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EVALUATION of ALTERNATIVE METHODS of ACHIEVING SEDIMENT QUALITY TARGETS

FINAL REPORT

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EVALUATION OF ALTERNATIVE METHODS OF ACHIEVING SEDIMENT QUALITY TARGETS

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EXECUTIVE SUMMARY

The objective of this report falls under the broader goal of assisting in the development and implementation of the Tampa Bay sediment quality management strategy. The specific objective of this memorandum is to evaluate the alternative management options available to achieve sediment quality targets. Therefore, this document describes alternative management options to achieve sediment quality targets and estimates of costs associated with these methods.

Contaminated sediment management options fall into two general categories, nonremoval and removal techniques. Nonremoval techniques involve the remediation of contaminated sediments *in situ* (i.e., in place). Removal techniques involve the remediation of contaminated sediments *ex situ* (i.e., out of place).

Nonremoval techniques for contaminated sediments include natural recovery, sediment capping, *in situ* containment (hydraulic modification), and *in situ* treatment. Nonremoval techniques are single-component remedial alternatives. They do not require sediment removal, transport, or pretreatment. As a result, nonremoval techniques are often less complex and have lower costs than multicomponent alternatives (e.g., combinations of removal, transport, treatment, and disposal). In some cases (e.g., *in situ* treatment), nonremoval technologies may be similar to the treatment and disposal techniques used with dredged sediments (USEPA, 1994).

Removal techniques for contaminated sediments include dredging and wet/dry excavation. Removal techniques are multi-staged remedial alternatives. They require sediment removal, transport, treatment, and disposal (USEPA, 1994).

FOREWORD

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1.0 INTRODUCTION

The major goal of the Tampa Bay Estuary Program (TBEP) is to develop and implement a comprehensive plan for the restoration and protection of Tampa Bay. Because of the need to address large-scale issues that impact the entire ecosystem, TBEP drafted a Comprehensive Conservation and Management Plan (CCMP) for the Tampa Bay Estuary and its surrounding watershed. Water and sediment quality was identified as one of the five most pressing problems facing Tampa Bay.

The principle reason that sediment quality was identified as a pressing problem was because NOAA documented adverse biological effects in Tampa Bay sediments, oysters and fishes as part of its National Status and Trends Program (Long, 1994). Data from chemical and toxicological analyses of sediments, chemical analyses of oyster tissues, and chemical and biomarker analyses of resident fish showed strong agreement. The northern portion of Hillsborough Bay was the most contaminated region in Tampa Bay. Other small areas in western Old Tampa Bay, along the western shore of Middle Tampa Bay, and in lower Boca Ciega Bay also showed signs of degraded sediment quality. The chemical analyses indicated that many different substances occurred in sediments, probably acting together to induce toxicity and other biological effects. The identification of these contaminants in tissues of oysters and fish, observations of biochemical responses in fish, and the occurrence of toxicity in laboratory tests indicate that chemicals were bioavailable in the sediments. Observations of acute and sub-lethal toxicity in sediment toxicity tests and biomarker responses in fish, furthermore, indicate these chemicals may pose a toxicological risk to local biological resources (Long and Greening, 1999).

Having identified areas in Tampa Bay that have contaminated sediments (Figure 1), the logical next step is to identify potential methods of remediation for these contaminated areas. However, a blanket approach to the problem is not advisable. Instead, an appropriate sediment management option should be selected on a case-by-case basis, after careful consideration of the risks posed by the contaminants, the benefits of the remediation, and the costs. Contaminated sediments may either be left in place or removed. Contaminated sediments should not be removed from a site if doing so would cause more harm than simply leaving them in place. If sediments are left in place, however, measures must be taken to limit the danger they pose to people and wildlife. Long-term biological and chemical monitoring should be established to measure any change in contaminant levels over time and the associated biological response (EPA contaminated sediments web page, <http://www.epa.gov/waterscience/cs/aboutcs/manage.html>).

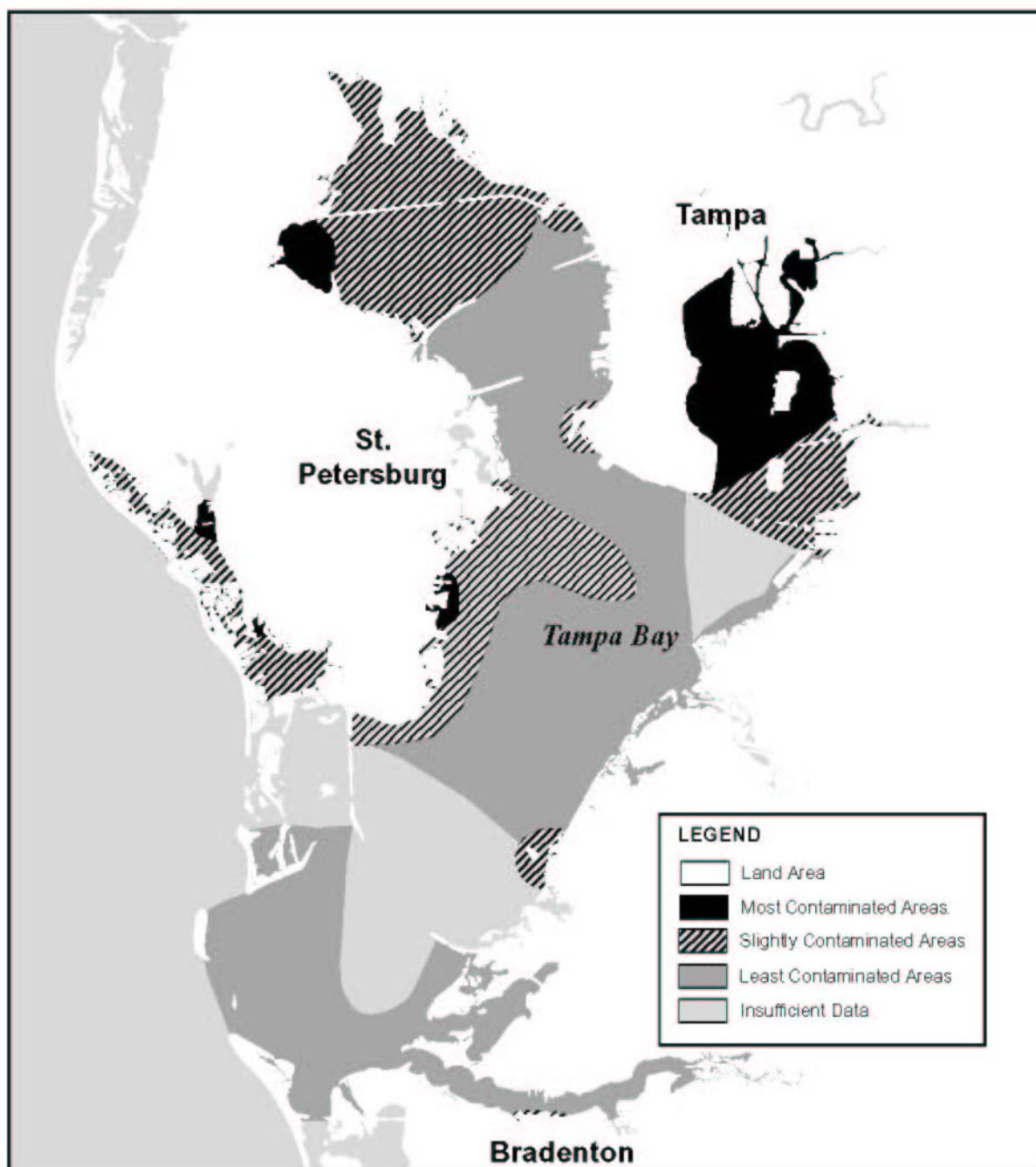


Figure 1. Map of Contaminated areas in Tampa Bay (Source: TBNEP, 1996)

1.1 Objective

The objective of this report falls under the broader goal of assisting in the development and implementation of the Tampa Bay sediment quality management strategy. The specific objective of this memorandum is to evaluate the alternative management options available to achieve sediment quality targets. These options may include:

Nonremoval techniques

- nonpoint source pollution control measures
- natural recovery
- sediment capping
- *in situ* containment

Removal techniques

- dredging
- dry excavation

2.0 MANAGEMENT OPTIONS

Contaminated sediment management options fall into two general categories, nonremoval and removal techniques. A summary of advantages and disadvantages associated with different management options can be found in Appendix A, Advantages and Disadvantages of Various Sediment Remedial Technologies (SMWG, <http://www.smwg.org/products/decisiontree/navframes/index.htm>). Basic fact sheets developed for the different management options by the Sediment Management Working Group can be found in Appendix B.

