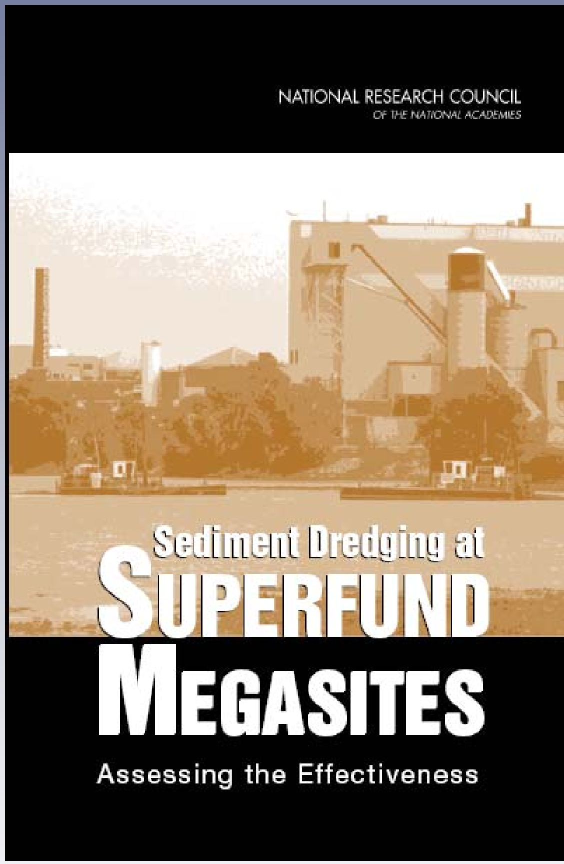

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Sediment Dredging at Superfund Megasites: Assessing the Effectiveness

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Army Engineer Research
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Federal Remediation Technologies Roundtable
Washington DC - June 5, 2008

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- Clay Patmont, Anchor Environmental, LLC.
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Statement of Task

Evaluate the expected effectiveness of sediment dredging in achieving risk reduction at Superfund megasites.

The committee was charged to consider:

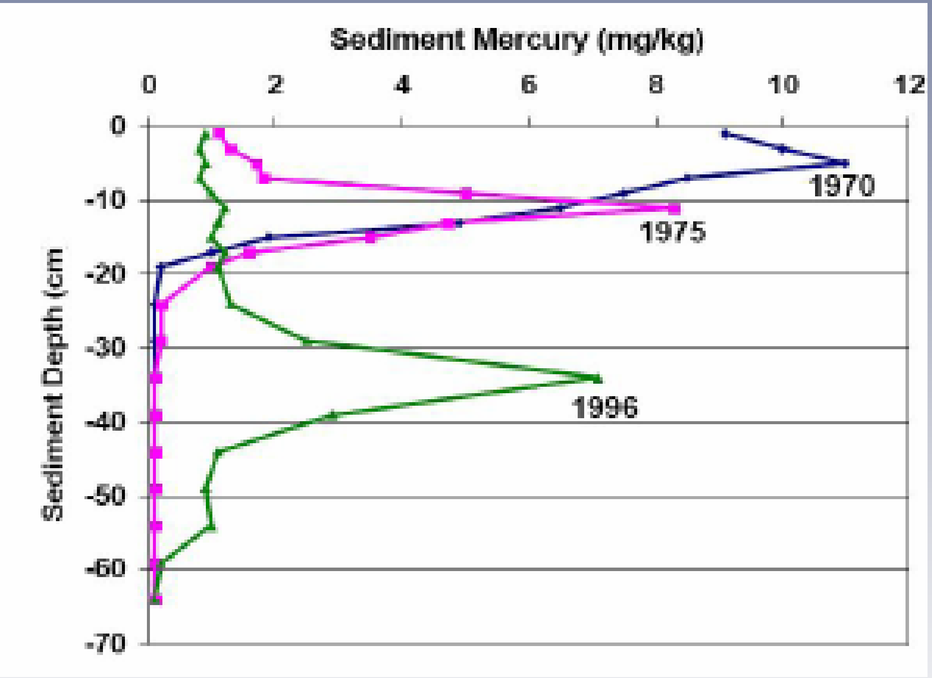
- Short and long-term effects on ecologic communities
- Site specific factors that contribute to or hinder effectiveness
- Whether current monitoring technologies are sufficient and how they can be improved
- How to improve sediment megasite decision-making in the future.

