eminent domain" authority. Again I mention that with the coastal management act, we do not have that "stick." I think we can turn this around and make it positive. If we work with the Federal agencies, especially the Corps, as closely as we should, perhaps that stick may not be necessary.

RESPONSE (Robert Cuellar): Our experience from the Texas Department of Highways and Public Transportation has been that we work very well with the Corps. We are the local sponsor of the Intracoastal Waterway, and the Corps has made it clear to us that anytime we can come up with upland disposal acreage, they would be glad, if it is economically feasible, to dispose on nothing but upland locations. Our problem that we tried to detail is being given \$1 million per biennium, and that is not going to buy a whole lot of upland disposal acreage. We have tried through the help of the agencies that are up here and the private landowners to try to find as much donated land or buy as much land as we can. Up until now we have been pretty much constrained by the amount of funding that is available. This is kind of what Susan was alluding to. I was just reminded of one of my mother's favorite prayers, which was "Today please send a blessing that is not a disguise." Up until now we have not had enough money to where we could not get to anything other than critically needed upland disposal sites. Somewhere down the road, I imagine we will be in a pretty tough location or spot where we are going to have the old benefit-to-cost ratio question come in. We are going to be caught between finding economic upland disposal sites versus an easier, lower cost alternative such as an open bay. Now the Corps has been very responsive to us, the Department. Their word to us is that if you find an upland site, then we will be glad to put the material on there. Their charge is to keep that waterway open.

COMMENT TO QUESTION (Pat Langan): It seems that we differ from you over in Mobile from what I have just heard. We accept the fact that open-water



disposal is an environmentally acceptable means of disposal. Major concerns are mounding, buildup, and changes in circulation and I think a great portion of the information gained under the \$35-million Dredged Material Research Program has verified that open-water disposal of dredged material is a viable option to consider. We look to improving open-water disposal techniques through such techniques as "thin-layer" disposal that one of our Mobile District (personnel) will discuss tomorrow. This is a comment to the question that was asked.

QUESTION (Terry Hershey): I am also naive in that I have heard that Louisiana wants it (dredged material). Why do you not take your money and hire a bunch of barges and send it to Louisiana? Why, they could use all the sediment from the whole country, and it would be only 20 percent, and that is a question. Why cannot you do that?

RESPONSE (Charles Groat): I think that maybe we are being innovative now. I am for that. If Mr. Lawrence will provide the barges and Texas with the billion dollars, we are in business.

RESPONSE (Robert Cuellar): Before we start handing that out, the problem is with one decimal point. It is \$1 million and not \$1 billion.

QUESTION (Brandt Mannchen): I have two questions, one for Susan and one for Mr. Pugh. Susan, could you briefly talk about the Matagorda pilot project that you just mentioned, and, Mr. Pugh, could you talk a little more about the improved productivity for fisheries? I wonder if you would elucidate which sites those are and what studies you have done to demonstrate that.

RESPONSE (Susan Rieff): I am going to defer part of that question, and I think that some people from our Department are going to speak a little later in the program, but real quickly this is an area in East Matagorda Bay where we had concerns about open-water disposal in the past. When that area came up for dredging again, our staff, working with the Highway Department and with the Corps, and also with the Agricultural Extension Service, I believe, contacted a landowner down there who had land which we felt was suitable for disposal. On a voluntary basis, the landowner agreed to a pilot project to allow deposition of some of this material on his property if we could turn this into a kind of experimental situation, and it seems to be going very well. This was originally conceived to be a one shot deal, and I am not sure what the potential is there for making this an ongoing activity at that site, but we were generally very well pleased with this. If you have any more

questions about it, I think that we are going to address this subject in a later technical session. If that does not help, please contact me later, and I will send you some information.

RESPONSE (James Pugh): From the standpoint of improved fisheries production in Galveston Bay and the Ship Channel area, the Port Authority is not a scientific agency and does not have people measuring things. One thing that we do see, though, is that since dredging the Houston Ship Channel was first dredged in 1870 and in all subsequent dredging for the widening and deepenings to different project levels, oyster production and fisheries production have continued to increase. We have learned from observation that these submerged structures that have been built in the bay for placement of the material from the ship channel have resulted in very rapid development into oyster beds. We do not have any empirical data to say that there are "this many" oysters in the new beds compared with the old beds, but it appears that those structures are very conducive and attractive to oyster bed development. We do not have, as the public Port Authority, a lot of definitive scientific data because we never kept records back in 1920 or 1940 of what the potential production of the bay was, much less the actual production. I hope that answers your questions.

## SESSION I: BEACH NOURISHMENT AND LAND STABILIZATION

Moderator: William T. Pearson, US Army Engineer Division, Southwestern

### OVERVIEW OF BENEFICIAL USES OF BERMS

Thomas W. Richardson  
Coastal Engineering Research Center  
US Army Engineer Waterways Experiment Station  
Vicksburg, Mississippi

#### Background

An underwater berm can be defined as a mound built on the ocean bottom to a specified height, length, and orientation, with length parallel to shore much greater than width perpendicular to shore. The Corps of Engineers is interested in underwater berms constructed from dredged material because, under the right conditions with proper design considerations, they can be used to help accomplish the Corps' dredging mission in a more cost-effective and environmentally responsible manner. Berms offer the additional possibility of making beneficial use of material which previously was simply discarded. The Corps has a history of involvement in building underwater berms beginning in the mid-1930's with a 200,000-cu yd berm off Santa Barbara, CA, in 20 ft of water and continuing with berms built off Atlantic City, NJ, and Long Branch, NJ, in 1948. The Atlantic City berm contained approximately 3.5 million cu yd placed in 38 ft of water. Subsequent monitoring of all these berms for a number of years after construction showed that they remained relatively stable.

#### Berm Types

There are two approaches that can be used in building underwater berms: the feeder concept and the stable concept. A feeder berm is one constructed of good quality sand placed in relatively shallow water, with the intent that the material will move out of the berm area and become part of the nearshore sand system. A stable berm is generally placed in deeper water, a wider

variety of material can be used in constructing it, and the berm itself is intended to be a relatively permanent feature. The potential benefits of a feeder berm are that it can become a sand source for nearby coastlines and, if located relatively close to the navigation channel from which the sand was dredged, can be a means of reducing overall costs by shortening haul distances. A stable berm can be constructed to shelter adjacent coastlines by partially reducing waves, particularly during large storms. If built from relatively clean sand, it can be used as a stockpile for future beach nourishment. The fact that a stable berm forms an identifiable feature on the bottom means that it has the potential to attract fish and it offers the possibility of reducing haul costs by allowing dredges to deposit material in a relatively concentrated area that can be close to the navigation channel.

### Pilot Study

The possibility for these and other benefits from underwater berms has generated considerable interest in evaluating them at different locations in the United States. One of the earliest efforts was a pilot study conducted in 1982 by the Norfolk District at the Dam Neck dredged material disposal site in the Atlantic Ocean off Virginia Beach, VA. The purpose of the pilot study was to see if an intentional design feature could be created on the ocean bottom using relatively poor construction material and conventional dredging and positioning equipment. Approximately 850,000 cu yd of silty sand was placed by two medium-sized, split-hull contract hopper dredges. Using conventional positioning equipment and sailing between two marker buoys, the dredges were able in a short time to create an underwater mound 11 ft high by 1,600 ft wide by 2,800 ft long. Monitoring by Norfolk District and the Coastal Engineering Research Center (CERC) for several years showed the mound remained stable in both configuration and position, with some initial adjustments of the upper layer during storms.

### National Demonstration

In part as a result of the Norfolk pilot study, the dredged material underwater berm was endorsed in principle by groups such as the Corps' Environmental Advisory Board, the Coastal Engineering Research Board, and the

NMFS. These endorsements contributed to an approval in 1985 by the Corps' Director of Civil Works for a National Demonstration of the underwater berm concepts. After nationwide investigation, Mobile, AL, was selected as the site for this demonstration, which consists of a feeder berm constructed of clean sand from entrance channel maintenance dredging and a stable berm constructed of material from Phase 1 of the Mobile Harbor deepening project. The feeder berm was placed in anticipation of its material gradually moving toward the west and contributing to the nearshore sand system off Dauphin Island. It was built in February 1987 by two shallow-draft, split-hull hopper dredges that placed material in 18 ft of water. The result was a feature approximately 1 mile long by 6 ft high containing 450,000 cu yd of sand. Construction of the stable berm is scheduled to begin soon. This feature will be much more massive than the feeder berm, containing approximately 18-million cu yd of widely varying material from Mobile Harbor. When completed, the stable berm will have dimensions of approximately 1 mile in width, 2-1/2 miles in length, and 20 ft in height.

The principal focus of the National Demonstration is a comprehensive monitoring program. The main purpose of this monitoring is to determine what happens to both berms. Secondary purposes are to assess why the berms behaved as they did and to determine any physical or environmental benefits that may result. Components of this monitoring program include Fathometer and side-scan surveys, periodic sampling of the berm material and surrounding areas, measurements of the wave climate, and tracking overall current patterns in the area using devices called seabed drifters. The drifters' carry cards intended to be returned by persons finding these devices and their use have helped generate favorable publicity for the berm demonstration through articles in local newspapers and personal contacts with citizens returning the cards. Other components of the monitoring program at Mobile include aerial photography and satellite imagery of the feeder berm and periodic fisheries' assessments at the stable berm site.

Monitoring of the feeder berm focuses on cross sections selected along the entire length of the berm. Results to date have indicated minor amounts of movement, a result attributed largely to an unusually mild wave climate in the 14 months since the feeder berm was placed. When monitoring begins on the stable berm, it will be concentrated on a test section that will be the first part of the berm to be built. After completing the test section, which will

contain approximately one-sixth of the total berm volume, the contractor will move to the other end of the berm area and begin building the remainder of the berm back toward the test section. Monitoring at the feeder berm site is scheduled to continue through December 1988. Stable berm monitoring will span a 3-yr period following the start of berm construction.

#### Other Berm Projects

After the National Demonstration at Mobile was underway, the New York District used the feeder berm concept at two concurrent projects on the south shore of Long Island to help alleviate erosion immediate downdrift of tidal inlets. In June to September 1987, the District constructed a feeder berm in 16 ft of water from approximately 400,000 cu yd of sand at both Fire Island Inlet and Jones Inlet. Each berm was approximately 8,000 ft long and 4 to 6 ft high and was placed using a medium-sized, split-hull hopper dredge. The District, with support from CERC, initiated a relatively simple monitoring program at each berm consisting of hydrographic surveys, sediment samples, observations of the nearshore wave and current environment, and aerial photography. Table 1 shows the actual cost of placing the Fire Island and Jones Inlets material in feeder berms versus the bid or estimated cost of other placement options. Obviously, the feeder berm concept at these two sites offered considerable cost savings as well as possible benefits to adjacent shorelines.

The Galveston District is currently investigating the feasibility of an underwater berm in conjunction with the Brazos-Santiago Pass navigation project near Brownsville, TX. Approximately 700,000 cu yd of material is dredged from this project each year. In conjunction with CERC, Galveston District is using methods such as seabed drifter studies, sediment samples, aerial photography, and current measurements to investigate several nearshore areas north of Brazos-Santiago Pass immediate offshore of South Padre Island. If a promising site can be located, Galveston District hopes to construct a berm later this year using 500,000 cu yd of sand.

## Summary

Underwater berms constructed from dredged material are beginning to attract nationwide attention as one way to make more intelligent use of material that at present is simply disposed. In addition to the National Demonstration at Mobile and other projects now under way, the Corps of Engineers has included a number of berm-related studies in its new Dredging Research Program. This 6-year, \$35-million R&D program has a single purpose: to lower the cost of Corps dredging in ways consistent with our mission performance and environmental responsibilities. We believe that underwater berms, properly implemented, can help us achieve this goal.

Table 1

Costs for Dredged Material Placement Alternatives,  
Fire Island Inlet and Jones Inlet, New York

<u>Project</u>	<u>Beach Nourishment</u>	<u>Ocean Mud Dump</u>	<u>Nearby Open Water</u>	<u>Near Beach Berm</u>
Fire Island	\$5.50 (BID)	\$4.50 (EST)	\$4.00 (BID)	\$2.23 (ACT)
Jones Inlet	\$5.50 (EST)	\$4.50 (EST)	\$4.00 (BID)	\$2.63 (ACT)

QUESTION (Dawn Whitehead): I just wondered if any of your berm projects have been exposed to hurricanes or tropical storm forces?

RESPONSE (Tom Richardson): Not to hurricanes, but the site at Dam Neck was exposed to several northeasters, which in that part of the world can be as damaging as hurricanes. In fact, we noticed very little change in overall elevation, but what we saw on the crest of that feature was an armoring of the berm with some of the finer material, which if you remember was silty sand. This was winnowed out and left a coarser blanket, which helped stabilize the berm. Again, the stockpiles that were done in the 1930's and 1940's also have remained quite stable over quite a period.

QUESTION (B. C. Gersch): What was the draft of these shallow draft barges which you took the material out to sea?

RESPONSE (Tom Richardson): I am going to defer this question to my friend in Mobile District, Mr. Pat Langan. Loaded about 12 ft.

## LOW WAVE ENERGY STABILIZATION OF SHORELINES

John Lesnick  
Moffatt and Nichol Engineers  
Raleigh, North Carolina

My topic is low wave energy stabilization of shorelines, and that brings to mind applications such as dredging and dredged material placement. I will leave it for you to think of specific applications which I will show to you that will work for your specific applications. I am presenting a paper under joint authorship. It will be called "Shoreline Erosion Control Demonstration Program Revisited" and will be authored by a number of persons including J. Comb from the New Orleans District, John Hawsley and J. Lochard from the Chief's Office, Eric Nelson from the Seattle District, and me. As I said, this paper will be released a little later on this year. But to give you some background, the Corps' interest in low-cost shore protection, if there is such a thing, goes back to 1974 with the WRDA, specifically Section 54 of that Act. This authorized the Corps to undertake a 5-year program to develop, demonstrate, and transfer knowledge about low-cost methods for shore protection.

The Corps conducted a national program from that point to plan, design, construct, monitor, and evaluate shore erosion control devices both structural and vegetative. These were confined to sheltered inland waters, and these methods are not applicable at all to the open coast but to sheltered low wave energy areas. The vegetative aspects of the program were coordinated with the SCS, who provided invaluable assistance to the Corps in conducting the program. Now in the original legislation, the Congress directed that six sites in Delaware Bay actually named in the legislation be selected and used. The northernmost site is Pickering Beach, and then moving to the south are the other beach sites. Two additional sites were required on the shorelines of the Atlantic coast, gulf coast, and the Pacific coast, and two in Alaska. Nothing was mentioned in Hawaii.

You might ask why the sites were chosen in Delaware Bay. The reason is that the Senator from Delaware was the congressman who initially got the ball moving on the legislation. After a lengthy screening search, the Corps finally came up with some additional sites, specifically: Roanoke Island on the North Carolina coast, which was the responsibility of the Wilmington



District; Jentzen/Stuart Beach causeways, which the Jacksonville District took care of; Basin Bayou, which is a state park on the Eglin Air Force Base property on the Florida Panhandle; and Fontainebleau State Park on Lake Ponchartrain, which the New Orleans District handled. Basin Bayou was handled by the Mobile District.

On the West Coast there was Alameda, which is in San Francisco Bay in the San Francisco District; Oak Harbor, which is on the Naval Air Station on Whibey Island in Puget Sound; Port Wing on Lake Superior; Geneva State Park on Lake Erie; and two sites in Alaska. Kooski, just north of the Arctic Circle, and Milchek are in the Alaska District.

Demonstration devices were ultimately placed at 12 of these sites as described in the final report of the project (which came to be known as the "Doorstop Report," which was 2-1/2 to 3 in. thick). Although no one uses it as a doorstop, it is a name that caught on. But only 12 of these sites had demonstration devices actually constructed. Roanoke Island, which the Wilmington District had, was a later site which fell through due to a lack of local cooperation, and nothing was ever built. Three of the Delaware sites that were named in the Federal legislation already had beach projects; nothing was done but to monitor those sites.

An additional 20 sites were selected from across the United States, which represented a wide range of shore protection devices that had already been constructed by others. Shoreline types and exposures were monitored during the program to try and gain additional insights. These monitoring only sites included two in this area: Beach City, TX, which was a concrete type bulkhead, and Shore Acres, TX, which was a concrete rubble revetment. The Holly Beach, Louisiana, Gummy Block revetment was also one of these sites.

The structures were conceived to be appropriate for the area in which they were placed as far as available local material, environmental practices, and whatever was important. For instance, timber structures were a big part of the structures built in the Pacific Northwest because timber is widely available there. Used steel fuel barrels were used in Alaska because they had no use for these. Vegetation was used heavily at the Fontainebleau site. Construction was basically completed by the end of 1978 at all sites, and the monitoring was continued through 1980. Therefore, there was a maximum of perhaps 2 years of site monitoring.

The purpose of my presentation is not to give you the history or background as that has been described in the final report and also in a series of guide books entitled, "Low Cost Shore Protection, A Guide for Local Officials." These have been distributed nationally and internationally, in fact. Two other companion reports with orange covers are for local property owners. A greenish-type cover is for engineers and contractors. So these are products that the Corps developed in the idea of information dissemination to the public.

The reason for this particular talk is that the Chief of Engineers in 1986 requested a revisit of all these demonstration sites. This was done to develop a better basis for evaluating their longevity; to provide additional data for design criteria that might be forthcoming and, if necessary, to redefine what is meant by low-cost shore protection; to provide additional opportunity for information transfer, which I suppose is my purpose today; to gain information gained from other sites with that obtained from the program; and also to determine what can be done to capitalize on the lessons learned.

So the authors visited the demo sites in 1986 and also during the summer of 1987 and were assisted by field personnel in that effort. We found that many of the original devices had failed in the intervening year; some had been removed by the local sponsors, and some had apparently been removed and were not apparent at all. Some were covered over by new construction and were no longer visible. But there were a few out there that were still functioning and serving a useful purpose, and I am going to concentrate on discussing those in the remaining few minutes.

Jentzen/Stuart Beach Causeways in south Florida: One of the devices was a series of concrete block revetments which were prepriority blocks at that time; some of these are still being sold and had names like monoslabs, turf-stones, and lockhard blocks, and we also had standard concrete blocks. In each case, we found that in some of the section, some worked fine, some length was stressed, and some had failed outright. We found that overtopping was a serious problem, as was the flat-platting of the blocks. The standard Corps guide on riprap usually includes some provision that the individual stones should not be pleated, but should be blockish or cubical at least in some fashion. The idea is that anything that is flat and platey like this is susceptible to be plucked out and moved by wave action or by undercutting by wave action, and that is exactly what happened. But one of the main problems

was overtopping; since then the structures have been covered over with groat in some sections, particularly in the upper portion of the device at the break in the slope, where the tendency for failure was the greatest.

Basin Bayou in the Panhandle: There was a sand bag and fence bulkhead which was built. Between January 1979 and July 1979, significant degradation of the fabric occurred. The fabric was supposed to be ultraviolet light stabilized, but it was not, and the structure failed very quickly and was gone within a year. Actually, it was gone within 6 months. The longard tube had been slashed 6 months later either inadvertently or otherwise in some fashion, and it had disappeared without a trace. It was rebuilt once, but it failed again and was never heard from again. This is called a surge breaker, which is a series of hollowed triangular prisms that are laid out in a fashion to create a breakwater. This structure is still in place and still functioning. Sand is accumulating behind it, even though there is very little sand in transit along the shore. An old device called a sand grabber is still in place, although it is heavily tilted towards the water with the tie rods. Basically, it is loose concrete block stacked up and then steel rebar placed through these and bent in order to hold the structure in place. The rods are totally gone and corroded, but the structure remains. This gives you some idea of the wave energy involved and the effects on the blocks. As an aside, these silt-type structures, such as the surge breaker, are still manufactured and marketed heavily, and the surge breaker is sold out of Chicago. There are still two products being sold in the Chesapeake Bay area; one of these is called the beach prism, which is 6 ft high, is hollow, and has the same kind of idea, just a little geometric arrangement, and the other is called a beach beam. So you may be hearing about these as these folks move around the coast and market their product. The sand grabbers are no longer being sold.

Fontainebleau State Park on Lake Pontchartrain, Louisiana: There were various combinations of blocks and mats tried there. The mats were basically filter cloth backing with small concrete blocks glued to them; as it turned out, the glue was very strong, and after 10 years the bond between the filter cloth backing and the blocks remained, and you could not pull the blocks free even if you wanted to. So the mat-type structures worked well, but the individual blocks did not work as well and were easily displaced and removed by users of the park to create pits. Some removed for use by fishermen. The individual blocks did not fare well, but the mats performed reasonably well.

Concrete blocks disappeared quickly for local construction projects. Timber piles with tires thrown over them like doughnuts were used to form a breakwater, and it is still there after 7 years. This picture is from last year and was taken at a time of extremely low-water levels on Lake Ponchartrain. The vegetation that you see is volunteer vegetation with some accretion behind it. This is one of the most interesting, low-cost shore protection structures and one possibly that merits some future research and development. You can see another view during normal water conditions. The most successful device that was tried during this program was the vegetation at this site and was an outstanding success. But engineers do not tend to do very well with it because it requires persistence and you have to replant it when necessary and do it over and over again until you are successful, assuming that the site is appropriate. The Boca Chito Conservation District staff did an outstanding job on this site and should be commended today. The *Spartina alterniflora* has become well established at this site. Keep in mind that this part of the shoreline looks like before and after the protection, and note that the vegetation has provided the only real success. This is the only site where vegetation was established and where there was any persistence involved in trying to get that to work.

Oak Harbor, Washington, Puget Sound: Some sand bags with cement were used for revetments but despite every effort to get these to work, they failed after a few years because of toe scour. They were even entrenched into the break several feet. There was a gabion revetment which failed when the baskets ruptured because of floating debris impacting on the basket. There was also a gabion breakwater up on Lake Erie that failed so the gabion structures did not work well at all where they were subjected to wave action. A used-tire bulkhead similar to the breakwater at Fontainbleau turned out to be successful. The really difficult problem was trying to find out how to filter the structure to keep the material retained because of these large voids between the tires. A section with filter cloth worked better than the section without one. Both parts of the structures worked, but the back bluff eroded down and provided material until enough coarse material was left behind to form its own filter. In the area where this would be subjected to waves constantly, the unfiltered portion of the bulkhead would have been a failure.

Standard timber construction was a complete success at this site also. Up at Lake Superior near Fort Wayne again, we have standard concrete blocks which were used. Again these failed because of toe scour and also some differential settlement within the foundation. These are called monoslabs as they are used primarily for parking lots and were tried for shore protection and marketed for that purpose. This structure was placed on fill; when the fill settled, the structure failed.

This was a series of H-piles driven into the bottom with railroad ties strung between the flanges; this turned out to be a successful, but rather expensive structure. The bank behind the structure was also sloped back, and that turned out to be a successful way to control that otherwise slumping bluff. At Geneva State Park, there was a Z-wall, which was actually designed for noise protection but tried for shore protection. Originally there were 14 panels placed, and as of last year only 8 of those remained, and there had been a considerable amount of accretion behind them. That is disappearing now as the structure is becoming shorter and shorter as the panels fall off. This structure is underlain by rock, so settlement is not a problem. This would fail at a soft bottom site.

What are the conclusions? We found that a 10-year structure life, while this is useful for economic evaluation purposes, is difficult to achieve because anything built to last 10 years will probably last 20 years and anything that is underdesigned will fail very quickly. We do not feel that forms or structures that are rigid are appropriate. Stone structures have a built-in design feature that overdesigns the structure for events and could be used with short-term erosion events. We found that low-cost shore protection can ultimately be defined for all sites. There is not a specific device, specific material, but it is the philosophy of design which says that you use the minimum amount of structure that you can get away with. Many people think that there is a sort of major bullet or device out there that can solve their problems. There is no such thing as low-cost shore protection, but such things as overtopping, toe protection, strength characteristics of the materials are very important. If you neglect them and attempt to build a "cheap" structure, you are going to suffer failure. These things are always forgotten in the search for innovative solutions, I have found, especially from marketing people. So the tried and proven methods are still the best. Annual costs are most indicative of what is low-cost shore protection rather than initial

costs. For instance, that sand bag bulkhead at Basin Bayou is \$30 a linear foot, and it failed in 6 months. The timber bulkhead I showed you at Oak Harbor cost about \$66 a linear foot and should last 25 to 30 years. If you run the numbers, you will find that the sand bag bulkhead has an annual cost of about \$65 a linear foot, and the timber bulkhead about \$6 a linear foot per year. So that the true costs that are low are those that last and one that is properly designed and built. Finally, vegetation is an excellent solution in the right location, but it requires persistence, and you have to keep replanting it; however, you do have something that is aesthetically pleasing and environmentally acceptable. This is not often understood by engineers on projects like this. This is not new, but we demonstrated some measures for low-cost shoreline protection.

---

QUESTION (Paul Carangelo): I am very encouraged by the results shown with the vegetation study indicating that persistence is required. Could you give us a dollar value on the cost of that persistence as compared with the timber pile bulkhead?

RESPONSE (John Lesnick): I am sorry, but I do not have those numbers with me. However, the structure was replanted by the local SCS District people, and I am not sure specifically of the number of plantings or cost. I can obtain those numbers for you if you like?

QUESTION (Cynthia Woods): I am with the Norfolk District. When you picked the different demonstration sites, did you take into account the currents, erosion, etc., at those sites? What I am concerned about is when you look at that failure, did you take into account that the same structure may have worked in an area with less erosion?

RESPONSE (John Lesnick): A large number of sites were evaluated for the demonstration and considered those factors. I do not know exactly how many sites were evaluated, but they were in the range of 100 to 200 sites and considered shoreline form, wave energies, bottom sediments, etc. These sites were selected as being representative of coastline and had local sponsors.

QUESTION (Cynthia Woods): With the failure, this was a 5-year study. In some of the areas that failed, were there any attempts to replace devices, and so forth?

RESPONSE (John Lesnick): No, one of the oddities there was a strict policy of no maintenance on purpose, thereby accelerating the failure process; they then could be identified earlier.

QUESTION (Julio Rodriquez): I am from the Panama Canal. We have had many problems through the years and have found some good solutions in the use of sheet piling. They work in freshwater and saltwater. Have you tried these?

RESPONSE (John Lesnick): We did not try them as they were considered to be high cost and conventional and not low-cost options. We figured that a lot of sheet pile structures were out there and a lot is known about them that we did not need to duplicate. They also fell outside the definition of low cost at that time.

# STABILIZATION AND DEVELOPMENT OF MARSH LANDS

Hollis H. Allen and Robert L. Lazor  
US Army Engineer Waterways Experiment Station  
Vicksburg, Mississippi

James W. Webb  
Texas A&M University at Galveston  
Galveston, Texas

## Introduction

Instability of dredged material disposal site shorelines caused by waves is a problem and is expensive to correct through traditional approaches such as riprapped revetment. The US Army Corps of Engineers (CE) has many dredged material shorelines that are subjected to moderate to high wave energies caused from wind fetch or ship wakes. Moderate to high wave energy environments are defined as having fetches over 9.0 km, and are areas typified by headlands and straight beaches. This paper discusses the stabilization of dredged material in such energy environments by using marsh. Such marsh also has the added benefit of providing wildlife and fisheries habitat. Various new and innovative approaches of establishing marsh have been recently used experimentally by the US Army Engineer Waterways Experiment Station (WES) to stabilize dredged material shoreline erosion (Allen et al. 1978; Allen and Webb 1983; Allen, Webb, and Shirley 1984; and Allen, Shirley and Webb 1986). Approaches used in moderate to high wave energy environments that show promise in stabilizing dredged material shorelines have been applied at three gulf coast locations.

## Marshes and Breakwaters

The WES has used three different kinds of marsh and breakwater combinations to stabilize dredged material. Marsh grass sprigs (rooted stems) are transplanted shoreward of a breakwater structure. The breakwater is only needed the first 2 to 3 years after planting, until the marsh sprigs spread by rhizomes and completely cover the target area (Newling and Landin 1985). Expedient and inexpensive breakwaters should be used since they are only



needed temporarily. The WES has used sandbag, floating tire (FTB), and tire-pole breakwater and marsh grass combinations to stabilize dredged material.

#### Sandbag breakwater

A sandbag breakwater was successfully constructed in 1975 and used through 1978 to develop salt marsh on a sandy dredged material site on Bolivar Peninsula adjacent to Galveston Bay, Texas (Figure 1) (Allen et al. 1978). A breakwater with a 305-m-long and 1.5-m-wide front was constructed from 0.5- by 1.04- by 2.9-m nylon-coated bags. Smooth cordgrass (*Spartina alterniflora*) and saltmeadow cordgrass (*S. patens*) sprigs were planted shoreward of the sandbag breakwater in experimental plots. The marsh was successful because of the protection afforded by the breakwater, which protected it from a 32-km northwest wind fetch that produces large waves in the winter. The sandbag breakwater provided enough initial protection of the transplants for marsh establishment to occur (Figure 2), and the marsh is still functioning very well (Newling and Landin 1985, Landin 1986).

#### Floating tire breakwaters

The FTB and shoreward salt marsh plantings have been successfully used to stabilize shores of unconfined dredged material deposits at sites on the gulf coast. In 1981, a two-tier FTB (Figure 3) and smooth cordgrass sprigs stabilized part of a dredged material dike in Mobile Bay at Gaillard Island (Allen and Webb 1983). The dike formed one side of a three-sided, 485-ha confined disposal facility (CDF) in the middle of Mobile Bay (Figure 4). The stabilized area is subject to an 11.2-km fetch from the north. The FTB was built and installed after a previous, conventional marsh planting had washed out.

A three-tiered FTB was tested in 1984, at Bolivar Peninsula, 1 km west of the 1975 site described under the sandbag breakwater. The configuration was selected for field testing after wavetank studies demonstrated that it could reduce wave energies by as much as 80 percent (Markle and Cialone 1987). Smooth cordgrass was planted shoreward of the breakwater using both conventional single stem and biotechnically stabilized transplants, which will be discussed later in this paper. Plantings unprotected by a breakwater were also established nearby as a control. Twenty-seven months after planting, the protected area had an average of 43-percent coverage by smooth cordgrass. The unprotected, conventional plantings did not survive. Forty-three percent coverage after 1 to 2 years is similar to that seen at the original Bolivar

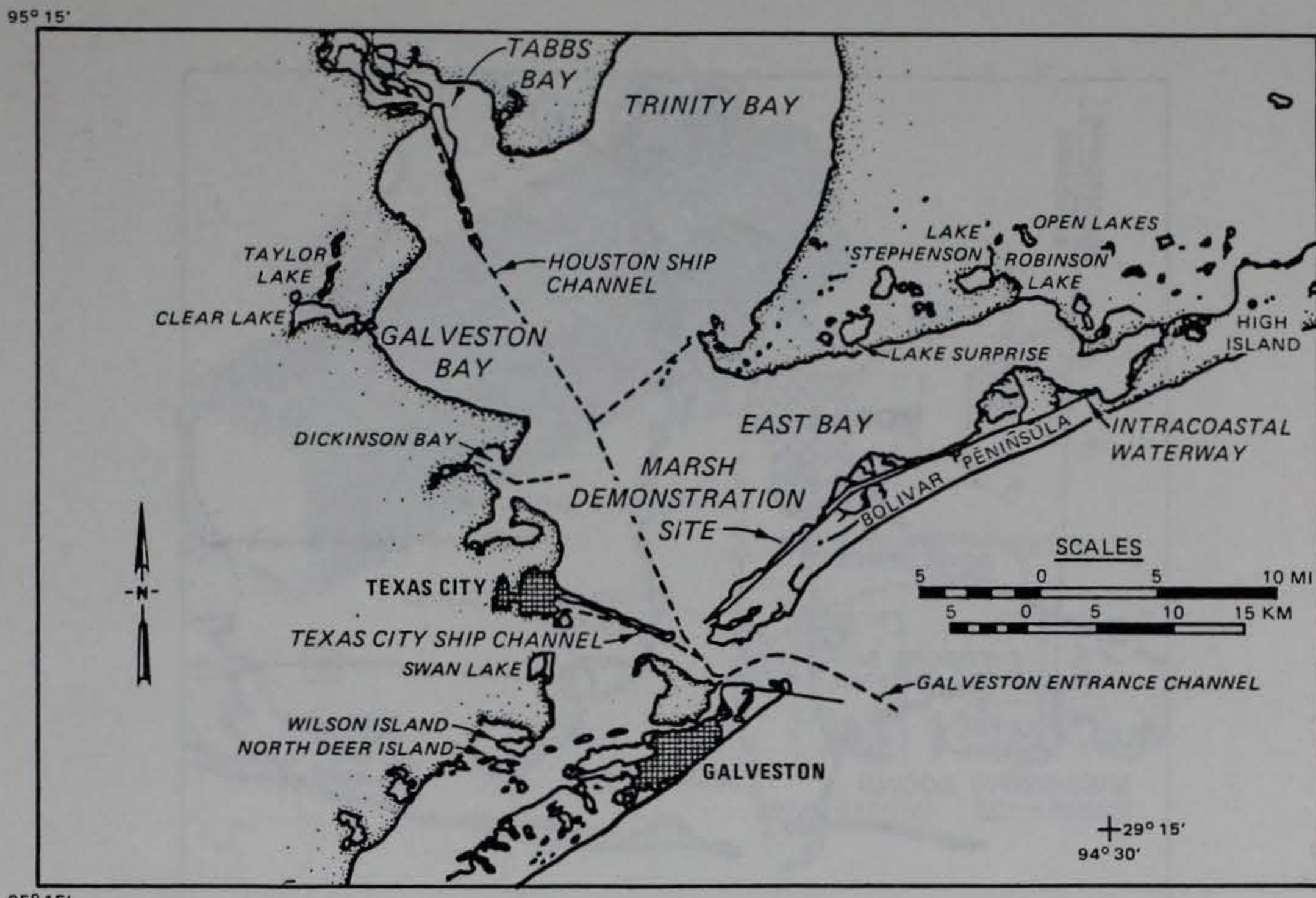


Figure 1. The Bolivar Peninsula marsh establishment site next to Galveston Bay, Texas

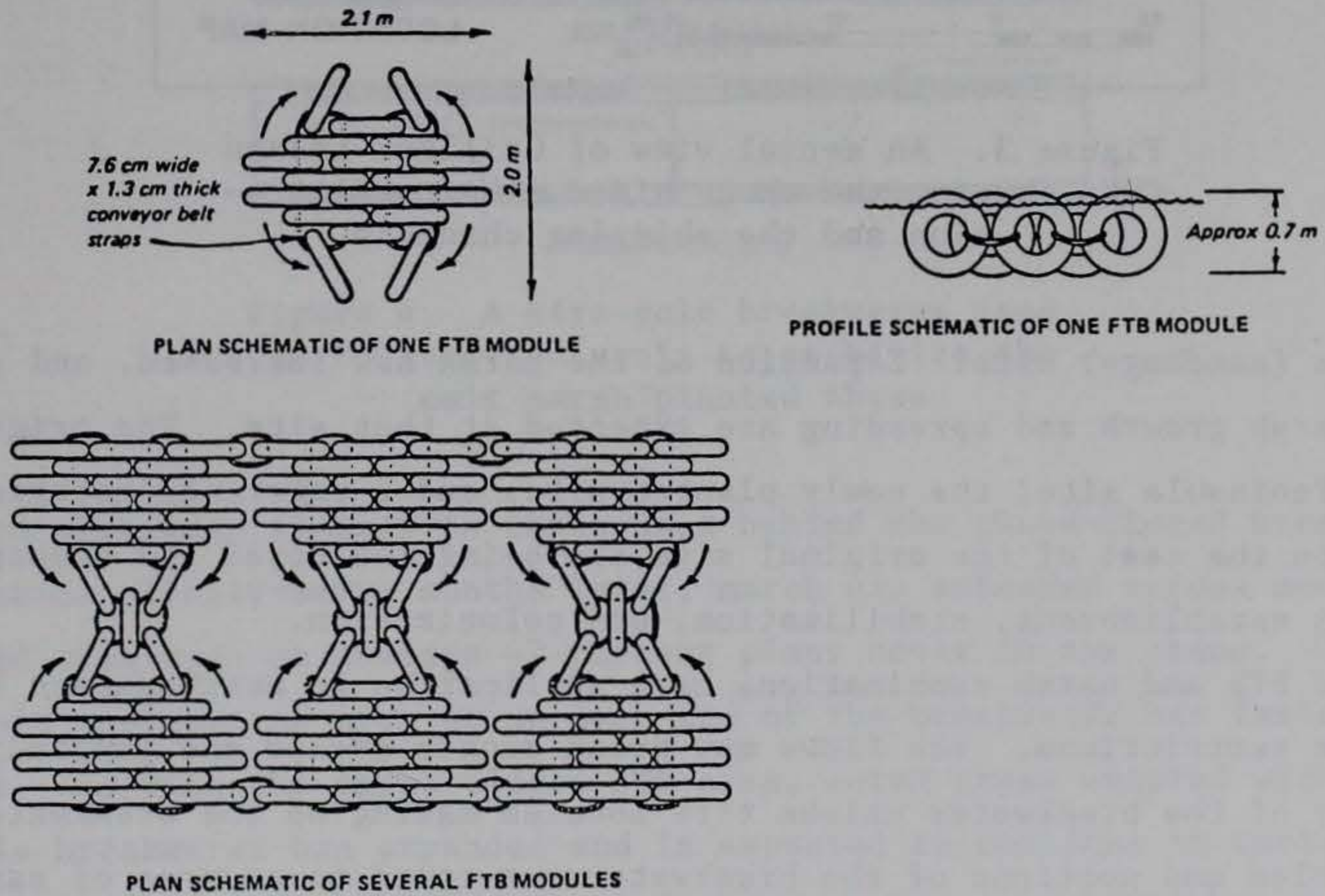


Figure 2. The marsh at Gaillard Island stabilized by two-tier FTB

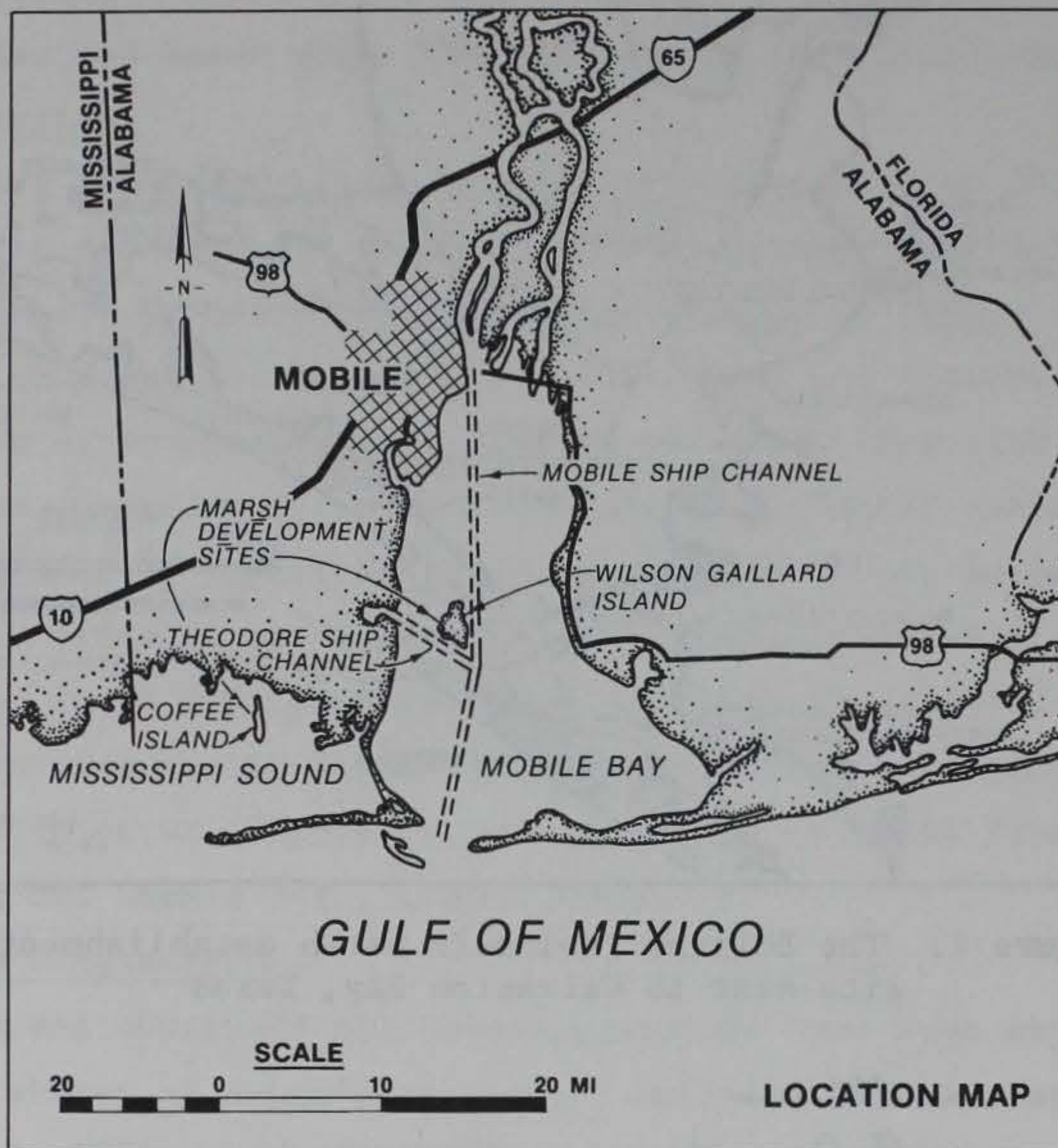


Figure 3. An aerial view of Gaillard Island CDF, showing the three-sided dike configuration and the shipping channels

Peninsula (sandbags) site. Expansion of the marsh has increased, and continued marsh growth and spreading are expected at that site. The original Bolivar Peninsula site, the newly planted site, and a reference material deposit to the east of the original site are being monitored and compared for long-term establishment, stabilization, and colonization.

The FTB and marsh combinations have application to northeastern US sites with some restrictions. Ice flows may break anchor straps and jeopardize the integrity of the breakwater unless tire modules making up the breakwater are disassembled and portions of the breakwater are towed to an area of safe-keeping for the winter. This can be achieved by tying several tire modules to a boat or barge and floating them elsewhere.

#### Tire-pole breakwater

Another breakwater structure consisting of tires threaded on 15.2-cm-diam poles (Figure 4) was also tested at the Bolivar Peninsula site in 1984.

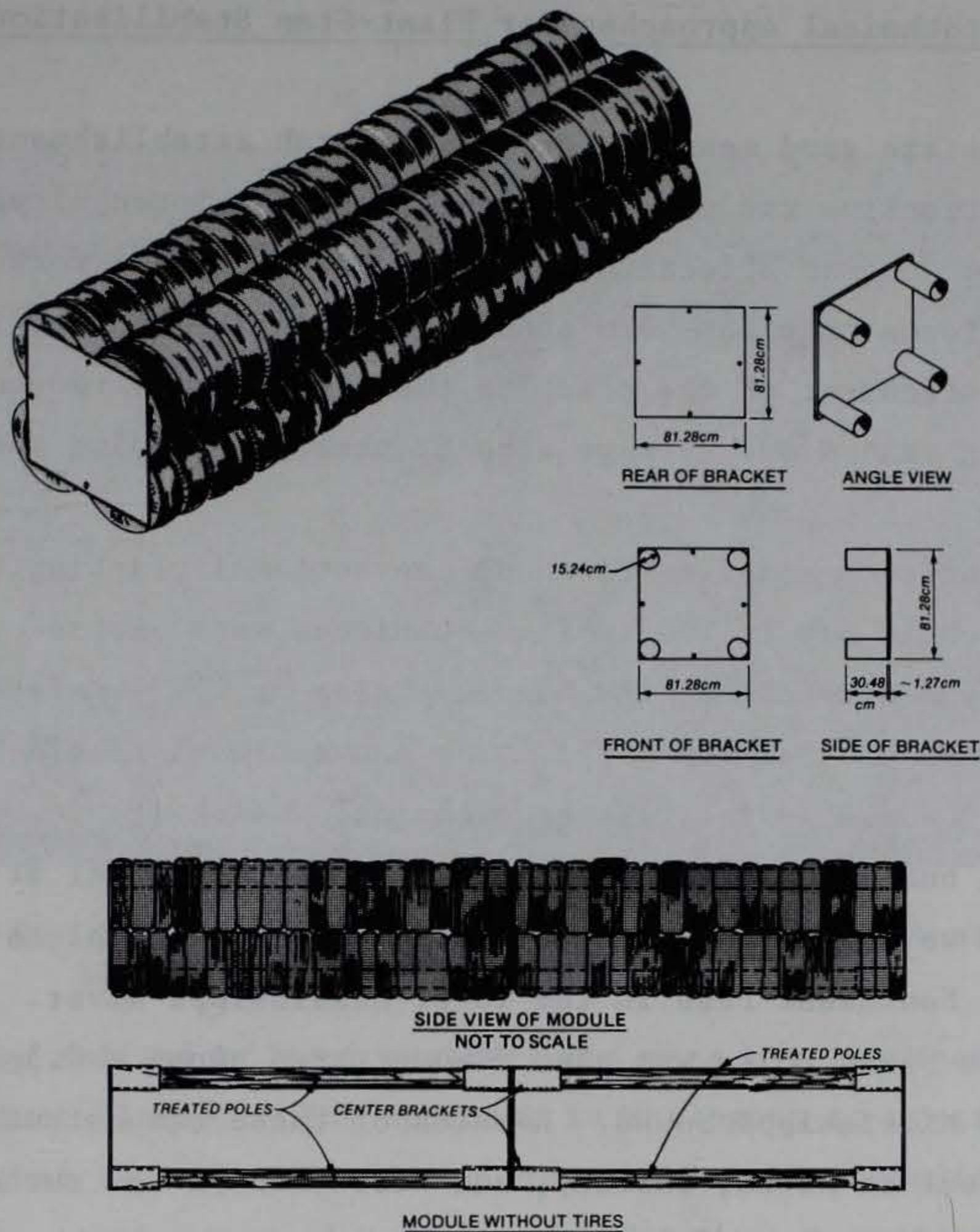


Figure 4. A tire-pole breakwater used at Bolivar Peninsula to stabilize the salt marsh planted there

Shoreward plantings similar to those used behind the three-tiered breakwater were tested. Twenty-seven months later, marsh has extended across most of the protected area with an average 47-percent plant cover in the stand. Only a relatively unprotected area at an open end of the breakwater has failed to vegetate. As with the three-tiered FTB area, marsh grass coupled with the tire-pole breakwater has expanded and is expected to continue to thrive.

Tire-pole breakwaters for initial marsh protection should be used with caution at northeastern US sites because of the potential for ice problems. Ice flows may create too much strain on the horizontal poles holding the tires, thereby breaking them and destroying the integrity of the breakwater.

## Biotechnical Approaches for Plant-Stem Stabilization

Breakwaters are good means of promoting marsh establishment, but other more visually attractive and possibly less expensive biotechnical approaches exist that may be just as effective. In 1983, WES began to work with planting techniques that focus on plant-stem stabilization. The concept is to strengthen the attachment of the plant to the substrate to reduce the likelihood of its being washed out by wave attack, thereby avoiding the necessity of a breakwater.

Twelve plant-stem stabilization and conventional planting techniques were tested in Mobile Bay in 1983. The techniques were exposed to waves of various fetches and directions, the maximum being an 11.2-km fetch from the north (Allen, Webb, and Shirley 1984). The conventional single-stem planting techniques proved unsuccessful. Three techniques using erosion control mats, plant rolls, and burlap bundles demonstrated enough potential at Gaillard Island that they were subsequently tested in demonstration plots at Bolivar Peninsula and at Southwest Pass in the lower Mississippi River. Potential usefulness of the plant rolls was also demonstrated along a 0.5-km front at Coffee Island in Mississippi Sound. Results of these demonstrations are described in detail in Allen, Shirley, and Webb (1986), and successful approaches are summarized as follows.

### Erosion control mat

A biodegradable fabric mat called paratex, which consisted of 0.1-kg/sq m natural fibers was laid like carpet on the shore at the previously described Bolivar Peninsula site. Single stems of smooth cordgrass were planted on 0.5-m centers through slits cut into the mat (Figure 5). The edges of the mat were nailed between 5- by 15-cm boards that were buried in the sediment (Allen, Webb, and Shirley 1984). Four 6- by 9-m plots of the planted mat were placed adjacent to, parallel with, and outside the immediate influence and protection of the breakwaters. Twenty-seven months later, three of four original plots remained with an average 41-percent plant cover. Success within the remaining plots was similar for both those plots protected by breakwaters and those unprotected.

This approach is currently being expanded to include mats that have "pregrown" marsh grass, in which smooth cordgrass seeds are sown on the mat, germinated, and allowed to grow to seedling stage in the nursery. When the



Figure 5. Single stems of smooth cordgrass to be planted in slits cut in paratex erosion control mat

seedlings develop sufficient root systems, the mats are transported to the field site for installation. The approach is analogous to pregrown lawn sod from nurseries that is transported to customers' lawns. Immediately upon installation, the marsh grass already has developed root systems that are ready to grow. When the mats arrive at the field site, segments of them are laid between woven wire and staked down with metal rebar to prevent washout.

#### Plant roll

A plant roll is constructed by placing soil and six transplant clumps (several stems with one intact root mass) at 0.5-m intervals on a strip of 3.7-m-long by 0.9-m-wide burlap. The sides and ends of the burlap are brought together around the plants and fastened with metal rings. This creates a 3-m-long roll of plants and soil (Figure 6). The plant rolls are placed parallel to the shoreline and buried to such a depth that only the plant stems are exposed.

A mixture of single-stemmed transplants and plant rolls were successfully used at a demonstration site at Coffee Island (Figure 3) in Mississippi Sound. The site consisted of clayey dredged material and had a maximum fetch of 16 km. Stabilization with smooth cordgrass was undertaken to control erosion. One row of plant rolls was placed end-to-end seaward of



Figure 6. Plant rolls waiting to be placed along the dredged material shoreline at Gaillard Island, Alabama

single-stemmed transplants (Figure 7a) over a linear distance of about 0.5 km to cover an area 5 by 10 m wide.

Periodic inspection of this demonstration planting revealed that new stems emerging from the plant rolls satisfactorily spread, established protection for single transplants placed behind them, and helped to stabilize the eroding dredged material face (Figure 7b). Recent inspection of the site found marsh fringe that showed signs of accreting sediment, a feature which will further protect the island from erosion.

Plant rolls containing smooth cordgrass are currently being tested at eroding dredged material sites along the Atlantic Intracoastal Waterway (AIWW) near Wilmington, NC. Waves from large pleasure boats are eroding the shorelines of dredged material deposits, and the plant rolls will be evaluated as to their effectiveness in controlling shoreline erosion from these types of waves. If they prove successful in this kind of situation, they may have broader applicability to sites farther north along the AIWW than previously thought.

#### Costs

Costs of biotechnical techniques using marsh are given in Table 1 and range from \$48 to \$154 per linear metre for a marsh 20 m wide (seaward to



a. Plant rolls in place at the field site



b. Plant rolls after 3 years

Figure 7. Plant rolls have been used to effectively stabilize erosive shorelines in Alabama and Texas



shoreward). Traditional erosion control construction techniques are much more expensive than these vegetation alternatives. For example, costs for rock revetments are approximately \$688 per linear metre for an area 20 m wide, and wood and steel sheet-pile bulkheads range in cost from \$1,575 to \$1,837 per linear metre (Eckert, Giles, and Smith 1978).

### Conclusions

Some of the biotechnical approaches described in this paper are still experimental in nature and must be used with that in mind. They do offer considerable promise as cost-effective stabilization alternatives to traditional methods such as riprap. They also have the additional values of providing wildlife habitat and being environmentally compatible, while improving site attractiveness.

Table 1  
Costs of Planting Technique\*

<u>Planting Technique</u>	<u>Cost per Plant</u>	<u>Cost/Linear Metre (20 m wide)</u>
Single-stemmed plants (conventional planting)	\$0.15	\$ 12.00
Plant roll	0.60	48.00
Paratex mat	1.58	126.00
FTB with planted sprigs	1.58	126.00
Tire/pole breakwater with planted sprigs	1.95	154.00
Sandbag breakwater with planted sprigs**	3.35	265.00

\* Costs are based on an hourly labor rate of \$6.00 plus \$0.10 per plant for digging, gathering, and transporting. Costs of materials are included; other direct and indirect costs are not included. Costs per linear metre also assume that plants are placed on 0.5-m centers and are planted in a swath 20 m wide.

\*\* Costs of the sandbag breakwater construction are based upon personal communication with James L. Wells, US Army Engineer District, Wilmington, 12 April 1988. Estimate is for a 1.5-m-high breakwater.

### Literature Cited

- Allen, H. H., Clairain, E. J., Jr., Diaz, R. J., Ford, A. W., Hunt, L. J., and Wells, B. R. 1978. "Habitat Development Field Investigations, Bolivar Peninsula Marsh and Upland Habitat Development Site, Galveston Bay, Texas: Summary Report," Technical Report D-78-15, US Army Engineer Waterways Experiment Station, Vicksburg, MS.
- Allen, H. H., Shirley, S. O., and Webb, J. W. 1986. "Vegetative Stabilization of Dredged Material in Moderate to High Wave-Energy Environments for Created Wetlands," Proceedings 13th Annual Wetland Creation and Restoration Conference, Tampa, Florida, pp 19-35.
- Allen, H. H., and Webb, J. W. 1983. "Erosion Control with Saltmarsh Vegetation, Proceedings 3rd Symposium on Coastal and Ocean Management, American Society of Civil Engineers, San Diego, CA, pp 735-748.
- Allen, H. H., Webb, J. W., and Shirley, S. O. 1984. "Wetland Development in Moderate Wave-Energy Climates," Proceedings Dredging '84 Conference, Clearwater Beach, Florida, pp 943-955.
- Eckert, J. W., Giles, M. L., and Smith, G. M. 1978. "Design Concepts for In-Water Containment Structures for Marsh Habitat Development," Technical Report D-78-31, US Army Coastal Engineering Research Center, Fort Belvoir, VA.
- Landin, M. C. 1986. "Wetland Beneficial Use Applications of Dredged Material Disposal Sites," Proceedings 13th Annual Wetland Creation and Restoration Conference, Tampa, FL, pp 118-129.
- Newling, C. J., and Landin, M. C. 1985. "Long-Term Monitoring of Habitat Development at Upland and Wetland Dredged Material Disposal Sites, 1974-1982," Technical Report D-85-5, US Army Engineer Waterways Experiment Station, Vicksburg, MS.
- Markle, D. G., and Cialone, M. A. 1987. "Wave Transmission Characteristics of Various Floating and Bottom-Fixed Rubber Tire Breakwaters in Shallow Water," Technical Report C-87-87, US Army Engineer Waterways Experiment Station, Vicksburg, MS.

---

QUESTION (Participant): Did you use different types of fertilizer?

RESPONSE (Robert Lazor): In the original Bolivar Peninsula study, there were different rates of fertilizer used at those sites. Those results indicated no significant differences in plant growth attributable to with or without fertilizer.

QUESTION (Bob Nailon): I am an extension agent over in Chambers County, Texas. What were your results on your multiple stem versus single stem transplants?

RESPONSE (Robert Lazor): Results indicated that single stem transplants work just as well as multiple stem transplants.

COMMENT (Bob Nailon): I am involved in a shoreline stabilization project in East Galveston Bay, and we found out that when you disturbed the soil that much with the multiple stem transplants, you left the soil open to wash-out and erosion. So we decided that single stem transplants worked best.

QUESTION (Gordon Thayer): One of the things that you did not speak about is the difference between greenhouse-grown plants and field-acquired plants?

RESPONSE (Hanley Smith): We have found that natural stock has greater survivability than greenhouse stock, and it is a lot cheaper.

# ENVIRONMENTAL CONSIDERATIONS IN USING BEACH NOURISHMENT FOR DREDGED MATERIAL PLACEMENT

David A. Nelson and Edward J. Pullen  
US Army Engineer Waterways Experiment Station  
Vicksburg, Mississippi

## Introduction

Coastal engineers have long recognized that beaches and associated dunes provide excellent protection against the effects of storms. Restored and nourished beaches and dune fields have proven their value not only as protection for shoreline erosion, but also as recreational areas for the public and as habitat for many coastal marine organisms. Though beach nourishment may be one of the most environmentally desirable and cost-effective shore protection alternatives, it is not without environmental consequences.

## Physical Effects

### Type and placement of equipment

Two primary methods of placing sand on a protective beach are land-hauling from a nearby borrow area and direct pumping of sand through a pipeline from offshore borrow areas using a floating dredge. Two basic types of floating dredges are used to remove material from the bottom and pump onto the beach. These are the hopper dredge (with pump-out capability) and the hydraulic pipeline dredge (suction dredge). Hydraulic pipeline dredges are better suited to sheltered waters where wave height is less than 1 m (CERC 1984). A cutterhead is often used on the suction dredge. The action of the cutterhead agitates the substrate to a greater degree than a suction dredge without a cutterhead, creating a greater potential for elevated turbidity levels and increased sedimentation rates.

