Strategies and Technologies for Cleaning Up Contaminated Sediments in the Nation's Waterways

The National Research Council Study

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Contaminated marine sediments pose a threat to ecosystems, marine resources, and human health. Sediment contamination also interferes with shipping activities and growth of trade resulting from delays in dredging and the inability to dredge the nation's harbors due to controversies over risks and costs of sediment management. Given that approximately 95 percent of total U.S. trade passes through dredged ports, potential economic impacts due to sediment contamination may be severe.

The management of contaminated sediments is complex and difficult. The factors that contribute to the complexity are many, exacerbate the problem, and result in non-cost-effective management actions with controversial outcomes and marginal benefits. These factors include

- High public expectations for protecting human health and the environment;
- Multiple stakeholder interests and priorities;
- Conflicting and overlapping jurisdictions of federal, state, and local regulatory authorities;
- Relatively low levels of contamination;
- Large quantities of affected sediments;
- Uncertainty in quantifying and managing risk; and
- Limitations of handling and treatment technologies.

An overview of a study performed by the National Research Council's (NRC) Committee on Contaminated Marine Sediments is provided here. The 15-member committee included national experts from academia, industry, and the professional services sector. The committee was established in the spring of 1993 and completed its work in the summer of 1996. The committee's deliberations were published in a report released by the NRC in March 1997. This report was a basis for discussions and presentations at TRB's National Symposium on Contaminated Sediments: Coupling Risk Reduction with Sustainable Management and Reuse held in Washington, D.C., in May 1998.

Scope of the NRC Initiative

The committee's charge was to

(1) Assess best management practices and emerging technologies for reducing adverse environmental impacts;

(2) Appraise interim control measures for use at contaminated sediment sites;

(3) Address ways to use and communicate information about risks, costs, and benefits to guide decision making; and

(4) Assess current knowledge and identify research needs for enhancing contaminated sediment remediation technology.

Technical information was reviewed and assessed. Committee members interacted closely with researchers, regulators, stakeholders, engineers and operators. Six case studies of contaminated sediment remediation were evaluated and one sediment remediation project site was visited. In addition, the committee conducted workshops on interim controls and long-term technologies, summarized site assessment methods, and evaluated the application of decision tools to the contaminated sediment management process. The results obtained from these tasks then were assembled and organized under three major categories: remediation technologies, project implementation, and decision making.

Remediation Technologies

Remediation technologies were grouped into four categories: interim control, in situ management, sediment removal and transportation, and ex situ management. The technologies were compared qualitatively in terms of state of maturity, frequency of usage, scale of application, cost per cubic yard, and use limitations. They were then scored and ranked according to four criteria:

effectiveness, feasibility, practicality, and cost. The committee also addressed the need for remediation technology research, development, testing, and demonstration. The following conclusions and recommendations were then formulated:

• Capping, containment and natural recovery are effective management methods for most contaminated sediments. Where remediation is necessary, high-volume low-cost technologies are the first choice, assuming they are feasible and succeed in attaining the required risk reduction for protecting human health and the environment. Because treatment is expensive, reducing volume is important.

• Treatment is usually justified only for relatively small volumes of highly contaminated sediments. Advanced treatment is too costly in the majority of cases, which typically involve low-level contamination.

• Cost data for full-scale remediation systems must be improved to allow for fair overall comparisons and development of benchmarks for R&D and systems design. Regulatory agencies should develop guidelines for calculating costs of remediation systems, including technologies and management methods. The agencies should maintain a database on the costs of systems that have actually been used.

• Natural recovery is viable and can be considered as an optimum remediation solution when contaminant concentrations are low. If natural recovery is not feasible, capping may be appropriate to reduce bioavailability. Monitoring is required to test the efficacy of capping. The use of capping might be advanced if it were viewed as a permanent remedy under Superfund.

• In situ chemical treatment has conceptual advantages but considerable R&D will be needed before successful application can be demonstrated. Similarly, using bioremediation to treat in-place sediments requires further R&D to resolve microbial, geochemical, and hydrological issues. Given the high costs of ex situ treatment relative to dredging, dredging technologies must be improved to enable sediment removal at near in situ densities and precise removal of contaminated sediments to limit the capture of clean sediments and water. In this manner, the volume of dredged material requiring containment or treatment can be reduced.

• Research is needed to improve control of contaminant releases, long-term monitoring methods, and techniques for preserving the capacity of confined disposal facilities (CDFs).

• The potential for constructing contained aquatic disposal (CAD) facilities on or near contaminated sites must be explored fully. Regulatory agencies should support research to improve design tools for preventing containment failure, improve monitoring methods for assessing long-term performance, control contaminant loss, and determine risk-reduction effectiveness through contaminant isolation.

• Regulatory agencies should support research for promoting the reuse of CDFs and CADs and for improving tools for the design and evaluation of their long-term stability and effectiveness.