Outline

- Introduction
- Evaluation of Dredging Effectiveness
- Monitoring at Sediment Megasites
- Improving Future Decision-Making

Risk-based Decision-Making

- Risk relates to exposures to contaminants above acceptable levels.
- Remediation should be designed to eliminate or reduce those exposures.
- Exposures are dictated by surface sediments – contaminants buried below the biologically-active zone are not available to organisms.
- Disrupting sediment beds to remove buried contaminants can expose organisms to otherwise inaccessible contaminants.
- However, removal of deeply buried contaminants may thwart future exposure and transport during severe events.



Historical changes in sediment core profiles of mercury concentrations in Bellingham Bay, WA. Source: Patmont et al. 2004.

Committee's Evaluation of Dredging Sites

- The committee examined experiences at 26 dredging projects and evaluated whether, after dredging, the cleanup goals had been met.
  - -Had a site achieved its quantitative cleanup levels (typically a specified contaminant concentration in sediment).
  - -Had a site achieved its remedial-action objectives (what the cleanup is expected to accomplish in the long term).
  - -Factors that contributed to the success or adversely affected dredging operations.
- Various sites were examined, including full-scale dredging projects, pilot studies at sites, and dredging projects within a large-scale remediation effort.

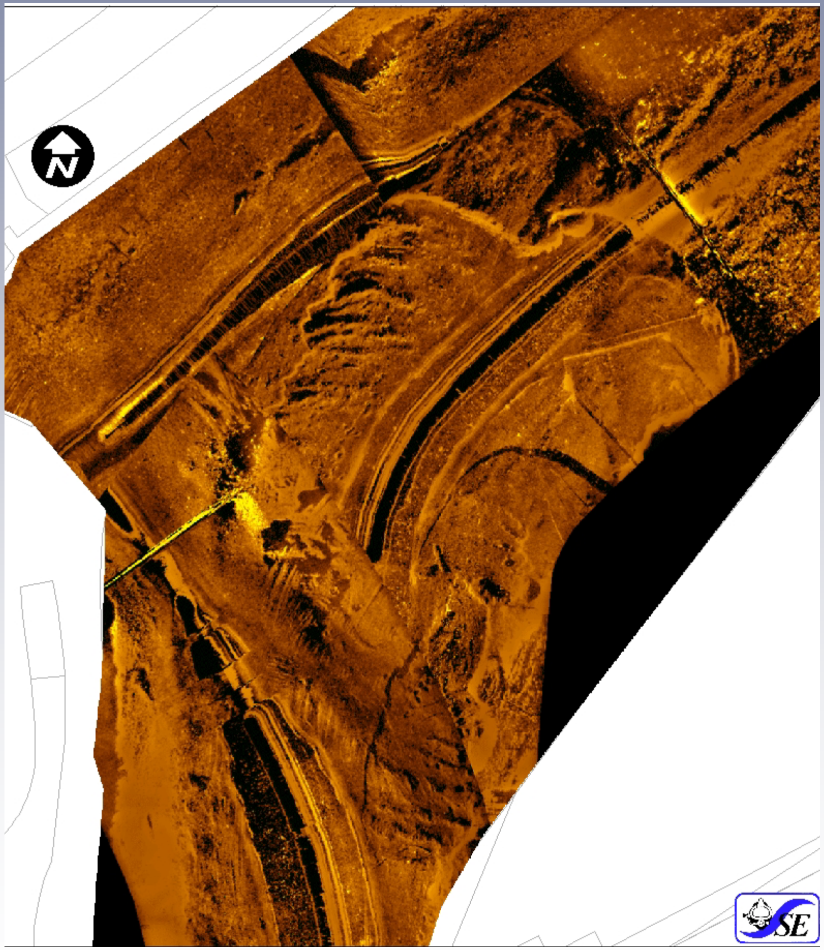
26 Environmental-Dredging Projects Selected for Evaluation

