COMMENTS ON ADVANCES IN DREDGING CONTAMINATED SEDIMENT

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PREFACE

Scenic Hudson, Inc. released a report in April 1997 entitled Advances in Dredging Sediment; New Technologies and Experience Relevant to the Hudson River PCBs Site.

The purpose of the report is to promote the idea that dredging is the preferred remedy for removing PCB-contaminated sediments sites in the Hudson River. Key findings of the report are as follows:

1. "The uncertainty that characterized EPA's 1984 "no action" decision about the Hudson River sediments has been replaced by extensive literature and governmental guidance on contaminated sediment remediation. This includes information on the capabilities of an appropriate operating procedures for available dredges, methods for selecting contaminated sediment remedies, and methods for estimating the outcomes of dredging and the alternatives."

Comment: The "no action" decision is still appropriate as the availability of new equipment in the United States for successful removal of contaminated sediment is very limited. No attempt has been made in the United States to remove sediments from a major river (at the Massena G.M. project the river was separated from the dredging location by an impermeable cofferdam).

2. ***Scenic Hudson, Inc.*** states that there is growing body of literature documenting successful remedial dredging projects. Dredging is now the preferred remedy at PCB-contaminated sediment sites. It has been included in 23 of 25 cleanup decisions at Superfund sites with PCB-contaminated sediment since 1984.

Comment: Several cleanup decisions listed in the ***Scenic Hudson, Inc.*** report are minor projects with low production that would extend the Hudson River cleanup over decades rather than months.

3. Several available dredges are capable of cleanups with virtually no resuspension of contaminated sediments. Impacts are limited to the immediate area of dredging.

Comment: None of the specially-built mechanical dredges for removal of contaminated sediments would be practical for deployment in the Hudson River; (The backhoe dredge designed for the Bonfouca, Louisiana project has a very low production rate and would not be suitable for the Hudson River Project).

SPECIFIC COMMENTS

About *Scenic Hudson, Inc.*

Scenic Hudson, Inc. is a multifaceted organization to protect the Hudson River Valley's water, land, air, historic and recreational resources. The report was prepared by non-engineers; dredging equipment and removal methods are essentially engineering activities.

Advances in Dredging (p. ES-2)*

The Assessment and Remediation of Contaminated Sediments Program (ARCS) summarizes the state-of-the-art in estimating contaminated losses. ***Scenic Hudson, Inc.*** states that several conventional dredges and the newer specialty dredges are designed specifically to remove contaminated sediments. In fact only two dredges have been specifically designed for the removal of contaminated sediments: 1) A backhoe dredge developed for the Bonfouca, Louisiana project, and 2) a Cable Arm clamshell dredge developed in Canada. The U.S. dredging industry has not developed any new successful hydraulic dredges specifically for the removal of contaminated sediments.

The 1996 ARCS report presents a table summarizing the suspended solids concentration for various dredges (Table 1), and the total number of kilograms of suspended sediments per cubic meter material dredged (Table 2). The report states in the section entitled "Closure on Losses during Dredging":

> "It is clear from the previous discussion of losses during dredging that a number of dredging equipment factors and interactions between sediment and water are likely to be important in predicting contaminant losses. Prediction, however, requires simplifying assumptions about the relative importance of these factors and interactions, followed by major extrapolations about the complex and transient conditions of the field environment. Field measurements of resuspension and desorption at the point of dredging supported by data on operational factors and ambient conditions are, therefore, essential to better understanding of contaminant release rates at the point of dredging. The number of such studies is rather limited. They are complex and expensive, involving major investments in

*Page numbers refer to the ***Scenic Hudson, Inc.*** Report.

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Table 1. Suspended Solids Concentrations Produced by Various Dredges[1]

