3.0 METHODOLOGY

3.1 PROBLEMS AND OPPORTUNITIES

As previously mentioned, the Miami River Federal Project does not have a DMMP or a disposal site for maintenance. Recent changes in 1999 to the cost share agreement (Federal/Non-Federal split) have fostered interest by the local sponsor to provide an interim upland staging area for the initial dredging of the Miami River. The local sponsor is providing one berthing area and one upland staging area for interim use during the Miami River dredging project. Dredging methodology and final disposal are being solicited through the Request for Proposal (RFP) process. All dredging will be performed in an environmentally acceptable manner in accordance with county, state, and Federal regulations. Final disposal will be at an approved solid waste landfill or other acceptable disposal area in accordance with all local, state, and Federal requirements.

3.1.1 Public Involvement

The public has been involved throughout the evaluation of this project. Public meetings have been held through the Miami River Coordinating Committee (in the early 1990s) and the Miami River Commission (MRC), Dredging Working Group (1998 through present). Recent minutes of the MRC are included in Attachment C. Additional public meetings have been held in the Melrose neighborhood near the Miami River by Miami-Dade County and the USACE. Public meetings have also been held twice by the Miami-Dade County Board of Commissioners.

3.1.2 Scoping

Scoping for the proposed project was initiated by letter in September 1991 distributed to the appropriate Federal, state, and local agencies, city and county officials, and other parties known to be interested in the project. Copies of the scoping letter, the mailing list of addresses used for distribution, and letters of response are included in the Environmental Impact Statement (EIS) (see Attachment D) prepared for this project. A public scoping meeting was held in Miami on September 5, 1991.

3.1.3 Public Meetings

In addition to the public scoping meeting that was held in Miami on September 5, 1991, other public meetings have also been held (see Section 3.1.1).

3.1.4 Compliance with Environmental Requirements

3.1.4.1 National Environmental Policy Act of 1969. The project complies with the National Environmental Policy Act of 1969, as amended, 42 U.S.C. 4321, *et seq.* P.L. 91-190.

3.1.4.2 Endangered Species Act of 1973. At this stage of planning, this project complies with the Endangered Species Act of 1973, as amended, 16 U.S.C. 1531, *et seq.* P.L. 93-205. Coordination with Federal and state wildlife officials will continue throughout the planning stage of the proposed project.

3.1.4.3 Fish and Wildlife Coordination Act of 1958. This project is currently being coordinated with the U.S. Fish and Wildlife Service (USFWS). A Coordination Act Report (CAR) is in development by the USFWS.

3.1.4.4 National Historic Preservation Act of 1966 (Inter Alia). Consultation with the Florida State Historic Preservation Officer (SHPO) has been initiated in accordance with the National Historic Preservation Act, as amended, 16 U.S.C. 470a, *et seq.* P.L. 89-655; the Archeological and Historic Preservation Act, as amended; and Executive Order 11593.

3.1.4.5 Clean Water Act of 1972. The project complies with the Clean Water Act, as amended, (Federal Water Pollution Control Act) 33 U.S.C. 1251, *et seq.* P.L. 92-500.

3.1.4.6 Clean Air Act of 1972. At this stage of planning, this project complies with Section 309 of the Clean Air Act of 1972, as amended, 42 U.S.C. 1857h-7, *et seq.* P.L. 91-604.

3.1.4.7 Coastal Zone Management Act of 1972. This project is consistent with the Florida Coastal Zone Management Program (see Appendix C) and complies with the Coastal Zone Management Act of 1972, as amended, 16 U.S.C. 1451, *et seq.* P.L. 92-583.

3.1.4.8 Farmland Protection Policy Act of 1981. No prime or unique farmland would be impacted by implementation of this project. The Farmland Protection Policy Act of 1980 and 1995, P.L. 97-98 is not applicable.

3.1.4.9 Wild and Scenic River Act of 1968. No designated Wild and Scenic river reaches would be affected by project related activities. The Wild and Scenic River Act of 1968, as amended, 16 U.S.C. 1271, *et seq.* P.L. 90-542 is not applicable.

3.1.4.10 Marine Mammal Protection Act of 1972. Incorporation of the safeguards used to protect threatened or endangered species during dredging and disposal operations would also protect any marine mammals in the area, therefore, this project is in compliance with the Marine Mammal Protection Act of 1968, as amended, 16 U.S.C. 1361, *et seq.* P.L. 92-522.

3.1.4.11 Estuary Protection Act of 1968. No designated estuary would be affected by project activities. The Estuary Protection Act of 1968, 16 U.S.C. 1221, *et seq.* P.L. 90-454 is not applicable.

3.1.4.12 Federal Water Project Recreation Act. The principles of the Federal Water Project Recreation Act, as amended, 16 U.S.C 460-1 (12), *et seq.* P.L. 89-72, do not apply to this project.

3.1.4.13 Submerged Lands Act of 1953. This project is in compliance with the State Sovereignty and Submerged Lands program and the Submerged Lands Act of 1953, 43 U.S.C. 1301, *et seq.*

3.1.4.14 Coastal Barrier Resources Act and Coastal Barrier Improvement Act of 1990. There are no designated coastal barrier resources in the project area that would be affected by this project. The Coastal Barrier Resources Act, 16 U.S.C. 3501, *et seq.*, P.L. 97-348, and Coastal Barrier Improvement Act of 1990 are not applicable.

3.1.4.15 Rivers and Harbors Act of 1899. The proposed work would not obstruct navigable waters of the United States. The proposed action has been subject to the public notice, public hearing, and other evaluations normally conducted for activities subject to the Rivers and Harbors Act of 1899, as amended, 33 U.S.C. 401, *et seq.* The project is in full compliance.

3.1.4.16 Anadromous Fish Conservation Act. As defined in the Anadromous Fish Conservation Act, 16 U.S.C. 757a-g, 79 Stat. 1125, as amended by P.L. 89-304, anadromous fish species would not be affected.

3.1.4.17 Migratory Bird Treaty Act and Migratory Bird Conservation Act. No migratory birds would be affected by project activities. The project is in compliance with the Migratory Bird Conservation Act, 16 U.S.C. 715-715d, 715e, 715f-715r; 45 Stat. 1222 and the Migratory Bird Treaties and other international agreements listed in the Endangered Species Act of 1973, as amended, Section 2(a)(4).

3.1.4.18 Marine Protection, Research and Sanctuaries Act. The Marine Protection, Research and Sanctuaries Act, 33 U.S.C. 1401, *et seq.* P.L. 92-532 (3[33 U.S.C. 1402](f)) does not apply to this project.

3.1.4.19 Magnuson-Stevens Fishery Conservation and Management Act. Magnuson-Stevens Fishery Conservation Act, as amended in 1996, 16 U.S.C. 1801, *et seq.* P.L. 94-265. This act requires that the effects of Federal projects on essential fish habitat be assessed. The environmental impact statement accompanying this document serves as the essential fish habitat consultation/assessment document.

3.1.4.20 E.O. 11990, Protection of Wetlands. No wetlands would be affected by project activities. This project is in compliance with the goals of this Executive Order.

3.1.4.21 E.O. 11988, Flood Plain Management. The project is in the base flood plain (100-year flood) and has been evaluated in accordance with this Executive Order. This project complies with the goals of this Executive Order.

3.1.4.22 E.O. 12898, Environmental Justice. On February 11, 1994, the President of the United States issued Executive Order 12898, *Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations.* The Executive Order mandates that each Federal agency make environmental justice part of the agency mission and to address, as appropriate, disproportionately high and adverse human health or environmental effects of the programs and policies on minority and low-income populations.

No minority or low-income populations would be adversely affected by project activities. This project complies with the goals of this Executive Order.

3.1.4.23 E.O. 13045, Protection of Children. On April 21, 1997, the President of the United States issued Executive Order 13045, *Protection of Children from Environmental Health Risks and Safety Risks*. The Executive Order mandates that each Federal agency make a high priority to identify and assess environmental health risks and safety risks that may disproportionately affect children and ensure that its policies, programs, activities, and standards address disproportionate risks to children that result from environmental health risks or safety risks.

3.1.4.24 E.O. 13112, Invasive Species. This executive order requires Federal agencies to consider the potential for proposed actions to promote the spread of invasive species. In southern Florida, invasive species such as Australian pine, Brazilian pepper, and melaleuca are typically found to colonize disturbed sites. Site disturbance associated with this project would involve the establishment of a staging area. However, because this project would be of short duration followed by restoration of the staging area, there would be limited opportunity for invasive species to become established.

3.1.4.25 E.O. 13089, Coral Reef Protection. The nearest known coral reef area to the mouth of the Miami River is offshore of Government Cut, approximately 4 miles from the river. It is currently anticipated that sediments suspended by the dredging activities will not adversely affect those coral reefs.

3.2 EXISTING CONDITIONS/CONDITIONS LIKELY TO PREVAIL WITHOUT A PLAN

The Miami River Federal project does not have a DMMP or a disposal site for maintenance. The authorized navigation project provides for a channel 15 feet deep throughout its 5.5-mile length. The bottom width of the channel varies. It is 150 feet wide from the confluence with Biscayne Bay for the first three miles, thence 125-feet for the next 1.1 miles, thence 90 feet wide for the last 1.4 miles. The last Federal dredging of the Miami River was done when the channel was constructed in 1933-34, when just over a million yards of material were removed from the project area. WRDA 86 authorized removal of polluted sediments, contingent on completion of feasibility study. The *Navigation Study for Miami Harbor (Miami River) Florida-Final Feasibility Report – 10001* (March 1990), prepared by the Jacksonville District USACE, notes an apparent justification for maintenance dredging the Miami River. The removal of river sediments would allow small ships more efficiently to utilize the Miami River and would impede harmful sediments from being reintroduced into the river and possibly transported to Biscayne Bay.

Ongoing navigation in the river promotes continued re-suspension of sediments. Vessels and their escorting tugs navigating the Miami River, as well as other watercraft, currently engage in a *de facto* form of dredging of shoals and shallow reaches of the waterway. Prop-wash agitation and bottom dragging suspend sediments and enable the channel to retain a depth that minimally enables navigation to continue. Prop wash from escort tugs also continually agitates bottom sediments outside the navigation channel, as they must use the entire river width to steer larger vessels up and down the river.

River discharge and tidal currents promote the transfer of suspended materials into Biscayne Bay. A turbidity plume at the mouth of the Miami River can be readily identified in virtually all aerial photographs of the area; the plume is also visible from vantage points at Brick ell Point, particularly during ebb tide. Studies of Biscayne Bay have concluded that the Miami River sediments are a significant source of contamination to Biscayne Bay (Long *et al.*, 1999).

Without the project, contaminated sediments would continue to be discharged into Biscayne Bay, which is documented in this DMMP to be an Outstanding Florida Water, an aquatic preserve, a National Park (at the southern reach), and a significant environmental resource. This DMMP documents the toxicity of the sediments, and the EIS and its accompanying Fish and Wildlife Coordination Act Report document adverse effects of the Miami River sediments on the Biscayne Bay ecosystem. It appears reasonable to conclude that the State of Florida and the Federal Government would not allow the unabated discharge of contaminated sediments from the Miami River to continue. If the contaminated sediments are not removed, the closure of the Miami River as a port facility may be the only recourse for protecting the integrity of the Biscayne Bay ecosystem.

3.3 FORMULATION OF ALTERNATIVE PLANS

3.3.1 Introduction

The planning process consists of a series of steps that identifies or responds to problems and opportunities associated with the Federal objective in the selection of a recommended plan. The process involves an orderly and systematic approach to making determinations and decisions at each step so that the public can be fully aware of the basic assumptions employed, the data and information analyzed, the areas of risk and uncertainty, the reasons and rationales used, and the significant implications of each alternative plan. Steps in this process are:

- Identification of problems and opportunities associated with the Federal objective;
- Inventory, forecast, and analysis of resource conditions within the planning area relevant to the identified problems and opportunities;
- Formulation of alternative plans through the establishment of goals and objectives and the identification of planning requirements;
- Evaluation of the effects of the alternative plans;
- Comparison of alternative plans; and
- Selection of a recommended plan based on the comparison.

The final recommended plan must meet the original project goal of presenting a management plan that identifies the specific measures necessary to manage the volume of material likely to be dredged over a 20-year period.

In achieving this goal, each of the alternatives was evaluated according to criteria specified in the EIS (Attachment D) of this document. The alternatives and the criteria were developed from meetings, discussions, and coordination with representatives of affected or interested agencies, organizations, and the public.

3.3.2 Federal Objective

The objective of this project is to develop a DMMP for the *Miami River Federal Navigation Project* that identifies specific measures necessary to manage the volume of material likely to be dredged over a 20-year period, from both construction and maintenance dredging.

3.3.3 Planning Goals and Objectives

In order to develop the DMMP, the objectives of the project must first be identified. The following planning objectives were established to address the problems and realize the opportunities identified, and to serve as guidelines for the formulation and evaluation of alternative plans.

- **Consider cost and effectiveness.** Evaluate the cost of the project, taking into account initial dredging costs and future dredge management costs. Additionally, determine whether the alternative will satisfy the Federal timeline for implementation and completion of the project.

- **Minimize adverse socioeconomic impacts.** Socioeconomic impacts include impacts to local businesses, residents, and recreation.

- **Minimize adverse environmental impacts.** Environmental impacts include impacts to fish habitat, water quality, wetlands, and air and noise quality.

The final recommended plan must provide a management plan that identifies specific measures necessary to manage the volume of material likely to be dredged over a 20-year period pursuant to the Federal project. Each of the alternatives was evaluated according to the above objectives. The goals and objectives were developed from meetings, discussions, and coordination with representatives of affected or interested agencies, organizations, and the public.

3.3.4 Performance Measures

Performance measures are quantitative or qualitative indicators of how well (or poorly) an alternative meets a specific objective. A set of performance measures has been developed for use as the basis for evaluation of the various alternatives for this project. These performance measures have specific metrics related directly to each of the project objectives. Table 1 provides a complete list of the performance measures and a comparison of the ability of alternatives to meet planning objectives.

Objective 1. Consider Cost and Effectiveness. It is the USACE's policy to accomplish the disposal of dredged material from navigation projects in the least costly manner.

PM1. Construction Cost. The total cost of dredging for each alternative is compared on a quantitative basis.

PM2. Future Dredge Maintenance Costs. This assessment is made to compare future dredge maintenance costs after completion of the initial dredging.

PM3. Implementation and Completion Schedule. A qualitative comparison of each alternative's ability to meet the Federal timeline for implementation and completion.

Objective 2. Minimize Adverse Socioeconomic Impacts.

PM1. Impacts to Businesses. Alternatives are qualitatively compared to assess the likely impacts on existing businesses.

Table 1. Performance Measures Summary

Summary of Performance Measures to Assess Each Alternative with Project Objectives				
OBJECTIVE 1. CONSIDER COST AND EFFECTIVENESS				
Measure	**Units**	**Alt 1**	**Alt 2**	**Alt 3**
PM 1. Construction Cost	$	71.7 million	C	NA
PM 2. Future Dredge Maintenance Costs	$	6.5 million	6.5 million	NA
PM 3. Implementation and Completion Schedule	f,p,n,m	f	f	NA
OBJECTIVE 2. MINIMIZE ADVERSE SOCIOECONOMIC IMPACTS				
Measure	**Units**	**Alt 1**	**Alt 2**	**Alt 3**
PM 1. Impacts to Businesses	f,p,n,m	f	f	NA
PM 2. Impacts to Residents	f,p,n,m	f	f	NA
PM 3. Impacts on Recreation	f,p,n,m	f	f	NA
OBJECTIVE 3. MINIMIZE ADVERSE ENVIRONMENTAL IMPACTS				
Measure	**Units**	**Alt 1**	**Alt 2**	**Alt 3**
PM 1. Impacts to Fish Habitat	f,p,n,m	f	f	NA
PM2. Impacts to Water Quality	f,p,n,m	f	f	NA
PM3. Impacts on Wetlands	Acres	0	0	NA

c = USACE to provide data
f = Full compliance
p = Partial compliance
n = Non compliance
m = Minimally satisfies
NA = Not applicable

Alternative 1, Base Plan
Alternative 2, Preferred Plan
Alternative 3, No Action (Status Quo)

Source: G.E.C., Inc., August 2001.

PM2. Impacts to Residents. Alternatives are qualitatively compared to assess likely impacts to local residents.

PM3. Impacts on Recreation. Alternatives are qualitatively compared to assess any possible impacts on recreation resulting from the project.

Objective 3. Minimize Adverse Environmental Impacts.

PM1. Impacts to Fish Habitat. Alternatives are qualitatively compared to assess the likely impacts on project area fish habitat.

PM2. Impacts to Water Quality. Alternatives are qualitatively compared to assess likely impacts to project area water quality.

PM3. Impacts on Wetlands. Alternatives are quantitatively compared to assess impacts on wetlands.

3.3.5 Planning Constraints

3.3.5.1 Socioeconomic Factors. There are numerous residences and businesses in vicinity of the proposed project. As a result, a policy of avoidance and minimization of impact to businesses, residences, and recreation, to the greatest extent practicable, is an important constraint in evaluating the alternatives.

3.3.5.2 Wetlands. Wetlands are generally not present in the vicinity of the proposed project but remain subject to evaluation under Section 404 of the Clean Water Act. Additionally, dredge pipeline routes are potentially subject to Section 10 of the Rivers and Harbors Act.

3.3.5.3 Protected Species. Coordination with USFWS, NMFS, and Florida Fish and Wildlife Conservation Commission (FFWCC) indicates species listed by both Federal and State governments as threatened or endangered are located in the vicinity of the proposed project and are subject to the Fish and Wildlife Coordination Act. Detailed information is presented in the Environmental Impact Statement.

3.3.5.4 Surface Water. The Miami River was originally classified by the State of Florida as a Class IV waterbody. In 1989, the river's classification was changed from Class IV to Class III. Class III waterbodies can support recreation and a healthy and well-balanced population of fish and wildlife. The Miami River does not technically meet all Class III standards at present; however, local interests have stated that the classification change was made so that the river could be regulated to ultimately meet those standards. The tidal portion of the Miami River lies within the Biscayne Bay Aquatic Preserve. All waters within the preserve are classified Outstanding Florida Waters. An Outstanding Florida Water (OFW) is a waterbody deemed worthy of special protection due to its natural attributes.

3.3.5.5 Costs. It is the USACE's policy to accomplish the disposal of dredged material from navigation projects in the least costly manner consistent with proper stewardship of natural resources and maintenance of a healthy human environment. The cost-share formula for Miami River was modified by Congress, with the Federal interest absorbing 100 percent of the dredging costs; the Federal government would provide 80 percent of the disposal cost except land purchase or lease, with the remaining 20 percent provided by local sponsors.

3.3.6 Project Requirements

The existing Federal project for Miami River provides for a navigation channel 15 feet deep throughout its 5.5-mile length. The project was authorized in July 1930. There has never been a maintenance-dredging project conducted on the Miami River. Therefore, there is not a dredging history or a historically used disposal site available. In 1993, a USACE report specifically addressed alternatives for the dredging and disposal of sediment from the Miami River.

Depths and widths along the river are shown in a typical cross section (Figure 2). This cross-section shows that the shoaled sediments lie above a rock layer and that the majority of those sediments are within the dredging template for the existing Federal project.

Preliminary estimates of sediment quantities are tabulated in Table 2. For purposes of this report it is assumed that the Federal navigation channel will result in approximately 600,000 cy of material dredged.

Table 2. Miami River Dredging Quantities for a 15-Foot Required Depth with 2 Feet of Allowable Overdepth

	Federal Channel	Non-Federal Dredging	Total
Required Depth (cy)	310,000	158,000	486,000
Allowable Overdepth (cy)	284,000	26,000	310,000
TOTAL (cy)	594,000	184,000	778,000

Based on survey N° 00-012, dated 21 August 1999,
3:1 side slope, and 10’ set back from all structures
Source: Jacksonville District USACE, 2001.

As shown in Figure 3, the reduced project dimensions are generally located along the outer edges of the main channel at the riverbanks. The depth and width near the channel center provide marginal clearance for the current vessel fleet operating at the port. However, those vessels require special handling in navigating the river because deposited river sediments have reduced the effective channel dimensions, which in turn limit the vessel maneuvering area. Furthermore, additional horsepower is needed to overcome the higher friction or drag effects between the vessel’s hull and the bottom and side sediments.

Channel shoaling also contributes to the mixing actions that resuspend river sediments. Channel shoaling compounds the mixing action by confining the displaced water moving around an underway ship's hull to a smaller area thereby generating higher velocities and increasing turbulence. Additionally, terminal operators load ships to their deeper drafts for the export of outbound commodities; these transits have to take advantage of the high tides. On outgoing tides and riverine flood flows, the resuspended sediments are transported from Miami River to Biscayne Bay.

Commercial vessels presently transiting the Federal project have drafts ranging from eight to 15 feet and beams varying from 30 to 45 feet. Current project channel widths are capable of handling those vessels safely and efficiently if the channel dimensions are maintained to the authorized dimensions.

It has been estimated that approximately 600,000 cy of sediments lie on the bottom of the lower 5.5 miles of the Miami River within the Federal navigation channel. The thickness of the sediment varies from one to three feet in the deeper parts of the river and as thick as five to 10 feet along the channel sides as shown in figures 2 and 3. The sediments in some areas have high silt-clay content, ranging from 61 to 82 percent. The unwanted sediments are the materials that have settled on the top of the rock layer.

Recent surveys indicate that approximately 500,000 cy of additional sediment exists in the Miami River in the areas outside the Federal navigation project. The "non-Federal" dredge material may be removed during the Miami River dredging project, but is a 100 percent local cost (no Federal cost share). Further, the 200,000 cy non-Federal quantity of dredge material does not include tributary channels to the Miami River. This 200,000 cy of sediment is expected to be removed at the expense of the local sponsor.

3.3.7 Alternatives

The dredging of the Federal project to the dimensions of 90 to 150 feet wide and 15 feet deep will require the removal of 242,912 cy of dredged material. Allowable overdepth dredging will be performed to a depth of 17 feet as a pay quantity, resulting in the removal of 270,654 cy of sediment. No deepening of the channel will occur. No limestone will be dredged, and no advanced maintenance dredging will be performed.

3.3.7.1 Alternative 1, Base Plan. The base plan for the Miami River dredging project is modeled after a conventional USACE dredging project.

Plans and specifications would be prepared, the project advertised, and an award would be made to the lowest bidder.

Sediments would be excavated by a mechanical dredge in phases over approximately five years.

The local sponsor would provide an upland interim staging area for unloading of dredged materials and dewatering or drying of material in a confined manner. Dried material would be hauled to and disposed at an appropriate upland landfill. The interim site will be restored to its pre-existing condition.

At the request of the local sponsor, the interim site cannot be utilized for conventional diking with open-air drying. Any plan that utilizes the interim staging area must confine or cover the material during the drying process. Open-air drying would not be allowed.

3.3.7.2 Alternative 2, Preferred Alternative. The preferred alternative is to issue a RFP. The USACE would then select a Contractor, who would work in partnership with the Jacksonville District to dredge the Miami River to remove contaminated sediments from the river and restore the river to its Federally authorized dimensions. The RFP solicitation would promote the use of innovative technology for disposing contaminated sediments, for reducing impacts to surrounding communities, and for capturing possible cost and time savings.