- Bayou Bonfouca LA
- Lavaca Bay, TX
- Black River, OH
- Outboard Marine Corporation – Waukegan Harbor, IL
- Commencement Bay–Head of Hylebos, Tacoma, WA
- Commencement Bay–Sitcum, Tacoma, WA
- Duwamish Diagonal, Seattle, WA
- Puget Sound Naval Shipyard, Bremerton, WA
- Harbor Island–Lockheed, Seattle, WA
- Harbor Island–Todd, Seattle, WA
- Cumberland Bay, NY
- Dupont–Christina River, DE
- Lower Fox River (OU-1), WI
- Lower Fox River (Deposit N), WI
- Lower Fox River (SMU 56/57), WI
- Ketchikan Pulp Company, Ward Cove, AK
- Newport Naval Complex–McCallister Landfill, RI
- GM Central Foundry, St. Lawrence River, NY
- Grasse River, NY (non-time-critical removal action)
- Grasse River, NY remedial options pilot study (ROPS)
- Lake Jarnsjon, Sweden
  Manistique Harbor, MI
- Reynolds Metals, St. Lawrence River, NY
- Marathon Battery, Hudson River, Cold Spring, NY
- New Bedford Harbor, MA (hot spot)
- United Heckathorn, Richmond, CA

Evaluation of Dredging Effectiveness

- Operational goals (mass removal or dredging to elevation) were achieved at many sites.
- Dredging is effective at removing large volumes of contaminated sediments from the environment.
  - This doesn’t necessarily equate to risk reduction, but can be useful if those sediments are likely to be transported to less contaminated areas.
- Dredging alone achieved desired contaminant-specific cleanup levels at only a few of the reviewed sites.
  - Capping after dredging was often necessary to achieve cleanup levels.
- At some sites, dredging achieved cleanup levels and presumably contributed to declines in biota contaminant concentrations.

Evaluation of Dredging Effectiveness



Difficulties achieving low post-dredging surface sediment contaminant concentrations arise primarily from:

- dredging’s limitations in fully removing contaminated sediments.

Courtesy of Marc Mills, US EPA - ORD

Evaluation of Dredging Effectiveness

(Dalton, Olmsted & Fuglevand, Inc. 2006)