Placement of equipment such as dredge anchors and pipelines can damage environmentally sensitive habitats such as coral reefs, seagrass beds, and dunes. Damage to coastal reefs has been caused by dragging of anchors or other equipment across a reef (Maragos et al. 1977; Spadoni 1979; Courtenay, Hartig, and Loisel 1980). In addition, the operation of equipment on the beach can damage dune vegetation.

### Borrow material composition

High-energy coastal beaches are usually composed of coarse material that allows oxygenated water to penetrate the sediments, thus preventing the accumulation of sulfides and saturating the sediment pore space with oxygen (Cox 1976). The beach sediments may be in equilibrium due to the prevailing physical forces, or they may be eroding or accreting. When material is deposited on a high-energy beach, it modifies the beach sand/water interface and sand grain-size distribution and increases the turbidity of the adjacent nearshore waters. Waves and currents tend to winnow the finer sediments and to suspend them in the water column. Parr, Diener, and Lacy (1978) observed at Imperial Beach, California, that fine sediments were rapidly sorted out of deposited sediments and that sediment grain-size distribution after about 4 months was comparable to the beach sediments prior to nourishment.

Sediments on most beaches range from fine sands to cobbles. The size and character of sediments and the slope of the beach are related to the natural forces to which the beach is exposed and the type of sediment available on the coast. Waves on ocean beaches suspend clays and silts along a shore. After moving away from the turbulent beaches, the fine particles settle on the bottom in the quieter waters of lagoons and estuaries or deeper offshore waters. Grain size may also affect the slope of the beach. Generally, the larger the sand particles, the steeper the beach slope. Changes in sediment character and transport in a bottom environment require an adjustment in the benthic communities. To minimize potential impacts, sediments used for nourishment should closely match the composition of the natural beach sediments and contain a low percentage of fine material.

### Material placement

Thompson (1973) and Oliver and Slattery (1976) noted that organisms adapted to unstable nearshore bottom conditions tend to survive perturbations better than those in more stable offshore environments. Burial of offshore benthic animals by nourishment material has a greater potential for adverse impacts because the subtidal organisms are more sensitive to perturbation than those in the intertidal and upper beach zone (Naqvi and Pullen 1982).

### Time of placement

Most studies indicate that the optimal time for beach nourishment from a biological standpoint is during the winter (Saloman 1974, Oliver and Slattery 1976, Reilly and Bellis 1978, US Army Corps of Engineers 1979) because the

spawning season for most nearshore and beach fauna occurs between the spring and fall. Potential harmful effects of nourishment activities are therefore minimized during the winter when larval recruitment is least apt to be severely affected. Spadoni (1978) concluded that summer is better for beach nourishment since the ocean is calmer during this period and allows rapid settlement of suspended sediments. However, during the winter season, there would be a minimal effect on the development stages of most nearshore and beach animals and on adult fishes which are less concentrated in the shallow beach zone.

#### Water quality/turbidity

Problems related to water quality and turbidity in the nearshore zone of a high-energy beach do not appear to be a major concern because the fine sediments that contain high levels of organic material and other constituents are rapidly transported offshore and sulfides are oxidized (Naqvi and Pullen 1982). However, high turbidities resulting from prolonged beach nourishment and/or erosion degradation of nourishment material may indirectly affect light-sensitive plants and animals. The reduced sunlight penetration into the water may impact nearshore corals, associated algae, and submersed aquatic vegetation. It may also affect the migration and feeding of visually oriented adult and juvenile fishes and the recruitment of larval and juvenile animals to the beaches. Turbidity resulting from beach nourishment generally creates only minor impacts in the surf and the offshore zones, except when light sensitive resources are involved (Naqvi and Pullen 1982).

#### Sedimentation

Monitoring of nearshore sedimentation following beach nourishment is important. Finer sediments are transported offshore and are deposited in the deeper, calmer offshore waters. In some cases, these sediments may smother nearshore reefs and seagrass beds and result in changes in the grain size of the bottom sediments and associated changes in the benthic communities. Thorson (1964) concluded that a reduction of light in the water may prevent or postpone larval settlement. High sedimentation rates may affect larvae by delaying their final descent onto the bottom, thereby subjecting them to increased predation.

#### Compaction of sediments

Coincident with changes in grain size and shape in beach material, an increase in compaction can result from beach nourishment. An increase in fine

material, mineralization or the binding together of particles, and the layering of flat-shaped grains may contribute to an increase in compaction. However, a greater occurrence of increased compaction is likely when sand is pumped onto a beach in a water slurry. This sand-water slurry allows maximum crowding of sand grains, which results in a very dense, compact beach (Smith 1985). In addition, equipment operation on the beach can cause compaction. Narrow-tracked vehicles do not distribute the weight of the equipment as well as wider tracked vehicles and cause greater compaction.

### Biological Effects

#### Effects on fish and other motile animals

Suspended solids in the water can affect fish populations by delaying the hatching time of fish eggs (Schubel and Wang 1973), killing the fish by abrading their gills, and anoxia (O'Connor, Neumann, and Sherk 1976). Fish tolerance to suspended solids varies from species to species and by age (Boehmer and Sleight, 1975, O'Connor, Neumann, and Sherk 1976).

Destruction of habitat rather than suspension of sediments seems to be the major danger to beach and nearshore fishes. Most of these animals have the ability to migrate from an undesirable environment and return when disposal ceases (O'Connor, Neumann, and Sherk 1976; Courtenay, Hartig, and Loisel 1980). Species that are closely associated with the beach for part of their life cycle are most likely affected by beach nourishment. Parr, Diener, and Lacy (1978) observed that beach nourishment did not prevent subsequent spawning of grunion (*Leuresthes tenuis*) at Imperial Beach, California. However, the dusky jawfish (*Opistognathus whitehursti*), a burrowing species with limited mobility and narrow sand grain-size requirements, was displaced by fine sediments on the east coast of Florida (Courtenay, Hartig, and Loisel 1980).

The loss of a food source by burial with nourishment sediments may also have some effect on motile populations. However, there is evidence that nourishment benefits some fish by suspending food material (Courtenay et al. 1972). Also, associated turbidities may provide temporary protection from predators (Harper 1973). Fishes have been attracted to dredging operations in Florida (Ingle 1952) and Louisiana (Viosca 1958) and to sand mining operations in Hawaii (Maragos et al. 1977).

Most long-term studies show that moderate to complete recovery of motile animals will occur within less than a year. Courtenay et al. (1972); Courtenay, Hartig, and Loisel 1980); Parr, Diener, and Lacy (1978); Reilly and Bellis (1978); and Holland, Chambers, and Blackman (1980) described motile fauna recovery following beach nourishment. Studies have shown that motile animals generally leave an area of disturbance temporarily, but return when the disturbance ceases. Oliver et al. (1977) observed that demersal fishes moved into an area within the first day after a disturbance. Courtenay, Hartig, and Loisel (1980) noted that lobsters, crabs, shrimp, and fishes left disturbed areas, but reappeared within 4 months after the disturbance. The motile animals that have stringent environmental requirements, i.e., a critical habitat requirement or food source, are most likely to be affected. Sherk, O'Connor, and Neumann (1974) found that demersal fishes are more tolerant to suspended solids than filter-feeding fishes.

#### Effects on benthos

Marine bottom communities on most high-energy coastal beaches survive periodic changes related to the natural erosion and accretion cycles and storms. However, nearshore communities are in a more stable environment and are less adaptable to such perturbations. Direct burial of nonmotile forms with beach nourishment material can be lethal, whereas motile animals might escape injury. Some infaunal bivalves and crustaceans can migrate vertically through more than 30 cm of sediment (Maurer et al. 1978). Survival depends not only on the depth of deposited sediment, but also on length of burial time, season, particle-size distribution, and other habitat requirements of the animals.

Following the initial burial and dredging of benthic animals, a short-term increase in diversity and number of opportunistic species may occur (Clark 1969; Gustafson 1972; Parr, Diener, and Lacy 1978; Applied Biology, Inc. 1979). These opportunistic species, which initially invade the disturbed area, are later replaced by resident species. A similar response can also result from natural events such as storms, hurricanes, and red tide (Saloman and Naughton 1977; Simon and Dauer 1977).

The recovery rate of preproject resident species will vary from one site to another. The rate of recovery has been reported to vary from 5 weeks to 2 years (Hayden and Dolan 1974; Saloman 1974; Parr, Diener, and Lacy 1978;



Reilly and Bellis 1978; Taylor Biological Company 1978; Tropical Biological Industries 1979; Marsh et al. 1980).

Recovery will depend on the species affected, the season in which nourishment occurs, and the recruitment of larvae into the area. The ability of most macrofauna to recover rapidly is due to (a) their short life cycles, (b) their high reproductive potential, and (c) the rapid recruitment of planktonic larvae and motile macrofauna from nearby unaffected areas.

#### Effects on oysters

The turbidity and increased sedimentation that can result from beach nourishment can be detrimental to oysters. Elevated turbidity can reduce oyster respiration and ingestion of food (Loosanoff 1962). Mature oyster reefs are more susceptible to elevated turbidity, sedimentation, and direct physical alteration than immature reefs because mature reefs are already stressed from crowding (Bahr and Lanier 1981). Even moderate disturbance of a mature reef can destroy it. Immature reefs can undergo rapid growth and thus are more resilient to disturbance (Bahr and Lanier 1981).

#### Effects on seagrasses and mangroves

Burial, uprooting, turbidity, and sedimentation as the result of beach nourishment may damage coastal vegetation (Zieman 1982). The two seagrasses, turtle and manatee, are slow to recover when rhizomes are severed and plants are uprooted (Godcharles 1971, Zieman 1975). Siltation and turbidity can cause suffocation and reduce photosynthetic activity in seagrasses (Thayer, Kenworthy, and Fonseca 1984). Covering of mangrove prop roots with fine material or water can kill the plants (Odum, McIvor, and Smith 1982).

#### Effects on corals

Corals are sensitive to covering by fine sediments. The hard corals are more sensitive than soft corals because they are unable to cleanse themselves of heavy sediment loads and are easily smothered. The soft corals are better adapted for survival in the nearshore areas subject to beach nourishment.

Coral damage as a result of beach nourishment is usually caused by elevated sedimentation rates and by direct physical damage to the reef. Sedimentation may inhibit the food-acquiring capability of the coral polyps and inhibit photosynthesis of symbiotic green algae, eventually killing the coral (Goldberg 1970; Courtenay et al. 1972).

On the other hand, studies have shown that coral reefs can withstand some sedimentation. Courtenay et al. (1974) studied the effects of beach

nourishment on nearshore reefs at Hallendale Beach, Florida. They noted that the reefs sustained short-term damage caused by fine materials eroding from the nourished beach, but 7 years later a resurvey of the reefs found no evidence of major reef damage (Courtenay, Hartig, and Loisel 1980; Marsh et al. 1980).

The recovery time for corals is directly related to the extent of initial reef damage. A reef that is badly torn and heavily covered with fine sediment may take a long time to recover or may never recover (Bak 1978).

#### Effects on nesting sea turtles

Nourishment can affect sea turtles directly by burying nest or by disturbing nesting during their spring and summer nesting season. Indirectly, beach nourishment or replenishment has the potential of affecting sea turtle nest site selection, clutch viability, and hatchling emergence by altering the physical makeup of the beach. Sand grain size, grain shape, moisture content, color, temperature, and the density of the sand may be altered.

Smaller grain size, flatter shaped grains, and greater density may cause compaction of the beach. A compact beach will inhibit nest excavation by sea turtles (Fletemeyer 1980, Ehrhart and Raymond 1983) and limit emergence of hatchlings (Mann 1977, Fletemeyer 1979). Mortimer (1981) and Schwartz (1982) report that an optimum range of grain size for hatching success was medium to fine (0.063 to 2.0 mm). Even though sand particle size for nesting sea turtles varies greatly from one nesting beach to another (Hirth and Carr 1970, Hirth 1971, Hughes 1974, Stancyk and Ross 1978), when sands are too fine, gas diffusion required for embryonic development is inhibited (Ackerman 1977; Mortimer 1979, 1981; Schwartz 1982). If sands are too coarse, the nest collapses and the hatchling turtles are unable to emerge to the surface (Mann 1978, Sella 1981).

Nest site selection, incubation duration, sex ratio, and hatchling emergence may be influenced by sand temperature (Mrosovsky 1980, 1982; Stoneburner and Richardson 1981). Sella (1981) reports that a prerequisite for normal nesting is a stable nesting temperature of 28° C for green sea turtles. Geldiay, Koray, and Balik (1981) report an inner nest temperature of 24° to 28° C (average 26° C) for loggerhead turtles. Lower ambient sand temperatures increase incubation time (Harrison 1952, Hendrickson 1958). Mrosovsky (1982) found that a 1° C decrease in nest temperature adds 5 to 8 days to incubation time. Morreale et al. (1982) found inner nest temperatures less than 28° C

induce all male hatchlings, whereas temperatures greater than 29.5° C induce nearly all female hatchlings. They also reported that inner nest temperatures greater than 28° C inhibit emergence of hatchlings from the nest presumably due to hatchlings cueing on cooler nighttime temperatures for nocturnal emergence.

Sand moisture content may be affected by grain size, grain shape, pore space, compaction, density, and other factors. Moisture can affect hatching success of sea turtles (Ackerman 1977, Mortimer 1981, Hopkins and Richardson 1984). Too much moisture may decrease gas diffusion to the nest due to water-logging of the sand (Ackerman 1977, Hopkins and Richardson 1984) while too little moisture may cause higher nest temperatures and egg desiccation (Mortimer 1981).

### Management Alternatives

#### Selection of equipment

A suction dredge with a cutterhead is less desirable than a dredge without a cutterhead for use in the vicinity of live coral reefs or other light-sensitive resources (Courtenay et al. 1975, Maragos et al. 1977). The suction dredge without a cutterhead is recommended because siltation is minimized and there is less potential for physical damage to the reef. To prevent sand compaction, wide-tracked vehicles should be used for moving equipment and material on the beach.

#### Selection of material

The composition of sediment at the borrow sites should closely match that of the natural beach sediments (Thompson 1973; Parr, Diener, and Lacy 1978; Pearson and Riggs 1981) and should be low in pollutants, silts, and clays. Minimum damage to the beach animals will occur when clean sand is placed on a sandy substratum. The damage may be great to the beach animals if fine organic-rich sediments are used. The vertical migration of infaunal animals may be inhibited when the particle size and composition of borrowed material differ from the original beach sediments (Maurer et al. 1978).

To minimize siltation and consequently potential anoxic conditions following beach nourishment, the percentage of fine sediment (less than 125 µm in size) should be kept to a minimum in the dredged material (Parr, Diener, and Lacy 1978). Silt, if present in the material, will be readily moved offshore.

It can be highly detrimental to corals and other beach and offshore benthic invertebrates. Sedimentation can result in the reduction of species diversity. If a key species is affected adversely, the entire animal community of the area may be altered.

Silt curtains can be used for containing silt sediments during construction; however, they are not effective for use in high-energy areas and for preventing long-term turbidity when silt is present in the material.

#### Material placement

Nourishment material should be placed as close to shore as possible to ensure the least harm to the more stable, but less resilient, offshore populations.

#### Time of placement

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. The nesting and spawning season would be past.

#### Sand compaction

The potential for sand compaction can be reduced by selecting coarse, round sand; by placing material in the intertidal area; by overfilling with more compatible material; and by tilling compacted material.

A coarse round sand should be selected for borrow material because the finer the sand, the greater the density of sand and thus the potential for compaction. A medium to coarse sand is less likely to compact and thus more suitable to burrowing animals. In contrast to flat sand grains, round sand grains will not layer when placed onto the beach in a water slurry. The layering of flat grains can reduce an animal's ability to penetrate the sand.

By placing material into the intertidal portion of the beach, two benefits can be achieved. One is that the maximum amount of existing beach is preserved. The second is that the material is sorted and reworked by wave action, which reduces compaction.

When less desirable material must be used, a medium-coarse sand could be placed over it. This would allow the beach to be more compatible to burrowing animals until the beach has a chance to be reworked by storms and wave action.

The natural softening and reworking of the beach can be simulated by tilling of a compacted beach. Equipment that will till to a depth of 45 to 60 cm is recommended.

#### Use of beach grasses

Wind erosion of beach sand can be another concern associated with nourishment. Beach plants can be used to reduce or prevent moving sand and for building dunes. Dunes can serve as a reservoir of sand to replenish the beach during wave erosion. Stabilizing sand is particularly desirable where roadways or private property may be covered by blowing sand. Species most commonly used for sand stabilization are saltmeadow cordgrass (*Spartina patens*), bitter panicum (*Panicum amarum*), American beachgrass (*Ammophila breviligulata*), European beachgrass (*Ammophila arenaria*), and sea oats (*Uniola paniculata*) (Pullen, Knutson, and Hurme 1984). These plants are desirable for sand stabilization because they spread rapidly and are easy to harvest, transport, store, and plant. They grow best in blowing sand and are perennials, thus providing year-round sand-trapping capability (Pullen, Knutson, and Hurme 1984). For conservation of sand and for esthetics, beach grasses can be planted after a beach has been nourished.

#### Conclusions

Erosion is a major problem along coastal shorelines. One of the most environmentally desirable and cost-effective shore protection alternatives is beach nourishment. However, as with any construction activity, there are environmental concerns. The major concerns related to beach nourishment are the time of material placement, the grain size of the material placed, and the compaction of the material after placement. Scheduling nourishment in the late fall and winter may be less detrimental than during the spring through early fall, when most coastal animals are spawning or nesting. The grain size of the material placed should be as similar to the natural beach sediments as possible. If a compatible sand size is used, most organisms will rapidly recolonize the beach. A change in sediment size may result in a change in organisms using the substrate. In addition, if the material is very fine, problems with turbidity may occur nearshore both during and after placement. Turbidity and sedimentation can be reduced by minimizing the silt and fine sediments in the borrowed material. Another physical change in the sediments

which can occur is increased compaction. This may be the result of an increase in fine material, mineralization or binding together of particles, and layering of flat-shaped grains. An increase in compaction of the beach sediments can make them less suitable for burrowing organisms, particularly sea turtles. When incompatible material must be used, some potential alternatives are (a) to overlay the renourished material with suitable sediments, (b) to preserve the existing beach by nourishing adjacent to it, and (c) to soften the new material by tilling. Planting beach grasses after nourishment will reduce blowing sand and create sand dunes. The sand dunes will then be a source of sand during storm erosion.

#### Acknowledgments

The authors thank Messrs. Tom Fredette, Doug Clarke, and Craig Smith for helpful suggestions on earlier drafts of the manuscript. The information presented herein, unless otherwise noted, was obtained from research conducted under the Environmental Impact Research Program of the US Army Corps of Engineers by the WES. Permission was granted by the Chief of Engineers to publish this information.

#### Literature Cited

- Ackerman, R. A. 1977. "The Respiratory Gas Exchange of Sea Turtle Nests, (*Chelonia*, *Caretta*), Respiratory Physiology, Vol 31, pp 19-38.
- Applied Biology, Inc. 1979. "Biological Studies Concerning Dredging and Beach Nourishment at Duval County, Florida, with a Review of Pertinent Literature," US Army Engineer District, Jacksonville, Jacksonville, FL.
- Bahr, L. M., and Lanier, W. P. 1981. "The Ecology of Intertidal Oyster Reefs of the South Atlantic Coast: A Community Profile, FWS/OBS-81/15, US Fish and Wildlife Service, Office of Biological Services, Washington DC.
- Bak, R. P. 1978. "Lethal and Sublethal Effects of Dredging on Reef Corals," Marine Pollution Bulletin, Vol 9, pp 14-16.
- Boehmer, R., and Sleight, H., III. 1975. "Effects of Suspended Marine Sediment on Selected Commercially-Valuable Fish and Shellfish of Massachusetts," Proceedings of the Seventh Annual Offshore Technology Conference, Vol 1, pp 133-141.
- Clark, M. B. 1969. "Distribution and Seasonal Dynamics of Animal Populations in San Diego Beaches," M.S. Thesis, San Diego State College, San Diego, CA.
- Coastal Engineering Research Center. 1984. "Shore Protection Manual," Vols. I and II, US Army Engineer Waterways Experiment Station, Vicksburg, MS.

- Courtenay, W. R., Jr., Hartig, B. C., and Loisel, G. R. 1980. "Evaluation of Fish Populations Adjacent to Borrow Areas of Beach Nourishment Project at Hallandale (Broward County), Florida: Vol. 1, Ecological Evaluation of a Beach Nourishment Project at Hallandale (Broward County), Florida," MR 80-1(1) US Army Corps of Engineers, Coastal Engineering Research Center, Fort Belvoir, Va.
- Courtenay, W. R., Jr., Herrema, D. J., Thompson, M. J., Azzinaro, W. P., and van Montfrans, J. 1972. "Ecological Monitoring of Two Beach Nourishment Projects in Broward County, Florida," Shore and Beach, Vol 40, pp 8-13.
- \_\_\_\_\_. 1974. "Ecological Monitoring of Beach Erosion Control Projects, Broward County, Florida, and Adjacent Areas," TM-41, US Army Coastal Engineering Research Center, Fort Belvoir, VA.
- \_\_\_\_\_. 1975. "Environmental Assessment of Offshore Reefs off Miami Beach, Dade County, Florida," US Army Engineer District, Jacksonville, Jacksonville, FL.
- Cox, J. L. 1976. "Sampling Variation in Sand Beach Littoral and Nearshore Meiofauna and Macrofauna," TP 76-14, US Army Coastal Engineering Research Center, Fort Belvoir, VA.
- Ehrhart, L. M., and Raymond, P. W. 1983. "The Effects of Beach Restoration on Marine Turtles Nesting in South Brevard County, Florida," US Army Engineer District, Jacksonville, Jacksonville, FL.
- Fletemeyer, J. 1979. "Sea Turtle Monitoring Project," Brevard County Environmental Quality Control Board.
- \_\_\_\_\_. 1980. "The Leatherback Turtle Without a Shell," Sea Frontiers, Vol 26, No. 5, pp 302-305.
- Geldiay, R., Koray, T., and Balik, S. 1981. "Status of Sea Turtle Population (*Caretta c. caretta* and *Chelonia m. mydas*) in the Northern Mediterranean Sea, Turkey," pp 425-434 In K. A. Bjorndal, ed, Biology and Conservation of Sea Turtles, Smithsonian Institution Press, Washington, DC.
- Godcharles, M. F. 1971. "A Study of the Effects of a Clam Dredge on Benthic Communities in Estuarine Areas," Technical Series Report 64, Florida Department of Natural Resources, Division of Marine Research, St. Petersburg, FL.
- Goldberg, W. M. 1970. "Some Aspects of the Ecology of the Reefs of Palm Beach County, Florida, with Emphasis on the Gorgonacea and Their Bathymetric Distribution," M.S. Thesis, Florida Atlantic University, Boca Raton, FL.
- Gustafson, J. F. 1972. "Ecological Effects of Dredged Borrow Pits," World Dredging and Marine Construction, Vol 8, pp 44-48.
- Harper, D. E., Jr. 1973. "Effects of Siltation and Turbidity on the Benthos and Nekton," Environmental Assessment of Shell Dredging in San Antonio Bay, Texas, Vol V, US Army Engineer District, Galveston, Galveston, TX, pp 114-123.
- Harrison, T. 1952. "Breeding of the Edible Turtle," Nature, Vol 168, pp 198.
- Hayden, B., and Dolan, R. 1974. "Impact of Beach Nourishment on Distribution of *Emeriat talpoida*, the Common Mole Crab," Journal of the Waterways, Harbors, and Coastal Engineering Division, Vol 100, pp 123-132.

- Hendrickson, J. R. 1958. "The Green Sea Turtle, *Chelonia mydas* (Linn.) in Malaya and Sarawak," Proceedings of the Zoological Society of London, Vol 130, pp 455-535.
- Hirth, H. F. 1971. "Synopsis of Biological Data on the Green Turtle *Chelonia mydas* (Linnaeus) 1758," FAO Fisheries Synopsis, No. 85.
- Hirth, H. F., and Carr, A. 1970. "The Green Turtle in the Gulf of Aden and the Seychelles Islands," Verhandelingen der Koninklijke Nederlandse Akademie van Wetenschappen, Vol 58, pp 1-44.
- Holland, T. H., Chambers, J. R., and Blackman, R. R. 1980. "Effects of Dredging and Filling for Beach Erosion Control on Fishes in the Vicinity of Lido Key, Florida," US Army Engineer District, Jacksonville, Jacksonville, FL.
- Hopkins, S. R., and Richardson, J. I., eds. 1984. "Recovery Plan for Marine Turtles," US Department of Commerce, National Oceanic and Atmospheric Administration, St. Petersburg, FL.
- Hughes, G. R. 1974. "The Sea Turtles of South-East Africa I. Status, Morphology and Distributions," Investigation Report No. 35, South African Association for Marine Biological Research, Durban, South Africa.
- Ingle, R. M. 1952. "Studies on the Effects of Dredging Operations Upon Fish and Shellfish," Technical Series No. 5, State of Florida, Board of Conservation, Division of Oyster Culture, Tallahassee, FL.
- Loosanoff, V. L. 1962. "Effects of Turbidity on Some Larval and Adult Bivalves," Proceedings of the Gulf and Caribbean Fisheries Institute, Vol 14, pp 80-95.
- Mann, T. M. 1977. "Impact of Developed Coastline on Nesting and Hatching Sea Turtles in Southeastern Florida," M.S. Thesis, Florida Atlantic University, Boca Raton, FL.
- \_\_\_\_\_. 1978. "Impact on Developed Coastline or Nesting and Hatching Sea Turtles in Southeastern Florida," Florida Marine Research Publication, Vol 33, pp 53-55.
- Maragos, J. E., Roach, J., Bowers, R. L., Hemmes, D. E., Self, R. F. L., Macneil, J. D., Ellis, K., Omeara, P., Vansant, J., Sato, A., Jones, J. P., and Kam, D. T. O. 1977. "Environmental Surveys Before, During and After Off-shore Marine Sand Mining Operations at Keauhou Bay, Hawaii," Sea Grant College Program, Working Paper No. 28, University of Hawaii, Honolulu, Hawaii.
- Marsh, G. A., Bowen, P. R., Deis, D. R., Turbeville, D. E., and Courtenay, W. R., Jr. 1980. "Evaluation of Benthic Communities Adjacent to a Restored Beach, Hallandale (Broward County), Florida: Vol. II, Ecological Evaluation of a Beach Nourishment Project at Hallandale (Broward County), Florida," MR 80-1(II), US Army Coastal Engineering Research Center, Fort Belvoir, VA.
- Maurer, D. L., Keck, R. T., Tinsman, J. C., Leathem, W. A., Wethe, C. A., Huntzinger, M., Lord, C., and Church, T. M. 1978. "Vertical Migration of Benthos in Simulated Dredged Material Overburdens Literature Review," TR D-78-35, US Army Engineer Waterways Experiment Station, Vicksburg, MS.
- Morreale, S. J., Ruiz, G. J., Spotila, J. R., and Standora, E. A. 1982. "Temperature-Dependent Sex Determination: Current Practices Threaten Conservation of Sea Turtles," Science, Vol 216, pp 1,245-1,247.



- Mortimer, J. A. 1979. "Influence of Beach Characteristics on Nesting Density, Site Fixity and Hatching Success of Green Turtles at Ascension Island (abstract)," American Zoologist, Vol 19, pp 954.
- Mortimer, J. A. 1981. "Factors Influencing Beach Selection by Nesting Sea Turtles," pp 45-52 In K. A. Bjorndal, ed., Biology and Conservation of Sea Turtles, Smithsonian Institution Press, Washington, DC.
- Mrosovsky, N. 1980. "Thermal Biology of Sea Turtles," American Zoology, Vol 20, pp 531-547.
- \_\_\_\_\_. 1982. "Sex Ratio Bias in Hatchling Sea Turtles From Artificially Incubated Eggs," Biological Conservation, Vol 23, No. 4, pp 309-314.
- Naqvi, S. M., and Pullen, E. J. 1982. "Effects of Beach Nourishment and Borrowing on Marine Organisms," MR 82-14, US Army Coastal Engineering Research Center, Fort Belvoir, VA.
- O'Connor, J. M., Neumann, D. A., and Sherk, J. A., Jr. 1976. "Lethal Effects of Suspended Sediments on Estuarine Fish," TP 76-20 US Army Coastal Engineering Research Center, Fort Belvoir, VA.
- Odum, W. E., McIvor, C. C., and Smith, T. J., III. 1982. "The Ecology of the Mangroves of South Florida: A Community Profile," FWS/OBS-81/24, US Fish and Wildlife Service, Office of Biological Services, Washington, DC.
- Oliver, J. S., and Slattery, P. N. 1976. "Effects of Dredging and Disposal on Some Benthos at Monterey Bay, California," TP 76-15, US Army Coastal Engineering Research Center, Fort Belvoir, VA.
- Oliver, J. S., Slattery, P. N., Hulberg, L. W., and Nybakken, J. W. 1977. "Patterns of Succession in Benthic Infaunal Communities Following Dredging and Dredged Material Disposal in Monterey Bay," TR 77-15, US Army Engineer Waterways Experiment Station, Vicksburg, MS.
- Parr, T., Diener, E., and Lacy, S. 1978. "Effects of Beach Replenishment on the Nearshore Sand Fauna at Imperial Beach, California," MR 78-4, US Army Coastal Engineering Research Center, Fort Belvoir, VA.
- Pearson, D. R., and Riggs, S. R. 1981. "Relationships of Surface Sediment on the Lower Forebeach and Nearshore Shelf to Beach Nourishment at Wrightsville Beach, North Carolina," Shore and Beach, pp 26-31.
- Pullen, E. J., Knutson, P. L., and Hurme, A. K. 1984. "US Army Corps of Engineers, Coastal Engineering Research Center's Ecology Program," Water Science Technology, Vol 16, pp 525-532.
- Reilly, F. J., Jr., and Bellis, V. J. 1978. "A Study of the Ecological Impact of Beach Nourishment with Dredged Materials on the Intertidal Zone," Technical Report No. 4, Institute for Coastal and Marine Resources, East Carolina University, Greenville, NC.
- Saloman, C. H. 1974. "Physical, Chemical, and Biological Characteristics of Nearshore Zone of Sandy Key, Florida, Prior to Beach Restoration," Final Report, US Army Coastal Engineering Research Center, Fort Belvoir, VA.
- Saloman, C. H., and Naughton, S. P. 1977. "Effects of Hurricane Eloise on the Benthic Fauna of Panama City Beach, Florida, USA," Marine Biology, Vol 42, pp 357-363.

- Schubel, J. R., and Wang, T. W. 1973. "The Effects of Suspended Sediment in Northern Chesapeake Bay," Powder Technology, Vol 6, pp 9-16.
- Schwartz, F. J. 1982. "Correlation of Nest Sand Asymmetry and Percent Loggerhead Sea Turtle Egg Hatch in North Carolina Determined by Geological Sorting Analyses," ASB Bulletin, Vol 29, No. 2, pp 83.
- Sella, I. 1981. "Sea Turtles in the Eastern Mediterranean and Northern Red Sea," pp 417-423, In K. A. Bjorndal, ed., Biology and Conservation of Sea Turtles, Smithsonian Institution Press, Washington, DC.
- Sherk, J. A., O'Connor, J. M., and Neumann, D. A. 1974. "Effects of Suspended and Deposited Sediments on Estuarine Organisms, Phase II," Reference No. 72-02, National Research Institute, Solomons, MD.
- Simon, J. L., and Dauer, D. M. 1977. "Reestablishment of a Benthic Community Following Natural Defaunation," In Belle W. Baruch Institute for Marine Biology and Coastal Research, Ecology of Marine Benthos, 1st ed. University of South Carolina Press, Columbia, SC.
- Smith, A. W. S. 1985. "Gold Coast Replenishment Program," Technical Report No. 72, Gold Coast Soils Laboratory, Queensland, Australia.
- Spadoni, R. H. 1978. "Environmental Monitoring of the Beach Restoration Project for the City of Delray Beach, Florida," Beach Seminar, Vol 1978, pp 38-54.
- \_\_\_\_\_. 1979 (Jul). "Reef Monitoring of the Delray Beach Erosion Project," Shore and Beach, Vol 47, No. 3, pp 12-16.
- Stancyk, S. E., and Ross, J. P. 1978. "An Analysis of Sand from Green Turtle Nesting Beaches on Ascension Island," Copeia, Vol 1978, No. 1, pp 93-99.
- Stoneburner, D. L., and Richardson, J. I. 1981. "Observations on the Role of Temperature in Loggerhead Turtle Nest Site Selection," Copeia, Vol 1981, No 1, pp 232-241.
- Taylor Biological Company. 1978. "Ecological Comparison of Beaches, Offshore Borrow Sites and Adjacent Bottom at Anna Maria Island and Treasure Island, Florida," Contract Report No. DACW17-78-M-1410, US Army Engineer District, Jacksonville, Jacksonville, FL.
- Thayer, G. W., Kenworthy, W. J., and Fonseca, M. S. 1984. "The Ecology of Eelgrass Meadows of the Atlantic Coast: A Community Profile," FWS/OBS-84/02, US Fish and Wildlife Service, Office of Biological Services, Washington, DC.
- Thompson, J. R. 1973. "Ecological Effects of Offshore Dredging and Beach Nourishment: A Review," MP 73-1, US Army Coastal Engineering Research Center, Fort Belvoir, VA.
- Thorson, G. 1964. "Light as an Ecological Factor in the Dispersal and Settlement of Larvae of Marine Bottom Invertebrates," Ophelia, Vol 1, pp 167-208.
- Tropical Biological Industries. 1979. "Environmental Impact Assessment of Beach Restoration Project at South Seas Plantation, Captiva Island, Lee County, Florida," Final Report, South Seas Plantation, Captiva Island, FL.
- US Army Corps of Engineers. 1979. "Effects of Dredging and Disposal on Aquatic Organisms," EM 1110-2-5031, Office, Chief of Engineers, Washington, DC.

Viosca, P. 1958. "Effects of Dredging Operations," Louisiana Wildlife and Fish Commission, 1956-1957 Biennial Report.

Zieman, J. C. 1975. "Quantitative and Dynamic Aspects of the Ecology of Turtle grass, Thalassia testudium," pp. 541-562 In L. E. Cronin, ed., Estuarine Research, Vol I, Academic Press, New York.

\_\_\_\_\_. 1982. "The Ecology of the Seagrass of South Florida: A Community Profile," FWS/OBS-82/25, US Fish and Wildlife Service, Office of Biological Services, Washington, DC.

# BEACH NOURISHMENT AND OVERVIEW OF SAND BYPASSING

James E. Clausner  
Coastal Engineering Research Center  
US Army Engineer Waterways Experiment Station  
Vicksburg, Mississippi

James M. Kieslich  
US Army Engineer District, Galveston  
Galveston, Texas

## Introduction

During maintenance dredging of inlet channels and harbors, there is an opportunity to bypass the dredged sand to downdrift beaches, significantly benefitting those beaches. This paper presents information on sand bypassing and its role in beneficial uses of dredged material. After a discussion on the reasons why sand bypassing is needed and how it is used, brief descriptions of the basic types of sand bypassing operations are presented. The success of sand bypassing operations is discussed, followed by descriptions of the environmental impacts of sand bypassing operations. Short summaries of several bypassing operations are presented. The second portion of the paper provides details on various beach nourishment projects located along the Texas coast.

The construction of jetties to provide safe navigation conditions at harbors or tidal inlets along sand coasts usually interrupts the natural littoral drift at the harbor or inlet. Sand that previously found its way from an inlet's updrift side to its downdrift side through natural processes is trapped in the updrift fillet, interior shoals, navigation channel, or is diverted to offshore shoals. The resulting starvation of the downdrift beach can cause serious erosion unless measures are taken to transfer or bypass sand from the locations where sand is trapped to the downdrift beaches.

It is important to note that sand bypassing is not the same thing as beach nourishment. Beach nourishment is the placement of sand on beaches to widen the beach and prevent damage to adjacent structures. The sand source for a beach nourishment project is often directly offshore the beach, and the nourishment project is usually not part of channel maintenance. While the same tools are used (dredges), generally the volume of sand available from

sand bypassing operations is not large enough to restore a severely eroded beach. Sand bypassing can help to maintain a nourished beach.

While performing its mission to keep navigation channels open, CE sponsored dredging operations sometimes excavate substantial amounts of clean sand suitable for beach placement. Most states and local governments now recognize the benefit of this sand to the maintenance of their beaches. Public Law 99-662 reduces the cost of placing this sand on the beaches by requiring the local sponsor to pay only 50 percent of the cost difference between the lowest cost disposal option and the cost of placing the sand on the beach when at least 50 percent of the benefits are nonrecreational. The CE is now placing increased emphasis on finding more effective methods to bypass sand before it deposits in the navigation channels and to reduce dredging and beach placement costs. In addition, future harbor and channel deepening projects will excavate even larger quantities of sand.

### Sand Bypassing Concepts

The simplest method in concept, but in some respects the most difficult to implement, is to remove sand accumulated in the fillet of the updrift jetty with a pipeline dredge and transfer it to the downdrift beach (Figure 1). However, the dredge may be difficult to operate in an area exposed to ocean waves. This difficulty led to the development of fixed sand bypassing plants. Earlier versions of these fixed plants were usually located on the updrift jetty and were partially protected from extremely large waves by the jetty and the shallowness of the water in front of them. Fixed bypassing plants are usually limited in the amount of sand they can intercept and handle because of their lack of mobility.

A recent improvement on this concept has been the use of a trestle placed some distance updrift of the updrift jetty. By using a series of suspended jet pumps from the trestle, a sand trap can be created which intercepts much of the longshore sediment transport (Figure 2), depending on trestle length. A very successful system has recently been built using this concept at the Nerang River Entrance in Queensland, Australia.

At some harbors along an open coast with a shore-connected breakwater, bypassing is performed by dredging the shoal that accumulates at the downdrift

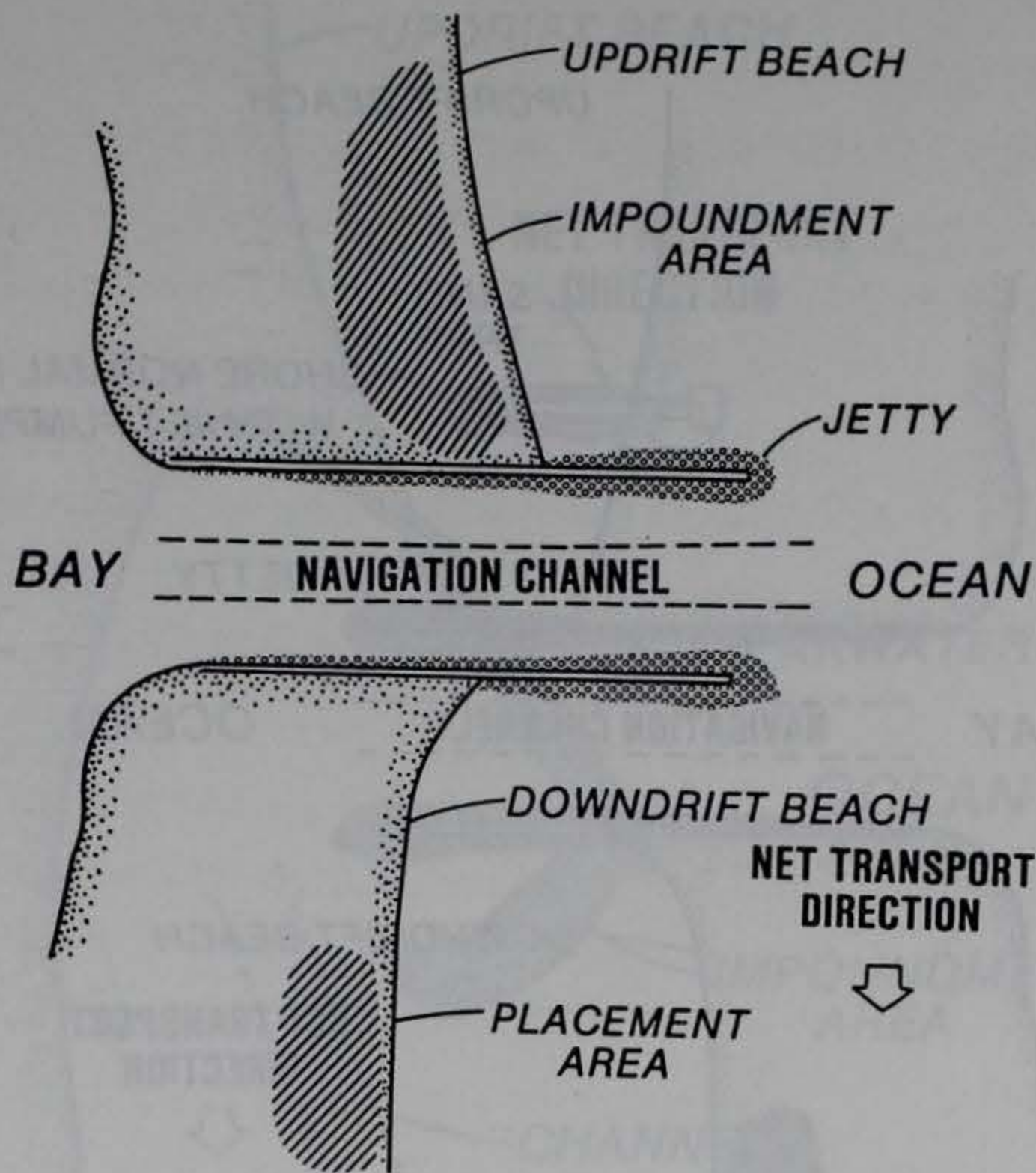


Figure 1. Sand impounded in updrift beach adjacent to jetty

end of the breakwater (Figure 3). The method has been used successfully at Santa Barbara, CA since 1935.

Weir jetty systems (Figure 4) have also been used to bypass sand. In this system, a part of the crest of the updrift jetty is depressed to form a weir section across which sand is transported by waves and tidal currents to a deposition area. A conventional pipeline dredge operates in the deposition turbidity curtains. Interference with sea bird nesting is controlled by seasonal restrictions on dredging operations. Interference with hatching of sea turtle eggs can be eliminated by removal of the eggs before they are buried by nourishment sand or timing the bypassing operation so as not to coincide with the egg hatching season.

The only serious potential problem associated with sand bypassing could result from using material dredged from inner harbors. In some cases the sediments in harbors have been contaminated with various toxic substances that concentrate on fine-grained materials. Present regulations and review procedures have thus far been adequate to determine the location of contaminated

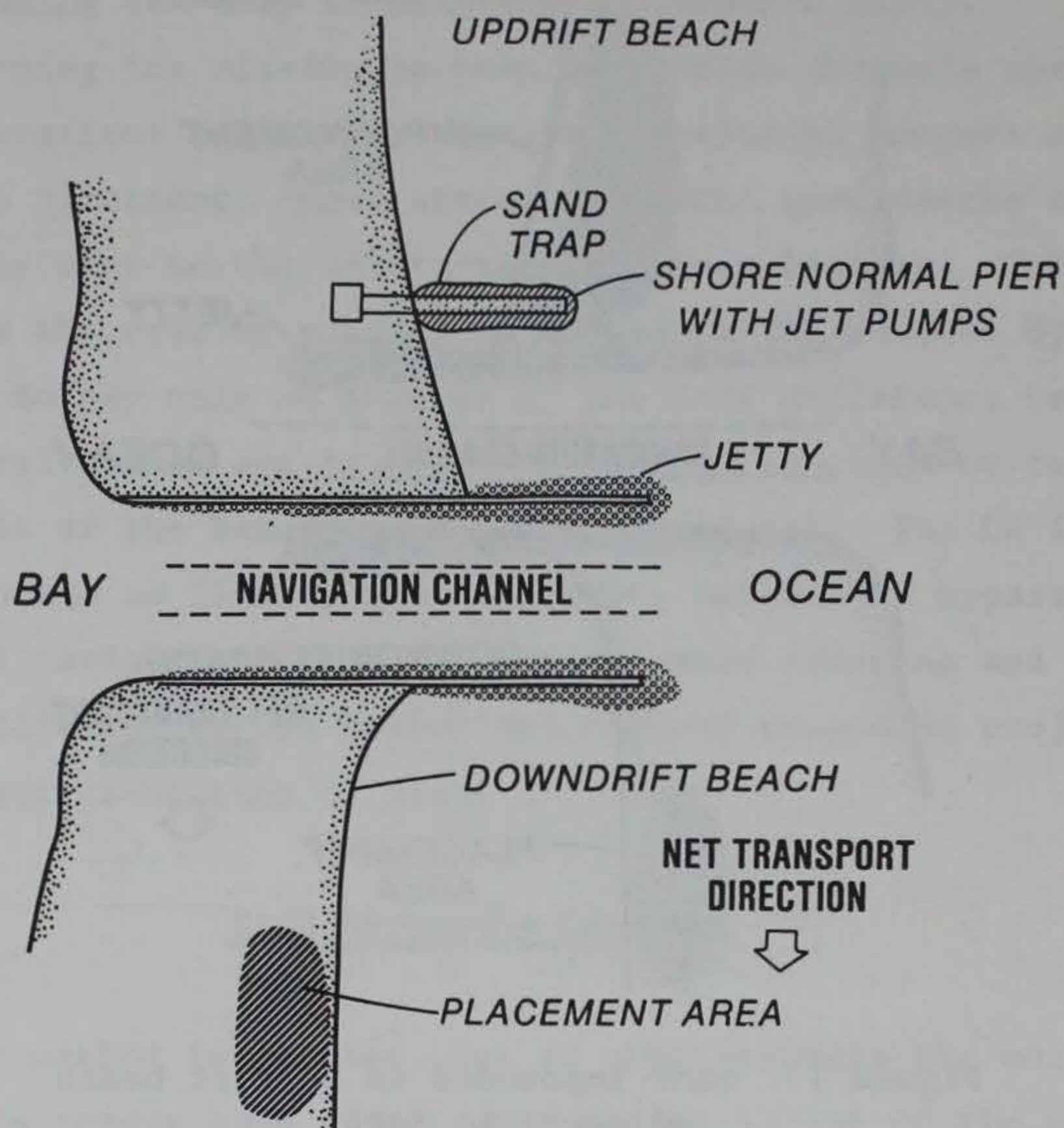


Figure 2. Shore normal pier with jet pumps used to create trap

sediments, and to the best of our knowledge, no significant amounts of these contaminated sediments have ever been bypassed and placed on US beaches. A list of present regulations concerning the environmental aspects of sand bypassing are presented in Table 1.

### Successful Sand Bypassing Systems

The following paragraphs describe three current, successful sand bypassing operations: two in the United States and one in Australia.

#### Channel Islands Harbor, California

This small craft harbor was constructed in 1961 in Oxnard, CA. It consists of a 2,300-ft-long detached breakwater and two entrance jetties (Figure 5). The detached breakwater traps nearly all the littoral drift, reduces loss of sediment into Hueneme Submarine Canyon, reduces shoaling of the harbor

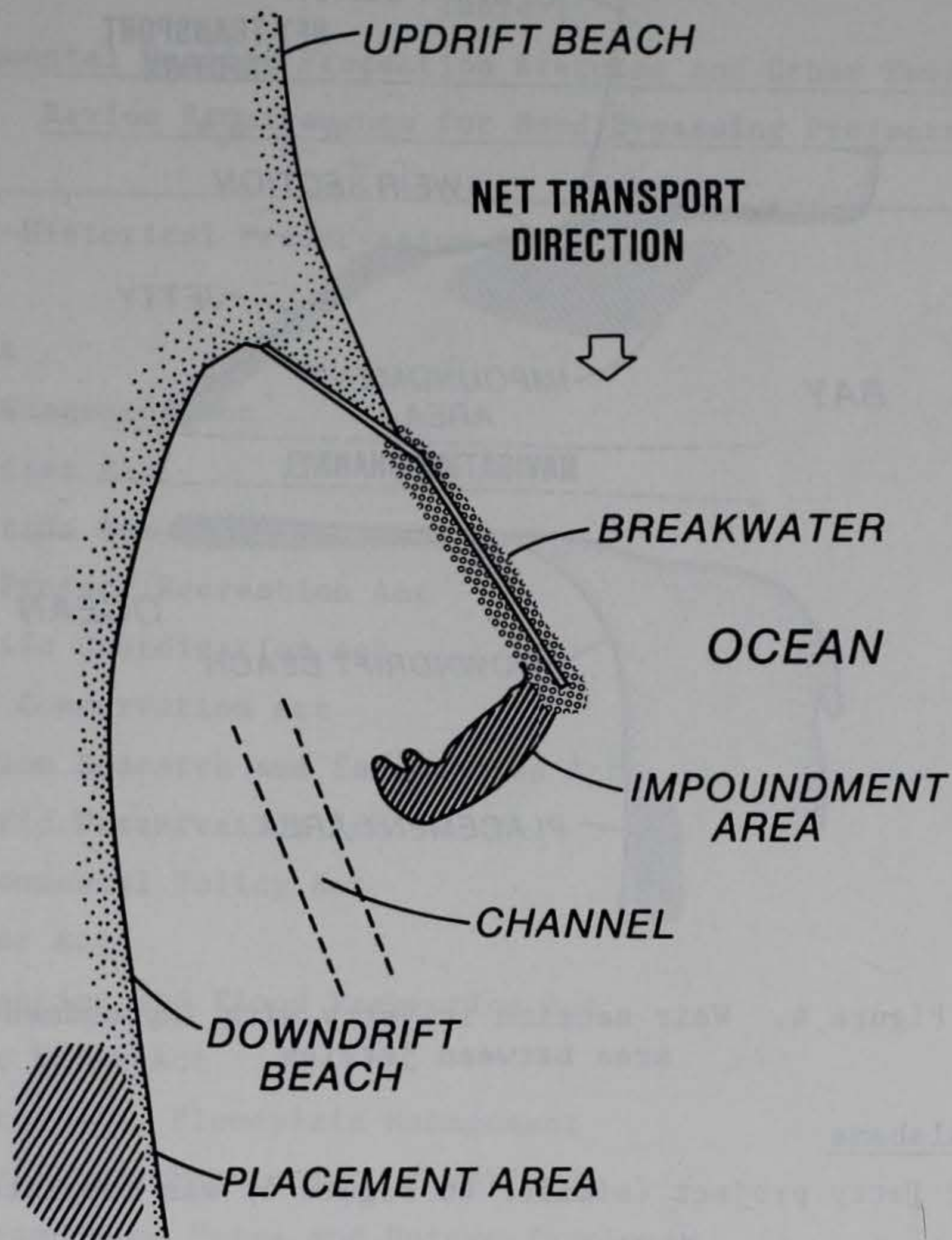


Figure 3. Impoundment area at distal end of a shore-connected breakwater

entrance, and provides protection for a floating dredge. The sand bypassing operation transfers sand approximately 1 mile to downdrift beaches, which were eroding due to the jetties constructed at Port Hueneme. The jetties were part of the overall harbor construction in 1940.

The 1960-61 dredging of the sand trap behind the offshore breakwater, the entrance channel, and the first phase of harbor development provided 6 MCY of sand. Since the initial dredging, the sand trap has been dredged approximately every 2 years with an average of 2,300,000 cu yd of sand bypassed during each dredging operation. The 31-million cu yd bypassed since this operation began have reversed the trend for severe beach erosion south of the project.



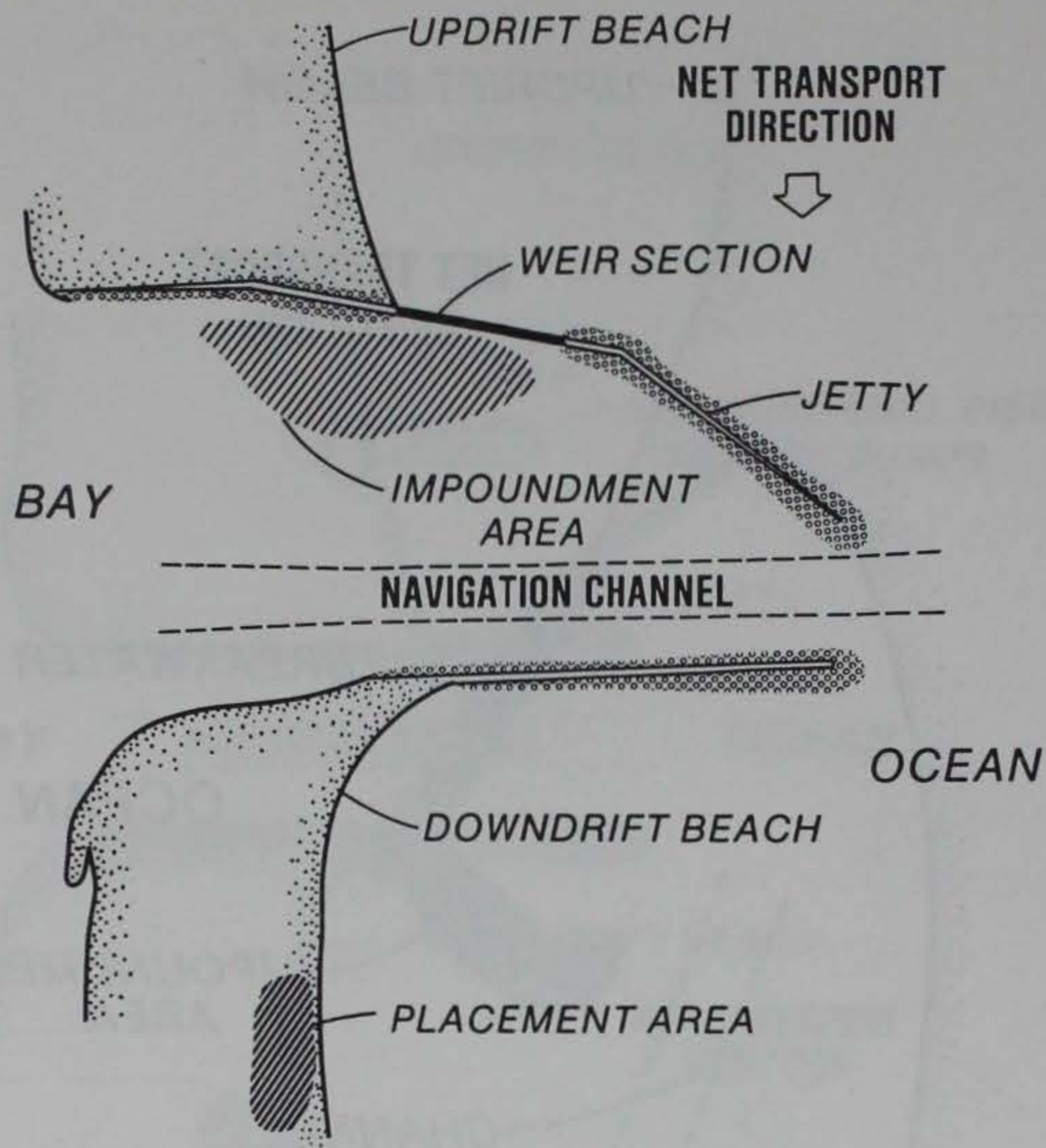


Figure 4. Weir section in jetty with impoundment area between jetties

#### Perdido Pass, Alabama

This weir jetty project (similar to Figure 4) was completed in 1969. To trap the westerly longshore sediment transport, the east jetty included a weir section 984 ft long at an elevation of 6 in. above mean low water. A 130,000-cu yd deposition basin was dredged between the weir and the channel.

Since 1971, the deposition basin and the channel have been dredged approximately every 2 years, bypassing an annual average of 180,000 cu yd. The Mobile District believes that if funds were available to dredge the deposition basin yearly, little or no dredging of the channel would be required.

Much of the beach front property immediately downdrift of Perdido Pass is privately owned. Sand is pumped from the deposition basin to nourish the downdrift beach. The jetties fix the location of the navigation channel. The updrift jetty limits the transport of sand into the deposition basin, affects the alignment of the updrift beach, and provides protection to a dredge operating in the deposition basin.

Table 1

Environmental Quality Protection Statutes and Other Environmental  
Review Requirements for Sand Bypassing Projects

---

Archaeological-Historical Preservation Act  
Clean Air Act  
Clean Water Act  
Coastal Zone Management Act  
Endangered Species Act  
Estuary Protection Act  
Federal Water Project Recreation Act  
Fish and Wildlife Coordination Act  
Land and Water Conservation Act  
Marine Protection Research and Sanctuaries Act  
National Historic Preservation Act  
National Environmental Policy Act  
River and Harbor Act  
Watershed Protection and Flood Prevention Act  
Wild and Scenic River Act  
Executive Order 11988, Floodplain Management  
Executive Order 11990, Protection of Wetlands  
Executive Memorandum on Prime and Unique Farmlands  
State Coastal Zone Management Plans  
County and City Restrictions

---

Shore-parallel detached breakwaters built updrift of inlets or harbor entrances have also been used to establish a sheltered deposition area where a dredge can operate to bypass sand (Figure 6). This concept has been used at two sites in southern California, where the longshore transport is nearly unidirectional.