Dredging would be performed by a mechanical dredge, hydraulic dredge, or a combination of both.

Under this scenario, the local sponsor would provide an interim upland staging area and interim berthing staging area adjacent to the river. Land easements and rights-of-way for the dredging project are the responsibility of the local sponsor. Miami-Dade County, which is pursuing the use of property near the Jai-Alai fronton. As mentioned, the interim staging area cannot be used for conventional diking with open-air drying. Therefore, any plan that utilizes this interim upland staging area must confine the material (e.g., geotubes, etc.). However, conventional diking and open-air drying can be used in the Miami River dredging project if the contractor provides another upland staging site acceptable to Federal, state, and local authorities.

3.4 EVALUATE/COMPARE THE EFFECTS OF ALTERNATIVE PLANS

This DMMP is focused on material management from maintenance of the Federal project in the lower five and a half miles of the Miami River at its mouth near Biscayne Bay.

3.4.1 Dredging Needs and Equipment

3.4.1.1 Introduction. The process of determining dredging needs and equipment requirements, which is tied to selecting removal and transport technologies, should be driven by treatment and/or disposal considerations. This is because treatment/disposal options typically have the higher cost and are more controversial from a social, political, or regulatory perspective. This section is an update of the December 1993 report entitled, *Alternatives for the Dredging and Disposal of Sediments from the Miami Harbor (Miami River) Project, Florida*.

A concern during the removal and transport of contaminated sediments is the danger of introducing contaminants into previously uncontaminated areas. Contamination during these steps could occur primarily from the resuspension of sediments during removal or from spills and leaks during transport. Accordingly, the decision to remove must be made only after careful consideration of all non-dredging remedial options, including no action and *in situ* containment or remediation. Of course, the nature of the contamination, or site considerations, may make removal and transport necessary.

The *Navigation Study for Miami Harbor (Miami River) Florida - Final Feasibility Report - 10011* (March 1990) prepared by the Jacksonville District USACE notes an apparent justification for maintenance dredging of the Miami River. The removal of river sediments would allow small ships more efficiently to use the Miami River and would impede harmful sediments from being reintroduced into the river and possibly transported to Biscayne Bay.

3.4.1.2 Special Dredging Considerations. Dredging of Miami River for navigation improvement is somewhat confined by existing physical conditions. Enlargement of horizontal dimensions for more channel width would require modification to existing channel banks and would create loss of property. Such a change must be supported with sufficient economic benefits to justify the relocation of existing facilities and loss of expensive real estate adjacent to the river. The vertical dimensions are constrained by an underlying rock layer that is the approximate lower boundary of the existing Federal project. The rock layer would be expensive to dredge and the impacts of any significant deepening on the Biscayne

Aquifer would be difficult to ascertain. Additionally, local shipping interests have not requested any channel improvements, other than channel maintenance, to service their existing and projected vessel fleets.

Most of the vessels using the Miami River are relatively large in relation to the channel dimensions. Most of these vessels require tug assistance for their river transits and some must utilize high tides. Most vessels require two tugs for a river transit, one with a towline attached to the bow of the ship and the second rigged with a towline to the stern. The tugs operate in tandem with the bow tug pulling the ship and the astern tug providing steerage. Movement of the larger commercial vessels is timed to coincide with the direction of the tidal flows to assist in control and movement.

3.4.1.2.1 Bridge Crossings. There are numerous bascule type drawbridges across the Miami River owned and operated by state or local governments. The operation of those drawbridges is governed by Title 33 of the Code of Federal Regulations for Navigation and Navigable Waters. In general, the regulations require that the draws shall open for an approaching vessel; however, from the hours of 7:30 a.m. to 9:00 a.m. and 4:30 p.m. to 6:00 p.m. Monday through Friday, except holidays, the draws need not be opened for the passage of vessels. Tug assistance is also required for most vessels in the event a draw is unexpectedly closed. The drawbridges are currently equipped with communication devices that facilitate the timing and coordination of vessel traffic to minimize delays. In addition, the river is spanned by several fixed bridges with sufficient vertical and horizontal clearances for the largest vessel currently operating on the river. The fixed bridges provide 75 feet of vertical clearance and the horizontal clearances for both bascule and fixed bridges vary from 75 to 94 feet.

3.4.1.2.2 Debris. Since the Miami River has never been maintenance dredged during the project's life a number of logistic considerations must be addressed prior to the initiation of construction. The amount of unclassified and miscellaneous debris expected to be in the river will require the use of a mechanical overwater crane to handle the debris prior to initiating actual dredging. Current bathymetric surveys do not sufficiently identify miscellaneous debris in the Miami River. Miscellaneous debris should be classified, removed, and disposed of prior to dredging the river. Dredging contractors indicated that the river might possibly be "dragged" to locate and remove the debris for disposal. However, removal of all of the debris prior to dredging is unlikely, as the methods for locating it are not perfect.

3.4.1.2.3 Construction Concerns. The construction or dredging of the project is projected to be done in phases and to take approximately 60 months to complete because of the complexity of the construction activities. Another factor affecting dredging activities is the shallow project depths that will limit construction access and not permit full loading of hopper barges if they are used for material transport.

Traffic congestion is another consideration affecting construction activities. The size of the ships transiting the river will necessitate frequent work stoppages for the dredge to be moved out of the way to enable passage because of the narrow channel widths and the close proximity of other vessels berthed alongside the channel. Because of the high volume of river traffic, the Contractor will have to conduct dredging operations in coordination with vessel movements and bridge openings that generally coincide with high tide. Some additional delays will occur while waiting for drawbridges to open during normal transits. Additional efforts and coordination with affected river users will be needed before and during construction.

Some type of mechanical dredge will be used for miscellaneous debris removal and dredging in tight confines (docks, bulkheads, etc.) regardless of the equipment selected for the main removal effort.

3.4.1.3 Types of Dredges Available. To increase efficiency and reduce sediment resuspension, dredges, operational controls, and barriers should be used together. Of these, dredges actually remove the sediments; operational controls and barriers minimize the resuspension and spread of sediments during removal.

3.4.1.3.1 Dredges. In the selection of a dredge type for removal of sediments, the following factors should be considered:

1. Volume: The volume of material to be removed will determine the scale of operations and the time frame available for removal. The preliminary volume quantities provided by the USACE, of dredged material to be removed from the Miami River Federal navigation channel is approximately 600,000 cy. The USACE estimates a phased dredging project will take approximately 60 months to complete while conversation with dredge contractors estimate 12-18 months for completion using innovative technology.

2. Location: The location factor involves both the physical setting of the project and the actual location of the sediments to be dredged in the river. Based upon the preliminary quantities provided by the USACE, approximately 25 percent of the total volume of material available to be dredged from the Miami River is outside the Operation and Maintenance (O&M) Navigation project. This percentage varies within each reach of the river with the largest percentage of material outside the O&M project occurring near the mouth of the Miami River. Consideration should be given to where the material is located as a pipeline or hydraulic dredge does not remove material efficiently close to bulkheads, piers, or other structures in the water. Material located in tight confines is best removed by a mechanical dredging process, which has better dredging accuracy and efficiency.

3. Material: Consolidated sediments, large amounts of debris, and contaminants are items of concern. The Miami River sediments located at the edges of and outside the O&M project are characterized as more consolidated than those in the navigation channel. The absence of maintenance dredging of this project insures that the classifying, removal and disposal of miscellaneous debris from the river must be addressed. Sediment analyses at various locations throughout the project indicate the presence of elevated levels of pollutants.

4. Pre-Treatment: Requirements of sediment treatment technology (dewatering, etc.) will affect the type and extent of dredging operations used in the project. The type of dredge selected can result in resuspension of sediments varying by orders of magnitude at the dredge site and disposal area.

There are three general types of dredges available for the removal of sediments: mechanical, hydraulic, and pneumatic. Historically, mechanical and hydraulic dredges have been the most common types used in the United States. Pneumatic dredges, which are relative newcomers, are generally manufactured overseas and have only limited availability; they have been developed specifically for small volumes of contaminated sediments. Because pneumatic dredges are not readily available, discussions of dredge selection for the Miami River will be limited to mechanical and hydraulic dredges only.

3.4.1.3.2 Mechanical Dredges. These dredges remove sediments by the direct application of mechanical force to dislodge sediment material. The force is commonly applied, and the material scooped away, with a bucket. The most commonly used mechanical dredge is the clamshell dredge. The clamshell dredge has widespread application for the removal of sediments, although the use of a modified, watertight bucket may be required to reduce sediment resuspension. In the case of the Miami River, the use of a watertight bucket may be detrimental to the operation depending on the amount of debris in the channel. Debris will prevent the bucket from closing completely, causing the material to discharge from the bottom and top. Removal of debris may be hindered because of those large items that do not fit within the closed bucket. . Dipper dredges, bucket ladder dredges, and dragline dredges are other mechanical dredges available to remove sediments but are generally limited in use because of excessive sediment resuspension.

3.4.1.3.3 Hydraulic Dredges. Hydraulic pipeline cutterhead suction dredges use centrifugal pumps to remove sediments in a liquid slurry form. They are widely available in the U.S. Because it is equipped with a rotating cutter apparatus surrounding the intake end of the suction pipe, it can efficiently dig and pump all types of alluvial materials and compacted deposits, such as clay and hardpan. This type of dredge has the capability of pumping dredged material long distances to upland disposal areas. Slurries of 10 to 20 percent solids (by dry weight) are typical, depending upon the material being dredged, dredging depth, horsepower of dredge pumps, and pumping distance to disposal area.

3.4.1.4 Cutterhead Dredges. The cutterhead dredge was developed to loosen densely packed deposits and eventually cut through soft rock; it can excavate a wide range of materials including clay, silt, sand, and gravel. The cutterhead is used to dislodge material and to act as an excluder to make sure the discharge pipelines do not become clogged with miscellaneous debris or items. The cutterhead dredge is suitable for maintaining harbors, canals, and outlet channels where wave heights are not excessive. Wave action should not be a concern when dredging the Miami River because of its protected location upstream of Biscayne Bay and navigational requirements of a *No Wake Zone* imposed on vessels traveling the river.

The excavated material may be disposed of in open water or in confined disposal areas located upland or in the water. In the case of open-water disposal, only a floating discharge pipeline, made up of sections of pipe mounted on pontoons and held in place by anchors, is required. Additional sections of shore pipeline are required when upland disposal is used. In addition, the excavated materials may be placed in hopper barges for disposal in open water or in confined areas that are remote from the dredging area.

Two advantages of utilizing a cutterhead dredge for dredging the Miami River are: the resuspension of sediment during a cutterhead dredging operation is limited and the dredge's capability of excavating most types of material and pumping it through pipelines for long distances to upland disposal site eliminates the need for rehandling.

The limitations of utilizing a cutterhead dredge for dredging the Miami River are as follows: cutterhead dredges generate large volumes of water in removing sediments that must be handled and treated prior to disposal or release. Most debris cannot be removed hydraulically. If a hydraulic dredge is used to dredge the Miami River, an additional mechanical operation will be needed to remove unclassified and miscellaneous debris prior to hydraulic dredging. Hydraulic cutterhead dredges cannot accurately and effectively dredge around bulkheads, piers, bridge abutments, bridge fenders, and other tight confines like those on the Miami River. A comparison of selected hydraulic dredges is shown in Table 3.

3.4.1.5 Mechanical Dredges

3.4.1.5.1 Dipper Dredges. The dipper dredge is essentially a barge-mounted power shovel. It is equipped with a power-driven ladder structure and is operated from a barge type hull. A bucket is firmly attached to the ladder structure and is forcibly thrust into the material to be removed. Dipper dredges normally have a bucket capacity of eight to 12 cy and a working depth of up to 50 feet. Production rates vary considerably.

The dipper dredge is best used for excavating hard, compacted materials after blasting. Although it can be used to remove most bottom sediments, the violent action of this type of equipment may cause considerable sediment disturbance and resuspension during maintenance dredging of fine-grained material. In addition, a significant loss of the fine-grained material will occur from the bucket during the hoisting process. The dipper dredge is most effective around bridges, docks, wharves, pipelines, piers, or breakwater structures, because it does not require much area to maneuver; there is little danger of damaging the structures since the dredging process can be controlled accurately. No provision is made for dredged material containment or transport; therefore, the dipper dredge must work alongside the disposal area or be accompanied by disposal barges during the dredging operation.

The advantages for using a dipper dredge on the Miami River are: the dredge requires less room to maneuver in the work area than most other types of dredges; and excavation is precisely controlled so that there is little danger of removing material from the foundations of docks and bulkheads when dredging is required near these structures. Dipper dredges are frequently used when disposal acres are beyond the pumping distance of pipeline dredges, because scow barges can transport material over long distances to the disposal area sites. The dipper dredge type of operation limits the volume of excess water in the barges, as they are loaded because the material is removed at its *in situ* water content.

Limitations of a dipper dredge include: difficulty in retaining soft, semi-suspended fine-grained materials in the buckets of dipper dredges. Scow-type barges are required to move the material to a disposal area, and the production is relatively low when compared to the production of cutterhead dredges. Ref: Dredging and Dredge Material Disposal, EM-1110-2-5025, 25 March 1983.

3.4.1.5.2 Bucket Dredges. The bucket type of dredge is so named because it utilizes a bucket to excavate the material to be dredged. Different types of buckets can fulfill various types of dredging requirements. The buckets used include the clamshell, orange peel, and dragline types, which can be quickly changed to suit the operational requirements. The vessel can be positioned and moved within a limited area using only anchors; however, in most cases anchors and spuds are used to position and move bucket dredges. The material excavated is placed in scows or hopper barges that are towed to the disposal areas. Bucket dredges range in capacity from one to 12 cy. The crane is mounted on a flat-bottomed barge, on fixed-shore installations, or on a crawler mount. Large variations exist in production rates because of variability in depths and materials being excavated. The effective working depth is limited to about 100 feet.

Bucket dredges may be used to excavate most types of materials except for the most cohesive sediments and solid rock. Bucket dredges usually excavate a heaped bucket of material, but during

Table 3. Comparison of Selected Hydraulic Dredges

Technique	Applications	Limitations	Secondary Impacts	Availability/ Transportability	Vessel Length Draft (ft)	Production (yd^3)	Maximum Depth of Use (ft)	Relative Cost*
Portable Hydraulic (including small cutterhead)	Moderate volumes of sediments; lakes and inland rivers; very shallow depths (to 18 inches)	Limited to waves of less than one foot; depending on model, has low production rates and limited depth	Moderate resuspension of sediments	Readily moved over existing roads, may require some disas-sembling; widely available	25-50/2-5	50-1,850	50	Low
Hand-held Hydraulic	Small volumes of solids or liquids in calm waters; for precision dragging	Operated from above-water units only in shallow waters	Moderate resuspension of sediments	Easily moved over existing roads; can be assembled using commonly available equip-ment	N/A	10-250	1,000	Low
Cutterhead	Large volumes of solids and liquids; up to very hard and cohesive sediments; calm waters	Dredged material is 80-90% water; cannot operate in rough, open waters; suscept-ible to damage and weed clog-ging	Moderate resuspension of sediments	Transport in navigable waters only; wide avail-ability	50-250/3-14	25-10,000	50	Medium

*Costs vary with site characteristics; cutterhead dredges may be the cheapest for a project involving more than a few thousand cubic yards.

Source: EPA/625/6-91/028, *Remediation of Contaminated Sediments*, April 1991.

hoisting turbulence can wash away part of the load. Once the bucket clears the water surface, additional losses may occur through rapid drainage of entrapped water and slumping of the material heaped above the rim. Loss of material is also influenced by the fit and condition of the bucket, the hoisting speed, and the properties of the sediment. Even under ideal conditions, losses of loose and fine sediments will usually occur. In addition, miscellaneous debris is likely to be encountered in the Miami River and would prevent the bucket from closing completely, causing material to discharge from the bucket. Special watertight buckets have been developed for use with mechanical dredges in areas containing contaminated sediments. These watertight buckets were developed to minimize the turbidity generated by a mechanical operation. The edges seal when the bucket is closed and the top is covered to minimize loss of dredged material. However, requiring a watertight bucket may be detrimental to the operation depending on the amount of debris in the channel. A watertight bucket does not function properly if debris in the bucket prevents it from closing. Additionally, the dredging of the Miami River will not likely involve material consisting solely of loose- and fine-grained sediments. For these reasons, it is believed that a watertight bucket will not be suitable for a mechanical dredging operation on the Miami River even though it would appear to generate less turbidity in the water column than a typical bucket. The turbidity reduction is an idealistic comparison that is not representative of the existing situation at the Miami River.

A comparison of turbidity generation in debris areas between a dipper dredge and a bucket dredge indicates that even though a dipper dredge has a higher drag associated with the dredging activity, it suspends less sediment than a partially closed bucket dredge.

The bucket dredge is suitable for excavating most types of material except for the most cohesive sediments and solid rock. Excavation can proceed at the sediments *in situ* water content. Therefore, the volume of excess water generated during the dredging process is minimal. Mechanical bucket dredges are highly maneuverable and most effective around bridges, docks, wharves, and piers; there is little danger of damaging the structures since the process can be controlled with good dredging accuracy. Mechanical dredges can remove all types of debris, which is of particular concern on the Miami River since the navigation channel has never been maintenance dredged.

It is difficult to retain soft, semisuspended fine-grained materials in the buckets of bucket dredges, which leads to the potential for large amounts of sediment resuspension. Scow-type barges are required to move the dredged material to a disposal area and the material must be rehandled. Production rates are generally lower than the production rates of hydraulic dredges. However, the limitation for production rates of mechanical dredges compared to cutterhead dredges for river dredging and transportation needs must be analyzed in light of the overall conditions on the Miami River (e.g., drawbridge opening restrictions, the amount of vessel traffic, processing rates at the disposal site, etc). In addition, the miscellaneous debris located in the Miami River would tend to make a hydraulic dredge operation less productive due to the inefficient removal of the debris, which is likely to clog the cutterhead. The USACE cost comparisons of mechanical vs. hydraulic dredging and transport show that over a long distance, the barging of material becomes more efficient than pumping. Hydraulic dredging is efficient as long as the transport distance remains within a cost-effective reach. Unit costs are typically higher than hydraulic dredges. However, when applying the criteria to the Miami River, the disadvantages in unit costs for mechanical dredges may not be true when all factors are considered such as numerous shutdowns and start-ups that will be needed by a hydraulic operation to maintain vessel traffic. Ref: Dredging and Dredge Material Disposal, EM-1110-2-5025, 25 March 1983

A comparison of selected mechanical dredges is presented in Table 4.

Table 4. Comparison of Dipper vs. Clamshell Bucket Mechanical Dredges[1]

Dredge Type	Percent Solids In Slurry by Weight[2]	Turbidity Caused	Open-Water Operation	Vessel Draft (ft)	Approximate Range of Production Rates (cy/hr)	Dredging Depths (ft)		Limiting Wave Height (ft)	Limiting Current	Lateral Dredging Accuracy[3] (ft)
						Minimum	Maximum			
Dipper	*In situ*	High	Yes[4]	[5]	30-500	0[6]	50	<3[7]	[8]	1/2
Bucket	*In situ*	High[8]	Yes[4]	[5]	30-500	0[6]	100[10]	<3[7,11]	[8]	1

[1]Prepared by WES.
[2]Percent solids could theoretically be zero, but these are normal working ranges. Percent solids = $\frac{\text{wt. of dry sediment}}{\text{wt. of wet slurry}}$
[3]Vertical accuracies are generally within ± ft.
[4]Limited operation in open water possible, depending on hull size and type and wave height.
[5]Depends on floating structure; if barge-mounted, approximately 5- to 6-feet draft.
[6]Zero if used alongside of waterway; otherwise, draft of vessel will determine.
[7]Depend on supporting vessel—usually barge-mounted.
[8]Literature implies that water current hinders dredging operations, but references avoid establishing maximum current limitations. For most dredges, limiting current is probably in the 3- to 5-knot range, with hopper and dustpan dredges able to work at currents of perhaps seven knots.
[9]Low, if watertight bucket is used.
[10]Demonstrated depth; theoretically could be used much deeper.
[11]Theoretically unaffected by wave height; digging equipment not rigid.

Source: EM 1110-2-5025, Dredging and Dredge Material Disposal, U.S. Army Corps of Engineers, 25 March 1993.

3.4.1.6 Additional Selection Criteria for Dredges. Most USACE dredging is performed by private industry under contract. The USACE as a general application does not place restrictions on dredging equipment but in the case of small disposal areas will limit the pumping rate for use of the area. Water quality and other environmental standards provide sufficient controls and limits for operations without the exclusion of specific equipment for a job. Environmental protection is adequate justification for carefully controlling the methods of operation for dredging. The type of dredging equipment, used for Miami River and all dredging activities, will be based primarily on the type, size, and location of the disposal area available and required environmental specifications to obtain water quality certification for that situation. The dredging of contaminated sediments requires careful assessment of the dredging operation. A comparison of hydraulic and mechanical dredges is shown in Table 5.

Table 5. Comparison of Hydraulic and Mechanical Dredges

Dredge Type	Advantages	Disadvantages
Mechanical	-Excavation can proceed at the sediment's *in situ* water content -Dredges are highly maneuverable -No depth limitations for clamshell dredges -All types of debris can be removed -Good dredging accuracy	-Potential for large amounts of sediment resuspension -Dredged material must be handled -Production capacity is generally lower than hydraulic -Unit costs are typically higher than hydraulic
Hydraulic	-Resuspension of sediment is limited -Dredged material can be piped directly to the disposal area, eliminating the need for rehandling -Production capacity is generally higher than mechanical -Unit costs are typically lower than mechanical	-Large volume of water removed with the sediment must be treated prior to disposal or release -Slurry pipelines can obstruct navigational traffic -Most debris cannot be removed hydraulically

Source: USEPA/625/6-91/028, *Remediation of Contaminated Sediments*, April 1991.

3.4.2 DISPOSAL OPTIONS AND SITES

3.4.2.1 Introduction. Based on earlier discussions and on comments and suggestions received from various public and private interests in the Miami area, a number of options for dredging, transporting, and disposing of materials dredged from the Miami River Navigation Channel have been identified for consideration. Disposal options considered include open water placement in the ocean or inshore areas, confined disposal in artificial islands such as used by the Port of Miami or similar structures, and disposal at upland sites including existing or newly developed landfill sites.

Special treatment systems are also considered in this analysis, including use of municipal sewage treatment plants, incineration and pozzolanic solidification (and stabilization) of the dredged solids. None of these processes greatly reduces the large volume of unwanted material that must ultimately be disposed of. These special treatment systems are discussed prior to consideration of disposal sites so that benefits, if any, accruing from the special treatment systems may be exploited in selecting a preferred disposal method and site location.

3.4.2.2 Sediment Quality/Potential Environmental Impacts. Sediments in the Miami River contain elevated concentrations of trace metals and petroleum hydrocarbons. Some analyses have detected synthetic organic compounds, including pesticides and PCBs. These deposits limit or obstruct navigational uses of the river; when agitated by vessel propeller wash, they become partially resuspended in the water column, causing temporary and localized increases in water turbidity. Pollutants present in the river sediment would concurrently become suspended. Most of these resuspended materials settle rapidly and redeposit a short distance from where displaced. The process of settling, resuspending and resettling, beginning with the original entry of a particle into the river and depositing in the channel, tends to wash out soluble pollutants.