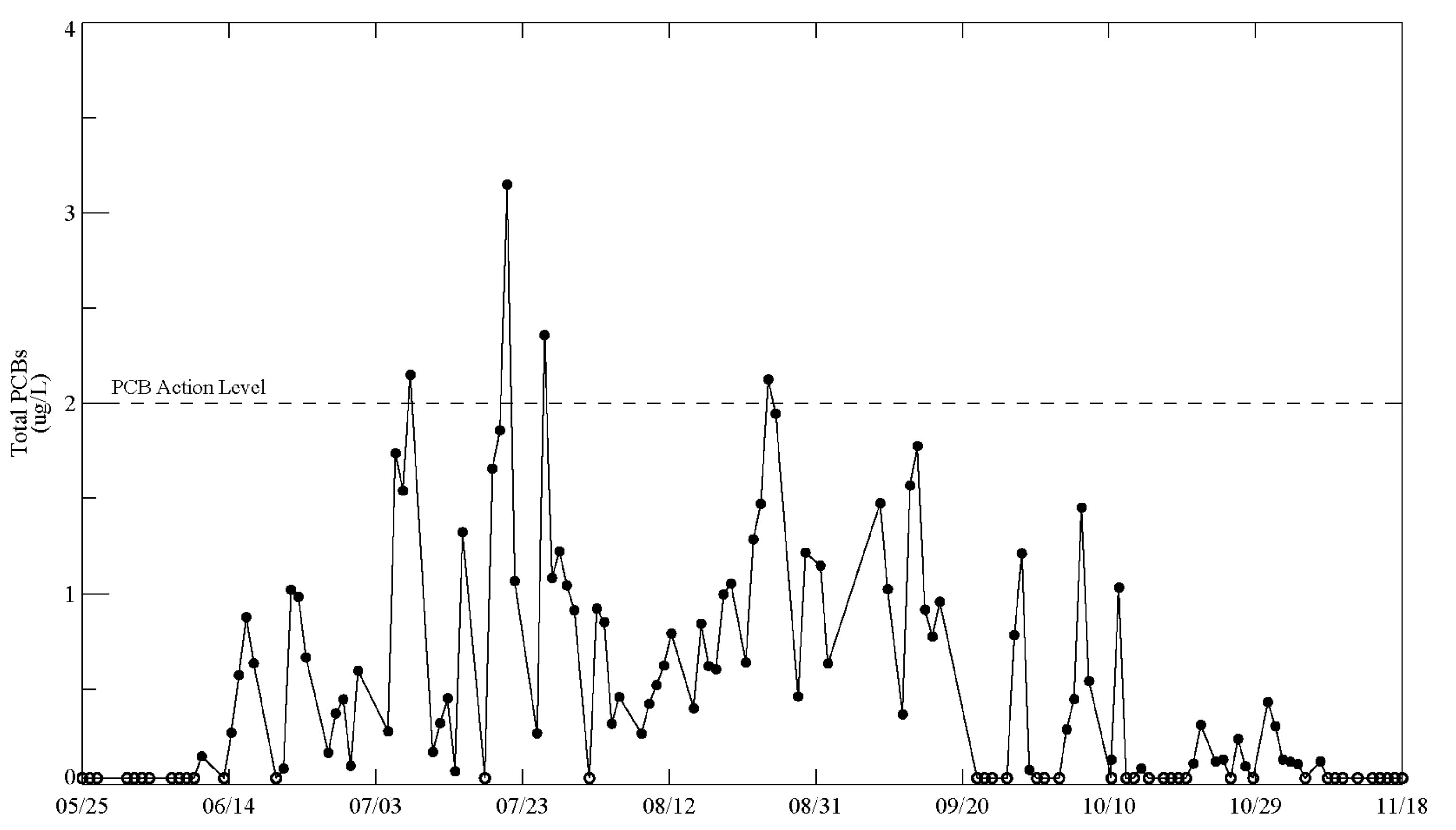
Difficulties achieving low post-dredging surface sediment contaminant concentrations arise primarily from:

- site conditions that limit complete removal of contaminated sediments.

➲ The result is residual contamination that hinders the ability to achieve risk reduction.

Evaluation of Dredging Effectiveness

- Dredging can cause releases of contaminants during operations that increase water column and fish tissue contaminant concentrations in the short term.



(NRC 2007; data from Alcoa 2006)

Evaluation of Dredging Effectiveness

- The longer-term benefits to human health and the environment of dredging contaminated sediments are not well understood or documented.
  - Monitoring at most sites does not include the full array of measures necessary to evaluate risk.
  - Dredging may have occurred in conjunction with other remedies or natural processes.
  - Insufficient time may have passed to evaluate long-term risk reduction.
- Due to these deficiencies, the committee was generally unable to establish whether dredging alone is capable of achieving long-term risk reduction.

So, Does Dredging Work or Not?

- There is not a single answer to this question.
- Results will be site specific and depend on site conditions, the adequacy of pre-dredging characterization of those conditions, and the implementation of the remedial action.
- For example…

Range of Experiences at Dredging Projects

Grasse River, NY

- Removed 24,600 cy in 2005.
- Average surficial sediment PCB concentrations increased after dredging from 4.1 mg/kg to 150 mg/kg. No cleanup level.
- Intended to remove 64,000 cy; Able to dredge 40% of the targeted area. Capped entire dredged area following remediation.
- Residuals: Average of 16 in. of contaminated sediments remained after dredging (range from 3 to 32 in.)
- Increased contaminant concentrations in fish and water during dredging

Head of Hylebos, WA

- Removed 404,000 cy from 2004 to 2006.
- Average surficial sediment PCB concentrations decreased after dredging from 0.69 mg/kg to 0.07 mg/kg. Cleanup level: 0.3 mg/kg.
- Sediments from targeted areas were successfully dredged. Had to cap one area due to remaining contamination.
- Residuals: No summary statistics; Ranged from 0 to >12 in. Residual contaminated sediments were below cleanup level.
- No sampling for contaminant concentrations in water and in fish.