2.1 Nonremoval Techniques

Nonremoval techniques involve the remediation of contaminated sediments *in situ* (i.e., in place). Nonremoval techniques for contaminated sediments include natural recovery, sediment capping, *in situ* containment (hydraulic modification), and *in situ* treatment.

Nonremoval techniques are single-component remedial alternatives. They do not require sediment removal, transport, or pretreatment. As a result, nonremoval techniques are often less complex and have lower costs than multicomponent alternatives (e.g., combinations of removal, transport, treatment, and disposal). In some cases (e.g., *in situ* treatment), nonremoval technologies may be similar to the treatment and disposal techniques used with dredged sediments (USEPA, 1994).

The amounts of sediment contaminants lost during and after remediation need to be estimated to determine the benefits of remediation and to evaluate the impacts of remedial alternatives. The mechanisms for contaminant losses associated with nonremoval technologies are summarized in Table 1.

Table 1. Mechanisms of Contaminant Loss for Nonremoval Technologies

Technology	Contaminant Loss Mechanisms
<i>In situ</i> Capping	Resuspension/advection during placement of cap Long-term diffusion/advection Long-term bioturbation Long-term erosion
<i>In situ</i> Containment	Resuspension during construction Loss during dewatering/filling Long-term seepage/leaching
<i>In situ</i> Treatment	Resuspension during treatment Long-term diffusion Long-term bioturbation Long-term erosion

Source: USEPA (1994)

Estimating contaminant losses for nonremoval technologies is difficult because of the lack of field monitoring data and standard procedures for assessing nonremoval technologies. Predictive models based on diffusion are conceptually applicable to most nonremoval technologies. However, predictive techniques are not available that account for any of the other mechanisms of contaminant loss associated with nonremoval technologies (USEPA, 1994).

Contaminant losses during placement of a cap, construction of an isolation wall, or the injection of reagents or additives for chemical treatment or immobilization can result in highly localized, but transient disturbances of contaminated sediment. At present, highly localized, transient contaminant losses associated with the implementation of nonremoval technologies cannot be predicted. In addition, nonremoval technologies involving several processing steps, especially those involving mixing of the contaminated sediments, will have more contaminant loss mechanisms to consider than simpler nonremoval technologies, such as *in situ* capping (USEPA, 1994).

Once the implementation phase of a nonremoval technology is completed, diffusion is the major contaminant loss pathway. Advection, bioturbation, and biodegradation can also be important in some cases, but can be avoided by careful planning, design, preproject testing, and monitoring. For example, sites with significant groundwater movement through the sediment (and associated significant contaminant losses) are not good candidates for nonremoval technologies. Controls for bioturbation should be part of engineering design, and the potential for biodegradation of solidified matrices following immobilization processing should be evaluated in a laboratory testing phase.

2.1.1 Nonpoint Source Pollution Control

Nonpoint source pollution control measures aim to reduce the quantity of contaminants that reach the water body. Stormwater runoff carrying fertilizers, pesticides, oil, and other contaminants from urban and agricultural lands contributes nearly half of Tampa Bay's total

annual nitrogen loading and more than 60 percent of the annual loadings of zinc, mercury, lead, and chromium (TBNEP, 1996). It is for this reason that The TBEP has already instituted several activities to address nonpoint source pollution due to stormwater runoff.

2.1.2 Natural Recovery

When considering how to reduce risks that contaminated sediments pose to human health and the aquatic environment, it is important to recognize the capacity of natural processes to “heal” the impacted environment. This is referred to as natural attenuation. This approach to sediment remediation relies on the powerful natural processes that are inherent within all aquatic systems to reduce chemical of concern (COC) bioavailability and potential transport. The natural attenuation of aquatic systems is driven mostly by quantifiable physical mechanisms such as mixing and in-place burial of contaminated sediments. If the source of contamination is adequately addressed, the contaminated sediments will be buried by progressively cleaner sediments. This natural sedimentation process can reduce the physical availability of COCs for potential transport downstream and similarly reduce the bioavailability of COCs for potential exposure to human and ecological receptors. Other potentially significant mechanisms include chemical processes such as adsorption and redox reactions and biodegradation (Brown, 1999 <http://www.smwg.org/products/decisiontree/navframes/index.htm>).

Despite today’s apparent emphasis on applying active remedial technologies in managing contaminated sediment, there is some evidence that natural attenuation can be applied as an effective remedial alternative or to enhance the protectiveness of other alternatives selected for aquatic sites. While the regulatory community and public tend to view the natural recovery of sediments as a no action alternative, the capacity for natural attenuation processes combined with performance monitoring may be a protective, feasible, and cost-effective alternative to be considered when evaluating potential remedies (Brown, 1999).

2.1.3 Sediment Capping

In situ capping is the placement of a covering or cap over an *in situ* deposit of contaminated sediment (Figure 2). The cap may be constructed of clean sediments, sand, or gravel, or may involve a more complex design using geotextiles, liners, and multiple layers.

In situ capping has been applied in riverine, nearshore, and estuarine environments. Conventional dredging and construction equipment and techniques can be used for *in situ* capping projects, but these practices must be precisely controlled. The success of projects to date and available monitoring data at several sites indicate that *in situ* capping may be an effective technique for long-term containment of contaminants (USEPA, 1994).

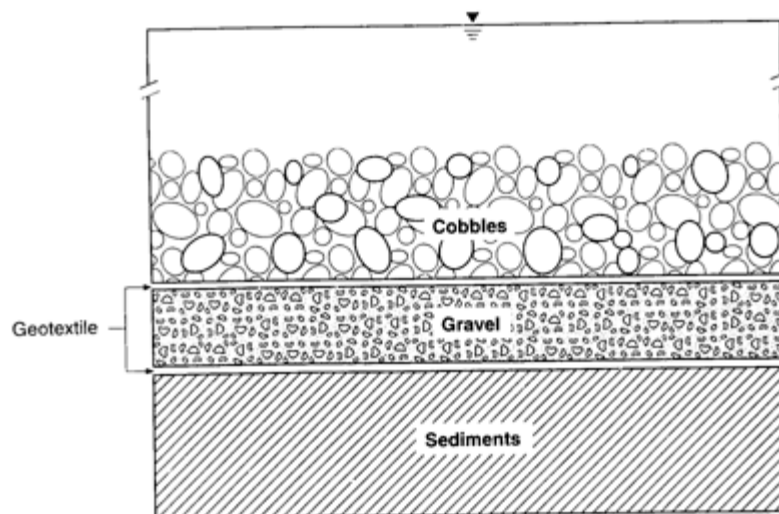


Figure 2. Typical sediment capping configuration (Source: USEPA, 1994)

The construction of an *in situ* cap represents a deliberate modification to the morphology of the bottom of a waterway. Future uses of the waterway may be limited by this modification. A variation of *in situ* capping involves the removal of contaminated sediments to some depth, followed by capping the remaining sediments in place. This method is suitable when capping alone is not feasible because of hydraulic or navigation restrictions on the waterway depth. It may also be used where it is desirable to leave the deeper, more contaminated sediments capped in place.

The primary technical considerations that affect the feasibility of *in situ* capping are the physical and hydraulic characteristics and the existing and future uses of the waterway. The suitability of *in situ* capping to a contaminated sediment site is less affected by the type or level of contaminants present, because it physically isolates the sediments and their associated contaminants.

