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FRAMEWORK FOR THE DEVELOPMENT OF THE NATIONAL SEDIMENT INVENTORY

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EXECUTIVE SUMMARY

In 1992, the U.S. Environmental Protection Agency (EPA) issued its draft Contaminated Sediment Management Strategy, which included a recommendation for the development of a national inventory of contaminated sediment sites. Also in 1992, Congress passed the Water Resources Development Act of 1992 (WRDA), which required EPA, in consultation with the National Oceanic and Atmospheric Administration (NOAA) and the U.S. Army Corps of Engineers (COE), to conduct a comprehensive national survey of data regarding aquatic sediment quality in the United States. In an effort to help meet the objectives of EPA's Contaminated Sediment Management Strategy and to comply with the mandates of the WRDA, EPA has initiated the development of the National Sediment Inventory (NSI). This document presents a framework for the development of the NSI. Included are a discussion of potential EPA program uses for the Inventory, a review of existing background studies and pilot inventories, a discussion of options considered for the development of the Inventory, a description of the option selected, and a summary of existing sediment assessment techniques.

The NSI will provide EPA with the ability to conduct a near-term screening assessment of the national extent and severity of sediment contamination across the country. Such an assessment would include the identification of sites that should be targets for future, more intensive study, either to justify and recommend regulatory actions for those sites which pose an obvious risk to the environment or to gather additional information for those sites which appear to be contaminated but for which there are insufficient data to reach a definitive conclusion. In addition, the Inventory will provide valuable information to assist EPA in achieving the other, more long-range goals of its draft Contaminated Sediment Management Strategy concerning pollution prevention, remediation, and dredged material management. Data in the Inventory can help EPA to identify point and nonpoint source discharges contributing to sediment contamination, identify chemicals of concern, and set priorities for their control. The Inventory will also provide information to assist in identifying and prioritizing sites for enforcement and remediation and in identifying technically and economically feasible alternatives for remediation. For dredged material management, data in the NSI can provide initial screening information to program managers concerning the location of potential and probable contaminated sites and identification of contaminants of concern.

EPA recently conducted a review of several existing studies of contaminated sediment problems and contaminated sediment inventory pilot studies. The purpose of this review was to assess the current understanding of problems associated with contaminated sediments and to build on the experience of other programs during the

development of the Inventory. The following sources of information were reviewed as part of this effort:

- *National Perspective on Sediment Quality* (Bolton et al., 1985);
- *An Overview of Sediment Quality in the United States* (Lyman et al., 1987);
- *Contaminated Marine Sediments—Assessment and Remediation* (NAS, 1989);
- *Summary Report for Contaminated Sediments Assessments in U.S. EPA Region IV Coastal Areas* (USEPA, 1991b) and *Draft Evaluation of the Region 4 Inventory of Coastal Sediment Sites* (USEPA, 1992a);
- *EPA Region 5 Inventory of Contaminated Sediment Sites* (USEPA, 1992b);
- The Gulf of Mexico Program's Toxic Release and Contaminated Sediment Inventories (TRI, 1992; unpublished information); and
- *Proceedings of EPA's Contaminated Sediment Management Strategy Forums* (USEPA, 1992d).

The review of these studies provided considerable insight into methods for evaluating contaminated sediments and the potential extent of sediment contamination. Examination of the pilot inventories also helped identify a number of concerns related to the development of the NSI, including the capabilities of different systems and software for performing data searches and compilations and the possibilities for storing detailed monitoring data or summary data in relational, searchable databases that would be nationally accessible.

Several options for the design of the NSI were considered in an attempt to address these and other concerns. Initially consideration was given to housing the NSI in an existing database system such as ODES (the Ocean Data Evaluation System) or STORET (the STOrage and RETrieval System). Because of data entry cost and data accessibility concerns, these options were ruled out until a modernized STORET system is available. The following options were given final consideration:

- Create an inventory of summary data only compiled by either EPA Headquarters or the Regions or
- Create an inventory of detailed monitoring data compiled by either EPA Headquarters or the Regions.

Based on an evaluation of the advantages and disadvantages of each of these options, EPA decided to create an inventory using detailed monitoring data. This inventory

will be compiled initially by EPA Headquarters and will include data from several potential sources, including:

- Select data sets from STORET, e.g.,
  - COE
  - U.S. Geological Survey (USGS)
  - EPA
  - States
  - BIOACC
- NOAA's National Status and Trends (NS&T) Program database
- ODES
- Region 4 Sediment Inventory
- Region 5 Sediment Inventory
- Gulf of Mexico Program Sediment Inventory
- COE Seattle District Sediment Inventory
- Great Lakes Sediment Inventory
- Environmental Monitoring and Assessment Program (EMAP)
- National Estuary Program (NEP)
- Fish and Wildlife Service (FWS)
- MacDonald Database
- USGS
- National Source Inventory

These and other sources of data will be evaluated for inclusion in the NSI. The determination as to whether a given database will be included in the Inventory will be based in part on the difficulty in obtaining the data, difficulty in analyzing the data, and compatibility with other data. Available resources will also be a consideration when determining which data sets to include.

Four major categories of detailed monitoring data will be collected for the development of the NSI (Table 1). Several minimum data parameters have been identified under each of these major categories. Some must be included in a database before the data will be added to the NSI; others would be desirable, but their absence

Table 1. National Sediment Inventory Data Category Summary

Minimum Data Element	Necessary	If Available	Comments
DATA RECORD			
In Computerized Format	●		With data dictionary specifying field names, widths, delimiters, or file structure
Location	●		Including waterbody name
Sampling Date	●		
Lat/Long	●		Conforming to EPA standards
Reach Number		●	
SITE CHARACTERISTICS			
Land Use		●	Urban, industrial, rural, etc.
Management Status of Site		●	Remedial actions, etc.
Location of Haz Waste/Superfund Site		●	
Spill Information		●	
Frequency of Dredging		●	i.e., dredging history
Point Source Information		●	Current/historical
Presence of Endangered Species		●	
QA/QC			
Source of Information	●		Sponsor or client name and address, name of analytical lab or principal investigator and address
Lab Methods		●	Quality of data to be coded, method detection limits used in analyses to be included
Field Methods		●	Quality of data to be coded
SAMPLING PARAMETERS			
Sediment Chemistry	●		
Total Organic Carbon		●	
Grain Size		●	
Acid Volitile Sulfides		●	
Biological Data		●	Biotoxicity, bioaccumulation
Fish Advisories		●	
Benthic Abundance		●	Benthic infauna, community, other indices
Fish Pathology		●	

would not necessarily preclude data from being entered.

It should be noted that although no data set will initially be excluded from the NSI because of a lack of information on quality assurance/quality control (QA/QC) procedures or concerns associated with the QA/QC procedures employed, EPA believes that information regarding the quality of monitoring and analytical data should be considered when identifying and evaluating potential and probable contaminated sediment sites. Therefore, EPA is preparing to include with the data in the NSI a basic screening assessment of the potential or probable quality of data (if known) from a particular data set. The name and address of a database contact will also be provided to allow the user of the data to acquire specific information concerning QA/QC samples, methods, and results. The results of QA/QC analyses will not be included in the NSI.

Once the NSI is in place, the data will be evaluated to identify those sediment chemistry sample observations which exceed predetermined threshold limits for each contaminant. (EPA is currently evaluating existing sediment assessment techniques that could be used to establish these thresholds.) The results of this evaluation will be a computer-generated detailed listing of all observations that exceeded the sediment quality threshold limits. Potential areas of concern will include those sites with sufficient information to be classified as contaminated as well as sites in need of further assessment. Additional data related to each river or coastal reach segment (based on EPA's Reach File) in which a sediment sample that exceeded a given threshold was taken will also be included in the NSI. Such information will include, when available, bioassay, bioaccumulation, benthic abundance, fish pathology, and fish advisory data. These data will be included to allow the users of the NSI to assess the correlation between sediment chemistry data and biological and other data.

All EPA Regional Offices will be sent a copy of the preliminary assessment and data for review. The Regions will then be asked to review and comment on the information presented. Specifically, they will be asked to identify and provide additional computerized databases not included in the NSI that can supplement the information presented. They will also be asked to gather additional QA/QC information for data taken from their Region that were included in the NSI but about which little or nothing is known concerning the QA/QC samples and procedures used when gathering and analyzing samples. Following Regional review, EPA Headquarters will enter the appropriate new data sets into the NSI and update the QA/QC and other information based on the input from the Regions. The data in the NSI will then be evaluated a second time.

Each of the sites identified based on the second, more complete evaluation of the data in the NSI will be categorized as either those for which sufficient data exist to characterize them as causing high risks or severe effects (probable contaminated sites) or those which may be contaminated but for which additional information and further assessment are needed (potential contaminated sites). This final categorization will be based on consideration of a number of factors, including the following:

- Number of chemicals exceeding threshold limits;
- Number of observations exceeding threshold limits;
- Severity of contamination (i.e., concentration of contaminants of concern);
- Biological evidence of contamination and impacts to support conclusions based on sediment chemistry data;
- Fish advisory information; and
- Quality of data used to identify the site as contaminated.

The final listing of sites resulting from the assessment of data in the NSI will represent a snapshot of sediment contamination problems across the country. Any site listed would be a target for future, more intensive study, either to justify and recommend regulatory actions for those sites that pose an obvious risk to the environment or to gather additional information for those sites which appear to be severely contaminated but for which there are insufficient data to reach a definitive conclusion.

The data compiled as part of the NSI can help managers prioritize future remediation, regulatory, or assessment activities; guide decisions regarding the appropriate type and scale of regulatory action needed to reduce contaminant inputs; and evaluate the effectiveness of existing technology-based effluent guidelines, water quality-based controls, and nonpoint source controls. The NSI data can also be used to help identify and prioritize on a local, state, regional, or national level those specific chemicals in need of stricter regulation.

EPA recommends that the NSI be maintained and updated on a regular basis to allow future assessments of sediment quality on a local and regional basis as well as nationwide. EPA also recommends that efforts be made to ensure that future sediment quality monitoring programs include additional information and parameter measurements (which may currently be missing from many data sets), which can be used to more accurately assess the potential environmental impacts of sediment contamination during future assessments. For example, sediment sampling programs should include the measurement of total or percent organic carbon content, sediment particle size, sediment reductive capacity, and salinity. The data should also meet certain minimum data quality objectives, and results of data quality evaluations should be reported with the data or, at a minimum, the QA/QC samples and procedures used should be identified.

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CHAPTER 1

INTRODUCTION

In recent years, the contamination of sediments in waterbodies of the United States has become a national ecological and human health issue of concern. In response to this concern, the U.S. Environmental Protection Agency (EPA) has proposed its draft Contaminated Sediment Management Strategy. One of the recommendations of this draft strategy is the development of a national inventory of contaminated sediment sites. In addition, recent legislation passed by Congress (the Water Resources Development Act of 1992, or WRDA) requires EPA to develop by 1994 a national inventory of sites with contaminated sediments. The purpose of this document is to present the proposed framework for the development of an inventory of contaminated sediment sites that will fulfill both the objectives of EPA's Contaminated Sediment Management Strategy and the mandates of the WRDA.

Background

Sediments have been described as the ultimate sink for pollutants (Salomons et al., 1987). If that were entirely true, however, there would be no need to be concerned about potential impacts from sediment-associated compounds. In fact, sediments can function as both a source of and a sink for contaminants in the aquatic environment, and they are capable of releasing contaminants to the overlying water and biota slowly over extended periods of time or very quickly due to natural or human perturbations. Likewise, compounds in sediment deposits may build up over time as a result of inputs from a combination of sources. The following sections present a brief overview of the potential sources of sediment contamination, the transport and fate of sediment-associated contaminants, and the potential environmental effects of these contaminants.

Sources

The problem of in-place, sediment-associated pollutants is both widespread and localized. All regions of the United States and all types of waterbodies are affected. Waterbodies usually receive both point and nonpoint discharges of pollutants as a result of the various human activities that take place there. For instance, bays and harbors are associated with contaminant sources from shipping, among other activities. Upper reaches of streams are usually polluted by local sources. Harbors, streams, and estuaries bordered by industrialized or urbanized areas tend to have elevated levels of metals, organics, and other compounds associated with human activity (Lyman et al., 1987). Sometimes the contamination is localized beneath an outfall of industrial or municipal waste; in other cases, natural mixing processes and dredging disperse the pollutants. Nonpoint sources of pollution such as surface water runoff and atmospheric deposition can also

contribute to widespread sediment contamination. In addition, pollutants from upstream sources are discharged into waterbodies by rivers and contribute further to the problem of sediment contamination.

The ubiquitous nature of trace organic and metal compounds in sediments near urban and agricultural areas and the association of large inputs of these contaminants with runoff events tend to support the importance of contributions from nonpoint sources, such as atmospheric deposition and land drainage. For example, mining is an significant source of sediment contamination in some regions, as are runoff and seepage from landfills, Superfund sites, and urban and agricultural runoff (Hoffman, 1985; Livingston and Cox, 1985; Ryan and Cox, 1985; Baudo and Muntau, 1990). Pollution from nonpoint sources is primarily related to land use characteristics. Agricultural runoff may contribute selenium, arsenic, and mercury and a wide variety of pesticides. Urban runoff is a frequently mentioned source of heavy metals, polychlorinated biphenyls (PCBs), and polycyclic aromatic hydrocarbons (PAHs). However, it is often difficult to determine the fraction of these contaminants contributed by runoff versus point source discharges because the same contaminants can come from both (Baudo and Muntau, 1990).

Although nonpoint sources may contribute the largest quantities of contaminants to the aquatic environment, the combined effect of varied source locations, hydrology, and sediment characteristics can lead to a large variability in the concentrations of contaminants found in a waterbody as a result of nonpoint sources (Lyman et al., 1987). Point source releases, including accidental or deliberate discharges, may result in elevated localized contamination. Purposeful and accidental contaminant additions include effluent discharges, spills, dumping, and the addition of herbicides to lakes and reservoirs. Both industrial and municipal point sources contribute a wide variety of contaminants to sediments. Municipal point sources include sewage treatment plants and combined sewer overflows (CSOs). Industrial point sources include chemical plants, pulp and paper mills, steel mills, metal-working plants, electroplating plants, tanneries, refineries and other petroleum industries, engine and automotive industries, and many other industrial categories.

Transport and Fate

Sediment contamination may be contributed in the form of solids (e.g., mine tailings), or contaminants may be discharged in the aqueous phase and sorbed onto sediments, which are then deposited. The residence time of contaminants in sediments depends on a number of biological, chemical, and physical factors such as the degree of binding to sediments and the degradation rate. Physical factors are perhaps the most important, however, because compounds that find their way to sediments tend to be those which are moderately to strongly sorbed, somewhat

volatile, and chemically stable (Gillett, 1983). Rivers with sufficient discharge velocity to resuspend sediments may flush themselves clean once inputs of contaminants cease. On the other hand, deep lakes and reservoirs act as giant settling basins for contaminated sediments and provide long residence times due to relatively limited resuspension, compared to rivers and near coastal environments. Dissolved compounds entering lakes, reservoirs, and especially estuaries and marine environments may precipitate, may flocculate, or may be scavenged by sorption onto other particles and thereby be incorporated into bottom sediments.

Once compounds reach the sediment, they are hardly static. Sediments should be viewed as dynamic systems. Not only are compounds transported with sediments through various physical processes including settling, resuspension, and deposition, but chemical reactions can also change the particle matrix and the chemical characteristics of sorbed contaminants. Infaunal organisms also redistribute sediments through their burrowing and home-building activities and are capable of unearthing old deposits (Krezoski and Robbins, 1985). Some animals feed by ventilating their burrows, which facilitates contaminant exchange with the water column (McCaffrey et al., 1980).

Biological and chemical processes affecting sediment contamination include sorption and desorption, degradation of organic matter, transformation of iron and manganese oxyhydrates to sulfides and vice versa, and biotransformation of contaminants by in situ macro- and microorganisms. These processes depend somewhat on sediment characteristics. Fine sediments tend to adsorb larger quantities of pollutants per gram than do coarse sediments because of their relatively higher surface area. Sorption of organic material to sediments is controlled to a large degree by the organic carbon content of the sediment. The higher the organic carbon content, the greater the ability of the sediment to bind and thereby accumulate organic pollutants, sulfur, and some metals. Enhanced sorption may also reduce the bioavailability of the contaminant to aquatic life.

Bioaccumulation and Potential Environmental Effects

Contaminated sediments can affect aquatic life by making some areas uninhabitable, by providing a source of contaminants to the aquatic food chain, and by adversely affecting the health of organisms (Lyman et al., 1987). For example, fin rot and a variety of neoplastic lesions have been found in fish living above sediments contaminated by PAHs located near a creosote plant on the Elizabeth River in Virginia, while liver tumors and skin lesions have occurred in brown bullheads from the Black River in Ohio, contaminated by PAHs from a coke plant (USEPA, 1992d).

Bioaccumulation of contaminants in fish tissue and contamination of the food chain are also important human health concerns because the consumption of fish represents the most significant route of aquatic exposure of humans to many metals and organic compounds (USEPA, 1992d). Many surface waters have fish consumption advisories or fishing bans in place because of the high concentrations of PCBs, mercury, dioxin, kepone, and other contaminants. There are currently at least 1,183 fish consumption advisories in place in the United States, affecting all but five states (Allison Greene, USEPA, Risk Assessment and Management Branch, Standards and Applied Science Division, Office of Science and Technology, telephone conversation, 19 November 1992). Water supplies also have been closed because of contaminated sediments, and in some places swimming is no longer allowed. Most sediment-related human exposure to contaminants is through indirect routes involving the transfer of pollutants out of the sediments and into the water column or the biota.

Several recent assessments of existing data on the Nation's marine and freshwater sediments indicate widespread and potentially serious contamination problems. However, some researchers and resource managers believe that sediment contamination problems are not widespread but limited to "hot spots" caused by historical rather than ongoing pollutant discharges. Thus, an inventory and evaluation of sediment quality data and associated information will yield greater insight into the nature and extent, as well as the causes, of sediment contamination in both freshwater and saltwater systems.

Purpose of the National Sediment Inventory

EPA proposed the development of a national inventory of contaminated sediment sites as part of the draft outline of the Agency's Contaminated Sediment Management Strategy, distributed on March 5, 1992 (USEPA, 1992c). The goals of this proposed strategy are the following:

- Prevent ongoing contamination of sediments that may cause unacceptable risks to human health or cause ecological harm, so that beneficial uses of the Nation's surface waters are maintained;
- When practical, clean up existing sediment contamination that adversely impacts the Nation's surface waters or their uses or that causes other significant effects on human health or the environment; and
- Ensure that sediment dredging and the disposal of dredged materials continue to be managed in an environmentally sound manner.

The Strategy is designed to help coordinate sediment quality assessment and management activities of EPA program offices and Regions, as well as other federal, state, and local agencies. The Strategy presents a plan of action for assessing, preventing, and remediating sediment contamination and for supporting ongoing Agency programs for the management of dredged material. EPA's proposed Contaminated Sediment Management Strategy has been presented at a series of public forums. The Agency is in the process of revising the Strategy, taking into consideration comments and recommendations voiced during the national forums as well as in formal written comments (USEPA, 1992d). Individuals who commented on the Strategy were in general very supportive of a national inventory of contaminated sediment sites but raised concerns regarding the quality of data included in the inventory and how this information will be used in the future management of contaminated sediments in the United States.