Substantial amounts of coastal maintenance dredging occurs at inlets with straight, shore normal jetties and is associated with the removal of interior (flood tidal) shoals, entrance channel shoals, or ebb tidal shoals (Figure 7). If pipeline (cutterhead) dredges are used to remove the shoals, bypassing is accomplished by pumping the sand through a pipeline to the

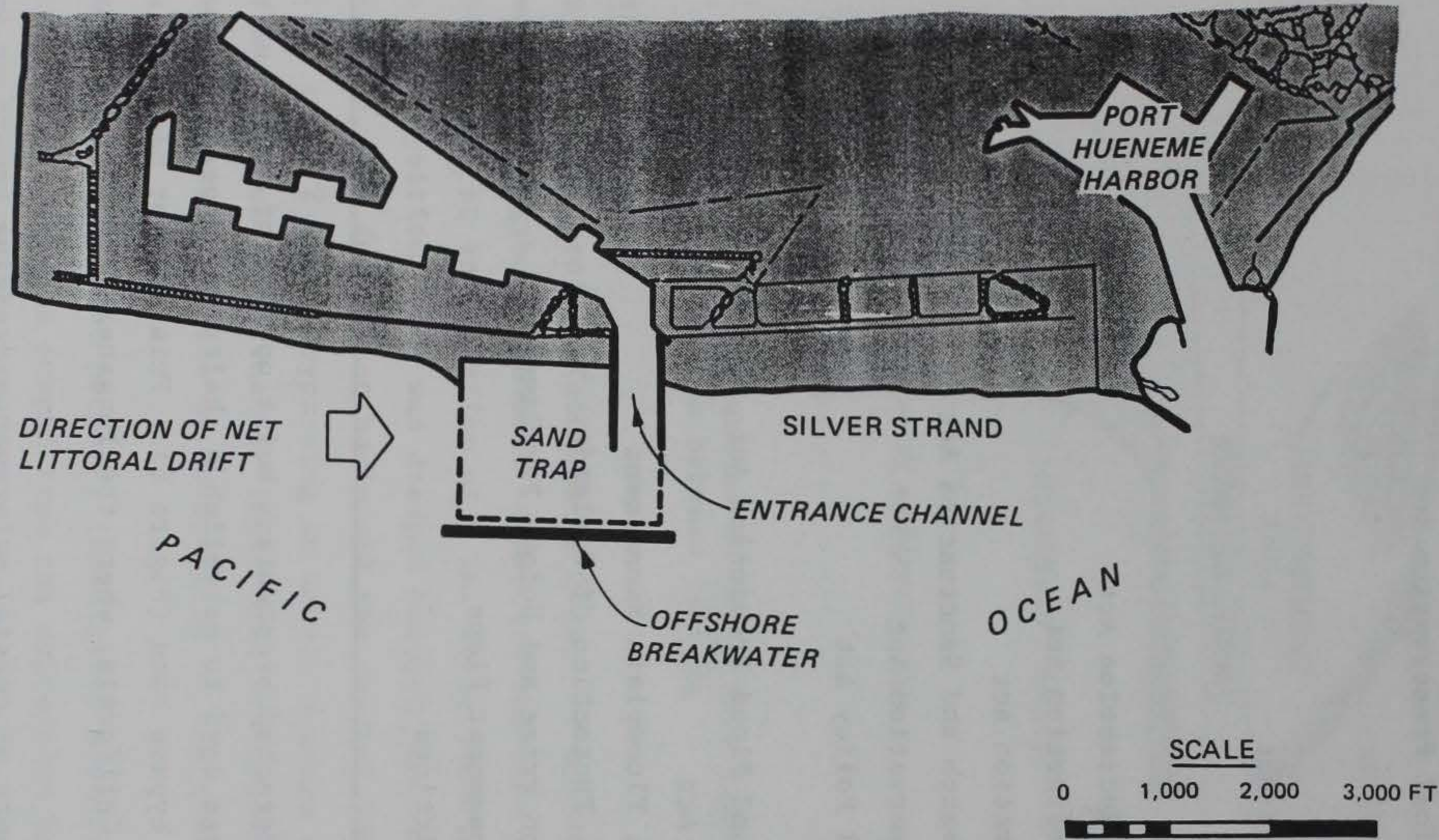


Figure 5. Channel Islands-Port Hueneme, California, bypassing project

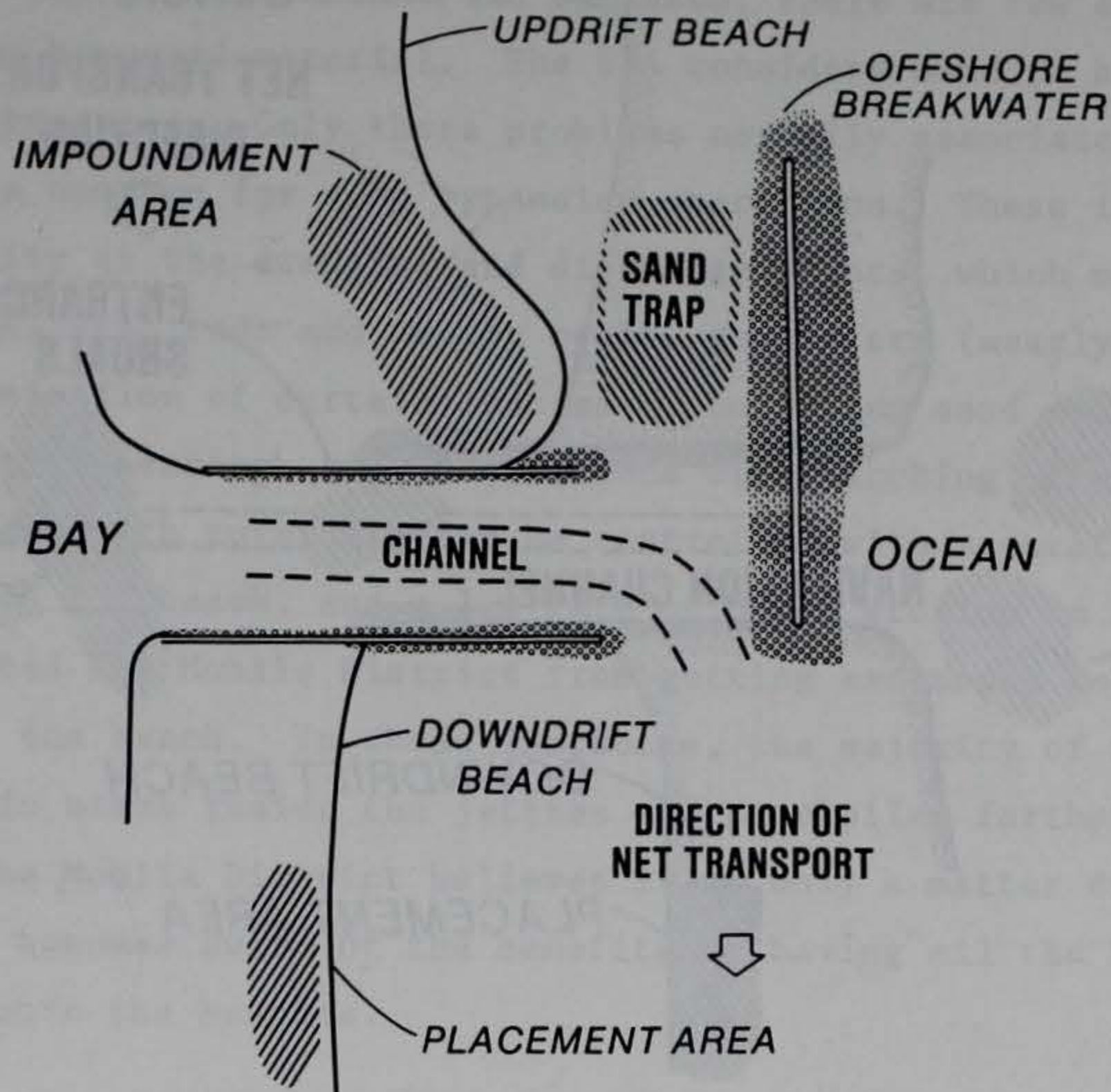


Figure 6. Impoundment area behind detached offshore breakwater

downdrift beach. If a hopper dredge is used to remove the shoals, there are three options for sand bypassing. First, the sand can be transferred from the dredge through a direct pump-out facility (e.g. single point mooring buoy and pipeline to shore) located just offshore of the placement area. Second, the hopper dredge can dump the sand in a protected area where a cutterhead dredge will rehandle the material and pump it to the downdrift beach. Finally, the hopper dredge can dump the material just offshore in a shore parallel feeder berm, with the intention that waves will move it onto the beach. This final method is a relatively new concept currently under development (see Richardson, p 88).

Nerang River Entrance, Queensland, Australia

A new inlet was constructed at the Nerang River Entrance on the east coast of Australia to replace the existing unstructured entrance, which was very hazardous due to the expansive, shallow ebb tidal bar. This a new inlet was completed in late 1985 and includes a trestle mounted, jet pump, sand bypassing system that started operations in May 1986. The sand bypassing

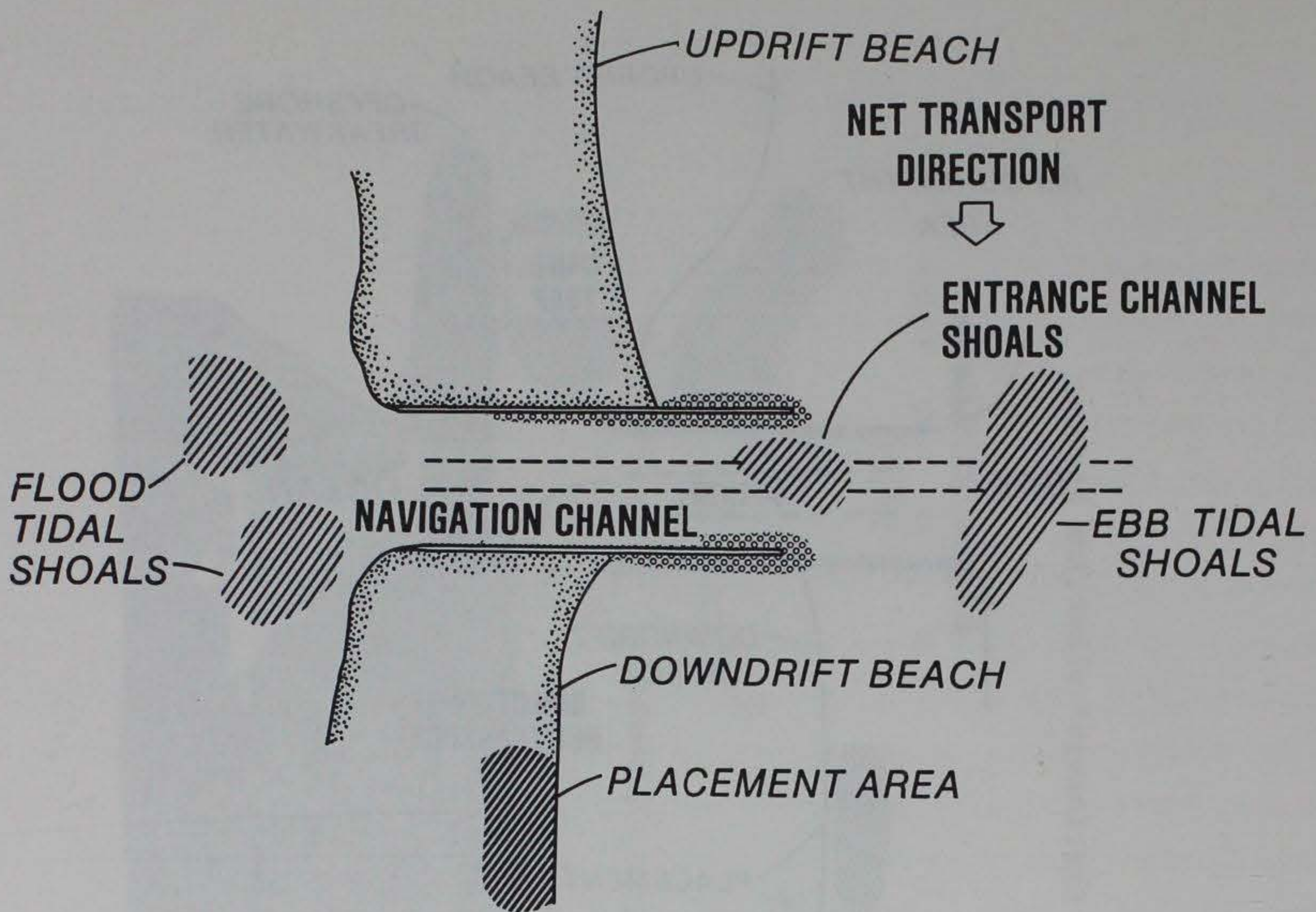


Figure 7. Typical locations of shoals at inlets

system is designed to bypass the net northerly littoral drift, estimated at 650,000 cu yd/year.

The bypassing system consists of a 1,600-ft-long trestle supporting 10 jet pumps that are placed every 100 ft along the outer 1,000 ft of the structure. Sand deposited in the trap created by the jet pumps is bypassed to the downdrift beach (similar to Figure 2). During the first year of operation, the system bypassed over 900,000 cu yd of sand. Component wear and clogging problems experienced during the first 2 years of operation appear to be at least partially solved, and the system continues to operate at or near design capacity (Clausner 1988).

#### Environmental Impacts of Sand Bypassing

To date, there have been no serious environmental impacts associated with Corps sand bypassing operations. Because the projects are bypassing sand, which came from local beaches and the nearshore zone prior to being

deposited in the navigation channel and bypassed, there are few environmental problems with the bypassed material. The EPA considers sand to be "clean," free of toxic substances. Only those problems normally associated with beach nourishment are a concern for sand bypassing operations. These include increased turbidity at the dredging and discharge points, which may be a problem for local shellfish beds and nearby reefs, short-term (nearly always less than 1 year) elimination of certain species of burrowing sand animals, interference with seabird nesting, and interference with hatching of sea turtle eggs. The problems with turbidity can be controlled with accurate dredging and sand placed on the beach, and a low rate of beach erosion in this area has sometimes prevented the Mobile District from getting easements to place bypassed sand on the beach. In these instances, the majority of the bypassed sand was placed in areas inside the jetties and stockpiled farther back in the bay. However, the Mobile District believes it is only a matter of time before the local public becomes aware of the benefits of having all the bypassed sand placed directly onto the beaches.

#### Beach Nourishment in the Galveston District

This slide shows a site near Port Mansfield, TX, about 40 miles north of Brownsville. During a scheduled dredging operation, the down drift site was selected as an optional dredged material disposal site. The contractor placed most of the material on the beach; however, we did not anticipate a norther (wind) blowing through right at project completion. Needless to say, the experiment was not a total success, but we did create one rather nice dredge disposal area.

Our only constructed beach nourishment project was completed in the bay near Corpus Christi in March 1978. This slide shows North Beach prior to construction and documents the small area available for recreation. The Corpus Christi Ship Channel is shown in the foreground of the slide, and Aransas Bay is in the background of the slide. We restored about 1 mile of the beach to a berm crest of +3 ft with a width of between 100 to 300 ft. This was done by first placing about 500,000 cu yd of silty material dredged from the bay on the beach with a hydraulic dredge. We then truck hauled in about 300,000 cu yd of coarse sand (river sand) from an inland source to cover the finer material. The project behaved mostly as expected, but the north end did erode

severely. A spit developed as the material was transported towards Aransas Bay. The project even did well during Hurricane Allen in 1980. Although the beach was eroded, the interface between the two layers of different-sized material remained sharp and distinct. We completed a rubble mound groin to stabilize the north end of the fill in November 1985. We also placed an additional 35,000 cu yd of sand updrift of the groin. There have been no problems with the project since that time.

The next project to be discussed is a sand bypassing project that is currently under construction at the mouth of the Colorado River about 50 miles southwest of Freeport, TX. We completed jetties at the entrance channel in December 1985. The east jetty includes a 1,000-ft submerged weir structure (whose elevation is at mean low tide). The impoundment basin that Jim referred to earlier to trap material that crosses the weir will be dredged within the next year. The impoundment basin will hold approximately 600,000 cu yd of sand and will need to be dredged every 2 years. There has been some erosion downdrift of the jetties, but it has not been significant since the navigation channel has not been dredged yet.

Earlier, Tom Richardson mentioned our project at Brazos-Santiago Pass near Brownsville which would determine the best location for nearshore placement of sand to nourish beaches. This is a picture of the pass. Note the intensive development north of the pass. This area has a historical beach erosion rate of between 5 to 10 ft a year and is heavily used for recreation. The results of this study are encouraging so far, and we are considering placing material offshore from South Padre Island this fall in the hopes of seeing how it will behave.

#### Literature Cited

Clausner, J. E. 1988. "Jet Pump Sand Bypassing at the Nerang River, Entrance, Queensland, Australia," Proceedings - Beach Preservation Technology '88, Florida Shore and Beach Preservation Association, Gainesville, FL.

QUESTIONS AND RESPONSES--BEACH NOURISHMENT AND LAND STABILIZATION

Moderator: William T. Pearson

QUESTION (Pat Langan): I would like to ask Mike on the Corpus job, what was the depth of fill of the fine-grained fill before you capped it with sand?

RESPONSE (Mike Kieslich): It varied along that 1.4 miles, but it typically was 3 to 4 ft. Then we placed about 1.5 ft of coarse sand on top of that.

QUESTION (John Arrington): Would sand bypassing work on Galveston Island?

RESPONSE (Mike Kieslich): We have talked about this on and off for about 10 years, and I think that it would, although it depends upon what beach that you would want to nourish. Technically, it can be achieved, and the equipment is available to do it. The problem is the economics. There is sandy beach material within the entrance channel, but typically the beaches that people want nourished are more than 10 to 15 miles from the entrance channel, and you are really pushing the economics of haul distances. It is possible, but the added costs would have to be incurred. This is why no action has occurred due to these added costs.

QUESTION (Forest Pruett): That jet pump arrangement which you talked about in Australia, has that been cost compared to traditional dredging equipment?

RESPONSE (James Clausner): I have some costs, and in fact it is cheaper, but you have to judge each project on its merits. At that particular site, the annual operating costs are about \$0.60/cu yd.

QUESTION (Forest Pruett): Are those systems stable so that you have enough uptime?

RESPONSE (James Clausner): This is a relatively new technology, but this system looks like it is going to be fairly reasonable; however, it is in truth the first jet pump system designed for this purpose. It looks very encouraging depending upon your site, as it is very site-specific.

QUESTION (Lim Vallianos): Question and inference proposed by the gentlemen who spoke about Prudo Bay, king pile and railroad tie breakwater or bulkhead versus the plantations of marsh grass. My recollection is that even though they came under the low-cost protection umbrella, they were segregated



in terms of wave energy, and what may be an important site for grass may not work for a site like Prudo Bay.

RESPONSE (John Lesnick): Sure, you are absolutely right. If you want a natural setting, then use grass versus some obtrusive structure like a bulkhead and then use vegetation. The Great Lakes sites are not low wave energy sites. The wave heights are almost comparable to open-ocean sites. However, those sites were included because they were mandated by the legislation, and those were the two sites that could be located and something could be built.

SESSION II: HABITAT DEVELOPMENT: CASE STUDIES

Moderators: Edward Klima  
National Marine Fisheries Service  
Galveston, Texas

Leland Roberts  
Texas Parks and Wildlife Department  
Austin, Texas

HABITAT DEVELOPMENT ON DREDGED MATERIAL

Hanley K. Smith  
US Army Engineer Waterways Experiment Station  
Vicksburg, Mississippi

A video presentation was shown. Copies of the video are available from Mr. Rick Medina (409-766-3962), US Army Engineer District, Galveston.

ENVIRONMENTAL ASSESSMENT OF DREDGED MATERIAL DISPOSAL  
ON GRAZING LANDS AT EAST MATAGORDA BAY, TEXAS

James W. Webb  
Texas A&M University at Galveston  
Galveston, Texas

Mary C. Landin  
US Army Engineer Waterways Experiment Station  
Vicksburg, Mississippi

Introduction

The environmental impacts of smothering high salt marsh with dredged material of various textures and thicknesses indicated that *Spartina alterniflora* stems could penetrate 23 cm of sediment deposited on top of plants (Reimold, Hardisky, and Adams 1978). This study suggested that smothering high marsh with dredged material could be a feasible disposal alternative. Open-water disposal in East Matagorda Bay has been opposed by environmentally concerned groups. A possible environmentally acceptable alternative is to dispose on upland and higher wetlands adjacent to the GIWW. A tract of land was located whose owner was interested in lessening damage to the bay ecosystem. At the request of the landowner, tests were designed to determine the effects of disposal of dredged material on the vegetation in terms of cattle utilization. The disposal area is a 300-acre disposal site established in the 1940's. During construction of the GIWW, the area adjacent to the waterway received disposal material. Since that initial disposal, the area has been used for grazing.

The CE Galveston District pumped silty dredged material on lands adjacent to East Matagorda Bay in September 1986 as a result of routine maintenance dredging. The effects of the material on revegetation were monitored. The study objective was to determine the environmental impacts of unconfined disposal of silty dredged material on range land vegetation.

Methods

Prior to the disposal of the silty dredged material, 50 permanent sampling stations were established in a grid pattern across the area. Ten

transects were established at 500-ft intervals perpendicular to the GIWW. Along each of the 10 transects, five sampling stations were marked with stakes at approximately 300-ft intervals. In addition, 25 sampling stations were established on adjacent land on the western side of the disposal area. Five permanent transects were established at 400-ft intervals with five sampling stations on each at approximately 300-ft intervals. Transects 9 and 10 plus plots 4 and 5 of Transect 8 in the disposal area were dropped from consideration because no dredged material reached those plots.

At each of the 68 sampling stations, data were collected (a) prior to disposal (1 July 1986), (b) approximately 1 week after disposal was completed (12 September 1986--soil salinity and dredged material depth), (c) at the end of the first growing season (16 November 1986), (d) at 1 year (July 1987), and (e) at the end of the second growing season (31 October 1987). In 1988, samples will be collected only at the end of the growing season.

At each sampling station, vegetation measurements were made in  $0.25\text{-m}^2$  plots randomly selected at each sample period. Percent cover of each species and total percent ground cover were estimated, and then biomass was determined for each species by clipping, drying, and then weighing each species. Leaf tips of the three dominant grasses were randomly collected at each station, oven-dried, and then chemical analyses for crude protein, acid detergent fiber, nitrates, potassium, phosphorus, calcium, and magnesium were made. From these analyses, digestible protein, total digestible nutrients, and energy were calculated.

Soil water salinity was measured when standing water was available. Dredged material salinity was measured at each sampling station from 15-cm deep samples. Soil particle size (before and after disposal) and possible toxic materials in the dredged material were analyzed on pooled soil samples (combined replications from equidistances from the GIWW). Depth of dredged material at each station also was measured.

## Results

The sediment was primarily silt (75 percent) with 15-percent clay and 8.4-percent coarse sand (Table 1). There was some variability across the site, but differences appeared to be random.

Dredged material depth was not uniform across the site. Frequent movement of the outfall pipe had been planned to ensure uniform disposal along the waterway. However, portions of the study area received large amounts of sediment, while parts of the area received little material (Table 2). Distance from the outfall largely determined the depth. The dredged material flowed approximately 1,600 ft from the outfall (approximately 1,800 ft from the GIWW). The greatest depth of sediment was near pipe outfalls. In general, sediment became thinner as distance from the outfall increased. However, a depression that generally held water in wet periods and that was dominated by *Paspalum vaginatum* received approximately 30,000 cu yd of dredged material. As a result, the entire pond bottom was covered with over 20 cm of sediment, regardless of distance from the GIWW or outfalls. Compaction of the sediment occurred over time. Approximately 1 year after disposal, the deepest sediment had compacted approximately 10 cm while the areas receiving little sediment had compacted only 1.5 cm (Table 3).

Total foliage cover (all plant species combined) in the disposal area declined from 76.3 percent in July 1986 to 37.7 percent in November 1986 following disposal and was still only 47 percent in July and October 1987 (Table 4). Differences among dates were statistically significant at  $P < 0.05$ . In the control area, combined species cover remained about 80 percent at all four dates. The data indicate that dredged material significantly covered plants. Plants were most significantly affected near the GIWW and in the depression area where depth of material was greatest. *Spartina spartinae* was the dominant species at higher elevations near the waterway. As a result, the foliage cover for *S. spartinae* declined from 23.9 to 14.8 percent following disposal, but the difference was not statistically significant. The cover remained at 12.5 percent 1 year later. *Paspalum vaginatum*, which was the most common plant in the depression area, significantly declined in percent cover from 21.7 to 5.3 percent following disposal. The cover for *P. vaginatum* increased to 9.1 percent in July and 12.3 percent in October 1987. *Spartina patens* also declined in cover, but differences were not significant.

Total biomass in the disposal area was significantly less following disposal (Table 5). Reduction in biomass of the three major grass species (*S. spartinae*, *S. patens*, and *P. vaginatum*) also occurred, but statistically significant differences among dates existed only for *P. vaginatum*. No recovery had occurred by July 1987.

Regression analyses showed that cover and biomass (all species combined, *S. spartinae*, and *P. vaginatum*) decreased as depth of sediment increased (Figures 1 and 2). The other dominant species (*S. patens*) also declined with sediment depth, but the decline in cover was not statistically significant. The evidence seems to indicate that 15 cm of sediment will greatly alter plant production. Percent cover (Table 6) and total biomass (Table 7) of plants at various depths of sediment deposition indicated that plant cover was not reduced by sediment depths less than 6 cm. A slight reduction in the amount of cover occurred between 6 to 12 cm. Drastic reductions in plant cover of each species occurred at 18 cm of material.

The leaf tips of the dominant grasses were analyzed for various chemical components to determine the effects of the dredged material on nutrient availability to cattle. Many measurements for each species in control and disposal areas varied seasonally (Tables 8, 9, and 10). Differences within the disposal area appeared to be seasonal rather than a result of the dredged material. The disposal area was significantly different from the control area for many measurements at different dates. In general, the disposal area was greater in crude protein and less in fiber than the control area in October 1987 (after disposal). The data seemed to indicate a slight beneficial effect of dredged material on plant nutrients when plants were not buried. The crude and digestible protein of *S. spartinae* was low, while fiber was high throughout the study (Table 8). Consequently, *S. spartinae* can be classified as low in nutritional value to cattle, regardless of the presence of dredged material. *Spartina patens* and *P. vaginatum* appeared to be better nutritionally in fall than summer.

Analyses to determine the presence of toxic substances in the disposal material were made in July 1986 (prior to disposal) and in November 1987 after disposal (Tables 11 and 12). On both dates the disposal area did not significantly exceed the control area in toxic substance measurements. However, in the disposal area, measurements in November for three toxic substances (chromium, copper, and zinc) did significantly exceed measurements made in July. In contrast, measurements for lead and nickel were less in November than July in the disposal area. Many substances were nondetectable in analyses. It appears that some substances were different by date, but significant amounts of toxic substances did not occur.

## Conclusions

- a. Vegetation composition, cover, and biomass were not significantly impacted when sediment depth (after compaction) was below 12 cm.
- b. Vegetation cover and biomass were significantly reduced when sediment depth exceeded 18 cm.
  - (1) Vegetation near outfalls was impacted because of depth of sediment.
  - (2) Vegetation in depressions was impacted by accumulation of sediment.
- c. Sediment filtered through vegetation up to 550 m from pipe outfalls, but significant changes in vegetation occurred primarily near outfalls or in depressions.

## Literature Cited

Reimold, R. J., Hardisky, M. A., and Adams, P. C. 1978. "The Effects of Smothering a *Spartina alterniflora* Salt Marsh with Dredged Material," Technical Report D-78-38, US Army Engineer Waterways Experiment Station, Vicksburg, MS.

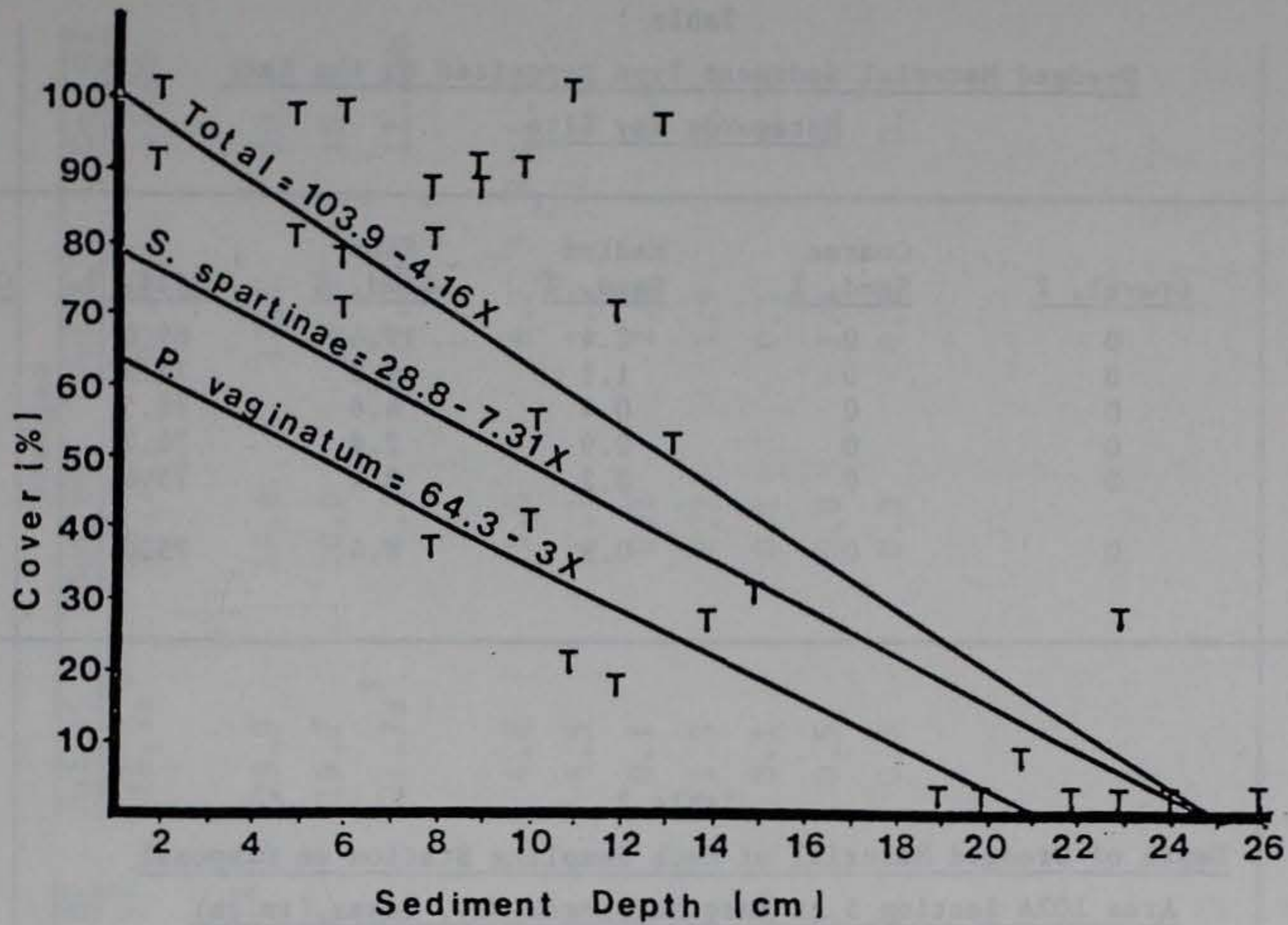


Figure 1. Plot of cover (total and dominant grasses) versus sediment depth in disposal area. Statistically significant ( $P < 0.05$ ) regression line, showed that cover decreased with increasing sediment depth for all plant species except for *Spartina patens*

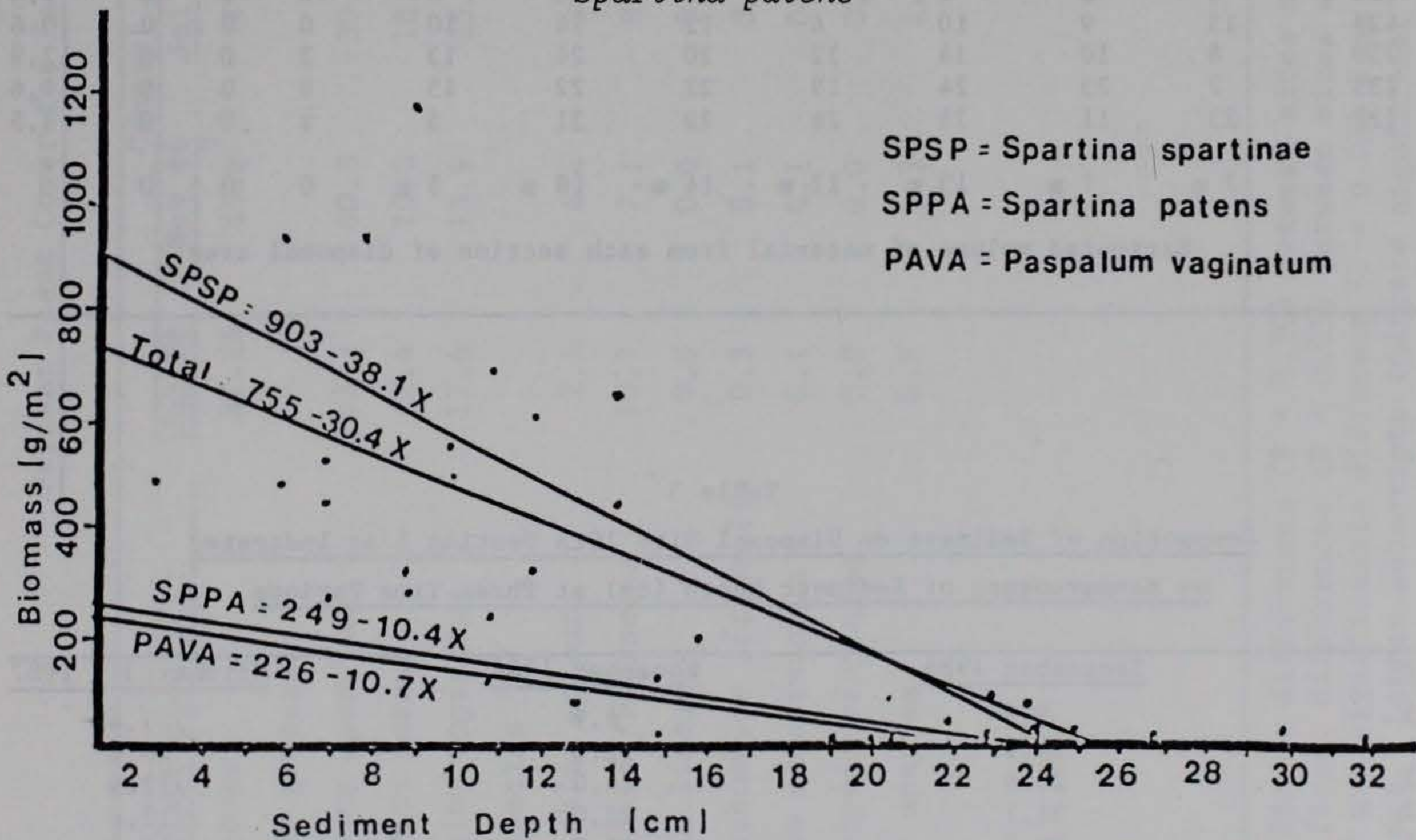


Figure 2. Plot of biomass (total and dominant grasses) versus sediment depth in disposal area. Statistically significant ( $P < 0.05$ ) regression lines, showed that biomass decreased with increasing sediment depth except for *Spartina patens*



Table 1  
Dredged Material Sediment Type Deposited on the East  
Matagorda Bay Site

<u>Distance</u> <u>from GIWW</u> <u>m</u>	<u>Gravel, %</u>	<u>Coarse</u> <u>Sand, %</u>	<u>Medium</u> <u>Sand, %</u>	<u>Fine</u> <u>Sand, %</u>	<u>Silt, %</u>	<u>Clay, %</u>
520	0	0	2.4	17.4	69.0	11.2
425	0	0	1.1	9.8	75.5	13.6
330	0	0	0.4	4.6	78.5	16.5
235	0	0	0.9	7.8	76.7	14.7
140	0	0	0.2	2.4	75.4	22.0
$\bar{X}$	0	0	0.9	8.4	75.0	15.6

Table 2  
Depth of Dredged Material at Each Sampling Station on Disposal  
Area 102A Section 5 at East Matagorda Bay, Texas (in cm)  
31 October 1987

<u>Distance</u> <u>m</u>	<u>Transect, cm</u>										<u>X</u>
	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>6</u>	<u>7</u>	<u>8</u>	<u>9</u>	<u>10</u>	
520	6	8	8	6	11	8	5	0	0	0	7.4
425	13	9	10	6	12	14	10	0	0	0	10.6
330	8	10	14	12	20	24	13	2	0	0	12.9
235	7	23	24	19	22	22	15	9	0	0	17.6
138	23	11	21	26	29	31	5	2	0	0	18.5
	7 m	7 m	15 m	12 m	14 m	18 m	5 m	0	0	0	

Estimated volume of material from each section of disposal area

Table 3  
Compaction of Sediment on Disposal Site 102A Section 5 as Indicated  
by Measurements of Sediment Depth (cm) at Three Time Periods

<u>Plot</u>	<u>September 1986</u>	<u>November 1986</u>	<u>October 31, 1987</u>
5	8.9	6.9	7.4
4	14.9	12.3	10.6
3	26.6	14.0	12.9
2	31.1	22.0	17.6
1	28.7	28.0	18.5

Table 4

Percent Plant Cover for Each Site at Each Month Sampled

Plant Cover, %	Control				Dredged			
	Jul 86	Nov 86	Jul 87	Oct 87	Jul 86	Nov 86	Jul 87	Oct 87
Total cover	82.20	80.8 <sup>2</sup>	77.8 <sup>2</sup>	82.7 <sup>2</sup>	76.3a <sup>3</sup>	37.7b	47.6b	47.0b
Dominant grasses								
<i>Spartina spartinae</i>	43.3 <sup>1</sup>	40.3	30.2 <sup>2</sup>	43.2 <sup>2</sup>	23.9	14.8	12.5	10.9
<i>Spartina patens</i>	12.4	20.0	18.4	9.4	19.7	10.0	15.0	10.2
<i>Paspalum vaginatum</i>	17.6	13.9	25.0	22.2	21.7a <sup>3</sup>	5.2b	9.0b	12.2ab
Other species								
<i>Distichlis spicata</i>	2.1	4.4	3.3	5.8	4.8	5.0	6.7	11.1
<i>Borrchia frutescens</i>	10.7	7.1	8.8	7.8	5.5	1.1	2.9	1.6
<i>Suaeda linearis</i>	0.0	0.0	0.0	0.0	0.1	0.2	2.1	0.6
<i>Monanthochloe littoralis</i>	0.3	0.1	0.0	0.0	1.3	2.2	1.9	2.1
<i>Lycium carolinianum</i>	0.1	0.1	0.6	0.0	0.1	0.1	0.1	0.5
<i>Salicornia virginica</i>	0.0	0.0	0.0	0.0	0.5	0.0	1.1	0.7
Other species	0.9	1.5	1.9	2.1	0.5	0.3	0.1	0.1

1 Significant differences ( $P < 0.10$ ) between sites at that date as determined by analysis of variance.

2 Significant differences ( $P < 0.05$ ) between sites at that date as determined by analysis of variance.

3 Cover was significantly different ( $P < 0.05$ ) from subsequent dates as determined by analysis of variance. Letter subscripts indicate significant differences among sampling dates.

Table 5  
Biomass of Each Plant Species at Each Site at Each Sampling Period

Plant Cover, g/m <sup>2</sup>	Control				Disposal Area			
	Jul 86	Nov 86	Jul 87	Oct 87	Jul 86	Nov 86	Jul 87	Oct 87
Total biomass	707.7	670.9 <sup>1</sup>	625.3 <sup>1</sup>	527.6 <sup>1</sup>	649.1a <sup>2</sup>	351.9b	399.2b	340.0b
Dominant grasses								
<i>Spartina spartinae</i>	365.2	295.1	231.7	217.1	243.7	150.2	135.7	133.6
<i>Spartina patens</i>	122.3	191.7	103.5	84.1	209.1	114.9	105.2	80.6
<i>Paspalum vaginatum</i>	78.2	62.6	131.7 <sup>1</sup>	78.5	100.9 <sub>a</sub> <sup>2</sup>	34.4 <sub>b</sub>	45.9 <sub>ab</sub>	42.2 <sub>ab</sub>
Other species								
<i>Distichlis spicata</i>	10.8	16.1	45.9	37.2	30.6	23.4	51.5	46.6
<i>Borrichia frutescens</i>	122.8 <sup>1</sup>	88.2 <sup>1</sup>	98.5 <sup>1</sup>	101.2 <sup>1</sup>	44.1	14.4	28.6	10.9
<i>Suaeda linearis</i>	0.1	0.0	0.0	0.0	0.4	0.7	15.0	2.7
<i>Monanthochloe littoralis</i>	1.1	0.2	0.1	0.1	8.9	9.4	12.1	9.0
<i>Lycium carolinianum</i>	3.0	0.4	9.7	1.5	1.9	0.1	1.6	1.9
<i>Salicornia virginica</i>	0.0	0.0	0.0	0.0	4.2	3.5	2.8	12.4

1 Significant differences (P < 0.05) between sites at date indicated. Determined by analysis of variance.

2 Significant differences (P < 0.05) among dates for the site indicated. Determined by analysis of variance. Letter subscripts indicate significant differences among sample dates.

Table 6  
Percent Cover of Plants at Various Depths of Sediment Deposition

	N	Depth, cm	Total Cover, %			
			Jul 86	Nov 86	Jul 87	Oct 87
Total	7	0-6 <sup>ns</sup>	74.2	70.0	79.2	86.4
Cover	14	6-12 <sup>1</sup>	78.5	51.8	67.5	66.4
Percent	5	12-18 <sup>ns</sup>	69.0	35.2	52.0	42.0
Cover	9	18-24 <sup>2</sup>	77.2a	4.1b	5.0b	3.7b
	3	24+ <sup>2</sup>	80.0a	1.6b	1.6b	3.3b

1 Differences significant among dates at  $P < 0.10$  as determined by analysis of variance F-tests.

2 Differences among dates significant at  $P < 0.001$  as determined by analysis of variance F-tests. Means with different letter are significantly different.

Table 7  
Biomass of Dominant Grasses Prior to and Subsequent to Burial at Various Depths of Sediment

N	Burial Depth cm	Total Biomass, g/m <sup>2</sup>			
		Jul 86	Nov 86	Jul 87	Oct 87
7	0-6	575.9	542.7	830.3	635.5
14	6-12	703.0	512.4	472.7	463.8
5	12-18	742.0	393.8	450.3	274.0
9	18-24	566.8a <sup>1</sup>	47.4b	48.9b	64.1b
3	24+	660.1a <sup>1</sup>	0.9b	2.5b	10.7b

1 Significant difference ( $P < 0.05$ ) among dates as determined by analysis of variance F-tests. Means with different letters are significantly different.

Table 8

Chemical Analysis (in Percentage of Weight) of *Spartina spartinae* Leaf Tips  
from Disposal and Control Site Plots at Each Sampling Date

	Jul 86		Nov 86		Jul 87		Oct 87	
	Control	Disposal	Control	Disposal	Control	Disposal	Control	Disposal
Crude protein	2.5 <sup>1,2</sup>	3.5 <sup>1</sup>	4.2 <sup>2</sup>	6.1	4.2 <sup>2</sup>	5.8	2.7 <sup>2</sup>	4.6
Digestible protein	0.5 <sup>1,2</sup>	0.5 <sup>1</sup>	1.1 <sup>2</sup>	3.0	1.1 <sup>2</sup>	2.6	0.3 <sup>2</sup>	1.5
Acid detergent fiber	41.0 <sup>1</sup>	38.7	40.7	39.9	36.5	38.3	38.4 <sup>2</sup>	40.1
Total digestible nutrients	50.5 <sup>1</sup>	51.6	50.5	50.1	53.8	54.1	54.0 <sup>2</sup>	51.7
Energy, mcal/lb	1.0 <sup>1</sup>	1.0	1.0	1.0	1.1	1.1	1.1 <sup>1</sup>	1.0
Phosphorus	0.1 <sup>1</sup>	0.1 <sup>1</sup>	0.2 <sup>2</sup>	1.0	0.1	0.1	0.1	--
Potassium	0.4 <sup>1,2</sup>	0.5 <sup>1</sup>	0.4	0.1	0.5 <sup>2</sup>	0.6	0.6	0.6
Calcium	0.5 <sup>1</sup>	0.5 <sup>1</sup>	0.7	0.3	0.5	0.4	0.6	0.6
Magnesium	--	--	0.3 <sup>2</sup>	0.4 <sup>1</sup>	0.3	0.2	0.3	0.4
Nitrates	0.9 <sup>1</sup>	0.1 <sup>1</sup>	0.1	0.0	51.8	34.8	20.6	23.7

154

- 1 Statistically significant ( $P < 0.05$ ) differences between dates for the site indicated, as determined by analysis of variance F-tests.
- 2 Statistically significant ( $P < 0.05$ ) difference between sites for the date indicated, as determined by analysis of variance F-tests.

Table 9

Chemical Analysis (in Percentage of Weight) of *Spartina patens* Leaf Tips  
from Disposal and Control Site Plots at Each Sampling Date

	Jul 86		Nov 86		Jul 87		Oct 87	
	Control	Disposal	Control	Disposal	Control	Disposal	Control	Disposal
Crude protein	3.4 <sup>1</sup>	--	5.0 <sup>2</sup>	6.8 <sup>1</sup>	4.7 <sup>2</sup>	6.8	3.8 <sup>2</sup>	5.5
Digestible protein	0.4 <sup>1</sup>	--	1.9 <sup>2</sup>	3.7 <sup>1</sup>	1.6 <sup>2</sup>	3.6	0.7 <sup>2</sup>	2.4
Acid detergent fiber	42.7 <sup>1</sup>	--	39.4 <sup>2</sup>	35.8	39.6 <sup>2</sup>	36.1	37.8	38.5
Total digestible nutrients	47.9 <sup>1</sup>	--	52.4 <sup>2</sup>	55.7	52.3	54.0	54.6	53.8
Energy, mcal/lb	1.0 <sup>1</sup>	--	1.0 <sup>2</sup>	1.1	1.0	1.1	1.1	1.1
Phosphorus	0.1 <sup>1</sup>	--	0.2 <sup>2</sup>	0.1	0.1	0.1	--	--
Potassium	0.4 <sup>1</sup>	--	0.4	0.4 <sup>1</sup>	0.4 <sup>2</sup>	0.6	0.6	0.6
Calcium	0.6 <sup>1</sup>	--	0.8	0.7 <sup>1</sup>	0.4	0.4	0.7 <sup>2</sup>	0.7
Magnesium	--	--	0.3	0.3 <sup>1</sup>	0.2	0.2	0.3	0.3
Nitrates	0.3 <sup>1</sup>	--	0.0	0.0	101.2	94.6	20.0 <sup>2</sup>	30.7

155

- 1 Statistically significant ( $P < 0.05$ ) differences between dates for the site indicated, as determined by analysis of variance F-tests.
- 2 Statistically significant ( $P < 0.05$ ) difference between sites for the dates indicated, as determined by analysis of variance F-tests.

Table 10

Chemical Analysis (in Percentage of Weight) of *Paspalum vaginatum* Leaf Tips  
from Disposal and Control Site Plots at Each Sampling Date

	Jul 86		Nov 86		Jul 87		Oct 87	
	Control	Disposal	Control	Disposal	Control	Disposal	Control	Disposal
Crude protein	6.5 <sup>1</sup>	8.4 <sup>1</sup>	12.4	14.6	8.1 <sup>2</sup>	9.8	5.8	6.3
Digestible protein	3.3 <sup>1</sup>	5.2 <sup>1</sup>	9.0	11.2	4.9 <sup>2</sup>	6.5	2.7	3.2
Acid detergent fiber	33.5 <sup>1</sup>	31.0 <sup>1</sup>	29.2	28.0	33.4 <sup>2</sup>	31.0	33.5 <sup>2</sup>	25.1
Total digestible nutrients	57.5 <sup>1</sup>	57.9	58.2	54.9	57.7	57.9	56.5	55.4
Energy, mcal/lb	1.1 <sup>1</sup>	1.2	1.2	1.1	1.1	1.2	1.1	1.1
Phosphorus	0.1 <sup>1,2</sup>	0.1 <sup>1</sup>	0.3	0.3	0.2 <sup>2</sup>	0.2	--	--
Potassium	1.1	1.0	1.2 <sup>2</sup>	0.7	1.2 <sup>2</sup>	1.8	1.2 <sup>2</sup>	1.7
Calcium	0.6 <sup>2</sup>	0.9	0.3 <sup>2</sup>	0.5	0.3 <sup>2</sup>	0.4	0.3 <sup>2</sup>	0.4
Magnesium	--		0.2 <sup>2</sup>	0.3	0.2 <sup>2</sup>	0.2	0.2	0.2
Nitrates	2.5 <sup>1</sup>	2.0 <sup>1</sup>	0.1	0.0	98.6	137.7	18.1 <sup>2</sup>	35.4

1 Statistically significant ( $P < 0.05$ ) differences among dates for the site indicated as determined by analysis of variance F-tests.

2 Statistically significant ( $P < 0.05$ ) difference between sites for the date indicated as determined by analysis of variance F-tests.

Table 11

Soil Salinity Analyses for Each Site at Each Sampling Date

	Control				Disposal Site				
	Jul 86	Nov 86	Jul 87	Oct 87	Jul 86	Sept 86	Nov 86	Jul 87	Oct 87
Salinity index	7.1b <sup>1</sup>	7.3b	10.2a	10.5a	15.1a <sup>1</sup>	52.8d	31.6b	26.3c	22.3c
Sodium adsorption ratio	18.0	17.2	18.0	24.6	21.5b <sup>1</sup>	53.9a	59.2a	32.9b	23.2b
Ph	7.8b <sup>1</sup>	7.7b	7.8b	8.1a	7.6a <sup>1</sup>	7.4b	7.4b	7.5b	7.7a
Ca, equivalent	17.6	13.4	16.0	16.2	23.7	31.6	27.7	31.0	27.1
Ca, ppm	352.2	267.4	320.9	307.2	482.7 <sup>2</sup>	631.1	554.4	620.5	540.7
Mg, equivalent	22.4	12.8	21.8	26.1	35.8	90.8	43.0	48.5	41.7
Mg, ppm	273.8a <sup>1</sup>	15.8b	266.7a	319.2a	435.9b <sup>1</sup>	1,108.0a	527.6b	591.0b	509.1b
Na, equivalent	84.0	59.9	77.9	104.6	124.6	415.8	320.5	209.6	147.9
Na, ppm	1,932 <sup>2</sup>	1,377	1,791	2,329	2,814d <sup>1</sup>	9,011a	7,341b	4,849c	3,521cd

1 Statistically significant ( $P < 0.05$ ) difference among dates for the site indicated as determined by analysis of variance F-tests. Means with different letters are significantly different.

2 Statistically significant ( $P < 0.10$ ) differences among dates for the site indicated as determined by analysis of variance F-tests.



Table 12

Sediment Analyses of Sediments on the Control and Disposal Area Prior  
to and Following Disposal at East Matagorda Bay, 1986

Analysis	Disposal Area		Control Area		Detection limit
	Jul 1	Nov 15	Jul 1	Nov 15	
Chromium, mg/kg	4.8	17.9 <sup>1</sup>	5.0	15.5 <sup>2</sup>	1.0
Copper, mg/kg	5.4 <sup>3</sup>	9.6 <sup>1</sup>	7.0	8.7	1.0
Lead, mg/kg	8.8	6.5 <sup>1</sup>	13.6	7.4	1.0
Nickel, mg/kg	16.0	11.7 <sup>1</sup>	18.9	11.7	1.0
Zinc, mg/kg	20.5	34.9 <sup>1</sup>	20.3	27.7	1.0
Oil and grease, mg/kg	821.8	461.9	527.0	301.5	5.0
Arsenic, mg/kg	ND	3.2	ND	3.1	1.0
Cadmium, mg/kg	ND	ND	ND	ND	0.1
Mercury, mg/kg	ND	ND	ND	ND	0.1
Selenium, mg/kg	ND	ND	ND	ND	0.5
Total PAH, mg/kg	ND	ND	ND	ND	0.2
Naphthalene, µg/kg	ND	ND	ND	ND	50.0
Acenaphthene, µg/kg	ND	ND	ND	ND	50.0
Fluoranthene, µg/kg	ND	ND	ND	ND	10.0
Benzo (A) pyrene, µg/kg	ND	ND	ND	ND	10.0
Total PCB's, µg/kg	ND	ND	ND	ND	5.0
P, p <sup>1</sup> - DDT, µg/kg	ND	ND	ND	ND	0.2
0.2 Chlordane, µg/kg	ND	ND	ND	ND	0.2
Toxaphene, µg/kg	ND	ND	ND	ND	5.0

1 Disposal area was significantly different ( $P < 0.05$ ) in measurement following disposal as compared with prior to disposal.

2 Control area was significantly different ( $P < 0.05$ ) in measurement at the two dates.

3 Control and disposal areas significantly different ( $P < 0.05$ ) at the date indicated.

## CREATION OF SALT MARSHES FOR FISHERY ORGANISMS

Thomas J. Minello and Roger J. Zimmerman  
National Marine Fisheries Service  
Galveston Laboratory  
Galveston, Texas

An experimental manipulation of transplanted *S. alterniflora* marshes is in progress in the Galveston Bay system under a cooperative MOA between the NMFS and the CE. Transplanted marshes do not appear to function like natural marshes for fishery organisms, and in part, this may be due to reduced marsh/water interface. Under the assumption that access by estuarine organisms to the marsh surface is regulated by the amount of marsh/water interface or edge, experimental channels are being created in two transplanted *S. alterniflora* marshes to test the hypothesis that the addition of these channels will increase densities of fishery organisms in the inner marsh.

At the Chocolate Bay site, four channels were designed and constructed by the CE during December 1986 in a previously established marsh. After 11 months, soil salinities near the channels were significantly lower than in the adjacent control sectors. Biomass and stem density of *Spartina* also appeared to increase near the channels in the inner marsh. In the spring of 1987, drop samples were collected at this site, and inner-marsh densities of crustaceans (including *Penaeus aztecus*) and fish were significantly higher in the experimental sectors with channels in comparison with the control areas. Sampling is being continued at this site, but these preliminary data suggest that the utility of transplanted marshes for estuarine fauna can be enhanced by increasing the amount of marsh/water edge.

The second MOA site is located on Pelican Spit. Dredged material was placed along the shoreline of the spit in November 1986, and a 7-acre *S. alterniflora* marsh was planted on this material during the spring of 1987. After 1 year, the marsh has become established with little erosion. Plans are currently being made to construct experimental channels at this site.

USE OF DREDGED MATERIAL ISLANDS BY COLONIAL NESTING WATERBIRDS  
IN THE NORTHERN GULF COAST

Mary C. Landin  
US Army Engineer Waterways Experiment Station  
Vicksburg, Mississippi

Introduction

Over the past 100 years, the CE has built over 2,000 islands during dredging operations, primarily while building the Intracoastal Waterway System and maintaining navigation channels and harbors. Until the 1970's, the CE did not build these islands with wildlife and fish habitats as objectives. Rather, material was sidecast or mounded up in adjacent shallow water areas until islands were formed, usually incidental to the primary goal of clearing and maintaining navigation channels. Increasingly, however, wherever the CE finds that dredging needs and islands coincide, it will try to minimize environmental impacts as well as enhance wildlife and fish habitat using the dredged material resource available from the dredging project (CE 1986).

Dredged material islands and their surrounding shallows are home or stopover points for numerous species of wildlife and fish. These include relatively few mammals, although raccoons, white-tailed deer, foxes, harbor seals, river otters, nutria, muskrats, beavers, coyotes, opossums, armadillos, cottontails, small rodents, and goats and other domestic/feral livestock and animals may visit or live year-round on larger islands. Island use by alligators and other reptilian and amphibious animals is also relatively common. Shrimps, blue crabs, and numerous species commercially important and sport fishes use the shallows in and around dredged material islands at various stages in their life cycles.

The primary use of dredged material islands is by numerous species of birds. These include a variety of songbirds, especially on islands close to the mainland and in a major migratory flyway. Migratory use by waterfowl, waterbirds, and raptors with water-related feeding habits is a very important use of such islands. Perhaps more importantly and certainly more conspicuously, these dredged material islands provide habitats for about 1 million

waterbirds each year from 37 different species (Landin 1980). The CE considers waterbird nesting on these islands as a highly desirable beneficial use of dredged material and encourages such use whenever possible.