Differences in Site Conditions Influence Results

Grasse River, NY

- Contaminated sediments underlain by bedrock and hardpan (not “dredgeable”).
- River channel deepened by blasting contains uneven substrate (ridges, gulleys, scattered boulders) beneath sediments that make dredge access difficult.
- Difficult to characterize the depth of contaminated sediment using standard characterization techniques due to heterogeneity of underlying material.
- Debris present; removed prior to dredging operations.

Head of Hylebos, WA

- Contaminated sediments underlain by dense, sandy material (“dredgeable”).
- Former tidal flat has relatively featureless and homogeneous substrate underlying contaminated sediments.
- Relatively easy to characterize the depth and extent of contamination based on historic channel depth and visual differences between contaminated and clean sediment.
- Debris present; removed prior to dredging operations.

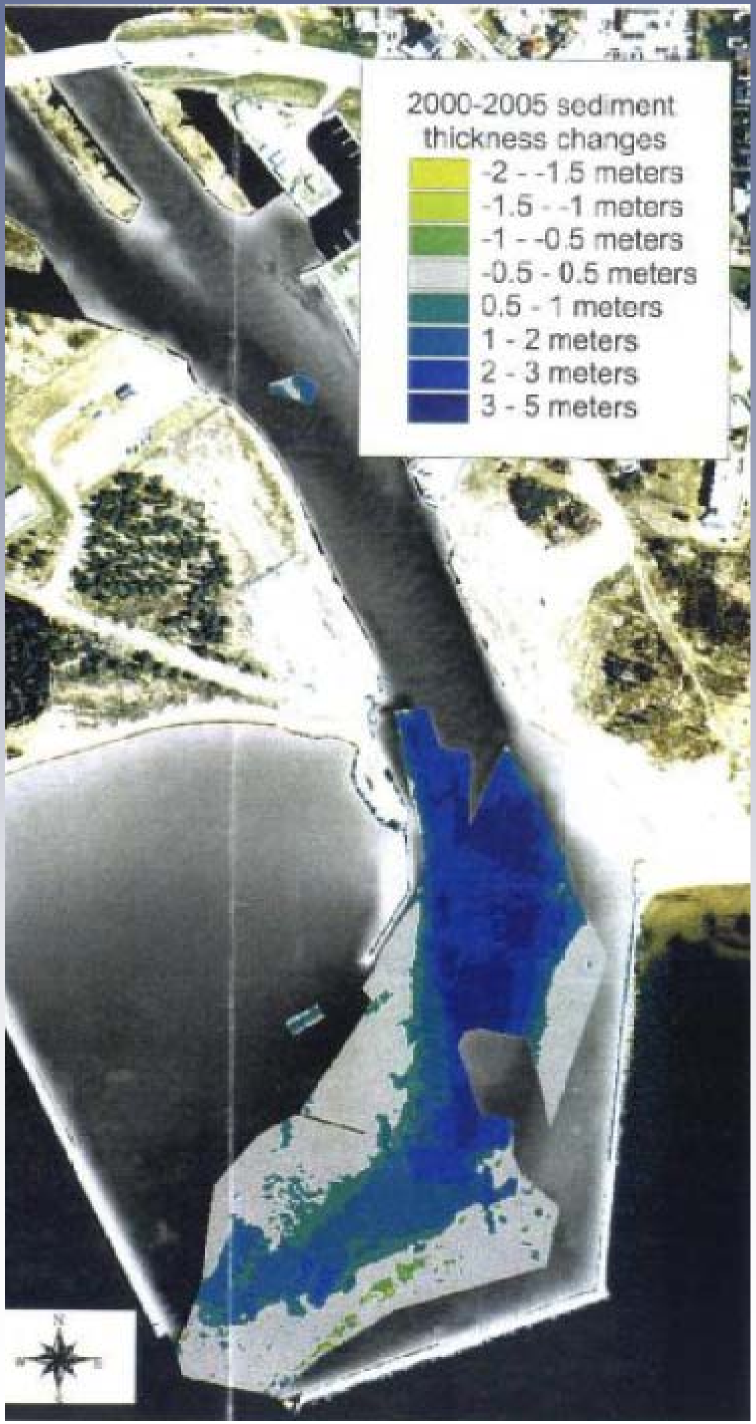
Manistique River and Harbor

- Removal was initially expected to take 3 seasons and remove 104,000 cy – project took 6 seasons and removed approximately 190,000 cy.
- Issues encountered in characterizing the extent of contaminated sediment and completely removing sediment residing over fractured bedrock.
- Cleanup level: average PCB concentration of 10 mg/kg throughout the sediment column within the AOC.
- Post-dredging average PCB concentrations (top foot) throughout the site were 9.0 mg/kg (2000) and 7.3 mg/kg (2001).

Manistique River and Harbor

Post-dredging Sedimentation

- Following cessation of dredging in 2000, there has been substantial sedimentation in the harbor.
- Upwards of 83,000 cubic yards were deposited in the harbor; in some places up to 5 meters thick.
- This has buried residual PCBs; in 2004 surface sediment average concentration was 0.88 mg/kg.
- Indicates the potential importance of other processes in combating residual contamination and achieving risk reduction.



Evaluation of Dredging Effectiveness

RECOMMENDATIONS:

- Remedies should be designed to meet long-term risk-reduction goals (as opposed to metrics not strictly related to risk, such as mass-removal targets).
- Environmental conditions that limit or favor the effectiveness of dredging should be given major consideration in deciding whether to dredge at a site.
- Resuspension, release, and residuals will occur if dredging is performed. Decision-making should explicitly consider those processes in expectations of risk reduction.
- To reduce adverse effects, best-management practices that limit resuspension and residual contamination should be used during dredging. The ability of combination remedies to lessen the adverse effect of residuals should be considered.