The ideal area for *in situ* capping would be sheltered and not exposed to high erosive forces, such as currents, waves, or navigation propeller wash, or to upwelling from groundwater (USEPA, 1994). Depending on the erosive forces present at a site, an *in situ* cap may have to be armored with stone or other material to keep the cap intact. Areas on five tributaries of the Great Lakes were examined under the ARCS Program in developing guidance on the hydraulic design of *in situ* caps (Maynard and Oswalt, 1993). River currents were the dominant erosive force in only one of five areas. The scour caused by navigation (recreational as well as commercial) was the dominant force in the other areas studied. The potential scour caused by large commercial vessels would necessitate very large armor stone, making *in situ* capping difficult in or near most active navigation channels (Environmental Laboratory 1987; Maynard and Oswalt 1993).

Capital costs for *in situ* capping include costs of capping materials, construction equipment, and labor. These costs will be influenced by the complexity of the cap design,

accessibility of the capping site, water depth, and other factors. If clean dredged material (e.g., from a navigation project) can be used in a capping application, capital costs could be greatly reduced.

Operation and maintenance costs include monitoring and periodic cap replenishment. Based on the experience of the Corps' New England Division with dredged material capping, the costs for a routine long-term monitoring cycle (bathymetric surveys and camera profile) are about \$30,000. This basic physical monitoring cycle is conducted every 2-3 years (USEPA, 1994).

2.1.4 *In situ* Containment

In situ containment, also known as hydraulic modification, involves the complete isolation of a portion of the waterway. Physical barriers used to isolate a portion of a waterway include sheetpile, cofferdams, and stone or earthen dikes. Figure 3 shows a river dam that was used as a hydraulic modification. The isolated area can be used for the disposal of other contaminated sediments, treatment residues, or other fill material. The area may have to be modified (e.g., slurry walls, cap and cover) to prevent contaminant migration.



Figure 3. Example of *in situ* containment (Source: SMWG, 1999)

The technical feasibility of using *in situ* containment is determined primarily by the physical conditions of the site. Areas that may be suitable for *in situ* containment include backwater areas, slips, turning basins, and some wide areas of rivers. Areas within active navigation channels are generally not suitable.

The primary factors limiting the feasibility of *in situ* containment are the potential impacts of the new fill on flow patterns, flooding, navigation, and habitat. Slips and turning basins are especially well suited, because they only need to be isolated at one end and can generally be filled without reducing the hydraulic capacity of the adjacent river channel.

In situ containment will require structural measures and environmental controls to isolate the containment area from the adjacent waterway and prevent unacceptable contaminant migration.

It may also be possible to completely reroute waterways with contaminated sediments. The waterway can then be dewatered, and the sediments removed, treated in place, or confined in place. This is an extreme measure and is only likely to be feasible for small waterways with limited flows.

2.1.5 *In situ* Treatment

Some treatment technologies have been developed specifically for *in situ* application, while others have been adapted from *ex situ* treatment applications. Figure 4 shows equipment used to inject chemicals into sediments as a form of *in situ* treatment. Most *in situ* treatment technologies could also be applied to sediments that have been dredged and placed in a disposal area. A summary of remediation technologies is presented in Table 2.

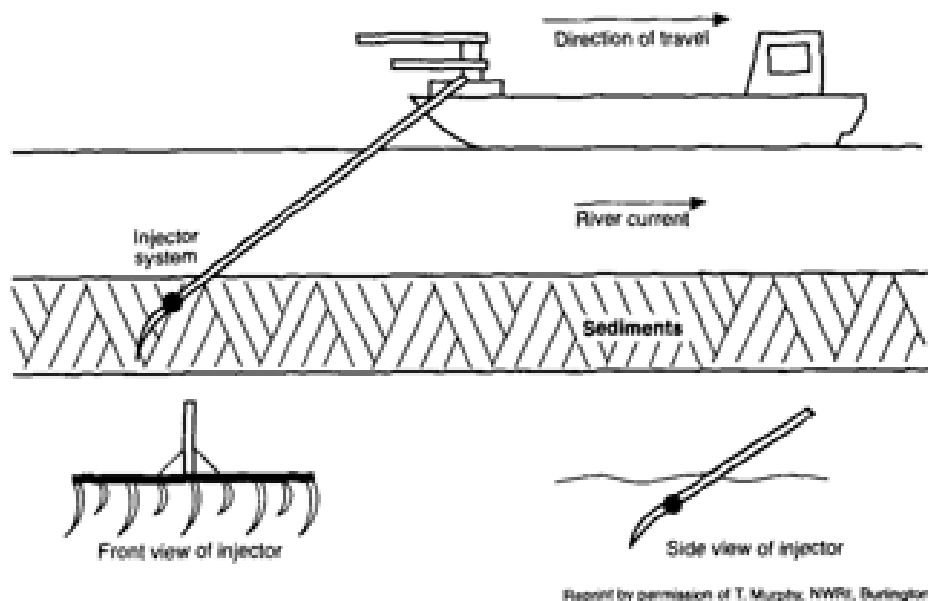


Figure 4. Equipment used for *in situ* chemical treatment of sediments (Source: USEPA, 1994)

Table 2. Summary of Remediation Technologies

Remediation Technology	Application	Feed Stream Characteristics	Effectiveness	Cost
Biological treatment	Pesticides, fuels, creosote, PCP, PCBs, some halogenated volatile organics, non-halogenated organics, aliphatics, aromatics, chlorinated aromatics	PH 4.5-8.5 Temperature 59 to 167 Moisture content 40 to 80% Nutrients C:N:P 100:10:1 to 100:1:0.5 Oxygen – 8 mg/L	Depends of feed stream characteristics.	\$80-\$150/cy (slurry phase) \$50-\$80/cy (solid phase)
Physical/chemical treatment				
KPEG dechlorination	Dioxins, PCBs, chlorobenzenes	PH > 2 Temperature 158 to 302 Water content < 20% Chlorinated organics < 5%	Efficiencies > 98% have been reported for PCBs. PCB removal to < 1 ppm is routinely achieved.	\$200-\$500/cy
Solvent extraction	PCBs, volatile organics, halogenated solvents, petroleum wastes, aromatics, metals	Oily organics < 40% Solid content < 20% Particle size < ¼ in	PCB reductions > 90% on harbor sediments	\$200-\$600/cy
Soil Washing	Heavy metals, halogenated solvents, aromatics, PCBs, chlorinated phenols, pesticides, gasoline, oil	Particle size 0.063-2 mm	90-99 % for volatiles, 40-90 % for semivolatiles	\$200-\$400/cy
Solidification/stabilization	Inorganics, some success with oily sludges and solvents	Organics < 20-45 wt% Semivolatiles < 1% Solids > 15% Oil and grease < 10 wt% Phenols < 5% PAHs < 1% CN < 0.3 wt%	Virtually total containment of insoluble metals; not effective on organics.	\$30-\$165/cy
Thermal Treatment				
Incineration	Volatiles, semivolatiles, PCBs, pesticides, dioxins/furans, organic cyanides	Moisture content < 50% Particle size 1-2 mm Alkaline metals < 5 wt% Halogens < 8 wt%	Greater than 99% for organics.	\$475-\$1,350/cy
Low temperature thermal desorption	Volatile organic compounds (VOCs) and semivolatile organic compounds (SVOCs)	Solids 1-1.5 in dia. Organics < 10% Boiling point < 800 Moisture content < 60% PH 5-11 Solids content > 20%	99% removal of VOCs and SVOCs	\$110-\$470/cy

Source: USEPA (1993)

Often times, multiple technologies must be used on the same sediment to achieve the desired remedial impact before disposal of the sediment.