The environmental impact of leaving the navigation channel deposits in place is unknown as described above, and water quality should improve gradually with continued and successful efforts to reduce and eliminate pollution sources on and along the river. Removal of the bottom deposits to restore the original rock bottom channel would eliminate the turbidity and other pollutant resuspension problems and improve the river bottom environment, perhaps permanently if pollution control initiatives are successful.

There will also be environmental consequences if the Miami River channel deposits are removed by dredging. Bucket or clamshell dredges agitate bottom deposits, and in lifting the buckets from the water, some of the material washes out into the water column of the river. A mechanical operation to remove the miscellaneous debris in the Miami River will have to be used in conjunction with mechanical dredging or in advance of hydraulic dredging. The dredging operation cannot be efficiently done any other way. A hydraulic dredge cannot remove debris. In the process of dredging, undetected debris will be hit, causing agitation of the bottom deposits.

Sediment data indicate that sediments are highly variable throughout the project area. Because of the nature of the sediments (fine-grained silts that are easily resuspended and flushed from the river), material outside the normal navigation channel that is not disturbed by vessel propeller wash may have higher pollutant contents than transient deposits affected by propeller wash. Vessel traffic in the Miami River continually agitates the river sediments. The Conceptual Water Quality Certification issued by FDEP requires monitoring of turbidity and compliance with a turbidity requirement 150 meters beyond the end of the Federal channel.

There are also environmental considerations associated with the waters separated from dredged materials incidental to their transportation, placement, decanting, and drying. If sediments were removed from the river bottom by suction dredge, the slurried materials would be piped to a transport barge or piped directly to a repository area surrounded by levees or other means to contain the excess waters. Excess waters must be decanted and these waters may contain pollutants elutriated from the river sediments. Elutriate leachability tests give an indication of how much pollutant will enter the water column when sediments are disturbed. These tests show that varying amounts of metals and some organic compounds are expected to enter the water during dredging or dewatering. Recent elutriate tests indicate the concentrations of trace metals will exceed state and local water quality criteria. Turbidity controls including water containment, treatment, and/or reuse can reduce pollutant releases from this source.

There are many environmental considerations associated with placement of dredged materials in a temporary or permanent repository location. In the case of Miami River sediments, over 600,000 cy of material from the Federal navigation project are involved, and large areas of terrain would inevitably be changed by such a large mass of material. Wetlands obviously should not be used for repository purposes, and nearly all uplands near Miami River are developed or are too small or valuable to be used for the purpose. In addition, these materials must be placed in such a manner that rainfall will not wash away deposited materials and clog or pollute surface water streams.

A major environmental consideration is the effect that rainwater infiltration and transit through deposited materials will have on ground and surface waters. Much depends on the physical and chemical characteristics of the soils used in constructing a fill. Materials dredged from the Miami River would be somewhat different from other local soils because of the typical scarcity of clay particles in river silt. Materials dredged from the Miami River are much higher in metals content than native soils, apparently because of pollutants that entered the river.

There are no known Federal, state, or local sediment standards specifically for soils and no standards for soils deposited in navigable or other river channels. Recent analyses of materials dredged from the bottom of Miami River indicate low levels of organic pollutants and trace metal concentrations that are elevated. Pollutant migrations from the repository site should be prevented if the soil particles are contained and not washed or blown away by rain and windstorms and if impermeable liners and cover materials are used to prevent leachate migration.

Pollution potential of solid waste is evaluated by chemical analysis based on an acidic extraction procedure such as "Toxicity Characteristics Leaching Procedure (TCLP)" which measures a potential of constituents to contaminate groundwater. Attachment E is a listing of the maximum concentration of contaminants for toxicity characteristic as determined using TCLP and local soil disposal criteria from DERM. The most recent TCLP tests made on sediments from the Miami River indicate that pollutants leached from the sediment, while not hazardous, do not meet criteria for unrestricted disposal as clean fill. This means they are suitable for disposal in an approved solid waste landfill, according to input from DERM.

Because the sediments contain contaminants, disposal will require very expensive procedures and facilities including liners and groundwater monitoring wells for the various yards and landfills used for receiving, loading for transport, and disposal of these soils. Compliance with local solid waste management plans and regulations is assumed to avoid adverse environmental effects, although the use of scarce local solid waste disposal space for such a large volume of dredged material may not be environmentally advantageous in the end. Construction of a solid waste landfill facility would be built in accordance with state and local regulations and subject to regulatory approval.

3.4.2.3 Transportation and Disposal Options. Simply stated, the transportation requirement associated with dredging Miami River deposits is lifting the silty deposits now on the river bottom, and delivering these dredged materials to a final repository or disposal facility without causing other significant environmental effects. However, accomplishing the transportation requirement is not a simple task. Large amounts of water are included or come into contact with dredged materials during the transportation process, and excess water must be separated from solid or solidified materials and either discharged to the environment or evaporated.

Two methods are available for dredging bottom deposits from the Miami River study area. One method involves using a cable suspended bucket or clamshell to scoop sediment from the river bottom, raising the material above the water surface, and dumping the dredged materials either directly on the river bank or into a barge for transport. The other method involves using a hydraulic dredge, which uses a cutterhead to dislodge the sediment, and pumps the material from the river bottom via a pipeline to a disposal area.

From an overall environmental standpoint, the handling of dredge production waters is a critical item of concern, since contaminants adhere to the fine sediment that is put into solution when stirred or elutriated. Mechanical dredges remove dredged material at its *in situ* water content, resulting in less dredge production water to be discharged. The trade-off in utilizing a mechanical dredge is the increased turbidity caused by the physical action of the dredge itself.

Hydraulic dredges do not stir up as much sediment in the river channel as mechanical dredges; however hydraulically dredged (pumped) river sediment is more watery and proper handling of the excess muddy water can be a difficult and expensive problem to solve. The hydraulic dredge makes an ideal solution of about 20 percent solids to 80 percent water. Pumped dredged materials are usually piped from the suction dredge directly to a diked dewatering and stockpile area or final disposal site. Sites large enough for constructing dewatering and storage facilities for hydraulic dredging, and pipeline rights-of-way, are generally not available in the proximity of the Miami River. Dredged materials could be piped directly to a barge located near the dredge, but handling and disposal of excess muddy water would be a problem.

The cable-suspended bucket or clamshell dredging system could be used to remove the deposits from the entire length of the navigation channel, and there are both advantages and disadvantages in comparison to suction dredges. The dredge barge and equipment can stop work quickly and, if necessary, be moved aside to allow traffic to pass in the narrow channel or to avoid injuring manatees observed in the vicinity. The materials scooped from the bottom would be much less watery than those pumped from a suction dredge. However, each bucket load of deposits lifted from the bottom would release sediments (turbidity) to the water column as the bucket is lifted out of the water and suspended over the water surface on its way to a depository (open-top barge or bank side storage pile). Water quality certification from DEP contains a turbidity requirement to be less than 29 Nephlometric Turbidity Units (NTUs) above background at the compliance point. A mixing zone of 150 meters beyond the end of the Federal Channel is established. The compliance point is at the end of the mixing zone. If an exceedence occurs, work stops until the problem is solved. This requirement will be included in the project specifications.

EAS Engineering, a contractor for Miami-Dade County, conducted an assessment in the early 1990s of open land parcels within a one-mile radius of the Miami River, from its mouth to the salinity control structure. Conceptually, upland parcels could be used for staging, storing equipment, dewatering, loading, and unloading vehicles, and other ancillary activities. Temporary use of one or more parcels along the riverbank, with suitable bulkhead or wharves, will be needed for staging dredge operations, for unloading barges and temporarily storing debris removed from river prior to dredging, and possibly for unloading dredgings for drying, treatment or transfer to other transportation media such as trucks or railcars.

Finding suitable sites near the river to permanently store or dispose of dredged material is complicated. Assuming adequate upland sites are available near the river, the environmental permitting of such a site(s) would be extremely difficult. Such sites are socially unacceptable due to urban locations in downtown Miami, and very costly to develop. The USACE states that the smallest cost-effective diked upland site would need to be a minimum of 15 acres in size. Sites smaller than 15 acres would be less cost effective to develop because most of the site land would be occupied by containment levees and dikes, leaving very little room for placement of dredged material. The volume of material to be dredged from the Miami River could require a minimum of three of these sites and preferably four.

There are few "usable" sites of 15 acres or more, and these include such highly valued parcels as public parks and the Melreese Golf Course.

Dredge buckets could be emptied directly onto the riverbank at only a few select sites. Therefore, it will be necessary to dump dredge buckets into open-top tank barges located conveniently near the dredge barge. The filled barges will then be moved either directly to a barge accessible disposal site or to one or more barge unloading and materials handling facility developed specifically for the project.

If a disposal alternative is selected that does not allow the dredged materials to be transported by barges directly to and unloaded at the final disposal location, the cost of disposal increases sharply. There would be significant costs for every additional handling, drying, processing, transportation, and tipping (disposal) process utilized in getting the dredged materials to a remotely located upland disposal site.

The lowest cost transportation (and disposal) option would be to empty hopper bottom barges offshore at a nearby designated ocean disposal site; however, an offshore disposal option is not available for materials dredged from Miami River because the material does not meet Federal criteria for ocean disposal. It is most likely that materials dredged from the Miami River will have to be extracted through the tops of barges in which the material is transported.

Bucket or clamshell dredges remove the sediment being dredged at nearly its *in situ* density and place it in barges or scows for transportation to the selected barge-unloading site.

It would be necessary for the staging area to be a confined (bermed and lined) facility. A small amount of excess water is also carried into the barges with the wet sediments emptied from the dredge buckets. Barges filled with the dredged materials could be unloaded "dry" by cable suspended clamshell or other bucket. The materials (sediments), while moist, could be loaded directly into dump trucks or railroad cars; however, escaping waters would cause traffic hazards and water pollution. It is probable that dredged materials scooped from transport barges will have to be stockpiled temporarily to accommodate a need to unload barges rapidly and to provide sufficient drying to avoid "dripping" dump trucks or railroad cars. Excess water, including rainfall accumulating in the barges, would have to be removed occasionally and treated or evaporated. One or more large tracts accessible by barge and surface transportation would be required for this method of barge unloading, and the site would have to be improved to prevent uncontrolled storm water or other pollutant discharge from the site.

A more efficient and lower cost means of removing dredged materials from open top barges is by slurring the sediments with water and pumping them through a pipeline to a diked decanting, drying storage area. An additional advantage is that little or no land area is required at dockside, and although larger landside facilities are required, diked areas can be constructed thousands of feet from the barge unloading area if they are accessible by pipeline. The technique has the disadvantage of introducing water into soils that will have to be dried later. However, water pollution is minimized or eliminated by using excess water decanted from the stockpile in the diked areas, returning to the barge unloading site through a pipeline parallel to the material slurry pipeline, and using this water to slurry the dredged materials pumped from transport barges.

3.4.2.4 Special Treatment Systems for Dredged Solids.

3.4.2.4.1 Use of Municipal Sewerage Facilities. Some local interests suggested considering the use of existing sanitary sewers along Miami River and routing the dredged material, in limited doses, to the Central Wastewater Treatment Plant located on Virginia Key to be processed with the city's sewage.

Aside from questions about the plant's ability to handle additional waste, there are fatal problems with the concept.

A 1988 analysis of sediment samples dredged from the Miami River indicates average composition is about 14 percent gravel, 59 percent sand, and 17 percent silt and clay. Gravel cannot flow with the liquid in a typical municipal sewer, and would rapidly cause sewer clogging. Sand damages sewerage system pumps, and in such large amounts would very promptly cause a system failure. Sand and gravel that reaches a sewage treatment plant is extracted in a "grit" removal unit at the inlet of the plant. If all of the sand and gravel now in the Miami River sediment, over a half million cy in volume, made its way through the sewers to the sewage treatment plant, the grit removal system would be overwhelmed and a very large material handling and disposal problem created.

The silt and clay portions of the Miami River sediment also include a small amount of organic matter that might benefit from "sewage treatment." The remainder of the silt and clay fraction would merely add bulk to the sewage solids that must be treated, although the metals present in the sediment may inhibit some biological processes at the plant. If all of the silt and clay now in Miami River sediments were fed gradually to the sewer system over a two-year period, approximately 8,000 cy per day of the material could arrive at the sewage treatment plant. This material would increase the volume of dry biotreated sludge produced at the plant by the equivalent of that from 1,600,000 persons served by the sewer system. Further, the introduction of salt water into a treatment facility has a potential for interfering with bacterial degradation of wastes and causing a plant upset.

USACE comments regarding this option suggest, "the concept of using any municipal sewerage facility needs to be dropped from consideration unless the local sponsor holds and saves the Government and its contractor harmless from any damage to pipelines, equipment, pumps, and/or processes at the treatment facility." Because of the potential for damage to the transmission system and the wastewater treatment process, the local sponsor has recommended that this option be removed from further consideration.

3.4.2.4.2 Incineration. Incineration refers to heat treatment of dredged materials by raising temperature in a furnace or kiln to a level high enough to destroy organic matter. The treatment is effective in removing organic pollutants such as PCBs, hydrocarbons, and pesticides. Such treatment of solids also vaporizes volatile metals such as mercury, and these pollutants and offensive combustion products must be removed from furnace exhaust gases and receive proper disposal. If kiln temperatures are elevated sufficiently, metal constituents in the dredged materials could become fused together in a rock-like aggregate that is less capable of yielding polluting metals by dissolution when exposed to mildly acidic waters such as rainfall.

Incineration would reduce the volume of solids to be disposed of by removing organic matter and moisture. However, there is very little organic matter in Miami River dredged materials, and simple outdoor stockpiling of dredged solids could achieve sufficient drying to accommodate truck or rail transport to a permanent repository or disposal site.

Although dredged materials scooped from transport barges could be fed directly to an incinerator system equipped to handle slightly watery soils, using fuel for heat to evaporate moisture is expensive and wasteful. In addition, it would probably be necessary to unload barges rapidly and stockpile (and air dry) dredged materials in order to operate an incinerator system at a constant and efficient rate. However, barge deliveries are necessarily intermittent, and delayed unloadings would involve costly demurrage. Since stockpiling and open air drying of dredged materials probably cannot be avoided, and air dried material can just as easily be transported to a repository/disposal site, incineration would be advantageous only if incinerated soils could be used directly as aggregate for concrete, road fill, cinder block manufacture, etc.

The use of incinerators for treatment purposes is a matter of concern in air quality maintenance. High temperatures produce significant nitrogen oxide and other pollutants emissions. Incinerator units must be equipped with scrubber systems to remove toxic organics and acidic decomposition products, and hazardous metals such as mercury and lead. It is ordinarily difficult to obtain permits to operate such a facility in a densely populated urban area such as the vicinity of Miami River. State regulations limit thermal treatment of materials containing elevated levels of heavy metals.

Cost is also a major consideration in choosing incineration treatment for dredged materials. Estimated costs for rotary kiln incineration of large volumes of dredged materials range from $135 to $540 per cy. For incinerating over 600,000 cy of Miami River sediment, the cost would exceed $80,000,000. Natural aggregate materials are available in the Miami area for about $5 per yard, and thus sale of incineration aggregate would not significantly reduce incineration cost but would reduce disposal cost if a large amount of "aggregate" could be sold as fast as produced.

Sale of all incinerator output produced from the Miami River project is not a realistic expectation. If incinerated materials must be transported to a disposal site, there is no significant advantage in using the expensive incineration process. Furthermore, metals concentrations exceed state criteria for incineration of contaminated soils. Incineration treatment for Miami River sediments does not appear to be feasible.

3.4.2.4.3 Pozzolanic Solidification and Stabilization (PSS). This treatment process involves solidification of the dredged material with cement. The process binds soils and pollutant materials that may be present in the river sediments into a concrete-like substance. The solidification process increases the bulk volume of dredged solids.

If pozzolanic treatment is used, it would be necessary to unload barge loads of the dredgings at a suitable site along Miami River, and to transfer the materials either to a stockpile for decant and partial drying or directly to a processing plant. The processed material can be cast into thin slabs for easy fracture and handling by bulk loaders or cast into convenient size cobbles or chunks for easy storage and conveyance.

Pozzolanic solidification and stabilization is not a final disposal process in itself. The process is expensive (costs estimated at $75 per cy of materials processed). The solidified materials must be put somewhere for final disposal, at additional cost. If a suitable disposal site is not in the immediate vicinity of the processing plant, additional material transfer and transportation costs are involved.

The regulatory status of pozzolanic solidified and stabilized material is uncertain. It is unlikely that the treated materials can be considered to be "dredged material" and thus be eligible for disposal at a designated ocean disposal site. Furthermore, there has been no test to prove that a pozzolanic solidification process will certainly and permanently eliminate the characteristics of Miami River sediment that now foreclose an ocean disposal option. In addition, the concrete-like castings or rubble produced would become "solid waste" if not used for some beneficial purpose such as construction material, and Florida Solid Waste Disposal Regulation 17-701.040 prohibits the use of solid waste (including clean debris and stabilized material) from being used as backfill in sinkholes, abandoned limestone quarries or gravel pits.

The cost for solidifying over 600,000 cy of Miami River sediment would exceed $45,000,000. A small part of this cost could be offset if a valuable product such as concrete construction blocks could be produced and sold, but the possibility of selling a significant percentage of the huge volume of "concrete" that would be produced is uncertain. Most of the produced material would have to be disposed of as solid waste (clean debris or stabilized material).

Solidification would not facilitate use of dredged materials for disposal/closure at a landfill. Pozzolonic solidified materials, ordinarily in the form of cobbles or rubble, would not impede horizontal or vertical migration of rainwater or leachate. Unsolidified dewatered dredged material would better serve the purpose.

There is no significant advantage to using pozzolanic treatment versus simple dewatering and drying of dredged materials. In view of the high cost of this and similar processes, such treatment does not appear to be feasible for the Miami River maintenance dredging project.

3.4.2.5 Open Water Placement. Open water placement includes ocean dumping and the filling in of man-made cavities (borrow areas) located in inshore areas. In assessing the need for ocean dumping, the USEPA/USACE *Green Book* states that initially, no disposal alternative is considered more desirable than any other, and that the evaluation is made on a case-by-case basis. That is, confined or upland disposal cannot be considered environmentally preferable to ocean disposal unless consideration of potential environmental impact (e.g., groundwater contamination, leachate, and runoff impact, permanent alteration of the site) shows it to be so. Similarly, ocean disposal cannot automatically be considered the most desirable alternative. Reference: USEPA 503/8-91/001 Evaluation of Dredged Material Proposed for Ocean Disposal.

3.4.2.5.1 Ocean Disposal. Dumping of dredged material at a designated ocean site is a disposal method frequently used in a maintenance-dredging situation. The operating cost of dumping in the ocean, if such were permissible, would be low in comparison to other disposal methods, because of the short distance from Miami River to the nearest designated ocean dumping site, and the convenience and economy of unloading hopper bottom barges at sea. From an overall (cost) economic assessment of disposal alternatives, it is less expensive to transport the dredged material offshore than to transport and place it in a landfill. However, the Miami River sediments do not meet the USACE/USEPA minimum criteria for disposal in the ocean dredged material disposal site (ODMDS). The ocean disposal option at the designated site is not a disposal option for the maintenance dredging operation for Miami River.

Ocean disposal on a one-time basis was proposed by the local sponsor. In order for "one-time" ocean disposal of Miami River sediments to be approved, potential alternatives for upland and nearshore disposal must be exhausted. It must be shown that there are no other economically feasible alternatives for sediment disposal. In general, the process for "one-time" ocean disposal would proceed as follows: permitting for transport and disposal of dredged material would be initiated by USACE. The application for dredged material disposal would include a determination of the need for ocean disposal. The Miami River sediments would have to be characterized by sampling and analysis in accordance with the *Green Book*, "Evaluation of Dredged Material Proposed for Ocean Disposal" (USEPA/USACE, 1991) which uses a tiered approach to the testing process for evaluating sediment suitability for ocean disposal. After testing is complete, the application for ocean disposal would be submitted for concurrence by the USEPA. If the USEPA does not concur with the suitability of the Miami River sediments for ocean disposal, an exception for a waiver could be requested. The recommendation for a waiver would originate from the District Engineer for the Jacksonville District USACE. The recommendation would have to be reviewed and concurred with at each step in the military chain-of-command until it reached the Secretary of the Army. If the Secretary of the Army concurred with the waiver recommendation, it would be forwarded to the Administrator of USEPA for a similar review and concurrence. USEPA Region IV stated that no precedent exists for a waiver request.

The waiver option would require strong justification and thorough documentation that the pollution sources that caused the current concerns with the Miami River sediments have been corrected and the problem will not reoccur. In addition, there must be no other economically feasible option for disposal of the Miami River sediment. A specific site for "one-time" ocean disposal must be designated and approved.

The designation of a "one-time" ocean disposal site for the Miami River sediments will require extensive study and sampling to assure no adverse impacts will occur. This will involve documentation of existing bathymetry, geological characterization, ocean currents, fisheries resources, etc. at the designated site. An environmental impact statement will probably be necessary for the "one-time" site designation. It should be noted that the designated ocean dredged material disposal site (ODMDS) for approved sediments in the Miami area remains designated an "interim" site because of environmental impact concerns. Attempts to resolve these concerns have been ongoing for years. In light of this, the designation of a "one-time" ocean disposal site will not be an easy, "quick-fix" solution for disposal of Miami River sediments.

Requests have been made by local interests to include a timeframe and cost estimate for the "one-time" ocean disposal alternative. Since this has never been attempted on a national level, much less on a state or local level, no previous timeframes or costs exist for comparison. A conservative estimate of 12-18 months for requesting a waiver to pursue "one-time" ocean disposal and 36-48 months for site designation, data collection, and assessing the environmental impact of the site designation are believed to be conservative estimates of this option's timeframe. Development of the cost for the "one-time" alternative is difficult due to the numerous uncertainties and variables that could be involved. Based on professional judgment and conversations with USACE and USEPA representatives, it is believed that a conservative cost of $2-4 million would be necessary for requesting the "one-time" waiver and designating a "one-time" disposal site. This cost would be in addition to the actual dredging costs.

3.4.2.5.2 Inshore Disposal. This concept of disposing of dredged materials would involve depositing the dredged soils in Biscayne Bay. While transportation and placement of dredged materials from Miami River to Biscayne Bay and placing the materials in a suitable repository may have some environmental consequences, there are at least two methods of depositing dredged soils in the Bay that are worthy of discussion, although difficulty in acquiring permits and high costs associated with providing adequate environmental protection may favor other dredged material disposal alternatives.

3.4.2.5.2.1 Fill Existing Holes in Bay. This disposal method would fill in deep holes from which fill materials were previously removed to build surrounding uplands or create islands in the Bay. The river sediments would be transported directly from the dredge machine to the disposal site by barge, deposited in the holes, and turbidity controlled by float-suspended silt curtains around the work areas. The object would be to raise bottom depth to the optimum for establishment or reestablishment of sea grass beds. Because of concerns about the possible toxicity of dredged material to certain indigenous species, it may be necessary to confine the material during deposition and cover such deposited dredged materials with a meter thick layer of "clean" sand or other suitable bottom material.