Type of Dredge	Suspended Solids Concentration	Remarks	Predictive Techniques
Cutterhead 10 rpm 20 rpm 30 rpm	161 mg/ℓ (sandy clay) 52 mg/ℓ (med. clay) 187 mg/ℓ (sandy clay) 177 mg/ℓ (med. clay) 580 mg/ℓ 266 mg/ℓ	Observations in the Corpus Christi Channel (Huston and Huston 1976)	
18 rpm 18 rpm	1 to 4 g/ℓ within 3 m of cutter 2 to 31 g/ℓ within 1 m of cutter	Soft mud at Yokkaichi Harbor, Japan (Yagi et al. 1975)	Proposed by Collins (1989)
Trailing suction dredge	Several hundred milligrams per liter above background (at surface and middepth). As high as several grams per liter	San Francisco Bay (Barnard 1978)	
	2 g/ℓ at overflow 200 mg/ℓ at 200 m behind	Chesapeake Bay (Barnard 1978)	No predictive techniques available
Mudcat dredge	1.5 m from auger, 1 g/ℓ near bottom (background level 500 mg/ℓ) 1.5 to 3.5 m in front of auger, 200 mg/ℓ surface and middepth (background level 40 to 65 mg/ℓ)		
Pneuma pump	48 mg/ℓ at 1 m above bottom 4 mg/ℓ at 7 m above bottom (5 m in front of pump)	Port of Chofu, Japan	No predictive techniques available
	13 mg/ℓ at 1 m above bottom	Kita Kyushu City, Japan	No predictive techniques available
Cleanup system	1.1 mg/ℓ to 7.0 mg/ℓ at 3 m above suction 1.7 mg/ℓ to 3.5 mg/ℓ at surface	Toa Harbor, Japan	No predictive techniques available
Grab/bucket/clamshell dredges	Less than 200 mg/ℓ and average 30 to 90 mg/ℓ at 50 m downstream (background level 40 mg/ℓ)	San Francisco Bay (Barnard 1978)	
	168 mg/ℓ near bottom 68 mg/ℓ at surface	100 m downstream at lower Thames River, Connecticut (Bohlen and Tramontaro 1977)	
	150 to 300 mg/ℓ at 3.5-m depth	Japanese observations (Yagi et al. 1977)	Proposed by Collins (1989)

(Continued)

[1] From Herbich and Brahme (1991).

Table 1. (Concluded)

Type of Dredge	Suspended Solids Concentration	Remarks	Predictive Techniques
Antiturbidity overflow system	6 mg/ℓ at surface 8.2 mg/ℓ at 1 m below surface	Side of the ship (Ofuji and Naoshi 1976) Japan	
	6.5 mg/ℓ at surface 8.9 mg/ℓ at 1 m below surface	Aft of the ship	No predictive techniques available
Antiturbidity Watertight buckets	30 to 70 percent less turbidity than typical buckets	Japan (Barnard 1978)	No predictive techniques available
	500 mg/ℓ at 10 m downstream from a 4-cu m watertight bucket		

Table 2. TGU's[1] for Different Dredges and Dredging Projects (Nakai 1978)[2]

Type of Dredge	Installed Power or Bucket Volume	Dredged Material			TGU kg/m³
		(d <74μ, %)[3]	d <5μ, %	Classification[4]	
Pump	4,000 hp	99.0	40.0	Silty clay	5.3
		98.5	36.0	Silty clay	22.5
		99.0	47.5	Clay	36.4
		31.8	11.4	Sandy loam	1.4
		69.2	35.4	Clay	45.2
		74.5	50.5	Sandy loam	12.1
	2,500 hp	94.4	34.5	Silty clay	9.9
		3.0	3.0	Sand	0.2
	2,000 hp	2.5	1.5	Sand	3.0
		8.0	2.0	Sand	0.1
Trailing suction	2,400 hp	92.0	20.7	Silty clay loam	7.1
	x 2	88.1	19.4	Silty loam	12.1
	1,800 hp	83.2	33.4	Silt	25.2
Grab	8 cu m	58.0	34.6	Silty clay	89.0
	4 cu m	54.8	41.2	Clay	84.2
		45.0	3.5	Silty loam	15.8
	3 cu m	62.0	5.5	Silty loam	11.9
		87.5	6.0	Silty loam	17.1
Bucket		10.2	1.5	Sand	17.6
		27.2	12.5	Sandy loam	55.8

[1] TGU = kilograms of suspended sediment per cubic meter material dredged.
[2] Nakai (1978) as cited by Herbich and Brahme (1991).
[3] d = diameter of soil particles.
[4] Classification is according to the triangular soil classification system.

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equipment (dredges) and chemical analyses. It is important, therefore, that future studies be designed to provide the maximum amount of information on relevant factors and interactions.

The predictive equations presented in this section may at first glance seem straightforward and easy to apply. For many of the variables in the equations, however, there is little guidance on selection of appropriate values. Application of these equations will necessarily involve judgment that can only be applied on a case-by-case basis."