While EPA was developing the NSI as part of its Contaminated Sediment Management Strategy, Congress passed the Water Resources Development Act (WRDA) of 1992. This Act requires EPA, in consultation with the National Oceanic and Atmospheric Administration (NOAA) and the U.S. Army Corps of Engineers (COE), to conduct a comprehensive national survey of data regarding aquatic sediment quality in the United States. As part of this requirement, EPA is to compile all existing information on the quality, chemical and physical composition, and geographic location of pollutants in aquatic sediment, including the probable source of such pollutants. The act requires EPA to report on the findings of this survey within 2 years of enactment of the WRDA.

To fulfill the statutory requirements of the WRDA and to advance the objectives of the Agency's Contaminated Sediment Management Strategy, EPA has begun the development of the NSI based on existing information. The purposes of this inventory are as follows:

- Obtain the best possible near-term assessment of the national extent and severity of sediment contamination (i.e., determine whether contaminated sediments are a localized, "hot spot" problem or a widespread, national problem);

- Identify areas that may be contaminated and in need of further assessment; and

- Identify areas with sufficient data to be characterized as causing high risks or severe effects so that Agency programs can target these areas for appropriate action.

In a parallel effort, EPA is also developing an inventory of potential sources of sediment contamination. Together, these two inventories will contribute to EPA's

ability to identify areas in need of enforcement or remediation or in need of reduced point and/or nonpoint source inputs of contaminants through increased effluent or best management practice (BMP) controls, as well as those areas in need of further assessment. These inventories will also be designed as a part of a comprehensive and continuing program to assess aquatic sediment quality trends over time and to assess the effectiveness of future sediment quality management programs.

As previously mentioned, the purpose of this document is to provide the framework for the development of the National Sediment Inventory. As part of this effort, an attempt has been made to identify the potential uses of such an inventory by various EPA program offices. A discussion of these potential uses is presented in Chapter 2 of this document. Chapter 3 presents a discussion of background studies and pilot inventories that were reviewed and provided insight and guidance for the development of the framework for the NSI. The options evaluated for the development of the Inventory are presented in Chapter 4. Chapter 5 presents the process selected for the development of the Inventory, its proposed structure, and the procedure to be used in reviewing and updating the information presented in the Inventory. Chapter 6 presents a summary of several sediment assessment techniques that are being considered for use in evaluating contaminated sediment data. The final chapter of this document presents the conclusions and recommendations for the continued maintenance of the NSI, which can be used for future assessments of national trends in sediment contamination.

CHAPTER 2

PROGRAM USES

EPA's Contaminated Sediment Management Strategy presents a plan for assessing, preventing, and remediating sediment contamination and supports ongoing Agency programs for the management of dredged material. The National Sediment Inventory (NSI) is an important tool that can contribute significantly toward fulfilling EPA's objectives related to each of these activities. The development of the NSI will represent a major step toward assessing the problem of contaminated sediment on a nationwide basis. The NSI will be a repository for sediment data that managers can use in conjunction with their own database systems to evaluate the extent and severity of sediment contamination across the country and to target chemicals for sediment criteria development. If the NSI is maintained and updated in the future, it can also be used in conjunction with other tools to assess trends in sediment quality and the effectiveness of existing regulatory programs at the federal, state, and local levels.

The NSI will contain a minimum set of data elements that must be present before data can be included in the database. These include information related to the sampling location, date, latitude/longitude, sediment chemistry, and source of data. Additional data that will be added if available include site characteristics such as land use, management status of the site, location of Superfund sites, spill information, frequency of dredging, point and nonpoint source information, and the presence of endangered species. Other QA/QC and sampling parameters to be added to the inventory if available include laboratory methods; field methods; total organic carbon (TOC); grain size (and other geological parameters); acid volatile sulfides (AVS); and biological, fish advisory, benthic abundance, and fish pathology data.

The NSI can contribute valuable data to assist EPA in carrying out its plan of action for preventing and remediating sediment contamination and for managing dredged material disposal. The potential uses of the NSI by various program offices related to these activities are summarized in Table 2-1. Examples of uses of the data in the NSI by EPA program offices related to their assessment, pollution prevention, remediation, and dredged material management activities are discussed below.

Assessment

Because assessment is the first step in identifying and remediating environmental pollution, EPA program managers could use data from the NSI as a screening tool to describe the nature and spatial extent of potential sediment contamination due to activities managed or regulated by their program area to determine whether the

Table 2-1. EPA Program Uses of the National Sediment Inventory

EPA Program Office	Relevant Statutes[a,b]	Program Uses of the National Sediment Inventory			
		Assessment	Pollution Prevention	Remediation	Dredged Material Management
Office of Air and Radiation (OAR)	1990 Amendments to CAA	Evaluate the contribution of atmospheric deposition to water and sediment quality problems	Target air pollutants contributing to regional-scale sediment contamination for revision of New Source Performance Standards (NSPSs) or establishment of more stringent National Ambient Air Quality Standards (NAAQSs)		
Office of Enforcement (OE)	OE's enforcement authorities are addressed in statutory authorities of other EPA programs listed	Target for inspection, enforcement, develop-ment of injunctive relief, and/or supplemental environmental projects	Identify need for injunctive relief and/or opportunity for supplemental environmental projects	Identify need for injunctive relief and/or opportunity for supplemental environmental projects	
Office of Emergency and Remedial Response (Superfund)	CERLCA/ SARA	Identify sites with potential contamination and possible follow-up in Superfund Site Assessment		Provide background data to supplement health and environmental risk data for the first stage of the Hazard Ranking System (HRS) Provide background data to identify Potentially Responsible Parties to initiate enforcement-based remediation	

Table 2-1. (Continued)

EPA Program Office	Relevant Statutes[a,b]	Program Uses of the National Sediment Inventory			
		Assessment	Pollution Prevention	Remediation	Dredged Material Management
Office of Federal Activities (OFA)	NEPA CAA §309	Evaluate the status of sediment quality and potential environmental issues Evaluate impacts of projects on sediment quality or impacts from sediment quality on projects	Identify opportunities for pollution prevention activities	Identify sites/areas where remediation can be used as a mitigative measure or project feature	Identify areas needing or requiring programmatic, long-term, and/or multi-agency NEPA analyses to address problems
Office of Federal Facilities Enforcement (OFFE)	OFFE's authorities are addressed in statutory authorities of other EPA programs listed Federal Facilities Compliance Act of 1992	Target for inspection, enforcement, develop-ment of injunctive relief, and/or supplemental environmental projects	Target and/or identify supplemental environmental projects and/or injunctive relief to prevent continuing sediment contamination	Identify need for supplemental projects and/or injunctive relief	Assist in characterizing sediment in dredged material management activities

Table 2-1. (Continued)

EPA Program Office	Relevant Statutes[a,b]	Program Uses of the National Sediment Inventory			
		Assessment	Pollution Prevention	Remediation	Dredged Material Management
Office of Pesticide Programs (OPP)	FIFRA §136(d)	Provide background data to estimate ecological and human health risks due to pesticides in sediments Target pesticides for further assessment Guide decisions regarding the appropriate type and scale of regulation	Target and prioritize pesticides for possible additional testing requirements, geographic labeling, or other restrictions, special review, or recommendation against reregistration Where endangered species are indicated as at risk, trigger review by the U.S. Fish and Wild-life Service (USFWS) and/or the National Marine Fisheries Service (NMFS)		

Table 2-1. (Continued)

EPA Program Office	Relevant Statutes[a,b]	Program Uses of the National Sediment Inventory			
		Assessment	Pollution Prevention	Remediation	Dredged Material Management
Office of Science and Technology (OST)	CWA §§301, 304, 307, 308	Evaluate effectiveness of existing technology-based effluent guidelines	Develop technology-based effluent guidelines for industries contributing to sediment contamination		
	CWA §304(a)	Target chemicals for sediment criteria development			
	CWA §303(d)		Recommend wider adoption of water quality-based (TMDL) discharge permitting and possible revisions of water quality-based limits in NPDES permits		
	CWA §404 and MPRSA §103	Evaluate the status of sediment quality in wetlands and coastal environments			Provide background data to evaluate the adequacy of existing tiered testing requirements for dredged material disposal
Office of Solid Waste (OSW)	RCRA §3004	Assist RCRA permittees in identifying past releases of contaminants		Identify waste disposal facilities possibly responsible for sediment contamination for corrective action	

Table 2-1. (Continued)

EPA Program Office	Relevant Statutes[a,b]	Program Uses of the National Sediment Inventory			
		Assessment	Pollution Prevention	Remediation	Dredged Material Management
Office of Toxic Substances (OTS)	TSCA §6	Estimate ecological and human health risks due to chemicals in sediments Target chemicals for further assessment Guide decisions regarding the appropriate type and scale of regulation	Identify and prioritize chemicals (Tier I review) for regulation and possible prohibition or use restriction	Identify possible violations of TSCA regulations and responsible parties for enforcement-based remediation Identify sediments requiring incineration or disposal in a TSCA-approved landfill because they contain PCB concentrations greater than 50 ppm	

Table 2-1. (Continued)

EPA Program Office	Relevant Statutes[a,b]	Program Uses of the National Sediment Inventory			
		Assessment	Pollution Prevention	Remediation	Dredged Material Management
Office of Wastewater Enforcement and Compliance (OWEC)	CWA §§301, 308, 402	Assess the extent and severity of sediment contamination by CSOs Identify potential sources of contaminated sediments Identify problem pollutants Evaluate whether current point source permit limits are sufficiently protective of human health and the aquatic environment Identify possible technology-based effluent discharge limit permit violations Identify sources that may be contributing to sediment contamination for further assessment and possible NPDES permit limits	Target CSOs and storm-water discharges requiring permits Identify multiple dischargers to single waterbodies with contaminated sediments for NPDES permit limits Target primary wastewater treatment dischargers for secondary treatment requirements Identify dischargers with permit violations responsible for sediment contamination for enforcement action	Identify dischargers with permit violations responsible for sediment contamination for enforcement-based remediation	
	CWA §§301, 304, 306, 307, 309, 402				

Table 2-1. (Continued)

EPA Program Office	Relevant Statutes[a,b]	Program Uses of the National Sediment Inventory			
		Assessment	Pollution Prevention	Remediation	Dredged Material Management
Office of Wetlands, Oceans and Watersheds (OWOW)					
• Assessment and Watershed Protection Division (AWPD)	CWA §303(d)	Evaluate the appropriateness of the TMDL program to address sediment contamination with the inclusion of releases of sediment pollutants to the water column in TMDL limits	Help prioritize watersheds for TMDL development		
	CWA §305(b)	Evaluate the quality of states' waters and prepare national water quality assessments			
	CWA §319	Evaluate the effectiveness of state nonpoint source control programs	Recommend more stringent nonpoint source controls and pollution prevention activities for land use practices contributing to sediment contamination		
	CWA §314	Evaluate the effectiveness of the Clean Lakes Program and identify emerging problems			

Table 2-1. (Continued)

EPA Program Office	Relevant Statutes[a,b]	Program Uses of the National Sediment Inventory			
		Assessment	Pollution Prevention	Remediation	Dredged Material Management
• Oceans and Coastal Protection Division (OCPD)	CWA §301(h)	Provide background data to assist in making decisions to grant waivers for secondary treatment discharge	Assist in evaluating the success of the discharger's monitoring program. Provide background data to monitor the effects of dumping into marine coastal waters		
	MPRSA §§201,202; CWA §403	Assess compliance with ocean discharge permits			
	MPRSA §§102, 103				Identification of chemicals of concern in the design of ODMDS monitoring plans
	CWA §320	Evaluate the extent and severity of sediment contamination in the Nation's estuaries			Supplement information gathering for Tier I assessments for additional chemical and biological testing
	CWA §115			Identify sites for potential removal of contaminated sediments through the Secretary of the Army	

Table 2-1. (Continued)

EPA Program Office	Relevant Statutes[a,b]	Program Uses of the National Sediment Inventory			
		Assessment	Pollution Prevention	Remediation	Dredged Material Management
• Wetlands Division (WD)	CWA §404 CWA §115	Evaluate the status of sediment quality in wetlands		Identify sites for potential removal of contaminated sediments through the Secretary of the Army	Supplement information for Tier I assessments for additional chemical and biological testing
Regional and State Programs					
• EPA Regions	Various federal and state legislation	Identify areas with potential and probable sediment contamination problems	Prioritize and develop management plans for affected waters	Provide background data to identify sites for enforcement-based remediation	Provide background information to develop Tier I assessments and develop feasible management alternatives
• States	Various federal and state legislation	Identify areas with potential and probable sediment contamination problems	Trigger voluntary state pollution prevention programs Identify waterbodies requiring TMDLs	Provide background data to identify sites for remediation	
• Great Lakes National Program Office	Great Lakes Water Quality Agreement	Supplement monitoring programs to determine compliance with existing regulatory programs and determine the need for remedial actions additional assessment activities	Prioritize and develop management plans for affected waters	Identify sites for remediation	

Table 2-1. (Continued)

EPA Program Office	Relevant Statutes[a,b]	Program Uses of the National Sediment Inventory			
		Assessment	Pollution Prevention	Remediation	Dredged Material Management
• Gulf of Mexico Program Office	CWA §104(b)(3)	Supplement monitoring programs to determine compliance with existing regulatory programs and determine the need for remedial actions additional assessment activities	Prioritize and develop management plans for affected waters	Provide background data to identify sites for remediation	
• National Estuary Program (NEP)	CWA §320	Supplement ongoing monitoring programs and determine the need for additional assessments Provide background data to develop characterization reports	Trigger voluntary pollution prevention programs		

[a]Statutes:
CAA - Clean Air Act
CERCLA/SARA - Comprehensive Environmental Response, Compensation, and Liability Act/Superfund Amendments and Reauthorization Act
CWA - Clean Water Act
FIFRA - Federal Insecticide, Fungicide, and Rodenticide Act
MPRSA - Marine Protection, Research and Sanctuaries Act
RCRA - Resource Conservation and Recovery Act
TSCA - Toxic Substances Control Act

[b]Programs may have statutory authority or oversight responsibilities.

sediments pose a threat. Several EPA program offices, including the Office of Air and Radiation (OAR), Office of Solid Waste (OSW), Office of Pesticide Programs (OPP), Office of Toxic Substances (OTS), Office of Water (OW), and others, could use the data in the NSI to consider the spatial scale over which sediments are contaminated by ongoing as well as historical sources of chemicals in an attempt to evaluate and improve the effectiveness of their existing regulatory programs.

Potential applications for evaluating the data in the NSI for assessment activities by EPA managers include:

- Evaluating the extent and severity of sediment contamination;
- Evaluating whether concentrations of contaminants are increasing or decreasing to determine whether current regulatory programs at the state, regional, and national levels adequately protect the quality of sediments;
- Monitoring the concentrations and types of contaminants in sediments surrounding discharges to assess compliance with current regulatory programs; and
- Targeting chemicals for sediment criteria development based on their geographic distribution and concentration in the sediments.

Office of Air and Radiation

The Office of Air and Radiation (OAR) is responsible for controlling the atmospheric deposition of contaminants under the Clean Air Act (CAA). As pointed out earlier, atmospheric deposition may be an important source of sediment contamination. The atmospheric loading of pollutants to aquatic systems has been demonstrated, and the potential for these contaminants to bind to sediments is significant. OAR could use the data in the NSI to assist in evaluating the presence of atmospherically-borne pollutants in contaminated sediments, using sediment chemistry data to determine whether existing control programs are effective.

Office of Enforcement

The Office of Enforcement (OE) is primarily responsible for the management, oversight, and direction of the Agency's enforcement program, including activity to enforce the Clean Air Act; Clean Water Act; Safe Drinking Water Act; Resource Conservation and Recovery Act; Comprehensive Environmental Response, Compensation, and Liability Act; Toxic Substances Control Act; Federal Insecticide, Fungicide, and Rodenticide Act; and Emergency Planning and Community Right-To-Know Act. The NSI will facilitate enforcement decision-making in a number of ways. First, the NSI will provide more reliable and consistent information than is currently readily available concerning risks posed by

contaminated sediment areas. Second, the NSI will provide valuable information useful in enforcement priority-setting. In certain individual enforcement actions, the NSI may also provide data to assist the Agency in (1) demonstrating an imminent and substantial endangerment (necessary in some causes of action), (2) providing key information on which appropriate injunctive relief can be fashioned, (3) demonstrating the gravity of the violations (relevant to the calculation of penalties), and (4) proving that violations occurred.

Office of Emergency and Remedial Response

The Office of Emergency and Remedial Response (Superfund) identifies, investigates, and remediates hazardous waste sites under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). Samples are collected to characterize releases of hazardous substances from a site and to determine whether such releases present a threat to human health, welfare, and the environment. In general, remediation program managers rely on states and Regions to bring to their attention sites with known or suspected contamination (USEPA, 1992d). Sediment chemistry and sampling location data from the NSI could supplement other data to assist in identifying areas where contamination is suspected, and states could use these data when developing their lists of sites for possible inclusion on the National Priority List (NPL) (USEPA, 1992d).

Where remediation activities have already been performed at selected Superfund sites, data from the NSI could assist in evaluating the success of the remediation by mapping sediment chemical concentrations over time and space at the remediated Superfund site.

Office of Federal Activities

The Office of Federal Activities is responsible for EPA's compliance with the National Environmental Policy Act (NEPA), as well as the NEPA environmental review program. The objective of the environmental review program is to ensure that EPA's general environmental expertise and regulatory experience are made available to federal decision-makers. This is carried out through interagency coordination early in relevant federal planning processes to identify significant environmental issues of concern to EPA; in-depth review of federal environmental impact statements and, as appropriate, environmental assessments; and follow-up coordination on actions where EPA has identified significant environmental impacts.

EPA could use the NSI for both the NEPA compliance and environmental review programs to obtain additional data on the affected environment and to help identify potential impacts of proposals.

Office of Federal Facilities Enforcement

The Office of Federal Facilities Enforcement (OFFE) is responsible for the enforcement of all applicable environmental statutes and regulations in which EPA has jurisdiction. This multimedia enforcement office establishes the framework that ensures that the federal government is accountable to the public for its environmental record. Using this accountability to establish credibility, OFFE's Ten-Point Strategic Plan calls for the office to enforce the law; increase citizen involvement in decision-making; incorporate environmental equity concerns; prevent pollution; accelerate the cleanup of CERCLA sites; accelerate the reuse of closed bases; promote the development of innovative technologies to improve and reduce the cost of environmental cleanup and management; address the environmental issues at the national nuclear weapons complexes; develop and implement multimedia enforcement; and ensure that federal agencies are receiving pertinent information and training with regard to environmental issues. OFFE could use the NSI in each of the 10 strategic points to ensure that the appropriate program office activities accurately reflect the federal facility environmental activities related to sediments. For assessment, this could include, but would not be limited to, the use of the NSI for targeted inspections and enforcement.