In situ treatment has several limitations. One such limitation is the lack of process control. Process control is contingent upon effectively monitoring conditions at the site, typically by performing sampling and analysis at appropriate frequencies, before and after treatment. The efficacy of *in situ* treatment of sediments is difficult to determine because of the nonhomogeneous distribution of contaminants, sediment physical properties, and treatment chemicals. One of the limitations of *in situ* treatment is the difficulty in ensuring uniform dosages of chemical reagents or additives throughout the sediments to be treated. Areas of sediment within the site may receive varying levels of treatment, with some areas of sediment being untreated while others are overtreated relative to the intended treatment goal. *In situ* treatment may be less cost effective than *ex situ* treatment when these factors are considered (USEPA, 1994).

Among the most significant limitations to *in situ* treatment is the impact of the process on the water column. Processes that would release contaminants, reagents, or heat, or produce other negative impacts on the overlying water column, are not likely to be acceptable for *in situ* sediment remediation. A suitable *in situ* treatment technology is, in most cases, one that can be applied with minimal disturbance of the sediment-water interface or one in which the process is physically isolated from the water column. There are two general methods of applying *in situ* treatment that address this limitation: surface application and isolation of the sediments prior to treatment. Several types of treatment processes might be used within these applications.

Surface application is the introduction of one or more material(s) (e.g., reagents, additives, nutrients) onto the sediments by spreading and settling, or injecting them into the sediments through tubes, pipes, or other devices. Researchers at the Canadian National Water Research Institute have developed and demonstrated equipment that is capable of injecting solutions of oxidizing chemicals into uncompacted sediments at a controlled rate (Murphy et al., 1993).

The second method for applying sediment treatment in place is by isolating the sediment from the surrounding environment. This method allows the use of reagents or process conditions that might otherwise cause deleterious effects to the waterway. Various types of equipment might be used for isolating the sediments, including a caisson, sheetpile cell, tube, or box. Within the enclosing caisson, the water may be removed or left behind. After the treatment is completed, the caisson can be removed and reset at an adjacent area.

Capital costs for *in situ* treatment include the costs of equipment, materials, reagents, and labor necessary to treat the sediments. The development and fabrication costs for the application equipment may be significant. A substantial amount of development cost may also be required for the treatment process itself, if it has not been applied *in situ* (USEPA, 1994).

2.2 Removal Techniques

Removal techniques involve the remediation of contaminated sediments *ex situ* (i.e., out of place). Removal techniques for contaminated sediments include dredging and wet/dry excavation. Removal techniques are multi-staged remedial alternatives. They require sediment removal, transport, treatment, and disposal (USEPA, 1994).

The amounts of sediment contaminants lost during and after remediation need to be estimated to determine the benefits of remediation and to evaluate the impacts of remedial alternatives. The mechanisms for contaminant losses associated with removal technologies are summarized in Table 3.

Table 3. Factors that Affect Contaminant Losses

Sediment Type and Quality	Grain size
	Sediment density
	Sediment cohesion
	Organic matter concentration
	Volatile substance concentration
Dredging Equipment and Methods	Type of dredge
	Dredge capacity or production rate
	Condition of equipment
	Equipment modifications
	Equipment reliability under varied conditions
	Operating precision of equipment
	Sediment loss during operations
Hydrodynamic Conditions	Training and skill of operators
	Water depth
	Morphology of shoreline and configuration of existing structures
	Flows and suspended solids concentrations
	Waves, tides, and currents
	Wind speed and direction
	Hydrological phenomena caused by dredging operations
Water quality	Temperature
	Salinity
	Density

Source: St. Lawrence Center (1993).

2.2.1 Dredging or wet excavation

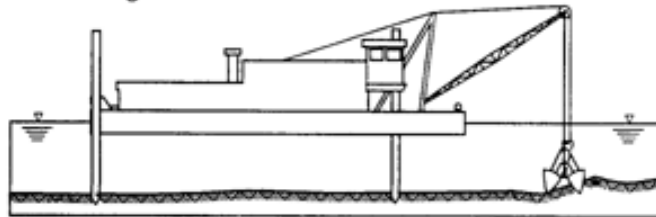
The removal or excavation of sediments from a water body, commonly known as dredging, is a process that is carried out routinely around the world. The term environmental dredging has evolved in recent years to distinguish dredging operations for the primary purpose of environmental restoration from those operations for the purpose of simply removing sediments. The most common purpose of dredging is to construct or maintain channels for navigation or flood control (Hayes, 1992). Environmental dredging operations usually involve relatively small volumes of sediment, with the objective of effectively

removing contaminated material in a manner that minimizes the release of sediments and contaminants to the aquatic environment.

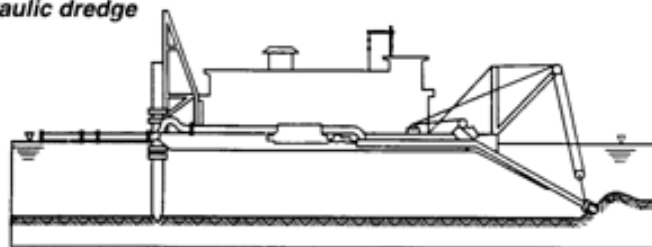
The loss of contaminants to the surrounding waters, or to the atmosphere, is of particular concern when dredging contaminated sediments. Because contaminants are generally bound to the fine particles, which are easily resuspended, efforts are focused on minimizing the amount of resuspension through innovative equipment design and operational controls. Further reductions in the transport of contaminants can be accomplished with barriers such as silt curtains, silt screens, and oil booms.

Dredging involves mechanically penetrating, grabbing, raking, cutting, or hydraulically scouring the bottom of the waterway to dislodge the sediment. Once dislodged, the sediment is lifted out of the waterway either mechanically, as with buckets, or hydraulically, through a pipe. Thus, dredges can be categorized as either mechanical or hydraulic depending on the basic means of moving the dredged material (Figure 6). A subset of the hydraulic dredges employs pneumatic systems to pump the sediments out of the waterway. These are termed pneumatic dredges.

Mechanical dredge



Hydraulic dredge



Source: USACE/USEPA (1992)

Figure 6. Mechanical and hydraulic dredges

The fundamental difference between mechanical and hydraulic dredging equipment is the form in which the sediments are removed. Mechanical dredges offer the advantage of removing the sediments at nearly the same solids content as the *in situ* material. That is, little additional water is entrained with the sediments as they are removed, meaning that the volume of the sediments is essentially the same before and after dredging. In contrast, hydraulic dredges remove and transport sediment in slurry form. The total volume of material is greatly increased, because the solids content of the slurry is considerably less than that of the *in situ* sediments.

A review of 44 remediation projects by Cushing (1999) revealed the overall costs for the dredging projects ranged from \$44 to \$1,842 per cy, with a median of about \$200 to \$275 per cy. The high overall cost is due to two primary factors: low production rates and high costs for disposal.

2.2.2 Dry Excavation

Dry excavation involves the following activities:

- Diverting water away from the targeted sediment area by means of rechanneling, bypass pumping, siphoning, or isolation with barriers
- Pumping the standing water out of the isolated target area
- Maintaining conditions as dry as practical in the target area by continually pumping out in-seepage and groundwater
- Removing the dry sediments with conventional excavating equipment.

The dry removed sediments may still require either additional land-based dewatering or stabilization/solidification, to be followed by landfilling or treatment and reuse. Dry excavation, by its nature, is typically limited to relatively small shallow target areas in streams or shallow lake, pond, or marsh areas of manageable size. Otherwise, the water diversion/removal logistics become prohibitive.

Cushing (1999) found that the overall costs for the dry/wet removal projects ranged from \$21 to \$1,500 per cy, with a median of about \$450 per cy. The high overall cost is due to the following three primary factors:

- Lower production rates than for traditional earth moving projects due to difficulties with accessibility and wet terrain
- Additional water control and handling requirements imposed for maintaining the dry condition
- High costs for disposal

3.0 ESTIMATING COSTS

This section discusses the development of cost estimates for sediment remedial alternatives to support the decision-making and implementation processes. There is no existing guidance on estimating costs specifically for sediment remediation projects; however, there is considerable guidance on estimating costs for general construction and some guidance for hazardous waste remediation projects. This discussion presents the cost estimating procedures used by the Corps for civil works projects and those used by the USEPA for Superfund projects. The appropriate guidance for most sediment remediation projects would include a combination of these approaches.