It is fairly obvious that it would be very difficult to predict the sediment resuspension rates during dredging, especially in a river environment such as the Hudson River. The ***Scenic Hudson, Inc.*** report glosses over the effects associated with sediment resuspension.

A recent report from Environment Canada (1997) states

"Conventional dredging technologies, both mechanical (open clamshell bucket, excavators, etc.) and hydraulic (e.g. suction pumps), are still commonly used in the Great Lakes. These technologies are dated and can no longer remove contaminated sediments adequately in ports and harbors throughout the world. Alternative sediment removal technologies must be developed and tested in order to remediate those areas."

Environmental Dredging (p. 10)

Scenic Hudson, Inc. states that the "rule of thumb developed in the early days of Superfund was that the sediment dredging may cause more harm than good and should be limited to use at sites with exceptionally severe contaminant impacts."

Comment: This is still, at present, the underlying consideration that resuspension of contaminated sediments by dredging action may cause greater environmental damage than no-action alternatives.

Scenic Hudson, Inc. mentions that the USEPA and the USACE cooperated on dredging field tests for the New Bedford Harbor Superfund Site.

Comment: Pilot dredging operations were conducted in the New Bedford Harbor from May 1988 to February 1989. Three types of dredges were deployed: cutterhead, matchbox and a horizontal auger. The dredges did not perform as well as expected in spite of the fact that the pilot study was: (1) carefully designed, (ii) the best of equipment available was employed, (iii) operational methods were modified to reduce resuspension of sediments, and (iv) was closely observed and monitored. The level of sediment resuspension was appreciable. In the Hudson River case resuspended PCB-contaminated sediments will be carried downstream by the river's currents. If a major storm or a flood occurs during dredging, a considerable amount of contaminated sediments will be washed downstream.

Specifically, the following was observed in dredging the New Bedford Harbor:

1. The cutterhead dredge generated the lowest amount of resuspended sediment. However, to reduce sediment resuspension at the cutter, several measures had to be taken including a reduction in swing speed, reduction in cutter rotation, and only a 2-foot advance per swing. These measures caused greater than expected reduction in production.

2. Dredging operations were delayed because of problems deploying and moving heavy swing anchors in shallow water. Other problems were related to a considerable amount of debris plugging the dredgeheads.

3. Two passes of the cutterhead dredge were required to reduce the average PCB level in remaining sediments to 8.6 ppm (after one pass the PCB level was 80.5 ppm).

4. Resuspension rates of sediments at the dredgehead varied from 12.0 to 329 grams per second. This means that in a 6-month, 10-hr/day dredging operation between 175,739 lbs to 4,778,357 lbs of sediment would be resuspended.

5. The average suspended solids concentrations measured around the contained aquatic disposal dredging operations were 32.5 and 175.8 mg/liter. Samples taken some 800 feet from the point of discharge indicated levels of suspended sediments from 12.0 to 98 mg/liter.

6. Capping of the confined aquatic cell was unsuccessful as the PCBs contents in the upper 24 inches of sediment measured four months later were between 0.1 and 95.9 ppm.

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7. The silt curtains deployed during the pilot study sustained substantial damage during severe weather. When the silt curtains were not deployed, high suspended sediments were observed up to 1,000 feet away from the dredging operation at the contained aquatic disposal site.

The subsequent Contract Price for dredging an additional 10,000 cubic yards was $19,357,720; numerous contract modifications have increased the contract to $21,165,436. Dredging in 1994 proceeded at a much slower pace than originally anticipated due somewhat to the extensive air monitoring effort (Otis, 1995).

The New Bedford project was small and expensive. Dredging caused the release of PCBs to the atmosphere and dredging activities were frequently stopped until the PCB count was reduced to a target level.

Scenic Hudson, Inc. mentions the work related to the Manistique Harbor Area of Concern (page 11).

Comment: In 1996, about 2,116 tons of sediment and other waste materials were shipped off site for disposal and over 35 million gallons of river water was treated (EPA, 1997). During the 1997 work season, the EPA expects to remove the temporary cover over the "hot spot" downstream of the city marina and dredge the area. Before commencing work in 1997, the EPA was to review historical operations; consider the most feasible option for proceeding based on the changing nature of the sediment and, if necessary, modify and upgrade work processes and equipment.