None of the existing Bay holes is large enough to handle all of the sediment now accumulated in Miami River, and many are not directly accessible by loaded transport barges. Transport barges loaded with dredged materials draw 10 feet or more of water, whereas the original water depth at many of the "holes" is considerably less than 10 feet. Most or all of the barge-transported soils would have to be scooped or pumped from the barges, transported some distance, and carefully placed in the Bay "holes." These operations are expensive and there is no way to avoid temporarily raising water turbidity and/or contaminant levels in the vicinity, although surrounding the work area with floating silt curtains could minimize the problem. Because Biscayne Bay is a State Aquatic Preserve and Outstanding Florida Water, regulations pertaining to dredge and fill activities are restrictive and prohibit disposal of dredged material within the boundaries of the Preserve. In addition, public concern for the Bay is very high. Environmental permitting for such a project would be extremely difficult.

The cost of procuring, transporting and placing "clean" cover materials to cap the bay holes filled with dredged material, would be very large. Providing a meter thick cover or cap of clean soils atop the holes would require over 300,000 cy of material similar to the natural bay bottom soils.

The total cost of disposing of materials dredged from the Miami River would most likely exceed the cost of simple dewatering, truck transport, and disposal of dredged solids at an upland disposal site. The risk of harming Biscayne Bay, along with higher comparative costs, makes it very unlikely that this alternative method of dredged material disposal would be favored by local interests.

3.4.2.5.2.2 Use As Fill Material for New "Islands." If any new "island" construction is to occur in Biscayne Bay, such as expansion of Port of Miami facilities, these dredged materials could be used in lieu of other fill materials. The only additional costs to that of ordinary ocean disposal would be that for removing dredged materials from barges, placing the materials in the fill, and controlling or removing turbidity from any decanted waters.

Obtaining permits for the construction of new “islands” in Biscayne Bay is unlikely because such construction would occur within Biscayne Bay. Furthermore, the sediment characterization of the dredged material indicates substantial silt content, indicating that the dredged material is not structurally compatible for use as fill.

3.4.2.6 Confined Disposal. Confined disposal refers to diked containment areas used to retain hydraulically transported (pumped) dredged material solids while allowing the carrier water to be released from the containment area. The most efficient method of using diked containment areas is associated with the use of hydraulic dredges pumping the dredged materials by pipeline to the solids retention basin. Where pipeline access to diked containment areas is not available, and bucket or clamshell dredges are used, dredgings could be placed in barges for transport to a location accessible by pipeline and there the dredged materials pumped from barges to diked containment areas, using a hydraulic unloader. Pumping material into a barge does not provide for an efficient operation unless the dredge is very small and the overflow does not cause a problem. This is not a viable option for dredging the Miami River.

The USACE states that distance is a factor that must be considered in the analysis of material transport from hydraulic dredging. For disposal areas located some distance away from the dredge site, accessibility by pipeline is only part of the problem. Costs, as well as the physical capability of pumping must be considered. Companies with hydraulic dredges typically have sufficient discharge pipe or can obtain additional pipe for economical dredging and transport to upland disposal areas within a two-to-four-mile radius of the dredging area. More than that is a problem. If a disposal area is located 10-15 miles from the dredging site, the use of a pipeline to transport the material is not the most efficient method of dredging and disposal.

There is at least one advantage in pumping barged dredgings versus pumping directly from a hydraulic dredge to a diked containment area. Hydraulic dredges pump large volumes of river water along with the sediments, producing a lot of surplus decant water that may have to be treated to meet effluent quality standards applicable in the locality. Where dredged materials are pumped from barges, decant water and rainfall in the diked areas can be recycled to the barges for use in slurring the dredging solids for pumping. Comparatively little, if any, effluent is associated with this barge pumping technique.

Florida Solid Waste Rule 403.7045 requires that dredged material or fill material shall be disposed of pursuant to a dredge and fill permit. Environmental consequences must be considered, and sale or use of such dredge and fill material may be restricted. Although no standards for dredged material exists, recent analysis of Miami River sediments indicate pollutant concentrations exceed criteria for unrestricted disposal, but are not considered hazardous.

Undoubtedly, location and environmental setting will have to be considered in approving a containment site for a dredge and fill permit.

In the 1993 Alternatives Report there were two areas where there was sufficient land to accommodate all the sediment to be dredged, barge mooring sites, and pipeline easements available for constructing permanent diked containment areas. One area is near Palmer Lake and the other is at Virginia Key.

If dredged material were deposited at the Old Virginia Key landfill, "closure" pursuant to state and local regulations would be required. This would entail some type of leachate remediation or confinement, methane gas collection, and capping with impermeable material. Furthermore, it is doubtful that the Miami River sediments would constitute suitable cover material. Therefore, the Virginia Key site was eliminated from further consideration. The Palmer Lake site was eliminated from further consideration because of several environmental concerns, the most important of which is the lake is winter habitat for manatees. Since completion of the 1993 report, *Alternatives for the Dredging and Disposal of Sediment from the Miami Harbor (Miami River) Project, Florida*, other potential dredged material disposal sites have been analyzed.

The former yacht basin is located on the right descending bank of the Miami River, across (south) the river from Gerry Curtis Park. The site includes two large covered boat slips and vacant land away from the river. A proposal was reviewed to bulkhead and fill the boatslips and use the vacant land for temporary upland disposal.

The FEC Bicentennial Park slip, located near the American Airline Arena on Biscayne Bay, was also considered for sediment disposal. The park and slip were a part of a land grant from the State of Florida to the City of Miami in 1919 that covers submerged lands. It was proposed to bulkhead and fill the slip, stabilize the dredged material, and cover it with some type of cap, creating a “vault.”

Concerns were raised by environmental agencies and organizations objecting to utilizing the slips as a final site for contaminated dredge spoil. Questions were raised regarding impacts to the Biscayne Bay Aquatic Preserve. As previously stated, the Biscayne Bay Aquatic Preserve Act generally prohibits the filling of the Bay with dredged material.

3.4.2.7 Disposal at Upland Sites. This disposal option involves placing dry or solidified and stabilized dredged materials in an existing or newly developed site meeting all state and local criteria. Material dredged from Miami River could become "solid waste" if it cannot remain in an approved dredge spoil containment area as authorized by a dredge and fill permit, and cannot be beneficially used in construction, concrete block manufacture, or for some other useful purpose.

Recent tests on Miami River sediment indicate the materials are not "hazardous" according to Federal and state quality criteria for solid waste. This is an important consideration because handling, transportation and disposal requirements for hazardous wastes are necessarily much more stringent and expensive than for non-hazardous materials. However, the material does not meet state and local soil remediation criteria, and thus cannot be used as unrestricted fill.

Materials dredged from Miami River would first be placed in barges, then moved to a barge-unloading site, and transferred from the barges to a temporary dredged material containment area. Bucket or clamshell dredged materials are mostly solids but do contain enough water to make infeasible the direct transfer of wet materials from the transport barges to dump trucks or rail cars. A temporary dredged material containment facility serves the purpose of decanting excess water from the dredged materials and allowing it to air dry sufficiently for loading into trucks or rail cars for transfer to a permanent repository/disposal facility.

When berthing areas are dredged for private interests, the usual practice along Miami River is for the bucket-dredged materials to be stacked on the ground near the riverbank for dewatering and drying. This method requires either dewatering controls or containment of the decant water. Because available sites along the riverbanks are quite small and temporary storage space is very limited, it may be difficult to move dried materials to the final disposal site fast enough to avoid costly "bottlenecks" and disrupt dredging operations. Furthermore, it would be impractical to bank dry close to 600,000 cy of dredged material in an urban environment similar to the Miami River. An alternative barge unloading and temporary dredged material containment system would involve pumping solids from the barges to diked containment areas located where sufficient land area is available.

In the case of bankside temporary containment, the perimeter of facility would need to be curbed to exclude entry of external drainage water and aid in collecting all decant water and rainfall runoff from the work area for treatment and monitoring for discharge to the river or sanitary sewer system. This method depends upon skilled operation of heavy equipment, which is very expensive, and rainy weather can cause expensive delays and possible disruption of dredging operations. The need for a repository or disposal site to accept delivery of materials on an uninterrupted basis will be difficult and expensive to satisfy.

Use of the barge pumping and diked dredged material containment and dewatering system has larger and more costly land acquisition requirements but has more dredged material storage space, has lower operating costs, and operations would not be seriously affected by inclement weather. Decant water and collected rainfall on diked areas could be recycled for slurring barged materials, reducing effluent discharge problems.

Location of diked dredged material retention facilities in the vicinity of Miami River may have high environmental protection costs. Fine-grained surficial soils are scarce in that area, providing little cover for the native rock of the Biscayne aquifer. Soils for dike construction would have to be imported, and containment systems of man-made materials may be needed to protect groundwater quality. Containment systems could be damaged in removing dried materials for transfer to a final disposal site.

3.4.2.8 Management Practice. The terms of a dredge and fill permit, and Federal, State and Miami-Dade County regulations would determine management practices. The dredge and fill permit must necessarily include provision for minimizing water turbidity associated with dredging operations, protection for endangered manatees, and limitations on dredged material decant water discharge. Dredged material handling and disposal operation will undoubtedly result in construction on upland sites necessitating permits requiring specific storm water management and control systems.

Removal of dredged materials from permitted dredged material containment areas or treatment processes must comply with all applicable state and Federal Regulations. If these materials are placed in solid waste disposal facilities, only approved facilities may be used, and the management plans for these facilities must be followed.

The pollution controls at the final disposal site would be imposed by environmental regulatory agencies.

3.4.3 SEDIMENT CHEMISTRY CHARACTERIZATION

The material now deposited in the Miami River Navigation Channel was deposited there subsequent to dredging the authorized depth into the native rock during the 1930s. The bulk of the deposited material consists of surficial soils eroded and transported from a large watershed area that includes much of Dade, Broward, and Palm Beach counties.

Drainage water carries soils and other sediment into the Miami River navigation area via Miami River Canal, South Fork and Tamiami Canal, Wagner Creek (Seybold Canal) and through numerous storm sewers serving nearby industrial, commercial and residential areas. Sediments in the Miami River also include soils abraded from the river's banks by tidal currents and wave wash, crushing and scraping by vessel collisions, and wharf construction activities. The deposits also contain materials not of soil origin including vegetation fragments, marine organisms and skeletal remains, and man-made pollutants.

Like many other streams in an urban environment, Miami River has been used as a receptacle and conduit for waste materials. Untreated sanitary sewage from the City of Miami was discharged deliberately and inadvertently for many years, and some still enters from sanitary sewer overflows, sewer leaks, and improper sewer connections to storm sewers, and from vessels using the waterway. Industrial activities, especially metalworking, cleaning and painting, and salvage associated with marine industries, have contributed pollutants to the Miami River. Persistent pesticides used on agricultural lands and urban lawns and gardens may have been attached to soil particles that were washed into the river and deposited. Fuels and lubricants spilled in the port and on streets and parking lots of the watershed also have entered the river.

Much progress in pollution abatement has been achieved in the Miami area in recent years. Storm and sanitary sewer systems have been improved and new construction is regulated. Marine and industrial facilities are inspected and pollution control regulations enforced. Some of the pollutants deposited over the years have decayed or been resuspended by vessel prop wash and removed from the river channel by river and tidal currents. The pollutants of major concern, according to previous investigations, are metals content in the sediments and sanitary hazards associated with notorious sewage pollution incidents.

Surficial soils in the Miami area consists primarily of limestone, sandstone, sand, and shells ordinarily covered with a moderate to thin layer of silty topsoil. On this basis, it would be expected that the natural metal content of river sediments should be high in silicon and calcium, but comparatively low in most other metals. A 1984 publication *Element Concentrations in Soils and Other Surficial Materials of the Conterminous United States, U.S. Geological Survey Professional Paper 1270*, confirms that *surficial* soils in the Miami area have higher than average concentrations of silicon and calcium and comparatively low concentration of other metals except tin, strontium, antimony and lead. Antimony and lead occurrence concentrations in the Miami area surficial soils are indicated to be among the highest in the United States. The report indicates that surficial soil concentrations of mercury, copper, and zinc in the Miami area are within or below average national concentrations. The high range of lead concentrations in surficial soils of the U.S. is indicated to be 30 parts per million (ppm) or more. The sediments of the Miami River are typically ten times this concentration.

3.4.3.1 Surface Water. The State of Florida has developed and implemented state water quality standards in conjunction with USEPA guidelines. The state regulates its waterbodies through a classification system that relates the water resource to its intended use. The major classes for Florida waters as originally formulated are:

Class I- Public Water Supply
Class II- Shellfish Propagation and Harvesting
Class III- Recreation/Propagation and Management of Fish and Wildlife
Class IV- Agricultural Water Supplies
Class V- Navigation, Utility, and Industrial Use

The Miami River was originally classified by the State of Florida as a Class IV waterbody. In 1989, the river's classification was changed from Class IV to Class III. Class III waterbodies can support recreation and a healthy and well-balanced population of fish and wildlife. The Miami River does not technically meet all Class III standards at present; however, local interests have stated that the classification change was made because the Miami River is part of the Biscayne Bay Aquatic Preserve and so that the river could be regulated ultimately to meet those standards.

3.4.3.1.1 Biscayne Bay Aquatic Preserve. The downstream portion of the Miami River, from the salinity dam near NW 36th Street to the river mouth, lies within the Biscayne Bay Aquatic Preserve. The preserve was designated in 1974 by the Florida Legislature and consists primarily of state-submerged lands and islands and the water column over all submerged lands within the Preserve. Those submerged lands within the preserve boundaries that are privately owned or leased or which have been deeded to the County or municipalities are also part of the preserve. All waters within the preserve are classified as Outstanding Florida Waters, Class III.

3.4.3.1.1.1 Outstanding Florida Water. An Outstanding Florida Water (OFW) is a waterbody deemed worthy of special protection due to its natural attributes. The designation OFW is given to certain waterbodies in the interest of maintaining the ambient (extant) water quality. In addition to meeting Class III numerical standards, no activities may be permitted that would result in degradation of water quality.

The majority of OFWs are found in parks managed by the state or Federal government. Examples of OFWs include wildlife refuges, marine sanctuaries, estuarine research reserves, aquatic preserves, scenic and wild rivers, and certain waters within state or national forests. Waterbodies are generally classified as OFWs because the managing agency has requested special protection to protect ambient water quality. Waterbodies not within a state or Federal managed area may be designated as "special water" OFWs if certain requirements are met, including a public process of designation.

An OFW designation affects activities that require a DEP permit and have the potential to lower ambient water quality. Activities such as fishing, boating, diving, and river setback ordinances are not affected by this designation.

3.4.3.1.1.2 Surface Water Improvement and Management Plan. Biscayne Bay was designated a priority water body by the Florida Legislature in the Surface Water Improvement and Management (SWIM) Act of 1987. The Biscayne Bay Surface Water Improvement and Management (SWIM) Plan was adopted in 1988 to maintain and improve water quality to protect and restore natural ecosystems and compatible human uses of Biscayne Bay.

SWIM develops improvement and management plans for at-risk waterbodies and directs the work needed to restore damaged ecosystems, prevent pollution from runoff and other sources, and educate the public. SWIM plans are used by other state programs to help make regulation and management decisions.

The Biscayne Bay SWIM Plan contains a priority list that emphasizes geographic areas where the most serious problems exist. Waterbodies within the priority list may be subjected to additional research, investigation, enforcement, or construction activities, according to their needs as assessed by the SWIM Plan. The Miami River/Canal is included in the Biscayne Bay SWIM Plan's Priority List.

3.4.3.2 Pollution Sources. Until the mid 1950s, local governments discharged wastewater directly into the Miami River. This practice was discontinued in the 1950s when regional treatment plants were completed. However, overflows and illegal connections intermittently discharge material into the river. Consequently, the river is periodically contaminated and water quality is further impaired.

Storm sewer outfalls are the greatest source of pollutants to the Miami River. In recent years, efforts have been made to abate stormwater discharges. All new developments are required to contain 100 percent of all on-site stormwater whenever feasible. Any work involving replacement or new construction of stormwater collection systems must have French drains or another suitable method that employs infiltration.

Abandoned vessels were a significant source of river pollution. At one time, the U.S. Customs Service had docked as many as 170 vessels along the river. Miscellaneous abandoned boats have also been a recurring problem. State and local interests have taken measures to prevent these abandonments by policing the river and citing violators.

Construction site dewatering, coastal construction, and industrial waste discharges are also prominent sources of pollution. Miami-Dade County has enacted local rules to regulate these activities by requiring annual operating permits. The county has hired several officers to increase local enforcement capacities and assure compliance with the permit program.

3.4.3.3 Previous Studies. Water and sediment contamination within the Miami River has been the subject of much concern in recent decades. Contaminant testing has been an ongoing procedure since the mid-1980s. A number of studies have been performed on behalf of the Jacksonville District of the USACE, and other Federal agencies, the State of Florida and Miami-Dade County. Although results from these studies do not always directly coincide, data comparison often reveals noticeable trends in contaminant levels. The following studies are representative of those conducted on Miami River sediments and are not intended to be inclusive.

3.4.3.3.1 Early Studies. As early as the 1970s, environmental scientists began to recognize that the Miami River was highly polluted and that it contributed a substantial amount of chemical pollutants to Biscayne Bay. A study performed by the University of Miami in 1983 detected high concentrations of hydrocarbons in the lower Miami River, with particularly high concentrations in the vicinity of the monorail bridge (2449 micrograms/gram) and the railroad bridge (459 micrograms/gram). Additional samples taken the following year revealed elevated hydrocarbon levels in the lower Miami River. Detectable concentrations of endosulfan were also detected in Miami River samples (124.2 ng/g).

The *FDEP Deepwater Ports Maintenance Study Technical Report on the Port of Miami and the Miami River* (1984) indicates that water samples collected from Biscayne Bay and the Miami River did not reveal excessive amounts of metals, except for mercury and silver, which were present in levels exceeding state water quality standards. Samples collected in the Miami River indicated the water column was stratified and anoxic along the bottom in some areas. Turbidity levels were extremely high in the river mouth, particularly during the wet season. Analysis of sediment samples revealed the river was a major source of cadmium, chromium, copper, mercury, lead, and zinc along the navigation channels on the south side of Dodge Island.

River and canal sediments were found to contain high concentrations of fine-grained silt particles that exhibit slow settling rates and are easily disturbed by vessel traffic. These sediments were observed to contain various levels of trace metals, pesticides, and PCBs.

Concentrations of mercury were elevated in all studies in the section of the river roughly from the Comfort Canal to the Seybold Canal. The concentrations were estimated to be between 0.2 and 0.5 ppb as indicated by the results of elutriate tests. Some of the exceedences could be attributed to natural background levels.

According to the National Park Service and other agencies, sediments from the Miami River damaged sea grasses in Biscayne Bay near the mouth of the river. Additionally, state water quality criteria were exceeded for mercury and silver during elutriate chemical tests, and various low-level effects occurred on organisms exposed to sediments during elutriate bioassays. Moreover, numerous public agencies reported that the sediments caused short-term violations of state water quality standards due to disturbances from vessel traffic.

3.4.3.3.2 ERCO Study – 1985. A study conducted by ERCO (a division of ENSECO, Inc.) in 1985 deemed the oceanic discharge of dredged material from the Miami River to be acceptable as judged by the toxicity criteria employed in the evaluation. Dredged material was collected from five sampling stations in the Miami River. Bioassays were performed for each of these stations using grass shrimp (*Mysidopsis bahia*), mysids (*Mysidopsis bahia*), and Atlantic silversides (*Menidia menidia*). The organisms were exposed to 100 percent suspended particulate phase of dredged material for 96 hours. Survival of the organisms in the dredged material was not significantly lower

(0.05 probability level) than survivors of control organisms exposed for 96 hours. Additionally, survival of brown shrimp (*Penaeus aztecus aztecus*), hard clams (*Mercenaria mercenaria*), and sandworms (*Nereis virens*) exposed for 10 days to control sediment and the solid phase of dredged material was not significantly different.

Tissues of organisms that survived exposure to the solid phase of dredged material usually did not contain significantly elevated (0.05 probability level) concentrations of cadmium, mercury, PCBs, aliphatic and aromatic petroleum hydrocarbons) as compared to tissues of control organisms. A statistical tendency for bioaccumulation was noted. The probability of harmful accumulation of petroleum hydrocarbons in the human food chain was judged negligible.

3.4.3.3.3 Summary of DERM Monitoring. A network of surface water monitoring stations within the Bay was established by the Miami-Dade Department of Environmental Resources Management in the late 1970s, with support from the State of Florida. The network was expanded to include the Miami River and other canals and tributaries in 1979 in connection with the Biscayne Bay Surface Water Improvement and Management Program. At present, 13 stations in the River and its tributaries are sampled on a monthly basis. This extensive database identifies broad scale geographic and temporal patterns or trends, establishes "background" or typical conditions, and assists with regulatory and permitting decisions. Results of this program have been summarized in various reports on the Miami River or Biscayne Bay (DERM, 1987, 1993; SFWMD, 1995; BBPI, 2001). This program has documented that water quality in Biscayne Bay meets or exceeds most State and local water quality criteria for Class III waters. However, water quality in canals and tributaries, including the Miami River, is poor compared to the downstream waters of the Bay. This represents a management concern, since Biscayne Bay, an Outstanding Florida Water body, is protected under state rules by antidegradation standards, which prohibit any activity that would degrade ambient or typical conditions. The Miami River is one of several urban tributaries that exhibits chronically elevated levels of coliform bacteria, an indicator of sewage pollution. Highest levels of coliform bacteria have been documented in Wagner Creek (Seybold Canal) and the lower portion of the River, but exceedences of State and local standards have been recorded throughout the River. It also is characterized by low dissolved oxygen. Compared to Biscayne Bay and some other canals, the Miami River exhibits relatively elevated concentrations of ammonia, nitrogen, total phosphate, color, and trace metals concentrations. The DERM database for all Miami River stations combined for the entire period of record (1979 to present) indicates turbidity is variable, ranging from 0.1 to 39.8 NTU. Mean and median turbidity levels for the River are 2.95 and 2.2 NTU respectively.

3.4.3.3.4 SLES Study – 1987. Savannah Laboratories and Environmental Services, Inc. (SLES) conducted a chemical analysis of water, sediments, and elutriate samples from the lower Miami River from Comfort Canal to Biscayne Bay. These analyses revealed that existing water in the Miami River is highly turbid, occasionally anoxic, and may exhibit isolated incidences of exceedences of state water quality standards for heavy metals. Sediments in the Miami River were found to contain high levels of heavy metals, PCBs, PAHs, oil, and grease. Elutriate results demonstrated that sediments mixing with water would generate mercury concentrations of approximately 0.3 ppb, exceeding the state water quality standard of 0.2 ppb. Incidents of state water quality standard exceedences were determined to originate from non-point outfalls from the urban areas of the river, and sediment agitation from vessel traffic.

3.4.3.3.5 PPB Studies

3.4.3.3.5.1 PPB Study – 1991. Water and sediment samples were collected by PPB Environmental Laboratories, Inc. (PPB) from the Miami River and the Miami Ocean Dredged Material Disposal Site in July 1991. A reference sediment sample and elutriate sample were analyzed.