### Types of Dredged Material Islands and Sites

There are generally four types of CE dredged material islands and sites used by colonially nesting waterbird species throughout North America. All four types have been built in northern gulf coast waterways. The first type, mainland disposal sites (diked and undiked) is less frequently used because they allow access to ground predators such as raccoons and coyotes. However, under isolated conditions, nesting colonies will occur on mainland sites. The second type, older undiked islands that were built prior to the 1970's, and the third type, diked islands (both new and modified) are the most commonly occurring colony islands.

The CE is moving more and more to construction of the fourth type of island, very large CDFs that can be used for decades for placement of material from more than one dredging project. This is the fourth type of site used by waterbirds. There are three CDFs in the northern gulf coast region, and all three are used by nesting seabirds (terns, gulls, skimmers, and pelicans).

In the northern gulf coast region, which includes the coastal area from Bradenton, FL, to the Mexican border, there are a total of 645 dredged material islands and sites. Table 1 shows numbers of islands by states and those with nesting colonies. The States of Florida (north of Bradenton) and Texas have the largest numbers of islands and sites, with 120 and 414 respectively. However, Florida still has a number of natural islands available for nesting waterbirds; therefore only 28 (23 percent) of the State's dredged material sites have nesting colonies.

By contrast, there is much less available natural habitat for nesting waterbirds in Mississippi, Louisiana, and Texas, where 68, 56, and 58 percent of all dredged material islands and sites have nesting colonies. The State of Alabama, with only 26 possible dredged material nesting sites, has only 7 with colonies. However, the Gaillard Island CDF in lower Mobile Bay, Alabama, has over 30,000 waterbirds from more than 20 species nesting on it and is an extremely important nesting site.

## Nesting Species

Twenty-seven colonially nesting waterbird species and several other non-colonial species are nesting on dredged material islands and sites in the northern gulf coast. Some species, such as least terns, brown pelicans, and laughing gulls, seem to prefer dredged material sites, as most of the nesting colonies of these species are on dredged material.

### Black skimmers

While black skimmers nest on isolated barrier islands and beaches in large numbers along the northern gulf coast, they also use dredged material islands extensively. For example, the largest black skimmer colony on the gulf coast (over 4,000 birds) is located on Gaillard Island CDF.

### Tern species

Seven species of terns--least, common, royal, Caspian, Sandwich, Forster's, and gull-billed--nest on northern gulf coast dredged material islands. In the case of the least tern, hundreds of pairs nest on Gaillard Island CDF in Alabama and on protected dredged material beaches in Mississippi, as well as numerous other dredged material and natural sites along the coast.

In most cases, royal terns will nest alone or with Sandwich terns. Caspian and gull-billed terns may also be found on the same island (but not in the same colony). Forster's terns seek herbaceous vegetation for nesting sites and are becoming more and more common on older gulf dredged material islands. All seven species nest on Gaillard Island CDF.

### Brown pelicans

The only brown pelican colonies in the States of Texas and Alabama are located on dredged material, on Pelican Island near Corpus Christi, and on Gaillard Island CDF near Mobile, respectively. Other brown pelican colonies occur on dredged material in Florida and in Louisiana. No nesting colonies occur in Mississippi. The first nesting on Gaillard Island occurred in 1983 with one successful nest (Landin 1986). By 1987, there were 331 nests and over 1,000 brown pelicans on the island (Figure 1). Early data in 1988 indicate that there are over 500 nests and about 2,000 brown pelicans using the island.

In Florida and Louisiana, brown pelicans are nesting in mangroves and other low-growing coastal trees. In Alabama and Texas, they are nesting

directly on the dredged material in nests built from twigs and driftwood 0.5 to 2 ft high. In 1988, for the first time, a few brown pelicans on Gaillard Island are nesting in low-growing shrubs that have reached sufficient height and strength to support nests.

#### American white pelicans

There is only one American white pelican nesting colony in the northern gulf coast region, and it is located in the Laguna Madre between Corpus Christi and Brownsville, TX. This dredged material island has been used by nesting white pelicans for decades (Chaney et al. 1978), but has not expanded into other parts of the coast with one temporary exception. In 1979, white pelicans were found establishing nests on a dredged material island in Galveston Bay, but the colony did not persist.

The only other year-round occurrence of white pelicans in the northern gulf is on Gaillard Island, where between 600 and 800 immature white pelicans live. They feed in the CDF containment pond, and it is assumed that as they reach breeding age, they are migrating to the large white pelican nesting colonies in the western United States. Preliminary breeding behavior has been observed on Gaillard Island CDF, but no nesting has occurred there (Landin 1986).

#### Gull species

Laughing gulls, by far, make up the largest numbers of individual waterbirds nesting on both dredged material and natural islands along the northern gulf coast. They are apparently highly successful nesters and have abundant food sources, as colonies consisting of 10,000 to 20,000 birds are not unusual in Florida (Figure 2), Texas, and Alabama (Schrieber and Schrieber 1978, Chaney et al. 1978, Landin 1986). All of these largest colonies are located on big dredged material islands or CDFs.

A very low number of herring gulls nest in scattered locations in the northern gulf coast region. These nesting occurrences can hardly be considered colonies, as usually only one to five pairs are found nesting. Herring gulls' primary breeding range is the northern United States, along the northeast coast and in the Great Lakes. Herring, ring-billed, and other northern-nesting gulls will overwinter in the northern gulf coast region by the thousands. They are frequently observed on dredged material islands and sites from October to March.

### Heron and egret species

Five heron and three egret species nest on dredged material islands and sites in the northern gulf coast region. These include great blue herons, little blue herons, tri-colored herons, yellow-crowned night-herons, black-crowned night-herons, great egrets, reddish egrets, and cattle egrets (Soots and Landin 1978). With the exception of the tri-colored heron and the addition of the green heron, these same species will nest in freshwater throughout the Mississippi River basin and other freshwater wetland sites. Because newer dredged material sites are usually not well vegetated, the species tend to congregate on older islands where successional stages have progressed to provide woody vegetation large enough to support nests. However, in south Texas, herons have been observed nesting in clumps of cacti as well as in small shrubs (Chaney et al. 1978). Most of these species also tend to nest in mixed colonies with other species.

With the exception of Florida and Texas dredged material islands, mixed species heronries are not generally as large as those that have occurred for many years on natural sites and islands. However, large heronries have occurred for 30 to 50 years on such dredged material sites as Bird and Sunken Islands in Tampa Bay (Figure 3), Big Pelican and North Deer Islands in Galveston Bay (Figure 4), and on other larger dredged material islands in the Texas waterway system (Dunstan 1978, Chaney et al. 1978).

### Ibis species

Three species of ibis nest on dredged material islands, primarily in Texas and Florida. In Florida, thousands of white ibises nest in Tampa Bay and other coastal waterway sites. In Texas, white ibises, glossy ibises, and white-faced ibises nest, the latter nesting only in Texas (Chaney et al. 1978). Although white ibises have been found nesting in mixed heronries 300 miles inland in Mississippi as far upriver as Yazoo City on isolated man-made sites (Landin 1985), colonies in Mississippi, Alabama, and Louisiana tend to be located on natural islands and sites, and only those sites in Louisiana have large nesting numbers of ibises.

### Cormorants

The double-crested cormorant overwinters and feeds during migration in all five states of the region. However, they primarily nest on dredged material in Texas and Florida and on natural sites in the other states. Their colonies are not large, but consist of up to 50 nests. Since they will nest

in both fresh and salt water, they have nesting colonies in the Mississippi River as well. The olivaceous cormorant is found in Texas only and nests in small numbers on man-made structures and other sites, including a few dredged material islands.

#### Roseate spoonbill

An increasing number of roseate spoonbills nest in Florida, and large numbers nest in the Texas waterway system. Many of these nest on dredged material islands in mixed heronries with herons, egrets, and ibises. This species may occasionally wander into Mississippi, Alabama, and Louisiana, but does not occur in large numbers. Roseate spoonbills are contact feeders (compared with terns, herons, and egrets that are visual feeders). They are often observed feeding in the shallow water and soupy mud flats of dredged material placement sites. It is a distinct possibility that the occurrence of large dredged material placement sites that provide this type of feeding habitat is a boon to the spoonbill population, especially in Texas where most such feeding observances have been made.

#### Other nesting species

Four other species nest in large enough numbers on dredged material islands and sites in the northern gulf coast region to be worthy of mention. They do not, however, tend to nest in large congregations, but nest in a few pairs together or in individual pairs. The species of most concern is the black-necked stilt, which is quite common on such sites as Gaillard Island CDF and on dredged material sites in Galveston Bay. They tend to nest in low vegetation around borrow pits and shallow swales formed by dredging and construction operations. The stilt population at Gaillard Island has increased dramatically since the island was built in 1981, with over 30 nesting pairs in 1987 (Landin and Miller 1988).

American oystercatchers and willets are more solitary nesters, and in general, there is usually one or more nests on dredged material islands in low-growing herbaceous vegetation each year. This is a more common occurrence in Florida. Clapper rails are also very common nesters in both planted and naturally colonizing salt marshes on gulf and Atlantic dredged material islands. Up to three nesting pairs have been found nesting in the relatively small planted marshes on Wilson Island in Apalachicola Bay, Florida (Newling and Landin 1985), and on Gaillard Island CDF in Mobile Bay (Landin 1986). In



addition to these, snowy plovers are rare nesters, and killdeers are frequent nesters on dredged material islands in the region.

### Attraction of Dredged Material to Nesting Waterbirds

There are some generalities about characteristics of dredged material islands and sites that can be stated. All five characteristics make these sites very attractive to nesting waterbirds and, depending upon the state of island development at a given time, regulate the species or group of species that will be found there.

First, dredged material sites in the northern gulf coast region, as is true elsewhere in US waterways, tend to provide isolation from ground predators and human disturbance. In the past, especially along the gulf coast, dredged material has often been viewed by citizen and developer alike as "spoil" and has not been considered useful for construction or for recreation. Therefore, these islands and sites were relatively undisturbed, a feature that is of great importance to nesting waterbirds or any other wildlife raising young.

Since waterbirds began to use these man-made islands in large numbers as early as the 1930's for nesting, some of the larger ones have come under the protection of such organizations as the National Audubon Society, county Boards of Supervisors with natural resource interests, State Departments of Natural Resources, and the National Park Service. Newer ones such as Gaillard Island CDF are posted to trespassers during the breeding season by the CE.

Second, dredged material sites generally provide a wide range of habitats and diversity to accommodate nesting waterbirds. Four successional stages can exist on a given dredged material island or on one large dredged material island, depending upon placement schedules and other climatic and construction factors. These are (a) bare ground, which is usually the habitat available immediately after the completion of a placement operation; (b) sparse herbaceous cover, the stage that occurs about 1 to 2 years after placement of dredged material; (c) denser herbaceous cover with some sparse, low shrubs that occur about 3 to 10 years after placement; and (d) tall shrubs and trees, which is the climax stage of vegetation on an island that has not had a new deposit of dredged material for about 10 to 20 years. Times of

successional stages vary within areas of the region. For example, south Texas is so hot and arid that trees seldom attain a height of over 20 ft and are of different species from those occurring in Galveston Bay (Chaney et al. 1978). Likewise, mangroves occur in dense stands on dredged material in the Tampa Bay area (Lewis and Lewis 1978), while willows, cottonwoods, cypresses, and other freshwater trees are more likely to occur above the winter kill zone that limits mangrove survival.

Third, ongoing dredging operations usually keep early successional stage habitats available without a great deal of expense or difficulty. Using Gaillard Island CDF as an example, this 7-year-old, 1,300-acre island already has three of the four stages of habitat available for nesting waterbirds. This CDF has been used for disposal of dredged material every year since its construction, and at the same time dike upgrading and repair has taken place. These ongoing construction activities have maintained large expanses of bare ground habitat ideal for black skimmers and tern species. The CDF's south dike has remained relatively undisturbed and has become densely vegetated. In its earlier plant growth stages, there were thousands of black skimmers and laughing gulls nesting on the south dike. The habitat is changing to support larger shrubs and small trees, and in 1988 herons and egrets have also moved to the south dike to nest, along with fewer skimmers and gulls. The larger gull and skimmer colonies are tending to move to less vegetated parts of the CDF. This rapidly evolving CDF already supports 30,000 nesting birds, and the limitations of available nesting habitat have not been reached.

Fourth, dredged material islands are usually located close to shallow water areas that provide feeding habitat. Over the years, dredged material has been placed in shallow water habitats, displacing that habitat type with islands. However, the surrounding sloping dredged material from unconfined disposal leading into the island beaches has generally been colonized rapidly with marine and aquatic organisms and seagrasses. These provide feeding areas for nesting waterbirds and enhance the possibility that they will select a certain island for nesting purposes.

Fifth, larger dredged material islands, especially CDFs, provide shallow water feeding habitats within the island complexes. Shifting sediment from current and wave action on newly placed dredged material islands, especially in Florida, has caused some islands to form shallow enclosed or semienclosed ponds. In addition, all CDFs have containment ponds that are usually quite

large (Gaillard Island's is 700 to 800 acres of shallow water). These containment ponds are not only protected from bay wave action, but are provided with tidal interchange through weirs. Abundant shrimps, crabs, and fishes are found in containment ponds, and they are prime feeding habitat for the nesting birds. On Gaillard Island, for example, both brown and white pelicans congregate and feed by the hundreds at the weir in the containment pond where water exchange takes place.

### Potential for Island Management

A relatively inexpensive, tremendous potential exists for dredged material island and site management using creative dredging work and cooperative, far-sighted management techniques. There are three ways in which the CE can manage dredged material islands and sites for wildlife and fish. The first is through the placement of dredged material on a timely, rotational basis to stabilize existing islands and to provide habitat diversity. The second is to work with other public agencies and the National Audubon Society and other concerned private organizations on a long-term basis to find ways dredged material can be used beneficially where waterbird nesting colonies or marine habitats are concerned. The third way the CE can and is managing dredged material islands is to post and to provide habitat protection at known nesting colonies on active CE projects.

The responsibility for management does not rest solely with the CE. Other Federal, State, and local governmental agencies must play active roles in nesting colony protection and in cooperative efforts with the CE to actively manage and maintain waterbird nesting sites on public lands. This includes allowing the CE to place dredged material that will keep diverse habitats available for the various wildlife species that use dredged material islands and sites.

The National Audubon Society and other resource-oriented private organizations also have a responsibility for management. They too should be involved in active nesting colony protection on private lands, in acquiring such sites so that they can remain valuable habitats, and in cooperative efforts with the CE, where sites under their organizational control can be nourished through beneficial applications of dredged material.

It is the responsibility of all these agencies and organizations to actively work with US citizens and to educate them concerning nesting colonies, critical habitats, and migratory bird protection. It is also the individual responsibility of trained scientists and engineers to explain why the United States has to dredge and what we can do with this dredged material resource that can be so mutually beneficial to us all.

### Summary

This brief overview into a very large subject at least gives an indication of the magnitude of use and the importance of dredged material islands and sites to colonial nesting waterbirds in the northern gulf coast region of the United States. There are 645 gulf coast dredged material islands and sites offering wildlife habitat development, natural resource recreation, marine and wetland enhancement or creation, and a myriad of other potential beneficial uses. Broad baseline data are available to give us insight on biological requirements of species using these sites and to allow us to develop intelligent strategies for dredged material wildlife and fish management. This is especially true for nesting habitats for the thousands of waterbirds using gulf coast dredged material placement sites.

### Acknowledgments

The overview presented here was based on the results of over 15 years of study of waterbird and other wildlife and fish use of dredged material islands and sites begun under the Dredged Material Research Program and continued under the Environmental Effects of Dredging Program, US Army Engineer Waterways Experiment Station, Vicksburg, MS.

### Literature Cited

Chaney, A. H., Chapman, B. R., Kargas, J. P., Nelson, D. A., Schmidt, R. R., and Thebeau, L. C. 1978. "The Use of Dredged Material Islands by Colonial Seabirds and Wading Birds in Texas," Technical Report D-78-08, US Army Engineer Waterways Experiment Station, Vicksburg, MS.

Dunstan, F. M. 1978. "Forty Years' Colonial Waterbird Data for Bird and Sunken Islands, Tampa Bay, Florida," Subcontract report to Technical

Report D-78-14 by the National Audubon Society, US Army Engineer Waterways Experiment Station, Vicksburg, MS.

Landin, M. C. 1980. "Building and Management of Dredged Material Islands for North American Wildlife," Proceedings 9th World Dredging Conference, Vancouver, British Columbia, Canada, pp 527-538.

Landin, M. C. 1985. "Bird and Mammal Use of Selected Lower Mississippi River Borrow Pits," Ph.D. Dissertation, Mississippi State University, Mississippi State, MS.

\_\_\_\_\_. 1986. "The Success Story of Gaillard Island: A Corps Confined Disposal Facility," Proceedings of 19th Dredging Seminary and WEDA, Baltimore, MD, pp 41-54.

Landin, M. C. and Miller, A. C. 1988. "Beneficial Uses of Dredged Material: A Strategic Dimension of Water Resource Management," Transactions of the 53rd North American Wildlife and Natural Resources Conference, Louisville, KY, pp 325-334.

Lewis, R. R., III and Lewis, C. S. 1978. "Colonial Bird Use and Vegetation Succession of Dredged Material Islands in Florida, Volume II (Vegetation)," Technical Report D-78-14, US Army Engineer Waterways Experiment Station, Vicksburg, MS.

Newling, C. J., and Landin, M. C. 1985. "Long-Term Monitoring of Habitat Development at Upland and Wetland Dredged Material Disposal Sites: 1974-1982," Technical Report D-85-5, US Army Engineer Waterways Experiment Station, Vicksburg, MS.

Schrieber, R. W., and Schrieber, E. A. 1978. "Colonial Bird Use and Vegetation Succession of Dredged Material Islands in Florida, Volume I (Wildlife)," Technical Report D-78-14, US Army Engineer Waterways Experiment Station, Vicksburg, MS.

Soots, R. F., Jr., and Landin, M. C. 1978. "Development and Management of Avian Habitat on Dredged Material Islands," Technical Report DS-78-18, US Army Engineer Waterways Experiment Station, Vicksburg, MS.

US Army Corps of Engineers. 1986. "Dredged Material Beneficial Uses," Engineer Manual 1110-2-5026, Office, Chief of Engineers, Washington, DC.

Table 1

Dredged Material Islands and Sites in the Northern Gulf Coast Region

	<u>Total Sites</u>	<u>With Colonies</u>	<u>Percent Use</u>
Florida (north of Bradenton)	120	28	23
Alabama	26	7	27
Mississippi	19	13	68
Louisiana	66	37	56
Texas	414	242	58
TOTALS	645	327	51



Figure 1. Brown pelicans began nesting in 1983 on Gaillard Island CDF in Mobile Bay, Alabama, when the site was only 2 years old. In 1988, there are over 500 pairs of adult pelicans nesting there, and about 2,000 brown pelicans living at the CDF



Figure 2. Thousands of laughing gulls nest on dredged material in large colonies in Florida, Alabama, and Texas and in smaller colonies in Mississippi and Louisiana. This colony in Tampa Bay, Florida, covers the entire island and has an estimated 50,000 nesting birds

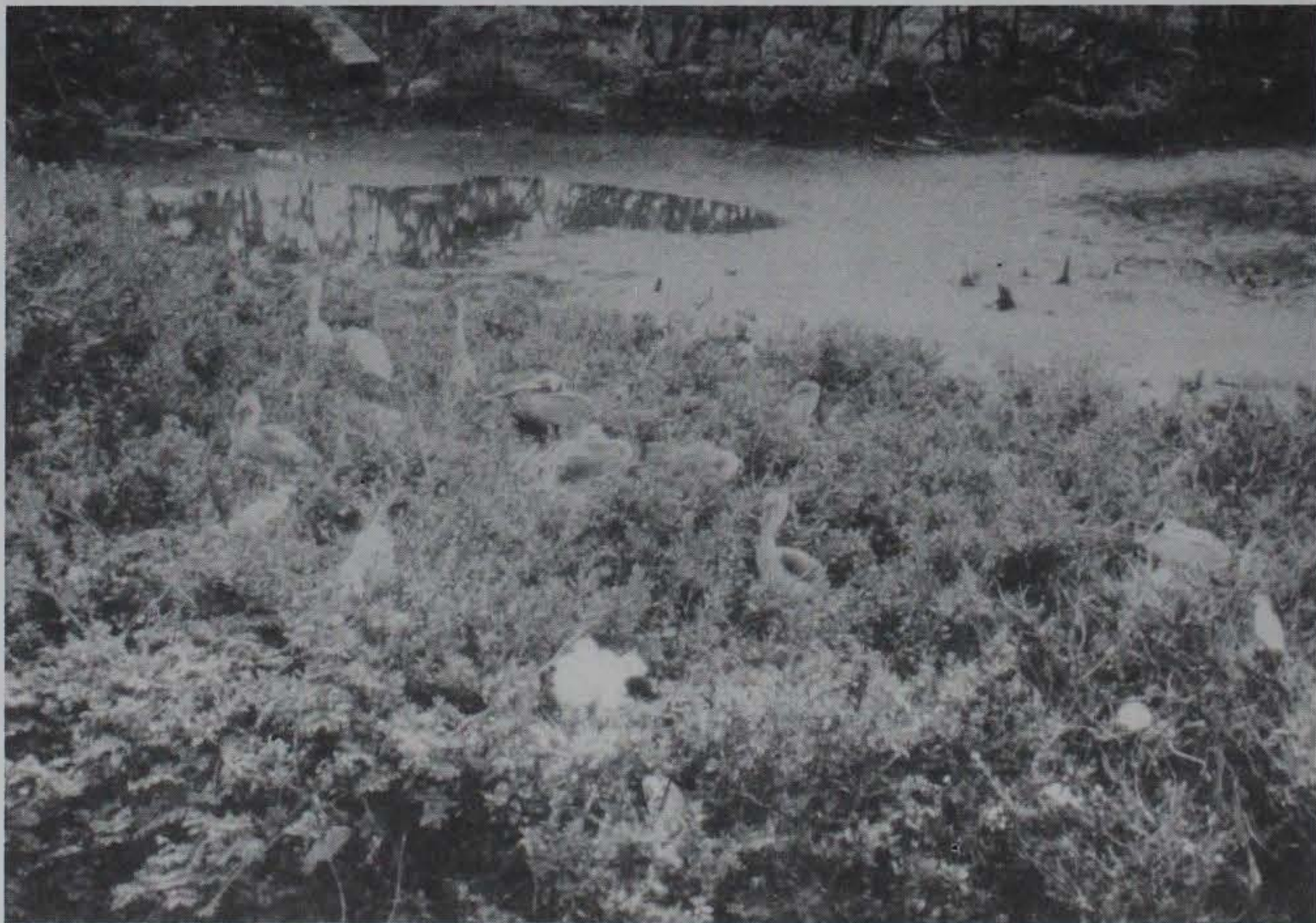


Figure 3. Bird and Sunken Islands in Tampa Bay were built of dredged material in 1931 and 1951, respectively. The islands are managed by the National Audubon Society, and an estimated 30,000 waterbirds nest each year



Figure 4. Big Pelican Island in Galveston Bay, Texas, is attached to the mainland via bridge. However, the industrial use of the island, plus the large size of the dredged material placement sites where the birds nest, allows adequate isolation for this mixed-species heronry to be successful



# BENEFICIAL USES OF DREDGED MATERIAL WITHIN THE NEW ORLEANS DISTRICT

Suzanne Hawes  
US Army Engineer District, New Orleans  
New Orleans, Louisiana

## Introduction

Coastal Louisiana was created as the Mississippi River meandered east and west across the state during the past 7,000 years. In this process, the river created a vast wetland complex of swamp and marsh. Today, however, there is a crisis along Louisiana's coast. The state is presently losing approximately 50 square miles each year (Wicker 1980). That is the loss of more than 1 acre while you are reading this paper. The active delta of the Mississippi River lost 100 square miles of marsh and gained 100 square miles of open water between 1956 and 1978 (Figure 1). If this present rate of loss continues, Louisiana will lose 1-million acres of wetlands by the year 2040, and the shoreline in the deltaic plain will be several miles farther inland than it is today (US Army Corps of Engineers (USACE) 1988). The reasons for this loss are complex. The major natural causes are subsidence and sea level rise (Figure 2), which act in concert to drown the marshes. In addition, man's activities have accelerated wetland loss. The same levees that allow man to live along the banks of the Mississippi also prevent sediment and freshwater from flowing over the banks during the spring floods, thereby nourishing the wetlands. Upstream reservoirs have severely reduced the amount of sediment flowing down the river. Oil and gas development has also caused direct loss of thousands of acres of marsh. Saltwater intrusion through some navigational channels has increased marsh loss.

The New Orleans District (NOD) removes approximately 30-MCY of material each year in its maintenance dredging program. There are many beneficial ways in which to use the material.

### Levee protection

Sometimes, when Federal or local levees are adjacent to a navigational channel, vessel traffic causes erosion on the levees. For instance, the GIWW runs along the southern boundary of the Lacassine National Wildlife Refuge. A



Figure 1. Land loss in the Mississippi delta  
(Source: USFWS-NWRC)

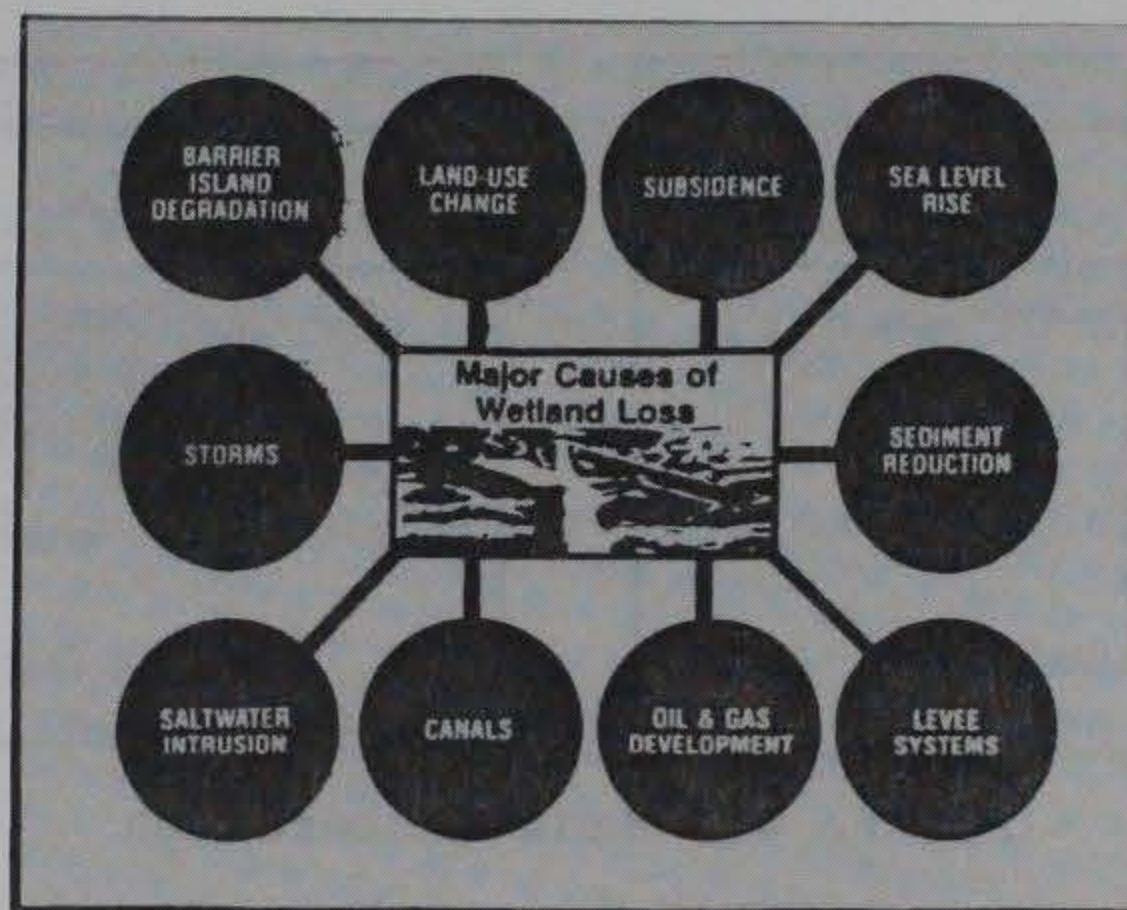


Figure 2. Major causes of wetland loss

refuge levee protects a large area of marsh and vegetated pond from erosion and salinity intrusion. Since this levee was in poor condition, the NOD placed maintenance dredged material landward of the levee in 1982 (Figure 3). The refuge used some of this material to build a new levee. The remainder of the material will protect the new levee and also be available for levee repair.

Bank restoration

Along the Barataria Bay Waterway, the NOD has used dredged material to build up the banks to prevent salt water from the waterway from entering an adjacent pond where it could endanger trees used by the bald eagle as nesting sites. Farther west, Grand Lake was threatening to break through its northern shoreline into the GIWW (Figure 4). If this had happened, the marsh north of

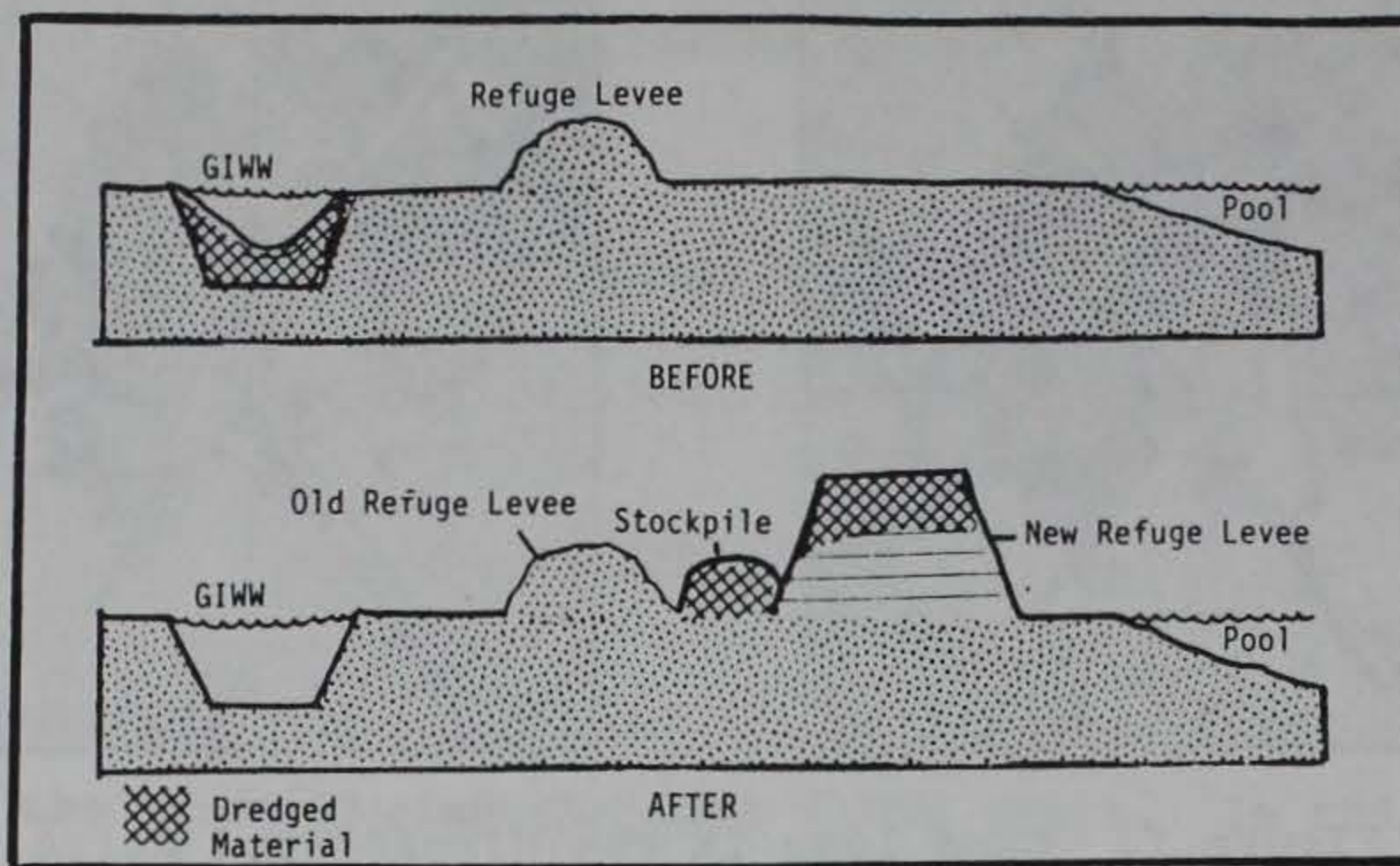


Figure 3. Levee protection

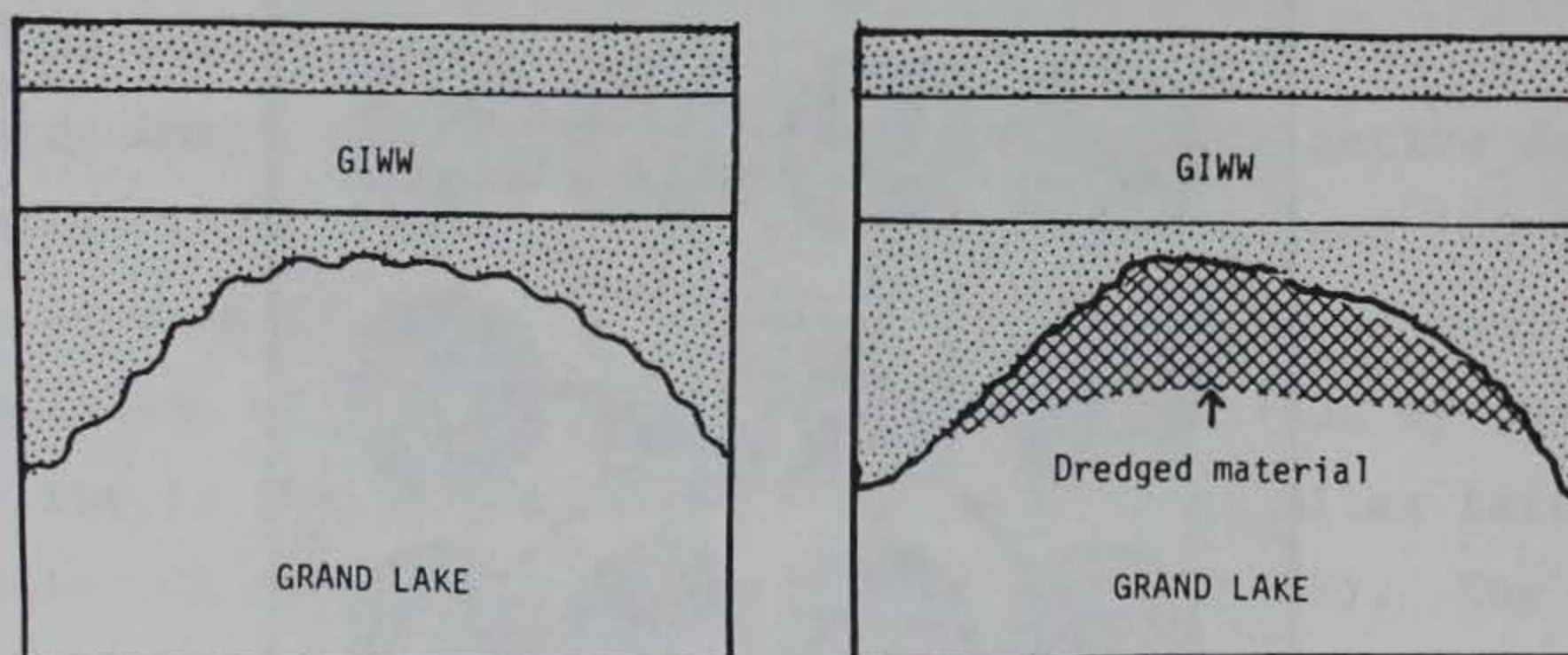


Figure 4. Bank restoration

the GIWW would have been threatened by erosion due to the longer wave fetch. The NOD placed dredged material in the thinner spots to rebuild the bank. The NOD has used a similar technique to restore the banks of Freshwater Bayou to protect adjacent marsh. The banks of the Mississippi River south of Venice are severely eroding, and here the NOD is presently building rock dikes and pumping dredged material behind them to restore the banks and reduce maintenance dredging costs.

#### Marsh nourishment

In some areas, the marshes are rapidly subsiding and breaking up. Marsh nourishment consists of placing the discharge pipeline at the top of the bank built from the previous dredging (Figure 5). The material filters through the brush and trees on the ridge, and only the fine material runs into the marsh. This method was used in 1986 along the GIWW in an eroding area. If the

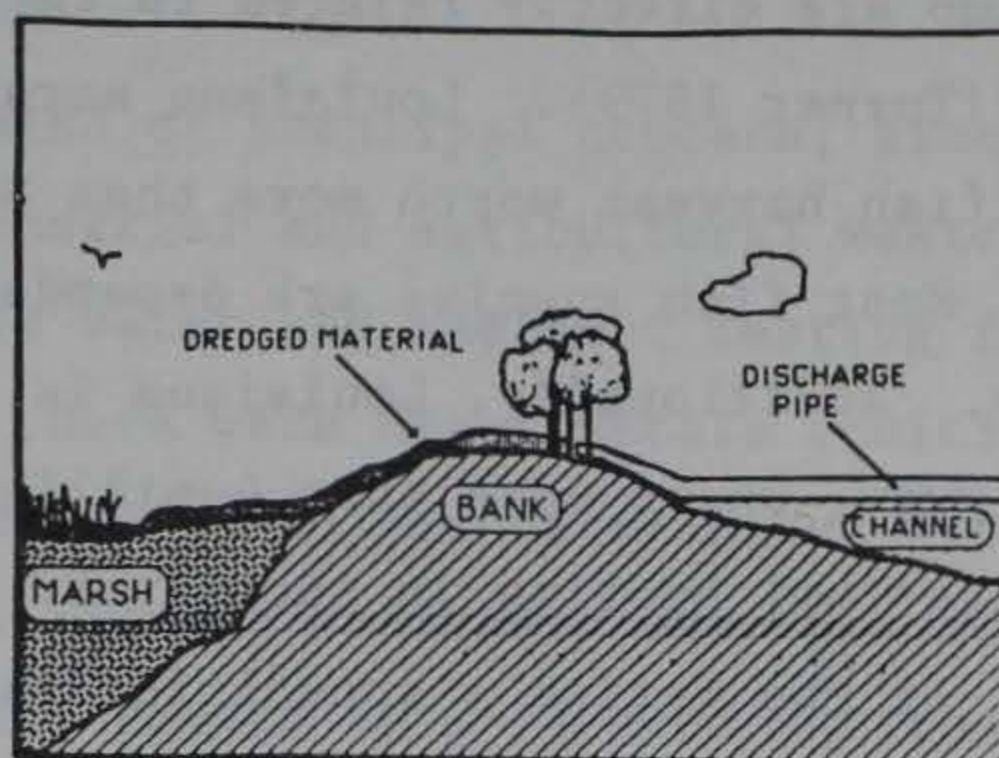


Figure 5. Marsh nourishment

pipeline is moved often, the layer of material is thin, and marsh grass can come up through it.

#### Bird nesting islands

A fifth use of dredged material is construction of bird nesting areas. We have created special seabird nesting islands at Baptiste Colette Bayou and in Mud Lake. Our most successful islands are 5 to 10 acres in size, 3 to 6 ft in height and 1,000 yd from shore (Clark 1985). There are several colonies of seabirds and wading birds nesting on dredged material within the NOD.

#### Marsh creation

A major use of dredged material is marsh creation.

#### Value of Marsh

In Louisiana, there are rapidly expanding areas of shallow open water that are prime candidates for marsh creation. To accurately assess the trade-offs, the value of shallow bays must be compared with marsh. Bays are inhabited by a moderately rich benthic community. Numerous juvenile fish and shellfish use the shallow waters as a nursery. During the winter, large numbers of waterfowl rest and feed there. The bays are obviously valuable habitat, but marshes are even more valuable. Marshes contain a more complex benthic community because the lower portions of the plants provide an additional area for benthic colonization. The marsh itself is more valuable as a nursery area because the plants provide hiding places where juveniles can escape predators (Minello and Zimmerman 1983). As marsh plants decay, they form detritus (finely divided particles of plants), which becomes surrounded by a halo of microorganisms. This detritus plays a vital part in the food web

of coastal areas (Odum and Zieman 1972). Evidence has been presented that commercial yields of shrimp are directly related to the area of intertidal marsh, not surface water (Turner 1979). Louisiana marshes sustain an annual commercial fish and shellfish harvest worth more than \$680 million. Sport fishing is also popular. Most fish species are dependent on marshes at some point in their life cycle. Additionally, Louisiana is located at the south end of the Mississippi flyway, where more than 4-million ducks winter in the marshes (USACE 1988). Waterfowl hunting in the flyway is valued at \$58 million/year. Forty percent of the Nation's annual fur harvest comes from Louisiana marshes and is worth more than \$17 million (USACE 1988). Thus, when compared with shallow open water, marsh is far more valuable, especially since it is a vanishing resource.

### Biological Impacts of Marsh Creation

Even if marsh is valuable, there are always trade-offs as open water is filled. As the dredged material is pumped over the bottoms, it smothers the benthos. The larger, rapid-burrowing, deep-dwelling organisms can generally burrow upward through approximately 8 in. of material (Oliver and Slattery 1976). Most fish, shrimp, and crabs can escape from the bay before it fills. When marsh is created in open water, the maximum amount of material is placed in the intertidal zone and is thus available for recolonization by benthos. This recolonization generally starts by three mechanisms: the upward burrowing mentioned previously, migration of adults from adjacent areas, and recruitment by juveniles. Recolonization, which is rapid in the fine sediments found in rivers, is generally underway in 6 months (Stickney 1972). If the dredged material has been kept to the right height, plants will colonize without man's help. Marsh is created within the NOD by regular movement of the dredge pipe once a specified height is achieved. Thus, the created marsh is a series of low mounds with an extensive marsh-water interface. Turbidity adjacent to the newly created marsh is high during and immediately after dredging. Primary productivity is temporarily reduced, and less photosynthesis occurs in the phytoplankton. The pumping rate of clams is reduced occasionally, and phytoplankton can flocculate.

## Water Quality Impacts of Marsh Creation

Water quality is also of principal concern, since the Mississippi and other rivers receive industrial and agricultural wastes. A contractor, MEL Inc., performed extensive water and sediment testing in the Mississippi delta. They found that there were heavy metals (calcium, cadmium, and mercury); pesticides (chlordane); and polychlorinated biphenyls (PCBs) in the sediments (USACE 1983b). If the sediments were placed within the intertidal zone, the pollutants would remain in a reduced environment and would be rapidly diluted by river and marsh waters.

The NOD also conducted seven bioassays in or near the delta between 1978 and 1982. Tests results showed mortality of less than 10 percent, with sediment from both the disposal site and the reference site. This indicates that contaminants in the dredged sediment should not have any short-term, acute toxic effects on the aquatic ecosystem. Ten-day solid phase bioaccumulation studies were conducted in six of the above bioassays. Results indicated that concentrations of contaminants in organisms in disposal site sediments were generally not significantly different from concentrations in fauna living in reference site sediment. Comparisons of the worst-case contaminant bioconcentration levels with the FDA "Action" levels for mercury, PCBs, DDTs, chlordane, and dieldrin showed that the levels in the test organisms would not have been toxic if these organisms had been consumed by humans. The NOD attempts to ensure that dredged material will be within the intertidal zone so that contaminants will be flushed or diluted away.

### Comparison of Newly Created Marsh and Older Created Marsh

To determine if marsh that has been newly created with dredged material is different from older marsh growing on dredged material, two areas were studied (USACE 1982). One was an older intermediate marsh near the mouth of South Pass, which that had most recently been disposed on in 1973. The other was a newer intermediate marsh near River Mile 10.5 of Southwest Pass, which had been most recently disposed in 1981. Both marshes had similar grain sizes; however, the old marsh had the most organic material. The old marsh had significantly fewer bioavailable nutrients in the sediments and interstitial water. Vegetative biomass was greater in the newer marsh.

The total number of stems per square metre was 350 in the new marsh and only 306 in the older marsh. This increased productivity could be due to the availability of nutrients in the new marsh. The new marsh was essentially 100 percent *S. alterniflora*, while the older marsh also included 14 percent *Scirpus americanus* and one percent *Sagittaria platyphylla*. This species difference could be due to age, since the most common colonizer of dredged material in the intermediate salinity areas in the delta is *S. alterniflora*. The dominance of this species might decrease as succession occurs. Salinity also could have played a part, since interstitial water salinities in the old marsh were slightly lower during the August sampling period. Species diversity for benthos and insects was low at both sites. The snail population was very impoverished at the new marsh, probably because the lush plant growth prevented growth of surface algae, the snail's major food. On the other hand, clam and crab populations were higher in the new marsh. The biota at these two sites was essentially similar to that found in "natural" marshes in the delta. The new marsh sediments had significantly greater amounts of all contaminants except phthalate esters.

#### Interagency Coordination

Prior to any maintenance dredging, the NOD holds an interagency-plan-in-hand inspection. State and Federal agencies are invited to join the NOD in an examination of the proposed disposal sites, and the District entertains their suggestions for judicious use of the dredged material.

#### Successful Marsh Creation

Table 1 indicates the acres of marsh that have been created by carefully choosing disposal sites and moving the dredge pipe as often as practicable. As can be seen, the NOD has tried to build marsh on public lands as often as possible; it has been built in state water bottoms in other cases. Occasionally, there is no choice but to place the dredged material in 4- to 6-ft-deep open water. It takes more than one dredging cycle to create marsh in such areas, and much material is lost. The ideal area for marsh creation is nearly totally enclosed ponds that are 1 to 3 ft deep. The utilization of sediment is more efficient in such areas. To estimate the initial height of the

Table 1  
Acres of Marsh Created

<u>Location</u>	<u>Land Ownership</u>	<u>Marsh</u>	<u>Mud Flats*</u>
MR-GO jetties unconfined	State	30	140
MR-GO inland confined	Private	20	
Tiger Pass unconfined	State	230	
Avoca Lake semiconfined	Private	600	
Sweet Lake unconfined	State	90	
Sabine NWR semiconfined	Federal refuge	200	
Atchafalaya Delta unconfined	State mgmt area	60	300

\* These will probably become marsh once dredged material is placed on them again.

dredged material, it is necessary to take into account such variables as consolidation, subsidence, erosion, accretion, water depth, and sediment type. As the District becomes more experienced, estimates become more accurate. In 1981, the NOD created 600 acres of marsh in Avoca Lake by partially diking the area and limiting the initial height 3.0 mean low ground feet. Now over half of this marsh is gone. In the next maintenance dredging, the District will increase the initial height of the material.

#### Constraints in Marsh Creation

The NOD marsh creation program is successful, and the District plans to continue it in the future. Dredging occurs on navigational projects where marsh creation is not authorized. Thus, the District must make as much marsh as possible with limited maintenance dredging funds. More marsh could be created if the pipe is moved more often or if booster pumps are used, but these procedures are not possible because they are costly.

#### Future Marsh Creation

Several hundred acres of marsh will be created along the Barataria Bay Waterway during the next few dredging cycles. As the Mississippi River is



deepened to 55 ft, there will be 57 MCY from initial construction and 30 MCY annually. It is estimated that 55 square miles of marsh can be created if all of this dredged material is used judiciously. In this case, the NOD has the money to move the pipe fairly often and to monitor results with high-altitude photography. On one side of the river, permanent peninsulas for the dredge pipe will be built; then marsh will be built between them. In other areas, shallow water will be filled. This District also plans to build several hundred acres of marsh along the Houma Navigation Canal.

### Solution to Problems in Marsh Creation

As a project evolves, work plans become more detailed. As work progresses from an EIS to the General Design Memorandum, to the Plans and Specifications, coordination occurs among engineers, soils scientists, hydrologists, and biologists from other agencies. Biologists also attend the preconstruction conference to alert the inspectors and contractors to the importance of marsh creation. Sometimes, however, the actual product is less than was planned. Two problems exist. Occasionally the dredged material becomes higher than specified for in the plans, and scrub shrub is created instead of marsh. The plans also specify that the dredge pipe should be placed no closer than 150 ft from existing marsh. However, sometimes soil conditions are poor, and the pipe is placed in such a way that marsh is covered. These problems occur when the inspector is not aware of the importance of height and distance criteria. A provision exists within ER 1110-2-1910, "Engineering Design and Inspection of Earthwork Construction," which mentions a document called "Engineering Considerations and Instructions for Field Personnel." This is a short document that can be written, which picks the vital ingredients out of the complexity of the Plans and Specifications and emphasizes special design features. It highlights special details, such as height of disposal.

### Summary

In summary, there are five basic uses of dredged material: levee protection, bank restoration, marsh nourishment, bird island construction, and

marsh creation. The District plans to continue using dredged material to enhance the environment.

#### Literature Cited

- Clark, E. S. 1985. "Seabird Use of Dredged Material Islands in Louisiana," In: Brodtman, N. V., Jr., ed., Second Water Quality and Wetlands Management Conference Proceedings, New Orleans, LA, 24-25 Oct 1985.
- Minello, T. J. and Zimmerman, R. J. 1983. "Fish Predation of Juvenile Brown Shrimp, *Penaeus aztecus* Ives: The Effect of Simulated *Spartina* Structure on Predation Rates," Journal of Experimental Marine Biology Ecology, Vol 72, pp 211-231.
- Odum, W. E., and Zieman, J. C. 1972. "The Importance of Vascular Plant Detritus to Estuaries," Proceedings of 2nd Symposium on Coastal Marsh and Estuarine Management, Louisiana State University, Baton Rouge, LA, pp 91-114.
- Oliver, J. S., and Slattery, P. N. 1976. "Effects of Dredging and Disposal on Some Benthos at Monterey Bay, California," Technical Paper 76-15, US Army Corps of Engineers, Coastal Engineering Research Center, Fort Belvoir, VA.
- Stickney, R. R. 1972. "Effects of Intracoastal Waterway Dredging on Ichthyofauna and Benthic Macroinvertebrates," Technical Report Series No. 72-74, Skidaway Institute of Oceanography, Savannah, GA.
- Turner, R. E. 1979. "Louisiana's Coastal Fisheries and Changing Environmental Conditions," Proceedings of 3rd Coastal Marsh and Estuary Management Symposium, Louisiana State University, Division of Continuing Education, Baton Rouge, LA, pp 363-370.
- US Army Corps of Engineers. 1982. "Mississippi River Channel Enlargement and Baton Rouge to the Gulf Supplement 2: Marsh Investigations," Delivery Order DACW29-82-D-0187, No. 5, Final Report, US Army Engineer District, New Orleans, LA.
- \_\_\_\_\_. 1983. "Bioavailability and Bioaccumulation Potential of Lower Mississippi River Delta Sediments Under Upland, Intertidal and Subaqueous Disposal," Delivery Order DACW29-82-D-1087, No. 12, Final Report, US Army Engineer District, New Orleans, New Orleans, LA.
- \_\_\_\_\_. 1988. "Crisis on Louisiana's Coast...America's Loss," Brochure.
- Wicker, K. M. 1980. "Mississippi Deltaic Plain Region Ecological Characterization, a Habitat Mapping Study. Users Guide to the Habitat Maps," FWS/OB5-79107, US Fish and Wildlife Service, Office of Biological Services.

USING NEW WORK AND MAINTENANCE MATERIAL FOR MARSH CREATION IN  
THE GALVESTON DISTRICT

Thomas H. Rennie  
US Army Engineer District, Galveston  
Galveston, Texas

My purpose this morning is to present an overview of how Galveston District is making beneficial use of both new work and maintenance material for marsh development and restoration.

Between 1975 and 1977, Galveston District was assisted by the WES in studying the feasibility of developing marsh on dredged material subjected to high wave energies. The study was done on the Galveston Bay side of Bolivar Peninsula across from Galveston. A sandbag breakwater was constructed, and the confined area was filled with maintenance material. The area was sprigged with *S. alterniflora* and *S. patens*. The marsh was successfully established and still exists. However, parts of the breakwater required restoration and maintenance, which increased costs. In 1984, WES established fixed tire-pole breakwaters about 1 mile west of the original site, and both protected and unprotected areas were planted with *S. alterniflora* in experimental plots. These plots included single stem sprigs, multistem sprigs, burlap bundles with sprigs, plant rolls with sprigs, and paratex biodegradable fabric mats with sprigs. In 1986, areas behind the breakwater had 40- to 70-percent cover. In nonprotected zones, plantings using paratex mats had the best success.

Under the NOAA/DA pilot study MOA on restoring and creating fisheries habitat, a cooperative pilot study was initiated between biologists from our construction-operations division and staff from the NMFS laboratory in Galveston to create a 7-acre intertidal *Spartina* marsh on Pelican Island Spit Disposal Area #45. This work is associated with one of four pilot studies that were selected from 45 candidate projects. Approximately 75,000 cu yd of maintenance material having a high sand content was hydraulically placed in shallow waters of the spit in November 1986 after the tern and black skimmer nesting season was over. To reduce mounding, the pipe was moved to about six locations. The resultant dredged material sloped from emergent to intertidal depths and was allowed to settle until April 1987 when 7 acres of

intertidal area was planted with *S. alterniflora* on 1-m centers. The planting and subsequent growth have been highly successful.

An example of the indirect use of dredged material to benefit the environment is the Taylors Bayou Drainage and Flood Control Project between Beaumont and Port Arthur, TX. Through cooperative efforts between Galveston District, the local sponsors and the Texas Parks and Wildlife Department (TPWD), two disposal areas currently receiving new work material from channel enlargement will be managed during nondredging periods to promote growth of vegetation desirable for waterfowl. Following cessation of new work disposal, the TPWD will use slide gates to control water levels in the ponded areas, which will allow for vegetation growth. Since one of these sites is adjacent to the J. D. Murphee Wildlife Management Area, this effort complements management work underway in the Murphee area.

Another example of the beneficial use of dredged materials is our Texas City Channel Project, which was authorized for construction by the Water Resources Development Act of 1986. The authorized plan includes enlarging the existing 40-ft-deep by 400-ft-wide Texas City Channel to 50 ft deep by 600 ft wide over its 6.7-mile length. As part of this plan, a long-range disposal plan has been developed that includes creating a 600-acre wetland area and a 90-acre recreational complex north of the Texas City Dike from project dredged material. For the wetland area, an outer levee will be constructed around 600 acres of bay bottom with new work material from the channel enlargement. The levee will tie to the northern edge of an existing island.

New work material will also be used to divide the area into five cells. An initial cell, up to 120 acres in size, will then be filled with maintenance material from the channel, worked to suitable elevations and planted with *S. alterniflora*. Openings would be designed to maintain adequate tidal exchange and permit access by fishermen. During a 2-year period before the next maintenance dredging cycle, an interagency team would monitor the progress of marsh development. Following success of this first cell, the other cells would be filled, planted, and monitored in succession until all 600 acres were planted. If any of the succeeding cells were unsuccessful, the program would be stopped. Presently, staff from our planning and engineering divisions is developing the specific marsh creation design in coordination with Federal and State agencies.

In 1979, a 3-acre prototype marsh was created on the northside of the Texas City Dike with new work and maintenance material from the Texas City Channel. The purpose of this prototype was to demonstrate that a marsh could be established on maintenance materials from the channel. The plantings were successful, and portions of the marsh exist today. Tests done on sediments and from the marsh have shown no problems with possible uptake of heavy metals from dredged materials.

The Galveston District Engineering Division has planned to create two marsh sites from new work material as part of mitigation for construction impacts associated with the Clear Creek Flood Control Project. The authorized plan of improvement for reducing flood damages in the Clear Creek watershed consists of approximately 22 miles of channel enlargement and bend easing to contain a 10-year frequency flood and a second outlet channel with a gated structure between Clear Lake and Galveston Bay. The Clear Creek watershed is located south of Houston, is within portions of four counties, and is the boundary between Harris and Galveston Counties.

One site will be created in association with channel enlargement construction for the lower reach of the project. Through cooperation of one of our local sponsors, Galveston County, this site will be located in a small cove off Clear Creek and adjacent to League City Park, a part of the Galveston County park system. To create the 4.1-acre wetland, a push-fill earthen dike will first be constructed across the cove to provide a breakwater to protect planted sprigs and to allow dewatering of the cove, if needed, prior to filling operations. New work material will be obtained from excavation of the nearby channel to be used both for the dike and for filling the marsh site. Surveyed biological elevations of nearby wetland vegetation will be used to determine a suitable bottom level of the new wetlands. The dike will be breached in a few places, and the entire area will be planted during spring with saltmarsh cordgrass.