Office of Pesticide Programs

The Office of Pesticide Programs (OPP) reviews the uses of new and existing chemicals to be registered as pesticides in order to determine their effects on nontarget organisms (USEPA, 1992d). OPP managers could use the data in the NSI to help assess the extent or spatial scale of pesticides present in sediments to guide decisions regarding appropriate registration actions. The presence of high concentrations of a pesticide at numerous sediment sites nationwide may indicate that the chemical has a high potential for transport away from the point of application and thus represents a potential route of exposure for nontarget organisms and may cause unreasonable adverse effects on the environment. The NSI will include available data on site-specific toxicological and environmental effects, which OPP can use as part of its assessment procedure, outlined in *Hazard Evaluation Division, Standard Evaluation Procedure: Ecological Risk Assessment* (USEPA, 1986). The procedure involves the review of existing laboratory and field toxicological data for the registration of any pesticide.

Office of Science and Technology

The Office of Science and Technology (OST) is currently developing chemical-specific sediment quality criteria that will be used in several EPA programs to set point source limits, evaluate the quality of dredged material proposed for disposal, and evaluate contaminated sites for remediation (USEPA, 1989). OST could use the data in the NSI to assist in identifying target chemicals of concern for sediment criteria development by listing those chemicals which are present in the highest

concentrations and those which have the greatest spatial coverage nationwide. Once these chemicals are identified, they could be further prioritized for criteria development based on characteristics such as bioavailability, persistence, and bioaccumulation potential depending on the parameters included in the data set.

The data in the NSI could also be used to assist in evaluating the effectiveness of the technology-based effluent guidelines and water quality-based limits developed by OST. Sediment chemistry data could be overlaid with point source discharges to determine whether sediment contamination may be a problem at any of the discharge sites. The NSI could also be used as a tool to help identify contributions of chemicals from nonpoint source discharges (urban and agricultural). Further evaluation using biological parameters such as fish consumption advisories, biotoxicity and bioaccumulation studies, fish pathology and benthic community structure could help to determine the magnitude of the contaminated sediment problem.

Office of Solid Waste

The Office of Solid Waste (OSW) is responsible for assessing whether releases from hazardous waste treatment, storage, and disposal facilities have contaminated sediments and determines corrective action, including possible remediation under the Resource Conservation and Recovery Act (RCRA). EPA inspects facilities that have applied for a RCRA permit, as well as facilities that ceased operations before the deadline for submitting applications for a final RCRA permit. If the inspection indicates that there is sediment contamination, a more extensive inspection can be performed to determine the extent of contamination. Data in the NSI could supplement other data and assist managers in determining whether hazardous waste facilities are being properly managed by overlaying areas of high pollutant concentrations in the sediments with hazardous waste facilities.

The Office of Toxic Substances

Under the Toxic Substances Control Act (TSCA), the Office of Toxic Substances (OTS) is responsible for assessing the risks resulting from possible releases of existing and new chemicals that are manufactured, distributed, or disposed of. The NSI could be a useful tool to help identify chemicals that occur in areas of contaminated sediment and that should be considered for further review. The presence of a chemical at numerous sites nationwide may indicate that the chemical poses an unreasonable risk to human health or the environment (USEPA, 1990). The data in the NSI could help to identify aquatic life or human health problems at contaminated sediment locations caused by known chemicals if the appropriate biological parameters are included in the data set. OTS managers could use such information to select chemicals for further assessment.

Office of Wastewater Enforcement and Compliance

The Office of Wastewater Enforcement and Compliance (OWEC) is responsible for issuing National Pollutant Discharge Elimination System (NPDES) permits to control point source discharges into the Nation's waters. OWEC managers could use the data in the NSI to determine whether the NPDES discharges are contributing pollutants that lead to sediment contamination and to help prioritize NPDES permit limits to protect sediment quality. By overlaying sediment "hot spots" with NPDES permit locations, program managers could review the overlapping data sets to determine which NPDES permitted facilities might be contributing to environmental impairment. The NSI could also be used to help evaluate the extent and severity of sediment contamination potentially caused by combined sewer overflows (CSOs).

Office of Wetlands, Oceans and Watersheds

The Office of Wetlands, Oceans and Watersheds (OWOW) is responsible for several major programs that potentially deal with contaminated sediments, such as nonpoint source pollution control; watershed protection; and, with the Army Corps of Engineers, dredged material disposal in the oceans and coastal waters of the United States.

The Assessment and Watershed Protection Division (AWPD) could use the data in the NSI as part of its assessment of nonpoint source control programs. The data could help AWPD to identify areas of high concentrations of pollutants in the sediment where point source controls are in place. Total Maximum Daily Loads (TMDLs) are equivalent to the loading capacity for a waterbody. TMDLs are used in watershed management to allow the water resource manager to determine the most effective point and nonpoint source pollution controls for a watershed (USEPA, 1991a). The NSI could be used to help target waterbodies in need of TMDLs by identifying potential "hot spots" in the watershed. The data could also be used to help evaluate the effectiveness of existing TMDLs, especially for waterbodies where releases of contaminants from sediments may contribute to violations of water quality standards (USEPA, 1990).

The Oceans and Coastal Protection Division (OCPD) is responsible for assessing and preventing pollution in the marine environment. OCPD and its Regional counterparts assess potential impacts of ocean discharges and monitor the effects of ocean dumping into marine and coastal waters. OCPD managers could use the data in the NSI to support these activities by overlaying ocean discharge and disposal sites with sediment contamination data. The National Estuary Program (NEP), which is managed by OCPD, targets selected estuaries for national assessment and pollution prevention activities. The NEP's estuary programs could use the data in the NSI as part of the mandatory characterization phase to identify contaminated sites within the estuary and target these sites for further action.

Regional and State Programs

The NSI will identify areas with potential sediment contamination. The approach for the NSI includes coordinating data review with EPA Regional offices' and states' programs to ensure that all relevant data have been included and appropriately evaluated.

Other regional projects, such as the Great Lakes National Program Office (GLNPO), the Gulf of Mexico Program Office (GOMP), and the National Estuary Program (NEP), could use the NSI to supplement monitoring programs and to determine whether additional assessments are needed where data gaps exist. The NEP could also use the NSI as a source of background information for the preparation of estuary characterization reports.

Pollution Prevention

EPA program managers have several tools available to control and prevent the release of contaminants into the environment. Potential sources of sediment contamination can be controlled at the national level through the registration of chemicals, the restricted use of specific chemicals, and the development of chemical-specific sediment quality criteria. On a local or site-specific level, managers can implement pretreatment technologies at discharge facilities, modify existing NPDES permits, and implement best management practices and TMDLs for watershed management.

Potential applications for the data in the NSI for pollution prevention activities by EPA managers include assisting in the following activities:

- Identifying point and nonpoint source discharges, associated industries, and other factors contributing to sediment contamination;
- Identifying chemicals of concern to set priorities for further regulatory/planning activities;
- Assessing the effectiveness of existing technology-based and water quality-based controls and the need for stricter controls of discharges with high chemical concentrations; and
- Identifying areas in need of controls to reduce agricultural and urban nonpoint source inputs.

Office of Air and Radiation

Through the issuance of National Ambient Air Quality Standards (NAAQSs), OAR can control emissions that may contribute to atmospheric deposition, leading eventually to sediment contamination. If atmospheric pollutants are suspected as sources of sediment contamination, the standards could be reviewed and reissued to restrict these atmospheric inputs. The 1990 amendments to the CAA include new, more stringent requirements for controlling toxic air pollutants. These new requirements will address stationary-source emissions that may be sources of sediment contamination. The data in the NSI could be used to assist in evaluating the effectiveness of these new controls, as well as in determining whether additional controls are necessary for controlling atmospheric inputs.

Office of Enforcement

Several OE policies encourage the adoption of compliance projects in enforcement settlements that permanently prevent pollutants from entering the environment. The NSI could greatly facilitate the adoption of pollution prevention projects by defendants in EPA enforcement actions. Enforcement decision-makers could use the NSI to help identify target pollutants contributing to the sediment problem, and to negotiate enforcement settlements that implement process changes, technologies, and house-keeping practices that will prevent future contamination.

Office of Federal Activities

The OFA could use the NSI as a tool to identify opportunities for pollution prevention and assist in coordinating EPA and interagency programs in this area.

Office of Federal Facilities Enforcement

The data in the NSI could provide information to identify supplemental environmental projects that would prevent continuing sediment contamination.

Office of Pesticide Programs

The data in the NSI could be evaluated based on chemical concentrations and scope of contamination to assist in prioritizing pesticides for possible additional testing requirements, use restrictions, special reviews, or recommendations against reregistration (Southerland et al., 1992). If it is determined that a pesticide is causing an unreasonable risk to human health or unacceptable adverse effects on the environment, OPP has several options to control and prevent further contamination. If the problem appears to be national in scope, OPP can cancel the pesticide's registration and ban its use. In site-specific or localized situations, OPP can modify the label to control or restrict its use.

Office of Science and Technology

The NSI could be a useful tool to help assess the effectiveness of treatment technologies on the bioaccumulation or bioavailability potential of chemicals regulated under technology-based effluent guidelines. For example, if discrete amounts of a contaminant meet applicable effluent guidelines but sediment sampling around industrial discharges shows elevated levels of the contaminant, the current guidelines may need to be revised to reduce the potential for environmental effects.

OST managers could also use data in the NSI to assist in efforts to control nonpoint source pollution. For example, chemical data can be downloaded and used to evaluate the impacts to waterbodies of pesticide applications in a geographic area. If pesticide concentrations are found far away from the source, then stricter measures may be needed.

Office of Toxic Substances

OTS managers can use several risk management tools to control the release of chemicals into the environment, ranging from information gathering, to imposing use restrictions, to banning the use of the chemical entirely. The data in the NSI could provide useful information on the distribution of the chemical under consideration—whether it is widespread or highly localized—and thereby provide OTS managers with one means of evaluating the degree of potential human or environmental exposure, the populations or ecosystems at risk, and the need for regulatory action to reduce environmental effects.

Managers at OTS could also use the toxicological information in the NSI in conjunction with other data to score chemicals for their potential for environmental effects, including acute or other toxicity to organisms in the environment, bioaccumulation in fish tissue levels resulting in fish consumption advisories, or evidence of ecological effects such as alteration of the benthic community structure (Davies et al., 1979; USEPA, 1990). Sediment bioassay data, coupled with chemical concentration data, could be used to help assess the degree of bioavailability of sediment-associated compounds.

Office of Wastewater Enforcement and Compliance

OWEC managers could use data in the NSI to help target CSOs and stormwater discharges requiring stricter permit requirements if sediment contamination is shown to be significant at these sources. The NSI could be used to help identify industrial and municipal dischargers that contribute to contaminated sediments in order to revise NPDES permit limits. The sediment chemistry data in the NSI could also be used to help support enforcement actions against permit violators if

significant levels of sediment contamination are observed at an NPDES-permitted facility.

Office of Wetlands, Oceans and Watersheds

Within OWOW, the AWPD and OCPD program offices could use the NSI to help evaluate point and nonpoint sources of concern and to develop appropriate programs of research and activities to control or prevent pollutant discharges.

Regional and State Programs

Regional and state program offices could use the data in the NSI to prioritize and develop management plans for waterbodies with potential and probable sites of concern. Information from the NSI could also be used to implement voluntary pollution prevention programs within states and under the NEP.

Remediation

The remediation of contaminated sediments is expensive and time-consuming. The NSI could be used as a tool to help prioritize sites requiring remediation based on chemical concentrations and adverse environmental effects. The NSI could also be used with other, more site-specific data to help identify responsible parties and facilitate enforcement-based remediation by geographically linking sources of contaminants to the concentrations of chemicals found in sediments.

Potential applications of the NSI to support remediation activities include:

- Assisting in the identification of point and nonpoint source discharges contributing to sediment contamination;
- Providing additional data for evaluating site-specific environmental and human health threats resulting from sediment contamination;
- Providing additional data for identifying and prioritizing sites for remediation based on the spatial extent and severity of contamination;
- Helping to identify technically and economically feasible alternatives for remediation; and
- Providing additional data to help in prioritizing sites for enforcement activities based on the spatial extent and severity of contamination.

Office of Enforcement

The restoration of ecosystems damaged by noncompliance with environmental statutes is strongly encouraged by several statutes and OE policies. Ecosystem restoration and sediment remediation projects have been successfully implemented through EPA enforcement settlements with defendants. The NSI could assist enforcement decision-makers in targeting enforcement activity in part based on the potential for sediment remediation. The NSI could also, in certain individual cases, help to establish the specific enforceable requirements for sediment remediation projects implemented through enforcement settlements.

Office of Emergency and Remedial Response

Contaminated sites are evaluated on a case-by-case basis within the context of the Hazard Ranking System (HRS) to determine whether they should be placed on the NPL (*Federal Register,* December 14, 1990). Although the guidance provided under Superfund is not specific to sediments, the HRS has been modified to include an evaluation of both human health and ecological impacts due to contaminated sediment exposure. Information contained in the NSI could be useful during the first stage of the HRS. The level of danger to human health or the environment could be assessed for in-place pollutants based on the severity of problems at contaminated sediment sites, including harmful exposure of humans through consumption of contaminated fish (as evidenced by fish consumption advisories); severe alterations in benthic community structure in the presence of elevated levels of pollutants; a high incidence of fin rot, tumors, or other pathological indicators in fish inhabiting the area; and a high degree of toxicity in the sediments at that site to benthic organisms.

The data in the NSI, together with other site-specific data, could also be used to assist in identifying Potentially Responsible Parties (PRPs) by geographically linking sources of contamination to chemical concentrations found in the sediments.

Office of Federal Activities

The data in the NSI could be used in conjunction with other information to help determine whether remediation is necessary at a site. Remediation could be performed as a project feature or a mitigative measure.

Office of Federal Facilities Enforcement

OFFE could use the NSI data throughout the CERCLA process to ensure that clean-up activities include the evaluation of contaminated sediment, where appropriate, and to identify the need for supplemental projects and/or injunctive relief at these CERCLA sites.

Office of Solid Waste

Once contaminated sediments are found at hazardous waste facilities, OSW managers perform detailed assessments to determine the extent of contamination. The NSI could assist in determining the geographic distribution of contamination from historic or ongoing discharges of hazardous waste from a site.

Office of Toxic Substances

As mentioned for Superfund and OSW, OTS managers could use data in the NSI, along with other site-specific data, to help identify possible violations of TSCA regulations and responsible parties for enforcement-based remediation efforts by geographically linking sources of contamination to the concentrations of chemicals found in sediments. For example, under TSCA's PCB disposal rule, sediments may be remediated based on site-specific risks (USEPA, 1992d).

Office of Wastewater Enforcement and Compliance

Once it has been confirmed that a discharger has violated its permit and that the discharger has caused sediment contamination, OWEC managers could use the data in the NSI together with other data to help prioritize these violations in the order of severity of impacts, based on toxicological information, and initiate enforcement-based remediation efforts.

Office of Wetlands, Oceans and Watersheds

Remediation activities for OWOW are limited to OCPD. This program office could use the NSI to identify sites in marine and estuarine locations needing remediation and to help plan programs for contaminated sediment removal or other appropriate actions to be conducted through the Secretary of the Army.

Regional and State Programs

The NSI could assist various EPA Regional offices, the Great Lakes and Gulf of Mexico Programs, and the states in development of contaminated sediment remediation projects by providing background data to identify sites for remediation.

Dredged Material Management

Dredging of the Nation's waterways is necessary to maintain open shipping channels for commercial and recreational navigation. The COE estimates that approximately 3 percent of the 400 cubic yards of material dredged annually is highly contaminated and that an additional 30 percent is moderately contaminated (OTA, 1987). The data in the NSI could be used by dredged material management

programs to provide additional background information to help evaluate the need for chemical and biological testing of proposed discharges.

Potential applications of the NSI to support dredged material management activities include:

- Providing additional background data to help evaluate the potential for sediment contamination of material proposed for dredging and disposal (Tier I);
- Assisting in the identification of chemicals of concern that might be targeted for more extensive bioeffects studies (Tier III); and
- Providing additional background information in the design of management and monitoring activities after disposal of dredged material has occurred.

Office of Federal Activities

Because OFA is responsible for EPA's environmental review program, the data in the NSI could be used by OFA and regional environmental review programs to help assess the need for comprehensive, programmatic environmental impact studies to address long-range planning for dredged material management.

Office of Federal Facilities Enforcement

When sites are subject to environmental regulation, the data in the NSI could be used to assist in characterizing sediment in dredged material management activities.

Office of Science and Technology

OST could use the NSI data to evaluate whether the present tiered testing requirements for dredged material disposal are adequate to determine the potential for sediment contamination.

Office of Wetlands, Oceans, and Watersheds

OWOW's Oceans and Coastal Protection Division (OCPD) co-regulates with the COE the disposal of dredged materials in ocean waters under section 103 of the Marine Protection, Research and Sanctuaries Act (MPRSA). A tiered testing protocol has been developed to determine the dredged material's suitability for ocean disposal. The protocol consists of four tiers: evaluation of existing data on potential sources of contamination, sediment chemical analyses, acute bioassays and bioaccumulation tests, and biological community field studies (USEPA, 1992d). Managers could use the data in the NSI to provide additional background

information to assist in performing Tier I evaluations of the dredged material, which use existing data such as sediment grain size, chemical concentrations, evidence of fish tissue contamination, and records of spills or discharges to evaluate the need for chemical and biological testing. The NSI could also be useful in assisting managers in designing their monitoring programs at ocean disposal sites, particularly in situations where sediments have proven to be problematic in harbors; however, no sediment chemistry or bioeffects data have been collected from disposal sites (USEPA, 1992d).

OWOW's Wetlands Division (WD) and the COE regulate the discharge of dredged materials into waters of the United States under section 404 of the Clean Water Act (CWA). A testing manual for the evaluation of dredged material proposed for discharge under section 404 of the CWA is currently under development. Modeled after the manual developed for dredged material disposal in ocean waters, the manual includes an evaluation of existing data on potential sources of contaminants. Managers could use the data in the NSI to help determine the need for chemical and biological testing, as required in performing Tier I evaluations of dredged material.

Regional and State Programs

EPA Regional offices could use the NSI data to assist in developing appropriate Tier I assessments of sediments targeted for dredging and disposal. The NSI could also be used as a tool to help develop feasible management alternatives in cases where dredging of contaminated sediments has been prohibited.

CHAPTER 3

REVIEW OF BACKGROUND STUDIES AND PILOT INVENTORIES

Prior to the development of the framework for the National Sediment Inventory (NSI), EPA conducted a review of several existing studies of contaminated sediment problems and contaminated sediment inventory pilot studies. The purpose of this review was to assess the current understanding of problems associated with contaminated sediments and to build on the experience of other programs during the development of the NSI. The following sources of information were reviewed as part of this effort:

- *National Perspective on Sediment Quality* (Bolton et al., 1985);
- *An Overview of Sediment Quality in the United States* (Lyman et al., 1987);
- *Contaminated Marine Sediments—Assessment and Remediation* (NAS, 1989);
- *Summary Report for Contaminated Sediment Assessments in U.S. EPA Region IV Coastal Areas* (USEPA, 1991b) and *Evaluation of the Region 4 Inventory of Coastal Sediment Sites* (USEPA, 1992a);
- *EPA Region 5 Inventory of Contaminated Sediment Sites* (USEPA, 1992b); and
- Progress Report on the Gulf of Mexico Program's Toxic Release and Contaminated Sediment Inventories (TRI, 1992; unpublished information);
- *Proceedings of EPA's Contaminated Sediment Management Strategy Forums* (USEPA, 1992d).