• R&D on ex situ treatment technologies is warranted in the search for cost-effective treatment of large sediment volumes. Bench- and pilot-scale testing of ex situ treatment technologies—and eventually full-scale demonstrations in marine systems—are needed to improve cost estimates, resolve technical problems, and improve treatment effectiveness.

• Additional R&D and demonstration projects are needed to improve technologies and reduce risks associated with developing and implementing innovative approaches. The advancement of cost-effective and innovative technologies could be facilitated by peer review of R&D proposals and side-by-side demonstrations of new and current technologies. Regulatory agencies should develop a program to support such R&D and demonstration projects.

Project Implementation

Although improvements in remediation technologies would contribute to cost-effective contaminated sediment management, a variety of practical issues must be addressed to remove constraints in project implementation. These include responsibility for source control, site characterization needs and technologies, interim controls, and promotion of beneficial uses. The committee's conclusions and recommendations regarding these issues included the following:

• Since ports currently bear an unfair share of the responsibility for remediation and placement of contaminated sediments, project implementation should transfer the burden for source control to states and polluters. Federal and state regulators, together with the ports, should investigate the use of appropriate legal and enforcement tools to require the upstream contributors to the contamination to share equitably in the cleanup costs.

• New and improved techniques are needed to reduce the costs and enhance the precision of site assessments. The use of remote sensing technologies—including rapid and accurate sensors—might accomplish this goal. Regulatory agencies should support R&D to advance the state of science in site-assessment technologies. Objectives should include the identification and development of advanced survey approaches and new and improved chemical sensors for surveying and monitoring.

• Where sediment contamination poses an imminent danger, administrative and engineering or struc-

tural controls can be used to reduce risks to humans and to ecological receptors from exposure to contaminated sediments over the short term, until a more permanent remedy can be implemented.

• Beneficial uses of dredged contaminated material can provide socially acceptable disposal alternatives. These uses could include, for example, creation of islands for seabird nesting, landfills for urban development, beach nourishment, wetlands, shoreline stabilization, topsoil for landfill covers, and other potential marketable uses. Regulatory policies developed to allow for placement strategies that incorporate the beneficial use of contaminated sediments should be enhanced. Regulatory agencies involved in contaminated sediment disposal should develop incentives for—and encourage implementation of—beneficial-use alternatives. Funding should be continued for R&D of innovative beneficial uses of contaminated sediments and the development of technical guidance and procedures for environmentally acceptable beneficial reuse.

Decision Making

Factors influencing decision making include regulatory realities, stakeholder interests, site-specific characteristics and data uncertainty, and availability of remediation technologies. The committee examined all of these factors and developed the following conclusions and recommendations:

• Stakeholder involvement early in the decision process is important to head off disagreements and build consensus among all involved. When decisions are complex and divisive, obtaining consensus among stakeholders can be facilitated by using formal, analytical tools, such as decision analysis.

• The trade-off evaluation of risks, costs, and benefits, and the characterization of their uncertainties in selecting a preferred management alternative offers the best chance for effective management and communication of the decision-making process to stakeholders. Risk analysis is an effective method for selecting and evaluating management alternatives and remediation technologies. More extensive use of appropriate methods for cost-benefit analysis has the potential to improve decision-making.

• Regulatory agencies should sponsor research to quantify the relationship between contaminant availability and corresponding human health and ecological risks. The main goal is to evaluate sediment remediation projects using performance-based standards, i.e., risk reduction from in-place sediments, disturbed sediments, and sediments under a variety of containment, disposal, and treatment scenarios. This is critical to the successful trade-off evaluations of risks, costs, and benefits to make technically defensible decisions in selecting a management alternative.

• The use of systems engineering can strengthen project cost-effectiveness and acceptability. In choosing a remediation technology, systems engineering can help ensure that the solution meets all removal, containment, transport, and placement requirements while satisfying environmental, social, and legal demands.

• Federal, state, and local agencies should work together with appropriate private sector stakeholders to interpret statutes, policies, and regulations constructively, so that negotiations can move forward and sound solutions are not blocked or obstructed.

• Regulatory agencies should continue to develop uniform or parallel procedures to address human health and environmental risks associated with freshwater, marine, and land-based disposal, containment, or beneficial reuse of contaminated sediments.

• Regulatory agencies should develop and disseminate information to stakeholders regarding the availability and applicability of decision analysis tools; appropriate risk analysis techniques for use throughout the management process, including the selection and evaluation of remedial alternatives; and the demonstration and appropriate use of decision analysis in an actual contaminated sediment remediation case.

• Existing cost-benefit analysis guidelines and practices developed by regulatory agencies should be modified to ensure comprehensiveness and uniformity in method application.

Summary

There are no simple solutions to the problems created by contaminated marine sediments. However, the NRC study summarized here indicates that careful problem formulation and good information provide the foundation for good decisions in managing contaminated sediments. Incremental improvements can be made in remediation technologies, project implementation, and decision-making and can result in cost-effective, socially acceptable, and environmentally sound solutions.

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