There is no comparison between this small project and the removal of 1.3 million cubic yards of sediment contained in "hot spots" in the Upper Hudson River.

Sediment Resuspension (2.3.1)

Comment: One of the difficulties is to estimate the volume of resuspended contaminated sediments using the innovative dredging process.

EPA ARCS Chapter 11 (1996) discusses the inavailability of estimating sediment solids losses as follows:

"Techniques for estimating sediment solids losses during hydraulic and mechanical dredging are available for conventional dredging equipment. Techniques are not available for innovative dredging equipment options. The available predictive techniques provide estimates of sediment losses in terms of mass loss per time or mass loss per in situ volume dredged. Exposure concentrations are not estimated. To estimate exposure concentrations, the predicted losses of sediment and associated chemical contaminants must be incorporated into water quality or exposure assessment models.

Techniques for estimating contaminant losses during dredging are still in an early stage of development. Field data on turbidity and suspended solids downstream of dredging operations are available, but measurement of losses at the point of dredging that gave rise to the reported data are largely lacking. Empirical correlations of sediment losses at the point of dredging with dredging operational parameters have been developed, but field validation data are scarce. The predictive techniques focus on losses at the point of dredging and are inherently a priori, although laboratory tests have been proposed. It is anticipated that the available correlations will be modified and improved as a result of ongoing studies."

Francingues and Averett (Patin, 1994) state:

"Principal concerns during excavation operations are the prevention of contaminant releases from the sediment being removed with subsequent transport of contaminants to a previously uncontaminated area and efficient removal of contaminated sediment without excessive overcutting. If an unavoidable release occurs, undesirable consequences could result in regards to the environment, costs, and public relations. Overcutting increases the volume of material for treatment or disposal and increases costs."

Scenic Hudson, Inc. states that "dredging equipment must be selected and operated with dredging efficiency as a goal." If "dredging efficiency" means high production rates then this also means "high resuspension rates" during the dredging process which is incompatible with "environmental dredging." New Bedford Harbor pilot dredging has shown that a reduction in resuspension rates resulted in a considerable reduction in production rates.

Other Potential Impacts (2.3.2)

Scenic Hudson, Inc. states "Silt curtains or other barriers can be used to mitigate these impacts in some situations."

Comment: Many factors contribute the effectiveness or ineffectiveness of physical barriers, including water current, water depth, wind, tides, wakes, waves, and floating ice or debris (p. 35). In general, plastic impermeable floating curtains are not effective when the current is over 1 ft/sec. Since such curtains are of limited depth, and most of the resuspension is generated near the bottom, the effect is only aesthetic - most of the resuspended sediment moves under the curtain. Silt curtains were ineffective in the New Bedford Harbor (as noted previously) and failed completely at the Massena (G.M.) NY site. At the Massena site silt curtains were replaced by impermeable steel sheet piling.

Capping (2.4.1)

Comment: Capping is one of the options to be considered when selecting the best method for isolating contaminated sediments. The cost of capping is much lower than the cost of dredging and subsequent treatment of contaminated sediments. What is not mentioned is there is little or no resuspension of sediments during properly conducted capping operations. The capping of contaminated material in open water sites began in the late 1970's. Since then a number of capping operations have been accomplished. Field experience has shown the capping concept is technically and operationally feasible.

The geochemical environment for subaqueous capping favors long-term stability of contaminants compared to the upland environment where geochemical changes may favor increased mobility of contaminants (Palermo, 1997).

No Action (2.4.3)

Comment: The "no action" alternative should always be considered on any project dealing with contaminated sediments. The site can be monitored over a decade or more to evaluate if any major change occurred. Sediment loading during a major flood event can be monitored as was measured by the HydroQual Company in 1997.

If any adverse changes are observed, the "no action" decision can be revisited.

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Dredging Technologies land Related Sediment Controls (p. 21)

Scenic Hudson, Inc. describes dredges available for contaminated sediment remediation.

Comments: Out of seven mechanical dredges listed only two specially-designed dredges, the backhoe and Cable Arm clamshell, are suitable for the removal of contaminated sediment. Because of low production, these dredges can only be used on small projects for the removal of sediment from highly contaminated pockets. The backhoe was only used on the Bonfouca Project in Louisiana and the Cable Arm was tested at Toronto Harbor, Ontario (209 cubic yards removed), Hamilton Harbor, Ontario (196 cubic yards removed) and Pickering, Ontario (196 cubic yards removed at a 30 cubic yards per hour production rate).