The following presents a summary of the purpose, approach, and results of each of these studies.

National Perspective on Sediment Quality (Bolton et al., 1985)

In November 1984, EPA sponsored a Sediment Criteria Development Workshop to assist the Criteria and Standards Division (CSD) in focusing its efforts toward sediment criteria development. The workshop presented the results of a preliminary national-scale inventory of existing sediment concentration data. The early

nationwide inventory was developed to determine the amount of data available to assess the status of the Nation's sediments and to perform a preliminary assessment of the data. The review was not intended to be exhaustive, but rather to highlight the strengths and weaknesses of existing data. A specific issue addressed in the document was whether many of the Nation's sediments would exceed sediment thresholds, developed based on the Equilibrium Partitioning Approach, or whether the majority of sites would be considered "clean" with the exception of a few localized hot spots. Thus, the study attempted to identify the incidence and geographic distribution of sediments with high sediment contaminant concentrations to gain a perspective on the extent of the problem. In addition to existing sediment concentration data, field studies that related concentration data to biological effects were reviewed.

The study briefly discussed several approaches for formulating defensible sediment criteria, including the development of criteria based on the following:

- Concentrations at a reference site (i.e., the Background Approach);
- Existing water quality criteria:
  - Sediment-Water Equilibrium Partitioning Approach,
  - Water Quality Criteria Approach;
- A set of new criteria developed from additional testing of benthic organisms:
  - Sediment-Biota Equilibrium Partitioning Approach,
  - Bioassay Approach.

Because many of these approaches are yet to be fully developed and refined, only limited details of the original proposed approaches were given, with the exception of the Sediment-Water Equilibrium Partitioning Approach.

The preliminary national-scale inventory of sediment concentration data relied on both marine and freshwater data housed in STORET (EPA's STOrage and RETrieval System), as well as reports produced by state and federal agencies. The initial assessment of sediment contamination was conducted by comparing sediment concentrations to threshold values derived for this purpose. Where applicable, threshold values used for ranking concentration data in STORET were based on the Sediment-Water Equilibrium Partitioning Approach (JRB Associates, 1984a, b). No effort was made to judge the adequacy of the Equilibrium Partitioning Approach for establishing sediment criteria at that time. In the Equilibrium Partitioning Approach, threshold concentrations are extrapolated from water quality criteria Final Chronic Values by assuming that chemical equilibrium has been

established between the concentration of the compound in the aqueous phase of the sediment interstitial water and the concentration of the compound in the organic carbon phase of the sediment. Because most of the sample locations in STORET do not provide a value for sediment organic carbon content, for the purpose of the initial study an organic carbon content of 4 percent was assumed. Threshold values were also derived for metals using the Equilibrium Partitioning Approach, even though partitioning of compounds to organic carbon has received limited acceptance as a binding mechanism for metals.

For convenience, the concentrations reported in the monitoring data were divided into four ranges, designated as Level 1 (less than the threshold value), Level 2 (1-3 times greater than the threshold value), Level 3 (3-10 times greater than the threshold value), and Level 4 (greater than 10 times the threshold value). The number of measurements made that were less than the detection limit was also noted. As an exception, a background approach was used to establish the criterion for PAHs. A sediment total PAH concentration of 1 ppm dry weight was established as the cutoff between nonpolluted and slightly polluted sediments.

EPA initially identified 48 chemical contaminants for inclusion in the data review. These contaminants fell into seven chemical categories:

- Polynuclear aromatic hydrocarbons,
- Pesticides,
- Chlorinated hydrocarbons,
- Mononuclear aromatic hydrocarbons,
- Phthalate esters,
- Metals, and
- Miscellaneous.

As a result of difficulties in accessing the data (possibly due to the way in which the data were requested), of the 48 compounds identified, data were retrieved from STORET for only 22. Notable exclusions were found among the PAHs, including acenapthene, benzo(a)pyrene, naphthalene, fluoranthene, chrysene, and pyrene. (Fluoranthene was not identified as a chemical for this study.) Notable exceptions among the pesticides identified for the study included endrin and dieldrin. Over 255,000 data records were processed. No attempt was made to judge the quality of the data or the sampling techniques. Marine and freshwater data were processed

separately because of the relatively large amount of STORET data for sediments in streams, rivers, lakes, and reservoirs compared to marine data.

Information in STORET was augmented with biological information collected for the same sites from the literature. Many sources of information in addition to journal articles and publications in the open literature and federal agency reports were identified; however, there was time to review only information from the open literature. Other notable sources of information identified but not incorporated into this analysis included the National Oceanic and Atmospheric Administration's (NOAA's) Ocean Pollution Data and Information Network (OPDIN), the National Oceanographic Data Center (NODC) Marine Toxic Substances and Pollutants Data File, and the computerized inventory of long-term monitoring programs prepared for NOAA's Ocean Assessment Division.

National maps and maps of each region of the United States were provided as part of the completed national inventory to illustrate the geographic distribution of sites with high contaminant concentrations. For each chemical, the 200 highest concentrations, or average concentrations for sites with multiple measurements, were identified and plotted. Symbols for various compounds were drawn on the maps at approximately the latitude and longitude of the sampling site where that compound had been detected. The open literature was then examined in an effort to find information indicating a correlation between sediment concentrations and benthic community structure. This effort was hampered by the large number of parameters examined and the lack of case study data for many chemicals.

STORET contained extensive freshwater sediment chemistry data but generally lacked biological data. Some correlation was found between sediment concentrations and benthic community impairment discussed in the literature for metals, PCBs, and PAHs, but not for the other compounds. The number of freshwater locations where data were collected for each compound is shown in Table 3-1. Where more than one sample was collected at the same station, the values reported were averaged.

The freshwater data were analyzed by plotting a cumulative frequency distribution of the log of the concentration for each compound. Data points reported as zero were noted to give an indication of the proximity of the threshold value to the detection limit. To add some perspective, the median, 90th, and 95th percentile concentrations were identified on the cumulative frequency distributions. Log concentration versus cumulative frequency plots were developed for the PAHs acenapthene, anthracene, benzo(a)anthracene, fluorene, and phenanthrene and the pesticides aldrin, chlordane, DDT, heptachlor, lindane, and toxaphene. Of the PCBs, only Aroclor 1016 (1221) data were evaluated. Aroclor 1016 (1221) is a mixture of PCB congeners that contains a greater percentage of the lower chlorinated analogues than do other Aroclor mixtures. The threshold criterion for

Table 3-1. STORET Sampling Stations for Freshwater Sediments by Compounds

Chemical	Number of Freshwater Sampling Locations	Percent in Level 1	Percent in Level 2	Percent in Level 3	Percent in Level 4
Copper	300	99.9	none	0.1	none
Lead	32,000	92.5	5.0	1.5	1.0
Mercury	25,000	92	4.0	2.0	2.0
Zinc	23,000	96	1.5	1.5	1.0
Nickel	16,000	57	32	7.0	3.0
Arsenic	16,000	94	3.5	2.4	0.1
Cadmium	20,000	97.5	1.0	1.0	0.5
Acenapthene	400	all	none	none	none
Anthracene	400	all	none	none	none
Benzo(a)anthracene	1,500	all	none	none	none
Fluorene	400	all	none	none	none
Phenanthrene	400	all	none	none	none
Diethylphthalate	400	64	20	16	none
Dimethylphthalene	300	65	34	1	none
Aldrin	20,000	97	2	0.5	0.5
Chlordane	13,000	77	16	5	2
DDT	17,000	89	7	3	1
Heptachlor	13,000	98	1	0.5	0.5
Lindane	4,000	96	1	2	1.0
Toxaphene	13,000	82	14	2	2
Aroclor 1016 (PCB)	900	82	7	8	3
Cyanide	1,200	63	10	10	17

Aroclor 1016 had to be derived in a special manner for the mixture or an assumption would have to be made regarding the most important component. Pavlov's approach (JRB Associates, 1984a) was used to derive threshold values for Aroclor 1016, which resulted in a threshold value believed to be lower than that for PCBs as a group. A threshold value of 0.28 mg/kg was used for both freshwater and marine areas, based on the water quality criterion for hexachlorobiphenyl.

The cumulative frequency diagrams for chemicals having over 5,000 points plotted as smooth s-shaped curves. The most useful information provided by the study of freshwater sediments was an illustration of the general scope of potential problems based on the percentage of sites above the threshold concentrations of the various contaminants.

STORET data for metal concentrations in freshwater sediments were quite extensive. For the metals lead, mercury, zinc, nickel, arsenic, and cadmium, the

database contained between 5,000 and 20,000 measurements for each metal. The copper data set was restricted to wet weight determinations because of limitations in the STORET data transfer. (There would be as much data for copper as for the other metals if these difficulties could be overcome in future evaluations.) Only 0.1 to 3 percent of the sites had metal concentrations at Level 4 (more than 10 times the threshold value). Freshwater data were not available for chromium.

Each of the PAHs identified for the analysis had a STORET data set consisting of approximately 400 freshwater measurements, with the exception of benzo(a)anthracene, which contained approximately 1,500 measurements. Although the most frequently measured PAH in freshwater sediments was benzo(a)pyrene, it was not included in the assessment because of difficulties in obtaining the appropriate data for this compound from STORET. The PAHs were ubiquitous, as reflected in the low incidence of no-detects. The overwhelming majority of the data was at Level 1 (i.e., no points on the cumulative frequency diagrams fell above the threshold values). Ninety-five percent of the reported concentrations were below 4.3 to 5.6 mg/kg, depending on the compound. Ninety-five percent of the data for benzo(a)anthracene were below 0.014 mg/kg. The only region where site-specific biological information was available for these compounds was the Great Lakes region, where toxicity tests had been conducted on the amphipod *Diporea* sp.

The STORET data set contained approximately 300 freshwater measurements for both phthalate esters. Cumulative frequency plots of log concentration for diethylphthalate and dimethylphthalate revealed that these compounds were also ubiquitous in the environment. In addition, about 35 percent of the sites had concentrations above the threshold. There were a few localized hot spots, although none of the data fell in the Level 4 range (i.e., more than 10 times the threshold).

STORET data on pesticides in freshwater sediments were relatively extensive; between 4,000 and 20,000 measurements were available for each pesticide. The median pesticide concentrations, in general, were well below the threshold concentrations. There were a few hot spots with more than 10 times the threshold value, but most sites fell within Level 1.

The STORET database contained 917 freshwater sediment measurements for Aroclor 1016. Approximately 18 percent of the data for Aroclor 1016 fell above Level 1, and 3 percent fell above Level 4. Insufficient STORET data were available to analyze any monoaromatic hydrocarbons.

Contaminant concentration data for marine environments were gathered from published literature, literature with limited distribution, and STORET. The data presented in the report were incomplete in terms of both incorporation of existing data and geographic coverage, but were provided to present a preliminary perspective on a national basis. A literature search for marine sediment data

uncovered a wealth of information on animal-sediment relations and contaminant effects in addition to chemical concentration data. Marine/estuarine data were placed on national and regional maps in the same manner as the freshwater data. Because STORET contained limited marine/estuarine data, only median concentrations of the various chemicals, rather than cumulative frequency distributions, were reported.

The status of the marine sediments was evaluated based on a comparison with threshold values developed using the Equilibrium Partitioning Approach, except in the case of polynuclear aromatic hydrocarbons, where the Background Approach was used. A sediment total PAH concentration of 1 ppm dry weight basis was chosen as the cutoff between polluted and nonpolluted sediments based on a publication by Hites et al. (1980).

The complete data for coastal sites were included as a tabular listing by site and contaminant that either indicated that no data were available or specified the magnitude of the concentration relative to the threshold value (i.e., Level 1, 2, etc.). PCBs, PAHs, and metals affected the most sites.

The most useful information that the study of marine and freshwater sediments provided was an illustration of the general scope and magnitude of the problem. Most of the sites had concentrations below the thresholds established for chemicals based on the Equilibrium Partitioning Approach. The median concentrations, in general, were well below the threshold concentrations. This was especially the case for metals and PAHs. Since the use of the Equilibrium Partitioning Approach for metals is questionable, other threshold values were also considered in the study. The lower threshold values for copper, lead, mercury, zinc, nickel, and cadmium established by EPA Region 5 would have resulted in between 6 and 31 percent of the data being reclassified above the Level 1 range. For arsenic, the alternate threshold of 3 mg/L suggested by EPA Region 5 would have reclassified 62 percent of the sediments into Levels 2, 3, and 4.

The PAHs and phthalates were ubiquitous, as reflected in the low incidence of no-detects. Although the phthalates were a concern in terms of the percentage of sites above the threshold, little toxicity testing was available for these compounds. PCBs and cyanide had the highest percentage of sites falling into the Level 4 category. Historic lack of concern about cyanide in sediments has led to a paucity of toxicity testing of cyanide in benthic organisms.

Marine contaminated sediments tended to be localized, with the vast majority of marine sediments unpolluted or unstudied. However, severe biological effects have been attributed to sediment contamination in the Puget Sound and New York Bight regions despite low concentrations of individual pollutants. The low concentrations

reported for these areas may reflect the lack of marine sediment chemistry sampling data available at the time of this report.

An Overview of Sediment Quality in the United States (Lyman et al., 1987)

The purpose of this study was to provide an overview of sediment quality in the waters of the United States with emphasis on contaminated sediment sites. The study was undertaken as an initial step toward the goal of compiling a comprehensive national assessment of the nature and extent of sediment contamination problems. Specific objectives listed in the report were to:

- Document the extent to which various sources are associated with sediment contamination problems;
- Document approaches to, and the effectiveness of, remediation of sediment contamination;
- Provide documentation of regional and state approaches to sediment contamination problem identification and response; and
- Provide support and perspective to the development and eventual implementation of sediment quality criteria through an inventory and description of known contaminated sediment problem areas.

The study attempted to provide a picture of the geographic distribution, areal extent, and severity of the contaminated sediment problem and to provide a better understanding of contaminant sources (both ongoing and historic), the sites involved, and the types of pollutants and their impacts. It was believed that existing data could be used to help establish sediment quality criteria.

This study primarily focused on identifying specific locations or problem areas with contaminated sediments, rather than on obtaining estimates of the concentration levels in sediments. Only an inventory of existing data was undertaken because it was believed that existing data in their current state do not lend themselves to in-depth analysis and review. Existing data, although extensive in some regards, are associated with varying sampling and analytical methods and are widely scattered in many state and federal offices. Often, data have not been compiled in a computer database or they reside in incompatible systems.

Information was gathered for the study from the recently published literature on sediment contamination and from a series of telephone and personal interviews with representatives of various federal and state agencies that deal with contaminated sediments. Agencies contacted included NOAA, U.S. Army Corps

of Engineers (COE), U.S. Army Toxic and Hazardous Materials Agency (USATHAMA), U.S. Fish and Wildlife Service (FWS), U.S. Geological Survey (USGS), U.S. EPA Environmental Research Laboratory-Narragansett, and the 10 EPA Regions. Contaminated sediment case studies with data documenting causes and effects were collected along with descriptions of contaminated sediment management approaches used by various state and federal agencies. Because of its emphasis on contaminated sediment management, this study relied to a greater degree on information presented in the literature and expert opinion than on chemical concentrations housed in databases. The classification of sediments as contaminated was somewhat arbitrary because it was based on the diverse classification techniques used by various agencies. The data collected, unfortunately, were somewhat anecdotal and could not be used to quantify the extent of the problem.

The information collected was used to compile a list of sediment contamination problem areas, with most attention given to sites where documentation was available. The list was not prepared based on a ranking of the worst sites, nor was it intended to be comprehensive. It represented an early attempt to link sites with sources. Based on information provided by the contacts, data gathering produced information on sites that were thought to contain in-place pollutants. The study did not attempt to present a detailed and complete analysis of in-place pollutants and was limited to providing subjective information. Studies reviewed of a more general nature included the following:

- *Identifying and Prioritizing Locations for the Removal of In-Place Pollutants* (Johanson and Johnson, 1976);
- *National Perspective on Sediment Quality* (Bolton et al., 1985);
- *Removal and Mitigation of Contaminated Sediments* (SAIC, 1985);
- *Preliminary Survey of Contaminant Issues of Concern on National Wildlife Refuges* (USFWS, 1986); and
- *National Status and Trends Program: Progress Report and Preliminary Assessment of Findings of the Benthic Surveillance Project - 1984* (NOAA, 1987).

In addition, existing databases were searched in an effort to compile existing sediment monitoring data for the purpose of determining how well different areas of the United States were represented by sampling. These data were compiled by the EPA Regions. As a result, some Regions were better represented than others, reflecting the lack of uniformity in regional data-gathering efforts.

The review of documents and discussions with experts resulted in the identification of 184 separate sites with noted or perceived impacts from in-place pollutants. Most of the sites were located in the Northeast, along the Atlantic and Gulf Coasts, and in the Great Lakes region. These are also the regions where most of the data are concentrated. Surface waterbodies of all types were affected. Heavy metals, PCBs, pesticides, and PAHs were the most frequently mentioned contaminants. Biological impacts included reproductive impacts, effects on the structure of the community, and fish kills. Bioaccumulation of compounds from sediments was severe enough in some cases to warrant fishing bans or occasionally to prevent the use of water supplies for drinking water.

Few new data were collected in this study. Instead, the study relied heavily on the results of Bolton and others (1985) for information on the number and level of various pollutants at sites across the United States. The tally of the number of sites was based on concentration data reported in published and unpublished literature and data housed in STORET for marine and estuarine sites. Since the compilation of data in the 1985 study was far from complete, it was difficult to draw more than very general conclusions. The study by Lyman and others (1987) presented the same data collected earlier in a different form, emphasizing the identification of specific harbors, bays, rivers, estuaries, lakes, and waterways that were potentially impacted and specifying the contaminants. Information from a survey of national wildlife refuges was treated in the same manner. The concentration frequency diagrams presented by Bolton et al. (1985) were reviewed. The study by Lyman and others (1987) identified the sites, by chemical category, for which one or more of the 48 chemicals identified by Bolton and others (1985) had been measured. Thus, the representation of each of the 48 chemicals, or groups of chemicals, at sites where chemicals had been detected was evaluated. The number of the sites having concentrations above predetermined threshold values was also indicated.

General observations and conclusions of the study were as follows:

- All major harbors, rivers, and estuaries bordered by industrialized or urbanized areas contain elevated levels of metals, organics, and other anthropogenic contaminants. Sometimes areas of contamination are highly localized and related to a point source discharge of industrial or municipal effluent. Pinpointing sources is not always an easy task because sediments can be highly mobile and can be altered by dredging.