The other marsh site will be created in Seabrook South as part of construction of a second outlet channel and gated structure into Galveston Bay and is a good example of how new work dredged material can be used beneficially to restore wetland habitat and at the same time reduce project costs. Seabrook Slough was selected as the area for marsh creation because it would be an opportunity for restoring marsh habitat that had occurred previously in the slough but had been lost through subsidence. A temporary cofferdam will

be constructed, and the resulting confined area will be drained to enable the gated structure to be built "in the dry." Originally, the material that was to be excavated from within the cofferdam was to be eventually hydraulically pipelined to a Houston ship channel disposal area some miles distant. Instead, this material will be excavated and moved a short distance by truck into Seabrook Slough, where the 5.0-acre site will be created by constructing a central push-fill road and then side casing the remaining new work material with cranes to the proper biological elevation. The site will be planted with smooth cordgrass, fenced, and monitored.

Within the past 2 weeks, a few residents from the Clear Lake area have suggested that Galveston District consider the use of new work material from lower reach construction to restore marsh in Clear Lake that was lost to subsidence in the last few years. A few small islands remain from this subsided area. The residents have presented their ideas to the agencies with which we coordinate on our projects. Further discussion of this proposal will occur with these agencies to consider its possible use as mitigation for part of the project impacts.

Although the general public may not be aware of the phrase "beneficial uses of dredged material," it is apparent that increasing numbers of individuals perceive that dredged material can be used in a positive way for habitat and recreational development. I expect this number to continue to increase along the Texas coast as further marsh habitat is lost in the future to erosion, subsidence, sea level rise, and human activity. It, therefore, behooves all concerned agencies to continue to work together to develop marsh creation projects to forestall or replace these losses along the Texas coast. Galveston District will continue to seek ways of using dredged material to the benefit of the environment and man.

OVERVIEW OF DREDGED MATERIAL MANAGEMENT  
IN THE VICKSBURG DISTRICT

Harold Lee and E. Gaylan McGregor  
US Army Engineer District, Vicksburg  
Vicksburg, Mississippi

The Vicksburg District encompasses approximately 68,000 square miles of land and water resources within the geographic area of northern Louisiana, southern Arkansas, and western Mississippi. Within this area, the District is responsible for maintaining navigation depths on approximately 950 miles of navigable waterways and assuring that flood flow-carrying capacities are maintained in an additional 2,600 miles of natural and man-made channels. In carrying out these assigned responsibilities, the Vicksburg District either moves or regulates the movement of 20 to 30 MCY of dredged material on an average annual basis.

Prior to the 1970's, the normal procedures for disposing of the "spoil" was overboard, or open-water, disposal for navigation dredging and random placement adjacent to the channel for flood-control work. These procedures provided the most economical means of handling the material, and the body of environmental law had not progressed to the point of requiring assessment of the impacts of long-term management of the vast volume of material generated by the Corps construction and maintenance programs in this way.

Even before the environmental conscience of the country was stirred, there were examples of beneficial uses of dredged material. The harbor at Vicksburg was developed on dredged fill and expanded with hydraulic fill from maintenance dredging. The latest expansion of the harbor was undertaken by the port commission utilizing material from the newly excavated channel and from Corps maintenance dredging in the Yazoo River.

On a number of our flood-control channels constructed in the 1920's and 1930's, there is no evidence of dredged material mounds today. The material has been used by adjacent property owners to fill and level their agricultural land. By today's standards, we might cringe at the thought of identifying this practice as a beneficial use since much of the filling was needed to convert swampland to agricultural use, but by the standards of the time, the material could not have been put to a better use.

As always, our engineering and construction practices are evaluated in light of current standards; so we find ourselves here to discuss beneficial uses of dredged material as if it were some new concept and as if, by implication, all past practices were of no benefit. In reality, we should recognize that only the standards have changed, and we must now exercise the creativity and innovation required for our practices to keep pace with the current principles and standards of our various professions.

I have selected a few examples of projects within the Vicksburg District to illustrate the potential uses of dredged material for commercial, industrial, and recreational purposes.

#### Case Study--Wild Cow Bayou

As a part of the Tensas-Cocodrie Pumping Plant Project in Concordia Parish, Louisiana, channel enlargement was required in Wild Cow Bayou, a natural meander loop of Bayou Cocodrie, to convey water from Bayou Cocodrie to the pumping plant located in the east bank levee of the Black River. The south bank of Wild Cow Bayou was forested at the time of construction, while the north bank was in agricultural use. For environmental reasons, it was determined that the enlargement would be done on the north side of the channel, with the dredged material to be deposited in open agricultural land. The local sponsor of the project was to provide all project lands and rights-of-way, with the channel enlargement rights-of-way to be acquired through construction easements rather than in fee title.

When the landowner refused to grant such easements because of the acreage that would be taken out of production, the District began to pursue an alternate disposal plan that would allow the landowner to reclaim use of the land once the channel enlargement was completed. The plan called for the dredged material to be shaped into a discontinuous embankment with gaps every 500 ft and at all natural drains. Additional right-of-way would have been acquired to limit the height of the embankment and accommodate a 1 vertical (V) on 20 horizontal (H) landside slope. The plan also included reforestation of the riverside slope and batture area. This plan was never fully implemented because of the additional costs involved that represented a deviation from Corps policy on project-related costs and real estate requirements.



The landowner eventually granted the necessary easements to complete the work, and the final configuration was a broad embankment with 1V:3H channel-side slope up to a height of 10 ft, then a 1V:20H slope up another 10 ft, and then down at a 1V:4H slope to natural ground. The landowner was able to farm the top and landside slopes of these mounds without any difficulty. A recent aerial inspection of the project revealed that the dredged material is being fully utilized in agricultural production.

#### Case Study--Tensas River Project

The concept that was not fully implemented on the Wild Cow Bayou Project has been dusted off and given a new title for one of the District's current projects on the Tensas River. The concept is now labeled "The Greenbelt Concept," and the environmental benefits of the concept are being more fully exploited in promoting the idea. There are also valid claims for long-term economic benefits associated with the plan, in that making use of the dredged material and right-of-way to reduce sheet erosion and improve bank stability will reduce future maintenance requirements. It is estimated that erosion along some 300,000 miles of streambanks in the United States is depositing roughly 500-million tons of sediment in those streams each year. The cost of removing sediments that eventually choke stream channels and reservoirs is estimated at millions of dollars annually.

On the Tensas River Project, the District proposes to acquire rights-of-way on both sides of the channel to establish or preserve vegetated buffer strips. The channel enlargement would be accomplished on one side only, with a 100-ft-wide buffer zone being established on the side opposite the cut and a 200-ft-wide buffer on the disturbed side. Within the 200-ft buffer, the dredged material will be placed in discontinuous embankments having 1V:5H side slopes. The 1V:5H slopes are considered critical to the success of efforts to reforest the dredged material and maintain the stability of the embankment. The embankment will intercept sheet flow and divert it to breaks in the embankment at natural drains and tributaries to the Tensas. The majority of these natural drains and tributaries are very shallow and support woody and herbaceous vegetation that will serve to filter the runoff. Planting and volunteer revegetation of the embankment will prevent erosion of the dredged material back into the channel.

From the environmental standpoint, the concept has obvious benefits in reducing turbidity and the introduction of agri-chemicals or other pollutants into the stream. The vegetated buffers would serve to improve water temperature and fisheries resources, as well as preserve the aesthetic values of the waterway.

The fate of the proposed "Greenbelt Concept" is as yet undetermined because of policy considerations on cost and because there is no local sponsor for the project.

#### Case Study--Port Development

The District has also been able to work with local governments and private industry to make beneficial use of material generated by construction and maintenance dredging in the area of port development. During the excavation of the Phillip Bayou Cutoff on the Red River Waterway in Louisiana, the City of Alexandria provided lands and containment facilities to utilize a major portion of the excavated material for the development of port facilities for the City. The City is now proceeding with development of the port.

On the Mississippi River at Lake Providence, Louisiana, an existing harbor facility has been expanded, and additional expansions are proposed, utilizing material from maintenance dredging at the entrance to the harbor. The port commission has lands and containment facilities prepared for the expansion when suitable materials are available.

A similar proposal by parish officials in Louisiana on the Red River pointed out one problem that must be overcome in order to expand this potential for beneficial use. The parish officials did not approach the District with the proposal for port development until the procurement process was underway on the item of work that would generate the material they were interested in, and their plans were not developed to the point that they could be accommodated without significant delays in the Corps construction contract. If the public were made aware of the volumes of material available for use and the constraints on obtaining the material early in the planning stages of a project, I believe more creative uses for the material would be developed by the public and by adjacent property owners.

## Case Studies--In-Stream Disposal

In some instances, our past practices of disposing of dredged material or utilizing stream control measures to reduce the volume of material to be moved have resulted in benefits that were not envisioned by the planners and design engineers.

On the Ouachita River in Louisiana, we have sidecast sand along the bankline for years, and this method is still used with the blessings of the various State and Federal agencies who review our plans. As a result of our maintenance dredging techniques, a number of beach areas have been developed that receive heavy recreational use.

On the lower Pearl River, similar procedures were used in the 1960's before maintenance of the project was abandoned. The Pearl River Basin was transferred to the Vicksburg District several years ago, and in 1985 when we began investigations on the feasibility of resuming maintenance dredging, we found that the natural and man-made bars were providing nesting habitat for the Ringed Sawback Turtle, which is a recent addition to the Endangered Species List. In the final analysis on this project, we found that by using the dredged material to enlarge the bars, we could complete the maintenance dredging without impacting the species and, in fact, would provide additional habitat that would be of benefit in the recovery of the species. Some of the bars are also receiving heavy recreational use.

On the Mississippi River, our contraction works were designed to reduce the volume of dredged material to be removed from the river by constricting the channel and keeping the velocity high enough to prevent deposition in the channel. These dikefields fill naturally during high river stages. During low stages, the vast bars created by the contraction works have provided nesting habitat for the interior least tern, another endangered species. Annual surveys are conducted to identify the active nesting areas, and all dredging permits are conditioned to eliminate the interference with the active nest sites.

### Summary

In the past, we have conducted our construction and maintenance dredging programs in a manner consistent with applicable legislation. Discharge sites

were selected by comparing alternatives and identifying the least damaging practicable alternative.

In the mid-1970's we initiated construction dredging on the Yazoo River as part of the Authorized Flood Control Project for the Yazoo Basin. At that time, the Federal Water Pollution Control Act amendments of 1972 and its implementing regulations and subsequent litigation, as well as Executive Order 11990, indicated that Federal projects should avoid destruction of wetlands in favor of other alternatives. The first items of work on what was identified as the Upper Yazoo Project included disposal areas in agricultural lands on the landside of the levees, rather than nearer wetlands on the riverside of the levee. Some of the areas were reclaimed by the landowners, while others remain as diked containment areas that have revegetated and possibly provide some habitat value.

In late 1976, a memorandum from the Council on Environmental Quality to all agency heads interpreted Section 101(b)(4) of the National Environmental Policy Act (NEPA) to require that adverse impacts of projects on "prime and unique farmland" be fully addressed in environmental documentation on all Federal projects. Thus, on some later items of work in the Yazoo Basin, dredged material was pumped even greater distances to upland forested areas. I point this out, only to say that in the Lower Mississippi Valley, and I assume in other parts of the country, our selection of discharge sites is becoming more restricted with the passage of each new piece of legislation and each new addition to the Endangered Species List. These restrictions provide a challenge that can be met through innovative and creative plan formulation and design. However, many agency philosophies and policies will have to be reshaped to promote full development of the concept of beneficial uses of dredged material in our inland waterways.

## SEAGRASS TRANSPLANTATION--IS IT A VIABLE HABITAT MITIGATION OPTION?

Gordon W. Thayer, Mark S. Fonseca, and W. Judson Kenworthy  
National Marine Fisheries Service, NOAA  
Southeast Fisheries Center, Beaufort Laboratory  
Beaufort, North Carolina

Dredging is not a thing of the past--it will be with us in perpetuity. The need for dredging has been on the rise and will continue to rise as we expand into the coastal zone. By the year 1990, it is predicted that 75 percent of the US population will live within 50 miles of the coastline including the Great Lakes (President's Council on Environmental Quality 1984). This expansion into our coastal zone is resulting in increased demand for dredging associated with the maintenance of navigable waterways and for housing and industrial development. This increase in development-related activities will be accompanied by a decrease in the availability of dredged material disposal sites.

These dredging needs usually conflict with resource agency mandates to conserve, maintain, and enhance the environment to ensure survival of fish, shellfish, and wildlife resources. The NMFS believes that a net loss of fishery habitat due to water development should be avoided (Lindall et al. 1979). In evaluating permit requests, the NMFS will consider and recommend mitigation only after a project has been demonstrated to be water-dependent, to have no feasible alternatives, and to clearly be in the public interest. The NMFS also recommends that habitat rehabilitation and generation (e.g., seagrass meadows) should be in-kind or nearly as identical as possible and onsite whenever feasible. The basic philosophy behind any mitigation effort that we recommend is that the habitat restoration or generation should eventually restore not only the physical habitat type but also its ecological functions.

Technology does exist to propagate marshes, mangroves, and seagrasses and to create unvegetated habitat using dredged material. However, only in few instances do we know the relative value to fisheries of the habitat that is being lost due to the disposal activity or the rate of natural recovery of the habitat that can be expected. Although transplanting of coastal plants has been used for many years to accelerate recovery, the science is still

young, imperfect and, we submit, experimental--we simply do not know the extent to which mitigation compensates for loss of habitat, the trade-offs that occur if out-of-kind mitigation is employed, or the rate of functional replacement if the plantings do succeed (Thayer 1987). The definition of mitigation or habitat restoration success is cloudy or is agency oriented rather than being based on ecological premises. Simply because transplanted habitats appear healthy does not necessarily mean that the system has developed functional relations similar to those of natural areas it has been designed to emulate or of the habitat it replaced. Quantitative assessments of man-made marsh, mangrove, seagrass, or intertidal unvegetated areas for use by fauna unfortunately have been rare. Frequently, State and Federal agency funding and manpower constraints are such that we cannot even follow up on the actions to evaluate success or failure. Virtually none of the mitigation approved in the US Army Corps of Engineers permit program in coastal areas receives monitoring or follow-up evaluation. Stipulations in permits may include replanting if the transplants fail, but because of the aforementioned constraints, we are not sure if this stipulation is or has been adhered to. Where data do exist, however, the assumption that man-created habitats function in a manner equivalent to natural habitats is generally unsupported (Thayer, Fonseca, and Kenworthy 1986; Fonseca 1987; Minello, Zimmerman, and Klima 1987; and this workshop).

Much of our restoration technology development efforts at the Beaufort Laboratory has been related to seagrasses. Beginning in 1981, the NMFS, the Beaufort Laboratory, and CERC (while at Fort Belvoir) initiated a cooperative agreement to study the transplanting of seagrasses for stabilization of subtidal dredged material and habitat development. This agreement was continued with WES when CERC moved to Vicksburg. Research under that agreement (between 1981 and 1986) developed cost-effective transplanting techniques, evaluated erosion control by these plant communities, provided operation cost estimates, and standardized restoration and management protocol for most North American seagrass species (Fonseca, Kenworthy, and Thayer 1982; Fonseca et al. 1985; Fonseca, Kenworthy, and Thayer 1987; Fonseca and Fisher 1986). Management of these submerged systems, however, is not without major problems.

Even with the extensive efforts directed at the development of a viable seagrass transplantation technology (see Fonseca, Kenworthy, and Thayer (1988) for chronological summary of 36 selected seagrass transplanting efforts),

seagrass transplanting as a general management tool is not working. Isolated cases of success or partial success can be found, but these are overshadowed by many costly failures. This lack of success is due largely to the general disregard for and the lack of scientific information on environmental requirements of transplant species. Irrelevant or incomplete criteria for success and inappropriate site selection criteria have been used. For example, success of a restoration has centered on percent survival of the plantings, rather than if the plantings spread, persisted, and actually created a habitat with functions equivalent to the seagrass habitat that had been lost (Fonseca 1987). The length of time for development generally is unknown and probably is both species and geographically specific. Sites for creating new seagrass beds have been and continue to be chosen on the illogical premise that absence of seagrass on the bottom constitutes some kind of a vacancy, rather than unsuitable environmental conditions at the site (Fonseca, Thayer, and Kenworthy 1987; Fonseca, Kenworthy, and Thayer 1988). This also assumes that unvegetated bottom is a biological desert, and this is not the case (Armstrong 1987). Because of the lack of understanding of the dynamics of seagrass meadows and growth strategies, restoration of these systems has not yet evolved into a reliable mitigative tool. To our knowledge, there has not been a seagrass restoration project that has prevented a net loss of habitat.

Many advances have been made in our collective understanding of the environmental factors that control seagrass meadow growth and development. Those advances, however, have not been adequately transplanted into management strategies for coastal plant systems. There is a large gap to bridge in order to use the available data in the management arena. For the dominant North American seagrasses, current regime, temperature, salinity, and more recently (and less completely), light availability have been studied to the point where these factors may be considered in determining if a site is suitable for planting. Of these four factors, light, temperature, and salinity are part of the list of factors that constitute water quality and are of great importance in the survival of seagrasses. We will address light briefly as an example of the need to incorporate water quality information into seagrass management strategies; discussion of other factors is provided by Phillips (1980); Fonseca et al. (1985); and Fonseca, Kenworthy, and Thayer (1987).

Light is an essential requirement for seagrass photosynthesis, growth, and development (Wetzel and Penhale 1983; Dennison and Alberte 1986; Dennison

1987). Studies have shown that the availability of light determines the magnitude of seagrass net production and biomass as well as the depth to which different species grow (e.g., Backman and Barilotti 1976; Drew 1979; Dennison and Alberte 1986; Bulthuis 1987; Dennison 1987). The response of seagrass photosynthesis to increasing light intensity is generally described by an initial linear response (Figure 1) as productivity increases proportionally to light intensity up to an apparent saturation level, where light is no longer limiting and production reaches a theoretical maximum value (e.g. Morgan and Kitting 1984, Fourqurean 1987, and references cited therein). The intersection of the light intensity response line with the X-axis is the compensation light intensity below which respiration exceeds photosynthesis and there is no net production. The initial slope ( $\alpha$ ) usually describes productivity at low light levels. All three of these parameters have been shown to increase with increasing temperature (Bulthuis 1983, 1987; Evans, Webb, and Penhale 1986; Marsh, Dennison, and Alberte 1986; Fourqurean 1987).

The length of the daily light period also influences seagrass growth and distribution (Dennison and Alberte 1985; Dennison 1987). For *Zostera marina*, the length of time ( $H_{sat}$ ) that quantum irradiance exceeds the apparent saturation level is perhaps even more important than the absolute intensity for photosynthesis and growth (Dennison and Alberte 1985, 1986; Dennison 1987) (Figure 2). This is not surprising because day length undergoes greater seasonal variation than does the maximum intensity.

The extent to which light becomes a critical factor for natural seagrass meadow development and transplant success depends on water depth and clarity. Plants growing in relatively clear, shallow water are exposed to nearly full sunlight, whereas those in deeper or turbid water receive much less solar radiation due to the attenuation of submarine light by water and/or suspended material. Therefore, turbidity may limit the success of transplant efforts and should be taken into consideration in evaluating sites. Information on photoperiod will revolutionize our ability to determine what is suitable habitat for seagrass transplanting and must be incorporated into site selection criteria and evaluation.

Additional information that should be incorporated into evaluations, not only of the rationale for issuing a permit affecting seagrass meadows but also in any mitigation plan, are seagrass population growth and coverage rates. The addition of new shoots varies not only among seagrass species but also



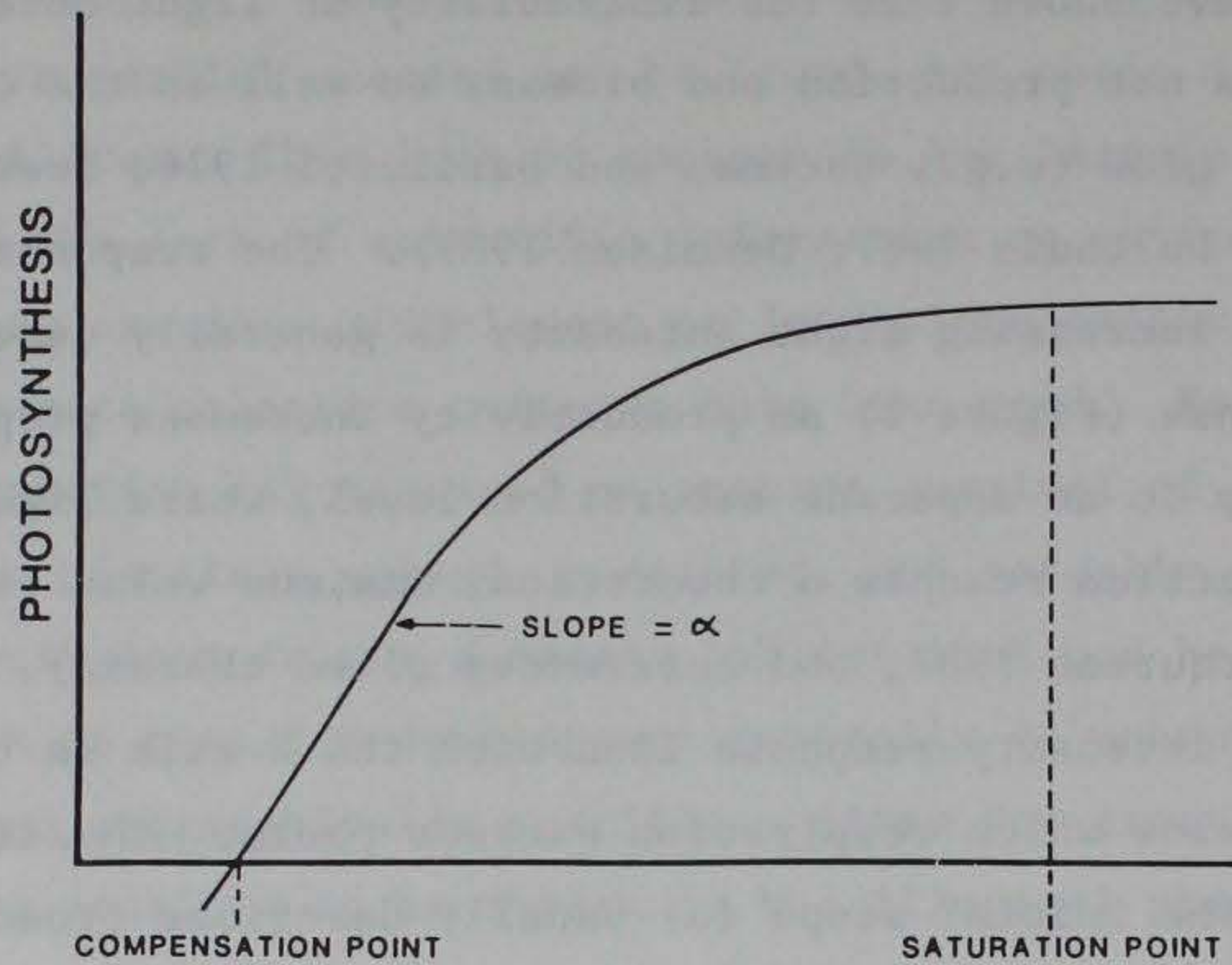


Figure 1. An idealized P-I curve for seagrass. Shown are the light compensation point, light saturation point, and initial response slope ( $\alpha$ )

geographically (Figure 3). Generally, *Halodule wrightii* and *Syringodium filiforme* add shoots more rapidly than does *Thalassia testudinum*. To achieve complete cover of *T. testudinum*, at an ambient density of 300 short-shoots  $m^{-2}$  (which is sparse), plantings on 1-m centers would require 4.0 to 4.7 years of growth. A similar planting of *H. wrightii* or *S. filiforme* may take as little as 160 to 250 days to achieve ambient densities. Additionally, since these data show such a slow recovery or coverage rate for *Thalassia* under the best of conditions, we contend that management strategies should hold *Thalassia* in a particular status for conservation.

These growth models, based on transplant research and monitoring, allow standardization of the approach to determining performance and compliance. With standardization, restoration projects involving seagrass transplants may be objectively assessed. The primary candidate species for transplanting in the subtropical United States are *Halodule* and *Syringodium*, and not *Thalassia*. Although percent survival of *Thalassia* transplants may be quite high, their slow coverage rate is unacceptable for a primary species in habitat restoration. If the goal of a mitigation project is to restore habitat function, then that should be done as quickly as possible. Again, the slow coverage rate of *Thalassia* disqualifies it from rapidly restoring habitat function

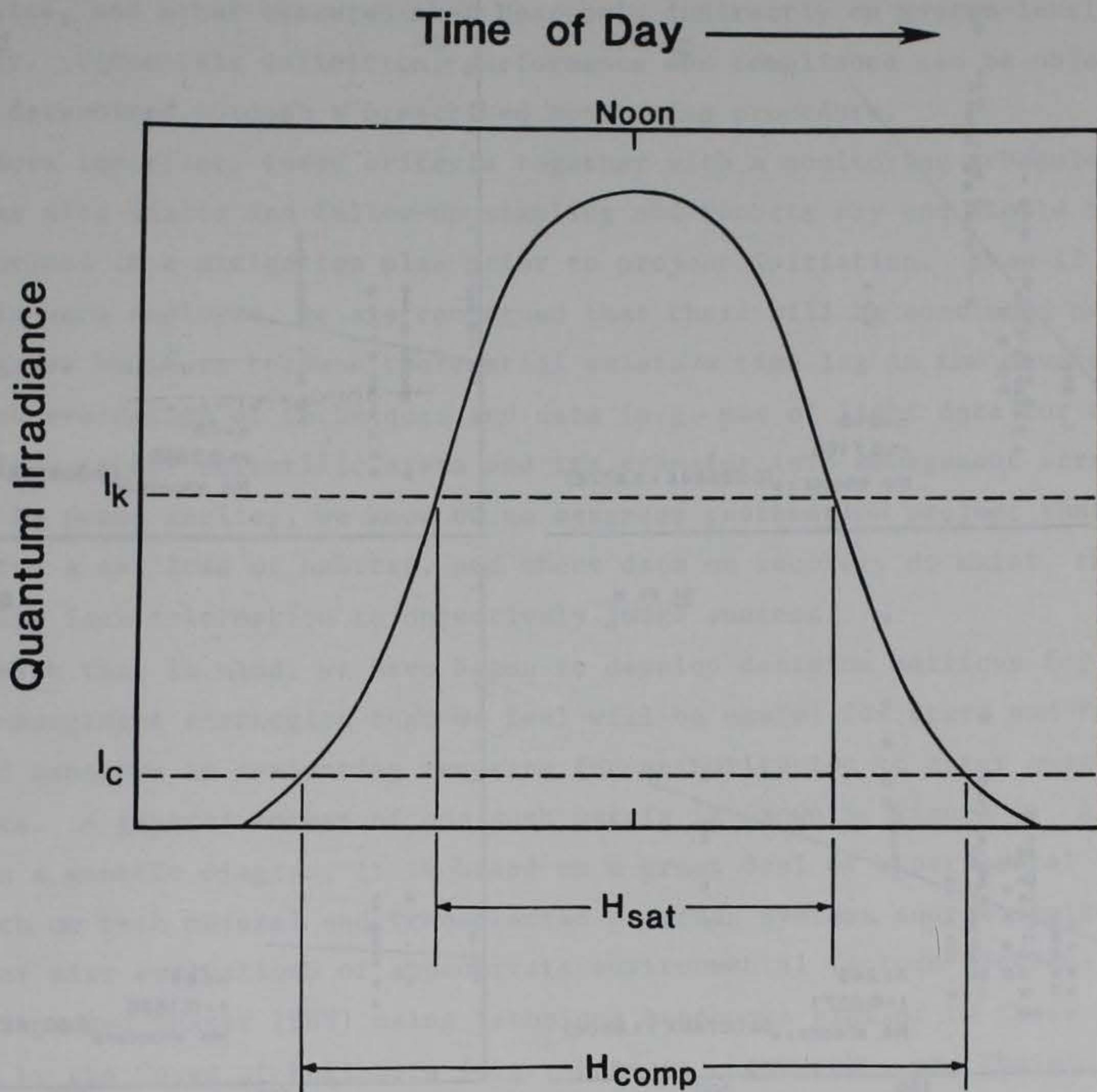


Figure 2. Generalized diurnal light curve. The interval between the intersection of the light saturation point ( $I_k$ ) and light compensation point ( $I_c$ ) for photosynthesis determine the daily periods of saturating ( $H_{sat}$ ) and compensatory ( $H_{comp}$ ) quantum irradiance (from Dennison 1987)

unless it is transplanted in extremely dense arrangements, but these efforts would be extremely costly.

Additionally, seagrass growth models developed under the CERC(WES)-NMFS agreement provide a quantitative definition of planting success. Success of the overall planting was defined as the area of bottom covered. Coverage is in turn defined as those areas where the rhizomes of the plants overlap. This definition should be used for seagrasses in lieu of percent survival, density,

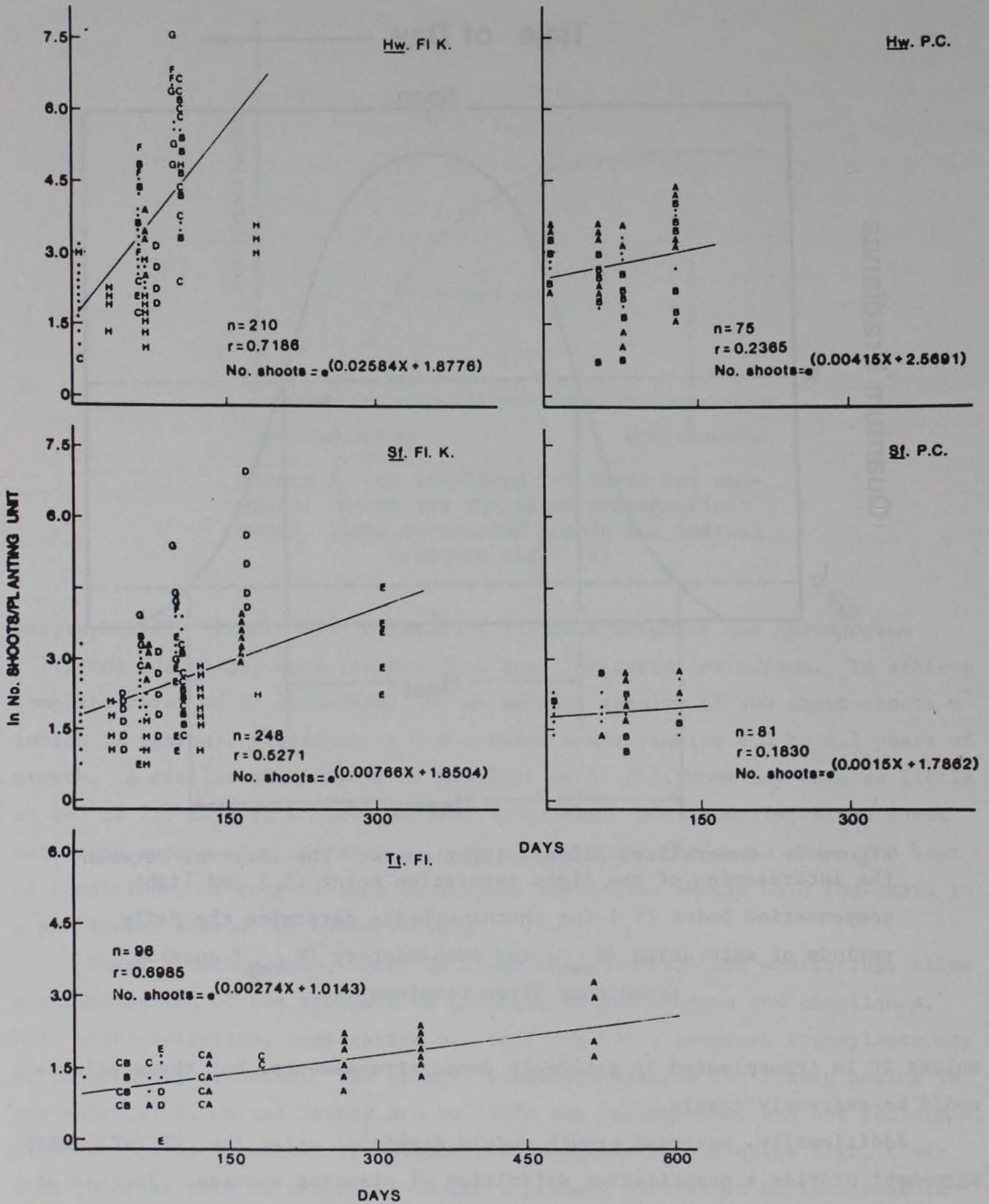


Figure 3. Natural log of number of shoots per planting unit regressed on time. FlK. = Florida Keys site; Fl = all Florida sites combined; P.C. = Panama City or northern Gulf of Mexico sites. Letters refer to individual planting units at different sites. Dots indicate several overlapping values. Regression equations are for lines shown. Each letter represents a different site. For details see Fonseca, Kenworthy, and Thayer (1987)

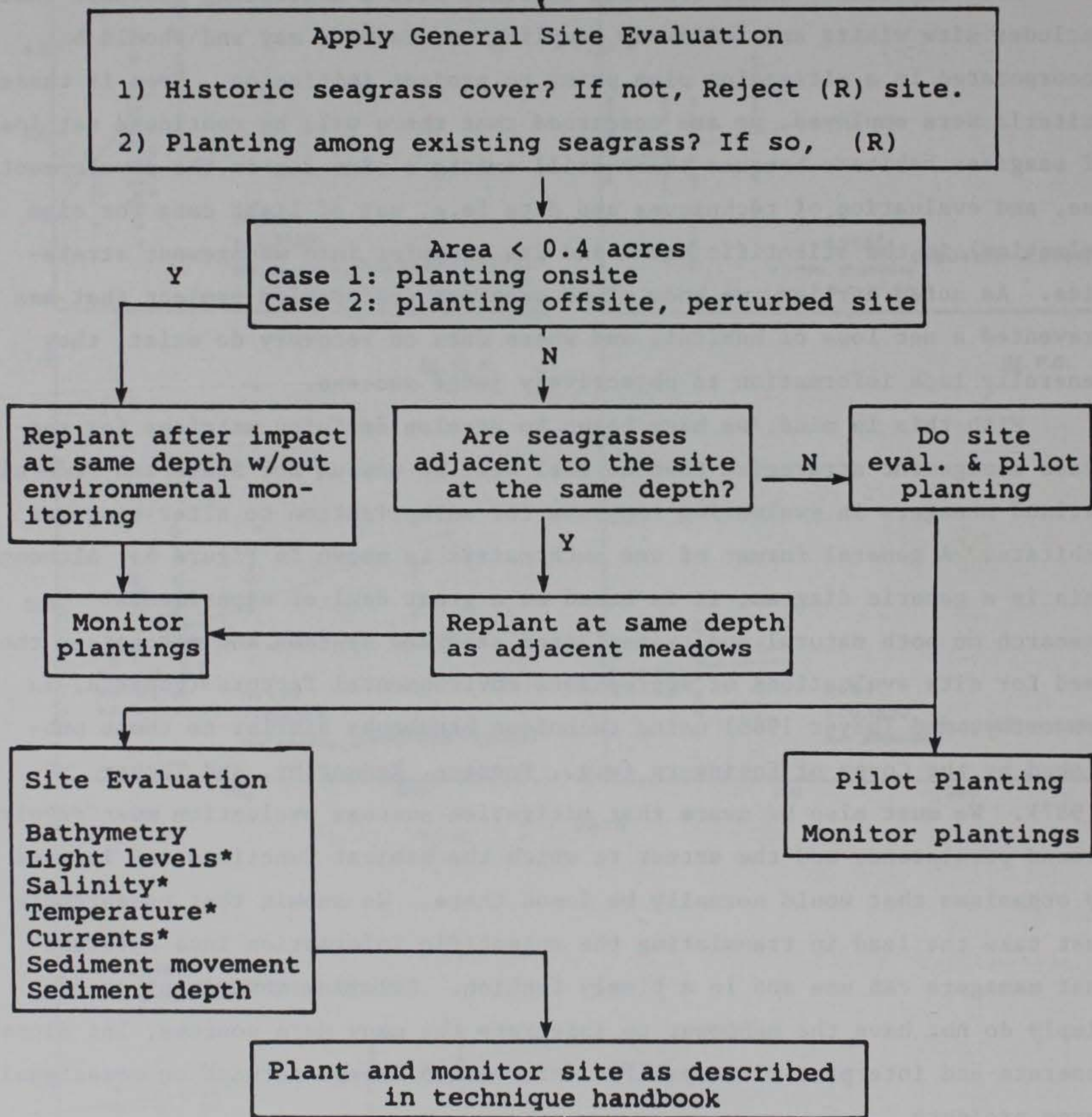
plant size, and other measures that bear only indirectly on system-level recovery. Given this definition, performance and compliance can be objectively determined through a prescribed monitoring procedure.

More important, these criteria together with a monitoring schedule that includes site visits and follow-up sampling and reports may and should be incorporated in a mitigation plan prior to project initiation. Even if these criteria were employed, we are concerned that there will be continued net loss of seagrass habitats because there still exists a time lag in the development, use, and evaluation of techniques and data (e.g. use of light data for site selection) in the scientific arena and its transfer into management strategies. As noted earlier, we know of no seagrass restoration project that has prevented a net loss of habitat, and where data on recovery do exist, they generally lack information to objectively judge success.

With this in mind, we have begun to develop decision matrices for seagrass management strategies that we feel will be useful for State and Federal wetland managers in evaluating requests for authorization to alter seagrass habitats. A general format of one such matrix is shown in Figure 4. Although this is a generic diagram, it is based on a great deal of experimental research on both natural and transplanted seagrass systems and recognizes the need for site evaluations of appropriate environmental factors (Fonseca, Kenworthy, and Thayer 1988) using technique handbooks similar to those published by the Corps of Engineers (e.g., Fonseca, Kenworthy, and Thayer (1987)). We must also be aware that mitigation success evaluation must revolve around persistence and the extent to which the habitat functions and is used by organisms that would normally be found there. We submit that researchers must take the lead in translating the scientific information into a format that managers can use and in a timely fashion. Existing management staffs simply do not have the manpower to integrate the many data sources, let alone generate and interpret site-specific information except perhaps on occasional large projects.

SEAGRASS SPECIES

LOCATION



\* Requires determination of appropriate time frame for accurate monitoring

Figure 4. An example of a generalized decision matrix for assessing transplant site selection and procedures (asterisk indicates that item requires determination of appropriate time frame for accurate monitoring)

## Literature Cited

- Armstrong, Neal E. 1987. "The Ecology of Open-Bay Bottoms of Texas: A Community Profile," US Fish Wildlife Service Biology Report 85, Vol 7, p 12.
- Backman, T. W., and Barilotti, D. C. 1976. "Irradiance Reduction: Effects on Standing Crops of the Eelgrass, *Zostera marina*, in a Coastal Lagoon," Marine Biology, Vol 34, pp 33-40.
- Bulthuis, D. A. 1983. "Effects of Temperature on the Photosynthesis-Irradiance Curve of the Australian Seagrass, *Heterozostera tasmanica*," Marine Biology Letter, Vol 4, pp 47-57.
- \_\_\_\_\_. 1987. "Effects of Temperature on Photosynthesis and Growth of Seagrasses," Aquatic Botany, Vol 27, pp 27-40.
- Dennison, W. G. 1987. "Effects of Light on Seagrass Photosynthesis, Growth and Depth Distribution," Aquatic Botany, Vol 27, pp 15-26.
- Dennison, W. C., and Alberte, R. S. 1985. "Role of Daily Light Period in the Depth Distribution of *Zostera marina* (Eelgrass)," Marine Ecology Progress Series, Vol 25, pp 51-61.
- \_\_\_\_\_. 1986. "Photoadaptation and Growth of *Zostera marina* L. (Eelgrass) Transplants Along a Depth Gradient," Journal of Experimental Marine Biology Ecology, Vol 98, pp 265-282.
- Drew, E. A. 1979. "Physiological Aspects of Primary Production in Seagrasses," Aquatic Botany, Vol 7, pp 139-150.
- Evans, A. S., Webb, K. L., and Penhale, P. A. 1986. "Photosynthetic Temperature Acclimation in Two Coexisting Seagrasses, *Zostera marina* L. and *Ruppia maritima* L.," Aquatic Botany, Vol 24, pp 185-197.
- Fonseca, M. S. 1987. "Habitat Development Applications: Use of Seagrass Transplanting for Habitat Development on Dredged Material," In M. C. Landin and H. K. Smith, eds., Beneficial Uses of Dredged Material, Technical Report D-87-1, US Army Engineer Waterways Experiment Station, Vicksburg, MS, pp 145-150.
- Fonseca, M. S., and Fisher, J. S. 1986. "A Comparison of Canopy Friction and Sediment Movement Between Four Species of Seagrass with Reference to Their Ecology and Distribution," Marine Ecology Progress Service, Vol 29, pp 15-22.
- Fonseca, M. S., W. J. Kenworthy, and G. W. Thayer. 1982. "A Low Cost Planting Technique for Eelgrass (*Zostera marina* L.)," Coastal Engineering Technical Aid No. 82-6, US Army Corps of Engineers, Coastal Engineering Research Center, Fort Belvoir, VA.
- \_\_\_\_\_. 1987. "Transplanting of the Seagrasses *Halodule wrightii*, *Syringodium filiforme*, and *Thalassia testudinum* for Habitat Development in the Southeast Region of the United States," Technical Report EL-87-8, US Army Engineer Waterways Experiment Station, Vicksburg, MS.
- \_\_\_\_\_. 1988. "Restoration and Management of Seagrass Systems: A Review," In: D. D. Hook, et al., eds, The Ecology and Management of Wetlands, Vol 2, Management, Use and Value of Wetlands, Timber Press, Portland, OR, pp 353-368.

- Fonseca, M. S., Kenworthy, W. J., Thayer, G. W., Heller, D. Y., and Cheap, K. M. 1985. "Transplanting of the Seagrasses *Zostera marina* and *Halodule wrightii* for Sediment Stabilization and Habitat Development on the East Coast of the United States," Technical Report EL-85-9, US Army Engineer Waterways Experiment Station, Vicksburg, MS.
- Fonseca, M. S., Thayer, G. W., and Kenworthy, W. J. 1987. "The Use of Ecological Data in the Implementation and Management of Seagrass Restorations," Florida Marine Research Publication Series, Vol 42, pp 175-187.
- Fourqurean, J. W. 1987. "Photosynthetic Responses to Temperature and Salinity Variation in Three Subtropical Seagrasses," M.S. Thesis, University of Virginia, Charlottesville, VA.
- Lindall, W. N., Mager, A., Thayer, G. W., and Ekberg, D. R. 1979. "Estuarine Habitat Mitigation Planning in the Southeast," In: G. A. Swanson, ed., The Mitigation Symposium, General Technical Report RM-65, US Forest Service, Rocky Mountain Forest Range Experiment Station.
- Morgan, M. D., and Kitting, C. L. 1984. "Productivity and Utilization of the Seagrass *Halodule wrightii* and Its Attached Epiphytes," Limnology Oceanography, Vol 29, pp 1066-1076.
- Phillips, R. C. 1980. "Planting Guidelines for Seagrasses," Coastal Engineering Technical Aid No. 80-2, US Army Corps of Engineers, Coastal Engineering Research Center, Fort Belvoir, VA.
- President's Council on Environmental Quality. 1984. "Fifteenth Annual Report on the Council of Environmental Quality," Executive Office of the President, Washington, DC.
- Thayer, G. W. 1987. "Habitat Development Applications: Opening Remarks," In: M. C. Landin and H. K. Smith, eds, Beneficial Uses of Dredged Material, Technical Report D-87-1, US Army Engineer Waterways Experiment Station, Vicksburg, MS.
- Thayer, G. W., Fonseca, M. S. and Kenworthy, W. J. 1986. "Wetland Mitigation and Restoration in the Southeast United States and Two Lessons from Seagrass Mitigation," Proceedings of the Second National Estuarine Research Symposium, Baton Rouge, 1985, Louisiana Sea Grant, Baton Rouge, LA, pp 95-117.
- Wetzel, R. L., and Penhale, P. A. 1983. "Production Ecology of Seagrass Communities in the Lower Chesapeake Bay," Marine Technical Society Journal, Vol 17, pp 22-31.

## QUESTIONS AND RESPONSES--HABITAT DEVELOPMENT

QUESTION (Dave Nelson): I agree generally with everything that you said, but one thing that disturbs me is that you make a comparison of a recently planted seagrass bed with a natural bed that has been in existence for a long time. That comparison bothers me a bit. Can you explain?

RESPONSE (Gordon Thayer): We are looking for a trajectory of habitat development. What we are trying to do is follow the old field work trying to follow the development of those systems over time, to look at the convergence of species that are present and the abundance of the transplanted systems and the natural systems. This will tell us how long it takes to reach some "measure of stability" to rebound from natural perturbations. Mother Nature played us foul with high temperatures, etc., which resulted in no results at this site at the end of 1 year. But we followed one for an additional 2 years and found out that it looks as if within the sequence of events of eelgrass in North Carolina, we are talking about replacement of "functions" maybe within 2 years. Why? I think that the resource agencies have to take into account that we are losing 2 years of secondary production and habitat use in their management plan. It is not there in year one. We are trying to replace what we have lost. This is a 2-year process for that species.

COMMENT (Ed Klima): Yesterday I made a presentation to the joint meeting of the Gulf of Mexico Fisheries Management Council and the South Atlantic Council to their habitat committees. These councils are the groups that develop management plans for shrimp, redfish, and other species throughout the Southeast region. The point here is that they are very concerned about habitat and are actively pursuing that in management plans.

QUESTION (Ed Klima): With major management actions being taken throughout the Southeast region by the States and Federal government, what are the next steps that need to be taken to address the items that you spoke about?

RESPONSE (Gordon Thayer): Ed, that is a tough question, and I may not be able to discuss this directly. Speaking from the standpoint of the majority of field biologists with NMFS, EPA, and USFWS, there is a lot of question as to the viability of mitigation as to the patterns of success and failure. In permitting, the contractor philosophy is to get in and to get out, and this applies across the boards. We do not have the manpower to



follow up on these projects. With Jacksonville District, we are examining 26 mitigation permits for success and are working with them on this. Additionally, I believe in up-front mitigation, but the technology is so new and experimental and should not be considered to be a panacea.

QUESTION (Chris Mathewson): It seems to me that in the surface-mining industry, this requires a 5-year bond with the mining companies. If you are going to deal with mitigation, we are effectively doing the same thing in submarine construction, that is, disturbing the habitat and re-creating some other type of habitat through beneficial use. There is a precedent for long-term monitoring of these sites.

RESPONSE (Gordon Thayer): I will defer this question to Don Moore (NMFS) or to Dr. Hanley Smith (Corps).

RESPONSE (Don Moore): In instances where NMFS makes that recommendation, the Corps regulatory functions groups do not concur. I have just reviewed a preproposal which showed up in the Federal Register that greatly increases the scope of nationwide permits.

QUESTION (Dave Nelson): I see seagrass transplanting in its infancy when compared with marshgrass transplanting, and we have heard a lot about marsh plantings, etc. Can you tell us how to create better seagrass habitat?

RESPONSE (Gordon Thayer): I keep seeing mitigation plans which trade off seagrasses with marshgrass, but the seagrasses grow too slowly. Let us try mixtures or succession of these seagrass species, and let us not plant in the patchy holes between the seagrasses. This is only temporary, i.e. stage one. We are asking the scientific community to provide you the information you need and for managers to use it.

## KEYNOTE LUNCHEON ADDRESS

### DREDGED MATERIAL DISPOSAL--WHAT IS IN THE FUTURE?

Gerald J. McLindon  
Planning and Environmental Design Consultant  
Baton Rouge, Louisiana

Several years ago when serving on the Chief of Engineers' Environmental Advisory Board, I had occasion to chat with GEN Jack Morris over lunch one day. In a reflective mood, he expressed deep concern that engineering works could cause so much environmental damage and opined that if engineers would study the ecological structure of particular habitats, they could build replacement habitats. When I mentioned this to others, the reaction on occasions was strong, "Who does he think he is--God--that he would create habitats?" From presentations at this conference, you know that Jack Morris was not pretending to be God, but rather was an enlightened, innovative, and dedicated engineer fully committed to the spirit of NEPA and the environmental ethic. Scientists and engineers are engaged in building habitats. We need many more who think like Jack Morris.

The dredging and disposing of sediment from the Nation's navigable waterways, which is the topic of this conference, is a gargantuan task of prime importance to the national economy and environmental well-being. Federal involvement in dredging began in 1824 when the Congress passed the General Survey Act. Since then, the US Army Corps of Engineers, under Congressional authorization in numerous Acts, has been responsible for most dredging projects on inland and coastal waterways, undertaken to provide safe and efficient navigation and to maintain ports and channels at authorized depths for handling the 2-billion tons of commerce transported over waterways each year.

It is estimated that in recent time about 300 MCY are excavated by the Corps of Engineers each year from the 25,000 miles of inland and coastal navigation ways serving over 400 ports and 130 of the Nation's largest cities. This is part of regular maintenance and improvement programs and represents more material than was excavated in building the Panama Canal and equal to the amount of excavation required for construction of the Tennessee-Tombigbee

Waterway. Those projects extended over years. Here we are speaking of disposing of these huge quantities each year, and there could be as much as 100 MCY dredged annually by other agencies and the private sector. In these terms it is possible to appreciate the magnitude of the task and the potential for environmental impact of these operations.

Disposing of dredged material introduces a unique set of environmental and economic problems, with techniques varying from region to region and project to project. The excavated material may be placed on land; in lake, coastal, or ocean waters; in the form of overboard disposal or bottom layers, berms, or islands; for beach replenishments or dumped in deeper waters; or used in restoration and creation of shallows and wetlands. The costs and existing technology of disposal limit the distance and height over which the materials can be transported, imposing limitations that place most sites within floodplains, waterways, or estuaries. These are areas of great environmental sensitivity.

When considering disposal techniques, it is useful to retrace man's utilization of estuaries and waterways. From earliest times, settlement, populations, culture, industry, commerce, and transportation have centered about waterways and estuaries. Today the preponderance of the world's major cities are located on them. In the United States, the eight most populous metropolitan regions are located on estuaries or the Great Lakes, as are 15 of the 20 largest cities and, consequently, the Nation's largest ports. By the year 2000, 75 percent of the population will live within 50 miles of the coast.

Estuaries and waterways were essential to survival of the earliest inhabitants, providing a means of food, clothing, shelter, and transportation. Early civilizations demonstrated great ingenuity and skills in handling water, whether it be in locating homes or building aqueducts. Later, waterways were the main avenues of access to the country for explorers and settlers. Because the estuaries provided ready navigation access and a bounty of fish, wildlife, and other amenities on land and water, they were logical sites for permanent settlements. However, over time, man's synergistic relationship with water was to change to one of confrontation. It seems that technological advances resulted in persistent destruction of natural resources and in particular to misuse of water and soil.

As cities were established and grew, estuaries were seen as prime locations for development. The influences of urbanization were to dominate the

water, tidal, and wetland areas. Consequently, environmental degradation in the Nation was sharply focused in the estuarine zone, around the Great Lakes, and in floodplains of our rivers. The encroachment and waste assaults on estuaries associated with development of and navigation to our larger cities is nearly overwhelming. Marshes and tidelands have suffered greatly as they were exploited for municipal and commercial use. Waterways were turned into virtual sewers. In those times, the Federal interest was narrowly construed, and the water areas and their inherent values were easily neglected. This is the genesis of contemporary dredge disposal problems. It has been a long-held common view that wetlands, submerged lands, intertidal areas, and estuarine shoals were no more than wastelands to be filled and "reclaimed" or "improved"--a concept that is not totally dead even in these days of environmental enlightenment.

Much of the development and filling process occurred in ignorance of the ecological and hydrological systems impacted. Harbor locations were based on suitable water depths, bank conditions for navigation requirements of the time, and settlement patterns. Wetland areas were filled and bulkheaded to create waterfront sites for wharfs, industry, transportation, recreation, residences, waste disposal, and myriad other uses. There was an exploitation of engineering advancements in dredging and hydraulic placement of materials. Development tended to face the land with the waterway treated as the "back-door," the loading zone, a divider, and an obstacle. In dock, wharf, and industrial areas, public access to the water was blocked.

States and localities owning water bottoms and submerged lands often treated them as real estate and sold or leased them on the condition that they were filled and made into fast land to be developed, thereby contributing to the economy of the area. One-third of the area of Boston is made land, and other cities were to cover vast areas of wetlands and water bottoms for building purposes. Unfortunately, over time, laws and government programs were to reinforce this position.

While some of the fill was accomplished using land-excavated materials or wastes generated in the urban area, very substantial waterside developments utilized dredged material excavated for the specific project, causing insult on the bottoms from which the material was excavated and the areas on which it was deposited. In some few instances, development occurred on sites that had

been set aside for disposal of material dredged from navigation waterways and that were developed subsequently.

It is not uncommon to find these earlier fills achieved by disposition of dredged material described as "beneficial" uses. While many were feats of engineering and others a necessary appendage of navigation and commerce, I share with one of this morning's speakers a reluctance to accept the remainder as "beneficial" uses of dredged material. In fact, I see many of them as accruing gains, generally short-term, to an individual, group, or municipality and long-term losses to the Nation. True, facilities such as San Francisco Airport and National Airport in Washington, DC, have been of phenomenal economic benefit to the locales and the traveling public and must be so recognized. Indeed, had it not been for the fill process, where could these facilities have been built?

A variety of uses for dredged material in upland areas have been accomplished including road and rail embankments, filling of pits and surface-mined areas, covers for sanitary landfills, and similar utilization. Other fill projects represent temporary economic and sometimes environmental gains with inherent long-term losses.

Many of the facilities constructed on the older bulkheaded and filled areas are now obsolete. While some harbor sides remain unused and dilapidated, many port cities are refocusing attention on waterways by undertaking renewal projects from comprehensive, area-wide clearance and rebuilding to rehabilitation of individual buildings. The new uses take advantage of the water vistas and physical access to the land-water interface. Many commercial and cultural uses have been developed, from shopping malls, to offices, museums, and recreational activities. Greenways and parkways are being laid down as part of the urban open-space plan and to reestablish urban wildlife and wetlands. These take advantage of the unique relationship of the water body to the urban setting. Many levees are now urban parkways. It has been recorded that for every \$1.00 spent on developing greenways along the waterfront, there is \$10.00 of commercial capital investment in the locale. Even so, as a society we have not yet learned to live with the dynamics of the beach.

Concomitant with the renewal of the old port areas is an appreciation of the surface water resulting from actions taken under the Clean Water Act. Rivers are being cleaned up, reducing contaminants in the water column and

bottom sediments; fishing and recreation have improved, and other amenities have been added. The effort to reduce contamination of surface water must be accelerated and a balance sought in development of water edges. There are far too many poorly designed and located nonwater oriented commercial and industrial uses and "second homes" cluttering the banks of waterways, many of them contributing pollution to the waters. The Corps, in concert with the conservation agencies, must inaugurate an educational program on preservation of natural areas and vegetation of the banks of waterways and prepare model ordinances which cities and counties can adopt to improve land use and the design and location of facilities and to control pollution and soil erosion from these activities.

There is no way of factoring in the economic losses sustained over time resulting from the loss and degradation of ecological systems buried under the fill. If we are to succeed in developing a program of beneficial use of dredged materials, we must be honest in our appraisals of the nature of the benefit, noting whether it is beneficial in terms of the total human environment and whether it is of short- and/or long-term benefit.

Sand, gravel, and shells are dredged for construction materials. In some areas considerable overburden must be removed, causing a disposal problem. The operations modify the bottom substrate, cause turbidity, impact the habitat of a range of organisms and creatures, and are detrimental to filter feeders. The disposal is for commercial purposes and usually involves temporary stockpiling on upland areas until trucked away for industry use. The Nation cannot exist without harbors, channels, and construction materials. The problem is finding ways to minimize the destructive side effects, and this is the thrust of ongoing research.

In the hinterlands, wetlands have been filled, drained, and otherwise modified to provide for agriculture and forest harvest. Vast forested areas, some constituting wetlands, were cleared for cropland. Tillage and cropping systems have greatly increased the rate of sedimentation, resulting in increased siltation that has clogged waterways and destroyed wetlands. In 150 years of expansion, we have reduced the agricultural soil sources of America by half, a feat which it is claimed rivals 6,000 years of husbandry in the Mediterranean. Runoff from agricultural activities contributed and still contributes to contamination of waterways to the detriment of aquatic habitat, benthic organisms, vegetation, fish, and wildlife (EPA 1987). We have

attempted to confine floodways by systems of levees, shunting land-building silts into the oceans. We have transported water for urban use from one river basin to another without regard to the consequences.

Under the scourge of development, in less than a century, we have lost over one-half of the total wetlands in the United States and still lose an estimated 300,000 to 450,000 acres each year. The impacts in our own region of the country give cause for alarm. The 1985 USFWS study showed that for the period mid-1950's to mid-1970's, the Southeast region of the country suffered the most severe losses. Nearly 8 million of the 9-million acres of wetlands lost during those decades occurred in this region. The reduction of the wetlands has been reflected in declining harvests of fish and fowl and must result in long-term negative effects (Brown and Olds 1987).