3.1 Purpose of Cost Estimates

Project cost estimates are required during all phases of a sediment remediation project, from initial planning, through detailed design, and during construction and operation. The purpose of the cost estimates will change as the project progresses. During the planning stages, cost estimates are used as a criterion for screening technologies and selecting the preferred alternative. At the detailed design stage, cost estimates are often used to compare technically equivalent features and identify those that may be suitable for value engineering studies. Following detailed design and preparation of plans and specifications, cost estimates are used to evaluate bids on project construction and operation. During construction, cost estimates are used for scheduling payments, contract negotiation, and dispute resolution.

The reliability of a cost estimate depends largely on the level of detail available at the time it is prepared. It also depends on the predictability of variables and factors used to develop the cost estimate. A thorough knowledge and understanding of the scope of work and all components associated with site remediation is necessary for the development of a reliable cost estimate, including a clear understanding of the construction operations and techniques that would be used.

Cost estimates should complement the decision path. For civil works projects, such as maintenance dredging, there are two types of cost estimates in the decision-making process: the current working estimate and the government estimate. The current working estimate is an estimate that is prepared and updated periodically during the planning and design of a project. The level of detail and reliability of this estimate reflect the current state of project evaluation and design (USACE, 1980). The current working estimate is a total project cost estimate, which includes all reasonable costs that will be required during project implementation (i.e., the estimated costs of construction and operation contracts, engineering and design efforts, construction management and real estate easements, and land acquisition). The current working estimate is used as a tool to support the decision-making process and control costs, and should be prepared with as much accuracy as possible, so that the total project cost estimate for site remediation can be relied upon at the earliest possible stage in the decision-making process.

For virtually all projects that are funded by the Federal government, and for most projects funded by other governmental agencies, a government estimate or equivalent is developed at the end of detailed design and immediately prior to the advertisement of the contract(s) for construction and operation (USACE, 1982). The government estimate is used to evaluate construction contract bids, control negotiations, establish a pricing objective for procurement and contracting purposes, and serve as a guide in developing progress payment schedules. It is a detailed construction cost estimate and does not include the other noncontract items of the current working estimate. The development of a government estimate for a Federal project must follow the procedures and guidelines of the Federal Acquisition Regulation (FAR) (48 CFR Chapters 1-99).

3.2 Elements of a Cost Estimate

A sediment remediation project has capital, operation, and maintenance costs. Capital costs include expenditures that are initially incurred to develop and implement a remedial action (e.g., dredging and transportation, construction and operation of a treatment system, construction of a disposal facility) and major capital expenditures anticipated in future years (e.g., capping a confined disposal facility [CDF] or decontamination of treatment equipment) (Burgher *et al.*, 1987). The following elements should be considered in developing estimates of capital costs (Cullinane *et al.*, 1986; Burgher *et al.*, 1987):

- Relocation costs
- Costs of lands, easements, and rights-of-way
- Land and site development costs
- Costs for buildings and services
- Equipment costs
- Replacement costs
- Disposal costs
- Engineering expenses
- Construction expenses
- Legal fees, licenses, and permits
- Contingency allowances
- Startup and shakedown costs
- Costs of health and safety requirements during construction

Operation and maintenance are post-construction activities needed to ensure the effectiveness of a remedial action (Burgher *et al.*, 1987). These activities might include treatment plant operations, surface water and leachate management at a disposal facility, and monitoring and routine maintenance at disposal sites. The following elements should be considered in developing estimates of operation and maintenance costs (Cullinane *et al.*, 1986a; Burgher *et al.*, 1987):

- Operating labor costs
- Maintenance materials and labor costs
- Costs of auxiliary materials and energy
- Purchased service costs
- Administrative costs
- Insurance, taxes, and licensing costs
- Maintenance reserve and contingency fund

The capital, operation, and maintenance cost data needed for preparing estimates are divided into two categories, direct costs and indirect costs. The direct costs are those that are directly attributable to a unit of work. They are generally referred to as labor, equipment, and material/supply costs. The labor rate, equipment rate, and material/supply quotes are readily available from many sources. However, production rates, hours of work,

size of crew, selection of equipment and treatment plants, and schedules are estimated largely from site-specific data.

There are some differences between the civil works and Superfund guidance for estimating indirect costs. The Corps approach considers indirect costs, sometimes referred to as distributed costs, to include all costs that are not directly attributable to a unit of work, but are required for the project. These costs might include field office and home office operations, permits, and insurance. The USEPA guidance for hazardous waste remediation (Burgher *et al.*, 1987) includes these costs, plus engineering expenses, startup/shakedown costs, and contingency allowances, as indirect costs. Indirect costs are typically estimated as a fixed percentage of the total direct costs.

For preliminary cost estimates, indirect costs (as defined by the Corps) may be estimated as 10-15 percent of direct costs. The USEPA guidance (Burgher *et al.*, 1987) offers the following numbers for estimating specific indirect costs:

- Engineering expenses (7-15 percent of direct capital costs)
- Legal fees, licenses, and permits (1-5 percent of total project costs)
- Startup and shakedown costs (5-20 percent of capital costs)
- Contingency allowances (15-25 percent of total capital costs)

When screening-level construction cost estimates are prepared, there are generally few details available that would warrant a detailed analysis of direct and indirect costs; total unit price data are often used instead. However, when a detailed construction cost estimate is required in the later stages of design and implementation, direct and indirect cost data are estimated separately.

The level of confidence of a cost estimate depends on the level of detail available at the time it is prepared. One method to improve the confidence in the cost estimate is to assess and include appropriate contingencies in the estimate. A contingency is a form of allowance to cover unknowns, uncertainties, and/or unanticipated conditions that are not possible to adequately evaluate from the available data. A guideline for contingency rates is shown in Table 4.

Table 4. Contingency Rates for Cost Estimates

Project Stage	Construction Cost Range			
	< \$500K	\$500K-\$1M	\$1M-\$5M	> \$5M
Feasibility				
Screening level	30%	25%	25%	25%
Preliminary design	25%	20%	20%	20%
Implementation				
Detailed design	20%	15%	15%	15%
Plans and specifications	15%	10%	10%	10%
Contract award	5%	5%	5%	5%

Source: Adapted from USACE (1992).

These rates are empirical and are only a guide. USEPA contingency allowances for feasibility studies (between 15 and 25 percent of capital costs) are in general agreement with the numbers shown in Table 5.

3.3 Development of Cost Estimates

3.3.1 Technology Screening

At the screening level, the project cost analysis is very crude and limited to available information on the sediments, site conditions, and technologies being considered. Because the level of detail is minimal at this phase, historical data and parameters of similar past projects are recommended for the development of the cost estimate. The USEPA has developed a Remedial Action Cost Compendium (Yang *et al.*, 1987) that shows the range of actual costs at Superfund projects.

Historical cost data on the pretreatment and treatment components are very limited, and in some cases the only data available are projections made by technology vendors based on bench- or pilot-scale applications. Cost projections for technologies that do not already have full-scale equipment with some operating history should be approached with a certain amount of skepticism. One of the major factors in the cost of many innovative treatment technologies is the investment required for the development, scaleup, construction, and testing of full-scale equipment. The amortization of these development costs greatly affects their unit costs and the degree of uncertainty associated with those costs. Very few remediation projects are able to bear these development costs alone, and few companies are willing to make this investment unless there is a clear indication that there will be a dependable market for the technology at several remediation sites. One potential solution to this handicap is for interests from several Areas of Concern having similar sediment contamination problems to join forces in financing the development or acquisition of a remediation technology.