Monitoring for Effectiveness

Current monitoring techniques are generally adequate for describing risk. However, they have not been adequately applied at many Superfund sites to describe whether long-term risk reduction objectives have been achieved.

- Sparse or incomplete monitoring data were collected.
- Selected organisms were not linked to remediation at the site.
- Preremediation monitoring approaches were not consistent with those used for long-term postremediation monitoring.
- Pre-remediation trends were not of sufficient duration to enable judging the effect of the remedial action.
- Monitoring was of insufficient quality or quantity to support rigorous statistical analyses.

Monitoring at Sediment Megasites

<u>RECOMMENDATIONS</u>:

We need to do a better job evaluating the effectiveness of remedial actions at Superfund sites.

- EPA should ensure that monitoring is conducted at all contaminated sediment megasites to evaluate remedy effectiveness.
- Descriptions of risk reduction require:
  - A pre-remedial baseline data set for comparison to post-remediation data
  - Appropriate controls and reference sites
  - Consistent sampling and appropriate statistical power.
- Monitoring data should be compiled and made publicly available such that it's possible to verify evaluations of remedial efficacy independently.

Improving Future Decision-Making

- The large spatial scale and long remedial timeframes of contaminated sediment megasites make it difficult to predict and quantify the human health and ecosystem risk-reduction benefits achieved by isolated remediations in a large-scale watershed.
- The complexity and heterogeneity of large-scale megasites suggest that a variety and combination of remedial approaches will often be appropriate.
- The committee’s retrospective analysis on ‘what works and why’ in sediment remediation is an essential part of a shared experience among regulators, practitioners, and the public. This type of effort needs to be ongoing.

Improving Future Decision-Making

- An adaptive-management approach is essential to the selection and implementation of remedies at contaminated-sediment megasites where there is a high degree of uncertainty about the effectiveness of dredging.

  This approach:
  - replaces the paradigm of establishing all remedial actions prior to implementation.
  - focuses on achieving objectives during a specified time frame.
  - is based on the use of monitoring data from pilot studies and ongoing remediation.
  - uses data collected during remedial operations to assess and improve remedies to optimize progress towards remedial goals.