Aluminum and iron were found in the reference sediment at higher levels than other metals, which were either not detected or detected in trace amounts. No pesticides, PCBs, PAHs, or phenolics were found in the elutriate.

Elutriate and whole sediment bioassays were performed by Barry A. Vittor & Associates, Inc., on seven channel material samples and a reference sample. Elutriate bioassays showed that survivorship of *Mysidopsis bahia*, *Menidia beryllina*, and *Crassostrea virginica* was significantly lower in elutriates of sampled sediments than in control water.

Whole sediment bioassays indicated that *M. bahia* was less affected by exposure to test sediments than *Ampelisca abdita*. Control survivorship was 96 percent for both species. *M. bahia* survivorship in selected channel samples was over 10 percent below that in the reference sediment. However, survivorship in other channel sediments was statistically lower than the reference station.

Overall survivorship in all channel samples was more than 20 percent below control sediment survivorship for *A. abdita*.

Bioaccumulation data showed that tissue hydrocarbon concentrations were below detection limits for all compounds tested. Lead appeared to be accumulated by both *Nereis virens* and *Macoma nasuta*, while *Macoma* exposed to sediments from the vicinity of Seybold Canal may have tended to accumulate several heavy metals, although statistically significant changes in tissue concentrations were not observed.

The 1991 bioassay tests on dredged material from Miami River indicate the material is not suitable for disposal at the designated offshore disposal site near Miami.

The sediments showed high levels of mortality in the amphipod *Ampelisca* sp. exposed to solid-phase sediments from all stations tested. Significant mortality also occurred in other test organisms exposed to solid-phase sediments from some, but not all, stations. Mortality among test organisms in suspended particulate bioassays was not considered to exceed criteria, considering dilution in the mixing zone. Results of these bioassays, however, generally indicate that Miami River sediment is not suitable for ocean disposal at the ODMDS.

3.4.3.3.5.2 PPB Study – 1995. A study conducted by PPB in July 1995 evaluated samples taken from six stations in the Miami River, one station in Miami Harbor, and two reference stations in waters near the Miami Ocean Dredged Material Disposal Site. The sites were sampled as part of the 1995 Miami River Maintenance Dredging 103 Evaluation.

Water column measurement for the sample stations indicated that warm, oxygen-poor conditions prevailed at all river locations. Higher oxygen values were reported from samples near the river mouth; these values reflect the influence of saline, highly oxygenated water from Biscayne Bay.

Elevated levels of cadmium, chromium, copper, lead, mercury, nickel, silver, and zinc were detected in samples. Low-to-moderate enrichment was noted for chromium, nickel, and zinc; moderate-to-high enrichment was noted for cadmium, lead, and copper. Silver and mercury, generally not present in estuarine systems, were measured in the range of 1-8 micrograms/gram (dry weight basis). All station sediments were essentially free of pesticides, PCBs, and PAHs.

Traditional bioassays were performed by Barry A. Vittor and Associates, Inc. on eight sediment samples. The bioassays indicated that *Mysidopsis bahia* and *Leptocheirus plumulosus* were affected by exposure to sample stations. Geobags™ whole sediment bioassays were performed to measure the ability of Geobags™ to minimize the toxicity and bioaccumulation of contaminated sediments in bioassay test organisms. Geobags™ were filled with test sediment, sewn, pressed with weights, and capped with Miami Harbor sediment. The Geobags™ bioassays indicated that *M. bahia* was affected by exposure to sample stations, while *Leptocheirus plumulosus* was generally not affected. The use of Geobags™ reduced toxicity in all sample stations in *L. plumulosus* but did not seem to limit toxicity in the *M. bahia* tests.

Elutriate bioassays showed that survivorship of *M. bahia* and *Menida beryllina* in control water was significantly greater than in 100 percent elutriates of selected sediment samples. Additionally, fertilization of *Lytechinus variegates* in control water was substantially greater than in 100 percent elutriates of selected sediment samples.

Bioaccumulation test results using Geobags™ capped with Miami Harbor sediment showed decreases in metal concentrations for both *Nereis virens* and *Macoma nasuta*. Decreases were higher for *N. virens* than for *M. nasuta*.

DERM commented on the Geobags™ tests, stating that,

> *. . . although Geobags containment appeared to reduce toxicity in amphipods, it did not eliminate it. In mysid assays, Geobags appeared to actually increase toxicity in controls and sample sediments. Geobags did not consistently reduce bioaccumulation of contaminants. None of these findings is particularly favorable for ocean disposal of the sediments.*

3.4.3.3.5.3 Hydrocyclone Report – 1997. In 1997, PPB Environmental Laboratories, Inc. conducted a study of contaminated sediments in the Miami River. The study located contaminated sediments within the river in addition to locating the contaminated fraction within the sediments.

Methodology involved collecting four samples from key locations along the navigable portion of the Miami River using a Van Veen grab sampling device. Homogenized sediments from the four samples were sieved using number 100, 200, and 325 mesh screens. The four fractions were tested for heavy metals. Results indicated that metal concentrations increased as grain size decreased. Evidence from the four fraction testing was used to set the operational parameters for hydrocyclone separation techniques.

Bulk sediments were separated, using the hydrocyclone/maximum density separator, into a coarse underflow and a fine overflow fraction. Subsequent analysis of the two fractions revealed metal concentrations (on average) 10 times higher in the fine overflow fraction than in the coarse overflow fraction.

DERM commented as follows:

> *The hydrocyclone bench tests of the Miami River sediment indicated that the coarse fraction was less contaminated than the fine fraction. However, limited analysis of sediment chemistry for selected metals showed that the coarse fraction samples did not always meet State of Florida soil cleanup target levels for residential direct exposure, and no leachibility testing was performed. Furthermore, supernatant water, even after flocculation, did not always meet State of Florida numerical criteria for marine surface water in selected tests. It is therefore premature to conclude that coarse sediment and water fractions produced by hydrocyclone treatment would meet regulatory requirements or reduce costs of dredging and dredged material disposal for the Miami River.*

3.4.3.3.5.4 PPB Study – 1999. In October 1999, water and sediment samples were collected at five stations on the Miami River by PPB to determine existing water quality and relate it to ship traffic and tidal cycle.

Turbidity, dissolved oxygen, conductivity, salinity, pH, temperature, and other water quality data were measured at one-minute intervals over an 11-hour period at each station. Water samples were collected hourly over the same 11-hour period. One sediment sample was collected at each station; additionally, a water and sediment sample from each station was collected and delivered to FDEP for chemical and biological testing. Comparison of the analytical results from PPB and the results from the FDEP laboratory showed generally good agreement for both water and sediment samples.

Turbidity values ranged from 0.6 – 34.3 NTUs. Other in situ water quality measurements yielded data consistent with previous studies of the Miami River. Heavy metals were generally either not detected or found at low levels in water samples. Copper levels were somewhat elevated, with values ranging from <2.0 micrograms/L to 98.0 micrograms/L. Pesticides and PCBs were not detected in any of the waters.

Heavy metals, particularly copper, chromium, cadmium, mercury, silver, and zinc, were found at elevated levels in most sediment samples. These findings are consistent with previous studies. Low levels of polynuclear aromatic hydrocarbons (PAHs) were detected in each of the sediments. Pesticides and PCBs were not detected by PPB in any sediment samples; however, FDEP detected residues of two pesticides and two PCBs in some samples.

Elutriate testing of the sediments indicated that, while there are significant concentrations of heavy metals in the sediments, mechanical mixing alone produces only modest releases of these metals into the water column. The potential does exist, however, for state water quality standards for metals and some organic compounds to be exceeded during dredging operations. With the exception of copper, 4,4'-DDD, and Endosulfan I, the elutriates did not exceed USEPA Region IV Ecological Acute Screening Criteria.

3.4.3.3.6 NOAA Study – 1999. A regional survey was conducted in 1999 under the administration of the National Oceanic and Atmospheric Administration (NOAA) to determine the distribution of chemical contaminants of sediments in estuarine and marine environments along the Atlantic coast.

Biscayne Bay was selected by NOAA because data from previous surveys had shown a potential for toxicity and other adverse biological effects within the bay. A total of 226 samples was taken in the Biscayne Bay area, including the Miami River. Four laboratory tests were run upon all samples:

1. Percent survival of *A. abdita* in 10-day tests of solid-phase sediments;

2. Changes in bioluminescent activity of *Photobacterium phosphoreum* in 15-minute Microtox bioassays of organic extracts;

3. Fertilization success of *Arbacia punctulata* in one-hour tests of the sediment pore water; and

4. Normal embryological development of *A. punctulata* in 48-hour tests of the pore water.

Additional bioassays were performed on selected samples. The concentrations of trace metals, pesticides, other chlorinated compounds, PAHs, and sedimentological features were determined in all samples.

Wide ranges in chemical concentrations and toxicity were observed throughout the study area. The data gathered by the survey indicated that sediments collected in the peripheral tributaries were much more toxic than those from the open water basins of the bay. Samples from the lower Miami River were the most toxic in the amphipod survival tests, the least sensitive of the four tests performed bay-wide. Copepod life cycle assays showed impaired reproductive abilities; samples from the lower Miami River were the most toxic.

Chemicals of highest concern were those that were elevated relative to numerical guidelines in the most samples, showed strongest concordance with measures of toxicity, and were most elevated in concentrations in which toxicity was most severe. Substances meeting these criteria included copper, lead, mercury, DDTs, and PCBs. Concentrations of cadmium, copper, lead, and zinc exceeded reference levels in many samples.

Elevated concentrations of mixtures of trace metals, PAHs, PCBs, and other chlorinated substances from samples collected in the lower Miami River were highly correlated with reduced amphipod survival. Many samples from the lower Miami River had relatively high concentrations of these substances and caused very severe toxicity in the amphipod tests.

The spatial extent of elevated chemical concentrations was two percent or less for all substances, indicating that significant contamination was restricted to the peripheral canals and tributaries of the Biscayne Bay area. Both the percentages of samples that exceeded numerical guidelines and the surficial extent of contamination as compared to the guidelines were lower than observed elsewhere in comparable studies elsewhere in U.S. estuaries.

Results from the survey indicated that the concentrations of chemical mixtures were sufficiently elevated in some sediments to contribute to acute and sublethal toxicity in laboratory tests. Concentrations of individual chemicals were restricted mainly to canals and tributaries, including the Miami River. Toxicity was likewise restricted in surficial extent to these areas. Toxicity as measured with sublethal urchin and Microtox tests was much more pervasive, however.

3.4.3.4 Summary. The Miami River has been contaminated from a variety of urban and rural pollution sources through time. Contamination testing for the river and its sediment has been ongoing for the past two decades.

Chronic and acute coliform bacterial contamination has been repeatedly noted in the Seybold Canal and the Miami River. Contamination is believed to result from sewage overflows and illegal connections.

The results of this testing generally indicate that Miami River sediments are not suitable for ocean disposal.

3.4.3.5 Conclusion. Non-metallic pollutants such as hydrocarbons, pesticides, and PCBs have been detected in Miami River sediments. Metal concentrations in the sediment samples are not high enough to cause dredged materials to be classified as "hazardous waste" under Federal or state criteria. Miami River deposits, in place, are not classified as "solid waste" although some debris, such as old refrigerators and steel cable, will have to be removed from the river bottom before dredge operations begin, at which point such debris if not salvaged would become solid waste.

Information provided by DERM indicates that Miami River sediments presently do not meet local "Clean Soil/Clean Backfill" criteria (Attachment E), indicating that DERM considers the material appropriate for disposal at an approved solid waste landfill.

Under ordinary circumstances, the most efficient means of disposing of silt deposits removed from navigation channels is to use the material for fill in a nearby location where and if it is permissible to deposit fill materials. In the absence of a suitable fill site, under favorable conditions, dredged materials can be placed at a designated offshore ocean dredged material disposal site (ODMDS). However, bioassay tests on dredged material from Miami River indicate the material is not suitable for disposal at the designated offshore disposal site near Miami. Silt content of Miami River sediment is too high for use for structural fills, and it cannot be used for unrestricted fill due to its contaminants.

3.4.4 Subsurface Geological Characterization.

The subsurface conditions of the project site were examined by drilling soil test borings in strategic locations. Six soil test borings were drilled in the subsurface of the Miami River to characterize the river sediments and substrate. The borings were drilled to depths of 3.7-7.2 feet below the surface of the land. Core boring logs and laboratory analysis cores taken from the Miami River are included in Attachment F.

The borings were drilled from April 2-3, 2000. The Vibracore tubes were split and logged by Law Engineering and Environmental Services, Inc., of Jacksonville, Florida. Samples were classified in the field by a geotechnical engineer in accordance with the United Soils Classification System. Grain size and settling rate distributions were performed on samples from selected sedimentary layers within the cores.

The borings show a significant amount of variation in sediment content; however, the disparity observed in the core logs is not atypical for the interpreted depositional environment. The borings are grouped according to shared characteristics for discussion purposes.

Four of the borings contain an upper layer of sand. The sand is fine, quartz-rich, with small amounts of silt, and ranges in color from light tan to brown gray. Gravel-sized lime rock fragments are present in one of the cores. This sand ranges in thickness from three to four feet in three of the borings; in the fourth boring, the sand comprises the entire core. Grain size for this upper sand unit exhibits a similar range and pattern in all four borings. Grain size values exhibit a typical distribution pattern and range from approximately 0.075 mm – 5 mm, with the majority concentrated between 0.8 and 0.15 mm. Approximately 13.5 percent of the total grains in the samples have grain sizes of less than 0.075 mm, the sieve diameter utilized. Settling rate curves reflect the same patterns observed in grain size distribution curves. This is to be expected as settling rate should be closely correlated to particle size.

Limestone is present beneath the sand unit in the other three borings. The limestone contains clasts ranging in size from fine sand to medium gravel, and ranges in color from tan to gray. No shell fragments are indicated. Grain size analysis reveals that most "grains" within the rock are larger than the upper size parameter of 0.5 mm. However, limestone is often deposited through chemical precipitation of calcium carbonate rather than accumulation and cementation of weathered fragments. Consequently, limestone typically exhibits a crystalline rather than a granular texture. In light of this, grain size distributions of limestone are not likely to contain meaningful data.

Two of the borings contain an upper layer of silt with small amounts of sand, trace organics, and brown-to-brown-gray color. The silt layer ranges from approximately 3 to 4 feet in thickness, and is underlain by approximately 2 feet of sand in one of the borings. The sand is fine, quartz-rich, with small amounts of silt, trace limestone fragments, and light tan in color. The lowermost layer in both cores consists of light tan limestone with sand to gravel sized clastic fragments. Measured grain size values for two silt samples range from approximately 0.075 – 0.5 mm, although a significant portion of the total grains (30.2 percent and 63.2 percent, respectively) falls below the lower size parameter of 0.075 mm. The greatest portion of measured grain sizes lies between approximately 0.0.75 mm and 0.5 mm, and both samples appear to exhibit normal sediment distribution and settling rate curves.

3.4.5 Alternative Comparisons

Two alternatives for dredging the Miami River have been proposed. Because the No-Action Alternative (Alternative 3) must also be considered, a total of three alternatives have been evaluated (alternatives 1-3).

Except for the No-Action Alternative, all of the alternatives involve dredging the existing Federal project to its authorized dimensions. It is assumed that one foot of advance maintenance dredging will be specified and the contractor will be paid for an additional foot of allowable overdepth dredging.

An upland staging area of approximately 8.5-acre in size and a riverside berthing area will be secured by the local sponsor and made available for the contractor's use.

3.4.5.1 Alternative 1: The Base Dredging Plan. The base plan is to dredge the Miami River to the authorized Federal channel dimensions and dispose of the dredged material in an environmentally acceptable manner in accordance with county, state, and Federal regulations.

It is assumed that dredging would be performed using a mechanical dredge with clamshell bucket. Material would be placed in open-top barges, which would transport the material to a berthing site. Barges would be unloaded using a hydraulic unloader, which would pump the slurry to an interim staging area.

The staging area would enable dewatering or drying of material to take place in a confined manner. Dried material will be hauled to and disposed of at an appropriate upland landfill.
Requirements for the interim staging area include:

- 10 acres (approximate) in size
- Located near river
- Industrial/commercial land use
- Locate near transportation

The local sponsor has worked to identify and secure, through purchase or lease, various land and easements to provide the necessary interim staging area. Federal funds cannot be used to cover these costs.

On October 3, 2000, the Board of County Commissioners of Miami-Dade County (the Board) gave conditional approval for a former parking lot located between NW 33rd and NW 36th Streets and NW 35th and NW 37th Avenues to be used as the interim staging area for the dredged material (Resolution No. R-1031-00). Figure 4 is the proposed interim staging area located at the parking lot.

In addition to the eight-and-one-half-acre County-owned site located at the parking lot, the County has leased a 6,880-square-foot site located in southern portion of the Jai-Alai parking lot to accommodate the rectangular configuration required by the USACE for the interim staging area. Since the interim staging area does not have direct access to the river, an interim berthing site is required to dock loaded barges until the dredged material is pumped to the staging area. The local sponsor has leased approximately 25,000 square feet (sq ft) of land plus 430 linear feet of Miami riverfront seawall and bulkhead located at 3700 NW North River Drive, Miami to be used by the USACE for dockage and landside operations to implement the Miami River Dredging Project. The interim berthing site provides adequate dockage space for barges, direct access to arterial roadways, a rail spur, and access to the interim staging area via an underground culvert.

At the request of the local sponsor, the interim site cannot be used for conventional diking with open-air drying. Any plan that utilizes the interim staging area must confine or cover the material during the drying process. Open-air drying will not be allowed.

3.4.5.1.1 Geotechnical Investigation of Interim Staging Area. Subsurface investigations were conducted by the USACE to explore and characterize the subsurface condition of the interim staging area. The subsurface conditions of the parking lot site were examined by drilling five soil test borings at strategic locations parking lot. Four borings were drilled to a depth of 30 feet, and one boring was drilled to a depth of 56.5 feet. Core boring logs of the parking lot site are included in Attachment G. The results of the core analyses were instrumental in determining the adequacy of the site.

The borings were drilled from November 8 – 15, 2000. Soil samples were collected using a split-spoon sampler. Samples were classified in the field by a geotechnical engineer in accordance with the United Soils Classification System.

The borings display general similarity in character, although variations exist within individual borings. All borings contain an upper layer of fill or cap material ranging in thickness from less than a foot to 3 feet. Fill material ranges from sand to gravel and is often capped by asphalt.

Three of the 30-foot borings contain limestone for the entire length of the core. The limestone is typically tan in color and contains minor amounts of sand. A zone of micro-oolites is generally present in the upper 3-5 feet of the limestone layer, and vugs and shell molds appear at depth. This zone is known as Miami Oolite, a well-documented Pleistocene limestone.

The deposits in these three borings are consistent with those of continental shelf environments. Micritic and micro-oolitic limestone deposits typically form in marine environments at intermediate depth; sand inclusions indicate that the environment was relatively near the paleoshoreline. Shell fragments are indicative of a marine environment.

The remaining 30-foot boring contains deposits that are somewhat different from the other borings. The upper portion of boring contains three distinct layers of sand beneath the asphalt cap. The upper sand layer is 1.5 feet thick, is silty with some clay and gravel, and is dark gray in color. Beneath this layer is approximately three feet of silty brown sand, which is in turn underlain by approximately three feet of poorly cemented calcareous tan sand with shell fragments. A layer of micritic, vugular, sandy, tan limestone is present to a depth of 18.5 feet; sand content within the limestone increases with depth. The remainder of the boring consists of very fine-fine calcareous tan sandstone.

The deposits within this boring may indicate a slightly more nearshore or near-sediment source environment than the previous borings. The higher sand content appears to indicate that the deposits formed at a shallower depth than the previous borings; however, the calcareous content of the sandstone and the limestone all point to a marine environment.

The 56.6-foot coring appears to combine the features of the two boring groups discussed above. Approximately 5.5 feet of sandstone is present beneath the asphalt/fill cap. The sandstone is very fine-fine, tan, quartz-rich, and contains calcareous cement. Shell fragments are found in the lower portion of the sand body. A limestone layer is present beneath the sandstone to a depth of 31 feet. The limestone is slightly sandy, micritic and micro-oolitic, and tan. Sand content increases with depth. Approximately three feet of medium-fine calcareous tan sandstone is found beneath the limestone layer. A thin interval of well-sorted, uncemented tan sand is found beneath this layer. The remainder of the core consists of micritic tan limestone with some sand content. Sand content decrease with depth, and shell molds and vugs are present at depth.

The deposits in this boring are consistent with those of a continental shelf environment. The intermediate sand content may indicate a slightly more nearshore or near-sediment source than the sand-rich boring discussed above.

Alternately, all borings may represent environments of equivalent depth and distance to shore. The variations in sedimentary content may be due to minor perturbations of the seafloor surface or the vagaries of longshore sediment transport. Although exact depths and shore distances cannot be determined from the available evidence, it is readily apparent that all borings represent a marine environment of intermediate depth.

There is not sufficient “construction quality” material at the interim staging area site to construct dikes. It will be necessary to import dike construction material for the interim staging area.

Return decant water will be discharged into the Miami River adjacent to the berthing site. The discharge will comply with the water quality certification, which requires turbidity to be at or below 29 NTUs above background within 150 meters (mixing zone) of the discharge point.

If dikes are used at the interim staging area, it will require an impervious liner to contain the dredged material and minimize potential site contamination. Due to the shallow groundwater table, the dikes and liner must be constructed above the grade of the parking lot.

Locals have inferred that the interim upland staging area will be required to meet Class I landfill requirements (State of Florida Department of Environmental Protection, Chapter 62-201, Solid Waste Management facilities). Class I type landfills constructed with composite or double liners, and a leachate collection and removal system are appropriate for dredged material disposal. Class I landfills are those which receive an average of 20 tons or more of solid waste per day.

Dewatering of the dredged material at the interim upland staging area maybe accelerated by use of underdrains, wicks, geotubes, or other dewatering technology. The dried material must be double handled by loading it into trucks or rail cars for transport to a final disposal site, an approved solid waste landfill.

At the request of the local sponsor, the interim staging area cannot be utilized for conventional diking with open-air drying. Therefore, any plan that utilizes this interim upland staging area must confine the material (e.g., geotubes, etc.). However, conventional diking and open-air drying may be used in the Miami River dredging project if the contractor provides another upland site. It is not likely, however, that open-air drying would receive approval at any other site in an urban setting.

Table 6 lists the Class I Landfills near the project area that could be used for permanent dredged material disposal and related information.

The following assumptions were made by the USACE in developing the base plan cost estimate and represent the technical approach for the Miami River Dredging Project. The dredging will be accomplished using a 10-CYD clamshell dredge which will load barges and haul the dredged material to the upland staging area. A 12-inch hydraulic unloader will then pumpout the loaded barges into the upland staging area. Return water discharge will be back into the Miami River through two weirs installed during the staging area construction. Existing heavy debris located in the river within the dredging limits will be removed prior to commencing the dredging. The heavy debris will be placed in the upland staging area, then hauled to the county landfill during the staging area offloading during the subsequent dredging event.

The cost for polymer injection into the discharge line during the hydraulic unloading process to increase the settling time of the dredge material fines in the staging area is included.