3.3.2 Preliminary Design

During the preliminary design phase, a limited number of remedial alternatives are evaluated in sufficient detail to make a selection for implementation. This phase is comparable to the feasibility study for Superfund projects. The preliminary design should contain sufficient engineering and design information that could readily lead into the next phase (the detailed design). The cost estimate should be prepared based on the latest information available and should include all reasonable costs required in the implementation phase. The estimate should incorporate costs for additional engineering and design, real estate easements and land acquisition, and construction costs. This cost estimate will serve as a baseline current working estimate for project management through the implementation phase.

The process for evaluating costs during a Superfund feasibility study includes the following steps (Burgher *et al.*, 1987):

- Estimation of costs
- Present worth analysis
- Sensitivity analysis
- Input to alternatives analysis

The accuracy of cost estimates for feasibility studies for Superfund projects should be within the range of +50 to -30 percent (Burgher *et al.*, 1987).

3.3.3 Implementation

This phase should include preparation of a detailed design and the plans and specifications for contracting the construction and operation of the remedial alternative. During the detailed design, cost estimates can be used to compare technically equivalent features in a process known as VE. VE is directed at analyzing the function of construction, equipment, and supplies for the purpose of achieving these functions at reduced life-cycle cost without sacrificing quality, aesthetics, or operations and maintenance capability (USACE 1987).

During the development of plans and specifications, a detailed government estimate is prepared. This government estimate is used to evaluate bids on project construction and operation contracts. Bids are evaluated for balance as well as dollar amount. Corps regulations for civil works projects will not allow a contract award if the low bid exceeds the government estimate by more than 25 percent. During construction, cost estimates are used for scheduling payments, contract negotiations, and dispute resolution.

3.3.4 Sources of Information

The accuracy of a cost estimate depends on the reliability of the information used in its development. For some of the components of a sediment remedial alternative there are a large number of sources of cost data available. A list of a few sources that could be consulted for cost estimates is shown in Table 5.

Table 5. Sources of Information for Cost Data

Source	Type of Information
R. S. Means Cost Data	Unit costs for various construction activities
Dodge Guide	Unit costs for various construction activities
Corps Unit Price Books	Unit costs for various construction activities
Marshall Stevens Index	Treatment plant and equipment costs and cost index
<i>Chemical Engineering</i>	Treatment plant and equipment costs
<i>Engineering News Record</i>	Construction cost index for updating construction capital costs
Civil Works Construction Cost Index System	Regional adjustment factors for construction costs
U. S. Department of Energy	Energy costs, including regional differences
U. S. Department of Labor	Labor costs, including regional differences
Federal Emergency Management Administration	Relocation costs

Source: USEPA (1994).

Construction costs may vary significantly from one region of the country to another. To convert approximate costs, area adjustment factors may be applied. Some Federal agencies, such as the U.S. Departments of Labor and Energy, maintain regional cost information. The Corps maintains a Civil Works Construction Cost Index System (CWCCIS), which may be used as a guide for regional construction cost adjustments.

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Appendix A
Advantages and Disadvantages of Various Sediment Remedial Technologies

Table D-1
Advantages and Disadvantages of Various Sediment Remedial Technologies

Remedial Technology	General Description	Typical Process Options	Specific Parameters to Consider	Potential Benefits	Potential Limitations	Precedent
In-Place Containment Technologies						
Engineered Capping	Controlled placement of various materials (e.g., sand, fill, gravel/cobbles, geotextile material) to physically isolate sediments from the overlying water column	Multimedia Sand cap AquaBlock™ Revetments	Cost/location of capping material source Sediment surface topography Flooding characteristics Groundwater flow Benthic activity Water depth Water velocity Navigational traffic Constraints on access Erosion potential Sensitive/protected biological environment	Reduction of COC bioavailability Reduction of water-column COC concentrations Facilitation of conditions conducive to natural degradation processes Minimization of downstream contaminated sediment migration	COCs remain in place Resuspension and/or mixing of COC-containing material during placement COC release in the water-column during placement Benthic community alteration Long-term diffusion/advection of COCs through cap material Long-term erosion Cap surface recontamination Alteration of river hydraulics Disruption to recreational and commercial in-river and near-shore activities Placement may be challenging in deeper waters, areas with wave action, boat traffic or large targeted surface area Navigational dredging requirements AquaBlock™ creates an effective low permeability area, but is more prone to erosion Sand/gravel cap may improve fish habitat areas, but may need to be supplemented with revetments in higher velocities Multimedia cap (w/geotextile) provides the greatest integrity in erosion prone areas	Convaire Lagoon (CA) Duwamish Waterway (WA) Puget Sound (WA) Hamilton Harbour (Ontario) St Lawrence River (NY) Sheboygan River and Harbor (WI) Central Long Island Sound Disposal Site (NY) Mud Dump Site (NY)

Remedial Technology	General Description	Typical Process Options	Specific Parameters to Consider	Potential Benefits	Potential Limitations	Precedent
Particle Broadcasting	Placement of a thin layer (generally several inches) of clean material (e.g., clean sediment, sand, topsoil, or mixture thereof) to mitigate chemical flux to the water column and enhance natural attenuation processes	None	Water depth Water velocity Sediment type Navigational traffic Flood frequency Groundwater flow Constraints on access Sediment surface topography Erosion potential Placement technique Cap material availability	Retardation of dissolved chemical flux to water column Translocation of bioturbation zone upward and out of contaminated sediment Acceleration of COC reduction in sediment, biota, and water column Limited effect on benthic community Less intrusive to the environment	COCs remain in place Limited precedent for use Installation of the appropriate thickness required Accurate placement of cap material Cap erosion Navigational dredging requirements Resuspension and/or mixing of existing sediments during installation Challenging to implement in deep water and/or over a large surface area Requires greater volume of material to achieve nominal depth	None
Hydraulic Modifications	Physical alteration of existing water body to help control the movement/release of tainted sediments and/or promote deposition of clean sediments	Rechannelization (construction of a "new" channel and diversion of the present channel) Damming Construction of sedimentation basins Subsurface diversion structures (control the movement/release of COC-containing sediment and promotes sediment deposition)	Areal extent of contaminated sediments Extent of development in surrounding area Physical configuration of river Space/access constraints Navigational traffic Available property Extent to which water levels would be raised Resident fish movement within the river (for damming technology) Areal extent of targeted sediment Water velocity Navigational traffic Flood capacity Erosion potential	COC-containing sediment physically separated from new channel Reduction of bioavailability Reduction of water-column and biota COC concentrations May enhance navigability Containment of COC-containing sediments within a smaller areal extent Controls contaminated sediment migration Promotes sediment deposition in the river	Alteration/modification of ecological habitat and surrounding area Available property Future use of old channel Flooding/hydraulic effects Alteration of benthic community and fish habitat Alteration of river hydraulics Topography Establishment of a habitat type that favors different aquatic species Resuspension of sediments during high flow events Upstream flooding considerations Available construction space Alteration of river hydraulics Sediment accumulation behind dam/sedimentation basin may require periodic removal High relative cost Limits movement of resident fish	Moss American Triana/Tennessee River Mississippi River