Hydraulic dredges would have to be specially designed or modified to minimize sediment resuspension . Also, the dredging method would have to be modified, i.e. reduction in cutter speed, reduction in swing speed, and limiting the depth of cut. The dredge must also be fully instrumented to provide the leverman with instant information on the depth of cut, position of the cutter, resuspension generated, etc. In environmental dredging, the production is substantially reduced.

Several dredges listed in this section are not available in the United States: 1) Clean-up dredge (Japan), 2) Oozer dredge (Japan), 3) Refresher dredge (Japan), and 4) Wide Sweeper dredge (Japan).

The Bucket Wheel, Dustpan and Hopper dredges are not suitable for the removal of contaminated sediments.

Physical Barriers (p. 35)

Comment: Silt curtains were discussed earlier commenting on Section 2.3.2.

Site Cleanup Descriptions (pp. 41-54)

Scenic Hudson, Inc. describes twenty-four contaminated sediment projects.

Comment: Twenty-four of the projects listed range from small demonstration projects to dredging in Cold Spring, NY in 1993/95 where some 71,240 cubic yards of sediment was removed. Five projects were in Japan. Two of the Japanese projects used equipment not available in this country (Osaka Bay- Oozer dredge, T-Bay and M-Bay - Refresher system). Four projects were in Canada; three were demonstration projects (Collingwood Harbor, Hamilton Harbor and the Welland River). One was a removal project at Pickering, Ontario, the total amount of sediment removed was only 196 cubic yards. Although useful information was obtained from the Canadian Projects, the demonstration projects are minuscule in comparison with the 1,305,000 cubic yards of contaminated sediments in the Hudson River. One project was in the Netherlands where a matchbox dredge was deployed. The matchbox dredge was also used in the New Bedford Harbor. The comparative resuspension rates and contaminant releases for the cutterhead, horizontal head, and matchbox dredges tested in the New Bedford Harbor dredging are shown in Table 3.

Table 3. Sediment Resuspension and Contaminant Release During Dredging Operations (Herbich 1993)

Dredge	Resuspension Rate g/sec	Total Suspended Solids mg/l	PCBs (ppb) Dissolved	Particulate	Total
Cutterhead	12	82	0.6	22.3	7.0
Horizontal Auger	329	1,610	10.1	200.3	2.0
Matchbox Head	46	319	0.5	56.9	54.9

At Massena, NY (General Motors site), the EPA Record of Decision (ROD) specified a 1 ppm PCB cleanup goal and a 10 ppm treatment goal in the St. Lawrence and Raquette Rivers. A cleanup level of 0.1 ppm was set for Turtle Creek (Mohawk Tribal Lands). After dredging was completed at Massena, an analysis of the samples indicated that PCB concentrations in all areas except one averaged less than 3 ppm (EPA, 1996. General Motors Superfund Site).

The area adjacent to the GM plant outfall, however, continued to show elevated PCB levels during dredging. Despite repeated dredging attempts, final sampling results showed an average of 25 ppm. With the exception of one sample at 6,000 ppm (out of a total of 113 different sample locations in the river), none tested above 100 ppm. By early November EPA determined that continued dredging was not likely to result in further PCB reduction.

U.S. Army EWES (1998) states:

> "The problem of adverse environmental impacts from dredging contaminated sediment has been recognized by the Dutch and the Japanese, who have developed specially-designed dredges, which are generally not readily available in the United States, for minimizing resuspension of contaminated sediment."

The Jones Act (46CFR292) strictly prohibits the importation of foreign-built vessels. The Jones Act has also restricted the importation of foreign-built dredges (Zappi and Hayes, 1991). The U.S. dredging industry has not developed any new hydraulic dredges specifically designed to minimize resuspension of sediment.

Scenic Hudson, Inc. mentions that the Pneuma Dredge operating in a water supply reservoir for the City of Santa Barbara, CA produced no apparent resuspension . Zappi and Hayes (1991) show that suspended solids 200 ft from the dredge were between 0.8 and 22.8 mg/l at the surface and between 0.3 and 12 mg/l at middepth. The main purpose of dredging was to remove accumulated sediment in the reservoir to restore water capacity of the reservoir (City of Santa Barbara, 1986).