- Although field studies documenting the relationship between elevated levels of contaminants in sediments and effects were limited at the time of the study, impacts of in-place pollutants were believed to be significant. In places where other sources of pollution have been

regulated, in-place contamination may be the primary source contributing to the impacts.

- The historical record of pollutant concentrations in sediments preserved by sediment cores shows that in-place contamination has increased rapidly through this century.

Heavy metals and metalloids, e.g., arsenic, were the most frequently mentioned contaminants; 69 percent of the sites contained at least one metal or metalloid. PCBs were mentioned at 34 percent of the sites; PAHs at 19 percent of the sites; pesticides at 26 percent of the sites; and other organics (including oil and grease, hydrocarbons, volatile organics, phenols, base/neutrals, and dioxin) at 25 percent of the sites. The pesticides most frequently found were DDT and its derivatives, dieldrin, and chlordane. These results were similar to those obtained by Bolton et al. (1985) for marine and estuarine sediments.

Specific locations and one or two pollutants of concern for each site were listed. The results presented by Lyman et al. (1987), however, may be misleading because the compounds identified reflect sampling at these sites that may have failed to detect additional compounds simply because they were not tested. Organics, for instance, are not as frequently monitored as metals. For example, the New England Division of the COE monitors for a list of metals and total PCBs. The limited number of compounds monitored are used by the COE as indicators of sediment contamination. Typically, only a few chemicals are analyzed by the COE and others. Nevertheless, the study clearly documented the existence of in-place pollution problems.

Contaminated Marine Sediments—Assessment and Remediation (NAS, 1989)

This report was prepared by the Committee on Contaminated Sediments and the Marine Board, Commission on Engineering and Technical Systems, of the National Research Council, based on the outcome of a symposium and workshop conducted by the Committee on Contaminated Sediments. The committee was convened in response to the growing national awareness of problems resulting from contaminated marine sediments and was composed of experts in aquatic toxicology, dredging technology, resource economics, sediment dynamics and transport, benthic ecology, environmental law, and public policy. At the symposium, invited papers were presented on the extent of sediment contamination across the Nation, methods for classification of sediment contamination, risks to human health and the ecosystem, and sediment resuspension and contaminant mobilization. Five case studies were examined to illustrate the different ways in which sediment contamination problems are being addressed: New Bedford Harbor, Massachusetts, and the upper Hudson River, New York (PCBs); James River, Virginia (kepone);

and Commencement Bay, Washington, and the Navy Homeport Project in Everett Bay, Washington (variety of chemicals). Two consecutive work group meetings were then held to discuss the extent, methods of classification, significance with regard to biological communities and human health, and resuspension of contaminated sediments, and the selection of appropriate, economically feasible management strategies and remedial technologies for handling contaminated sediments. Major findings and recommendations of the committee with regard to the issues covered at the symposium are detailed in the report.

The committee defined contaminated sediments as those sediments which contain chemical substances at concentrations that pose a known or suspected environmental or human health threat. Although studies by the U.S. EPA and NOAA's National Status and Trends Program have identified widespread contamination and hot spots in coastal waters near major urban areas, the committee concluded that "adequate data do not currently exist for comprehensively pinpointing or prioritizing candidates for remedial action" (NAS, 1989, 1-2). In addition to collecting data, the committee noted that research, development, and the use of assessment methodologies must focus on identification of biological impacts and favored a tiered testing approach. Human health risks should be examined from an epidemiological perspective. Other recommendations included research into sediment transport, dredged material management strategies, contaminant source control, and well-focused monitoring efforts.

The NAS (1989) report noted that the location and extent of contaminated marine sediments should be comprehensively assessed on a national basis, but that such efforts should not duplicate the National Status and Trends (NS&T) program or involve detailed mapping. This national assessment could delineate contaminated sediments, while the search for new sites or reclassification of known sites could continue as remediation was under way.

The importance of having appropriate data for analysis of contamination was noted. The committee found that different programs had collected data for different purposes with varying approaches and stated that data should not be used beyond the limits or intent of the original monitoring program. Furthermore, there have not been any generally accepted and validated sampling and analysis techniques, testing protocols, or classification methodologies that would allow data comparisons. The Committee proposed setting national criteria, standards, or guidelines to achieve this purpose. An interagency committee was also proposed to evaluate existing and emerging data on sediment contamination to focus limited resources where research and monitoring were needed, to reduce redundancy, and to eliminate improper uses of data. Criteria review, laboratory bioassays, and infaunal surveys should be used to determine and evaluate the significance of contamination.

With regard to the use of data from various programs, workshop participants noted that EPA's STORET system contained data that had not been validated by comparison with primary literature sources and different sample collection techniques and analytical protocols had been used at different sites. One of the work groups believed that most of the STORET and literature data on sediments were best interpreted in a qualitative sense.

Summary Report for Contaminated Sediment Assessments in U.S. EPA Region IV Coastal Areas (USEPA, 1991b)

In an effort to better manage coastal and marine waters within Region IV, existing data from reports and state and federal agency databases were compiled into a dBASE III+™ format. The resulting database of contaminated sediment sites was designed to help provide an understanding of potential and actual contaminated sediment problems and to assist in coastal management decision-making.

Data were collected from 80 different references including universities, COE dredging evaluations, state reports, NOAA Sea Grant Program reports, laboratory reports, journal articles, city reports, South Florida Management District reports, and studies by FWS, USGS, and EPA. A significant portion of the sediment quality information obtained came from Florida's Department of Environmental Regulation sediments database. Most of the data available for liquid, suspended solid, and solid bioassays and bioaccumulation and toxicity tests were obtained in conjunction with dredged material evaluations by the COE using procedures outlined in the EPA/COE dredged material testing manuals. Other data were gleaned from various reports and in most cases represented summaries of information rather than raw data.

Data quality objective considerations for including or excluding data focused primarily on the availability of records of where samples were taken; data were not included in the inventory if the sample location could not be determined. If the sample data could not be located, the report data were used. Information on sampling methods, analysis methods, and parameters analyzed was included in the files if available. The parameter fields from ODES were used initially to describe the data; however, efforts to enter data into ODES were abandoned and the data were entered into dBASE™ files.

The data collected for each sample included sample identification and location information. Each sample was given a unique identification number. (The latitude and longitude descripters were not available for the majority of sites; therefore, locations were estimated using maps.) Only concentration data for sediments were entered. The depth at which the sample was taken was included when it was available. The 129 EPA priority pollutant numbers were used to identify the

chemicals. If a chemical was not on the priority pollutant list, an additional number was used. Only information available for specimens identified in the EPA EPA/COE's "Green Book" was included in the bioassay data. Although a screening process was developed to determine the minimum level of acceptability for data prior to their inclusion in the inventory, the study mentioned a high variability in the quality of the data collected.

The Florida Department of Environmental Regulation (FDER) represented the major source of government data. A regional STORET retrieval was not mentioned in the pilot inventory although some of the data reviewed had been entered into STORET. (STORET contains primarily inland data, whereas the Region 4 inventory focused primarily on coastal areas.) The FDER files contained data on metals, pesticides, PAHs, alkanes, and phenols. Data on the latitude and longitude of stations and on sampling and analytical methods were also included in the FDER files.

The pilot inventory represents data collected from all coastal states in the Region, with the majority of the sample sites located in Florida (571 of 817 sites). Analytical data were available for metals and for organic constituents for most of the sites represented in the inventory. Analytical data for pesticides were much more limited.

Preliminary review of the pilot inventory data was based on the comparison of concentration data to NOAA guidance levels for lead and copper. Analysis indicated that lead and copper concentrations exceeded guidance levels for sediment contamination in several samples taken from sites located primarily in Florida. Locations that exceeded NOAA guidance levels for lead included Miami River, Florida; Perdido Bay, Florida; Pascagula Ship Channel, Mississippi; Lower Hillsborough River, Florida; Indian River Lagoon, Florida; St. Lucie Estuary, Florida; St. Johns River Estuary, Florida; Choctawhatchee Bay, Florida; Manatee Pocket, Florida; and Charleston, South Carolina. Locations that exceeded the guidance levels for copper in Florida included Miami River, Lower Hillsborough River, Indian River Lagoon, St. Lucie Estuary, St. John's River Estuary, Choctawhatchee Bay, and Manatee Pocket.

A more detailed evaluation of the Region 4 data has been conducted (*Evaluation of the Region 4 Inventory of Coastal Sediment Sites*, USEPA, 1992a). This more complete analysis indicated that the data were characterized by a lack of TOC and grain size data for normalization of chemical concentrations of contaminants, as well as limited biological toxicity data, and that a majority of samples were from contaminated sites versus "background" samples. Therefore, the MacDonald (1992) weight-of-evidence approach adopted for the proposed FDER sediment quality guidelines was used to obtain the Threshold Effects Level (TEL) and Probable Effects Level (PEL) values for 20 metal, organic, and pesticide

contaminants. Identified regional chemicals of concern included metals (arsenic, lead, mercury, copper, silver, and zinc) and organics (chrysene, pyrene, fluoranthene, phenanthrene, PCBs, and acenapthene). The calculated Effects Index (the sum of the ratios of all contaminants to their TELs for the given site) was also used to rank sites by levels within the categories of metals, organics, and pesticides. Further work is under way to address limitations identified in the use of this procedure and to evaluate sources of contaminants in relation to contaminated sites.

EPA Region 5 Inventory of Contaminated Sediment Sites (USEPA, 1992b)

A pilot inventory of sites that are suspected or known to have contaminated sediment problems is being conducted by EPA Region 5. The inventory is being developed as part of EPA's national strategy for addressing contaminated sediment issues. Some of the objectives of the inventory are to assist in determining the extent of contaminated sediments in the Region; to aid in locating problem sites; to help in determining where additional studies are needed; and to aid in determining where prevention, remediation, and enforcement actions are needed. The pilot inventory has also been designed to serve as an initial framework for the National Sediment Inventory.

Information is being collected from several sources for inclusion in the pilot inventory. These sources include the EPA Region 5 Environmental Review Branch, EPA Region 5 Superfund, EPA Region 5 Water Division, EPA Great Lakes National Program Office, COE, USGS, STORET, and State agencies. Several of these agencies use STORET to store their data. In these cases, data from STORET were used only when the primary source of data was not available. The information on a particular site was taken from only the two most recent available reports for inclusion in the inventory.

The database is designed to include information on the site identification, site characterization, sediment sampling, and biological sampling results. The site identification specifies a location by the site name, county, state, latitude and longitude, USGS hydrologic unit, and EPA reach number. The reach numbers for the site locations are obtained from STORET. The characterization of the site describes the area as a whole and includes data on the size of the sampling area, the reach description, the industries within the reach, receiving waters, land use, and site status. The characterization also includes whether the sampling area is within a Federal Navigation Channel and, if so, the dates of the last two dredgings, known impacts to the site, and fish advisory information. The sediment sampling data fields divide the sampling information on chemicals into chemical classes. Additional information on the physical description of the sediments, the results of grain size analysis, and benthic community information are included. The sediment

sample data also include the number and type of samples, the sampling equipment used, and the depth of maximum concentration if a core sample was used. Data fields are also provided for additional types of testing and comments. The biological sampling data fields include a complete reference for each biota sampling. The date of sampling, species sampled, and type of samples (including tissue analysis, benthic community analysis, and sediment toxicity/bioassay testing) are recorded. Sediment toxicity testing data include date of sampling, date of testing, test duration, species, type of assay, number of samples, and results. A data field for comments is also included.

The data fields in the Region 5 inventory are divided into key fields and abstract fields. Key fields include information such as the site name, the state, sampling dates, chemical parameters, and site characteristics. The abstract fields provide additional information such as the descriptive variables and references. The abstract fields cannot be searched. The Region 5 contaminated sediment inventory data are being entered into a dBASE™ file. The Region V inventory currently includes data for all locations in the Region for which data were available. Prioritization of these sites is currently under way.

As of the date of the Region 5 draft report, sediment and fish sampling information had been collected for most of the states within Region 5. The State of Wisconsin identified approximately 190 sediment sampling sites. The Wisconsin Department of Natural Resources (WDNR) is collecting and organizing its sediment data, and much of the information is in the form of sampling results rather than in report format. Fish sampling information was obtained from WDNR's Fish Sampling database.

The State of Michigan identified approximately 99 sediment sites. The Michigan Department of Natural Resources (MDNR) maintains a database of sampling reports. The MDNR also publishes an annual fish sampling report that includes fish sampling reports for most sediment sites.

The State of Minnesota identified approximately 45 sediment sampling sites. STORET is the primary source of sediment information in the state. The Minnesota Pollution Control Agency supplied fish sampling information for the last 2 years. Sampling information prior to the last 2 years was in STORET.

Sediment data have been collected from several departments within the Ohio Environmental Protection Agency. Additional data obtained in a lakes sampling study and a toxic metals sediment study, as well as fish sampling data, will be provided by EPA. Approximately 14 sites have been identified thus far from the Ohio data.

As indicated in the EPA Region 5 draft report, data collection for the inventory had not been completed in some states. Only data for Lake Michigan Basin sites for Indiana and Illinois have been entered into the database. Other data will need to be compiled and collated in the contaminated sediment database in order to address the purposes of the National Sediment Inventory.

Progress Report on the Gulf of Mexico Program's Toxic Release and Contaminated Sediment Inventories (TRI, 1992; unpublished information)

The Toxic Substances and Pesticides Subcommittee of the Gulf of Mexico Program and EPA Region 6 have jointly funded two projects under the Gulf of Mexico Program to examine sediment contamination in the nearshore waters of the Gulf of Mexico. Because sediments in the Gulf are heavily impacted by industrial discharges, especially those related to the oil industry in Texas and Louisiana, a Pollutant Source Inventory for sediment-associated chemicals was undertaken to identify the amounts and kinds of chemicals discharges. A Contaminated Sediment Inventory that identifies sites of contamination in the nearshore waters of the Gulf of Mexico is also being developed.

The Pollutant Source Inventory was prepared under the direction of the Toxic Substances and Pesticides Subcommittee of the Technical Steering Committee for the Gulf of Mexico Program. The inventory was compiled from data in (1) the Toxics Release Inventory of the Gulf of Mexico (an inventory and evaluation of surface water discharges for industrial and municipal sites in the coastal zone as reported in EPA's Toxic Chemical Release Inventory (TRIS) and Permit Compliance System (PCS)); (2) a separate evaluation of pesticides applied to cultivated fields that could drain into the Gulf (Pait et al., 1992); and (3) a separate evaluation of discharges from nearshore oil and gas platforms, including land oil spills and fluids forced out of sediments during offshore drilling operations (produced waters). The sites were limited to those known to be contaminated, such as sites identified as not meeting water quality standards in accordance with section 304(l) of the Water Quality Act, those sites closed to fish and shellfish harvesting because of contamination, and other contaminated sites known to the Subcommittee. The potential impacts, based on toxicity, of chemicals and pesticides from these sources were compared for 29 estuarine drainage basins entering the Gulf. A report on the results of the Source Inventory, *Impact of Toxic Substances and Pesticides on Nearshore Gulf of Mexico: A Preliminary Comparison (Toxicity Indices) of Twenty-five Estuarine Drainage Systems Based on Release of Toxics from Industrial and Municipal Sites and Pesticide Run-off from Agricultural Operations in 1989*, is now under review.

The Sediment Inventory for the Gulf of Mexico is patterned after that of Region 4, using information obtained primarily from databases maintained by

Region 4 and Region 6, and from monitoring efforts in the coastal counties of Texas, Louisiana, Mississippi, Alabama, and Florida. The purpose of the inventory is to determine the nature and extent of sediment contamination in the nearshore waters of the Gulf of Mexico, identifying sites in terms of locations, types, and potential impact of pollutants present. The project will ultimately prioritize geographic areas of concern with respect to the potential toxicity of the sediment.

Data requested for retrieval and entry include detailed monitoring data collected since 1980 on sediment chemistry, toxicity, bioaccumulation, and associated grain size. Databases examined include the Region 4 inventory, STORET, EMAP (Environmental Monitoring and Assessment Program), Mississippi Sound Study, Mobile Bay Study, Houston Ship Channel Study, and Calcasieu Lake Study. Common elements among the data sets, such as station identification, locations (longitude/latitude), analyses, and concentrations of chemicals, are loaded into a FOCUS database. Variable or unique elements that help to determine a data set's utility are identified in a written abstract with the contact for the submitting agency. These elements include QA/QC information, methodology, evaluations, additional data, and STORET analysis. The chemical and biological information being collected is concurrently assessed by a set of sediment quality guidelines based on the ER-L (effects range-low) and ER-M (effects range-medium) values and MacDonald's (1992) TELs (threshold effects levels) and PELs (probable effects levels) for approximately 30 contaminants. Data gaps are also being identified, including locations that lack biological testing where chemistry data levels of contamination equal or exceed guidelines, locations where contaminants of concern have not been tested, and locations that have been undersampled.

The Sediment Inventory is nearly completed. Site evaluations will determine the scope of sediment contamination problems and identify toxic chemicals and geographical areas of concern. Additional ranking procedures based on the available and missing chemical and biological data will be used to prioritize sites potentially in need of remediation and areas in need of additional monitoring. Contaminated sites will ultimately be matched with sources from the Gulf of Mexico's Pollutant Source Inventory and reported fish consumption advisories. This information will be available in a Gulf of Mexico Program toxics and pesticides characterization report later this summer (Catherine Fox, USEPA, Risk Assessment and Management Branch, Standards and Applied Science Division, Office of Science and Technology, personal communication, 11 March 1993).

Proceedings of the EPA's Contaminated Sediment Management Strategy Forums (USEPA, 1992d)

During 1992, EPA sponsored a series of public forums for the purpose of discussing the draft outline of the Agency's Contaminated Sediment Management

Strategy. Each forum addressed a different issue related to the Strategy. The topics for each forum were as follows:

- The geographic extent and severity of contaminated sediments (April 21-22, 1992, Chicago, Illinois);
- Building alliances among federal, state, and local agencies to address the problem of contaminated sediments (May 27-28, 1992, Washington, DC); and
- Outreach and public awareness (June 16, 1992, Washington, DC).

The following subsections describe the specific issues discussed at each of the forums and present the conclusions reached and recommendations made as a result of these discussions.

Extent and Severity of Contaminated Sediments

Three specific topics of concern were addressed at the first forum: (1) the extent of sediment contamination, (2) the severity of contamination with respect to human health effects, and (3) the severity of effects with respect to ecological effects. A series of presentations were given addressing each of these topics.

During the first series of presentations, evidence was given illustrating the widespread nature of the problem of sediment contamination, with toxic hot spots occurring in many areas across the United States. For example, the COE estimates that 12 million of the 400 million cubic yards of sediment dredged each year from the Nation's waterways are contaminated. Data from NOAA's National Status and Trends Program indicate that sediment contamination is most severe near densely populated urban areas.

Data were also presented to suggest that direct or indirect exposure to contaminants in sediments can adversely affect human health. Although no acute or observable toxicity resulting from exposure to contaminated sediments is evident, effects on human health are seen in potential increased incidence of cancer, reproductive or developmental toxicity, or neurotoxicity. The consumption of fish tissue contaminated through bioaccumulation from sediments is a major concern, although the effects of chronic exposure to contaminants from fish tissue is poorly documented.