Table 6. List of Class I Landfills in Miami-Dade and Broward Counties, Florida

Name	Address	City	Ownership _Type	Company_ Name	Prop_ Area	Disposal _Area	Life (yr)	Waste (ton/day)	Design_ Capacity	Fee ($/ton)	Liner	Location	Distance (mile)
Broward City Interim Contingency LF	U.S. 27 & Sheridan Street	Pembroke Pines	County	Broward County Utilities Div	588	263	35	2000	3000	37	Plastic	Other	35
Broward Co. South Resource Recovery	STRD 441 & 84	Fort Lauderdale	County	Wheelabrator South Broward Inc.	210	61	20	2000		27	Plastic	Wetland	34
Central Sanitary Landfill & Recycling Center	3000 NW 48th St (Hilton Rd)	Pompano Beach	Private	Waste Management Inc. of Florida	494.2	384	20	4000	1000	40	Plastic	Other	34
Medley Landfill and Recycling Center	9350 NW 89th Ave	Medley	Private	Waste Management Inc. of Florida	113	25	25	512		34*	None	Other	14
Medley Landfill and Recycling Center	9350 NW 89 Avenue	Medley	Private	Waste Management Inc. of Florida	157.6	73.5	4	1500	1500	27	Plastic	Floodplain	14
South Dade Shredded Waste Landfill	SW 248th St & 97th Ave	Goulds	County	Metro Dade County Public Works	333	218	5	2500		59	Plastic	Floodplain	23
South Dade SW Reduct Facility	SW 97th Ave & SW 248th St	Goulds	County	Metro Dade County Solid Waste Management	54	54	20	300		61*	None	Floodplain	23
Coral Springs Dump	Sawgrass Expwy. & 139 S	Coral Springs	County	Coral Ridge Properties	40	40	20	0			None	Other	25
North Reg WWTP Sludge Landfill	Copans & Powerline Rd.	Pompano Beach	County	Broward Co. Public Works	132	0	20	70			Plastic	Other	31
Davie Landfill	4001 SW 142 Ave.	Davie	County	Broward Co. Envir. Services	209	148	25	600			Plastic	Floodplain	19
Broward Co. Interim Contingency LF	US 27 & Sheridan St.	Pembroke Pines	County	Broward Co. Utilities Division	588	263	35	2000	3000	37	Plastic	Other	19
C B Smith Park Dump	Flamingo Rd and Pine Rd	Hollywood	Municipal	City of Hollywood	200	10					None		14
Port Everglades Central Disposal	McIntosh Rd. & Eller Dr.	Fort Lauderdale	Private	Central Disposal	10	0					None		20
58 St. Landfill	8831 NW 58 St.	Miami	County	Miami-Dade DSWM	640	560		7747			None	Other	6

Name	Address	City	Ownership _Type	Company_ Name	Prop_ Area	Disposal _Area	Life (yr)	Waste (ton/day)	Design_ Capacity	Fee ($/ton)	Liner	Location	Distance (mile)
South Dade Dump	SW 97 Ave. & SW 248 St.	Goulds	County	Metro Dade Co. Public Works	54	54	5	1450		59	None	Floodplain	20
South Dade SW Reduction Facility	SW 97 Ave. & SW 248 St.	Goulds	County	Metro Dade Co. Solid Waste	54	54	20	300			None	Floodplain	20
City of Miami Beach Ojus Landfill	20735 NE 16 Ave	North Miami Beach	Municipal	City of Miami Beach	149	125	25				None	Other	12
Munisport-North Miami Landfill	14301 Biscayne Blvd.	North Miami	Municipal	Munisport Inc. & North Miami City	350	0	4	3030			None		9
Town of Surfside Dump	4600 NW 215 St.	Carol City	Municipal	Town of Surfside	100	0					None		11
Tony Waher Dump	NW 107 Ave. & NW 135 Ave.	Hialeah Gardens	Private	Tony Waher	15	15		18			None	Other	10

*Personal communication.

Source: Florida Department of Environmental Protection web site, updated May 10, 2000.

The dredge material will be pumpout out of the dredge barges into Geotubes. The Geotubes will dewater the material and store it prior to final removal and hauling to the approved Dade County Class I landfill.

The dredge material disposal work is based on using Mirafi Brand GT-500 polypropylene geotubes to contain the material at the upland staging area. The use of a polymer flocculent additive to the dredge material to increase the dewatering period is also included in the base plan.

The disposal area will be lined with a landfill type impermeable polyliner. The liner will be replaced during each subsequent dredging event following the initial offloading of existing dredge disposal material from the prior event. The dredge soil will be truck hauled to the county lanfill for final disposal following the first dredging event. A tipping fee of $59 per ton for using the county landfill is included in the estimate, based on one ton per bank cubic yard of dredged material. (MCACES Gold Edition 9-9-20, *Miami River FY-02 Maintenance Dredging and Disposal, U.S. Army Corps of Engineers.)*

3.4.5.2 Alternative 2: The Preferred Alternative. The USACE sent a Request for Information (RFI) to about 36 dredging companies, 10 environmental/remediation firms, 12 waste management companies, and the Dredging Association during the period of February 5-20, 2001. The RFI sought industry comments on the most environmentally and economically feasible method for dredging the Miami River. The main concern of the RFI focused on the disposal of contaminated sediments. Responses to the RFI from 17 firms indicated that leaving disposal means and methods entirely up to the contractor is the contractual alternative recommended by the industry. Contractors want the flexibility to identify alternatives for a permanent disposal or beneficial use of the contaminated sediment from the Miami River. From the responses to the RFI, it appears that there are a variety of dredging technologies, sediment decontamination, and beneficial reuse processes that could provide a suitable solution for dredging and disposal of the contaminated Miami River sediment.

The preferred alternative is to issue a Request for Proposal (RFP) and select the best method of dredging and disposal based on “source selection criteria” to be determined by the source selection team. This procurement would be solicited in accordance with USACE guidance, *Contracting for Best Value – Best Practices Guide for Source Selection.* The Government will identify the source selection team. The RFP solicitation process would encourage the successful contractor to propose alternative disposal or treatment of the sediments to minimize the impacts on the local community. The Government will select the successful proposer using criteria that will consider the overall best value to the government, including but not limited to efficiency, technical experience, neighborhood and environmental protection, as well as cost. The Government will contract with the successful proposer and oversee construction of the project. The selected contractor must obtain all Federal, state, and local permits or approvals for the proposed sediment treatment and/or disposal method. The RFI and a memo summarizing the respondents input are shown in Attachment H. Also included in Attachment H is USACE guidance, *Contracting for Best Value- Best Practices Guide for Source Selection*, which elaborates on the RFP process.

3.4.5.2.1 Innovative Technology. The USACE plans to issue an RFP for use of innovative technology to dredge and dispose of the Miami River sediments.

Highlighted here are many innovative technologies in various stages of development that are available for consideration. A national workshop was held in May 2000, which resulted in a publication that summarizes some of most readily available technologies that have been used in other projects involving contaminated sediments. The following excerpts are included in the Miami River DMMP in an effort to identify the various innovative technologies available for consideration during the RFP process.

During 1999, the U.S. Section of the Permanent International Association of Navigation Congresses recognized the need to address the state of the practice of innovative dredged sediment decontamination and treatment technologies. As a result, the U.S. Section held its first specialty Workshop on *Innovative Dredged Sediment Decontamination and Treatment Technologies* on May 2, 2000 in Oakland, California as part of its annual meeting. Objectives of the workshop were to conduct a critical review of selected technologies demonstrated for decontamination and treatment of contaminated dredged sediments generated from large-scale navigation dredging projects and assess the beneficial use potential of the projects generated by the technologies. A technical review panel consisted of experts and potential technology users from the navigation industry, private consulting firms, and academia. Invited speakers from a variety of technology development firms made presentations. Six formal presentations were made on technologies being used in Europe. What follows is a summary of the dredged sediment decontamination and treatment technologies presented at the PIANC Specialty Conference.

Increasing controversy over adequate management of contaminated dredged material (CDM) also adversely impacts the Nation's waterborne transportation infrastructure and commerce by stopping or delaying dredging projects. The Nation is facing a monumental task in managing contaminated sediment outside navigation channels without the benefit of cost-effective sediment remediation technologies. Innovative management solutions for these sediments must include affordable decontamination, treatment, and beneficial uses of the residual end products.

Treatment is defined as a way of processing CDM with the aim of reducing the amount of contaminated material or reducing the contamination to meet regulatory standards and criteria. Treatment techniques are available for different types of contaminants in CDM. Some of these techniques are still in a demonstration stage, while others are approaching large-pilot scale or full-scale operations. Because the CDM may contain various mixtures of heavy metals, petroleum hydrocarbons, and organochlorine compounds, they present a formidable challenge to treatment or decontamination technologies. Therefore, significant innovation will be required to bring a viable treatment or decontamination scheme to solve CDM in navigation projects.

3.4.5.2.1.1 Description of the Specialty Workshop

The objectives of the workshop were to conduct a critical review of selected previously demonstrated technologies for decontamination and treatment of CDM generated from large-scale navigation dredging projects; and to assess the beneficial use potential of the products generated by the technologies. To achieve these objectives, the workshop planners convened a technical review panel consisting of experts and potential technology users from the navigation industry, private consulting firms, and academia, and invited speakers from a variety of technology development firms (TDFs) to make presentations. Six formal presentations were made on technologies being used in the United States and two guest speakers provided additional information on technologies being used in Europe.

The invited TDFs were requested to focus their presentations on the ability of their technologies to handle the volumes of sediment and production rates typically associated with large-scale navigation dredging projects. They were requested to address the following topics:

1. Technology Description and Technology Availability
    - Description of the technology and its unique characteristics
    - Marketable products produced
    - Current availability and scale of demonstration
    - TDFs capability to fully implement technology

2. Applicability to Large-Scale Navigation Projects
    - Quantity of dredged sediment (or other media) on which technology has been demonstrated
    - Demonstrated ability to process dredged sediment (or other media) in excess of 35,000 cy per month

3. Logistical and Regulatory Requirements
    - Degree of incorporation of the technology in an overall sediment management program
    - Amount of site preparation and required utilities for operation of technology plant
    - Particular facility siting requirements including land area
    - Environmental and/or regulatory barriers to implementation to the technology

4. Net Cost
    - Potential profit from sale of product resulting from applying technology to dredged sediment
    - Estimated costs for ranges of dredged sediment production rates and project size/duration including production costs, delivery costs, and tipping fees
    - Particular physical and/or chemical characteristics of dredged sediments that significantly impact costs

The TDFs were also requested to address the following factors where applicable, particularly for those technologies that have not been demonstrated on dredged sediments on a large scale:

- Current state of technology development and time required for commercialization
- Factors affecting technology performance when applied to dredged sediments
- Estimates of performance for application of the technology to dredged sediment remediation
- Factors affecting economics of the technology
- Estimates of the capital and operating costs for the technology for ranges of project sizes
- Examples of application of the technology to dredging projects or remediation of contaminated sediments
- Unknowns or potential problems associated with applications of the technology to dredged sediments
- Health, safety, and environmental risks or related areas of concern associated with application of the technology to dredged sediments

At the conclusion of the presentations, the technical review panel and the audience were invited to ask questions and provide comments. The review panel then provided a brief comparative analysis of each technology as a means of clarifying the information presented and stimulating further discussion between the presenters and the audience. After completion of the comparative analysis, the technology presenters and the review panel led an open discussion on barriers to implementation of the technologies on dredged sediments. Barriers from both the TDFs and potential users' perspective were identified. Possible solutions or ways to minimize the barriers were also discussed.

3.4.5.2.1.2 <u>Presentation of Technologies</u>

The technologies are categorized under two groups. The first category of technologies includes those that achieve contaminant destruction using thermal processes. The technologies presented, identified by their product, include:

- Blended (construction-grade) cement
- Building bricks
- Glass aggregate
- Lightweight aggregate

The second category of technologies includes those that achieve contaminant extraction, partial removal, or contaminant using non-thermal processes. The technologies presented include:

- Flowable fill
- Electrochemical remediation
- Sediment washing
- Solidification/stabilization

The information presented by each TDF is summarized under six topic headings including:

- Technology Description – a description of the technology process, product produced, and unit processes incorporated in the technology
- Demonstration Scale – the scale at which the technology has been demonstrated, pilot-scale and/or full-scale demonstration sites, and results of demonstrations
- Commercial Availability – commercial-scale applications, availability of equipment required for commercial application, and actual or proposed applicability to large quantity dredged sediment operations (greater than 35,000 cy per month)
- Beneficial Use Applications – description and actual or proposed use of product produced by technology
- Logistics and Regulatory Requirements – amount of total sediment management program achieved by technology, sitting and utility requirement, regulatory requirements including permits based on unit operations and generated wastes or discharges
- Estimated Costs – estimated capital and operating costs by range or processing rates, required tipping fees, marketability and potential price of produced product, and factors including dredged sediment characteristics affecting costs

Not all TDFs provided all the information requested as noted in the particular technology discussions. Availability of information varied depending on the demonstration scale achieved for a particular technology. Although some of the information was incomplete, an attempt was made to develop a comparative summary of the information presented in a tabular format. This summary is presented and discussed later in the report. It should be noted that the information on the various technologies presented and discussed in this report was provided by the TDFs and has not been verified by PIANC or the authors.

In addition to the technology presentations, barriers to implementation of decontamination and treatment technologies, which were identified during the conference, are discussed, including economic, logistical, political, and liability barriers. Possible solutions and opportunities to overcome or minimize the barriers are discussed, and conclusions presented.

3.4.5.2.1.3 Thermal Contaminant Destruction Technologies

Blended (Construction-Grade) Cement

This technology is an advanced thermo-chemical manufacturing process for decontaminating wastes including dredged sediments, soils, and sludges, and producing a marketable product. Using this technology, dredged sediment can be transformed into construction-grade cement that meets ASTM standards. During the process, organic contaminants are destroyed with destruction and removal efficiencies greater that 99 percent achieved. Heavy metals are immobilized in the cement matrix, thus limiting their mobility and allowing attainment of Toxicity Characteristic Leaching Procedure (TCLP) regulatory criteria.

In operation, the water content of the dredged sediment (or other waste) is reduced using waste heat from the thermal process. The sediment is then transferred into a rotary kiln melter where fuel, air, and modifiers are introduced. A clinker-type material is transferred to a pulverizer/mixer where additional additives are introduced and mixed, resulting in a construction-grade cement product. Modifiers and additives used in the process are formulated based on the chemical and physical characteristics of the sediment (or other waste) feed stream. Modifiers are inexpensive materials typically used in cement manufacturing. Off-gas from the kiln is treated in a secondary combustion chamber; heat from the gas is recovered for use in drying the feed stream; and, the gas stream is passed through a final cleanup process prior to discharge to the atmosphere.

The technology has been evaluated on both bench and pilot scales (up to one ton per day) for dredged sediments from various sites in New York, New Jersey, and Michigan. A demonstration plant designed to treat 30,000 to 150,000 cy of sediment is under construction in New Jersey. Another demonstration will be conducted on 2,000 to 5,000 cy of sediment from the Detroit River in Michigan. Engineering has been completed on a 100,000 cy/year process module and a 500,000 cy/year plant composed of five modules. The technology has not been demonstrated for large-scale (greater than 1,000,000 cy) dredging projects.

During these demonstrations, numerous samples were collected for analysis. Analytical results are available on organic contaminant destruction, heavy metal immobilization, pilot-scale air emissions, and cement product quality. The results have shown that the process is effective in destroying organic contaminants, immobilizing metals, and producing a quality product. Concentrations of trace metals in the blended cement have been shown to be comparable with those reported for Portland cement.

The technology is not currently being used to treat CDM on a commercial scale; however, large-scale demonstration projects will be completed in the near future. All equipment required for commercial application is available. Much of the equipment used in the process is identical to, or similar to, that used in the commercial cement industry. Equipment required for off-gas treatment is routinely used in other industries and is readily available. Various vendors willing to provide turnkey production plants have been identified.

For a large quantity dredged sediment operation (greater than 35,000 cy per month), the TDF proposes to use four modules, each with a capacity of 100,000 cy per year. The production rate would be in excess of 200,000 tons per year, less than 20 percent of a typical full-scale cement plant. Marketability for this volume of product should be good. Approximately 100 million metric tons of cement is used annually in the United States.

The product has been tested and shown comparable in performance to commercial Portland cement. In addition to general commercial use, other markets identified by the TDF include: general construction for sediment processing stakeholders, grouting of underground storage tanks, soil conditioning at landfills, sediment stabilization processes, and construction of retention walls in mines where sediment is used for backfilling.

The process is only one component of the process train required to move dredged sediment from the channel to the end-use. Transportation and storage for raw and processed sediment must be designed and implemented on a site-specific basis. The processing plant requires a constructed site large enough for the equipment and material storage; required utilities include water, fuel, and power utilities. Storage of dredged sediment is required to provide a steady flow of raw sediment to the plant. No wastewater is generated during the process that requires disposal. This excludes wastewater from dewatering that is included in other processes. Debris from the screening process must be transported off site for disposal. No specific residue-requiring disposal was identified as being generated in the off-gas cleanup process.

Variability in the physical and chemical characteristics of the dredged sediments was deemed not to affect the technical performance of the process. Factors identified as affecting process costs are discussed in the "Estimated Cost" section.

With respect to regulatory requirements, the processing plant requires permits similar to manufacturing process plants including an air permit. No wastewater discharge permit is required, since no wastewater is discharged. Specific permitting requirements will vary depending on the state in which the system is operated.

The capital cost for a 500,000 cy/year processing plant is estimated at $100 million. Operating costs were provided based on a dedicated 500,000 cy/year plant using a 20-year life span. Several scenarios were detailed including the use of different fuels (natural gas versus high-BTU-content waste slugs) and different market prices for the product. A full market value for cement of $70.00/ton and a discounted value of $35.00/ton were used for illustrative purposes. The tipping fee required for the process to break even ranged from ($7.66) [profit] to $33.69/cy. The profitable scenario was based on use of a waste material as a fuel source for which a tipping fee was collected and full market value for the cement product.

Favorable costs for the process require a steady and guaranteed supply of sediment or other waste material (e.g., soils, sludges, ash, etc.) and a guaranteed buyer and stable price for a period of at least 10 to 20 years. Several factors that would affect the overall cost were noted. Excessive moisture content would reduce the quantity of product. A non-steady supply of sediment would require larger storage capacity, thus increasing capital costs. Use of additional waste materials, particularly high-

BTU materials, would reduce the treatment cost and would supplement and level the feed of raw materials to the process. Non-continuous processing of sediment would increase the product cost.

Building Bricks

A TDF in Hamburg, Germany manufactures building bricks from CDM. Using this technology, dewatered contaminated sediments are used in the production of regular bricks suitable for use in the building industry. During the drying and ceramization process, organic contaminants are oxidized and metal contaminants are converted to stable immobile compounds or are volatilized.

In operation, the fine grain portion of dewatered dredge sediments is used as the raw material for the bricks. The dredged sediments are dewatered and segregated in a system prior to being transported to the facility. Analytical data indicate that a large percentage of the contaminants are associated with the fine-grained fraction (less than 63 µm) of the sediment. At the manufacturing facility, the sediment is mixed with natural clay and ground brick in a pan mill. The mixture is dried from 30 percent moisture to below 2 percent moisture content using a steam dryer. The water removed (in the form of vapor) is condensed and treated using an activated carbon system. The mixture from the steam dryer is dry-pressed to form the bricks that are then placed in a kiln. The bricks are dried at a temperature of 1,115°F. The temperature is then increased to 1,950°F for the ceramization process. The bricks are cooled and prepared for shipment. Flue gas from the process is treated with calcium hydroxide and activated carbon, and passes through a fabric filter prior to discharge.

The building brick technology is in full-scale production, producing five million bricks per year utilizing 35,000 metric tons per year of heavily contaminated, dewatered sediments. The bricks manufactured by the process have been thoroughly tested and found to be in full compliance with Germany's strict building material regulations. The bricks are being used commercially in Northern Germany's building industry.

Brick manufacturing technology is being used on a commercial scale to treat CDM. Typical brick manufacturing equipment is used. Flue gas is being treated using conventional air pollution treatment equipment.

Currently, approximately 100,000 cy of dredged sediment (prior to dewatering) are being used in the process. The capacity of the process could easily be scaled up to handle in excess of 35,000 cy/month if a market were developed for the produced bricks.

The bricks produced by the process are suitable for use in all types of commercial and residential building projects. Different sizes and styles of bricks can be manufactured based on market demands.

The brick manufacturing process is only one component of the process train required to move dredged sediment from the channel to the end use. Because only the fine-grained sediment is used in the process, dewatering and separation of the sediment is required. Transportation and storage of raw sediment and the final brick product are required. The processing plant requires extensive site preparation and facility construction along with water, fuel, and power utilities. Storage of dewatered dredged sediment is required to provide a steady flow of raw sediment to the plant. Storage for the natural clay used in the process is also required. Wastewater from the dewatering process requires treatment prior to discharge.

Debris from the screening and separation process must be managed and disposed of properly. Residue from the flue gas treatment process must also be managed and disposed of properly.

The impact of sediment variability on the technical and economic performance of the process was not discussed. However, the dredged sediment characteristics must be consistent to ensure a quality product.

With respect to regulatory requirements, the processing plant requires permits for operations including an air permit. A permit for discharge of the wastewater from the dewatering process is required. Permits for disposal of debris and the remaining sediment fraction after screening also are required.

Cost estimates were presented based on a process capacity of 20 to 60 million bricks per year using 300,000 to 900,000 metric tons per year of dredged sediment. This represents an increase of four to twelve times the current production rate of the plant in Germany. A capital investment of $25 to $80 million would be required excluding the facility required to screen and separate the dredged sediment. The market value for the brick produced was assumed to range from $0.10 to $0.40 per brick. The tipping fee required for the process to break even ranged from $20.00 to $60.00 per metric ton.

Favorable costs for the process require a steady and guaranteed supply of sediment and a stable market for the bricks produced over the life of the plant. Specific factors affecting costs were not identified.

Glass Aggregate

A TDF partnership markets the Plasma Vitrification Technology. Plasma vitrification is a high-temperature thermal process for converting waste to energy and decontaminating wastes including dredged sediments, wastewater sludge, and bio-solids. Using this technology, dredged sediments can be transformed into molten glass and cooled to form glass aggregate. The aggregate can be used as a raw material in the manufacture of architectural tile, glass fiber, sandblasting grit, roadbed aggregate, and roofing granules. During the process, organic contaminants are destroyed by combustion, with destruction efficiencies greater than 99 percent achieved. Heavy metals, along with mineral phases, are fused into glass thus limiting their mobility and meeting TCLP regulatory criteria.

In operation, the dredged sediment is screened and partially dewatered using conventional techniques. The sediment is desalinated with a simple rinsing and dewatering process. The sediment is then injected in front of a plasma torch with temperatures in excess of 5,000°C. Fluxes are added to modify the properties of the final product. The molten material is collected in an associated chamber and passes through a quench chamber from which the vitrified product is collected. The glass aggregate is shipped off site to conventional manufacturing operations where the final products are produced.