Remedial Technology	General Description	Typical Process Options	Specific Parameters to Consider	Potential Benefits	Potential Limitations	Precedent
Removal Technologies						
Dredging	Excavation of sediment from a water way, removed sediment will require subsequent management	Hydraulic (e.g., cutterhead, horizontal auger, dust pan, match box, clam suction) Mechanical (e.g., clam shell bucket, backhoe, bucket ladder, dipper, dragline) Specialty (e.g., PNEUMA® Pump, Dry Dredger™, Soli-Flo)	Desired solids concentration Dredging production rate Dredging accuracy Sediment/dredging depth Ability to handle debris Water depth Water velocity Navigational traffic Access constraints Presence of boulders/debris Bottom conditions Disposal requirements	Permanently removes contaminated sediment	Residual sediment due to mixing of COC-containing material with underlying material or surrounding sediment during dredging Areas missed by dredge Sediment resuspension/downstream migration Elevated COC levels in residual sediments Long- or short-term increases in COC bioavailability Alteration or destruction of benthic community Achieving low COC cleanup levels unlikely Presence of boulders/debris	Sheboygan River and Harbor (WI) Grasse River (NY) St Lawrence River (NY) New Bedford Harbor (MA) Manistique River and Harbor (MI) Marathon Battery (NY) Shawasssee River (MI) Williamette River (OR) Duwamish Waterway (WA) Waukegan Harbor (IL) River Raisin (MI) Monguagon Creek (MI) Willow Run Creek (MI) Lake Jarnsjon (Sweden)
Dry Excavation	Removal of sediment following significant dewatering of the water body, removed sediment will require subsequent management	Area dewatering achieved via sheeting, coffer dam, water-filled structures, soil dams, by-pass pumping	Water depth Water flow/velocity Groundwater flow/infiltration Navigational traffic Access constraints Volume of water to be removed/contained Location, configuration, and extent of targeted sediment	Permanent removal of contaminated sediments	Residual sediment may contain elevated COC levels Long- or short-term increases in COC bioavailability Suspension and downstream transport of residual sediment Alteration or destruction of benthic community Inability to remove all sediment due to the presence of an impenetrable surface Inability to maintain "dry" conditions Excessive disruption to in-shore near-water recreational activity	Ruck Pond (WI) Unnamed Tributary (OH) Rouge River-Evans Product Ditch (MI) Town Branch Creek (KY)

Remedial Technology	General Description	Typical Process Options	Specific Parameters to Consider	Potential Benefits	Potential Limitations	Precedent
Management Technologies						
Treatment	Management of removed sediments prior to disposal	Dewatering (e.g., filter press, hydrocyclone) Stabilization (typically used to meet disposal requirements)	Sediment/COC type Available space Water content of removed sediments COC concentration Management of water generated from dredge spoils Ultimate disposal location Location of treatment facility	Dewatering reduces wet volume (and potentially weight) of sediment for disposal Stabilization increases volume of sediment May decrease mobility of sediment	Obtaining necessary space requirements usually slows down removal operation	Typically utilized at most removal sites
Disposal	The final disposition for sediments that are removed/treated	In-water/upland confined disposal facilities (CDF) On-site/off-site landfills beneficial reuse	Volume of sediment COC concentration Access/space requirements Navigational traffic	Mitigation of potential risks associated with removed sediment	Necessary space requirements Interference with boat traffic Location of disposal facility Availability and capacity Increased risk of exposure and transportation accidents	CDF, New Bedford Harbor (MA) Landfills: most other removal sites

Appendix B
Sediment Management Options Fact Sheets

FACT SHEET:

Engineered Capping

Description:

Controlled placement of various materials (e.g., sand, fill, gravel/cobbles, geotextile material, etc.) to physically isolate sediments from the overlying water column. Typical process options include: multi-media cap, sand cap, AquaBlok™, and revetments. Typical cap thicknesses range from 0.5-3 feet.

Scale of Implementation:

Full-Scale

Precedence (full-scale):

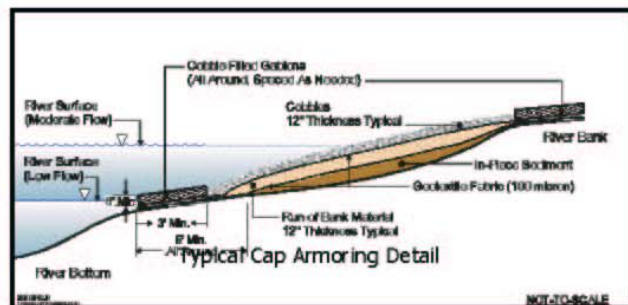
- ✓ Convair Lagoon (CA)
- ✓ Duwamish Waterway (WA)
- ✓ Puget Sound (WA)
- ✓ Hamilton Harbour (Ontario, Canada)
- ✓ St. Lawrence River (NY)
- ✓ Sheboygan River and Harbor (WI)
- ✓ Central Long Island Sound Disposal Site (NY)
- ✓ Mud Dump Site (NY)

Documented Effectiveness Toward Risk Reduction:

- ✓ reduces chemical bioavailability
- ✓ reduces water-column chemical concentrations
- ✓ can facilitate conditions conducive to natural degradation processes
- ✓ minimizes downstream migration of contaminated sediment
- ✓ can improve fish habitat areas

For More Information:

- ✓ USEPA ARCS Program: *Guidance for In-Situ Subaqueous Capping of Contaminated Sediments*. EPA 905-B-96-004. September 1998.
- ✓ Hazardous Substance Research Center and USEPA Great Lakes National Program Office. "Proceedings from: In-Situ Capping of Contaminated Sediments – A Seminar for Decision Makers." Chicago, IL. November 20-21, 1996.



Critical Engineering Design Issues Influencing Effectiveness:

- ✓ cost/location of capping material source
- ✓ sediment surface topography
- ✓ flooding characteristics
- ✓ ground-water flow
- ✓ benthic activity
- ✓ water depths/velocity
- ✓ navigational traffic
- ✓ access constraints
- ✓ erosion potential
- ✓ sensitive/protective biologic environment

Short-/Long-Term Issues:

- ✓ chemical remains in-place
- ✓ resuspension and/or mixing of contaminants during placement
- ✓ chemical release in water column during placement
- ✓ benthic community alteration
- ✓ long-term diffusion/advection of chemicals through cap material
- ✓ long-term erosion
- ✓ cap surface recontamination
- ✓ alteration of river hydraulics
- ✓ disruption to recreational and commercial in-shore and near-shore activities
- ✓ placement may be challenging in deeper waters, areas with wave action, boat traffic or large targeted surface area
- ✓ navigational dredging requirements
- ✓ gas generation (sediment decomposition)

FACT SHEET:

Dredging

Description:

Excavation of sediment from a waterway. Removed sediment will require subsequent management. Typical process options include hydraulic (e.g., cutterhead, horizontal auger, dust pan, matchbox, plain suction); mechanical (e.g., clamshell bucket, backhoe, bucket ladder, dipper, dragline); and specialty (e.g. PNEUMA[®] Pump, Dry Dredge[™], SoliFloSM).

Scale of Implementation:

Full-Scale

Precedence (full-scale):

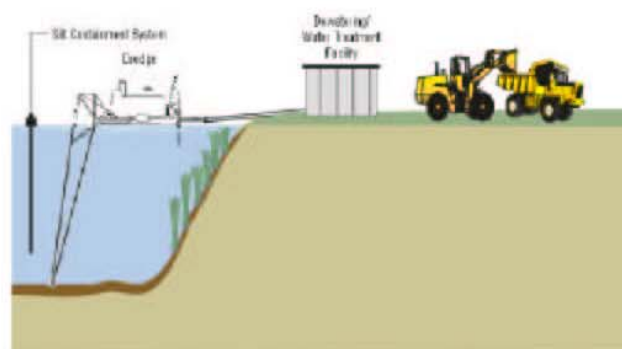
- ✓ Sheboygan River and Harbor (WI)
- ✓ Grasse River (NY)
- ✓ St. Lawrence River (NY)
- ✓ New Bedford Harbor (MA)
- ✓ Manistique River and Harbor (MI)
- ✓ Marathon Battery (NY)
- ✓ Shiawassee River (MI)
- ✓ Willamette River (OR)
- ✓ Duwamish Waterway (WA)
- ✓ Waukegan Harbor (IL)
- ✓ River Raisin (MI)
- ✓ Monguagon Creek (MI)
- ✓ Willow Run Creek (MI)
- ✓ Lake Jarnsjon (Sweden)

Documented Effectiveness Toward Risk Reduction:

- ✓ permanently removes sediment from aquatic environment

For More Information:

- ✓ National Research Council. *Contaminated Sediments in Ports and Waterways: Cleanup Strategies and Technologies*. National Academy of Sciences. 1997
- ✓ USEPA. ARCS Program. *Remediation Guidance Document*. EPA-905-R-94-003. October 1994.
- ✓ Herbich, J.B. *Handbook of Dredging Engineering*. McGraw Hill, Inc. 1992