While the destruction of wetland and submerged lands went on unabated at the midcentury, there were disjointed expressions of concern manifest in a variety of ways. National conservation organizations had reacted over the years, normally emphasizing their particular area of interest. The National Audubon Society was concerned with programs and areas particularly essential to bird life. Resources for the future provided leadership in support of rational use of the Nation's resources. Beginning in 1953, the Nature Conservancy sought out and acquired unique natural areas threatened by development. In the late 1950's and 1960's the Sierra Club, Wilderness Society, National Wildlife Federation, Izaak Walton League, and other conservation organizations initiated legal actions as a salient means of protecting environmental quality in the estuarine coastal zone and inland waterways.

Naturalists of the era had written with conviction of the widespread damage being exerted on the environment under the all-pervasive pressure for development. There are excellent treatises from this period on the nature and character of ecosystems and the effects of the assaults perpetrated upon them. One of the first overall studies of an estuarine system was of San Francisco Bay, carried out by Mel Scott, a research city planner of the Institute of Governmental Studies at the University of California, Berkeley. Begun in 1961 and published in 1963, the dissertation built on Scott's previous work on metropolitan planning in the Bay Area. Recording the history of bay fills, the study recognized important ecological, fish, wildlife, and esthetic attributes of the estuary, but essentially is an appeal for coordinated planning of conservation and development in the Bay Area. As Scott notes, the purpose of

his work was "to attempt to convince local governments that if they expect effectively to influence the course of future events, they must develop some agreement on matters affecting the Bay" (Scott 1963).

Scientists and those committed to maintenance of a full variety of natural plant and animal communities had pursued sporadic studies of the aquatic environment. Accumulated evidence of the damage in aquatic systems highlighted "the failure of knowledge of estuarine environments to keep pace with the necessity to resolve problems arising from their intensive use" (US Department of the Interior 1970). In an attempt to get a grasp of the basic sciences and effects of intensive use, a Conference on Estuaries was held at Jekyll Island, Georgia, in March 1964. In that same year, the American Fisheries Society held "A Symposium of Estuarine Fisheries" in Atlantic City to discuss conflicts in estuary use and the threat to the fisheries. In July 1967, a "Marsh and Estuary Management Symposium" was held at Louisiana State University in Baton Rouge. The public and professional concern of the time gave impetus to many more symposia on the subject (US Department of the Interior 1970).

Public reaction will cause Congress to give consideration, and in instances, to act upon issues. As a means of evaluating the manner in which we have implemented environmentally oriented programs, it is useful to recall the progression of environmental legislation and the Congressional expectations for agency decision-making processes. In the Federal Power Act as amended in 1935, Congress required the Federal Power Commission (FPC) to consider in their project planning commerce, water power, and "other beneficial public uses, including recreational purposes." Later the courts were to conclude that this requirement imposed a responsibility on the FPC "to investigate and consider less environmentally damaging alternatives to any proposal." That sounds familiar, does it not? It is interesting that this mandate was in place 50 years ago and gives us a measure of how slow we have been to react to this precedent-setting requirement. It seems to have had little impact on the problems created by estuarine development or the design of dredging programs in the period before 1970.

The Historic Sites Act (1935) prescribed a national policy of Preservation of Historic Properties. The Fish and Wildlife Act as amended in 1958 was enacted to help guarantee that fish and wildlife values were fully considered in Federal water resource projects by requiring Federal agencies to consult



with USFWS and State wildlife authorities in planning water resources projects. This Act was fundamental to good dredging practices, but was not a comprehensive approach to preserving water bottoms or wetlands. The National Historic Preservation Act of 1966 created a similar consultation mechanism to protect historic buildings and sites from encroachment by federally funded projects.

One of the most important legislative actions affecting waterways, wetlands, and dredging was the Clean Water Act of 1966, which governs discharges into the waters of the United States. The implementing regulations set standards of water quality to be met for direct discharges into waterways, thereby influencing water quality and of dredged material, and the all important Section 404(b) regulating the filling of wetlands. Prior to 1970, there were many other Acts addressing some aspect of environmental concern and preservation of natural resources, recreation activities, and natural beauty. The Estuary Protection Act of 1968 assigned to the Secretary of the Department of Interior special responsibilities for studying estuaries of the United States and developing the means to protect, conserve, and restore them. The direct result of the Act was the National Estuary Study of 1970, delineating the characteristics of and problems identified in estuarine areas. This study turned individual and corporate concerns into action programs.

The states had also taken steps to secure their estuaries, coastal areas, wetlands, and waterways. Far-reaching and often innovative legislation was enacted by Massachusetts (1963), North Carolina, Connecticut (1969), New Jersey (1969), California (1960--San Francisco Bay Conservation and Development Commission), Florida (1969), and Wisconsin. However, review of state plans and policies on estuarine management undertaken in the National Estuary Study found that they tended to be fragmented and provincial in that they lacked regional and national perspective, demonstrated poor coordination between agencies at the Federal and State level within states and between states, lacked authority and/or desire to regulate activities for protection of estuarine areas, lacked funding to carry out innovative programs of protection and restoration, and displayed a low degree of public involvement.

With rising public interest and expectations in a wide variety of issues, many of which were environmental, the Congress had become disillusioned at the decision-making processes in government institutions and with the unresponsiveness of agencies to expressed public concerns. If used,

Federal acts in place in the 1950's and 1960's could have provided the means of resolving most of the identified problems. Instead, because of institutional inertia, many well-intentioned programs appeared to generate massive new problems. It seems as though the proverbial "two-by-four" has to be used to get agencies to concentrate on what was being asked of them. Seldom was an objective achieved following the initial statement of legislative purpose. With the intention of correcting this, two Acts were passed in 1966. The first, the Administrative Procedures Act (APA), which, as tempered by judge-made rules on review, required agencies to take a wider array of public interests into account in carrying out their statutory missions. Based on the APA, the evolving standards of judicial review called for agencies to establish procedures for principles decision-making, for articulation in the record of the reasoning which supports the decision taken, for elaboration of the risks which the proposed action entails, for discussion and consideration of alternatives as a test of the soundness of decisions made, and for increased public participation in the process (Anderson 1973). The second piece of legislation was the Freedom of Information Act, which guarantees the access of any citizen to factual or investigatory information on Federal programs and projects.

A complementary enactment was the Intergovernmental Cooperation Act of 1968, which required that the Federal Executive establishment conduct its planning and development programs with balanced consideration of all public interests. It required the President to "establish rules and regulations governing the formulation, evaluation, and review of Federal programs and projects having a significant impact on area and community development. . . ." And it directed that such rules and regulations "provide for full consideration of the concurrent achievement" of specified objectives "to the extent authorized by law," and that reasoned choices among such objectives be made when they conflict.

The Act mandates standards for the planning of Federal and federally assisted development programs and projects. It requires that "all viewpoints --national, regional, State, and local--be fully considered and taken into account"; that State, local, and regional objectives "be considered and evaluated within a framework of national public objectives, as expressed in Federal law"; and that "available projects of future national conditions and needs of regions, States, and localities be considered. . . ." It is obvious that legislative intent offered opportunities if not mandates for levels of

achievement in environmental protection which were not fulfilled by Federal agencies.

These Acts were precursors of NEPA, the all-encompassing Federal legislation incorporating environmental considerations in all aspects of agency decision making. The Act was a strong statement articulating the desire of Congress to redirect national priorities and reform the process of Federal policy making, thereby altering substantial outcomes (Miller, Anderson, and Liroff, undated). As noted by commentators, Congress aimed at altering the very personality of government with NEPA policy permeating every other policy pursued by government.

Discussing the legislation, Senator Jackson placed much of the blame for environmental degradation on the unresponsiveness of government institutions. The Senate report stresses this aspect:

As a result of . . . failure to formulate a comprehensive national policy, environmental decision making largely continues to proceed as it has in the past. Policy is established by default and inaction. Environmental problems are only dealt with when they reach crisis proportions. Public desires and aspirations are seldom consulted. Important decisions concerning the use and the shape of man's future environment continue to be made in small but steady increments, which perpetuate rather than avoid the recognized mistakes of previous decades (Miller, Anderson, and Liroff, undated).

The NEPA calls for maintaining conditions under which man and nature can exist in productive harmony and fulfill the social, economic, and other requirements of present and future generations of Americans. Commenting on this aspect of the Act, Anderson (1973) holds that an agency should discuss the actions it proposes from the standpoint of a trustee for future generations [emphasis added] and justify, in writing, any decision to incur lasting losses for the sake of short-term gains. This is a concept to which we must adhere in designing all programs.

The development of legislative intent based on public concern and newly gained knowledge following identification of man's impact on natural systems are the weft and warp of the canvas upon which we must portray the image of our works. We must ask, "How effective is our dredging program, and is it designed with the well being of future generations in mind?"

It is popular to cite the findings of the Brookings Institute study, "Can Institutions Change," which concluded that of all Federal agencies, the Corps of Engineers had made the most significant adjustments in the way of

doing business in light of the requirements of NEPA. Even the most severe critics of the Corps will agree that there have been quantum changes in environmental sensitivity within the organization in the last two decades. Not the least of these have been changes in the dredging program for inland waterways, the Great Lakes region, and the coastal zones of the country.

To implement the new construction-environmental ethic, the Corps has developed a multidisciplinary staff of outstanding professionals to address the engineering, economic, social, environmental, and aesthetic issues of every project. The fact that the Corps is assigned the major responsibility for dredging means that the corporate experience is brought to bear in each project. Disposal processes are designed recognizing the controlling factors of:

- a. Distance from dredging site.
- b. Type of dredged material.
- c. Physical and biological characteristics of potential sites.

While there are regional and even project differences, there are large areas of commonality and opportunities for technology transfer. Very specific and continuing assignments have been made to research the technology of dredging and beneficial use of dredged materials. The follow-up Dredging Operations Technical Support (DOTS) Program is available to all who engage in dredging.

In papers presented thus far, you have heard of disposal processes for filling upland areas for a variety of uses from industrial sites to highways to recreation areas as well as surface mine reclamation and solid waste management. Where the material has to be placed along a waterway edge, site selection is by multiagency, multidisciplinary teams with the objective of avoiding environmentally sensitive areas. The two-cell dike system is used, producing return water of high quality and superior terrestrial habitat. Buffer strips are maintained to screen the disposal areas, and the sequencing of placement of maintenance dredging is designed to permit some portion of disposal areas to be in vegetation successional stages of years 1 through 5 to 7, which appears to produce the most productive habitat for a number of wildlife species. Artificial gravel substrates and riffle habitats have been developed to replace in part those lost through dredging and/or impoundments. Sanctuary areas have been established where no dredging is permitted. Bank high dikes have been constructed on the upper end of shorter bendways to

maintain the integrity of the bendways--the list goes on, with creative uses of the material being developed according to need, opportunity, and innovation. But development close to waterways is restricting potential uses and sites for disposal of dredged materials.

In the coastal region, underwater berms are being built to reduce erosion caused by storm wave action; there are wetland and marsh creation and restoration; creation of new shallows, thin-layer deposition, natural and mechanical beach nourishment and shoreline stabilization, bird islands, and similar activities characterize some of the uses.

In designing projects that minimize environmental impact, communication and cooperation between concerned Federal and State agencies have been mixed--good in some regions, poor in others. De-emphasis of the Water Resource Council has hampered the achievement of full cooperation. In some areas and between certain agencies, the relationship tends to fit the description of a judge when he said that agency should not act "as an umpire blandly calling balls and strikes" for those appearing before it. How many times is the interagency relationship a reactive rather than a proactive posture? In some few cases, the "Gottcha" principle is still followed. This is practiced by sitting on the sidelines allowing the Corps to proceed to the point of pumping the excavated material to a site, at which time the other agency head decries, "Gottcha--you are doing it all wrong."

Because many of the disposal practices are new, untried, and untested, it is not always possible to predict the outcome. Section 404 requires that habitat development and restoration, by definition, should have environmental enhancement and maintenance as their initial objective. The fact that a created wetland may support wetland type vegetation or display other wetland characteristics does not mean that it will replicate the full array of natural wetland functions. Nor is it preordained that in time man-made wetlands will not function as effectively as the long established natural wetland. Time is an essential factor in developing full functioning of replacement habitats. The designers are fully conscious that the creation of wetlands is not an opportunistic venture. They know that through experimentation and monitoring, they may learn how a wetland functions and may replicate it, if not on the chosen location, then elsewhere. It is possible that a man-made wetland may turn out to be a wet meadow or some new habitat, in which case it still serves a useful purpose. Unfortunately, there are those who, as critical observers

rather than participants in the arena, will call the strikes, emphasizing any perceived negative qualities of a project. They respond to the concept of habitat restoration and building in a series of "knee-jerk" reactions, even before the preliminary results are in. How much better it would be if they would give of their knowledge to advance the concept or provide innovative alternatives.

All of the facts on how wetlands and marshes function are not known. Much research is being undertaken. Of particular merit is the River Wetland Demonstration and Research Project underway on the Des Plaines River. Here eight research areas have been set up with complete control over the water budget and water chemistry and with remotely controlled instrumentation. Concurrent with this effort, the Corps, Department of Interior, NMFS, Tennessee Valley Authority, Soil Conservation Service (SCS), US Forest Service, Bureau of Mines, and others have undertaken several wetland research investigations. The EPA is beginning a comprehensive research program. Carrying out this work is expensive and time-consuming. The Des Plaines River Project is estimated to cost \$1 million/year for 10 years. To get maximum benefit from the studies mentioned and others, agencies undertaking the work must join in developing a master plan of study. The plan must outline the focused objectives of the studies; identify with regional characteristics; represent river, lake, and coastal wetlands and marshes; determine fresh, brackish, and saltwater conditions and climatic differences. There must be a study of the ability of wetlands to handle a range of pollutants over the long term. Essential elements of the plan are a coordinated data base and the ability to replicate experiments under a variety of conditions, including regional characteristics. Academic researchers should be invited to contribute, and public input is necessary. It must become a fully coordinated project with a high level of technology transfer. Further, there must be direct involvement of agencies not previously associated with the dredging program. Also, it must be recognized that no one agency has the expertise, funding, or time to pursue all aspects of the research problem. By coordinating work and, where possible, by pooling resources, information, and reporting, it is probable that useful results will be obtained within budgets and in a reasonable period of time. Presently, a Federal agency should be assigned the lead role in coordinating the several wetlands research studies and structuring the Master Plan of Study, with other Federal and State entities serving as cooperating agencies.

While great strides have been made in developing a viable dredging program and commendations are due those who have developed and carried out innovative approaches, reviewing the problem and the existing programs, it is obvious that current efforts have not yet lived up to the declaration of faith inherent in NEPA, nor have we acted as trustees for future generations. The efforts are fragmented, not part of a coordinated multiobjective national plan. Most decision makers and scientists continue to address selected estuaries on an individual basis with little or no directed comprehensive focus (NOAA 1986). Further, there has not been a demonstration of the high hopes of Congress for sweeping changes in policies and decision-making processes encompassing the total problem.

One of the prime articles of NEPA is mitigation--and in dredging mitigation by avoidance can take several forms.

#### Soil and Water Conservation

If, where appropriate, increased emphasis can be placed on reducing the entrance of sediments into surface waters, perhaps the amount of dredging and disposal can be reduced (Lambertson 1987). This is a challenge of primary concern to the SCS. Although the SCS has been operating for over 50 years, less than half of the Nation's farms practice soils conservation; consequently, soil loss from agricultural lands is at unacceptably high levels.

The SCS was given considerable aid towards fulfillment of its mission under provisions of the 1985 Food Security Act (The Farm Bill). These provisions are:

- a. The Conservation Reserve, which offers farm producers financial help in retiring highly erodible cropland. Up to half the cost of establishing permanent grasses, trees, etc., will be paid for, and an annual rental, based on bids to the Federal government, will be paid on the land withdrawn from tillage for 10 years. The target is to withdraw 45-million acres of highly erodible lands from tillage.
- b. Conservation Compliance requires that the farmer who keeps highly erodible lands in tillage must apply a locally approved conservation plan or lose certain USDA benefits.
- c. If annually tilled crops are planted on highly erodible soils that had not been in crop production during the period 1981-85, the land tilled must be under an approved conservation plan, or the farmer will lose certain USDA benefits.

d. Conversion of wetlands to croplands after 23 December 1985 and maintaining them in tillage will cause loss of certain USDA benefits.

It is disappointing that farmers have to be paid to engage in good farming practice. In the past, taxpayers have had to pay for correction of erosion problems caused by poor husbandry. Further, the 10-year period out of tillage is not enough. These lands should be held permanently in grass and/or timber.

These are good first steps, but greater efforts must be made. Ten years ago I recommended that if soil conservation was not practiced in all land (not just highly erodible land), the farmer should lose all government benefits. This must be done if we are to get the costs of water treatment and dredging under control. How foolish to grant subsidies to farm operations that run counter to good environmental practices and require costly remedial programs elsewhere to overcome the impacts of these subsidized operations.

It would be good policy for SCS to calculate the amount of soil erosion and surface runoff from each watershed now in agriculture based on the natural vegetation for the area before settlement and farming. The target should be to reduce soil erosion to this level through a series of innovative practices, which could include conservation plans, ground-water recharge, creation of wetlands, sediment ponds, and other control devices. This and other soil and water conservation practices should be undertaken in river basin planning carried out by the SCS in a joint planning program with the Corps.

Where appropriate, bank stabilization should be carried out, using vegetation to control erosion and bank cutting whenever possible. It must be recognized that some bank cutting is essential to maintaining ecosystems.

Flood-protection programs for agricultural lands subject to the 10-year flood should be abandoned. With huge farm surpluses, there is no reason to keep these lands in crop production. If they are maintained in grass or trees, the occasional floods should have no appreciable adverse impact. Any Federal flood-control program should require guarantees from the State and/or local sponsors that they will implement flood-reduction programs. The Corps should prepare a manual on ways of reducing floods, to be used by State and local authorities.

Soil conservation should be extended to urban and industrial areas and particularly to construction sites. An interagency task force, under the lead of SCS, should be formed to develop standards, techniques, and administrative



procedures to effect the reduction of soil erosion and surface water pollution from these urban areas.

In scoping these improvements, the Nation cannot afford the 50 years it has taken to implement the present limited conservation plans. A target date of 10 years for accomplishment should be the objective.

### New Ship Design

Basic ship design has not changed since the Phoenician era. The time is past due for radical changes in ship and barge configurations. Lessons to be derived from the Falkland Island war warn us that from the national security standpoint, this Nation must improve the capability for putting a large number of troops and supplies over open beaches and through shallow harbors. Even in commerce, it is impractical and uneconomical to consider deepening and maintaining navigation channels in harbors around the world to handle deeper draft ships. It has been part of economic folklore that deep draft vessels are more efficient in the movement of cargo. What is meant is that larger ships are more efficient. The deep draft reference is a fixation of uninspired technology. The time has come for intensive research into the design of very large ships with shallow draft and barges capable of carrying greater loads using the prevailing channel depths of inland and coastal waterways. There should be ships for use on inland waterways and new equipment and techniques for loading and unloading cargo.

A year ago, I recommended establishment of the National Navigation Research Center at the National Aeronautics and Space Administration (NASA) test facility in Mississippi. There are several complementary research centers at the site. The research envisioned would include new and more efficient ship design allowing shallower drafts for very large ships. Achievement of this goal would improve the capacity and efficiency of a large number of ports and eliminate the need for "topping off" cargos. Over time shallow draft vessels will reduce or eliminate the need to dredge navigation channels in rivers, harbors, and estuarine areas. This action will require industry support and Congressional initiative. If the design of ships can be improved, American shipyards will experience a revitalization of production.

## Analysis and Evaluation of Existing Ports

Almost all of our ports have reached an advanced stage of obsolescence. There is need for extensive changes in loading facilities and warehousing. In many instances, the present location of wharves and piers requires excessive dredging to keep them operational. Consideration should be given to new cargo-handling facilities incorporating advanced loading equipment with new wharves/docks located where water currents will self-scour the approach channels and dockside areas.

Some tough decisions will have to be made about the need for deeper channels to serve ports far removed from the oceans. In my opinion, it is ridiculous to deepen the channel up to Baton Rouge when there are so many nondredging alternatives. Likewise, the multiplicity of ports must be questioned. Better loading and transfer facilities with shallow draft barges/ships could reduce or eliminate the need to dredge a large number of channels and harbors.

The proposal would need Congressional initiative authorizing the evaluation study and for the Corps to provide design services to port authorities on location of facilities.

These are but a few proposals. There should be a National Advisory Task Force established representing Federal and State agencies; engineering, economic, social science, and environmental disciplines; and farming and shipping industries to study and make recommendation on ways and means of reducing siltation and the need for dredging.

When the dredging and disposal program now in place is examined, it is evident that despite all our efforts in research and cooperation between agencies to find solutions, the program is plagued by lack of information and is in large part a series of separate actions. Last year at the Beneficial Uses of Dredged Materials Conference in Baltimore, MG Hatch said, "If we are to realize the full potential of [beneficial uses], an essential next step is the development of a logical, technically based framework or strategy for employing beneficial uses, particularly in the area of habitat development." That makes good sense, and I suggest it be carried a stage further.

Much of our dredging planning is based on available knowledge, previous practice, and best professional judgment. The planning of navigation channels in coastal areas reminds me of the evolution of highway planning. Initially

"good" highway layout called for the shortest distance between two points-- the straighter the better! Then comes the realization that consideration of topography could reduce construction costs, balance cut and fill, provide far more interesting and consequently safer driving experience, and improve esthetics of the roadway. Thus came the "fitted" highway. Later consideration encompassed environmental sensitivity so that the highway blended effectively with the natural environment.

When planning navigation waterways, there is a rapid focus on the terminals of the channel. In open water, we are never quite sure whether there are alternate locations that may have lower environmental impact. In the past, when dealing with the aquatic environment, it seems that coordination with USFWS may not have been exercised to the full and environmental assessments may have been a conformation to the law rather than a scientific inquiry. Even the Habitat Evaluation System has shortchanged the aquatic habitats. The spirit of NEPA is founded in the premise that utilization of resources in an environmentally compatible way requires that we know what the existing condition is and how it will be impacted by the proposed activities--and these effects must be considered early in planning so that changes can be made to ameliorate the impacts, if warranted.

In developing his ecological method for regional planning, Ian McHarg (1969) established a system for identifying what was on the ground and the land capability and suitability in ecological terms. In essence, the base document was an ecological inventory. He described it as a simple sequential examination of place in order to understand it. The understanding reveals the place as an interacting system, a storehouse and a value system with secondary and tertiary values and from most to least, what habitats are valuable, what are critical, and whether some are replaceable. From this information, it is possible to prescribe potential uses, not as single activities but as association of these.

McHarg (1969) noted:

It would appear that the ecological method can be employed to understand and formulate a plan with nature . . . perhaps to Design with nature.

If such an approach were used in analysis of the coastal areas, estuaries, waterways, and Great Lakes, it would be possible to display attributes, intrinsic values, and area suitability for water bottoms and edge areas. From the display, the condition or quality of habitat can be identified, indicating

the most productive and sensitive areas and those where remedial or restorative actions are required. A GIS system such as GRASS will enable manipulation of information, permitting comparison of alternative area suitability for channel alignments, harbor facilities, underwater disposal areas, and opportunities to create new or improved habitat, marshes, and wetlands and to correct identified problems. The states must develop a complementary plan for upland locations for disposal and uses for the excavated materials, including stockpiling for future use by public and private entities. Under a comprehensive plan, existing conditions and materials can be matched with area potential so that the impacts of dredging and disposal can be minimized and as many operations as possible designed to sustain and enhance the environment. This will result in balanced use and conservation of resources.

The task of inventorying the water areas seems great until it is realized that much of the information needed has or is being collected by one or more agencies or institutions. The question is, has it been used effectively? When consideration is given to the environmental assessments, estuary studies, wetlands inventory, aquatic Habitat Evaluation Procedures (HEP) and other surveys made by Federal, State, and local agencies and universities through Sea Grant programs, Wetlands Institutes, Geological Surveys, coastal and coastal zone management studies, and other works, the major task, at least for estuarine and inland waterways, is not so much undertaking surveys as it is providing the technical and scientific framework for compiling the information into a usable system. There is also need to design the strategy for continuing to collect, analyze, monitor, and update the information. Pilot projects on ecological inventories of water bottoms have already been undertaken in Chesapeake Bay and Mississippi Sound and elsewhere.

There is talk about the level of cooperation between agencies, but in honesty there is much more that can be done. Agencies need to accept responsibility for developing certain aspects of the information as part of the required total plan for environmentally sound decision making. There must be an elimination of the need to second-guess agencies and institutions. There must be full cooperation and outreach in developing and undertaking the grand plan. By accepting assignment, pooling resources, standardizing data bases, utilizing the wide range of professional services available, and inviting public participation, it should be possible to accomplish the objectives.

Essential to the work is a comprehensive, readily accessible data base and compatible or common modeling procedures. Most agencies have data bases in a variety of media. Again a task force should be constituted to design the data base required for a comprehensive national plan, one to which all can contribute and which can be accessed easily. It is my recommendation that the data base be built upon the existing Sea Grant system and that regional depositories be established at the Sea Grant Colleges.

The topic of cooperation is one of vital interest. A few years ago, I undertook a study of cooperation between the Corps and conservation and development agencies. While there were gaps and conflicts and insensitivities in the relationship of the Corps to other agencies, surprising to me was the discovery that the greatest conflict was between conservation agencies where each stressed their particular bias in formulating proposals, interpreting surveys, and advancing mitigations. These conflicts were far more intense than difference between development and conservation agencies. It was evident that in all agencies some individuals were unable to discuss differences of opinion with others and so, in ignorance, maintained opposition to projects and programs.

In the study I found that personnel moved freely from the Corps to the conservation agencies and vice versa. This was particularly true of those in natural science disciplines. I was shocked to find some offices of Federal conservation agencies belittling the qualifications of Corps biologists and archeologists, viewing them as not possessing competencies requisite for professional practice. Many of the biologists had previously worked for such agencies and had been found to be fully competent! This type of backbiting destroys all incentives to cooperate, is totally despicable, and reflects most unfavorably on the office and agency espousing such sentiments. Let it be clear the natural scientists in the Corps are consummate professionals by any standards and outstanding contributors to the advancement of the sciences.

The Nation and the world knows of the drastic loss of coastal marshes and wetlands in Louisiana caused in part by too little sediment being transported into adjacent wetlands. Indeed one sure way of getting your name in the paper or of appearing on TV is to wave your arms and proclaim that each year 60 square miles of Louisiana wetlands is being lost--but that does not solve the problem. Although not involved in the project, I am aware of at least five organizations with an interest in identifying and/or finding

solutions to the problem. Each has information, expertise, and ideas. There are differences in approach. Each group will subscribe to some aspects of a very long list of potential causes and problems, but there is no consensus. Possible solutions to the problem will not be forthcoming until agencies, groups, and individuals join in a concerted effort to compile and analyze existing information, to identify data and research gaps, and to develop a plan for a comprehensive approach seeking solutions. Although funds are scarce and no one agency can underwrite all that needs to be done, monies are being disbursed for unrelated and not always successful projects. This is one situation where a cooperative structure is sorely needed.

Of interest is the fact that when GEN Heiberg was District Engineer in New Orleans, the Atchafalaya Basin Project was a bone of contention, and opposing viewpoints were expressed by various interest groups. The beginning of the solution was getting the groups around one table talking to each other and trying to understand the basis for their differences and the areas of agreement. Some differences were maintained until the end, but the group helped formulate one of the most innovative and successful conservation plans in the Nation.

Oil drilling has been blamed for much of the wetlands loss, yet oil companies drilling offshore and in the Louisiana wetlands are vitally interested in the well being of the region and maintenance of healthy marsh and wetland areas. Some oil companies own large acreage of wetlands and want to see them preserved. It is my belief that oil companies will be willing to pay for compiling existing information on the Louisiana coastal wetlands for input into a group data base, as the basis for a comprehensive plan. It is also probable that they would contribute some services and computer time to implement research required by this study.

Access for oil drilling in the wetlands is vital to the Nation's security. A chilling fact is the knowledge that should a full mobilization state of emergency come about, the Nation could not support itself for very long on self-produced oil. We need an energy plan to conserve the resource as well as the discovery of new oil fields. We must find ways of extracting the resource with minimum environmental degradation. For too long we have argued about the issue of oil production in coastal wetlands. Now we need answers based on fact. It is my opinion that by mid to late 1990's a number of oil-producing nations will focus on export of finished products only--with crude oil being

processed in their own country or countries in the region. If this comes about, even without a national emergency, this will have a profound effect on the country's economy. The search for new oil sources will intensify at that time.

An hypothesis has been developed that there are large reserves of oil under the gulf coast region at depth, which will be tapped when drilling technology has been developed to mine up to 40,000 ft. In seeking solutions to the problems of oil drilling in coastal wetlands, the problems should not be viewed as of declining importance or an activity that can be curtailed. It could be that exploration for oil in the gulf region is on the threshold of vast discoveries which could result in a frenzy of activities in the future. Should this happen, let us be sure we have planned for the eventuality.

In summary, reduction of dredging, beneficial use of dredged material, and reduction of environmental insult will not come about by incremental, disjointed projects, regardless of how dedicated individuals or institutional groups may be. The need is for an all-encompassing national program embodying coordinated studies within a logical technically based framework. It can be accomplished. McHarg (1969) described planners for ecological planning system as

. . . working men [and women] who care not only to preserve, but to create and manage . . . who are instinctively interested in the physical and biological sciences and who seek information so that they may obtain license to interpose their creative skills upon the land.

Are we such people, and do we have the courage to undertake the task as trustees for future generations?

#### Literature Cited

Anderson, Frederick R. 1973. "NEPA in the Courts: A Legal Analysis of the National Environmental Policy Act, Resources for the Future," John Hopkins University Press, Baltimore, MD.

Brown, James D., and Olds, Warren T. 1987. "Wildlife and Dredge Material in the Southeast," Beneficial Uses of Dredged Material, Proceedings of the First Interagency Workshop, 7-9 Oct 1986, Pensacola, FL, Technical Report D-87-1, US Army Engineer Waterways Experiment Station Vicksburg, MS.

Lambertson, Ronald E. 1987. "Viewpoints of the US Fish and Wildlife Service on Beneficial Uses of Dredged Material," Beneficial Uses of Dredged Material, Proceedings of the First Interagency Workshop, 7-9 Oct 1986, Pensacola, FL,

Technical Report D-87-1, US Army Engineer Waterways Experiment Station, Vicksburg, MS.

McHarg, Ian L. 1969. Design with Nature, The Natural History Press, Garden City, NY.

Miller, Alan S., Anderson, Frederick R., and Liroff, Richard A., Undated. "The National Environmental Policy Act and Agency Policy Making: Neither Paper Tiger nor Straitjacket," 6 ELR 50020.

Minello, Thomas J., Zimmerman, Robert J., and Klima, Edward F. 1987. "Creation of Fishery Habitat in Estuaries," Beneficial Uses of Dredged Material, Proceedings of the First Interagency Workshop, 7-9 Oct 1986, Pensacola, FL, Technical Report D-87-1, US Army Engineer Waterways Experiment Station, Vicksburg, MS.

Scott, Mel. 1963. "The Future of San Francisco Bay," Institute of Governmental Studies, University of California, Berkeley, CA.

US Department of the Interior. 1970. "National Estuary Study," Bureau of Sports, Fisheries and Wildlife and Bureau of Commercial Fisheries, Washington, DC.

US Environmental Protection Agency. 1987. "Estuary Program Primer," National Estuary Program, Office of Marine and Estuarine Protection, Washington, DC.



## SESSION III: INNOVATIVE USES AND CONCEPTS

Moderator: George W. Johnson, Jr.  
US Army Engineer Division, Southwestern  
Dallas, Texas

### DEVELOPMENT AND OPERATIONS OF THE CONTAINMENT AREA AQUACULTURE PROGRAM (CAAP) DEMONSTRATION SHRIMP FARM

Richard Coleman and Jurij Homziak  
US Army Engineer Waterways Experiment Station  
Vicksburg, Mississippi

Durwood Dugger  
Mariquest, Inc.  
Port Isabel, Texas

#### Introduction

The CE currently uses dredged material containment areas (DMCA) to dispose of a large portion of the approximately 250 to 300 MCY of sediment dredged annually (Engler, Patin, and Theriot 1988). Containment areas became common after 1970, when open-water disposal of dredged material was first replaced by confined disposal (Lunz and Konikoff 1986). A number of authors (e.g., Palermo, Montgomery, and Poindexter 1978; Walski and Schroeder 1978; Medina 1983; Kyzer 1984) discuss various DMCA features and operations in detail. A summary of DMCA characteristics is given by Lunz and Konikoff (1986).

Because most DMCA are located on privately held land, the acquisition of disposal acreage is often a problem for dredging project sponsors. High real estate costs and limited budgets preclude outright purchases in most instances. Leases or easements are also difficult to acquire because material disposal is often perceived as waste disposal. The long-term nature of the disposal agreements and the lack of adequate compensation add to the difficulty of acquiring suitable acreage for DMCA.

With the proper inducement, suitable real estate can be acquired. Because landowners retain the right to use the acreage for activities that do not interfere with the disposal of dredged material, the demonstration of a

financially attractive use of the site may increase the availability of DMCA real estate. This has been the focus of ongoing programs within the CE, to develop beneficial use concepts that will materially assist in the retention and acquisition of disposal sites.

Aquaculture is perhaps one of the most financially attractive beneficial uses of DMCA (Homziak and Lunz 1983). The multiple use of DMCA, primarily for periodic disposal of dredged material but with culture operations interspersed among disposal events, has many attractive features (see reviews in Lunz 1983; Lunz and Homziak 1983; Lunz, Nelson, and Tatem 1984). There are a number of design characteristics of pond production systems (Wheaton 1977, Stickney 1979) that are shared by enclosed DMCA (Lunz, Nelson, and Tatem 1984; Lunz and Konikoff 1986). Common features include perimeter levees to retain water, construction on relatively impervious soils, incorporation of designs facilitating water drainage, and water discharge control structures. Both facilities also require that certain common regulatory requirements be satisfied for construction and operation (Dugger and Roegge 1983, Younger 1985). Other notable DMCA features include locations on or adjacent to waterways in coastal areas, often on large tracts of land and near transportation routes or major markets (Lunz 1983; Lunz, Nelson, and Tatem 1984; Lunz and Konikoff 1986).

Benefits to an aquaculture enterprise from multiple use of DMCA are numerous. Costs associated with land acquisition, levee and water control structure construction, and related items such as road access to sites could be fully or partially subsidized by either the Federal government or by the local sponsor of the dredging project. Greatly improved access to suitable lands and use of areas already designated as DMCA should aid in overcoming two major impediments to aquaculture development in the United States, permit requirements for water use and coastal development (McGlew and Brown 1979, Stickney and Davis 1981) and lack of access to suitable coastal sites (Glude 1977, National Academy of Science 1978). Landowners would benefit by realizing greater revenues from their property, either through increased value from improvements or in the form of user lease fees.

With the inducement of increased revenue, the CE and the local sponsors of dredging projects should encounter less difficulty in locating containment area sites. Because of an estimated need for an additional 7,000 acres for DMCA annually (Lunz and Konikoff 1986) and the overall benefits to be realized from a successful multiple use (Lunz, Nelson, and Tatem 1984), the CE has

undertaken the study of the technical and economic feasibility of containment area aquaculture.

### Development of the CAAP

Precedents for the use of active DMCA for purposes other than material disposal exist (Harrison 1983), as do lease agreement and permitting procedures allowing third parties to use DMCA for compatible activities (Dugger and Roegge 1983, Lunz 1983). Aquaculture in DMCA was first proposed during the Dredged Material Research Program (DMRP) after it was learned that dredged material was generally not toxic to aquatic organisms (see review in Tatem 1983). In aquarium bioassays using Houston Ship Channel sediments (Milligan 1983) and in field tests in active DMCA (Quick and Morris 1977, Quick et al. 1978), exposed penaeid shrimp (*Penaeus aztecus* and *P. setiferus*) did not bioaccumulate contaminants present in the sediments. Quick and Morris (1977) simulated conditions within DMCA by lining experimental ponds with dredged material. Brown shrimp grown in these ponds grew 30 percent faster and had only slightly lower survival in these ponds than shrimp grown in unlined control ponds. A trial conducted within an active DMCA near Freeport, TX, successfully produced a crop of white shrimp (*P. setiferus*) (Quick et al. 1978, Milligan 1983).

While these results demonstrated the technical feasibility of culturing food grade quality shrimp in active DMCA, production economics was unfavorable. High costs for postlarval shrimp, the direct result of the inadequate maturation and seed stock production technology available at that time (Quick et al. 1978), burdened the project. Combined with reliance on native species with unfavorable production characteristics (Lawrence, Johns, and Griffin 1984), commercial development of DMCA shrimp aquaculture was unattractive (Lunz and Konikoff 1986). As a result, interest in further development of the concept was lost.

Developments in shrimp aquaculture since 1980 include several major break-throughs (see reviews in Lawrence, Johns, and Griffin 1984; Aquacop 1985; Chamberlain 1985; Lawrence, McVey, and Huner 1985; Primavera 1985). These developments have promoted the growth of a commercial shrimp culture industry (Griffin, Lawrence, and Johns 1985; Lawrence, McVey, and Huner 1985) and led to a renewed interest in containment area aquaculture.

An experts workshop was convened by the CE in 1983 to assess the feasibility of containment area aquaculture in the light of these recent advances. The conclusions were that aquaculture in DMCA was feasible, desirable for the growth of the aquaculture industry, and compatible with disposal of dredged material under most circumstances (see reviews in Homziak and Lunz 1983).

As a result of these findings, the CE, through the WES in partnership with the Galveston District, is currently conducting a 3-year aquaculture demonstration project in an active DMCA near Brownsville, TX. Mariquest, Inc., operates the farm under contract to the CE and contributed significantly to the design and development of the site. The purpose of the demonstration is to establish, for both the CE and the aquaculture industry, the economic and technical feasibility of containment area aquaculture as a noncompetitive multiple use of DMCA. Technical feasibility, from the CE perspective, can be demonstrated only by the successful coexistence of aquaculture with dredged material disposal, the primary function of DMCA. To meet CE needs for additional disposal acreage, this concept would apply primarily to the acquisition of new DMCA, not to retrofitting existing sites to aquaculture use.

Specific objectives of the demonstration include (a) determination of design specifications, site evaluation, and construction methods; (b) development of management strategies that allow aquaculture operations and material disposal to coexist; (c) documentation of construction and production costs to objectively evaluate economic feasibility; and (d) compilation of technical information generated by the demonstration. A series of information transfer documents for use by landowners, potential culturists, and CE District personnel will outline and recommend procedures to allow aquaculture as a multiple use of DMCA.

#### Brownsville Demonstration Project

Site operations are being managed by Mariquest, Inc., under contract to the CE. Two suitable DMCA of approximately 120 acres each were identified along the Brownsville Ship Channel (BSC) for the demonstration (Figure 1). The property is leased from the Brownsville Navigation District (BND) and from private landowners. The western and eastern sites were designated Sites A and B respectively (Figure 2). Both sites had been used for dredged material

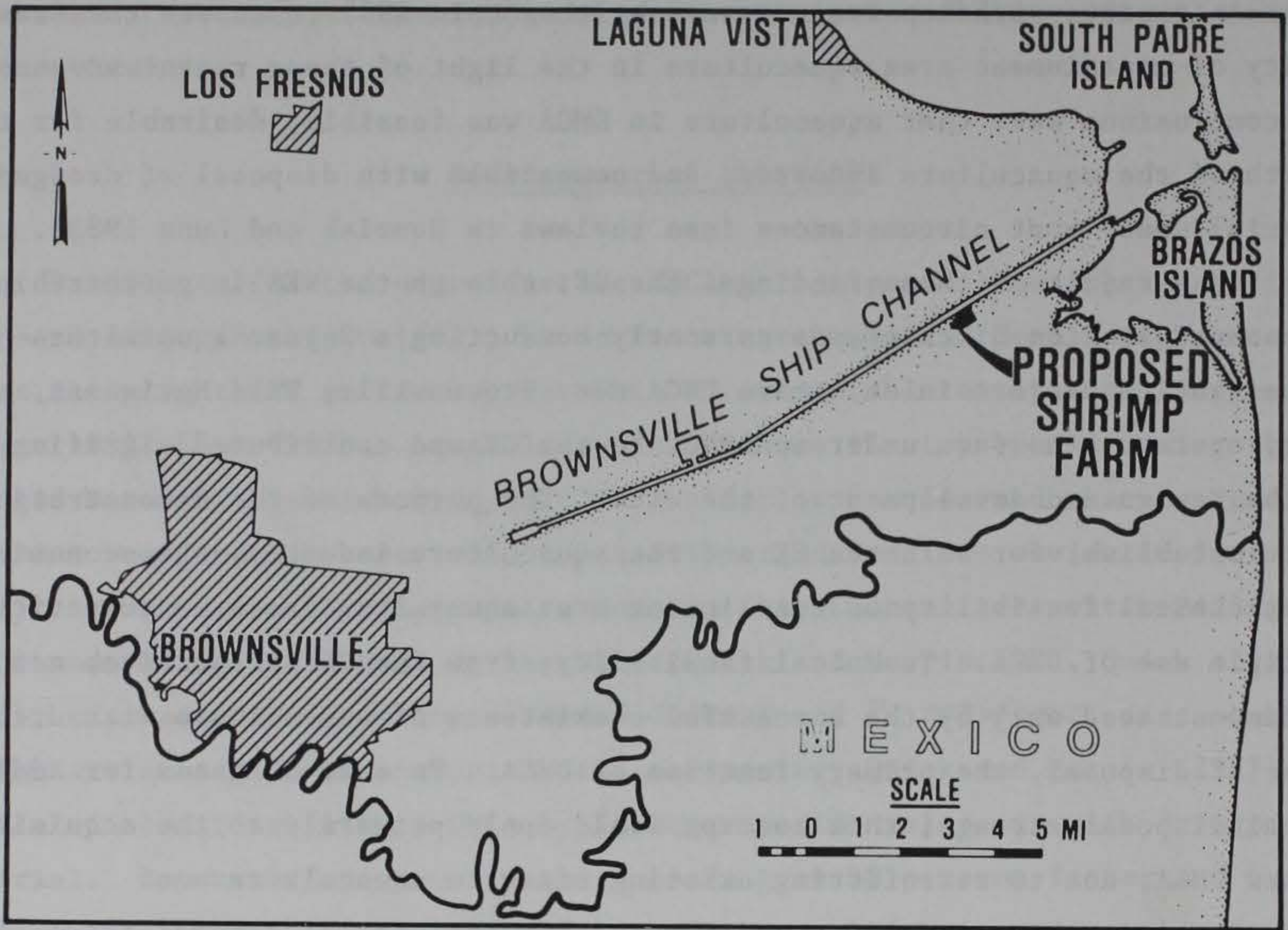


Figure 1. Map of southeast Texas showing location of CAAP shrimp production demonstration facility

disposal in the recent past, and Site B has received material dredged from the BSC in 1987.

A review of water quality and environmental conditions at the BSC is provided by Espey, Huston and Associates (1981) and Bowles (1983). Conditions are suitable for the culture of marine shrimp. Comprehensive chemical and biological sediment analyses (Lee and Jones 1984) did not detect any potential contaminants in the dredged BSC sediments that would affect the health of cultured animals or render the product unfit for consumption.\*

\* Personal Communication, 1988, Dr. Henry Tatem, US Army Engineer Waterways Experiment Station, Vicksburg, MS.

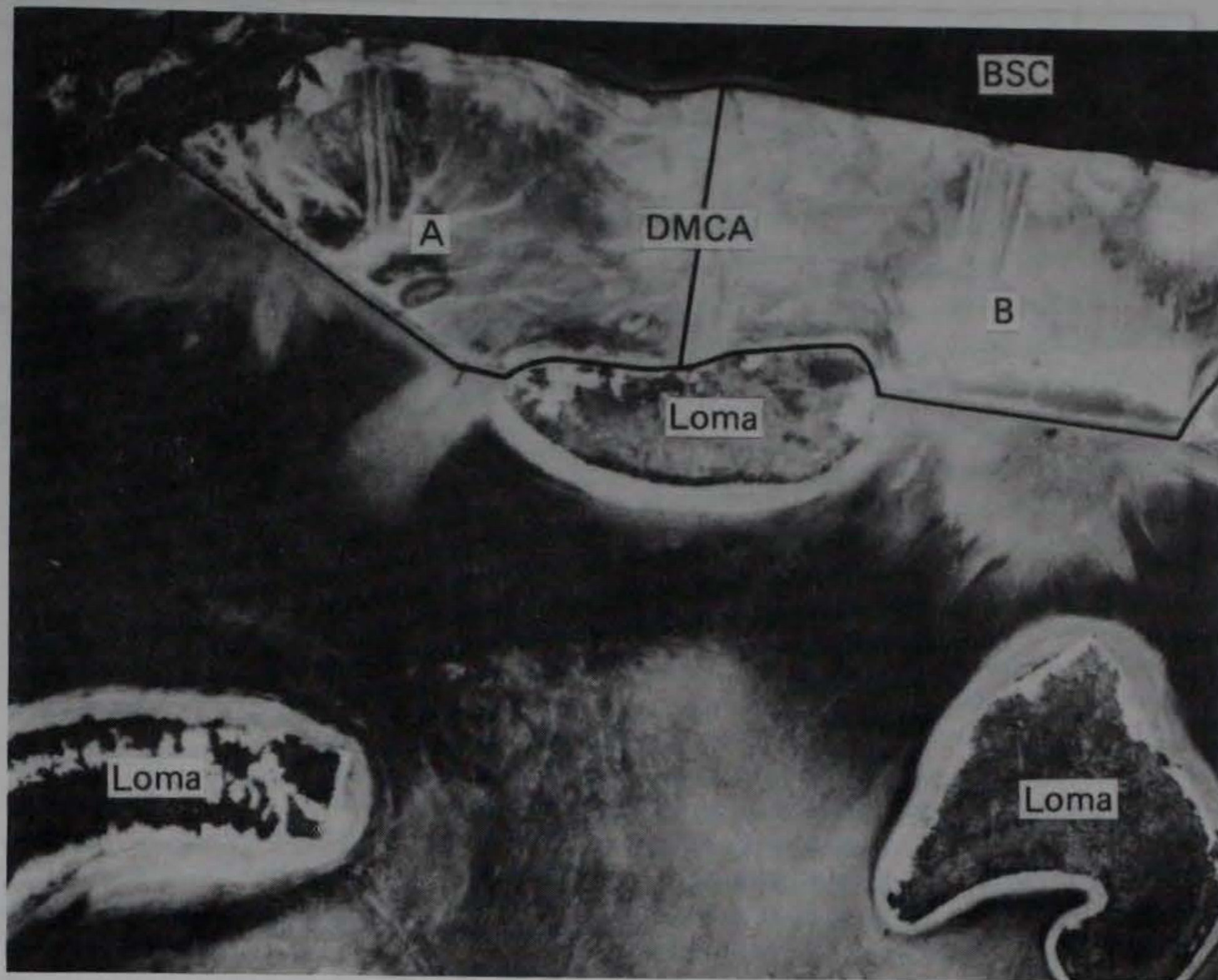


Figure 2. Aerial views of DMCA selected for the demonstration (Sites A and B). The BSC and clay dune areas (LOMA) unsuitable for pond construction are shown. The top of the figure is approximately north

### Construction

Existing works on the sites were modified to accommodate the aquaculture demonstration. The topographic high points along the north levee were removed, and a raised operations area of approximately 2.5 acres was constructed near the northeast corner (Figure 3). A plan sketch of the facility and operations area is shown in Figure 4. Figure 5 provides an overview of the nursery pond and other structures. Water is taken from the intake canal by two 10,000 gpm diesel pumps located in the pumping station and passes through a predator filter system (250- $\mu$  screen) into the water supply canal that supplies the nursery pond and, via a water distribution structure (Figure 6), to ponds A and B or into the nursery pond as needed. The structure also allows juvenile shrimp from the nursery to be directed into either pond. Water levels are maintained, and effluent discharge is through a drain harvest/water control structure (Figure 7) located along the north levee of

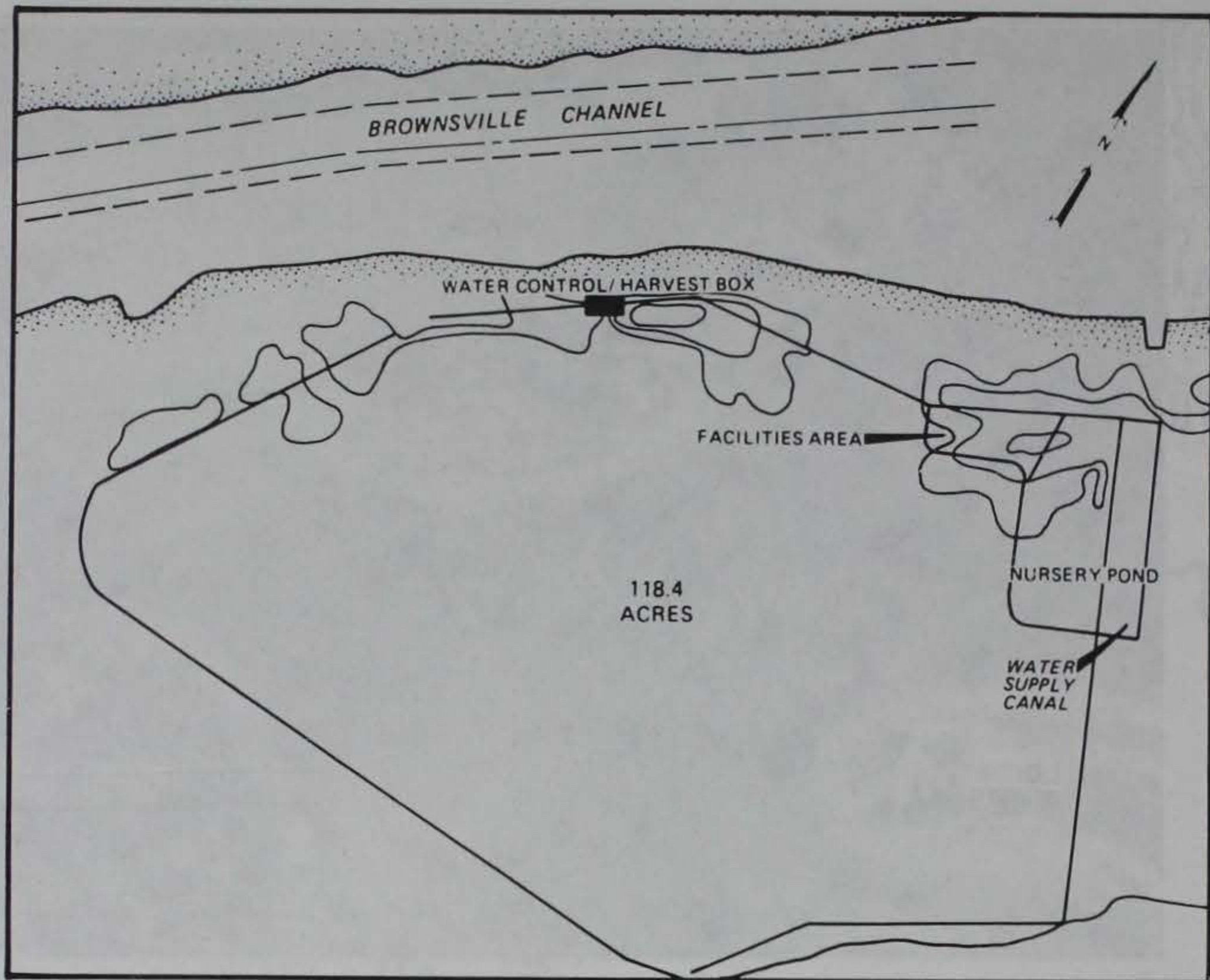


Figure 3. Plan sketch of Site A showing preconstruction elevation contours and locations of the main pond features, including the levees, water control/harvest box, facilities area, nursery pond, and water supply canal

each pond. A harvest basin or sump accommodates the cod end of the harvest net. Support facilities include a boat landing, fuel storage, two 20 kW diesel electric generators, and a desalination system in the pump house, a laboratory/residence trailer, feed storage building with a feed boat dock, and a workshop/storage barn.

The Site A levees, canals and other earthworks were completed by the spring of 1986 (Figure 8). The levees enclose both the main grow-out pond of approximately 104 acres in pond A and a smaller nursery pond of about 4 acres. Work on Site B is in progress (Figure 9), and the approximately 125-acre pond will be in production in 1988.

### Production Plan and Operations

Because of its superior production characteristics (Chamberlain, Hutchins, and Lawrence 1981; Lawrence, McVey, and Huner 1985), a white shrimp,

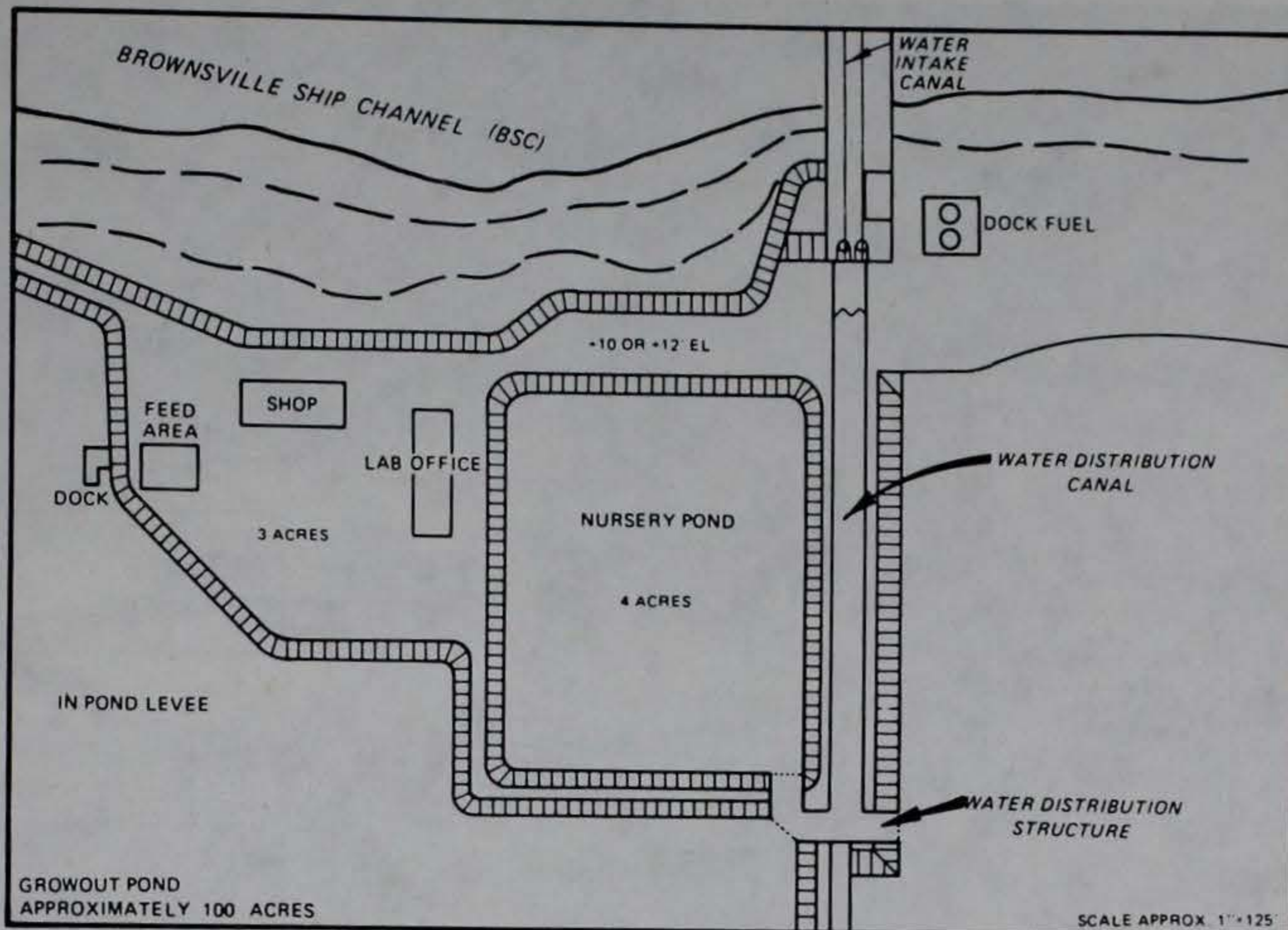


Figure 4. Sketch of the northeast corner of Site A showing details of main production components. Locations of water intake and supply canals, nursery area, facilities and operations management area, pump station, predator filter and water distribution structure in relation to ponds A and B are indicated

*P. vannamei*, was chosen as the primary species for the demonstration. Initial production assumptions included stocking 4-million postlarval *P. vannamei* per crop in the nursery, a crop cycle of approximately 18 weeks (4 to 6 weeks in the nursery pond and the remainder in grow-out), two crop cycles annually, growth averaging 1 g/week over each crop cycle, 50-percent survival, and a feed conversion ratio of 2:1. Production targets were 60,000 to 100,000 lb of whole shrimp in the 31 to 50 tail count size range. These assumptions were fairly conservative and compare with commercial culture practices in south Texas (Chamberlain, Haby, and Miget 1985; Chamberlain 1986). Production plans center on producing two crops annually (Sadeh et al. 1986) from a spring and a summer stocking.