Evidence exists to link elevated concentrations of metals and organic chemicals in sediment and elevated tissue burdens in aquatic organisms. Such tissue burdens can result in a variety of effects including neoplasms, cataracts, enzyme induction, fin rot, other lesions, decrease in the abundance and variety of benthic species, and

others. However, assessing ecological effects is more difficult than delineating the extent of sediment contamination or even estimating potential human health effects because important effects manifest themselves in ways that are often difficult to detect.

Two major conclusions were reached at the end of the first forum: (1) contaminated sediments are a national problem and (2) human health problems and ecological harm have been documented at a number of contaminated sediment sites. In addition, participants agreed that existing data on the extent of sediment contamination are decentralized, and they generally supported the development of a national inventory of contaminated sites based on site chemistry, health effects, and intended uses. Participants also agreed that integrated assessments encompassing the following are necessary to appraise the status of an ecosystem:

- Toxicity assessments;
- Sediment chemistry analyses;
- Tissue chemical analyses;
- Pathobiological studies; and
- Community structure studies.

Building Alliances

The forum on building alliances among federal, state, and local agencies to address the problem of contaminated sediments was conducted in three parts to address the following activities: assessment, prevention, and remediation. Presentations were made regarding cooperation among the various government sectors during each of these activities.

Participants agreed that the assessment of contaminated sites is an area in which EPA's Contaminated Sediment Management Strategy needs clearer direction. The Strategy must define contaminated sediments more precisely and propose a mechanism for the effective use of assessment data to support sediment management programs. In addition, participants felt that the Strategy should identify and promulgate consistent quality assurance/quality control protocols for sediment sampling and bioeffects testing, focus more attention on nonpoint source (NPS) contamination, and actively encourage coordination with state agencies. Panelists were divided on the following two issues:

- Should the Strategy encourage an effects-based assessment approach or the development of numerical sediment quality criteria?

- Should the Strategy specify uniform effects-based testing methods or call for different but comparable effects-based testing methods?

In terms of pollution prevention, participants urged EPA to clarify several aspects of the Strategy. Participants felt that EPA should state clearly how sediment quality criteria will be used as part of the Strategy. They also felt that EPA should include stronger provisions for prevention of NPS contamination and should identify ways to improve coordination between state and federal agencies. Participants also urged EPA not to rely too heavily on models and to recognize the value of case studies in understanding the problems associated with contaminated sediments.

Participants agreed that contaminated sediment remediation must be limited to human health and ecological risk reduction, although some participants cautioned that human health risk assessments that are too conservative can lead to higher remedial costs with little marginal benefit. Participants suggested that the Strategy also address liability to facilitate more timely remedial actions. Finally, participants believed that EPA should provide guidance on specific issues related to managing contaminated sediments, including the following:

- Remediation of oil spills;
- Disposal of contaminated dredged material;
- Aquatic construction and maintenance activities;
- Management of sediments contaminated by stormwater discharges and other nonpoint sources; and
- Use of natural recovery options.

The following overall conclusions were agreed on following discussions of the need and approach for building alliances to address the problem of contaminated sediments:

- EPA should expedite implementation of the Strategy;
- Development of a contaminated sediment inventory is a high-priority need;
- More attention should be focused on NPS contamination in the Strategy;
- Addition of sediment toxicity and bioaccumulation tests to chemical registration under the Federal Insecticide, Fungicide, and Rodenticide

Act (FIFRA) and the Toxic Substances Control Act (TSCA) is a high-priority need to prevent point and nonpoint source contamination of sediments; and

- Consideration should be given to developing an integrated federal agency strategy on contaminated sediments.

Outreach and Public Awareness

Recommendations for effective public outreach were made by representatives from state government and private sector organizations. The private sectors represented included the regulated community, environmental advocacy groups, and public awareness groups. The following recommendations concerning outreach and public awareness were made by representatives from each of these groups:

- State government
  - EPA should use existing state networks for public involvement and information dissemination and allow states flexibility in adapting the Strategy to local situations.
- Regulated community
  - Sediment contamination is a local, "hot spot" problem, not a national problem.
  - EPA should subject all data and conclusions about sediment contamination to rigorous review.
  - Contaminated sediments should be defined with respect to human health and ecological risk, not numerical chemical criteria.
- Environmental advocacy groups
  - Current EPA public outreach efforts are inadequate.
  - The public lacks confidence that EPA has a rational, defensible program to manage contaminated sediments.
  - EPA should take advantage of existing communication networks to present information on contaminated sediments; establish face-to-face contact whenever possible through meetings, workshops, or conferences; and develop more engaging written and graphic information.

- Public awareness groups. EPA should engage in the following activities to promote public awareness:

  - Make sure outreach efforts address specific needs of various target audiences.
  - Design materials to foster participation in effective policy making.
  - Build consensus among conflicting interests.
  - Develop a framework of institutions that will be self-sustaining and carry the work of sediment management into the future.

Participants in the forum on outreach and public awareness were in agreement on several issues related to EPA's Contaminated Sediment Management Strategy. Participants agreed that EPA should get the public involved as soon as possible, clearly indicating how long cleanup will take, conveying complete information without skimping on details, and communicating the health risks associated with sediment contamination in terms analogous to comparable risks that the public can understand. EPA should link the contaminated sediment issue to visible effects, such as beach closures and fish tissue consumption advisories. EPA must articulate and remain accountable for achieving short-term goals and celebrate interim successes while working toward long-term restoration. Finally, participants emphasized that EPA must engage in active dialogue with the public and must be responsive to public concerns.

CHAPTER 4

OPTIONS CONSIDERED FOR THE DEVELOPMENT OF THE NATIONAL SEDIMENT INVENTORY

As discussed in the previous chapter, a number of studies and pilot inventories have attempted to assess the extent of chemical contamination in the Nation's freshwater, estuarine, and marine sediments. Much has been learned to enable federal, state, and local agencies to begin developing appropriate methods of remediation and initiating enforcement actions to prevent future pollution problems at known sites. Although these efforts have been important in calling attention to the problem of habitat degradation and human health risks related to contaminated sediments on a local and regional level, a comprehensive national study will determine more accurately and more uniformly the extent and severity of the problem so that managers can more effectively focus scarce resources and management approaches on areas impacted by contaminated sediments. As discussed previously, EPA's proposed draft Contaminated Sediment Management Strategy called for (1) the identification of a list of chemicals of concern based on toxicity, persistence, and propensity to bind to sediment particles; (2) the identification of sources of chemicals of concern in sediments; and (3) the identification of sites with contaminated sediments based on existing information. The latter two tasks require the development of two inventories, the Inventory of Sediment Contaminant Sources (the Source Inventory) and the National Sediment Inventory.

The Source Inventory, now being developed, will list chemicals that have been detected in sediments and the facilities responsible for these pollutant discharges based on information contained in existing databases such as STORET, ODES, EMAP files, pilot inventories, and other databases; and chemical concentrations in sediments reported in the literature. The Toxic Chemical Release Inventory System (TRIS) and Permit Compliance System (PCS) databases will be used to determine important point source dischargers of sediment-associated chemicals. Pollutants of concern will be ranked by criteria based on chemical adsorption/persistence and ecotoxicity. The Source Inventory will also attempt to identify nonpoint source (agricultural and urban) inputs.

The proposed National Sediment Inventory (NSI) that is described in this document will be a summary of locations known or suspected to have contaminated sediments based on detailed monitoring data from national, regional, and state sampling programs. The NSI will include concentrations of chemicals of concern measured in sediments at each site, as well as other physical and chemical parameters when available. The Inventory will also include available information on environmental effects such as fish tissue contaminant concentrations, fish consumption advisory information, sediment toxicity data, benthic community impairments, and other information. Possible techniques to be used for determining whether sediments are contaminated include available sediment quality guidelines for conventional, metal, and organic pollutants

such as those used by Regions 4 and 5 and other programs for their inventories of contaminated sites.

This chapter presents a discussion of options considered for the development of the NSI. The benefits and disadvantages of each option and the relative costs involved are provided.

Options Considered

Several options have been considered for the development of the NSI to compare feasibility, level of effort required, time, costs, and other factors. Early considerations by EPA for the development of the NSI focused on obtaining all detailed sediment and related monitoring data from various databases and entering them into a single existing repository to be used for analysis and identification of contaminated sites. This approach seemed to be the simplest in overall design and utility. Existing national repositories available to house sediment data include STORET and ODES. Figures on available data compiled by ERG (1991) indicated that there were approximately 26,600 sites for which sediment chemistry and related monitoring data were available. Data from 85 percent of these sites had been entered into STORET; data from 4 percent had been entered into ODES; and data from 11 percent were in hard copy only or had been entered into other computer formats. Another advantage of using STORET as a national repository was the large community of skilled users (1,100 persons across the country) who regularly enter their data on a voluntary basis. STORET also provides potential users with access to other information that could be used to analyze sediment data, including water quality and fish tissue data, NPDES permit data, watershed information, and population data. STORET, with the Reach File, provides many opportunities to link and interface with these data sources for streams, lakes, and coastlines. Also, the system is immediately accessible at EPA workstations on local area networks (LANs) in each Regional Office, most state offices, and many federal agencies. Moreover, STORET has an extensive capacity to house additional data that is far beyond the capabilities of ODES and dBASE™.

For several reasons, however, both STORET and ODES were dropped from consideration as the repository for the NSI. The costs associated with entering data into ODES was the reason most often cited for not using it to house the Inventory. Although many believe most of the Nation's sediment chemistry data, particularly freshwater data, currently reside in STORET, it was dropped from consideration mainly because of the difficulties often cited in entering and accessing STORET data, the lack of QA/QC data, and the lack of fields to hold the ancillary information necessary to evalute sediment quality. As an alternative, this work will be coordinated with "STORET Modernization" to facilitate the incorporation of data into a modernized STORET system which is currently under design.

Examination of the Region 4 and Region 5 database formats, as well as other options, identified a number of concerns for the design of the NSI including the capabilities of different systems and software for performing data searches and compilations and the possibilities for storing detailed monitoring data or summary data in relational, searchable databases that would be nationally accessible. The operation of the Inventory will require consideration of who would evaluate existing data and at what level (Headquarters, Regional, or state level); what kind of assessments would be needed to fully understand the problem at a particular site; and which program uses would require what information. Planning these operational details would ensure inclusion of the most essential features and aid in identifying an existing database system into which the inventory could be integrated. At a minimum, the NSI must be capable of maintaining biological, QA/QC, and other forms of data as well as chemical data; it must be relatively easy for EPA Headquarters, the Regions, and states, in addition to other federal agencies and researchers, to access, evaluate, and update data; the Inventory must be relatively inexpensive to maintain and operate; and it must be flexible enough to be modified as our scientific understanding of contaminated sediments develops.

Following numerous discussions with EPA personnel and others, two primary options for the design of the NSI were considered: (1) the development of a summary inventory based on a statistical evaluation of individual databases and (2) the development of an inventory containing detailed monitoring data from which assessments would be conducted to identify potentially contaminated sites. The variations on each of these options are discussed below. A summary of selected attributes and problems associated with each option is presented in Table 4-1.

Option 1. Inventory of Summary Data Only

The option of developing an inventory of summary data was based on the approach used by Region 5 (see Chapter 3). Under this approach data from individual databases are summarized before the data are compiled into a single database. Sediment chemistry data, as well as biological and other forms of data, would be included in the summary inventory. The inventory produced by this approach would contain only certain data parameters for each site; abstracts of QA/QC procedures and observed impacts; and calculated mean, maximum, and minimum concentrations of chemicals of concern.

Compiled by EPA Headquarters. Under this option, EPA Headquarters would evaluate and summarize the data from individual databases and create the summary inventory. The actual detailed data would not be compiled into a single database. EPA would access and summarize data from STORET, ODES, and NOAA's National Status and Trends program, as well as from other EPA program offices. The summary inventory would then be sent to the EPA Regions for review. The Regions would

Table 4-1. Comparison of Selected Attributes and Problems Associated With Each Option

Option/Type of Inventory	Data Compiled By	Data Evaluation By	Potential Data Sources	Software Required	New Parameters Required	Advantages	Disadvantages
Summary Only	EPA Headquarters (FY 1993)	EPA Headquarters (FY 1994) Summary inventory sent to Regions for review and supple-mentation (FY 1994)	STORET, COE, NOAA, Gulf of Mexico Program, Region IV inventory, Region V inventory, Region X inventory, NEP, EMAP, ODES, USGS, FWS, others	Yes Initial database uploads, consolidation, and evaluations will use existing mainframe tools PC-based versions sent to Regions for review and update	Yes Abstract fields for summary information	Single entity responsible, more control over database Analyses could be conducted with software from data source Less computer space required than including all detailed monitoring data Would provide "big picture" Cost less in FY 1993 than if each Region produces own database	May miss important data initially May lack pertinent analytical software or have different calcula-tions Evaluations of data summaries would not be as accurate as using detailed monitoring data Updates and criteria reevaluations difficult to perform

Table 4-1. (Continued)

Option/Type of Inventory	Data Compiled By	Data Evaluation By	Potential Data Sources	Software Required	New Parameters Required	Advantages	Disadvantages
Summary Only	Each Region (FY 1993)	EPA Headquarters (FY 1993/1994) consolidates and evaluates summary data from each Region and compiles it into summary database Summary data reviewed and supplemented by Regions (FY 1994)	All available detailed monitoring data from above sources and others	Yes Databases for each Region would have to be constructed and/or modified, then loaded into EPA Headquarters' database	Yes Abstract fields for summary information	More rigorous validation of data quality possible Utilization of local experience in assessing sediment contaminant problems and efforts by all organizations within each Region involved in sediment data collection Less computer space required than including all detailed monitoring data	Each Region may do validations differently Process may move too slowly Evaluations of data summaries would not be as accurate as using detailed monitoring data Difficult to reevaluate database as criteria change Each Regional database would require continued maintenance and regular uploads Cost more due to work on guidance by EPA Headquarters, search for appropriate data sets, summarization by each Region

Table 4-1. (Continued)

Option/Type of Inventory	Data Compiled By	Data Evaluation By	Potential Data Sources	Software Required	New Parameters Required	Advantages	Disadvantages
Detailed Monitoring Data	EPA Headquarters (FY 1993)	EPA Headquarters (FY 1993) Detailed monitoring data sent to Regions for review and supplementation (FY 1994), then upgraded and reevaluated by Headquarters (FY 1994/1995)	All available detailed monitoring data from above sources and others	Yes Initial database uploads, consolidation, and evaluations will use existing mainframe tools PC-based versions sent to Regions for review and update	No Existing parameter names and values to be standardized and data dictionary prepared (Data quality code to be added for each data set)	Single entity responsible, more control over database Common access and simultaneous use with database on mainframe As evaluations and criteria change, reevaluations easier with all detailed monitoring data in one repository in one format Analyses could be conducted on subsets of data (e.g., by data quality codes, by available TOC data, by Region, etc.) Cost less (and takes less time) in FY 1993	May miss important data initially

Table 4-1. (Continued)

Option/Type of Inventory	Data Compiled By	Data Evaluation By	Potential Data Sources	Software Required	New Parameters Required	Advantages	Disadvantages
Detailed Monitoring Data	Each Region (FY 1993)	EPA Headquarters (FY 1994) consolidates and evaluates detailed monitoring data from each Region	All available detailed monitoring data from above sources and others	Yes Standardized PC-based software structure and design will need to be developed by Headquarters for use by Regions Headquarters database uploads, consolidation, and evaluations will use existing mainframe tools	No Existing parameter names and values to be standardized and data dictionary prepared (Data quality code to be added for each data set)	More rigorous validation of data quality possible Utilization of local experience in assessing sediment contaminant problems and efforts by all organizations within each Region involved in sediment data collection	Each Region may perform validations differently Process may move slowly and could affect completion date Would require strict adherence to guidelines provided by EPA Headquarters and reviews to ensure compatibility for consolidation Cost more in FY 1993

correct any errors noted in the summary inventory and would supplement the inventory with data from individual database not already summarized by Headquarters.

Since EPA Headquarters would have primary responsibility for the development of the summary inventory, procedures for identifying appropriate data, performing summary statistics calculations, and compiling the data could be more easily controlled than if each Region were compiling a separate summary inventory. Having a single entity preparing the inventory would also cost less in terms of providing guidance and training by EPA Headquarters since there would be less need for extensive review of regional inventories to ensure their compatibility. Summary statistical analyses could be conducted using the software compatible with the original data source, and then the summary statistics and other data could be downloaded into the summary database. A single summary inventory would allow quicker review of pertinent nationwide information and take up less computer space than one containing individual data points, allowing more flexibility in file size and hardware requirements.

One major disadvantage of the summary inventory is the difficulty in reevaluating the original data as criteria for sediment contamination change. Each database would have to the reanalyzed and the summary statistics run again. Then the summary inventory would have to be updated. Another disadvantage of EPA Headquarters preparing a summary inventory is that important regional data, available in a local but not national inventory, could be overlooked initially. Although the Regions would review and supplement the summary inventory the following year, summary statistics would need to be recalculated each time sediment chemistry data were found for a site or each time new developments in sediment quality criteria assessments established new chemical contaminant thresholds. This would require a complete reanalysis of the detailed monitoring data from each database used in the summary inventory.

Compiled by Each Region. Because of the great diversity in sediment research and data collection, it may be more appropriate to establish inventory programs by EPA Region, based on the pilot inventories done by Regions 4 and 5, and to collect only summary information into a national inventory. Each Region would be responsible for identifying data from the above list of data sources and obtaining all pertinent data from all of the categories of available data. The data would be carefully scrutinized for minimum quality control requirements (for example, each Region could track down original sources of data and validate the STORET records). Headquarters would provide guidance on minimum data requirements; exactly what types of information are needed for the inventories; the scope and extent of analysis and discussion; the types of analyses to be performed (e.g., mean, maximum, minimum for a particular chemical at a particular site derived from all data or only those meeting certain quality control requirements); and the site summarization format. The summary inventory thus completed would be sent to Headquarters, consolidated, evaluated,

and entered into the summary inventory on one system for each Region, and/or all summaries would be placed on EPA's mainframe.

The NSI created in this manner would be sent back to the Regions so that they could review the information and supplement it as necessary. Once gathered into the inventory, the data could be used by the Regions to perform regional assessments of sediment contamination.

Performing the assessment by Region would have the advantage that data could be more rigorously examined, including going back to the original reports to determine the methods used in biological and chemical analyses and to assess data quality. Furthermore, sediment conditions differ throughout the country and are influenced by local environmental changes that may be recognized only by local expertise. The effort would allow an opportunity for coordination of Regional organizations involved in sediment data collection.

A disadvantage of each Region setting up its own inventory is that Regional inventories would have to be maintained on a continuing basis, with provisions made for uploading them periodically into the national inventory. Also, additional costs and time would be required in terms of development of guidance and training by Headquarters, identification of appropriate data sets and their summarization by each Region, and compilation of summary data into a database for each Region.