The glass aggregate process has been evaluated on both bench and pilot scales for dredged sediments from New York/New Jersey Harbor. Approximately 17 metric tons of contaminated New York/New Jersey Harbor sediment were converted into glass during several demonstration projects conducted at a demonstration facility operated by the TDF and monitored by the U.S. Department of Energy's

Brookhaven National Laboratory. A preliminary design for a full-scale plant has been completed. The technology has not been demonstrated for large-scale dredging projects.

During the bench and pilot studies, samples were collected and analyzed. Analytical results are available on glass characteristics, heavy metal immobilization, and organic contaminant destruction. The results indicate that the process is effective in destroying organic contaminants, immobilizing metals, and producing a quality product.

The process is not currently being used on a commercial scale to treat CDM. The TDF has signed contracts for full-scale plasma systems to treat waste materials other than sediments in several foreign countries. The equipment required for commercial application is unique to the plasma process and must be designed and fabricated for the application. Conventional screening and dewatering equipment is used for that portion of the process.

Preliminary information was presented on a plant capable of treating 500,000 cy per year of sediment. This information is discussed in the "Estimated Cost" section.

The TDF has proposed that the glass aggregate produced from dredged sediments can be used as a raw material in a variety of manufacturing applications. As part of the pilot testing conducted, the glass aggregate product was used to produce finished paver's tile utilizing a manufacturing technology. The tile has a potential high market value. The total market capacity was not quantified.

The process is only one component of the dredged sediment process train required to manage the sediment from generation to end-use. Transportation and storage for raw and processed sediment must be designed and implemented on a site-specific basis. The processing plant requires a constructed facility to house the processing equipment and sediment storage with water, fuel, and power utilities. Storage of sediment is required to provide a steady flow of raw material to the plant. Wastewater from the dewatering and desalination processes may require treatment prior to discharge. Debris from the screening process must be managed and disposed of.

The impact of sediment variability on the technical and economic performance of the process was not discussed. However, the dredged sediment characteristics must be consistent to insure a quality product.

With respect to regulatory requirements, a full-scale processing facility would require permits for operation including an air permit or waiver. Permits for discharge of wastewater and disposal of the debris from the screening process would be required.

Cost estimates were presented based on a process capacity of 500,000 cy/year generating 139,000 metric tons/year of glass slag that would be used to manufacture 196,000 metric tons/year of tiles. A capital investment of $80 to $90 million would be required. The market value for the tiles manufactured was assumed to range from $1.25 to $2.00 per square foot. The tipping fee required for the process to break even ranged from $25.00 to $29.00/cy.

Favorable costs for the process require a steady and guaranteed supply of sediment and a stable market for the glass aggregate produced over the life of the plant. Specific factors affecting costs were not identified. It was noted that additional waste materials could be processed if required to supplement and level raw material feed to the process.

Lightweight Aggregate

The technology is a rotary kiln-based thermal process for the production of an ASTM-grade expanded clay lightweight aggregate, which is used worldwide in building material applications. Inherent to the high temperature process is the ability to decontaminate dredged sediments effectively. Organic contaminants are thermally destroyed with destruction efficiencies greater than 99 percent. Heavy metals are immobilized in the aggregate thus limiting their mobility and meeting TCLP regulatory criteria.

In operation, the dredged sediment is screened to remove large stones and debris, and then dewatered using mechanical and thermal processes. The dewatered sediment is then processed in a combined grinding and thermal drying process to achieve a uniform consistency. The material is mixed with water and extruded into pellets approximately 0.5 inches in diameter by one inch long. The pellets are then fed into a kiln for firing at a temperature in excess of 2,100° F, where they expand to about 1.3 times their original size. The expanded clay aggregate is then cooled and stockpiled. Off-gas from the kiln is cooled with the heat recovered, recycled, and used elsewhere in the process, and passed through a final cleanup process prior to discharge. Residue from screening is landfilled.

The lightweight aggregate technology has been evaluated on a bench scale for sediments from various sites on both the East and West coasts. The TDF is currently developing dredged sediment projects ranging from 500,000 to 3,000,000 cy/year. The specific projects were not identified, and none is yet in full operation.

No analytical testing results were presented for the lightweight aggregate product. Test results are reportedly available on ASTM-procedure testing conducted on samples of the product and TCLP testing conducted to determine metals mobility.

The process is not currently being applied to dredged sediments on a commercial scale; however, several full-scale projects are under development. The equipment required for commercial application is available. Much of the equipment used in the process is identical to, or similar to, that used in the commercial aggregate manufacturing industry. The mixing and pelletizing equipment is commercially available. Equipment required for off-gas treatment is routinely used in other industries and is readily available. The TDF has teamed with vendors in the mining industry willing to provide engineering, design, construction, and pyroprocessing equipment. Project specific pilot testing is required to obtain operational data and parameters for scale up to commercial production. This testing can be completed in about two months using about 10 cubic yards of material.

Specific information on a system capable of processing greater than 35,000 cy/month was not presented. Marketability of the product should be good if required product quality can be continuously met. The TDF has estimated the national market for lightweight aggregate at approximately 17 million tons per year with only 10 million tons per year currently being produced or imported.

The product has been tested and shown comparable to, or better than, existing commercially available expanded clay, shale, or slate lightweight aggregate. Potential applications identified include: geotechnical fill; ready-mix or structural concrete; masonry blocks; specialty concrete products; horticulture; and road and bridge paving.

The manufacturing process is only one component of the dredged sediment process train required to manage dredged sediment from generation to end-use. Transportation and storage facilities for raw and processed sediment must be designed and implemented for the specific project. The processing plant requires a constructed site of approximately 15 acres excluding material storage areas. Required utilities include water, fuel, and electric power. Storage of dredged sediment is required to provide a steady flow of raw sediment to the plant. Wastewater from the dewatering process requires treatment prior to disposal. Debris from the screening process requires management and disposal.

The impact of sediment variability on the technical and economic performance of the process was not initially discussed. However, the dredged sediment characteristics must be consistent to insure a quality product. During subsequent discussion, the TDF personnel indicated that high sediment variability would result in a product of lesser quality if the input feed material were processed without screening or refinement.

With respect to regulatory requirements, a processing plant would require permits for operation, including an air permit. Permits for discharge of the generated wastewater and disposal of the debris from the screening process would be required.

No project specific capital or operating costs was presented.

3.4.5.2.1.4 Non-Thermal Extractive/Containment Processes

Flowable Fill

A TDF markets a flowable-fill technology that consists of a non-thermal, mixing process using chemical additives to transform dredged sediments into a flowable construction fill product. During the process, contaminants are not destroyed, but their mobility is reduced due to chemical stabilization and incorporation in the physical matrix of the product. Reduction in mobility of two to three orders of magnitude is not unusual depending on the contaminant species.

In operation, the dredged sediment is screened to remove large debris and then transferred to a blending mixer. Some dewatering of the sediment may be required prior to processing. Proprietary silicate binders, fine aggregate waste material, and water are added to the mixer and the mixture is thoroughly blended. Once blended, the product is transferred directly to mixer vehicles for immediate transport to the place of use. The product requires immediate use and cannot be stored for any extended period. No off-gas requiring treatment is generated during the process.

The flowable fill technology has been evaluated on both bench and pilot scales (up to 30,000 cy) for dredged sediments from two sites in New York. Fixed and mobile production facilities have been developed with maximum daily outputs in excess of 6,000 cy/day. Production runs of up to 10,000 tons of dredged sediment have been completed. Debris up to 16 inches in diameter has been successfully passed through the system. The technology has not been demonstrated for large scale dredging projects.

During the demonstrations, analytical testing was conducted but no specific chemical results were presented. Leach testing reportedly indicated a two to three order of magnitude reduction in contaminant mobility. Physical testing indicated strengths of approximately 200 psi after 28 days of curing with some degradation of strength noted after two months in a dry environment. Pilot-scale demonstrations have shown that the product characteristics are more than adequate for use as a commercial fill agent. The Port Authority of New York and New Jersey has approved flowable fill product with up to 75-percent dredged sediment content as structural fill.

The flowable fill technology has been used to process contaminated sediments on a commercial scale at materials processing rates exceeding 200,000 tons per year for a single urban market. Dredged sediment used in the commercial application was obtained from a confined disposal facility. A majority of the equipment required for commercial application is available since the process uses conventional concrete batch plant equipment. Conventional screening equipment is used to remove large debris.

No specific information was presented on a system capable of processing greater than 35,000 cy/month; however, sufficient operational data have been developed to allow scale up to that level of production. Such a production rate would require a market for the product in sufficient proximity to allow real time delivery to the site of use since the product cannot be stored.

The flowable fill product is used as a replacement for compacted fill in construction. The product is delivered on demand in a mixer truck to the construction site. It is self-leveling and self-compacting, thus achieving some economy over traditional solid fill material. The product must compete with other fill materials manufactured using waste such as coal ash and foundry sands.

The flowable fill process provides several components of the dredged sediment process train required managing sediment from generation to end-use. These components include treatment and transportation of the product to the final point of use. Raw sediment transportation and storage must be designed and implemented for the specific project. The processing plant requires a constructed site large enough for the concrete-type batch plant and raw sediment storage. Either a mobile or a permanent plant can be set up on the site. Required utilities include water and power. Storage of dredged sediment is required to provide an immediate source of raw material for the on-demand process. Wastewater from any required dewatering requires treatment prior to discharge. Debris from the screening process must be managed and disposed of.

The impact of sediment variability on the technical and economic performance of the process was not discussed. However, the dredged sediment characteristics must be consistent to insure a quality product.

With respect to regulatory requirements, environmental permitting will be required for the flowable fill process plant, depending on the jurisdiction governing the production facility and the classification of the sediments. Permits for discharge of any generated wastewater and disposal of debris from the screening process would be required.

The capital cost for a processing plant was not presented. Production and delivery costs are estimated to range from $12 to $20/cy. Required tipping fees range from $5 to $20/cy excluding sediment transportation and management costs. Specific operational factors affecting cost were not presented.

Favorable costs for the process require a steady and guaranteed supply of sediment and a market for the flowable fill product. The product value is variable depending on demand, but typically, ranges from $10 to $40/cy delivered to the construction site. The product must be competitively priced with similar products available in the area manufactured from other waste materials.

Electrochemical Remediation

A TDF under license to the European technology developer markets ElectroChemical Remediation Technologies (ECRTS). There are two principal ECRT technologies: (1) ElecroChemical GeoOxidation (ECGO) which mineralizes organics to their inorganic components, and (2) Induced Complexation (IC) which enhances the mobilization of metals to be plated on electrodes. These technologies can be used as an *ex situ* or as an *in situ* process. The technologies are based on imposing a direct electrical current through the contaminated material with a superimposed alternating energy current using buried electrodes. The superimposed electrical field creates an induced polarization effect in the sediment that, in turn, induces redox reactions that decompose organic contaminants through ECGO and provide enhanced mobilization of metals through IC. Removal efficiency is contaminant specific, and the treatment process treats clays and silts much more rapidly than coarse-grained sands and gravels. The process does not produce a final marketable product, but rather affects a reduction in contaminant concentrations thus allowing: (1) the sediment to be left in place, (2) the sediment disposed as non-hazardous waste, or (3) reuse of the sediment as a soil-like product after further processing.

For application of the technology, the sediment is treated *in situ* or in a confined area. Electrodes are installed either through borings in the material or as "sheet" piles on approximately 10-meter centers. Local electrical power is passed through proprietary direct current/alternating current converters and then the current is applied to the sediment through electrodes emplaced in the sediment. Optimum remediation is generally achieved in less than six months.

The ECRTs have been used primarily to remediate soils in upland locations. The IC technology has been used on a demonstration scale to remediate 168 cubic yards of mercury-contaminated sediment in Scotland. Additionally, the technology has been evaluated on a bench scale (26.4 gallons) for dredged sediments in Germany. This technology was developed in Europe and has primarily been applied to sites in Europe. No specific information was presented on pilot or full-scale demonstration of the technology on dredged sediments.

At the Scotland demonstration project, average total mercury concentrations decreased from 243 mg/kg to 6 mg/kg after 26 days. Analytical results from the 14-day bench-scale test conducted on dredged sediment from the German site indicated an oxidation of organics resulting in the elimination of all color and odor and a marked decrease in metal concentrations. Reduction in metal concentrations ranged from 78 to 94 percent.

The ECRTs are not currently being applied on a commercial scale to treat CDM. Contaminated soil volumes in excess of 150,000 metric tons have been successfully treated in mostly upland applications in Europe. The equipment required for commercial application of the ECRTs is unique but not site specific. System layout must be designed and constructed specifically for each site depending on site characteristics. The equipment used (electrodes, wiring, and generators) is relatively small and easily transported from site to site. Procedures for installation of the electrodes vary depending on the physical characteristic of the material being treated. Specific information on a system capable of treating greater than 35,000 cy/month was not presented.

The ECRTs are contaminant treatment processes typically conducted without production of a marketable product as a primary goal. If concentrations of contaminants in dredged sediment can be sufficiently reduced, the treated sediment can be converted to a manufactured soil through addition of bulking materials. Marketability of such a final product was not discussed.

As previously discussed, the ECRTs can be applied either as an *ex situ* or *in situ* process. With respect to dredged sediment, the process could be applied to sediment previously dredged and managed in a confined disposal facility. The sediment must be trafficable to allow installation of the electrodes and associated wiring. Siting requirements for the equipment are minimal, with electrical power being the only utility required for the process. Further processing of the sediment to produce a marketable manufactured soil would require additional equipment and would involve excavation of the sediment and mixing with bulking materials. The resulting product would have to be packaged or transported in bulk to the point of sale or reuse. The primary waste stream produced from the application of the ECRTs consists of electrodes plated with metals. Metals can be recovered from the electrodes in a metallic form, which can be recycled.

The affect of sediment variability on the technical and economic performance of the technology was not discussed. Environmental permitting requirements were not discussed.

Capital costs for the equipment were not presented; however, since the technology is a turnkey treatment process, the cost of the equipment is included in the per unit treatment price. For sediment treatment, general preliminary engineering cost estimates for non-specific contaminated materials were estimated to range from $130/cy for treatment of 3,000 cy of material to less than $33/cy for treatment of greater than 100,000 cy of material. Specific operational factors affecting cost were reported as: type of contaminant, total physical depth of sediment to be treated, and physical location of the site containing the sediment.

<u>Sediment Washing</u>

This technology is a multi-staged sediment washing and organic oxidation process for decontaminating dredged sediments and producing a marketable fine-grained soil-like product for reuse after the addition of bulking materials. During the process, organic material is stripped from the solid particles. Removal efficiency is contaminant specific.

In operation, the dredged sediment is screened and then high-pressure water and chemical cleaners are used to strip the outer layers of organic material from the sediment particles. Organic material is removed using diffused air flotation. Organic and inorganic material is stripped from the sediment particles using high-pressure water and chemicals in a collision chamber. Organic material is oxidized by means of chemical oxidizer addition and processing in a cavitation unit. Reductions of strongly hydrophobic contaminants have been achieved. The treated sediment slurry is dewatered using a centrifuge and hydrocyclone. Bulking materials are added and mixed to produce a manufactured soil. Wastewater from the process is recycled into the process and/or treated and discharged.

The technology has been evaluated on both bench and pilot scales (up to 10 cy/per hour) for dredged sediments from upper Newark Bay. A full-scale system capable of processing 40 cy/hour (250,000 cy/year) is being designed and will be constructed starting in 2001. The full-scale facility will process contaminated sediment from dredging sites in New Jersey.

During the pilot-scale demonstration, numerous samples were collected for analysis. Analytical results are available on organic contaminant removal, heavy metal removal, air emissions, and physical characteristics.

Results from the testing indicated removal of individual polyaromatic hydrocarbons (PAHs) up to 78 percent and individual metals up to 92 percent, respectively, per washing cycle. Full-scale design data was developed including oxidant dosing requirement, process retention time, and quality requirements for recycled water.

The technology is not currently being used to treat contaminated sediment on a commercial scale. However, plans are in place to have a 250,000-cu-yd/year facility operational by 2002, and increase the capacity to 500,000 cy/year by the end of 2002. Some of the equipment required for commercial application of the technology is custom-designed and fabricated. Commercially available equipment is used for material handling and water treatment.

Specific uses and marketability of the treated sediment to be generated from these facilities were not identified. Potential beneficial uses of the treated sediment identified during the presentation are discussed in the next section.

A manufactured soil product was produced from the treated sediment. The treated sediment from the process is proposed for use as: manufactured top soil; manufactured potting soil; construction fill aggregate; wetlands restoration; landfill cover; and Brownfields redevelopment.

The treated sediment from the process has the characteristics of a damp, fine-grained soil. Addition of bulking agents, potentially other waste materials, is generally required to produce a marketable product.

The technology is only one component of the dredged sediment process train required managing sediment from generation to end-use. Transportation and storage facilities for raw and processed sediment must be designed and implemented. Barge transportation of dredged sediments is planned for the treatment plants to be constructed over the next two years. Site requirements for a 250,000-cu-yd/year facility were identified as 10 to 15 acres for the treatment facility and associated structures, and five to 10 acres for treated sediment storage. A 27-acre site has been acquired for construction of the proposed 500,000-cu-yd/year facility. Utility requirements include water and electrical power. Transportation infrastructure is required for transporting large volumes of the final product to the point of ultimate use. Debris from the screening process must be transported off site for disposal. Limited air emissions do not typically require off-gas treatment. Wastewater from the process is treated and recycled into the process with only limited discharge.

Physical and chemical characteristics of the dredged sediment identified as affecting technical and associated economic performance include particle size distribution, and type and concentration of contaminants. Factors affecting economic performance include volume of sediment to be treated and availability of a local market for the manufactured product.

With respect to the environmental regulatory requirements, a processing facility typically requires air discharge, wastewater discharge, and recycling permits. A variety of conventional permits is required for site construction depending on facility location.

A range of capital and operating costs were presented based on the proposed facility to be constructed over the next two years. Initial capital costs were estimated to range from $5 to $10 million with an additional $3 to $5 million required to boost the capacity to 500,000 cy/year. Operating costs were estimated to range from in excess of $160/cy at 30,000 cy/year, to less than $20/cy at a processing capacity of 500,000 cy/year. Specific elements included in the cost estimates were not identified. Favorable costs for the process require a steady supply of sediment to allow for continuous operation of the facility. Market value for the manufactured soil product and impact on operating costs were not presented.

Solidification/Stabilization

The solidification/stabilization technology presented was developed and used to cap an old city landfill in Elizabeth, New Jersey, using dredged sediment. This technology is a non-thermal, mixing process using chemical additives to transform dredged sediments into a structural-capping product. Contaminants are not destroyed during the process, but their mobility is reduced due to chemical stabilization and incorporation in the physical matrix of the product. Reduction in mobility is dependent on the contaminant and the type and amount of chemical additives used.

In operation, the dredged sediment is screened to remove large debris and then transferred to a pug mill. Solidification additives (Portland cement was used for this particular project) are added and mixed into the sediment. The resulting mixture is transported to the work site where it is allowed to dry and gain strength because of hydration of the additives. The material is then spread and compacted to provide a smooth, hard surface.

The solidification/stabilization of CDM has been repeatedly demonstrated on all scales. The Elizabeth, New Jersey project was a full-scale commercial operation. A total of 750,000 cy of dredged sediment was processed and used as capping material at the site. The TDF has initiated another capping project in Bayonne, New Jersey, where approximately 4.5 million cy of dredged sediment from New York Harbor will be solidified/stabilized using Portland cement and used to construct a structural cover over a 38-acre former municipal landfill and a 97-acre industrial site. No analytical results on the raw sediment or final product were presented.

The processing plant incorporates conventional equipment including a pug mill, material storage silos, feeder belts, and construction machinery. Other suitable mixing equipment is also commercially available. This process can be readily on a commercial basis to sites where structural fill or structural cover is required and dredged sediment of sufficient quantity is conventionally available. The technology can be easily scaled up by increasing equipment size or by operating multiple plants in parallel.

With respect to product marketability, solidified/stabilized dredged sediment can be used as a replacement for compacted fill or capping material in construction, typically in the form of land recovery. The material must be finally placed shortly after processing due to the setting reaction that occurs due to hydration of the cement. Use of contaminated sediment in the process often requires engineering controls to minimize the potential for leaching of contaminants. The material must compete with other materials and processes primarily on an economic basis.

For the projects presented, the TDF provided a complete process train for movement of the dredged sediment from the harbor to the end use. A dredging contractor dredged the sediment using a clamshell dredge and placed in barges. The barges were transferred to a docking area adjacent to the site where the sediment was off-loaded and transferred to the processing plant. After processing, the material was trucked to the working face of the capping area and deposited. After curing for a short period, the material was spread and compacted.

The processing plant requires a constructed site large enough for the equipment and additive storage. Electric power is the only required utility. The small quantity of water required for equipment washing can be trucked and tanked at the site. No large-scale storage of dredged sediment was required for the project presented due to the method of supply and near availability of the sediment. The process is also applicable to projects where sediment storage is required to maintain a continuous supply of raw sediment. No wastewater or off-gas stream requiring treatment or disposal is generated during the process. Debris from the gross screening process generally must be transported off-site for disposal.

The impact of sediment variability on the technical and economic performance of this process was not discussed. However, the dredged sediment characteristics must be consistent to insure a quality product.

With respect to regulatory requirements, the following environmental permitting and approvals are typically required for the process: closure and post-closure approvals (for landfills); remedial investigation and remedial action plan approval; erosion control plan; wetlands delineation; permit to accept recycled materials; acceptable use determination for dredged sediment; development permit; stormwater management plan; and dredging permits.

No itemized capital or operating costs were presented. The Port Authority of NY/NJ paid $56/cy for dredging, transporting, and treating the CDM at the Elizabeth, New Jersey site.

3.4.5.2.1.5 <u>Summary Comparison of Processes and Technologies</u>

A summary of the information presented by the TDFs is presented in Table 7 for comparison purposes. Some of the information is incomplete because it was not presented by the TDFs. In comparing technologies, it should be noted that the technologies vary in their maturity and scale of demonstration. Capital and operation and maintenance (O&M) costs are highly dependent on specific site conditions, dredged sediment characteristics, and the marketability of the product produced.

3.4.5.2.1.6. <u>Barriers to Technology Implementation</u>

After the technology presentations were completed, an open discussion led by the technology industry representatives and the review panel resulted in the identification of a number of barriers to implementation of the innovative technologies. The barriers identified are briefly discussed below.