#### 1987

Two semi-intensive crops were produced in 1987 in Site A. The two production periods were a spring stocking (24 weeks from March-September) and a





Figure 5. Aerial view of the nursery pond and main facilities and operations area sketched in Figure 5. The Browns-ville Ship Channel is at the bottom of the photograph.

Pond A is on the right; pond B is on the left

summer stocking (22 weeks from July-December). High salinity (36 to 41 ppt) during the nursery phase of the second crop and an early cold snap in October both significantly affected second crop growth and survival, and thus production. Actual production, in pounds of whole shrimp, was 106,037 lb from the spring stocking and 48,025 lb from the summer stocking. On a per acre basis, spring production was 1,019 lb/acre and summer was 466 lb/acre. Average annual production of whole animals was 77,031 lb/crop and 741 lb/acre. Feed conversion ratios were exceptionally good, at 1.5:1 for the first crop and 0.68:1 for the summer crop. Overall survival (nursery and grow-out combined) was 74 percent and 59 percent for the spring and summer crops, respectively.

Tail weights were 67 percent and 56 percent of total harvested weight for the spring and summer crops. In the spring crop, 81 percent of the harvest was in the 31- to 50-tails/lb range, over 97 percent between 31 to 60 count. The most common sizes were 36 to 40 (29.4 percent) and 41 to 50 (47.8 percent). Tail sizes were smaller and size distributions were very wide

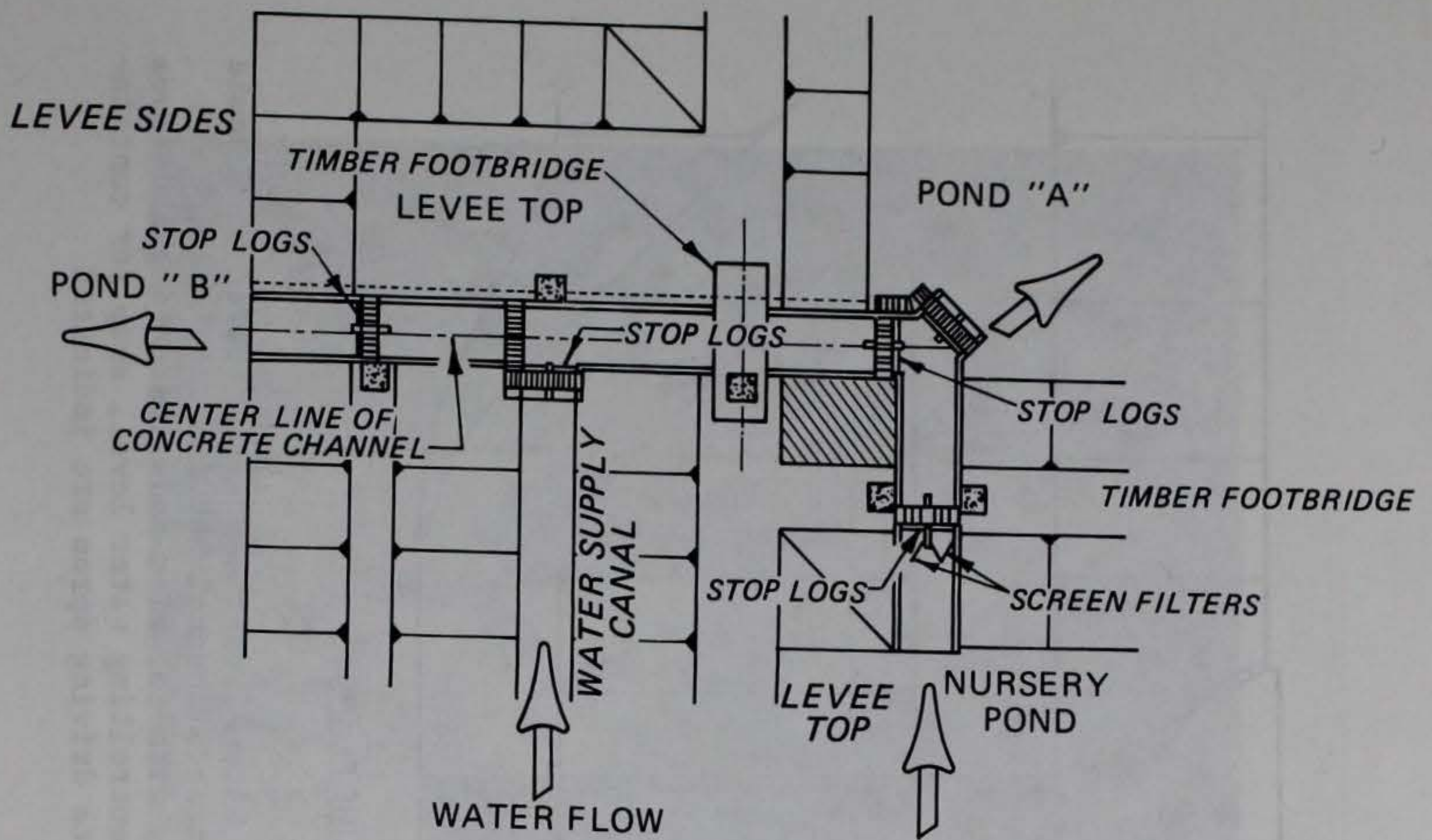


Figure 6. Drawing of the water distribution structure showing the main components, overhead view. Water flow is along bottom of channels (large arrows indicate direction of water flow); sloping levee sides are indicated by "Y"-shaped lines, with the wide ends indicating the levee top. Stop logs adjust water level and thus water flow; screens act to keep shrimp in nursery pond. The design allows the nursery to drain into either pond A or B, or for incoming water to be channeled to fill either or both ponds A and B

in the second crop, with no clear class structure. Tail sizes (including PUD), by percent, for the summer crop are given in Table 1 below.

Table 1  
Percent Distribution of Tail Sizes, Summer Crop

<u>Count</u>	<u>Percent</u>
36-40	14.2
41-50	4.8
51-60	17.4
61-70	13.2
71-80	21.0
>90	33.1

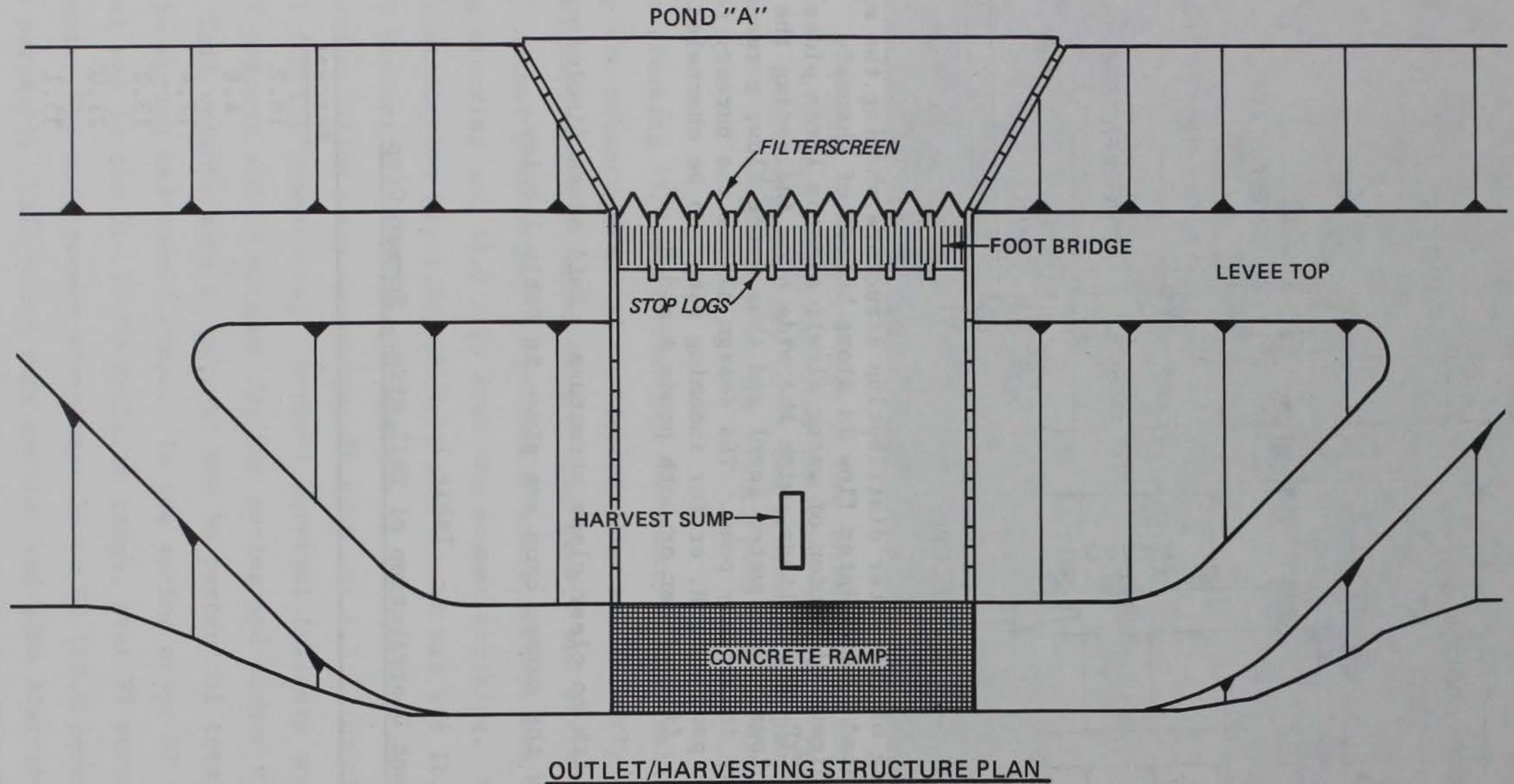


Figure 7. Drawing of the water control/harvest structure at Site A, overhead view. Water flow would be from top to bottom of the drawing. The structure is a concrete channel set into the main pond levee; sloping levee sides are indicated by "Y"-shaped lines, with the wide ends indicating the levee top. Shrimp retaining screens, dam boards (stop logs) for controlling water level, sump for containing the cod end of the harvest net, and the concrete driving apron are indicated



Figure 8. Site A following modifications for aquaculture demonstration. Lines correspond to plan in Figure 3 and trace the levees bounding the main and nursery ponds, the water distribution canal, and the main facilities area.

The BSC and the LOMA are indicated

The quality of the product is excellent: Most of the 1987 crop has been sold at significantly above the market prices. Proceeds from crop sales return to the US government.

#### 1988-89

Site B will be used for two semi-intensive crops in 1988. Production in Site B follows disposal of dredged material in 1987 to test the compatibility of aquaculture with disposal operations. Lessons from the first production year are being incorporated into production plans for upcoming crops. Stocking levels will increase from about 38,000/acre to 48,000/acre in pond B to further improve yields. Growth and survival of *P. vannamei* in the second crop appeared to have been adversely affected by high-salinity conditions experienced in mid and late summer. To resolve this problem, a 5:1 ratio mix of *P. vannamei* and *P. stylirostris*, a species tolerant of higher salinities, will be stocked. Increased stocking densities will compensate for reportedly poorer



Figure 9. Site B under construction. The view is towards the west, with the BSC in the upper left of the photograph and the Gulf of Mexico at the top

survival of *P. stylirostris*. Nursery times will be kept closer to 30 days/crop.

Two semi-intensive crops, an extensive crop and a winter cool water tolerant shrimp crop, are planned for 1988. Crop cycles planned include:

- a. A spring stocking of 6 million (largely *P. vannamei*) in pond B (March-August).
- b. An extensive, low-management effort stocking a mixed 3 million of *P. vannamei* and *P. stylirostris* (May-October/November).
- c. A second semi-intensive stocking of pond B (July-November/December), with a larger proportion of *P. stylirostris*.
- d. A cool water tolerant shrimp crop in either pond (September 1988-April 1989); availability will determine species stocked.

To determine the cost and returns realized from managing DMCA for extensive shrimp culture, pond A will be stocked at low density and managed extensively in 1988. Extensive production trials will run concurrently with semi-intensive operations in pond B. Because operating capital requirements for extensive management are significantly lower than for more intensive culture systems and many pond construction costs are subsidized in containment

area aquaculture, the successful demonstration of an extensively managed shrimp crop may allow for greater participation by small investors/landowners in this program.

The production year will end with a trial crop of cool water tolerant shrimp species (*P. orientalis* or *P. japonicus*, depending on availability of postlarvae) grown over the winter of 1988-89. A successful cool water shrimp crop will allow year-round operations in subtropical regions and will allow shrimp farming in a much larger region. This will allow the results of the DMCA shrimp farming demonstration to be applied directly to a large region of the coastal United States, enhancing the program's ability to acquire and retain real estate for DMCA.

### Conclusion

Significant progress towards the successful demonstration of the commercial possibilities of DMCA aquaculture has been made. A second production year will allow for better estimates of production, identification of problem areas, and improvements in management strategies. Testing various production and stocking scenarios will allow for a thorough economic feasibility analysis. All technology transfer documents are in varying stages of preparation: site selection and acquisition, legal and regulatory requirements for DMCA aquaculture, economic analysis of the demonstration, model budgets for various potential DMCA aquaculture enterprises, and engineering designs and descriptions of project production methods.

Interest in this demonstration within the CE, by local agencies, and by the industry is high. A number of private investors are awaiting this year's trial results before entering into negotiations with the CE and landowners to develop multiple-use DMCA. This clearly indicates that the DMCA aquaculture program is meeting its intended goal. The successful demonstration of the concept on a commercial scale will allow the industry, landowners, dredging sponsors, and the CE to realize the benefits of multiple use of DMCA.

## Literature Cited

- Aquacop. 1985. "Overview of Penaeid Culture Research: Impact on Commercial Culture Activity," Proceedings of the First International Conference on the Culture of Penaeid Prawns/Shrimps 1984, Iloilo City, Philippines, pp 3-10.
- Bowles, W. F. 1983. "Intensive Survey of the Brownsville Ship Channel," Texas Department of Water Resources, Report IS-55.
- Chamberlain, G. W. 1985. "Biology and Control of Shrimp Reproduction," In G. W. Chamberlain, M. G. Haby, and R. J. Miget, eds., Texas Shrimp Farming Manual, Texas Agricultural Extension Service, Texas A&M University Research and Extension Center, Corpus Christi, TX, pp III-1 to III-41.
- \_\_\_\_\_. 1986. "1985 Shrimp Grow-Out Results," Coastal Aquaculture, Vol 3, No. 2, pp 1-9.
- Chamberlain, G. W., Haby, M. G., and Miget, R. J., eds. 1985. Texas Shrimp Farming Manual, Texas Agricultural Extension Service, Texas A&M University Research and Extension Center, Corpus Christi, TX.
- Chamberlain, G. W., Hutchins, D. L., and Lawrence, A. L. 1981. "Mono- and Polyculture of *Penaeus vannamei* and *P. stylirostris* in Ponds," Journal of the World Mariculture Society, Vol 12, pp 251-270.
- Dugger, D. D., and Roegge, M. A. 1983. "Operating a Mariculture Facility in a Dredged Material Containment Site: The Legal Framework," J. Homziak and J. D. Lutz, eds., Aquaculture in Dredged Material Containment Areas, Proceedings, Miscellaneous Paper D-83-2, US Army Engineer Waterways Experiment Station, Vicksburg, MS, pp 29-54.
- Engler, R. M., Patin, T. R., and Theriot, R. F. 1988. "The Corps' Environmental Effects of Dredging Program," Miscellaneous Paper D-88-2, US Army Engineer Waterways Experiment Station, Vicksburg, MS.
- Espey, Huston and Associates. 1981. "Final Environmental Report, Proposed Deep Water Channel and Multi-Purpose Terminal Construction and Operation Near Brownsville, Texas," \_\_\_\_\_.
- Glude, J. B. 1977. "NOAA Aquaculture Plan," National Oceanic and Atmospheric Administration, Washington, DC.
- Griffin, W. L., Lawrence, A. L., and Johns, M. A. 1985. "Economics of Penaeid Culture in the Americas," Proceedings of the First International Conference on the Culture of Penaeid Prawns/Shrimps, 1984, Iloilo City, Philippines, pp 151-160.
- Harrison, R. 1983. "Legal Environment of a Containment Site: Laws Governing the Acquisition, Maintenance, and Operation of Dredged Material Disposal Sites," J. Homziak and J. D. Lutz, eds., Aquaculture in Dredged Material Containment Areas, Proceedings, Miscellaneous Paper D-83-2, US Army Engineer Waterways Experiment Station, Vicksburg, MS, pp 191-196.
- Homziak, J., and Lutz, J. D. 1983. Aquaculture in Dredged Material Containment Areas, Proceedings, Miscellaneous Paper D-83-2, US Army Engineer Waterways Experiment Station, Vicksburg, MS.

- Kyzer, I. B. 1984. "Management of Dredged Material Disposal Areas," In R. L. Montgomery and J. W. Leach, eds, Dredging and Dredged Material Disposal, Proceedings of the Conference Dredging '84, Vol 2, 14-16 November 1984, Clearwater Beach, FL, American Society of Civil Engineers, New York, NY.
- Lawrence, A. L., Johns, M. A., and Griffin, W. L. 1984. "Shrimp Mariculture State of the Art," Sea Grant Publication TAMU-SG-84-502, Texas A&M University, College Station, TX.
- Lawrence, A. L., McVey, J. P., and Huner, J. V. 1985. "Penaeid Shrimp Culture," In J. V. Huner and E. E. Brown, eds., Crustacean and Mollusk Culture in the United States, Avi, Westport, CT.
- Lee, G. F., and Jones, R. A. 1984. "Evaluating the Water Quality Significance of Dredged Sediments," In R. L. Montgomery and J. W. Leach, eds., Dredging and Dredged Material Disposal, Proceedings of the Conference Dredging '84, Vol 2, 14-16 November 1984, Clearwater Beach, FL, American Society of Civil Engineers, New York, NY.
- Lunz, J. D. 1983. "Applicability, Costs and Benefits of Mariculture in Containment Areas," In J. Homziak and J. D. Lunz, eds., Aquaculture in Dredged Material Containment Areas, Proceedings, Miscellaneous Paper D-83-2, US Army Engineer Waterways Experiment Station, Vicksburg, MS.
- Lunz, J. D., and Homziak, J. 1983. "Aquaculture in Dredged Material Containment Areas: An Assessment of the Prospects," Paper presented at Aquaculture '83, Fish Culture Section, Washington, DC.
- Lunz, J. D., and Konikoff, M. 1986. Proceedings of the International Symposium on Ecology and Management of Wetlands, Charleston, SC, July 1986, I. Curl, ed., Croom Helm Ltd., Beckenham, Kent, United Kingdom, pp 292-299.
- Lunz, J. D., Nelson, D. A., and Tatem, H. E. 1984. "Aquaculture in Dredged Material Containment Areas," In R. L. Montgomery and J. W. Leach, eds., Dredging and Dredged Material Disposal, Proceedings of the Conference Dredging '84, Vol 2, 14-16 November 1984, Clearwater Beach, FL, American Society of Civil Engineers, New York, NY.
- McGlew, P. A., and Brown, D. E. 1979. "Legal and Institutional Factors Affecting Mariculture in Texas," Coastal Zone Management Journal, Vol 6, pp 69-88.
- Medina, R. 1983. "Site Description of Dredged Material Containment Areas: An Overview of Physical, Chemical and Biological Features," In J. Homziak and J. D. Lunz, eds., Aquaculture in Dredged Material Containment Areas, Proceedings, Miscellaneous Paper D-83-2, US Army Engineer Waterways Experiment Station, Vicksburg, MS, pp 7-20.
- Milligan, D. 1983. "Selection Criteria and Procedures for Establishing Mariculture Facilities in Existing Containment Areas," In J. Homziak and J. D. Lunz, eds., Aquaculture in Dredged Material Containment Areas, Proceedings, Miscellaneous Paper D-83-2, US Army Engineer Waterways Experiment Station, Vicksburg, MS, pp 153-162.
- National Academy of Science. 1978. "Aquaculture in the United States: Constraints and Opportunities," The National Research Council, Washington, DC.



- Palermo, M. R., Montgomery, R. L., and Poindexter, M. E. 1978. "Guidelines for Designing, Operating, and Managing Dredged Material Containment Areas," Technical Report DS-78-10, US Army Engineer Waterways Experiment Station, Vicksburg, MS.
- Primavera, J. H. 1985. "A Review of Maturation and Reproduction in Closed Thelycum Penaeids," Proceedings of the First International Conference on the Culture of Penaeid Prawns/Shrimps, 1984, Iloilo City, Philippines pp 47-64.
- Quick, J. A., Jr., and Morris, J. A. 1977. "Experimental Extensive Culture of Penaeid Shrimp in a Simulated Dredged Material Disposal Area," Proceedings of the World Mariculture Society, Vol 7, pp 305-325.
- Quick, J. A., Jr., Milligan, D. J., Hill, S. E., Hover, R. J., and McIlhenney, W. F. 1978. "Field Demonstration of Shrimp Mariculture Feasibility in Dredged Material Containment Areas," Technical Report D-78-53, US Army Engineer Waterways Experiment Station, Vicksburg, MS.
- Sadeh, A., Pardy, C. R., Griffin, W. L., and Lawrence, A. L. 1986. "Uncertainty Consideration Resulting from Temperature Variation on Growth of *Penaeus stylirostris* in Ponds," Texas Journal of Science, Vol 38, pp 159-173.
- Stickney, R. R. 1979. Principles of Warm Water Aquaculture, Wiley-Interscience, New York, NY.
- Stickney, R. R., and Davis, J. T. 1981. "Aquaculture in Texas: A Status Report and Development Plan," Sea Grant College Program, Texas A&M University, College Station, TX.
- Tatem, H. E. 1983. "Aquaculture and Dredged Material Containment Sites: Significance of Contaminated Sediments," In J. Homziak and J. D. Lunz, eds., Aquaculture in Dredged Material Containment Areas, Proceedings, Miscellaneous Paper D-83-2, US Army Engineer Waterways Experiment Station, Vicksburg, MS, pp 169-190.
- Walski, T. M., and Schroeder, P. R. 1978. "Weir Design to Maintain Effluent Quality from Dredged Material Containment Areas," Technical Report D-78-18, US Army Engineer Waterways Experiment Station, Vicksburg, MS.
- Wheaton, F. W. 1977. Aquaculture Engineering, Wiley-Interscience, New York.
- Younger, W. R. 1985. "The Permitting Experience: It's a Regulatory Football Game," In G. W. Chamberlain, M. G. Haby, and R. J. Miget, eds., Texas Shrimp Farming Manual, Texas Agricultural Extension Service, Texas A&M University Research Extension Center, Corpus Christi, TX, pp II-7 to II-14.

---

QUESTION (Participant): If you fill the harvest drain structure with additional dredged material, can the structure handle this?

RESPONSE (Richard Coleman): Yes, the structure can handle this.

QUESTION (Jim Gilmore): What type of filter system did you use?

RESPONSE (Richard Coleman): We used a 250- $\mu$  predator control screen, which did a pretty good job.

THIN-LAYER PLACEMENT OF DREDGED MATERIAL:  
A METHOD FOR REDUCED ENVIRONMENTAL IMPACT

Susan Ivester Rees  
US Army Engineer District, Mobile  
Mobile, Alabama

Introduction

The Mobile District is blessed by white sand beaches and highly productive shallow estuarine systems. These features provide significant economic resources in terms of tourism and a vast seafood industry and provide for a quality of life that is closely guarded by the residents of the gulf coast. The blessing, however, becomes a curse when we try to fulfill our mission of maintaining our coastal navigation projects in an environmentally sensitive manner. Annual maintenance requirements of the 21 coastal navigation projects and 340 miles of Gulf Intracoastal Waterway within the Mobile District range between 18 to 20 MCY, the majority of which is fine-grained in nature. This material is placed in a variety of disposal sites including upland, gulf, and open water adjacent to the channels.

Mobile Bay is a submerged river valley located between Mobile and Baldwin Counties in south Alabama. The estuary is approximately 31 miles long in the north-south direction and 23 miles wide at its widest point. The average depth of the bay is 9.7 ft. Mississippi Sound is a lagoon-type estuary of the coasts of Alabama and Mississippi separated from the Gulf of Mexico by five barrier islands and remnants of the St. Bernard subdelta. Mississippi Sound is 81 miles long in the east-west direction and 15 miles wide with an average depth of 9.9 ft (Figure 1). Bottom elevations in these estuaries have remained stable through time except in the navigation channels and areas designated for dredged material placement, where some shallowing has occurred. This is especially true of areas where new work placement has occurred and in areas near the mainland shore. Due to impacts to circulation and water quality, the State of Mississippi has placed a limit on height of disposal areas; i.e., a disposal area may not be elevated such that water depths are less than 4 ft mean low water (mlw).

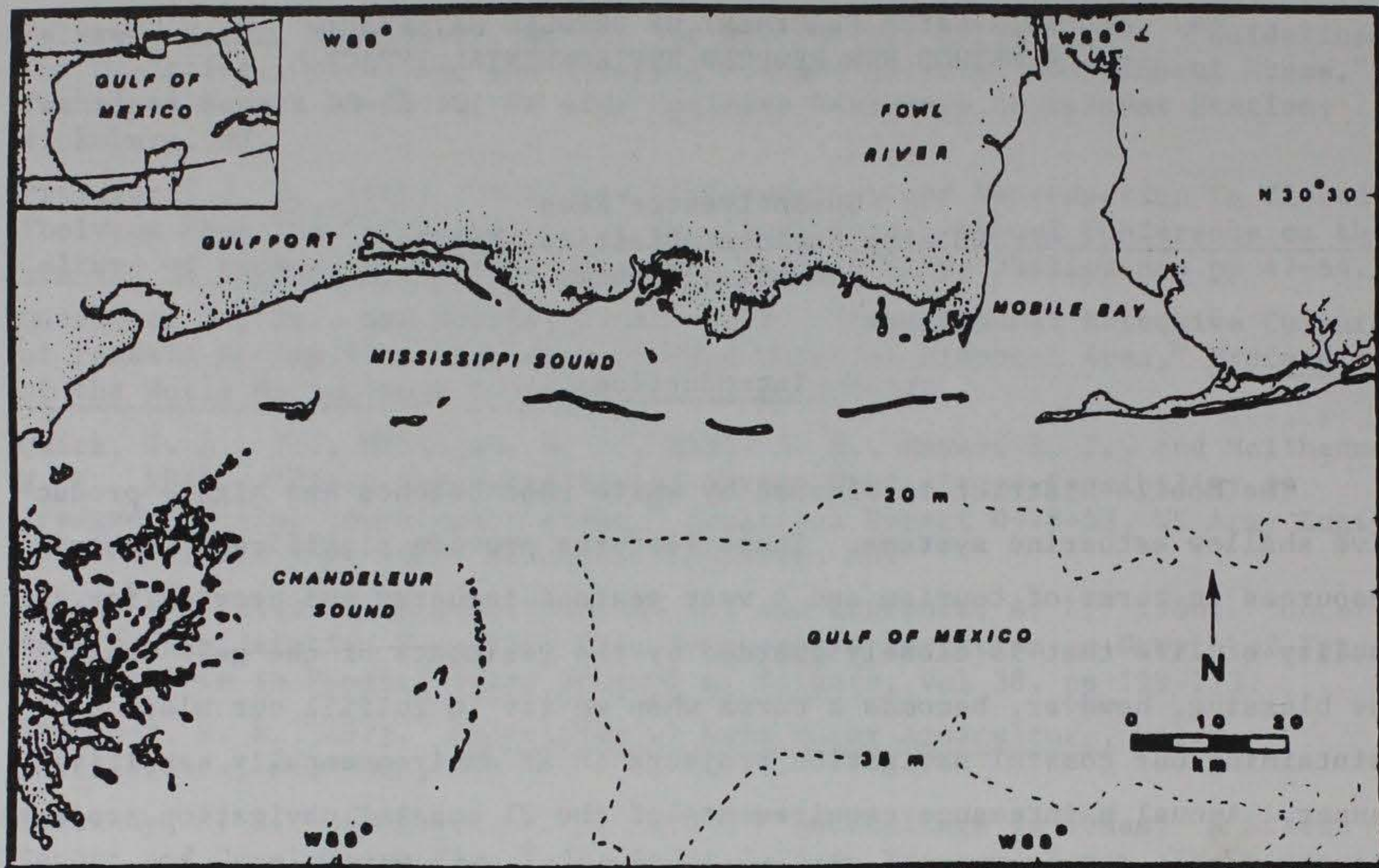


Figure 1. Map of Mobile Bay and Mississippi Sound area

Much of the maintenance dredging within the District is accomplished via open-water disposal in areas adjacent to the navigation channels. This method of disposal has come under increasing opposition from Federal and State environmental agencies and in at least one case had prevented the continued maintenance of a small project on the western shore of Mobile Bay. To provide for long-term maintenance of this project, the Mobile District in cooperation with other agencies developed a compromise plan that included both upland disposal and a modification of the conventional overboard disposal practice. This modification, thin-layer placement, was devised in an effort to reduce the short-term impacts associated with overboard disposal. As part of the compromise plan, an extensive monitoring program was initiated to assess the impacts associated with thin-layer placement. This paper summarizes the methodology utilized to attain the thin-layer and the results of the monitoring program.

#### Compromise Plan

Fowl River is a small coastal stream on the western shore of Mobile Bay (see Figure 1). In 1973, the Mobile District constructed an 8- by 100-ft

channel for commercial fishing and recreational boating interests. At the time of construction, open-water and wetland areas were utilized for dredged material placement. Between 1973 and 1984, the project was maintained only three times. Each time problems with lack of adequate storage in the disposal placement areas were experienced. These problems became extreme, and in 1985 only a portion of the channel was maintained. At this time a dragline was utilized with the dredged material being placed in dump trucks for transport to an off-site disposal area at a cost of approximately \$10.50/cu yd. Approximately 1 week later, Hurricane Elena crossed the area and caused shoaling of the just-maintained project to the point that it was not usable by the commercial fishing fleet. At this point it was evident that to be able to continue maintenance of this project, a long-term dredged material placement plan was essential.

In October 1985, the Mobile District, in coordination with Federal and State regulatory agencies, devised a plan whereby a combination of upland and open-water disposal methods would be utilized during maintenance scheduled for 1986. Past experience has strongly indicated that if mounding with consequent alterations to current and salinity patterns was avoided, open-water placement could be an environmentally acceptable placement technique. In this case the dredged material was to be placed in open water in a thin layer (6 to 12 in.) in an effort to reduce both short- and long-term impacts to the Mobile Bay estuarine system. As part of this compromise plan, an extensive monitoring program was developed to quantify the impacts of thin-layer placement. We believed that thin-layer placement would have smaller impacts than conventional open-water disposal, and if it could be accomplished cost effectively, this method would provide a means of long-term disposal planning at Fowl River and possibly other similar small navigation projects in the Mobile District.

#### Disposal Methodology

Prior to initiation of dredging, a management plan was devised that would result, theoretically, in a lift of dredged material no greater than 12 in. in the designated placement site. A 20-in. portable dredge with plastic dredge pipeline, two ball and bell vertical swivels mounted on pontoon barges, discharge barge with tug assist, and a wing-mounted baffle plate were

utilized in the disposal operation. The plastic line terminated at a swivel joint attached to steel dredge pipe approximately 200 ft long with a baffle spreading device on the outer end (Figure 2).

The plan assumed that every grain of dredged material removed from the channel and pumped to the disposal area would drop directly out of suspension to the bottom at that particular placement point and that dredged materials would exit the pipe in a continuous flow. Production rates were calculated, taking into account type of material to be dredged, depth, and length of channel. These rates varied between 945 cu yd/hr in the western part of the channel, required dredge depth of 14 ft, to 600 cu yd/hr in the eastern limits of the channel, required dredge depth of 10 ft. With this information, we determined that at any specified location the discharge barge would be moved in a 200-ft radius, 300-deg arc about the swivel joint. The discharge barge was moved by means of the baffle, which was attached to winches on the discharge barge and, when needed, with the assistance of the shallow draft tug. After approximately 1 hr, the swivel joint would be relocated to a specified location within the disposal area. In this way the dredged material would be placed in a series of overlapping arcs approximately 400 ft in diameter throughout the designated area.



Figure 2. Swivel joint, discharge barge, and baffle spreading device

## Monitoring Plan

The monitoring plan provided for quantitative information relative to the initial impacts associated with thin-layer placement of dredged material and the recovery of the impacted area through time. The objectives of the monitoring effort were: (a) to assess the changes in sediment characteristics resulting from thin-layer disposal; (b) to evaluate the effectiveness of the particular dredge plant used in attaining a uniform thin-layer overburden; (c) to determine the areal extent of the overburden and changes in distribution of disposed material through time; (d) to determine the persistence of the overburden through time; (e) to assess the impacts of this disposal on benthic resources; (f) to establish the rate and method of recovery of the benthos to preproject levels; and (g) to determine the impact on fishery resources utilization of the area as compared with reference areas. The monitoring plan consisted of five interrelated components: bathymetry; water quality; benthic macroinfauna, including community data, biomass, and sediment particle size; vertical sediment profiling; and fish. Bathymetric surveys were accomplished 2 weeks prior and 6 and 20 weeks after placement. Water quality surveys occurred prior to and during placement. Macroinfauna, vertical sediment profiling, and fish were assessed prior to and 2, 6, 20, and 52 weeks after placement. In addition, to account for the temporal and spatial variation resources within Mobile Bay, the study area was arranged in a series of three areas: the designated disposal area in the center, followed by a fringe area approximately 1,500 ft wide, and in turn by a reference area approximately 2,000 ft wide.

## How Did We Do?

Actual performance of the work resulted in average production rates of 487 and 497 cu yd of material per hour in the 14-ft dredged depth and the 10-ft dredged depth channel sections, respectively. The discharge barge was moved a total of 41 times during the job, indicating that approximately 78 percent, or 184 acres, of the designated disposal area would have been utilized. Detailed bathymetry, performed as part of the monitoring program, however, indicated that approximately 350 acres was impacted by placement of

material varying in thickness from 6 in. to 2 ft. This will be discussed in more detail below.

Results of the three bathymetric surveys identified specified regions of sediment accumulation ranging between 6 in. and approximately 2 ft within both the disposal and surrounding areas, with the greatest accumulation occurring within the disposal area. The 6-week survey showed a sediment covering of 6 in. or greater over a total of 203 acres. Twenty-four percent of this area was covered with greater than 1-ft and 1 percent with 2 ft or greater. The area designated for placement of dredged materials encompassed approximately 240 acres paralleling the channel for 4,000 ft at a distance of 1,050 ft from the southern limit of the channel. Results of the 6-week survey showed that dredged material covered only 82 acres of the designated area. The remaining material was located on approximately 121 areas adjacent to the southeast corner of the designated area. The 20-week survey showed that areas with sediment accumulation of 6 in. or greater decreased to approximately 150 acres. In addition, the total volume of accumulated sediment within the 203 acre area decreased by about 10 percent. These decreases are thought to be due to compaction of the sediments and natural sediment migration and dispersion as a result of tidal currents and wave action.

Comparison of water quality data taken 2 weeks prior to placement operation and during the placement indicates that no significant impacts to dissolved oxygen, temperature, or salinity resulted from the thin-layer placement. It should be noted that Mobile Bay experiences wide fluctuations in these parameters naturally in both short-term and long-term (seasonal) episodes. Total suspended solids concentrations in the disposal plume were significantly higher than background concentrations. These concentrations are highly variable with depth and within the plume. Concentrations were highest nearest the discharge point and down current from that point. Background levels were attained within 800 to 1,600 ft of the discharge.

Macroinfaunal community of the project area is dominated by polychaetes, molluscs, and crustaceans. Dominant forms included *Mediomastus ambiseta*, *Parandalia americana*, *Macoma* sp., *Paramphinome pulchella*, and *Rhynchozoela*. These species are characterized by short generation times, small size, high fecundity, and high larval availability and are characteristic of a physically controlled, middle salinity estuary. The community is usually described as being a Stage I or pioneering sere. The characteristics of such a community

are that they sometimes have eruptive population growth, exhibit a high biomass turnover rate, and are generally tolerant of a variety of physical and chemical perturbations in the environment. A large degree of spatial heterogeneity was observed for the macroinfauna community that could directly be related to the variation in bottom type and depth in the study area. Temporal variability was observed to be greater than the spatial differences in the Fowl River area. Peak abundances were noted in April and September, with lowest abundances in October. Comparing areas that were known to be impacted by the placement of material (via information from bathymetry and sediment profiling) with areas not impacted indicated that numbers of organisms, taxa, and species were reduced in the placement areas. These reductions continued through the 6-week sampling period, but by 20 weeks the areas known to have received dredged material were very similar to areas that had not. Although differences were noted, they were not statistically significant. Variability in individual species, spatial variability, and variation in community structure were not found to be related to the placement of dredged materials. Spatial variability appeared to be more a function of bottom type and depth rather than being related to the disposal operation. Seasonal trends are most likely driven by changes in the physical and chemical environment rather than changes brought about by the placement activities.

Vertical profiles into the bottom of the area suggest that the bottoms are dominated by physical disturbances. Inshore sandy areas were dominated by sand ripples on the order of 1 to 2 cm in height. Muddy areas were characterized by a uniform surface and layering of subsurface sediments. Approximately three to five layers of different grey color tone sediments were observed at most sampling locations.

As described previously, the macroinfauna is considered pioneering or Stage I community development. The presence of burrowing polychaetes, the only subsurface fauna seen in any of the profile photographs, indicated that the total community could be late Stage I. The general nature of the infaunal communities or successional stages did not change from June 1986 to January 1987. Even 3 weeks after disposal, there was evidence that the fauna had burrowed through (up or down) and had recolonized the surface of the dredged material. A broad-scale recolonization even occurred after the placement operation as seen in 2-week postplacement profiles. The entire surface on the reference, fringe, and placement areas was colonized by the capetellid



polychaete *Mediomastus*. Areas that received dredged material were similar with respect to recruitment to areas known to have been unaffected by material placement.

When thicker than a few centimetres, the dredged material was easily recognized by its lighter grey color tone and more uniform texture relative to background sediments. Thin layers, however, were difficult to identify because sediment reworking obscured the signature of the dredged material. This reworking was observed in many of the 2-week postdisposal photographs and continued throughout the study period.

Dominant fish in the area include: bay anchovy, hardhead catfish, fringed flounder, spot, Atlantic croaker, bighead searobin, and least puffer. Placement of dredged material may have had a temporary effect on the utilization of the area by spot, but this did not extend for more than 6 weeks. Fringed flounder and Atlantic croaker showed a highly significant relationship to the placement of material. Approximately 99 percent of all fringed flounder were collected during the 2- and 6-week postdisposal sampling efforts. In addition, a large percentage of the Atlantic croakers were collected during the 6-week postdisposal period. These data suggest that these species were attracted to the study area by the presence of the newly worked dredged material. Alternatively, filter feeders such as the bay anchovy appeared to be displaced from the disposal area after placement of material.

#### What Does It All Mean?

Previous studies on the impact of overboard disposal in the Mobile Bay-Mississippi Sound area indicated that it required from 12 to 18 months for areas to repopulate to near preplacement conditions, a period which many of the regulatory agencies consider unacceptable. Thin-layer placement was developed in an effort to reduce this period, and therefore impacts to the estuarine system, to a level that could be considered acceptable. In addition to resulting in lessened environmental impacts, the technique had to be cost-effective and operationally feasible.

From the information gathered and summarized, we believe that this technique, with some modification, represents a viable alternative to the conventional method of overboard disposal in specific instances. The assumption that every grain of dredged material removed from the channel and pumped to

the disposal area would drop directly out of suspension to the bottom at the particular placement point is not realistic. Information on prevailing currents within the area at the time of disposal and the type material being dredged needs to be utilized in determining the configuration of the placement area and the placement management plan. In addition, better estimates of production and the relationship of production to amount of material placed on the bottom needs to be defined. With better information and additional experience, it should be easy to obtain a specified thin lift within an open-water placement area.

The impacts associated with thin-layer placement of dredged material at Fowl River are short term and localized to the actual area that was covered with dredged material. Considering the natural fluctuations within Mobile Bay, the impacts associated with this operation are within the natural variability of the ecosystem and therefore would not result in unacceptable impacts.

In addition to the Fowl River study, a similar study has been performed at Gulfport, MS, to determine the ability to thin-layer new work materials and the impacts associated with this action. Based on the results of the bathymetric surveys, the benthic invertebrate sampling, and the vertical sediment profiling, dredged material was disposed in the designated disposal area. The thickness of the layer varied between 6 in. to 1 ft based on bathymetry and only slightly greater than 6 in. based on sediment profiling. The layer was only slightly detectable at some sampling locations by the 20-week postplacement survey; however, there was evidence that the sediments were being transported in a southwesterly direction.

Impacts to the benthic community was observed in terms of lowered abundances and slightly lower numbers of species at the sampling locations directly impacted by the placement operation. This observation was corroborated with the biomass data and the vertical sediment profile images in terms of successional stages of the benthos. By the 6-week postplacement survey, some recovery of the benthic community was observed in both an increase in the numbers and kinds of organisms at the impacted stations. By the 20-week postplacement survey, no differences between the disposal, fringe, or reference sites could be detected. This recovery paralleled the disappearance of the dredged materials observed in the bathymetry and sediment profile surveys. In part, the disappearance of the material could be directly attributable to the

biological reworking of the dredged materials, incorporating them with the underlying sediments. In the case of Gulfport, recovery of the area in terms of the macroinfauna was primarily mediated by rapid adult migration into the area and some survival and subsequent migration through the dredged materials. No large-scale larval recruitment was noted, but this was due more perhaps to seasonal factors since the recovery occurred through the winter months.

The impacts on fishery utilization resulting from the thin-layer placement of new work material appear to have been confined to spot and least puffer. This impact was short term as populations that were noticeably low during the 2-week postplacement monitoring period had returned to normal by the 6-week monitoring. There was no observable impact on the fisheries resource as a whole, either short or long term. This reflects the differences in the community types of the benthic macroinfauna and fisheries resource populations. The relative sessile benthic population displayed more sensitivity to the area limited perturbation of thin-layer placement than did the motile fishery resources.

These results confirm that in certain circumstances the thin-layer placement of dredged material in open-water disposal sites results in lessened environmental impacts as well as being an economically viable alternative to conventional overboard disposal.

---

QUESTION (Participant): Would you expect the same results if you dredged the main channel and disposed of the material alongside the channel in the bay throughout the whole length of the channel?

RESPONSE (Susan Ivester Rees): Not really, because I think the scale that you mentioned is much larger, and we would have to proceed on a case-by-case basis.

QUESTION (Participant): Can you tell us how many cubic yards were placed in the thin-layer site?

RESPONSE (Susan Ivester Rees): Approximately 315,000 cu yd, which costs approximately \$400,000 for dredging and \$400,000 for monitoring. This was verified by Mr. Pat Langan, Operations Division, Mobile District.

QUESTION (Thomas Rennie): Was the monitoring program as costly as the dredging operations?

RESPONSE (Susan Ivester Rees): Yes, we entered the monitoring program with all of the agencies agreeing that the results of this program could be

used in other areas. We monitored what we felt were the most important aspects of the concept and the impacts with thin-layer disposal. This was done with full Federal costs.

COMMENT (Susan Ivester Rees): Another similar project with new construction materials has been conducted in Mobile District, but the results have not been received yet.

## THE DREDGING RESEARCH PROGRAM

Lim Vallianos  
US Army Engineer Waterways Experiment Station  
Vicksburg, Mississippi

### A New Start in Dredging Research and Development

This fiscal year (FY 1988), the Corps of Engineers launched a major R&D program to address problems and needs arising in the performance of its dredging mission. This effort, having the title Dredging Research Program, is a major thrust toward developing improved technologies that can effect reductions in the costs of dredging operations. The program focuses on a broad horizon of problem areas related to the physical aspects of dredging or dredging projects. The needs of the Corps in terms of research pertaining to the environmental aspects of dredging will continue to be met through numerous ongoing activities that together are referred to as the Environmental Effects of Dredging Programs. A close coordination of activities and integration of results of the Dredging Research Program and Environmental Effects of Dredging Programs will assure that the attainment of increased cost efficiencies in dredging operations will be consonant with the Corps' environmental responsibilities.

### The Corps Dredging Mission

The US Army Corps of Engineers Directorate of Civil Works is involved in virtually every navigation dredging operation performed in the United States. In total, the Corps' dredging mission entails maintenance and improvement of some 25,000 miles of commercially navigable channels serving some 400 ports, including 130 of the Nation's 150 largest cities. The connecting waterways to our ports and harbors handle about 2-billion tons of commerce each year, as waterborne transport continues to be the most cost- and energy-efficient means of shipping bulk cargoes such as a coal, grains, petroleum products, chemicals, ores, and finished metal products. The significance of this commerce to the economic prosperity of the United States is reflected by statistics which indicate that 20 percent of all jobs in this country depend in some way on

waterborne commerce. In addition, the waterways network constitutes an infrastructure component vital to the Nation's defense capabilities.

To accomplish its task in maintaining and operating the Nation's existing navigation system, the CE dredges, on an average, between 250 and 300 MCY of sedimentary material at a current expenditure level of about \$400 million/year, making dredging the single most costly item in the Corps' civil works operations/maintenance budget. Further, recently authorized improvements to the waterways and harbors of the United States call for new work dredging by the Corps that will demand an average expenditure of \$200 million annually for the next 10-year period. Also, the Corps is directly involved in supporting the US Navy's dredging programs in both maintenance and new work areas.

#### Need for a Dredging Research Program

Though the Corps has had its dredging mission for over 200 years, this organizational responsibility has, in the past two decades, experienced dramatic changes in its relationship with other interests, with its means of execution, and in the variations of dredging work load. Little has to be said of the significant changes in conducting dredging operations and the coordination of such operations with other interests as a result of environmental concerns and controls identified in the National Environmental Policy Act of 1969 and subsequent Federal and non-Federal legislation. In terms of the means of executing the Corps' dredging mission, particularly that portion requiring hopper dredge plant, important changes occurred as the bulk of field operations shifted from the once large government fleet to private sector. With respect to workload variations, a long period in which the Corps' dredging mission was almost totally one of maintaining existing waterways and harbors changed with passage of the Water Resources Development Act of 1986. This legislation, which was several years in the making, authorizes major improvements to existing navigation projects and, as stated previously, calls for new work dredging that will cost about \$2 billion over the next 10 years. Future changes are not expected to be any less dramatic than those that have occurred in recent years. The Corps will continually be challenged in pursuing optimal means of performing its dredging function as the government seeks to reduce budget deficits and as non-Federal interests assume greater financial burdens in support of improving and maintaining navigation projects.

However, these challenges provide vast opportunities for government and private sector to serve the Nation's needs in new and innovative ways. To exploit these opportunities to the fullest extent, the Corps must affirm and enhance its recognized expertise in the operational aspects of dredging. A means toward that end is the implementation of an applied R&D program of a size and scope sufficient to meet the demands of changing conditions and to generate significant technological advances and new directions that will be adopted by all dredging interests. The Corps took such action in response to the environmental concerns and pressures of over a decade ago, and the result was a position of world leadership that continues today.

### Development of a Dredging Research Program

The concept of the Dredging Research Program emerged from the leadership of the Corps' Dredging Division, which was at that time a component of the Water Resources Support Center but has recently been assigned to the Directorate of Civil Works. Developing a large research program is a complex process involving many organizational elements having interests and functional roles in the general area to be investigated. Accordingly, the Dredging Division and the Directorate of Research and Development began over 3 years ago to bring such elements together in a coordinated effort to develop a program consistent with the Corps' broad base of dredging research needs. Specifically, the program formulation was the product of contributions from the Corps' operating Division and District offices having dredging responsibilities; the staff of the Dredging Division; and elements of the Directorates of Civil Works, Engineering and Construction, and Research and Development. Additionally, as the program was taking shape, the Coastal Engineering Research Board endorsed such a program in response to a charge from the Chief of Engineers to identify areas with high potential for large paybacks on the investment of Corps research dollars.

The primary benchmark set for development of the program was that, however structured, the program would be directed at providing improved technologies for needs identified by the primary Corps users, namely, the field operating Division and District offices. Numerous means were used to garner research needs from the field operating offices. These included meetings, workshops, the dredging establishment's computer conferencing system,

correspondence, and telephone communications. The needs identification process was iterative, beginning with a compilation of over 60 potential research topics and associated priorities. Over time, these potential topics were screened and rescreened to arrive at a program consisting of the highest priority topics appropriate for government research and one that was of manageable scope and within realistic budgetary limits. In this connection, the problems identified by the field offices and counterpart headquarter Directorates were provided to the Directorate of Research and Development to formulate into specific applied research work units describing objectives, research methodologies, expected user products, and task/cost schedules. The Directorate of Research and Development delegated the primary responsibility for accomplishing this task to the WES, which prepared the basic research documentation. The documentation was reviewed by the various organizational elements participating in program development and adjusted as required, preparatory to final program formulation. On finalizing descriptions of the research activities and costs, the WES prepared a proposal document entitled "Dredging Research Program Development Report" dated September 1986. This document recommended a research program to be conducted over a finite time span of 6 years at a total cost of about \$35 million.

#### Authorization of the Dredging Research Program

After review and approval of the Dredging Research Program proposal by the Director of Civil Works, it was submitted to the Office of the Assistant Secretary of the Army for Civil Works where it was favorably received and in turn presented to the Office of Management and Budget. The Office of Management and Budget endorsed the recommended Dredging Research Program and included it as a \$3 million line item in the President's FY 88 budget proposal to the Congress, where again, it found favorable reception and support at the \$3-million level. Finally the Dredging Research Program was authorized as a \$3-million new start effort on 22 December 1987, when the President signed into law the Permanent FY 1988 Continuing Resolution.



## Technical Components of the Dredging Research Program

The Dredging Research Program's technical structure consists of five problem areas of investigation, each of which is composed of work units that are generically similar and, in some cases, interdependent. Currently, there are 23 work units in the entire program. Those presently participating in accomplishing this research effort include the following:

- a. US Army Engineer Waterways Experiment Station.
  - (1) Coastal Engineering Research Center.
  - (2) Hydraulics Laboratory.
  - (3) Geotechnical Laboratory.
  - (4) Environmental Laboratory.
- b. Engineer Topographic Laboratories.
- c. Corps of Engineers Districts and Divisions.
- d. Various Research and Development contractors.

Other elements of the Corps may be involved in the Dredging Research Program at a later date. An outline of the current program activities is provided below in terms of problem areas, related work units, and their objectives.

### Problem area 1-- analysis of dredged material disposed in open waters

- a. Calculation of boundary layer properties. To develop better methods of calculating boundary layer properties for analyzing behavior of submerged disposal areas.
- b. Measurement of entrainment and transport. Acquisition of field site data sets for input to improving the calculations of boundary layer properties--to include near-bottom shear stress, fluid motion, bed form, and sediment concentration.
- c. Numerical simulation techniques for evaluating short-term fate and stability of dredged material disposed in open waters. Improvement of computational methods to predict short-term (minutes to hours) fate of dredged material released from individual operations in both coastal and estuarine environments.
- d. Numerical simulation techniques for evaluating long-term fate and stability of dredged material disposed in open waters. Improvement of computational methods to predict fate of disposed material in open-water sites for periods of months to years.
- e. Field techniques and data analysis to assess open-water disposal. Collection and analysis of synoptic data over field sites as input to improving simulation methods and development of improved site monitoring techniques.

Problem area 2--material properties related to navigation and dredging

- a. Rapid depth and density measurements in fluff and fluid mud. Development of instrumentation and operating procedures for rapid surveys of the properties of fluid mud deposits in navigation projects.
- b. Definition of navigable depth in fine-grain sediment. Determination of navigable depth by criteria relating properties of fluff or fluid mud deposits to their effects on vessel motion.
- c. Rapid measurement of properties of consolidated sediments. Development of an electronic package to send and analyze acoustic signals to obtain subaqueous geotechnical information such as density, shear strength, and grain-size characteristics.
- d. Descriptors for bottom sediments to be dredged. Establishment of standard dredging-related soil descriptors and the correlation of these descriptors with dredging equipment performance.
- e. Descriptors for rock material to be dredged. Establishment of standard dredging-related rock descriptors and the correlation of the descriptors to the mechanical dredgability of rock.

Problem area 3--dredge plant equipment and system processes

- a. Improved draghead design. Improving the efficiency of dragheads working in compacted fine sands, in cohesive muds, and, when working, in deepened channels.
- b. Improved educators for sand bypassing. Design, fabrication, and field testing new-generation eductor system for sand bypassing.
- c. Increased dredge payload for fine-grain sediments. Develop procedures, designs, and/or appurtenances to increase hopper bin or barge payloads when dredging fine-grain sediments.
- d. Dredging manuals. Preparation of manuals containing state-of-knowledge technology for performing dredging projects.
- e. Portable single-point mooring buoy for hopper dredge direct pump-out. Develop design for a portable, direct pump-out single-point mooring buoy and anchor system to facilitate beach nourishment and nearshore disposal from hopper dredges.

Problem area 4--vessel positioning, survey controls, and dredge monitoring systems

- a. Integrated vertical control and seastate system. Development of a real-time system for measuring and reporting project site tide and wave conditions in offshore open waters.
- b. Horizontal/vertical positioning system utilizing GPS satellite constellation. Development of a three-dimensional dynamic positioning system for dredging and hydrographic surveying operations that does not require a series of shore stations for positional reference.

- c. Production meter technology. Evaluation of accuracy and reliability of production meters when used in a variety of dredging situations with emphasis on inspection/management applications.
- d. Technology for monitoring hopper loads. Defining and assembling new reliable systems that will provide real-time monitoring of draft and sediment densities in hopper loads and dump scows.
- e. Silent inspector. Development of a standard, unmanned contract monitoring and reporting system that can be used on any type of dredge equipped with a minimum complement of process and position instrumentation.

Problem area 5 -  
management of dredging projects

- a. Operations research description of dredging project management. Development of a comprehensive model of dredging project management activities that can predict effects of decisions or incremental project changes on the total project cost.
- b. Open-water disposal site planning, design, and operation. Development of overall guidance for optimizing utilization of open-water disposal sites.
- c. Analysis of dredging cost estimating techniques. Review of technical aspects and methods used in the cost-estimating procedure as a basis of identifying where further research may be needed to make the cost-estimating procedure more consistent, technically defensible, and rigorous.

Technology Transfer

The effectiveness of a quality research program can be measured by the timeliness with which its findings reach the primary users and the extent to which the users apply those findings. The Dredging Research Program will utilize various media to assure expedient transfer of results and methods to facilitate their utilization. Specifically, results of the program will, as appropriate for the case, be presented in: a periodic bulletin; manuals; specifications; technical reports; technical notes; miscellaneous papers; computer software and user guides; instructional videotapes; lectured training courses, meetings, workshops, and symposia; and one-stop consultations by the program manager and principal investigators.

## Program Management Structure

The Dredging Research Program is managed through a hierarchical structure beginning at the upper tier with programmatic responsibilities vested in a group of three primary and four advisory technical monitors representing the Directorates of Civil Works and Engineering and Construction, Office of the Chief of Engineers. As mentioned in regard to program development, the constituent elements of the Dredging Research Program primarily reflect needs and associated priorities arising from the Corps' operating Division and District offices. This will continue to be the case throughout the life of the program. Accordingly, a group of 15 field representatives referred to as the Field Review Group has been delegated to serve as an advisory and review body reporting to and assisting the technical monitors in performing their overall management function. Beyond the programmatic level, execution of the research effort has a management progression that begins at the Directorate of Research and Development and flows to the management infrastructure of the Corps laboratories engaged in the program. Overall responsibility for execution of the Dredging Research Program is assigned to the WES, where the day-to-day program activities are directed by the program manager. Assisting the program manager in the general technical direction of the Dredging Research Program is the Interlaboratory Standing Committee, consisting of 10 supervisory-level representatives of the WES laboratories and support groups involved in the Dredging Research Program. Detailed technical oversight of the program is delegated to five technical managers who are respectively assigned to each basic problem area and who report directly to the program manager. The technical managers are also active principal investigators in one or more work units within their problem area. The names and organizations of the individuals comprising the management structure described above are given on the attached listing.