Option 2. Inventory of Detailed Monitoring Data Only

The option of developing an inventory of detailed monitoring data grew from the above concerns that summary data could not be easily reevaluated whenever additions or deletions were made in the database following Regional reviews or following uploading of data from each Region, or if there were changes in sediment quality criteria. Also, a detailed monitoring inventory could hold more information and be more useful for other types of evaluations than the summary database. For this approach, all categories of detailed monitoring data that exist in database formats are provided by STORET, ODES, COE, NOAA, and other EPA and COE programs. These databases would be compiled into an inventory containing sediment chemistry data, as well as biological and other forms of data. The inventory produced by this approach would contain all pertinent data parameters for each site (with standardized parameter names and values), summary information on QA/QC procedures and observed impacts, concentrations of chemicals of concern measured during different studies, and pollutant source information. The detailed monitoring inventory would then be evaluated according to predefined criteria, with results presented in report format.

Compiled by EPA Headquarters. In this option, EPA Headquarters would be responsible for obtaining all categories of detailed monitoring data available from the above agencies and consolidating these data. The quality of the detailed monitoring

data would be assessed to the extent possible and coded by a screening assessment of QA/QC information. All detailed sediment chemistry data would be evaluated to select sites of concern based on established sediment quality criteria. (This approach is similar to that used in the Gulf of Mexico Program's Contaminated Sediment Site Inventory.) A preliminary summary report identifying chemicals and sites of concern and other information would then be prepared. The summary report and detailed monitoring data for each Region would be sent to the Regions for review. A final summary report and inventory would then be prepared after reevaluating all of the detailed monitoring data. The detailed monitoring data would be available to the Regions.

A single entity compiling the detailed monitoring data would have more control over the identification of appropriate data, standardization of parameter names and values, programming that may be required to consolidate the data and convert units, manipulation of the data to ensure compatibility with statistical software and database formats, and preparation of reports than if each Region were compiling a separate detailed monitoring database. Having a single entity consolidating the data would also cost less, since each database would be reviewed only once to ensure compatibility. Although a detailed inventory containing individual data points would take up more computer space than one containing only summary data, the preparation of the database by EPA Headquarters should minimize redundant data points during the initial consolidation process.

The disadvantage of EPA Headquarters consolidating the detailed monitoring data is that important Regional data could be overlooked initially, perhaps necessitating extensive changes and additional evaluations depending on the strength of data collected in the above agencies' sediment quality databases.

Compiled by Each Region. For this option, EPA Headquarters would provide detailed guidance on minimum data requirements, parameter names and values, data quality information, data formatting, and other factors so that all categories of detailed monitoring data could be gathered by each Region and consolidated into a single database. Each Regional database would be consolidated by EPA Headquarters into a single database and evaluated using established sediment quality criteria. The detailed monitoring database would then be evaluated to identify areas of concern.

This system would allow each Region to identify the most useful and accurate data sets. By allowing the work to be divided by Regions, databases could be scrutinized carefully by workers within each area who would be able to assess the quality of the data and their significance for priority contaminated sediment consideration based on localized variables that could differ around the country. Regions would gain further expertise in the sediment data and in using the database and inventory, thus strengthening their information base and their understanding of local contaminated sediment problems. As with a Regionally prepared summary database, more effort

on the part of the Headquarters personnel would be required in the first year to provide guidance to each Region and to develop the database. Stringent review of each database would also be required before it could be consolidated into the national detailed monitoring database to ensure compatibility and reduce problems during subsequent evaluations.

Discussion of Option Selected

The final design of the NSI was determined on the basis of comparisons of the benefits and disadvantages, and relative costs, of each option (Table 4-1). This evaluation indicated that an analysis of detailed monitoring data (Option 2) compiled by EPA Headquarters would be the best approach for the Inventory. The approach for developing this inventory is described in the following chapter.

While summary information would take up less computer disk space and probably allow quick retrievals of site information, evaluations of data summaries to identify and prioritize chemicals and sites of concern would not be as accurate as using detailed monitoring data. A major disadvantage of the summary approach is that once EPA Headquarters has prepared the summary inventory, changes in the inclusion of sites would require extensive reanalysis of the original data if sediment quality thresholds for chemicals were changed. Statistical procedures for different inventories could lack pertinent analytical software or have different calculations. If summary statistics had to be performed by hand, as done by the Region 5 inventory, additional personnel would be required to examine each data set, perform the calculations, and then recheck the calculations for errors.

Each change in the summary inventory required by limited or ongoing Regional review and supplementation would provide opportunities for further mistakes to be made and possibly entered into the database, necessitating extensive quality control. Also, as noted by Manheim (1991), the disadvantage of summarizing information is that the goals of synthesis will invariably change over time. If only the synthesis information is stored, the basic data may ultimately be lost, making reanalysis very costly. Furthermore, different managers may be using the inventory for different purposes at the same time to examine different sediment problems. Summary information might not provide all the parameters required for such different analyses. Extensive programming, parameter identification, summary statistics calculations, development of summarized abstracts for certain types of information (QA/QC, environmental impacts, site descriptions), and data entry would require more time, personnel, and funds than simply working with detailed monitoring data. Thus, these concerns, especially recent developments and changing procedures in establishing criteria for evaluating toxicities of chemically contaminated sediments, suggest that the summary database approach would not be appropriate on a national scale.

By consolidating all detailed monitoring data into a single inventory, evaluations of the data could be performed at any time as sediment contamination thresholds are updated. Assessment and coding of data quality would allow certain subsets to be used for different types of evaluations. Such coding could also indicate whether sufficient high-quality data had been collected at a particular site or whether further analyses were necessary. Additional data, identified during Regional reviews, could be more easily tailored for loading to the national database. Furthermore, future collections of detailed monitoring data could be easily added and evaluated. While there is great interest, in general, in the collection and interpretation of new data rather than historical data, existing data are more significant for sediments than for measurements of the water column and biota because changes in sediments take place more slowly (Manheim, 1991). Thus, having all current detailed monitoring data together in one inventory with the capability of adding data as they are collected would allow timely comparisons to assess the impact of various management approaches, such as pollution prevention, remediation, and/or dredged material management programs, on sediment quality in the United States.

The development of the inventory by a single entity, EPA Headquarters, would permit control of data compilation and more uniform quality assessments. This would also eliminate the need to check each Regional inventory for compatibility and extra programming that may be required if the guidelines that were provided are not strictly followed. Problems encountered during inventory consolidation, such as variable names for the same parameters or concentration units that must be converted to the units used by sediment quality criteria for evaluations, could be corrected for the entire database at the outset. Quality assurance procedures established prior to database consolidation and manipulation could also be more easily monitored for a single entity than for multiple Regions. EPA is anticipating that available resources will be less in FY 1993 than in FY 1994. Headquarters will be in a better position to develop the detailed monitoring database at the start, with more funds available for distribution to each of the Regions the following year for data review and supplementation. The total funding allocated to the development of the NSI and evaluation of the data in the NSI to identify potential and probable contaminated sediment sites is estimated to be $750,000 to $1 million (FY 1993 and FY 1994).

The development of a single inventory by EPA Headquarters with EPA Regional review of this database is the most cost-effective approach to developing the NSI. Since the assessment of sediment data is still an evolving science and the criteria used to evaluate the extent of contamination may be modified, it is believed that a reevaluation/recreation of a summary inventory would be required and may result in an overall increased cost of 30-50 percent. Similarly, if Regions were to develop independent detailed inventories, each Region would be charged with investigating the availability of additional data and compiling readily available data. By centralizing readily available data compilation and eliminating the cost to EPA Headquarters of aggregating Regional databases, the chosen method should result in a decreased

cost of 40-60 percent. In addition to a cost increase, the overall 2-year schedule may be jeopardized if either of the other options is selected.

CHAPTER 5

APPROACH FOR DEVELOPING THE NATIONAL SEDIMENT INVENTORY

The development of a detailed monitoring database that provides end-user computing or "ready-to-go" applications software is beyond the regulatory time schedule and resource constraints of the current effort. In addition, no resources have been identified for continued training, operation and maintenance, or support. As a result, the first phase of developing the National Sediment Inventory is to aggregate data from diverse sources, evaluate selected data, and disseminate the preliminary evaluation and data to EPA Regions for review. The form of the transmission of data to EPA Regions has not been finalized; however, it is expected that XBASE-compatible files would be the likely format along with a hard-copy report summarizing the preliminary evaluation. The types of sample data will include sediment chemistry, bioassay, bioaccumulation, pollutant source, and fish advisory data. Sediment chemistry, biological effects data, and QA/QC will be initially evaluated by EPA Headquarters in order to identify potential areas and chemicals of concern.

By providing the data in a generic form along with a report summarizing the analysis, Regions will be able to adopt portions of the data into their existing systems or will have the necessary skill levels to use EPA-standard software such as dBASE™. By having both the hard-copy report and data, more in-depth reviews are anticipated during the second phase of the National Sediment Inventory development. The Regional Offices will be able to review and evaluate all the detailed data. The Regions may then provide EPA Headquarters with additional data to be included with a revised analysis. EPA Headquarters will conduct a second evaluation of the revised NSI and create a final report.

In addition, this project will be coordinated with concurrent projects such as "STORET Modernization" and other Office of Information Resource Management (OIRM) activities. For example, a necessary portion of this task is to develop "cross-walks" between the naming conventions for sediment data used by existing data systems. As a result, the lessons learned from this effort will be helpful for the ongoing efforts under STORET Modernization. This cooperative effort will also facilitate the incorporation of the data into a modernized STORET system at a later time.

The following sections describe the process to be used in developing the NSI. It should be noted that several critical issues—for example, data structure, data prioritization, quality assurance/quality control (QA/QC) evaluation procedures, and methods for defining thresholds above which a site will be considered contaminated—have yet to be resolved. These issues and others are currently

being addressed. In addition, decisions on other issues may change over the life of the project. Note that in the discussion that follows, reference to the National Sediment Inventory refers to the data to be included for analysis, not an information system to be developed.

Development of the National Sediment Inventory

Categories of Data to Be Evaluated

Four major categories of detailed monitoring data will be considered for the NSI: data record, site characteristics, QA/QC, and sampling parameters (Table 5-1). The organization of the information presented in Table 5-1 (and throughout the remainder of this chapter) is for convenience of presentation and subsequent discussion and does not necessarily reflect the computerized data structure and format that will be implemented for the NSI. Several minimum data parameters have been identified under each of these major categories. Some of these parameters must be available before the data will be included in the NSI; others would be desirable, but their absence would not preclude data from being included. The general tendency of this effort is to include rather than exclude data for this screening-level analysis. Invariably, the minimum data requirements for inclusion in this inventory may preclude the use of certain portions of the inventory for other program objectives described in Chapter 2. With proper identification, it is believed that other programs will be able to selectively choose data for their requirements. The major data categories and minimum data elements are described further below.

Data Record. The data record must be in computerized format and must include a data dictionary specifying field names, widths, delimiters, or file structure. Other data that must be included in the data record are sampling location (including waterbody name), sampling date, and latitude/longitude. If available, the reach number (based on EPA's Reach File) should also be included.

Site Characteristics. There are several pieces of information related to site characteristics that, if available, would be considered during the development of the NSI, although none are considered critical pieces of information without which data would be excluded. These include land use (e.g., agricultural, rural, urban, commercial); management status of the site (i.e., whether remedial activities are currently being performed and by whom); whether the site is a hazardous waste facility or Superfund site or whether an accidental spill has occurred at the site; the frequency of dredging/dredging history at the site; the identity and location of point source discharges (current and historical) in the vicinity of the site (including the use of the National Source Inventory); and the presence of endangered species.

Table 5-1. National Sediment Inventory Data Category Summary

Minimum Data Element	Necessary	If Available	Comments
DATA RECORD			
In Computerized Format	●		With data dictionary specifying field names, widths, delimiters, or file structure
Location	●		Including waterbody name
Sampling Date	●		
Lat/Long	●		Conforming to EPA's standards
Reach Number		●	
SITE CHARACTERISTICS			
Land Use		●	Urban, industrial, rural, etc.
Management Status of Site		●	Remedial action, etc.
Location of Haz Waste/Superfund Site		●	
Spill Information		●	
Frequency of Dredging		●	i.e., dredging history
Point Source Information		●	Current/historical
Presence of Endangered Species		●	
QA/QC			
Source of Information	●		Sponsor or client name and address, name of analytical lab or principal investigator and address
Lab Methods		●	Quality of data to be coded, method detection limits used in analyses to be included
Field Methods		●	Quality of data to be coded
SAMPLING PARAMETERS			
Sediment Chemistry	●		
Total Organic Carbon		●	
Grain Size		●	
Acid Volatile Sulfides		●	
Biological Data		●	Biotoxicity, bioaccumulation
Fish Advisories		●	
Benthic Abundance		●	Benthic infauna, community, other indices
Fish Pathology		●	

QA/QC. The only QA/QC information that must accompany the data before they can be considered for inclusion in the Inventory is information on the source of the data. The name, organization, address, and telephone number of the individual who collected the data or who can address questions concerning the data collection and analysis procedures must be provided. If available, information on the field and laboratory samples and methods used should also be included with the data.

Information on several types of QA/QC samples and procedures that can influence the quality of the data and can be used to check the quality of data will be analyzed for data sets to be included in the Inventory, if available. Although none of this information is necessary before a data set can be included, evaluation of such information will provide an indication of the quality of the data used to target a specific site. If the QA/QC evaluation procedures are unknown or known to be inadequate, then the data will be coded accordingly. The site should be considered only potentially contaminated, and additional information gathering and assessments would be recommended.

A much more limited version of the QA/QC evaluation procedure for historical databases developed for EPA's Great Lakes National Program Office (GLNPO) (Schumacher and Conkling, 1990) is envisioned for use as part of the development of the NSI. In the GLNPO procedure, various QA/QC components were grouped into five general categories that encompass the major areas of concern in a good quality assurance program. Each component then received a ranking as to its perceived importance in the assurance of good-quality data, and each ranking was given a score. The scores were then summed to provide an overall assessment of the likely quality of a database. Table 5-2 presents the QA/QC categories and components that were evaluated as part of the GLNPO procedure. For the purposes of the NSI, it is envisioned that the individual databases that make up the Inventory will be given one of three broad classifications based on an evaluation of the QA/QC components used:

- Adequate QA/QC used,
- Inadequate QA/QC used, and
- Unknown QA/QC.

The precise method of scoring the quality of a given data set for the purpose of the NSI is currently under examination. If the user of the data wishes to acquire more detailed information concerning the quality of data in a data set, the user will have to contact the database contact directly.

Sampling Parameters. All of the sediment chemistry data will be evaluated to identify the potential areas and chemicals of concern. Other types of detailed sampling data to be included in the NSI, if available, include biological data (i.e., biotoxicity and bioaccumulation), pollutant source benthic abundance, and/or fish

Table 5-2. QA/QC Components Used in the GLNPO Procedure

Category	Component
Accuracy	Certified Reference Material Mid-Range Audit Sample Low-Level Audit Sample QC Check Sample Detection Limit QC Check Sample
Precision	Field Duplicate Analytical Duplicate Preparation Laboratory Duplicate Standard Duplicate Matrix Spike Duplicate
Spike Recovery	Matrix Spike Surrogate Spike (organics)
Blanks	Calibration Reagent Field Cross-Contamination Field Reagent (preservation)
Miscellaneous	Instrument Calibration Instrument Detection Limit Ion Chromatograph Resolution Chemistry Relationships (expected correlations among different parameters) Improper Sampling Technique Method Error or Problem Improper Holding Times Improper Sample Storage Techniques Lack of Methods Comparability Among Analytical Laboratories

pathology. In addition, information on fish advisories in the vicinity of the site (if any) will be collected. Tables 5-3 through 5-8 list the data parameters that will be included in the NSI when available, for sediment chemistry, bioassay, bioaccumulation, benthic abundance, fish pathology, and fish advisory data, respectively. The organization of the information presented in Tables 5-3 through 5-8 is for convenience of presentation and does not necessarily represent the data structure and format that will be implemented for the NSI.

Inventory Organization

The development of a detailed monitoring database that provides end-user computing or "ready-to-go" applications software is beyond the scope and resources of the current effort. In addition, no resources have been identified for continued training, operation and maintenance, or support. As a result, the emphasis of the initial phase is to aggregate data from diverse sources, evaluate selected data, and disseminate data to EPA Regions for review and update. The NSI, when distributed to EPA Regions, will consist of XBASE- (i.e., dBASE™-) compatible files. By providing the data in a generic form along with a report summarizing the analysis. Regions will be able to adopt portions of the data into their existing systems or use EPA-standard software such as dBASE™ to browse the data. To promote the dissemination of the Inventory to groups outside the Agency such as universities, the use of CD-ROM technology and INTERNET will be further investigated and implemented, if feasible.

The structure and organization of the disseminated files will be developed to ensure that pertinent data collected for a specific sample can be retrieved even though the data may reside in separate data files. This approach represents a balance between the competing requirements associated with the remainder of this effort (described in other chapters) and allowing for enhancements so that other program areas can use the data from this effort for screening-level analyses as well. During the review and initial release of the NSI, it is expected that EPA Regions, program offices, or other groups will adopt portions of the Inventory into their existing systems or will have the necessary skill levels to use an appropriate PC-based database management system. Minimum skill levels would be required to browse data (e.g., users would need to develop indexes and relate files). More advanced skills would allow more sophisticated analyses.