Typical Dredging Components

Critical Engineering Design Issues Influencing Effectiveness:

- ✓ desired solids concentration
- ✓ desired production rate
- ✓ dredging accuracy
- ✓ sediment/dredging depth
- ✓ ability to handle debris
- ✓ water depth
- ✓ water velocity
- ✓ navigational traffic
- ✓ access constraints
- ✓ the presence of boulders/debris
- ✓ bottom conditions
- ✓ disposal requirements
- ✓ weather
- ✓ location, configuration, and extent of targeted sediment

Short-/Long-Term Issues:

- ✓ residual sediment due to mixing of constituent-containing material with underlying material or surrounding sediment during dredging
- ✓ areas missed by dredge
- ✓ sediment resuspension/downstream migration
- ✓ elevated chemical levels in residual sediments
- ✓ long- or short-term increases in chemical bioavailability
- ✓ alteration or destruction of benthic community
- ✓ achieving low chemical cleanup levels unlikely
- ✓ presence of boulders/debris
- ✓ exposure of more highly contaminated sediments
- ✓ cannot achieve 100% removal; remaining residuals available for future exposure

FACT SHEET:

Dry Excavation

Description:

Removal of sediment following significant dewatering of the water body. Removed sediment will require subsequent management. Typical process options include area dewatering achieved via sheeting, coffer dam, water filled structures, soil dams, and by-pass pumping/siphoning.

Scale of Implementation: Full-Scale

Precedence (full-scale):

- ✓ Ruck Pond (WI)
- ✓ Unnamed Tributary (OH)
- ✓ Rouge River-Evans Product Ditch (MI)
- ✓ Town Branch Creek (KY)

Documented Effectiveness Toward Risk Reduction:

- ✓ permanently removes contaminated sediment from aquatic environment

Critical Engineering Design Issues Influencing Effectiveness:

- ✓ water depth
- ✓ water flow/velocity and variability
- ✓ ground-water flow/infiltration
- ✓ navigational traffic
- ✓ access constraints
- ✓ volume of water to be removed/contained
- ✓ location, configuration and extent of targeted sediment
- ✓ weather



Dry Excavation Activities

Short-/Long-Term Issues:

- ✓ residual sediment may contain elevated chemical levels
- ✓ long- or short-term increases in chemical bioavailability
- ✓ suspension and downstream transport of residual sediment
- ✓ alteration or destruction of benthic community
- ✓ inability to remove all sediment due to the presence of an impenetrable surface
- ✓ inability to maintain "dry" conditions
- ✓ excessive disruption to in-shore near-water recreational activity

For More Information:

- ✓ National Research Council. *Contaminated Sediments in Ports and Waterways: Cleanup Strategies and Technologies*. National Academy of Sciences. 1997
- ✓ Thomas H. Praeger, P.E., Stuart D. Messur and Richard P. DiFiore. "Remediation of PCB-Containing Sediments Using Surface Water Diversion "Dry Excavation": A Case Study." *Wat. Sci. Tech.* Vol. 33, No. 6, pp. 239-245, 1996.
- ✓ USEPA ARCS Program. *Remediation Guidance Document*. EPA-905-R94-003. October 1994.
- ✓ Herbich, J.B. *Handbook of Dredging Engineering*. McGraw Hill, Inc. 1992

FACT SHEET:

Hydraulic Modifications

Description:

Physical alteration of existing water body to help control the movement/release of tainted sediments and/or promote deposition of clean sediments. Typical process options include rechannelization, damming, sedimentation basins, and subsurface structures.

Scale of Implementation:

Full-Scale

Precedence (full-scale):

- ✓ Mississippi River (subsurface structures)
- ✓ Moss American (rechannelization)
- ✓ Triana/Tennessee River (rechannelization)

Documented Effectiveness Toward Risk Reduction:

Damming, Sedimentation Basins, Subsurface Structures

- ✓ containment of constituent-containing sediments within a smaller areal extent
- ✓ controls the migration of contaminated sediments
- ✓ promotes sediment deposition in the aquatic environment

Rechannelization

- ✓ constituent-containing sediment physically separated from new channel
- ✓ reduction of bioavailability
- ✓ reduction of water-column and biota chemical concentrations
- ✓ may enhance navigability



River Dam

Critical Engineering Design Issues Influencing Effectiveness:

- ✓ extent to which water levels would be raised
- ✓ need for resident fish movement within the river
- ✓ areal extent of targeted sediment
- ✓ water velocity, depth, etc.
- ✓ navigational traffic
- ✓ flood capacity
- ✓ erosion potential
- ✓ extent of development in surrounding area (rechannelization)
- ✓ physical configuration of river (rechannelization)
- ✓ available property/space/access constraints

Short-/Long-Term Issues:

- ✓ alteration and/or modification of existing ecological habitat and surrounding area
- ✓ establishment of a habitat type that favors different aquatic species (sedimentation basin)
- ✓ resuspension of sediments during high flow events
- ✓ upstream flooding considerations
- ✓ available property/construction space
- ✓ alteration of river hydraulics
- ✓ sediment accumulation behind dam/sedimentation basin may require periodic removal
- ✓ limits movement of resident fish (damming)
- ✓ future use of old channel (rechannelization)
- ✓ topography (rechannelization)

For More Information:

- ✓ USEPA. Superfund at Work: Success in Brief. EPA and Olin Clean Up Triana Site: "A Major Victory for the Environment." EPA 520-F-93-001.1993

FACT SHEET:

Management Technologies - Treatment/ Disposal

Description:

Treatment - Management of removed sediments prior to disposal. Typical process options include dewatering (e.g., filter press hydrocyclone), and stabilization (typically used to meet disposal requirements). High cost and limited marginal increased benefit typically precludes use of chemical removal/destruction treatment processes.

Disposal - The final disposition for sediments that are removed/treated. Typical process options include in-water/upland confined disposal facilities (CDF), on-site/off-site landfills, and beneficial reuse.

Scale of Implementation: Full-Scale

Precedence (full-scale):

Treatment

- ✓ Dewatering and/or stabilization typically utilized at most removal sites

Disposal

- ✓ CDF: New Bedford Harbor (MA) and many navigational dredging sites
- ✓ Landfills: most other removal sites

Documented Effectiveness Toward Risk Reduction:

Treatment

- ✓ dewatering reduces wet volume (and potentially weight) of sediment for disposal
- ✓ stabilization increases volume of sediment
- ✓ may decrease mobility of sediment

Disposal

- ✓ mitigation of potential risks associated with removed sediment



Confined Disposal Facility

Critical Engineering Design Issues Influencing Effectiveness:

Treatment

- ✓ sediment/constituent type
- ✓ available space
- ✓ water content of removed sediments and final desired solids content
- ✓ constituent concentration
- ✓ management of water generated from dredge spoils
- ✓ ultimate disposal location
- ✓ location of treatment facility
- ✓ presence of oils

Disposal

- ✓ volume of sediment
- ✓ constituent concentration
- ✓ access/space requirements
- ✓ navigational traffic

Short-/Long-Term Issues:

Treatment

- ✓ obtaining necessary space requirements
- ✓ can limit removal operation rates

Disposal

- ✓ necessary space requirements
- ✓ interference with boat traffic
- ✓ location of disposal facility
- ✓ availability and capacity
- ✓ increased risk of exposure and transportation accidents
- ✓ permitting

For More Information:

- ✓ USEPA. *National Conference on Management and Treatment of Contaminated Sediments*. Proceedings. Cincinnati, OH, May 13-14, 1997. EPA-625-R-98-001, August 1998.
- ✓ National Research Council. *Contaminated Sediments in Ports and Waterways: Cleanup Strategies and Technologies*. National Academy of Sciences, 1997.
- ✓ USEPA ARCS Program. *Remediation Guidance Document*. EPA-905-R-94-003, October 1994.