TECHNICAL MONITORS AND ADVISORS  
HEADQUARTERS, US ARMY CORPS OF ENGINEERS

Directorate of Civil Works

John Perez  
Operations & Readiness Division

Rixie Hardy  
Operations & Readiness Division

Don Pommer (Advisory)  
Operations & Readiness Division

Directorate of  
Engineering and Construction

M. K. Miles (Advisory)  
Engineering Division

Glenn Drummond  
Engineering Division

Benjamin Kelly (Advisory)  
Engineering Division

FIELD REVIEW GROUP  
DIVISION AND DISTRICT OFFICES

Henry R. Schorr  
New Orleans District

Robert J. Hopman  
North Pacific Division

Robert A. Neal  
North Central Division

Ronn Vann  
Norfolk District

Larry A. Rabalais  
Lower Miss. Valley Division

Douglas M. Pirie  
South Pacific Division

James W. Erwin  
South Atlantic Division

H. Ronald Kreh  
Philadelphia District

Barry W. Holliday  
Wilmington District

Herbie A. Maurer  
Galveston District

I. Braxton Kyzer  
Charleston District

Pat Langan  
Mobile District

Vyto Andreliunas  
New England Division

Charles E. Settoon  
New Orleans District

Fred Weinmann  
Seattle District

NOTE: All DRP information on pages 266 and 267 has been updated for February 1990.

DIRECTORATE OF RESEARCH AND DEVELOPMENT  
OFFICE OF CHIEF OF ENGINEERS

Jesse A. Pfeiffer  
Civil Works Program

PROGRAM MANAGER  
WATERWAYS EXPERIMENT STATION

Clark McNair  
Coastal Engineering Research Center

ASSISTANT PROGRAM MANAGER  
Carolyn Holmes  
Coastal Engineering Research Center

INTERLABORATORY STANDING COMMITTEE  
WATERWAYS EXPERIMENT STATION

Charles C. Calhoun, Jr.  
Coastal Engineering Research Center

Thomas W. Richardson  
Coastal Engineering Research Center

H. Lee Butler  
Coastal Engineering Research Center

Richard A. Sager  
Hydraulics Laboratory

William H. McAnally  
Hydraulics Laboratory

William D. Martin  
Hydraulics Laboratory

Paul F. Hadala  
Geotechnical Laboratory

Robert M. Engler  
Environmental Laboratory

Monroe B. Savage  
Instrumentation Services Division

Paul K. Senter  
Information Technology Laboratory

TECHNICAL MANAGERS  
WATERWAYS EXPERIMENT STATION

Nicholas C. Kraus  
Coastal Engineering Research Center  
Technical Area 1

Don C. Banks  
Geotechnical Laboratory  
Technical Area 2

Virginia R. Pankow  
Hydraulics Laboratory  
Technical Area 3

Andrew W. Garcia  
Coastal Engineering Research Center  
Technical Area 4

Michael J. Trawle  
Coastal Engineering Research Center  
Technical Area 5

## THE CORPS/EPA FIELD VERIFICATION PROGRAM (FVP)

Robert L. Lazor  
US Army Engineer Waterways Experiment Station  
Vicksburg, Mississippi

### Introduction

Evaluation of proposed dredged material discharges under Section 103 of the Ocean Dumping Act and Section 404 of the Clean Water Act requires field-verified, state-of-the-practice procedures for predicting and assessing environmental effects. The FVP is a cooperative effort between the US Army Corps of Engineers (CE) and the US Environmental Protection Agency (EPA) to field verify various testing procedures for implementing Section 404 and 103 requirements. Promising evaluative procedures were applied to a maintenance dredging operation near New Haven, CT. There, the impacts of a highly contaminated sediment placed in upland, wetland, and aquatic disposal environments were tested. The FVP is a 6-year program initiated in 1982.

### Objectives

The three objectives of the FVP are to: (a) document in the laboratory predictive methods for assessing the effects of disposal of contaminated dredged material, (b) verify these methods in the field following disposal, and (c) conduct a comparative assessment of dredged material disposal in aquatic, wetland, and confined upland disposal environments.

### Project Description

The dredging site was Black Rock Harbor (BRH), located in Bridgeport, CT, where maintenance dredging provided a channel 46 m wide and 5.2 m deep at mlw (Figure 1). Approximately 55,000 cu m of material was dredged during April and May 1983 and deposited in 20 m of water in the northeastern corner of the Central Long Island Sound (CLIS). The CLIS is a historical open-water dredged material disposal site (1.8 by 3.7 km), located approximately 15 km southeast of New Haven, CT (Figure 1). Bathymetric profiles associated with

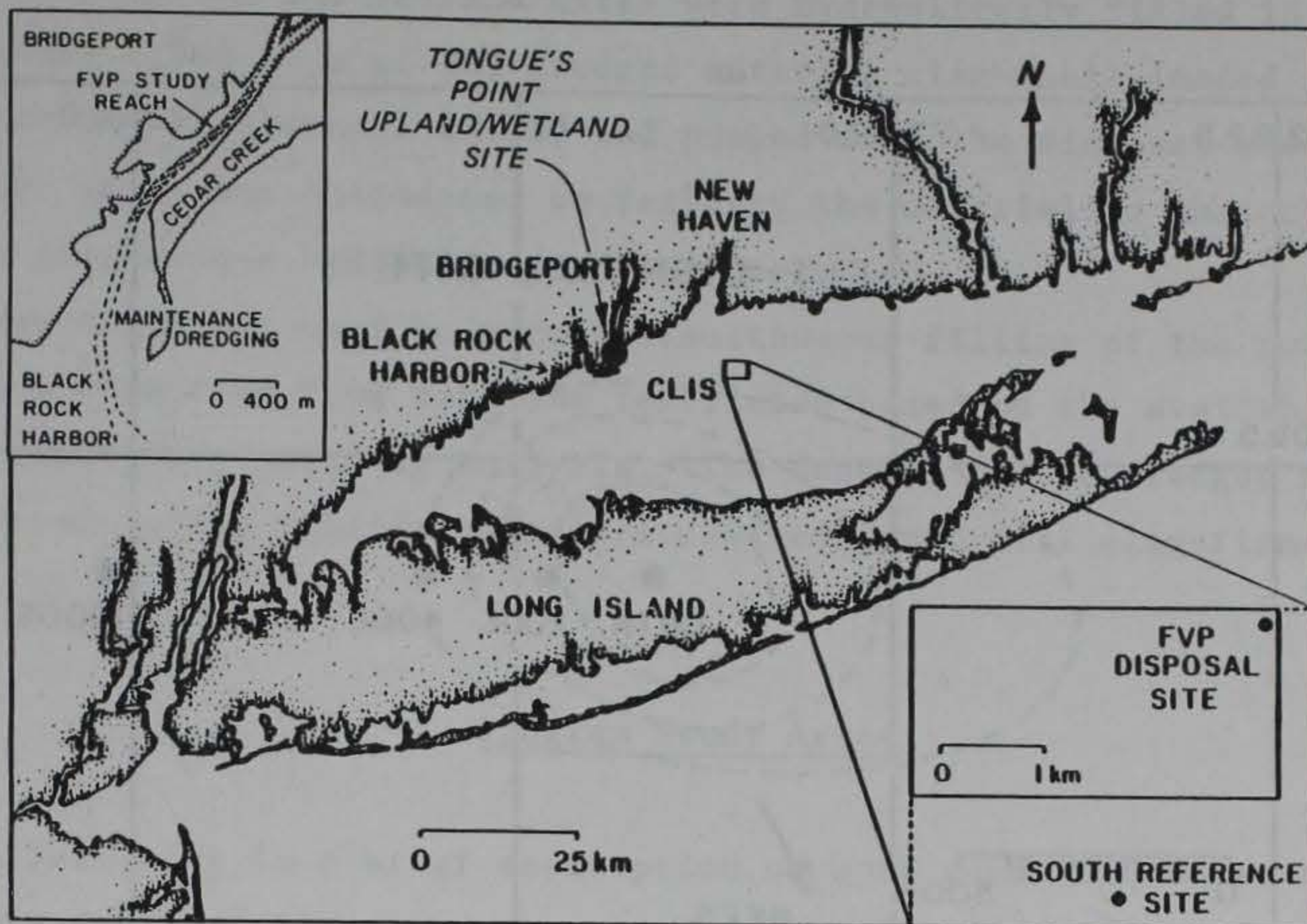


Figure 1. Central Long Island Sound (CLIS) disposal site and BRH dredge site

the CLIS open-water site are provided in Figure 2. The sediment was clam-shell dredged and deposited with bottom-opening barges.

Two confined upland/wetland disposal sites were constructed at Tongue's Point, CT, adjacent to Bridgeport Harbor, and located approximately 6 km from the Black Rock Harbor Channel (Figure 1). The upland/wetland sites were created by grading and dike construction along the desired alignments (Figure 3). Material was excavated from the area planned for the wetland to allow placing dredged material at elevations suitable for wetland substrate. The excavated material was used to construct the upland dikes to contain dredged material at elevations suitable for upland disposal area.

The upland site has a surface area of approximately 2,418 sq m within the inside dike toes. The bottom of the site was graded to elevation plus 2.13 m mlw. The depth of the dredged material was approximately 0.91 m following disposal, sedimentation, and consolidation. The wetland site had a surface area of approximately 744 sq m within the inside excavation toes. The bottom of the site was graded to approximately elevation plus 0.91 m mlw. The depth of the dredged material fill was also 0.91 m following sedimentation and consolidation.



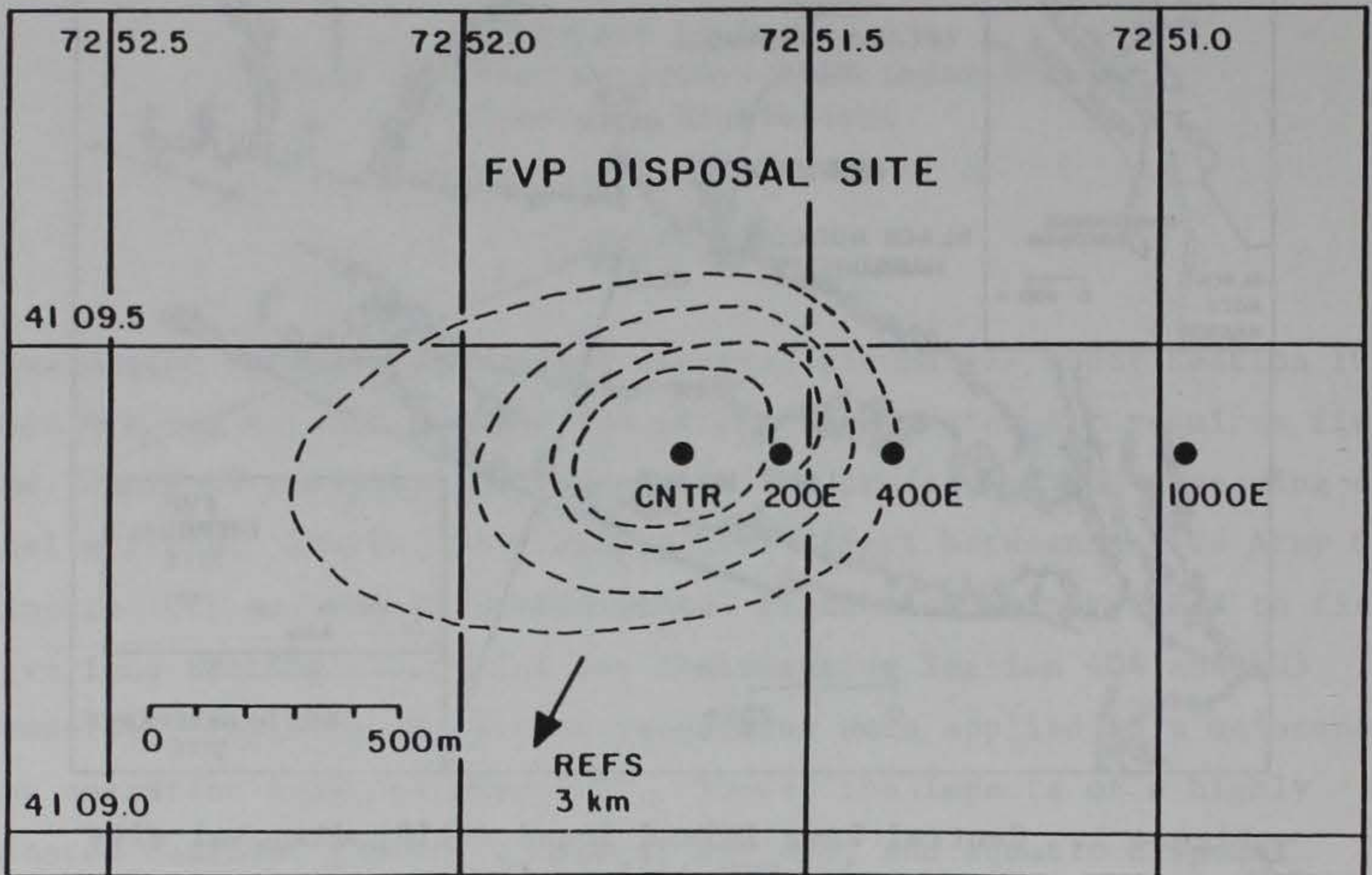


Figure 2. FVP disposal site

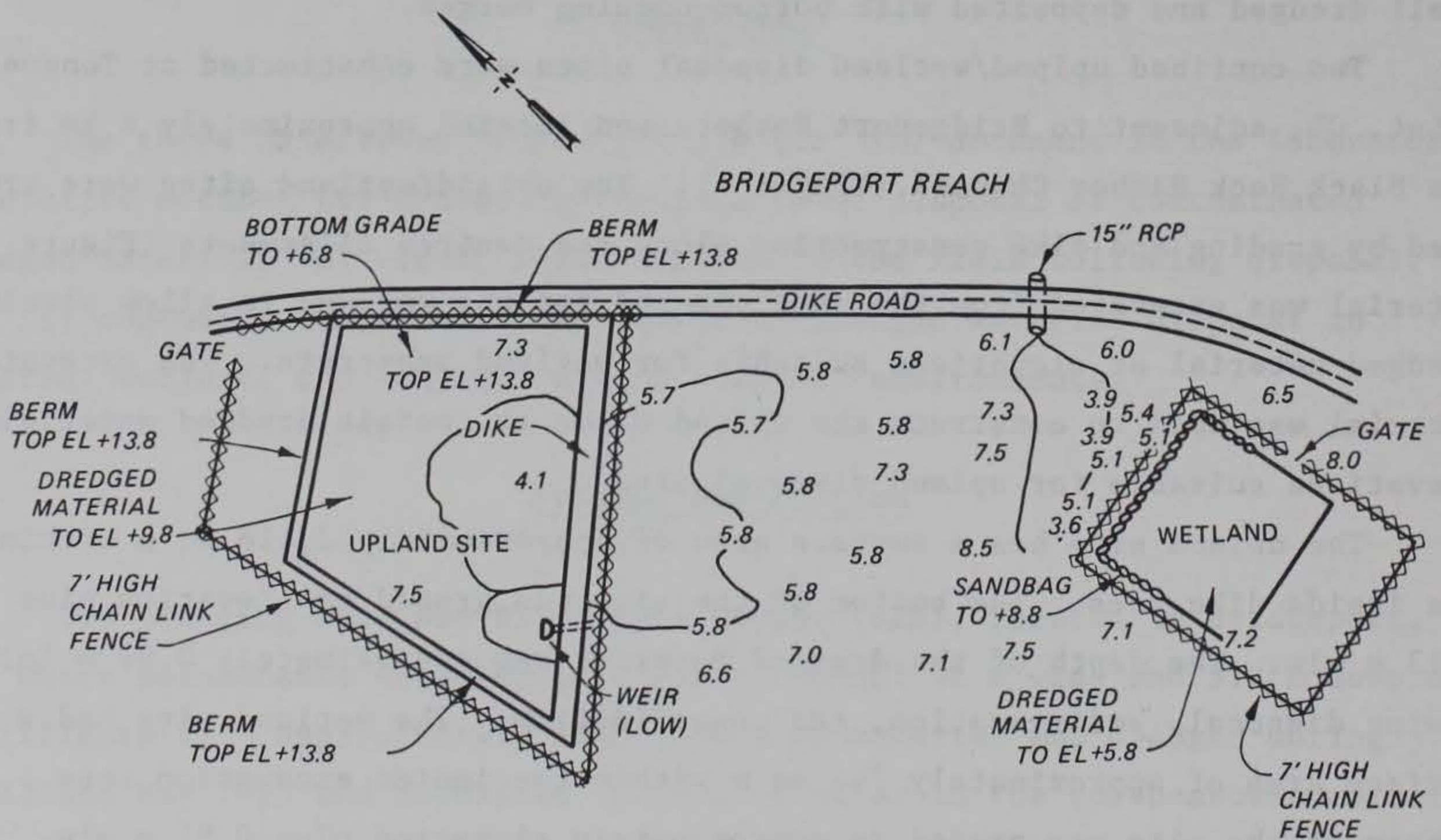


Figure 3. Bridgeport Harbor

The two upland and wetland sites were hydraulically filled in 1983 with approximately 4,590 cu m of BRH dredged material clam-shell loaded into scows, transported to the disposal sites, and pumped into the disposal areas. Adjacent harbor water was introduced to reslurry the material so that the pumping operation simulated a hydraulic dredging operation.

A wye valve was used to permit simultaneous filling of the two areas. The maximum effective flow rate was restricted based on the available surface area and laboratory settling analysis. The density of the dredged material was monitored during filling to ensure desired final fill elevations and density.

### Program Study Areas

The following is a brief description of work conducted under the FVP. More detailed descriptions, summary, and synthesis of findings of the FVP will be reported in the Proceedings of the Sixth International Ocean Disposal Symposium (in preparation).

#### Aquatic (open-water) disposal studies

Studies included in this work area address: (a) bioaccumulation of contaminants by aquatic animals, (b) consequences of bioaccumulation in aquatic animals, and (c) effects of aquatic disposal on community structures.

Bioaccumulation of contaminants by aquatic animals. Levels of bioaccumulation of selected contaminants over time, the biological and physical factors affecting bioaccumulation, and the variability of bioaccumulation predictions were documented in the laboratory. Bioaccumulation has been determined under field conditions and compared with laboratory predictions to verify the accuracy of the prediction methods. These studies have been conducted by the EPA's Environmental Research Laboratory at Narragansett (ERLN), RI. The ERLN is the lead EPA laboratory for research on aquatic disposal.

Consequences of bioaccumulation in aquatic animals. Several physiological indices of biological health were tested in organisms that have accumulated contaminants from dredged material. These indices, previously developed by EPA for use in nondredged material regulatory programs, include: scope for growth (an energy assessment of physiological impacts), genetic and reproductive effects, enzyme systems, and histopathological parameters. These responses have been investigated both in the laboratory and the field.

Effects of aquatic disposal on community structures. The effects of contaminated dredged material disposal on community structure and recolonization were determined by measuring mortality, reproduction, and intrinsic rate of growth in selected populations within aquatic communities. These assessments, conducted by ERLN, have been documented in the laboratory and verified in the field.

#### Upland disposal and wetland creation studies

Studies conducted by WES include work on the: (a) effects of upland disposal on water quality, (b) bioaccumulation of contaminants in upland and wetland plants, and (c) bioaccumulation of contaminants in upland and wetland animals.

Effects of upland disposal on water quality. Laboratory tests for predicting effluent quality were conducted on BRH sediments prior to placement in the confined disposal area. The confined disposal area was designed, operated, and managed to ensure optimum fill configuration for the field studies and evaluation of water quality effects. During filling operations, water quality parameters were monitored extensively for influent and effluent and at selected stations within the disposal area. Following disposal, the quality of surface water runoff was determined by controlled simulation of rainfall and collection of surface water samples. Monitoring wells were placed around and within the disposal area, and ground-water samples collected prior to, during, and after filling.

Bioaccumulation of contaminants in upland and wetland plants. First generation test procedures were verified at the field site, and laboratory bioassay tests were conducted under wetland and upland conditions. Field bioassay tests were conducted to verify laboratory test results.

Bioaccumulation of contaminants in upland and wetland animals. Existing upland and wetland laboratory animal bioassay test results were field tested for verification. Laboratory procedures developed in Europe included those using selected upland and wetland animals.

## The FVP Program Synthesis

Results of the aquatic, wetland, and upland studies will be synthesized in an FVP Synthesis Report and will provide a comparative assessment of effects associated with the various disposal options.

### Bibliography

- Dillon, T. M. 1986. "The Field Verification Program - A Progress Report on the Aquatic Disposal Alternative," Environmental Effects of Dredging Programs, Information Exchange Bulletin D-86-2, US Army Engineer Waterways Experiment Station, Vicksburg, MS.
- Folsom, B. L., Jr., and Lee, C. R. 1986. "Plant Bioassay of Dredged Material," Environmental Effects of Dredging, Technical Note EEDP-02-1, US Army Engineer Waterways Experiment Station, Vicksburg, MS.
- Gentile, J. H., Scott, K. J., Lussier, S., Redmond, M. 1985. "Application of Population Responses for Evaluating the Effects of Dredged Material," Technical Report D-85-8, prepared by the US Environmental Protection Agency, Narragansett, RI, for the US Army Engineer Waterways Experiment Station, Vicksburg, MS.
- Johns, D. M., Gutjahr-Gobell, R., Schauer, P. S. 1985. "Use of Bioenergetics to Investigate the Impact of Dredged Material on Benthic Species: A Laboratory Study," Technical Report D-85-7, prepared by the US Environmental Protection Agency, Narragansett, RI, for the US Army Engineer Waterways Experiment Station, Vicksburg, MS.
- Lake, J., Hoffman, G. L., and Schimmel, S. C. 1985. "Bioaccumulation of Contaminants from Black Rock Harbor Dredged Material by Mussels and Polychaetes," Technical Report D-85-2, prepared by the US Environmental Protection Agency, Narragansett, RI, for the US Army Engineer Waterways Experiment Station, Vicksburg, MS.
- Nelson, W. G., Black, D., and Phelps, D. 1985. "Utility of Scope for Growth Index to Assess the Physiological Impact of Black Rock Harbor Suspended Sediment on the Blue Mussel, *Mytilus edulis*: A Laboratory Evaluation," Technical Report D-85-6, prepared by the US Environmental Protection Agency, Narragansett, RI, for the US Army Engineer Waterways Experiment Station, Vicksburg, MS.
- Palermo, M. R. 1984. "Sites Constructed for FVP Upland/Wetland Studies," Environmental Effects of Dredging Programs, Information Exchange Bulletin D-84-1, US Army Engineer Waterways Experiment Station, Vicksburg, MS.
- \_\_\_\_\_ . 1986. "The Field Verification Program - Containment Area Effluent Quality," Environmental Effects of Dredging Programs, Information Exchange Bulletin D-86-4, US Army Engineer Waterways Experiment Station, Vicksburg, MS.

Peddicord, R. K. 1982. "Expanded Field Studies to Be Conducted at Black Rock Harbor," Dredged Material Research, Information Exchange Bulletin D-82-2, US Army Engineer Waterways Experiment Station, Vicksburg, MS.

Pesch, G. G., Muller, C., Pesch, C. E., Heltshe, J., and Schauer, P. S. 1985. "Application of Sister Chromatid Exchange in Marine Polychaetes to Black Rock Harbor Sediment: Laboratory Documentation Phase," Technical Report D-85-1, prepared by the US Environmental Protection Agency, Narragansett, RI, for the US Army Engineer Waterways Experiment Station, Vicksburg, MS.

Rhett, R. G., Simmers, J. W., and Lee, C. R. 1986. "Upland Bioassays of Dredged Material," Environmental Effects of Dredging, Technical Note EEDP-02-2, US Army Engineer Waterways Experiment Station, Vicksburg, MS.

Rogerson, P. F., Schimmel, S. C., and Hoffman, G. L. 1985. "Chemical and Biological Characterization of Black Rock Harbor Dredged Material," Technical Report D-85-9, prepared by the US Environmental Protection Agency, Narragansett, RI, for the US Army Engineer Waterways Experiment Station, Vicksburg, MS.

Scott, John, et al. 1987. "Impact of Open-Water Disposal of Black Rock Harbor Dredged Material on Benthic Recolonization at the FVP Site," Technical Report D-87-4, prepared by the US Environmental Protection Agency, Narragansett, RI, for the US Army Engineer Waterways Experiment Station, Vicksburg, MS.

Simmers, J. W., Rhett, R. G., and Lee, C. R. 1986. "Wetland Animal Bioassay of Saltwater Dredged Material," Environmental Effects of Dredging, Technical Note EEDP-03-1, US Army Engineer Waterways Experiment Station, Vicksburg, MS.

Simmers, J. W., et al. 1987. "The Field Verification Program - A Progress Report on the Confined Upland and Wetland Creation Disposal Alternatives," Environmental Effects of Dredging Programs, Information Exchange Bulletin D-87-3, US Army Engineer Waterways Experiment Station, Vicksburg, MS.

Skogerboe, J. G., Lee, C. R., and Price, R. A. 1986. "Upland Disposal Site Management for Surface Runoff Water Quality, Environmental Effects of Dredging, Technical Note EEDP-02-3, US Army Engineer Waterways Experiment Station, Vicksburg, MS.

Zarogian, G. E., Pesch, C. E., Schauer, P. S., and Black, D. 1985. "Laboratory Evaluation of Adenylate Energy Charge as a Test for Stress in *Mytilus edulis* and *Nephtys incisa* Treated with Dredged Material," Technical Report D-85-3, prepared by the US Environmental Protection Agency, Narragansett, RI, for the US Army Engineer Waterways Experiment Station, Vicksburg, MS.

## NEW FEDERAL REGULATIONS ON DREDGING

Joseph R. Wilson  
US Army Corps of Engineers  
Washington, DC

### Introduction

On 26 April 1988, the Corps published final changes to our maintenance dredging and disposal regulations in the Federal Register. The changes revise and update the 1974 rule which provided a regulatory framework for establishing compliance with environmental laws, presidential executive orders, and other agency regulations.

Since the Corps issued the existing dredging regulation in 1974 for Corps projects, numerous environmental laws, regulations, policy changes, and court actions have occurred. Before discussing the applicable laws and how we addressed compliance with those laws, I would like to briefly define the objectives of the final rules.

- a. Provide a framework for establishing environmental compliance. This regulation was designed to provide a step-by-step procedure to ensure full compliance with the applicable environmental laws and regulations. This includes compliance with state procedures administered under the Clean Water Act (CWA) and Coastal Zone Management Act (CZMA).
- b. Address problems identified since the last revision. This regulation clarifies and corrects problems in the environmental aspects of the national dredging program that have occurred since the rules were issued in 1974.
- c. Provide currency with laws and regulations. This regulation implements changes that have occurred in the environmental laws and regulations. This includes policy and administrative changes that have occurred in the Corps since 1974.
- d. Implement research and development. As many of you know, the Corps has spent a great deal, something in excess of \$100 million through Congressional appropriations over the past 15 years, on pure and applied research regarding dredging and evaluation of the environmental consequences of disposal. We believe this research should play an important role in determining dredged material disposal options. Unfortunately, to date, this research has not had the influence on disposal site selection and use that we believe Congress contemplated. Continued maintenance of some Corps navigation projects will depend upon our ability to find cost-effective, environmentally responsible dredged material disposal sites. We are hopeful that, through the new dredging regulations, this past and

on-going research will play a more important role in the ultimate selection of dredged material disposal options.

- e. Assure a clear distinction between dredged material disposal and fill activities. The assumptions for dredged material disposal and fill activities are different. Dredging involves relocating naturally occurring sediments. Fill activities, on the other hand, involve intentionally replacing an aquatic area with dry land. We have attempted to stay away from the controversial issues associated with the Corps' Section 404 regulatory program, particularly those issues associated with fill activities.
- f. Develop a management strategy for contaminated dredged material. Several of our ports and harbors contain highly contaminated sediments. The Corps has been working for a number of years developing a management strategy to deal with these highly contaminated materials. In August of 1985, the Water Resources Support Center through the WES completed a testing protocol and management strategy for contaminated dredged material. We plan to incorporate this management strategy into the regulation.
- g. Establish an ocean dumping policy and procedures. The Ocean Dumping Act (ODA) provides authority in Section 103 for the Corps to designate ocean dredged material disposal sites in the event that EPA designated sites are not feasible for use. The Corps has not exercised full flexibility in ocean disposal site designations. The regulation addresses this concern and the need to ensure that cost-effective and environmentally acceptable ocean sites are available when needed through updating our procedures for such Corps designation actions.
- h. Ensure compliance with State CWA and CZMA procedures. The Corps and many states have been experiencing difficulty communicating respective authorities and responsibilities under the CWA and CZMA with regard to administration of these laws. We have developed procedures for implementing the CWA and CZMA that recognize the authority of State agencies while requiring the states to be responsive to Corps' requests for certification. This is a major area of controversy with both the states and the Corps.
- i. Address State ownership of dredged material. In some instances, the Corps has been required to seek State land use permits for dredging in State waters. We do not believe that moving naturally occurring sediments from a Federal navigation project affects State ownership of the material to the degree that movement necessitates specific State approval.
- j. Address long-term disposal site designation. As the traditionally used upland disposal sites reach capacity, the Corps must develop innovative approaches for disposal of the large volumes of dredged material generated annually. The disposal sites for many of our navigation projects are specified on a year-to-year basis. This method of site location is expensive, time-consuming, and unpredictable. The Director of Civil Works recently approved an in-depth study to include demonstration projects that will result in detailed policy and procedure as guidance on long-term disposal site

selections. This initiative will also include the dredged material disposal needs of local interests.

- k. Resolve overlapping jurisdiction in the territorial sea. In some cases, the jurisdiction of one environmental law overlaps that of another. The most notable is the CWA and ODA in the territorial sea. In some instances environmental evaluations have been conducted under both statutes. In developing environmental legislation, Congress often provided high levels of protection for one media (CWA, CZMA, Clean Air Act, etc.) without consideration for the other media. This is especially troublesome with regards to dredged material disposal. We are trying to establish the multimedia assessment approach where all alternatives are considered on an equal basis.
- l. Reaffirm the importance of navigation. Over the past several years we have not given proper attention to the Federal responsibility and the Congressional mandate for maintaining a safe, reliable, and economically efficient interstate navigation system.

#### Laws That Apply to Dredging Activities

I would like to discuss how the proposed dredging regulation meets these objectives. I should point out that these objectives or problem areas are manifest through the environmental laws. Although more than 25 laws and executive orders apply to dredging and disposal activities, only about 10 require documentation and/or public coordination to demonstrate compliance.

I will talk briefly about each of the laws that require documentation or public coordination and discuss how the proposed regulation updates the 1974 rule.

#### The National Environmental Policy Act

The NEPA requires full disclosure and public involvement in the documentation process. The environment must be fully considered in decision making. During the past several years, a number of Corps field offices have been updating and revising NEPA documents that were determined to be outdated. No such requirement exists in NEPA or the implementing council on environmental quality or Corps NEPA regulations. The NEPA documents are only revised when there are sufficient changes in the dredging or disposal plan to warrant re-evaluation under NEPA. Such decisions are made on a case-by-case basis.

#### River and Harbor Act (permits only)

The River and Harbor Act requires a permit for structures or work in navigable waters. This law is primarily focused towards protection of



navigation. The River and Harbor Act allows the Corps to assure that such permitted work will not have an unacceptable impact on navigation. I mention the River and Harbor Act because it provides the basic charter for Federal involvement in activities affecting navigation.

#### Clean Water Act

The CWA regulates the discharge of dredged or fill material in waters of the United States and wetlands. Regulated activities must be coordinated with the public, and discharge sites must be specified through the 404(b)(1) guidelines. The CWA also requires that the Corps seek (and I emphasize seek) water quality certification from the State for discharges of dredged material. The Corps has been experiencing a number of difficulties with the states in several specific areas under the CWA:

- a. The amount of time allowed the states to act on requests for water quality certification. We assert in the regulation that the states are allowed 6 months as a maximum. The CWA allows a reasonable period of time, but no more than 1 year. Our regulation will allow 2 months as a reasonable period of time and 6 months as a maximum.
- b. The type of information that should be supplied to the states to support our request for certification. We believe that the Corps' public notice and information from the 404(b)(1) evaluation report that demonstrates compliance with established State water quality standards is sufficient.
- c. The proposed rule also establishes the new term "Federal Standard" that we will be using as a guide in formulating environmentally acceptable alternatives. This approach will ensure a desired level of national consistency in our dredged material management. When State agencies attempt to impose unreasonable conditions, controls, or requirements above those required by Federal law, we will be asking the State or the local sponsor to fund the additional requirements.

#### Coastal Zone Management Act

Activities affecting a state's coastal zone must be certified as complying with the CZMA. Regulated activities must be coordinated with the public. We are experiencing problems under the CZMA that are similar to those under the CWA. In essence, we do not believe that the Corps should plea on bended knee for permits from the states to maintain navigation. The major area of controversy with the regulation is with the states over the proposed CWA and CZMA changes.

#### Endangered Species Act

The Endangered Species Act requires that activities be conducted so as not to jeopardize the continued existence of threatened or endangered species.

There is a formal procedure for compliance with the Endangered Species Act. Our intent in the proposed rule is to assure that this formal procedure is followed, but at the same time avoid conducting unnecessary endangered species surveys.

#### Fish and Wildlife Coordination Act

This Act requires that Federal agencies consult with the USFWS and the State Fish and Game Agency and consider their recommendations in decision making. This Act requires that we fully consider the concerns of the USFWS and State Fish and Game Agencies. We are not bound by their recommendations. Furthermore, we have clarified that funding is not required for fish and wildlife coordination activities under the maintenance dredging program. Fish and game agency concerns are considered along with other public interest factors.

#### Historic Resource Laws

These laws provide for protection of properties listed on the National Register of Historic Places and provide that unidentified significant historic resources eligible for listing on the National Register not be adversely affected. The proposed rules clarify that historic resource investigations are not normally required for previously constructed navigation projects and previously used disposal areas. The advisory council on historic preservation has advised us that the term "cultural resources" is vague and misleading and that the term "historic properties" should be used instead to more accurately reflect those properties that are accorded protection under the historic preservation acts.

#### Ocean Dumping Act

The ODA provides for regulation of the transportation for disposal of dredged material in ocean waters. Regulated activities must be coordinated with the public and specified as complying with environmental criteria developed by EPA in coordination with the Corps of Engineers. We are working with EPA on proposed revisions to these ocean disposal criteria. As part of this proposal, the Corps would publish a separate regulation addressing the need for and alternatives to ocean disposal for dredged material. We envision such a regulation to take the form of a coastal dredged material management philosophy, as this involves weighing and balancing alternatives.

#### Wild and Scenic Rivers Act of 1976

This Act requires that activities not adversely affect values for which a wild and scenic river was established. This Act is administered by the

National Park Service, and a wild and scenic river inventory is kept by that agency.

#### Coastal Barrier Resources Act of 1982

This Act prohibits activities that promote development on listed coastal barrier islands. Although maintenance dredging is exempted, new work dredging is not. The USFWS administers this Act. Presently, there are 159 "units" comprising about 740,000 acres and 681 miles of ocean-facing shoreline on the Atlantic and gulf coasts protected under the Act.

#### Water Resources Development Act of 1986

The WRDA requires cost-sharing for deep draft navigation projects.

#### Water Quality Act of 1987

The Water Quality Act (WQA) of 1987 establishes a number of programs to expand and strengthen the CWA. Several of these programs, listed below, affect Corps activities.

- a. Nonpoint source pollution. The WQA authorizes funding for State implementation of nonpoint source programs. States must develop programs to implement best management practices by August 1988.
- b. Estuaries. The WQA sets up a national estuary program requiring implementation of regional management plans to include consideration of disposal activities with each identified estuary.
- c. Storm water runoff. The EPA will promulgate regulations governing permit application requirements for storm water discharges associated with industrial activity by February 1989.

Now that you have an understanding of the Federal laws that apply to maintenance dredging and disposal activities, I would like to briefly describe how the Corps dredging regulation may benefit the national dredging program and our project sponsors.

Many of the states under the CWA and CZMA have been imposing excessive conditions and controls as a prerequisite to their required approvals. The regulation provides Corps field offices with uniform procedures for negotiating with State agencies. Such procedures will also notify the State agencies of the Corps' course of action when State agency requirements exceed those necessary in establishing alternatives through the Federal environmental compliance process. The State water quality and coastal zone certification procedures should result in more timely dredging of most navigation projects.

The term "Federal Standard" should prove invaluable to management of the Corps' national dredging program. When negotiating conditions, controls, requirements, mitigation, etc., we do not have a standard from which to

evaluate agency comments. This new term will provide a baseline from which the Corps can negotiate. The Federal standard is defined as the dredged material disposal alternative(s) identified by the Corps which represents the least costly alternative consistent with sound engineering practices and meeting environmental standards mandated by the CWA or ODA.

The proposed revisions establish procedures for inclusion of project beneficiaries in the environmental compliance process for Corps projects. This is a follow-up on a 1984 initiative of Mr. Gianelli, the former Assistant Secretary of the Army (Civil Works). The evaluation of the related activity will include compliance with the substantive requirements of the permits regulations so that the necessary Corps compliance process is completed.

We are establishing procedures that provide guidance on the development of regional general authorizations based on intended navigation project purposes. Conceptually, the District Engineer would geographically specify the navigation project boundaries. These areas would generally include port facilities, industrial canals, etc., adjacent to navigation channels. Activities that would fulfill the intended project purposes would be authorized on a categorical basis, such as maintenance dredging and disposal in designated disposal areas, mooring dolphins, wharves, site development fills, etc. These general authorizations differ from regional general permits in that they would authorize all categories of activities in a specific geographic region based on the intended Corps project purposes instead of a single activity in a geographic region. This process would also notify prospective applicants of parameters for development in specified geographic regions.

Finally, we are hopeful that the regulation revision will encourage those in the private sector seeking a Corps Section 404 permit to follow our lead with regards to evaluating and testing of dredged material. With our experience and the significant Congressional appropriations for dredging and disposal research, we view ourselves as leaders in determining the appropriate tests to be conducted on dredged material and determination of the most feasible locations for disposal.

FEDERAL, STATE, AND INDUSTRY PANEL: CONCLUSIONS AND OBSERVATIONS

Dr. Sammy Ray (Panel Moderator)

In concluding this last session, I was thinking of looking at things from different perspectives. I have not had much experience in delving with problems associated with dredged material, and I remembered Frank Wheeler's comments that dredged material was soil that had been submerged and was valuable, and we need to keep it where it is. Additionally, when Charles Groat started talking, I had already made up my mind and had made some comment yesterday that the thing that we can do is to not let that material get in the waterways and we not have to deal with it. I once thought that was a viable approach, but after Charles Groat started to talk, and I began to feel sorry for Louisiana because this water does not have as much silt as it used to and that is why our marshes are having their problems. Then after the excellent talk by Dean McClindon, I thought that he was right in "let's keep that material" and let Charles Groat in Louisiana find some other way. In other words, what is valuable in Iowa may not be valuable in other areas.

Dr. Charles Groat  
(Louisiana Department  
of Natural Resources)

Perhaps the easiest way for Louisiana to deal with its marsh loss problems is to pipe the 400 MCY of dredged material from other areas in the United States to Louisiana. This would be less controversial than putting it in the river.

The bad news that Louisiana has the most marsh loss of any states is countered by the good news that Louisiana probably has the easiest time coming to some consensus with what we should do to beneficially use dredged material in Louisiana. We have more options for more sites and less controversial disposal sites in terms of impacts of disposal sites. We strongly believe in Louisiana that we should restore wetlands in Louisiana rather than letting them degrade into other environments. We wish to enhance wetland development in Louisiana, and the problem in Louisiana is not what to do with dredged material but how to pay for it. Under the existing economic environment and navigation limitations with dredged material, where you are constrained by an acceptable method not necessarily by commonly acceptable methods which cost

more money, we have to find some way to agree on sites, which is easy, but to agree on a way that is beneficial to all interests with proportionate funding.

Finally, in summary, in Louisiana we can find the sites, the acceptable uses, and this is being done now. The question is how we can do that on a big enough scale to be meaningful and be economically sound and thereby solve one of the biggest problems in its history.

Dr. William Kruczynski  
(Environmental Protection Agency)

I am going to present the perspective of the EPA on beneficial uses of dredged material.

The EPA is a partner with the Corps in the dredge and fill program. Our responsibility is to review Section 10/404 permit applications and Federal dredging projects for compliance with environmental guidelines. We also designate offshore disposal sites for ocean dumping of dredged materials.

Some recent statistics on the volume of dredged material are interesting. Annually, approximately 400-million cu yd of material is dredged from waters of the United States. Approximately 90 percent of that material is from maintenance of existing channels and 10 percent is from new work. Sixty-four percent of this volume is generated from the Gulf of Mexico. Therefore, it is very appropriate to hold this meeting on the gulf coast; this is where the problem is. Twenty-one percent is generated in the Atlantic Ocean and 15 percent from the Pacific Ocean.

Approximately 60 percent of all dredging is conducted in estuaries. Estuaries receive and accumulate the sediment load of rivers that discharge into them. We support the notion that others have addressed at this conference, namely that pollution should be addressed at the source. If we are overwhelmed with the volume of material to be dredged and this material is the result of erosion, then we need to implement strong programs to regulate erosion. If we are successful in limiting the amount of material washing into our waterways, then we may not be faced with as many difficult decisions concerning where we can dispose of this material and cause the least environmental harm.

Estuaries are very productive biological systems. Making decisions concerning disposal without overall management objectives could lead to the degradation of delicately balanced ecological systems. We need to develop

management plans for water bodies based upon an understanding of what is limiting their maximum ecological functions. We have to make decisions regarding disposal of dredged material based upon whether it is consistent with a management plan and whether it will maintain or improve the ecological integrity of the water body. Such a plan is currently being developed for Mobile Bay.

Approximately 35 percent of dredged material is placed in diked upland disposal areas, and approximately 11 percent is used in a "beneficial" way. Within the last 10 years, approximately 9 percent of dredged material has been used to create intertidal marshes, and approximately 2 percent has been used to create islands. Thus, a relatively small volume of the annual amount of dredged material generated annually has been used in an innovative way. However, it is possible that islands and marshes were created with dredged material in water bodies which were not limited in their functioning by lack of a sufficient number of islands or acreage of marshes. If we are committed to utilizing dredged material in the most beneficial way, we need to develop interagency management plans and base our decisions on disposal of dredged material upon the best scientific evidence available.

I think we all agree that wetlands are important, that in many areas wetlands are being lost due to natural and man-induced activities, and that certain wetland systems can be created. Thus, when possible, we should use dredged material to create wetlands where they are being lost. It is a shame that we cannot take all of the dredged material to coastal Louisiana and use it to create marshes in areas where we have documented the recent losses of existing marsh due to subsidence and man's activities.

However, we cannot give Agency approval to any general plan to create marsh through disposal of dredged material in open water. Before we can commit to any plan to do this in any water body, we need to compare the environmental losses of filling shallow aquatic habitat with the environmental gains of creating marsh habitat. This comparison is very difficult to quantify since the values and functions of the two different habitats are not the same. It is also important to recognize that coastal systems are dynamic and that any attempt to stabilize them may not be ecologically beneficial nor a wise appropriation of resources.

The EPA has several programs that affect dredge and fill activities. Under the National Estuary Program, we are examining in detail approximately 10 estuaries. Many of these estuaries have site-specific problems, but some

of them have problems that are found in many estuaries. We hope that what we learn from these studies can be used to develop management plans for many of our Nation's estuaries. Also, we have initiated a new program called the Near Coastal Waters Program, and we have three pilot projects in estuaries under this program. The nearest of these is Perdido Bay, Florida. Under this program, we are examining different ways of addressing estuarine management including active public involvement.

We have also recently started a new program called the Gulf Initiative, and we will open an office for that program in Slidell, LA, in the near future. It is our intention that the Gulf Initiative will provide the focus for all activities affecting those waters and that local, State and Federal agencies will support our efforts to bring about effective and consistent management of our gulf coast resources. If you did not see the video on the Gulf Initiative, which was presented yesterday, I urge you to do so whenever you can. This is an exciting new program, and we need your support to make it work.

The EPA has a National Wetlands Research Program located in Corvallis, OR. This group is studying three components of wetlands: (a) the effectiveness of mitigation including wetlands creation, (b) the role of wetlands in maintaining water quality, and (c) an assessment of cumulative impacts of wetland losses. Also, this research team is currently preparing a booklet on how to evaluate mitigation proposals.

These new programs are evidence of the commitment of the Administrator to put the "E" for "Environment" back into the Environmental Protection Agency. I can commit to you that EPA supports beneficial uses of dredged material provided that it is performed as part of a study with monitoring so that we can quantify results. The EPA Region IV has recently worked closely with the Mobile District on several experimental uses of dredged material including thin-layer disposal and hopper barge overflow. We have reviewed available information of thin-layer disposal and think that it is a promising technique; however, we feel that current information does not support use of this technique over large areas of bay bottoms.

Someone who spoke before me mentioned the problems associated with interpretation of data from elutriate testing. I agree that there are problems with this testing. In Region IV, we are requiring that bioassays be



performed with elutriate testing to address the bioavailability of contaminants.

A lot of technical issues and tools have been discussed at this workshop. It is my opinion that we need to develop management plans to guide us in our environmental planning so that we can utilize dredged material when possible to help correct problems. The EPA is committed to work with all other agencies to develop the most beneficial disposal options. I am confident that if we work together, we can maintain or improve our valuable natural resources for future generations.

Mr. George Rothen (Chief, Construction-  
Operations Division, Galveston District)

I would like to say that it is a privilege for my office to have the lead in the Galveston District for this workshop and to recognize Rick Medina for being the workshop coordinator and Robert Lazor, who has been detailed to the District since April, to assist us. I would like to commend the planning committee for their efforts. I think that the workshop has been very productive. The interest is high as measured by the participation and the questions, and we have had some very interesting papers. Many of the concepts offered in the papers have application to the Galveston District. I also have some concerns which I would like to share with you.

If we are to capitalize on the resources made available by the beneficial uses of dredged material research, then we must consider all of the options that are available for dredged material disposal. It concerns me that, by policy, resource agencies in Texas are opposed to open-water disposal of dredged material, and I hope that some of the information presented during the last 2 days will be cause for reconsideration of what can be done with dredged material for beneficial purposes. I can assure you that this District is not an advocate of open-water disposal as the only solution, nor wetland or upland or ocean disposal as the sole option. We need to look at each project on a case-by-case basis in terms of the public interest.

I also have a concern about the perception (and I hope to work hard to correct this situation) that our coordination may not always be in good faith. I assure you that we are trying to coordinate in good faith, and the reason we host our annual dredging conference is to present to you our dredging for the current year as well as for next year for your review and comment. Our flexibility decreases as our work schedule draws near. We do need your

recommendations, and we seek and welcome them. We do hope, however, that your recommendations will be more than "don't put it here."

Perhaps to give you some insight into what triggers our dredging program in the District, I am going to present a few items that we have covered in the last few days. The Galveston District has a mandate to maintain approximately 1,000 miles of navigation channel in the State of Texas. These projects serve some 22 ports of which 12 are deep-draft ports and provide a direct lifeline to jobs, standards of living, and the economy of the region, State, and Nation. As such, we must do our very best to maintain these channels on a timely basis because postponements will have a direct impact on the users. So again, I would like to emphasize the need for your recommendations and comments with adequate lead time to address those comments and still permit time to adjust our plans. Additionally, I would like to reiterate what the speaker from the New Orleans District discussed, and that is that we can only adjust within the authority delegated to us by that project and also within the funds appropriated by Congress.

In closing, our annual dredging program is about 40 MCY or 10 percent of the nationwide total. If we accept the figure that either 60 or 90 percent of the dredged material is suitable for beneficial uses, and use this material as a resource, then we can do a great deal to protect those environmentally sensitive areas that each of us is concerned with. I can assure you that we are very serious in applying the beneficial uses concept and look forward to your cooperation in this endeavor.

Mr. William G. Wooley, Chief  
Planning Division, Galveston, District

Thank you very much, Dr. Ray. I consider it a distinct honor to be a member of this panel and to be given the opportunity to express my observations on this workshop. It has been a most impressive conference, not only because of its content and objectives, but because of the people it has attracted as participants. I am awed that a group of this size and stature, with diverse charters, can come together for a few days for the purpose of resolving common problems. The very fact that there has been a workshop dealing with beneficial uses of dredged material represents progress--and the taxpayers of Texas and the Nation are better off for it. Perhaps we, in the Galveston District, however, have benefited most from the conference.

The Galveston District is basically a coastal District, responsible for administering and managing the Corps' Civil Works activities along the entire Texas coast. We work in the coastal environment daily. Almost every project or action or decision involves dredging, or filling, or wetlands, or some combination of these factors.

It may be a flood-control or navigation channel, a levee or seawall, shoreline erosion-control measures or structures, but material is being removed, added, stacked up, or moved around in some way. In the sensitive coastal area, these activities are of substantial interest to a lot of people and frequently lead to some interesting challenges, many of which have been clearly articulated during the past 2 days. In this area, the challenges involve both problems and solutions.

The place to begin to meet the coastal challenges is in the planning stage. Planning is where things start; so it is important to get off to a good start. Decisions made during the planning process determine the success of a project. Planning involves "counting the benefits and the costs," all costs--engineering, social, environmental, and economic.

Some costs are difficult, if not impossible, to assess completely. We do not always have perfect foresight or a full understanding of long-term consequences of certain situations, including dredged material placement. Ecological systems are complex and always involve uncertainty; therefore, it sometimes seems easier to "just say no," or use the "put-it-anywhere-but-here" approach. As a planner, however, I feel a responsibility to the people we serve to deal with the uncertainties, to be innovative if possible, and when necessary, to take calculated risks.

The best way to minimize the amount of risk associated with an action is through communication and coordination with experts in the various fields. Such communication increases the level of confidence in available alternatives and increases the odds that a sound decision will be made. We often find that the "experts in the field" do not always have "Ph.D." following their names. Frequently, local residents, who have a keen sense of their surroundings and who live and work in the coastal area, have valuable insight to problem solving.

Differences of opinion can be expected when changes are being considered, and I view this as a healthy circumstance. Honest differences assure that each issue is identified and addressed. It becomes counter-productive,

however, when premature and preconceived conclusions lead to polarized opinions and positions. It then becomes very difficult, indeed, to address issues in an objective manner. In those cases, continuing communication and coordination is the only real course of action.

In addition to establishing effective communications between the professionals, we have to communicate with the public as well. It has been mentioned before in this conference, but it can stand repeating--if dredged material can be used as a resource, it does not need to be labeled as "spoil." Although it is difficult for some of us to break a habit learned over many years, the "S" word creates a negative public perception and a bias which is difficult to overcome.

We need to increase the public's awareness of the beneficial uses of dredged material and correct misconceptions that all dredged material is toxic waste. Too frequently, we find that before we can talk of beneficial uses of dredged material, we must first overcome this negative bias. I believe the effort needed to correct misconceptions could be better used to assure that the public receives the maximum benefit for its investment--and the public will have a larger say in these investment decisions.

Under the provisions of the 1986 Water Resources Development Act, local interests are required to share the cost of planning studies to develop a project, as well as pay a higher percentage of the construction costs. It seems only fair that those who pay get more to say in what they are paying for, an application of the "Golden Rule," (i.e., those with the gold, rule). This increased local say will also change the way business has been done in the past and will require a lot more communication with the local people putting up the money.

To conclude, I believe that honest and open communication, without the posturing and concern over who wins, will go far in assuring that all of our resources are effectively and efficiently used. The resulting product will add to the Nation's wealth and increase the environmental productivity, assuring that we all win. It is not a question of whether we have the ability to achieve successes, for ample ability is present at this conference. It seems to be a question of our willingness to work together, not just to produce a good solution, but to produce the best solution. Thank you.

Mr. Rollin MacRae  
Texas Parks and Wildlife Department

We have come here to enhance our ability to cooperate and not just coordinate in the low end of that spectrum. I have been to several of these dredging conferences, and they have all been very beneficial to me. Some of the ideas that first surfaced in these conferences in 1986 and 1984, I and others brought back to Texas. Some of the pilot projects reported here were brought up in those previous conferences. We can bring some of this technology, some of these beneficial uses, home.

Whatever that granular white stuff was that was shown earlier (Florida beach sand), we do not have in Texas, and we cannot ship our dredged material to Louisiana even if the Corps could pay for it, and they cannot. But sometimes we get side-tracked on some minor issues, and I agree that there is a tremendous burden carried by the language that we use. We alienate each other almost every time that we talk. What is wrong with "spoil," which previously meant treasure or plunder? We have turned this around, and we now know it as the loser who gets the spoils. We have proven in study after study that dredged material is a valuable resource, and it deserves the name "spoil," or "treasure," which is rich in organic and other components. For example, we have seen that dredged material can sometimes enhance agricultural lands that are poor. We have built bird islands with dredged material, and any number of other improvements. I think that if there is a negative connotation to the word "spoil," it got there because of the perceived use and effect, and we can turn this word around quickly and make "spoil" a nice word again.

We have heard a lot about costs and benefits, and, unfortunately, my perspective is that we cannot have the benefits most of the time because we cannot afford the costs. That cost is calculated in dollars and is not in the Corps' or our appropriations. Therefore, we cannot have the benefits and must suffer the detriments in the foreseeable future on our projects all over Texas. There will be pilot projects and demonstration projects, but unless we can somehow coordinate and cooperate to justify the costs of these beneficial uses in the project planning, then we will not get the benefit of this. I intend to assist all who would like to undertake these projects. Our agency has been involved in most of these projects, without benefit of any money sometimes. There are things that the Corps can do and we can do to assist the

Corps with this. We wish to work together, and our Director, Susan Rieff, pledged our support along those lines the other day. We will support the State Highway Department in acquisition of disposal sites in uplands and other initiatives. We will put in money and sweat if we cannot get money to hopefully achieve some of these goals.

What we need to approach is management schemes. We have a bays and estuaries team that is funded by Texas, in cooperation with other agencies, that is seeking to better understand our bays and estuaries. We are in coordination with the Colonial Waterbird Society to find where we need islands, what islands we do not need, and how to manage the ones that we have or intend to build. Somewhere in the future, we will be able to understand the bays well enough to tell the Corps where to put the spoil, in a cooperative sense, and we will have to work harder to come up with better solutions-- cooperatively.

Mr. Richard Gorini  
(Port of Houston Authority)

I have been on the job in Houston for 2 weeks and formerly worked in the State of Washington, which has a history of environmental conservation and involvement for many years in the areas of shorelines, water quality, etc. Washington State has fewer population, and the people that live in the Houston metroplex would cover 63,000 square miles of Washington. Washington also has a shorter history of development and therefore the opportunity to make fewer mistakes. I was also a speaker at the first Beneficial Uses of Dredged Material Workshop in Pensacola, FL, in October 1986. I am in a state that has a longer history with the issues tougher, more complex, and difficult to make. I am proud to be associated with a port that plays such a vital economic role in this region. Mr. Pugh stated yesterday that the port intends to carry out its mission in an environmentally sound manner, but it is always a balancing act with the hard economic realities as time goes on, and the need to stay competitive in that environment never abates.

Workshops such as these not only show how our knowledge and techniques are growing, and I note with approval, a better participation with other State and Federal, private agencies and interests. I also note continuing skepticism, and I hope that by continuing these workshops and continuing the dialogue with other speakers, we will work to ameliorate the skepticism

because you cannot change the missions of the different entities. We all have an equity in the outcome of this, and that concludes my talk.

Dr. Hanley Smith (US Army  
Engineer Waterways Experiment Station)

I hope to give you a research perspective on this meeting and cannot speak for the whole research community. I am going to give you some of my ideas as a scientist. In most cases, research outcomes are usually in printed documents. In this workshop, you see a lot of good research that is not being used or rather not being accepted. In research, information is generally placed in peer-reviewed journals, usually critiqued later. Most of the dredging research is in the gray literature and as such not found in the referred literature. I have worked long enough to learn that in a great many cases that a short-term fix is needed now, and many simply cannot wait 5 years for the answer. Too often we overlook the necessity for a long-term solution. We need to focus on problem solutions for long-term problems not by patching short-term studies. A good question to consider is whether man-made habitats function as natural habitats. It will be years before we have the answer to that question. That question is pivotal to a lot of habitat questions issued.

Many of the most beneficial uses of dredged material will not be proven or accepted until proven over the long-term, and I thank you.

## CLOSING REMARKS

COL John A. Tudela

Thank you, Dr. Ray, and I want to thank you for moderating this workshop. This conference has set a tone of cooperation for future conferences, and the bottom line is improved interagency cooperation and coordination. We realize that by working together we can attain a better awareness in this area. There is a cry for more cost-effective, timely, environmental solutions to all these challenges. The public and citizenry deserve the best from us, and perhaps they would not like to hear what we tell them, but they definitely deserve timely and professional answers.

You have heard a lot, such as mitigation by avoidance. We have heard that the soil conservationists have to do a better job. We have heard that we might have to re-evaluate the shipping industry with the redesign of new ships. We have heard MG Hatch discuss "paralysis by analysis." In short, I hope that you carry with you a message to your respective headquarters, and the message is that we have set the tone, and the tone is cooperation. I thank you very much for coming. On behalf of the entire District, I appreciate your contribution to this workshop and will send the proceedings of this workshop. Again, thank you very much.