(1) **The decontamination/treatment technology must be integrated into an overall dredged sediment management plan.** A decontamination/treatment process is only one component of the total process train required to manage dredged sediment from generation to final use of the produced product. The decontamination/treatment process must be well integrated into this process train. Transportation, storage, and conditioning of the sediment both before and after treatment processing are other

Table 7. Comparison of Innovative Decontamination/Treatment Technologies

Evaluation Factors	Technologies							
	Blended (Construction-Grade) Cement	**Building Bricks**	**Glass Aggregate**	**Lightweight Aggregate**	**Flowable Fill**	**Electrochemical Remediation**	**Sediment Washing**	**Solidification/ Stabilization**
Demonstrated on sediments	Sites in New York, New Jersey, and Michigan	Port of Hamburg, Germany	New York Harbor	Various Sites	Sites in New York	Port of Hamburg, Germany and Union Canal, Scotland	Upper Newark Bay	New Jersey New York
Scale of demonstration	Pilot scale (1 ton/day)	Full scale (35,000 metric tons/yr)	Pilot scale (13.4 cy)	Bench scale	Full scale (200,000 tons/yr)	Bench scale (100 liters); field-scale (220 cu meters)	Bench and pilot scale (10 cy/hr)	Full scale (750,000 cy)
Effect on contaminants	Organics thermally oxidized; metals immobilized in cement matrix	Organics thermally oxidized; metals immobilized or volatilized	Organics thermally oxidized; metals immobilized in glass	Organics thermally oxidized; metals immobilized in aggregate	Reduced mobility due to stabilization and incorporation in physical matrix	Organics decomposed by redox reactions; metals mobilized to electrodes where they are deposited	Organics are oxidized; metals are removed	Incorporated in physical matrix of product
Commercial availability	Process not applied to sediments on commercial basis; equipment available	Process being conducted on commercial basis; equipment available	Process not applied to sediments on commercial basis; equipment unique to process	Process not applied to sediments on commercial basis; equipment available	Process commercially available	Process not applied to sediments on commercial basis; equipment configured specifically for each site	Process not applied to sediments on commercial basis; some of the equipment is custom designed and fabricated	Process commercially available
Beneficial uses	Cement for general construction, soil stabilization, and solidification	Commercial/ Residential construction	Architectural tile; glass fiber; blasting grit; aggregate; glass cullet	Geotechnical fill; concrete/ Masonry aggregate; horticulture; road paving	Replacement for compacted fill	Manufactured soil by addition of bulking materials if sediment removed from site	Manufactured soil by addition of bulking materials	Compacted fill; capping

Table 7 (cont'd). Comparison of Innovative Decontamination/Treatment Technologies

Evaluation Factors	Technologies							
	Blended (Construction-Grade) Cement	**Building Bricks**	**Glass Aggregate**	**Lightweight Aggregate**	**Flowable Fill**	**Electrochemical Remediation**	**Sediment Washing**	**Solidification/ Stabilization**
Siting requirements	Land area for melter and material storage; water, fuel, and power utilities	Land area for kiln and material storage; water, fuel, and power utilities	Land area for plasma arc facility; dewatering and desalination facilities; water, fuel, and power utilities	15 acres plus material storage; water, fuel, and power utilities	Land area for batch plant and material storage; water and power utilities	Process is conducted either ex-situ or in-situ; power utilities	15-25 acres for 250,000-cy/yr facility; water and power utilities	Land area for mixing equipment, additive storage; power utilities
Waste streams generated	Debris from screening; off-gas	Debris from screening; wastewater; off-gas	Debris from screening; wastewater	Debris from screening; wastewater; off-gas	Debris from screening; wastewater	Limited residues (sediment remains in place if conducted in-situ); electrodes with deposited metals may require disposal or recycling	Debris from screening; limited air emissions; limited wastewater; non-hazardous sludge from water treatment system	Debris from screening
Permits required	Air; solid waste	Air; wastewater; solid waste	Air; wastewater; solid waste	Air; wastewater; solid waste	Wastewater; solid waste	None identified	Air and wastewater discharge; recycling	Recycling
Capital costs	$100 million for 500,000 cy/yr	$25-$80 million (brick plant only; 300,000-900,000 metric tons/yr of sediment)	$80-$90 million (500,000 cy/yr of sediment)	Not provided	Not provided	Not provided	$8-$15million (500,000 cy/yr of sediment)	Not provided

Table 7 (cont'd). Comparison of Innovative Decontamination/Treatment Technologies

Evaluation Factors	**Technologies**							
	Blended (Construction-Grade) Cement	**Building Bricks**	**Glass Aggregate**	**Lightweight Aggregate**	**Flowable Fill**	**Electrochemical Remediation**	**Sediment Washing**	**Solidification/ Stabilizaton**
Processing costs	$45-$50/cy	$25-$75/ metric ton	Not provided	Not provided	$12-$20/cy	$130/cy for 3,000 cy to less than $33/cy for volumes greater than 100,000 cy	$160/cy for 30,000 cy/yr to $20/cy for 500,000 cy/yr	$56/cy (includes sediment dredging, transporting, and treating)
Tipping fee required	$0-$35/cy	$20-$60/ metric ton	$25-$29/cy	$15-$30/cy	$5-$20/cy	Included above	Included above	Included above

Source: *Journal of Dredging Engineer*, Western Dredging Association, Volume 3, No. 2, June 2001.

required components of the total process and minimize the total cost of dredged sediment management.

(2) **Funding and dredging contracts are typically negotiated on a short-term basis.** Federal and state funding for dredging activities is generally appropriated on an annual basis; funding may expire at the end of the fiscal year. As a result, contracts are written only for the period of time for which the money is available or may require annual appropriation for a longer-term contract. Without long-term contracts and a guarantee of income, it is difficult for TDFs to acquire the capital required to construct the decontamination/treatment facilities. These types of facilities generally require a long operating period to amortize the initial investment to allow for reasonable unit costs. In addition, TDFs cannot negotiate long-term contracts with chemical, reagent, and material suppliers, which limits their ability to obtain the supplies at the lowest possible price.

(3) **Competitive procurement processes discourage capital investment and cooperative agreements.** Under current competitive procurement methods and typical single contractor awards, it is generally not economically feasible for TDFs to invest the capital required to construct a processing facility. There is no guarantee that the TDF will be the low bidder on future contract competitions and awards. The TDF must bear the cost of periodic proposal preparation that is passed on to the user as an indirect cost. Competitive procurement and single awards also discourage cooperative activities and agreements between TDFs where sharing of proprietary information is required since the TDFs may be competitors during future procurement actions. Such cooperation between TDFs may be highly beneficial to the agency responsible for dredged sediment management.

(4) **Potential delays/work stoppages due to public agencies and/or representatives.** The potential sensitivity of dredging projects, particularly those involving contaminated sediments, can result in the delay or stoppage of facility construction and/or operation. Project delay or stoppage represents a significant economic risk to the TDFs.

(5) **There is a lack of consistency in or in some cases an absence of, state regulations covering the marketing and use of recycled CDM.** Regulations pertaining to acceptable levels of contamination in recycled sediment products often vary from state to state, making marketing of such products difficult. In some states, no such regulations exist. This represents a potential risk to TDFs trying to market the products since future regulations may result in the products being deemed unacceptable for certain, or all, uses.

(6) **There is a poor public perception or fear of certain decontamination/treatment technologies.** Certain technologies, (i.e., thermal destruction) are poorly received by the public. They do not want such facilities constructed in their "backyard". Such opposition typically results in a lengthy, costly operating permit negotiation. In the worst case, operating permits are denied.

(7) **The intermittent nature and variation in chemical and physical characteristics of a typical dredged sediment stream presents a problem with real time**

application of a decontamination/treatment process. The dredged sediment stream produced by a dredge can be highly variable in flow volume, solids content, particle size, and contaminant concentrations. These variables can significantly affect the successful application of a decontamination/treatment technology, resulting in a poor quality product.

(8) A market for recycled dredged sediment products must be developed. Favorable costs for application of decontamination/treatment technologies generally require that the recycled product produced have a market value. Such a market must generally be developed, which requires effort and time. In some cases, the product must replace other products already in the market place. In these cases, the product must be shown to be superior or less expensive than the existing product.

(9) Product buyers often have a poor perception of recycled product. Recycled products are often deemed inferior to virgin products. These perceptions must be overcome by demonstration or price differential to market the product successfully.

(10) Resistance from labor groups to displacement of traditional products and associated jobs. Introduction of a new product (such as a recycled dredged sediment product) into the market place can result in the displacement or replacement of a traditional product. This can result in the loss of jobs or, more typically, a shift in jobs. Labor groups tend to resist such changes that can affect the ability to market the new product.

(11) There are potential long-term product liability and legal responsibilities associated with a recycled product. The manufacturer of a recycled product that incorporates contaminated material is at risk for long-term product liability and the associated legal ramifications. The real or perceived potential public exposure to such contaminants and potential for migration of such contaminants into the environment presents a long-term risk of lawsuits and legal responsibility for cleanup with associated potentially high costs.

3.4.5.2.1.7 Overcoming the Barriers to Technology Implementation

The discussion on barriers to technology implementation led to a discussion of possible methods, activities, and procedural changes, to aid in overcoming or minimizing such barriers. Those identified are briefly discussed below.

(1) Long-term forecasting of dredging requirements and likelihood of funding. Information on long-term dredging requirements from the responsible agencies and estimates of potential funding levels would aid TDFs in preparing for and acquiring funding necessary for technology implementation including design of equipment and facilities. This information should include locations and estimates of volumes and contaminant concentrations.

(2) Public funding of centralized dredged sediment storage and management facilities. Most all of the decontamination/treatment technologies require a continuous supply of homogeneous dredged sediment that has been screened and partially dewatered. The agencies responsible for dredging can benefit from having a funded public entity operate a long-term centralized sediment storage and management facility. Sediment from various dredging projects in the area could be stored and conditioned at the facility. Space would be available for various TDFs to construct processing plants on, or adjacent to, the storage facility.

(3) **Use of other waste streams to insure continuous feed stream to process.** Other waste materials may be available in the area that can be incorporated in the process to minimize the impact of variability in dredge sediment flow to the process.

(4) **Processing of other waste stream to augment income.** Substantial tipping fees may be generated from the treatment of other waste streams using the processing facility. This could help lower the per-unit cost for processing dredged sediment.

(5) **Partnering between TDFs would increase the volume of recycled dredge sediment that can be marketed.** The market demand for recycled dredge sediment products directly affects the sustainable production rate and the per-unit processing costs. The higher the volume of products sold the more sediment that can be processed at a favorable per-unit cost to the responsible agency. Thus, the optimum scenario is to have multiple TDFs producing a variety of products, thus reducing the impact of market variability.

(6) **Decouple product from the treatment process.** With respect to public perception of a product, it is important to de-emphasize the fact that the product is generated from the treatment of CDM. The product should instead be promoted based on its quality and cost advantage for a particular market.

(7) **Mandate use of recycled dredged sediment products in public projects.** Mandating the use of recycled products in public projects has been successful in creating a market for other waste materials. Such a mandate for recycled dredged sediment products would create and sustain a market for these products. Many of the dredged sediment products can be incorporated as construction materials in construction projects.

(8) **Provide education on the benefits of using recycled dredged sediment products.** Education of potential product users and the public is required to overcome the poor perception and/or fear of process technology and recycled dredged sediment products.

3.4.5.2.1.8 Findings and Conclusions

The focus of the PIANC Specialty Conference was on technologies that are generally applicable to contaminated sediments and that have the potential to process large amounts of sediments, that is, sediment quantities in excess of 1,000,000 cy. Essentially all dredged material decontamination/treatment technologies that are capable of processing this quantity of dredged sediment fall into one of two basic categories, thermal destruction technologies and non-thermal technologies that separate or stabilize contaminants. Destruction technologies are generally thermally based. Non-thermal processes often provide only slow or minimal destruction of organic contaminants. Sediment decontamination technologies that are capable of processing large volumes of dredged material are designed to avoid disposal costs for the treated residue by producing a saleable product material.

Thermally based treatment/destruction technologies have the advantage of significant destruction of at least the organic contaminants in the dredged material. Conventional incineration faces significant community acceptance issues despite the potential for achieving essentially complete destruction of the bulk of the contamination. There is a potential for greater community acceptance with the production of blended cement, lightweight aggregate or glass from the dredged material if contaminant migration issues can be resolved. However, the use of cement kilns raises air emissions permit and community acceptance issues similar to those for a conventional incinerator. The production of lightweight aggregate from dredged sediment employs rotary kiln technology for the destruction of contaminants and production of the aggregate. Similar air emission permitting and community acceptance issues can arise. The production of glassy products from dredged material employing a plasma torch has been tested on a demonstration scale. This process has relatively high energy and capital costs but produces a clean product. It is most likely to be used for small volumes of highly contaminated dredged material unless the costs can be offset by the value of the product produced.

Non-thermal separation and stabilization technologies that have been proposed for contaminated sediments include sediment washing and processes that seek to produce fill material in which the contaminants are effectively contained. Soil washing technologies serve to reduce contaminant levels by partial removal of fines and organic material containing contaminants. The net result is a reduction of the more soluble contaminants in the sediments by factors ranging from two to 10. Reductions in contaminant concentrations of less soluble components, such as PCBs or high molecular weight PAHs, are likely to be less than a factor of two. In many situations, this may be insufficient to allow significantly expanded uses of the treated material over the untreated dredged material. The goal of most soil washing technologies is production of a manufactured soil.

Stabilization technologies introduce additives to the dredged material to produce flowable or solid fill material. Contaminant levels are normally unchanged except for dilution due to the additives or the mixing with other fill components. The resulting stabilization, however, is expected to significantly reduce the potential for leaching of the contaminants. A significant barrier to use of the resulting material, however, is the lack of regulatory standards for the product. Fill-product criteria based upon total contaminant levels are not likely to significantly expand the potential uses of this material, while fill-product criteria based upon leachate tests such as the TCLP may not receive sufficient community acceptance.

The treatment of CDM becomes more attractive if alternate management options, such as disposal in a less secure (and less expensive) landfill are not available. Some benefit may be gained from partial decontamination, but if there is no potential for expanded use of the dredged material, it is unlikely that these processes can compete economically with direct disposal of the dredged material in a landfill. The products of each of the above processes have the potential to offset part of the cost of treatment, although introduction of these products in large volumes is likely to have a significant negative impact on their value in the marketplace. The costs of these processes are also likely to be high, except when a large-volume dredged sediment stream can be guaranteed to allow the economies of scale. It has been estimated, but not demonstrated, that all processes except the plasma torch technology can be applied for between $30 and $70/cy of dredged sediment if amounts greater than 100,000 cy/year for between 10 and 20 years can be guaranteed. The success of the various technologies and the products they produce currently depends upon community and regulatory acceptance of their respective operations and the proposed uses for the resulting products.

A number of barriers to technology implementation have been identified. These include: integration of treatment technologies into overall dredged sediment management; conventional short-term, competitive procurement processes which hinder capital investment and limit the TDFs ability to procure required materials and supplies at the lowest possible price; lack of consistency between or total absence of applicable state regulations on acceptable uses of process products; residual levels of contaminants in products and process effluent streams; public concern about technologies/processes used to treat and manage sediments; intermittent nature and variations in sediment characteristics associated with typical dredging projects; required development of market and acceptance of products produced from dredged sediments; resistance from labor groups to displacement of traditional products and associated jobs; and long-term product liability and legal responsibilities associated with products.

Potential methods, activities, and procedural changes which may aid in overcoming or minimizing such barriers include: long-term forecasting of dredging requirements and funding availability; public funding of centralized dredged sediment storage and management facilities; processing of other waste streams in treatment facilities to insure a continuous-feed stream and lower per-unit processing costs based on additional tipping fees; partnering between TDFs to increase overall product markets; decoupling a product from the treatment process; mandating use of recycled dredged sediment products in public projects; and educating the public in the benefits associated with using recycled dredged sediment products. Some of these changes will probably be required to foster and stimulate the implementation of these innovative decontamination and treatment technologies. Regardless of the decontamination or treatment technology selected for a navigation project, the economic and environmental benefits must be clearly identified and articulated to project sponsors, the public and other stakeholders. (Innovative Dredge Sediment Decontamination and Treatment Technologies, Journal of Dredging Engineering, Vol. 3, No. 2, June 2001)

3.4.5.3 Alternative 3: No-Action Alternative. Under the No-Action Alternative, the status quo would be maintained. The river would not be dredged and would continue to be subjected to sedimentation. Waterborne access would continue to deteriorate. Vessels navigating the Miami River engage in a *de facto* form of dredging of shoals and shallow reaches of the waterway. Prop-wash agitation and bottom dragging suspend sediments and enable the channel to retain a depth that minimally enables navigation to continue.

Although this alternative fails to meet the planning goals, objectives, and requirements, it evaluation is required by Section 1502.14 of the Council on Environmental Quality regulations implementing the National Environmental Policy Act.

3.4.6 Engineering, Design, and Costs

3.4.6.1 Upland Area Surveys. Upland area surveys were necessary to determine the elevations for real estate analysis and economic analysis, and for disposal area designs and capacities. Survey and mapping was provided by Miami-Dade County.

Survey plats for the interim staging area are attached in Attachment I.

3.4.6.2 Hydrographic Surveys. No additional hydrographic surveys were necessary to evaluate the alternatives. A hydrographic survey was conducted by the Jacksonville District USACE in 1999 and was used to calculate dredge quantities for the Miami River project.

The 1999 hydrographic survey for the Miami River is attached in Attachment J.

3.4.6.3 Subsurface Investigations. Subsurface investigations were conducted on the interim staging area by the USACE. These investigations were to explore and characterize the site. A discussion of the investigation results is included in Section 3.4.5.1 – The Base Dredging Plan.

3.4.6.4 Geotechnical Engineering Evaluations and Recommendations

Engineering evaluations are typically made using the results of the field and laboratory work to:

1. Evaluate the suitability of it *in situ* materials for reuse in dike construction.
2. Prepare preliminary design and construction recommendations for earthen dikes.
3. Develop preliminary design and construction recommendations for weir foundations.

No lab testing was performed on this project. However, the samples are archived in the USACE warehouse.

3.4.6.5 Cost Estimates. Cost estimates have been made using the design conditions for proper evaluation of all reasonable alternatives to obtain a selected plan for recommendation. The estimated cost for the recommended plan is $71.7 million.

3.4.6.6 Additional Considerations. Specific concerns have been voiced regarding odor of dredged material, bird activity, noise, and traffic. At the request of the local sponsor, the interim staging area cannot be utilized for conventional diking with open-air drying. Therefore, any plan that utilizes this interim upland staging area must confine the material (e.g., geotubes, etc.). However, conventional diking and open-air drying can be used in the Miami River dredging project if the contractor provides another upland site and all approvals are received.

3.4.6.6.1 Odor Control. There is no evidence, either anecdotal or from the sediment sampling and analyses, that indicates the Miami River dredge spoil will present objectionable odors.
Communication with representatives responsible for permitting small private dredging projects on the Miami River indicate odor has not been a problem or resulted in complaints from the public.

However, in the unlikely event that malodors are present, such odors would be managed in accordance with the following USACE references, and the most likely countermeasure would probably be a peppermint spray misting system, similar to the one used at the Central Wastewater Treatment plant located on Virginia Key.

3.4.6.6.2 Birds. Concern has been raised over the issue of birds being attracted to dredged material at the interim upland staging area and the potential problems with aircraft operations at nearby Miami International Airport.

It is unlikely that birds would be attracted to dredged material as a source of food. Because sediments in Miami River are in an environment devoid of oxygen and salinity is highly variable, benthic organisms are sparse. There is little reason to suspect that there are sufficient amounts of invertebrates present to attract significant numbers of birds.

According to local officials who regulate small private dredging projects on the Miami River, birds are not attracted to dredged sediments.

3.4.6.6.3 Noise Environment. A noise environment characterization was attempted on March 20-22, 2001 using a Quest M-39 Logging Noise Analyzer. The instrument was in the backyard of the house at 3586 NW 35th Street, the residence nearest the proposed dredge-processing site. Readings were taken for approximately 10.25 hours on March 20, from 0730-1814, and for approximately 25 hours on March 21-22, from 0610-0742.

Because average wind speed exceeded 12 miles per hour during the entire period of survey, the results and analysis are presented in the form of a preliminary noise reconnaissance, not a definitive noise study.

The site selected for the noise level recordings is located approximately 180 feet east of NW 37th Avenue, in a mixed residential/commercial/light industrial area that could be characterized as relatively noisy. Flights into and out of Miami International Airport occur just south of the site, major thoroughfares carrying large volumes of traffic are located nearby, and various scrap metal, recycling, and cargo-handling enterprises are located in the vicinity.

Measurements taken during March 20 indicate average background A-weighted hourly equivalents (Laeq1h) of 66.8 dBA. The maximum level recorded was 85.8 dBA. Measurements taken during March 21-22 indicate an average noise level of 64.5 dBA, a maximum of 102 dBA, and a LDN of 70.1 dBA.

Sound levels within the range of 60-66 dBA are on the order of those encountered in a business office during working hours. As a basis of comparison, a noise impact of 66 dBA resulting from a highway improvement project would require the consideration of noise abatement measures.

A sound level of 85 dBA is a level roughly equivalent to standing beside a street with average traffic.

A reading of 102 dBA is on the order of a rock concert or a pneumatic chipper. It is likely that this level was recorded when a jet aircraft passed directly overhead.

The 70.1 dBA LDN is obtained by adding a 10-dBA penalty (per convention) to the average noise level during the period 10:00 p.m. – 7:00 a.m. The actual noise level during that survey period was about 60.1 dBA.

Both the river where the dredging will take place and the staging area site are located within extensive industrial/heavy commercial areas. Additionally, the Miami International Airport is located within 0.5 mile from the north end of the proposed project and less than 5 miles from the farthest point of the project, at the mouth of the river. Aircraft departing and arriving Miami International, river vessel traffic signaling to bridges to open and close, high level industrial activity along most of both river banks, high volumes of truck and other vehicular traffic along most of both river banks, and a train track paralleling the north river bank in the northern portion of the proposed project, as well as other noise sources, all contribute to a high level of ambient noise in the project area.

It is unlikely that any engine noise generated by the dredges and associated watercraft would create noise levels that significantly exceed those levels produced by recreational, commercial, and industrial activities that currently take place along the Miami River. The temporary nature of the construction and the attenuation of noise by distances from residential centers are expected to minimize adverse impacts of the project.

3.4.6.6.4 Traffic. Traffic counts provided by the Miami-Dade County's Capital Improvements/ Construction Coordination Section indicate average daily volumes (total, both directions) of 24,173 vehicles per day (vpd) on NW North River Drive at NW 37th Avenue and 3,104 vpd on NW 37th Avenue.

Peak hour for both roadways occurred from 0700-0800, when approximately 977 vehicles (8.3 percent) were counted on NW River Drive and 155 (11 percent) vehicles were counted on NW 37th. Higher counts were also noted on both roadways during the hours 1100-1200 and 1600-1700. Traffic on NW North River numbered 672 vehicles (5.7 percent) and 860 vehicles (7.3 percent), respectively. Traffic on NW 37th numbered approximately 135 vehicles (9.5 percent) for both hours.

Except for its terminal at NW 36th Street and NW North River, there are no traffic controls present on NW 37th Avenue, and level of service is good.

Concerns have been expressed by citizens and city and county officials over the additional traffic on streets and highways near the project site generated by the handling of the large amount of sediments to be dredged from the Miami River. However, because the nature of the sediment handling operation is determined by the contractor, the implications of the operation on vehicular traffic cannot be determined in this document. The Contractor will be required to be responsive to complaints about traffic problems created by his activities. Should this become a problem, the Contractor will be required to alter numbers of vehicles, sizes of vehicles, and/or times of vehicles on the road to meet the needs of the public, particularly during rush hours.

3.5 SELECTED PLAN

The selected plan has not been chosen. The USACE intends to issue a RFP. The RFP that provides the government the "best value" will be chosen at a future date.