Water Depth and Site Access (5.3)

Comments: Because of shallow depths near the Hudson River's banks, overhanging trees, rocks and debris, it would be difficult to dredge a specified layer of contaminated sediment. Overdredging and underdredging would inevitably occur resulting in the removal of more sediment than required, mixing of contaminated and uncontaminated sediments (in case of overdredging), and leaving some contaminated sediments which may be moved by river currents downstream (in case of underdredging).

Water Current (5.4)

Comment: Currents in the Hudson River would prevent the deployment of silt screens that extend to the bottom of the river.

Depth of Contaminated Sediment and Dredge Accuracy (5.5)

Scenic Hudson, Inc. states: "Despite the large size of the Hudson River PCBs site, dredge accuracy is not likely to be a critical selection factor."

Comment: Dredging accuracy is a very important factor. Overdredging would greatly affect the size of the disposal area and the magnitude of the treatment plant. Even 0.5 ft of overdredging would add considerably to the total volume of sediments to be dredged.

Production Rate and Sediment Density (5.6)

Comments: As indicated earlier, the production rates of environmental dredging are considerably less than the rates for removal of contaminated sediments on Superfund Projects ranged from 5 to 100 cubic yards per hour . Assuming an average rate of 50 cubic yards per hour, it would take ten years and seven months to complete dredging of contaminated sediments from the Hudson River. Dredging would seriously affect the traffic on the river because of placement and movement of discharge pipes, movement of barge tows, movement of work boats, fuel barges, etc. Recreation in the Hudson River would also be seriously affected for safety reasons.

Dredge Availability

Comment: As mentioned earlier, the Jones Act strictly prohibits the importation of foreign-built dredges.

Cost

Comments: Major cost implications include:

1) dredge production rate,
2) dredge downtime due to environmental consideration (e.g. excessive resuspension of sediment, excessive air pollution, pipe joint leakages, barge leakages,

3) depth of cut and vertical control required,
4) will a PCB cleanup level be targeted, or a specific depth of cut be specified,
5) location of disposal site or sites,
6) contractor liability and insurance costs.

Other cost implications include:

1) definition of hot spot areas,
2) type of pipe for transport (steel or PVC); type of fittings (welded, fused or bolted),
3) extent of wetlands encroachment and resultant mitigation,
4) dredge and barge availability for use with PCB-contaminated sediments,
5) barge interference with river traffic,
6) point of origin for dredging equipment (mobilization and demobilization),
7) fuel costs,
8) testing and extensive inspection.

RECOMMENDATIONS

Scenic Hudson, Inc. endorses and recommends dredging as a component of the Hudson River PCB remedy.

Comment: Several alternatives should be considered and thoroughly evaluated for a project of this magnitude The alternatives should include:

1. No-action (relying on natural capping and/or recovery),
2. Capping of hot spots (armoring required),
3. Removal of contaminated sediments by dredging (disruption of river traffic and recreation, danger of collisions and accidents).
4. A combination of 1-4 (selective methods for specific locations).

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SUMMARY

1. *Scenic Hudson, Inc.* prepared a report entitled Advances in Dredging Contaminated Sediment. The purpose of the report is to promote the idea that dredging is the preferred remedy for removing PCB-contaminated sediments from the Hudson River.
2. The report, prepared by non-engineers, is misleading in many sections; it favors dredging alternative and ignores the difficulties and complexities of dredging 1,305,000 cubic yards of sediment in a major river.
3. There is no comparison between many of the minor projects briefly summarized in the report and the removal of 1,305,000 cubic yards of contaminated sediment.
4. Techniques for estimating contaminants losses during dredging are still in an early state of development.
5. Typical silt curtains will not be effective in a river environment such as the Hudson.
6. The dredging industry has not developed any new successful hydraulic dredges specifically designed to minimize resuspension of sediment. Foreign dredges cannot be used in the United States.
7. It would be difficult to dredge a specific layer of contaminated sediments near the banks of the Hudson River due to shallow water, overhanging trees, rocks and debris.
8. Dredging accuracy is very important in the removal of contaminated sediments; overdredging would considerably affect the disposal volume and treatment of contaminated sediments.
9. It would take at least a decade or more to dredge contaminated sediments from the Hudson River. Secondary contamination is likely to occur.

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10. Several alternatives should be considered and thoroughly evaluated for a project of this magnitude.

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