The specific data to be included in the Inventory will be developed in the future once the nature of all the data has been determined. The database structure, format, and data dictionaries of the following efforts will be considered as starting points for this effort:

- Seattle COE Sediment Inventory
- Region 4 Sediment Inventory

Table 5-3. Sediment Chemistry Sample Parameters

Category	Parameters	Importance of Parameter	
		Necessary	If Available
Sample Information	Sample number	X	
	Sample depth (upper and lower)		X
	Sampling equipment		X
Analysis Information	Environment from which sample was taken (i.e., suspended, bottom, dissolved, etc.)	X	
	Replicate number		X
	Name of chemical	X	
	CAS number	X	
	Concentration measurement for chemical	X	
	Units	X	
	Sign (+ or -)	X	
	Extraction method		X
	Instrument used		X
	Detection limit (if observation is below detection limit or not detected)	X	
	TOC		X
	Grain size		X
	AVS		X
	Other geologic information		X

Table 5-4. Bioassay Sample Parameters

Category	Parameters	Importance of Parameter	
		Necessary	If Available
Sample Information	Sample number	X	
	Upper/lower depth of core samples used as exposure medium		X
	Environment from which sample was taken (e.g., bottom sediment, interstitial water, elutriate, etc.)	X	
	Collection method		X
Bioassay Conditions	Bioassay type	X	
	Number of organisms originally present in each sample replicate		X
	Exposure duration	X	
	Taxonomic code	X	
Analysis Information	Units used to report concentration	X	
	Concentration of dilution used in bioassay	X	
	Variable measured (e.g., LC_{50}, count of live offspring, etc.)	X	
	Measure or count	X	

Table 5-5. Bioaccumulation Sample Parameters

Category	Parameters	Importance of Parameter	
		Necessary	If Available
Sample Information	Sample number	X	
	Specimen number or composite number	X	
	Gear type		X
	Taxonomic code	X	
	Number of individuals		X
	Tissue sampled	X	
Analysis Information	Replicate number	X	
	Name of chemical measured	X	
	Units used to measure chemical	X	
	Concentration	X	
	Extraction method		X
	Instrument used		X
	Detection limit	X	
	Wet or dry weight	X	

Table 5-6. Benthic Abundance Sample Parameters

Category	Parameters	Importance of Parameter	
		Necessary	If Available
Station Information	Sample number	X	
	Sieve mesh size		X
	Core grab surface area		X
	Number of samples		X
	Sampling equipment		X
	Sample depth		X
Bottom Characterization	Bottom type		X
Species Abundance and Biomass Data	Taxonomic code	X	
	Number of individuals	X	
	Wet weight of individuals	X	

Table 5-7. Fish Pathology Sample Parameters

Category	Parameters	Importance of Parameter	
		Necessary	If Available
Station Information	Collection method		X
Individual Record	Specimen number	X	
	Taxonomic code	X	
	Sex		X
	Length		X
	Length units		X
	Method used to measure length		X
	Weight		X
	Weight units		X
	Method used to measure weight		X
	Disease	X	
	Health status		X
	Pigmentation		X
Lesion Record	Lesion	X	
	Severity		X
	Host response		X
	Organ/Suborgan		X

Table 5-8. Fish Advisory Parameters

Parameter	Importance of Parameter	
	Necessary	If Available
Species Affected	X	
Sizes (length or weight)	X	
Contaminants	X	
Reach Number (or other location identification)	X	
Thresholds for Issuing Advisory		X

- Gulf of Mexico Program Sediment Inventory
- NS&T (NOAA)
- EMAP
- ODES
- Puget Sound Ambient Monitoring Program
- Region 5 Sediment Inventory
- USGS
- Great Lakes Sediment Inventory

The key issues associated with this evaluation will be organization, national consistency, and breadth of data elements.

Sources of Data to Be Included in the National Sediment Inventory

Depending on available resources, data from the following existing computerized databases will be included in the National Sediment Inventory:

- Select data sets from STORET, e.g.,
  - COE
  - USGS
  - EPA
  - States
  - BIOACC
- NS&T (NOAA)
- ODES
- Region 4 Sediment Inventory
- Region 5 Sediment Inventory
- Gulf of Mexico Program Sediment Inventory
- COE Seattle District Sediment Inventory
- Great Lakes Sediment Inventory
- Environmental Monitoring and Assessment Program (EMAP)
- National Estuary Program (NEP)
- FWS

- MacDonald Database
- USGS
- National Source Inventory

Data Collection Procedures

Only data collected since 1980 that are currently maintained in computerized format will be included in the NSI. Hard copy data will not be included. Because of limited time and resources, data sets will be prioritized for integration based on geographic coverage and quality, as well as the types of information they contain. The major source, in terms of geographic coverage, of sediment chemistry data will be STORET. EPA will conduct an assessment of existing sediment and related data in STORET. Data from select data sources in STORET will be transferred to the Inventory. These would include data from USGS, COE, EPA, state, and other possible databases housed in STORET. Biological data maintained in STORET (i.e., National Study of Chemical Residues in Fish) will also be included in the Inventory. EPA will also compile the data from the Region 4, Region 5, COE Seattle District, Great Lakes, and Gulf of Mexico sediment inventories and biological data currently in ODES and enter these into the Inventory. NOAA will provide EPA with data from its NS&T program for incorporation into the Inventory.

Other databases from such programs as EPA's EMAP and NEP, USGS, and MacDonald database will also be investigated to determine the feasibility of including them in the Inventory. This will again be determined to a large degree by the available resources as well as the difficulty in obtaining this information, the difficulty in analyzing the data, and their compatibility with the structure of the Inventory.

Initial Evaluation

Once the National Sediment Inventory is in place, an evaluation of the data will be conducted to identify those sample observations that exceed the threshold limits for each contaminant. The results of this evaluation will be a computer-generated detailed listing of all observations that exceeded the sediment quality threshold limits. For inland areas, EPA's River Reach System will be used to organize the report by watersheds. Organization of results for estuaries and open waterways has not been finalized. It should be noted that any sediment chemistry measurement that exceeds the threshold limit for a contaminant will be included as long as the measured value was also greater than the detection limit for that observation,

regardless of whether the detection limit was lower or greater than the threshold limit.

Additional data related to each potential area of concern in which a sediment sample that exceeded a given threshold was taken will also be included in the initial evaluation. The National Source Inventory will be used to identify point and nonpoint source discharges contributing to sediment contamination. Such information will include, when available, bioassay, bioaccumulation, benthic abundance, fish pathology, and fish advisory data. These data will be included to assist the Regional reviewer in assessing the ancillary data. Biological and other forms of data can then be used to further justify the inclusion of a site on the list of high-priority sites. An evaluation of QA/QC data using an approach similar to that used by GLNPO will also be conducted. The results of this evaluation will be a ranking of the potential quality of the data in each data set as good quality, poor quality, or unknown quality. Overall summary statistics will also be developed for the initial evaluation, defining, for example, the total number of samples per area, the total number of observations per sample, the total number of observations exceeding threshold limits for each contaminant, the percentage of all observations exceeding threshold limits, and the total number of reaches affected nationally and by EPA Region and state.

It is currently envisioned that the initial evaluation will include selected portions of the following information, as available:

- Reach identification (alternative approaches for estuaries and open waters are still under consideration)
  - reach name
  - reach number
  - state
  - county
  - waterbody name
  - waterbody type (river, lake, coastal)
  - upstream lat/long
  - downstream lat/long
  - reach length
  - site states (remediation or regulatory action, none)
  - dredged? (last two dates dredged)
  - land use/land cover (if known)
  - industries within reach (names, SIC code, NPDES number)
- Sediment chemistry sampling information
  - contaminant, CAS number, and threshold limit

- source of data (agency identifier)
- sample location (lat/long)
- Reach File Index
- date of sample
- sample number
- measurement value that exceeded threshold
- units
- magnitude of threshold exceedance (e.g., 1x, 5x, 10x, >10x)
- QA/QC qualifying code (e.g., acceptable, poor, unknown)
- summary information (i.e., total number of threshold exceedances for each contaminant in the reach)

For each reach in which one or more sediment quality measurements exceed a threshold limit, the Inventory would include a listing of other monitoring data or fish advisory information for that reach, if available. When possible, this information would include selected portions of the following:

- Sediment toxicity/bioassay testing

  - source of data (agency identifier)
  - location where sediment sample was taken (lat/long)
  - date of sampling
  - sample number
  - species name and code
  - test duration
  - type of assay
  - minimum value
  - maximum value
  - median value
  - units
  - number of samples
  - results
  - QA/QC qualifying code

- Bioaccumulation testing

  - source of data (agency identifier)
  - location where sample was taken (lat/long)
  - date of sampling
  - sample number
  - contaminant measured
  - species name and code
  - type of sample (i.e., tissue analyzed: whole body, fillet, other organ)
  - minimum value

- maximum value
- median value
- units
- QA/QC qualifying code

- Benthic abundance information

  - source of data (identification number)
  - location where sample was taken (lat/long)
  - sample number
  - date of sample
  - indices measured
  - results
  - QA/QC qualifying code

- Fish advisory information

  - extent of fish advisory (lat/long)
  - fish species
  - sizes
  - contaminants
  - threshold for issuing/lifting advisory
  - date advisory started

- Fish pathology information

  - source of information (agency identifier)
  - location of sample (lat/long)
  - date of sample
  - sample number
  - species name and code
  - impairment observed
  - QA/QC qualifying code

Review of the National Sediment Inventory

During 1993 EPA will compile the preliminary National Sediment Inventory. Each Region will be sent a Regional Sediment Inventory (e.g., the data used in the evaluation) and a preliminary report describing the NSI and the assumptions and procedures used in developing the preliminary report and a preliminary list of areas and chemicals of concern. The Regions will also be provided with the NSI documentation and procedures for conducting their own assessments of the data if desired. The Regions will be encouraged to correct inaccurate analyses and

nominate additional data not part of the original data compilation for inclusion during a revised analysis. It will also be the responsibility of EPA Regions to correct source databases or notify data owners of inaccurate data.

The EPA Regions will identify additional computerized databases that can supplement the information presented in the NSI; for example, additional biological data or sediment contamination data for areas of the country for which EPA Headquarters did not have data. If the Regions are able to identify additional relevant databases, they will acquire copies of these databases on disk and provide them to Headquarters for possible entry into the NSI.

The Regions will also review the QA/QC information for the data. For those data in the Inventory for which the quality of the data is unknown, the Regions should contact the source of the data to determine what QA/QC samples and procedures were used during sample collection and analysis. Based on their findings, the Regions can include an analysis of QA/QC information in the analysis. Gathering the QA/QC data for samples that are included in the Inventory and for which the data quality is unknown will take a considerable amount of effort on the part of the Regions because, depending on the Region, much of the sediment chemistry data may come from STORET, which does not contain detailed data quality information.

Following Regional review, EPA will select and include selected additional data from the 10 Regions into the NSI. These data will be evaluated a second time in a more complex manner, and the results will represent the final report. Other federal agencies, EPA program offices, and regions, as well as states, will be involved in formulating the approach for the second evaluation.

Each of the identified sites will be categorized as either those for which sufficient data exist to characterize them as causing high risks or severe effects or those which may be contaminated but are in need of additional information and further assessment. This categorization will be based on consideration of a number of factors, including the following:

- Number of chemicals exceeding threshold limits;
- Number of observations exceeding threshold limits;
- Severity of contamination (i.e., contaminant concentration);
- Biological evidence of contamination and impacts to support conclusions based on sediment chemistry data;
- Fish advisory information; and

- Quality of data used to identify the site as contaminated.

A final report describing the process used to develop the NSI and the evaluation process will accompany the Inventory. As with the preliminary report, the final report will also provide guidance on accessing and evaluating the data in the Inventory. The report will also explain the assumptions made in categorizing chemicals of concern and in categorizing sites as being potential or probable contaminated sites.

Schedule

Figure 5-1 presents the proposed schedule for the completion of milestones related to the NSI. The design of the Inventory is scheduled to begin in January of 1993, and completion of the preliminary report and Regional Sediment Inventories is scheduled for December of 1993. Regional review and comment and update of the Inventory are planned to occur from January through mid-summer of 1994. The final National Sediment Inventory, which will incorporate the input from the Regional Offices, is scheduled for completion in December of 1994.

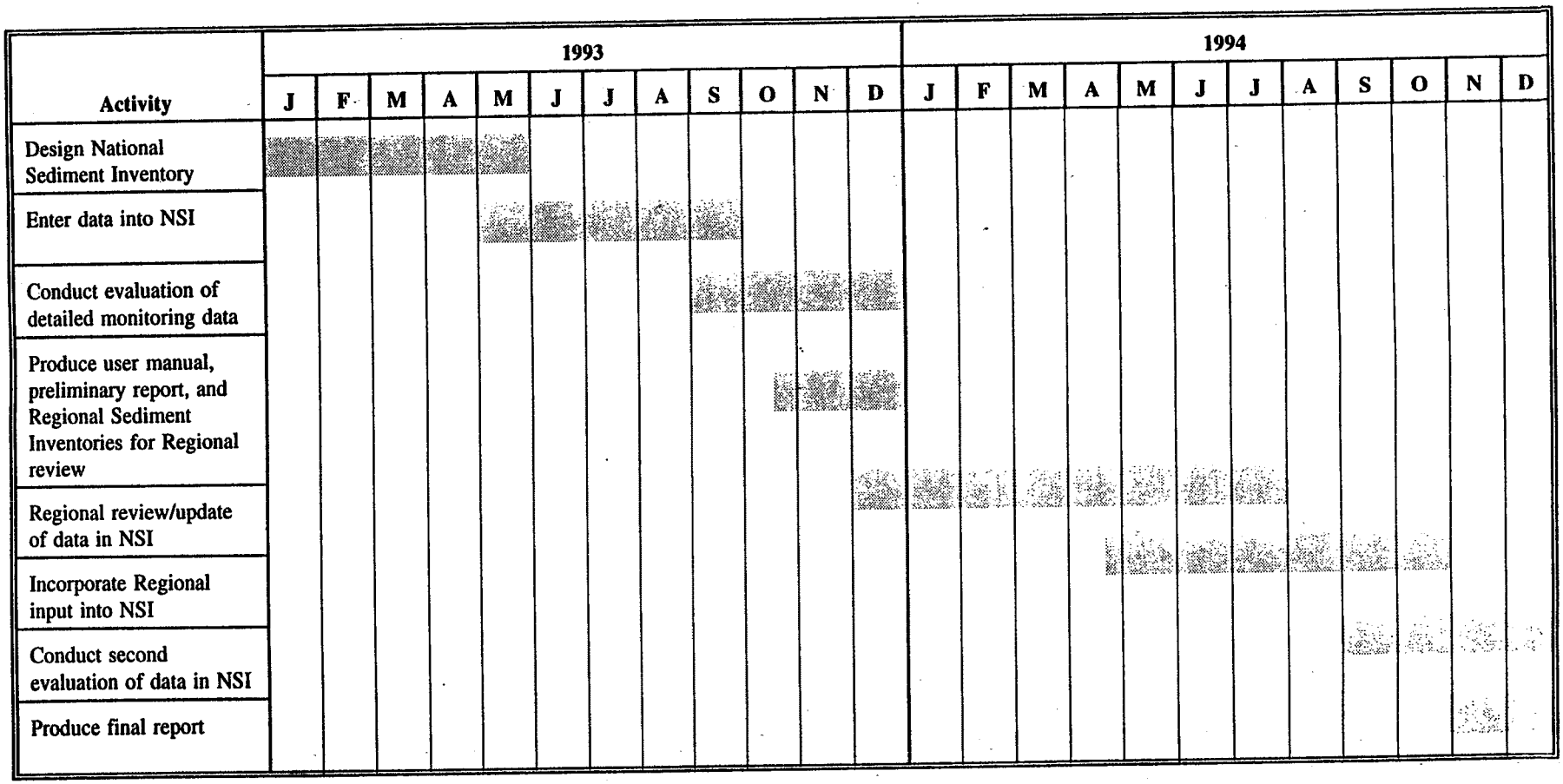

Figure 5-1. Milestones for Completion of the National Sediment Inventory

CHAPTER 6

SEDIMENT ASSESSMENT TECHNIQUES

Sediment assessment is a procedure used to interpret the significance of contaminant levels measured in sediments, accounting for differences in contaminant bioavailability caused by site-specific properties of sediments (Adams et al., 1992). Several sediment quality assessment techniques are briefly reviewed below for their data requirements and surrounding issues. A more complete review of this topic may be found in USEPA (1992e), Adams et al. (1992), and Long and Morgan (1990). A number of sediment assessment approaches and several more "weight-of-evidence" approaches or combinations of approaches have been adopted by programs, such as the "Green Book" method for dredged material disposal in ocean and near coastal waters adopted by EPA's Oceans and Coastal Protection Division (OCPD) (COE and USEPA, 1991a), the Long and Morgan (1990) approach adopted by NOAA's National Status and Trends (NS&T) Program, and the tiered approach used in the Great Lakes region by the International Joint Commission (IJC).

There appears to be no single method for identifying contaminated sediments that will apply in all cases because of the variability in sediment properties controlling the bioavailability of contaminants in sediments, the variability in the sensitivity and behavior of organisms, and the confounding effects of other chemicals. The need for a timely assessment of existing sediment quality in the United States will help drive the selection of an approach that will work, given available data and resources, despite the current level of uncertainty regarding processes controlling bioavailability and toxicity of compounds in sediments.

As described previously, the first NSI evaluation to identify potential chemicals and areas of concern will be based on sediment chemistry threshold exceedances. The second, more complete evaluation will include biological as well as data quality information. Input from other federal agencies, EPA program offices and Regions, and states will be included in this process to identify chemicals of concern and potential and probable areas of concern. The following sediment quality assessment techniques will be considered in developing these lists. The process will likely involve a point system similar to Region 5's prioritization of sites project.

The sediment quality assessment techniques being reviewed for consideration for use in the development of the National Sediment Inventory include the following:

- Equilibrium Partitioning
- Sediment Quality Triad
- Bulk Sediment Toxicity

- Interstitial Water Toxicity Evaluation
- Apparent Effects Threshold
- Spiked Sediment Toxicity
- Tissue Residue
- Screening-Level Concentration
- Long and Morgan (1990)
- MacDonald (1992)

The approaches for deriving sediment quality criteria as reviewed by USEPA (1992e), Adams et al. (1992), and Long and Morgan (1990) are summarized in Table 6-1.

Equilibrium Partitioning

In the Equilibrium Partitioning approach, interstitial water concentrations of individual chemicals are predicted from equilibrium partitioning theory and compared with water quality criteria derived from chronic water-only exposure to test organisms. This method is protective of aquatic organisms whose primary route of exposure to contaminants is through contact with sediment interstitial water (primarily benthic organisms that burrow in sediment). A key assumption is that the appropriate toxicological endpoints and sensitivities of benthic organisms can be considered to be the same as those of the test species for which the final chronic values were derived. The method can be applied to nonpolar, nonionic chemicals in sediments having organic carbon contents in the range of 0.2 percent to about 30 to 40 percent (D.M. DiToro at EPA Science Advisory Board meeting, Crystal City, Virginia, 10 June 1992).

Sediment Quality Triad

In the Sediment Quality Triad approach, the correspondence between sediment chemistry, toxicity, and biological effects is used to indicate the spatial distribution of sediment contamination and define "hot spots" within a site by distinguishing high levels of biological effects relative to a suitable reference station. This approach has an advantage over the bulk sediment toxicity approach in that it considers multiple categories rather than a single category of information and therefore may be classified as a weight-of-evidence approach. The method can be

Table 6-1. Data Requirements and Issues Related to Sediment Assessment Techniques

Approach for Sediment Assessment	Data Requirements	Issues
Equilibrium Partitioning	• bulk chemistry • organic carbon content (May be applied to summary data)	• Applies to only one class of compounds, the nonpolar, nonionic chemicals • Does not account for exposure through ingestion, which is important for compounds with high K_{ow}s • Does not account for the joint action of chemicals • Can be applied only to those chemicals for which a WQC is available or for which there is a sufficient database on effects • Does not apply to sediments with organic carbon content below about 0.2%
Sediment Quality Triad	• bulk chemistry • toxicity (several species and endpoints desirable) • benthic community (or possibly bottom fish histopathology) • organic carbon content (Requires extensive detailed monitoring data)	• Requires a complete set of consistent individual monitoring data at each station • Subjective judgment is required to develop SQC • Requires the use of a reference site • Does not allow calculation of statistical confidence intervals for SQC • Does not address causality or the mechanisms contributing to bioaccumulation
Bulk Sediment Toxicity	• bulk sediment toxicity (often more than one test species or bioassay type) (Designed for use with detailed monitoring data.)	• Cannot be used to develop SQC • Does not address causality • Requires the use of a reference site • Does not address the mechanisms contributing to bioaccumulation

Table 6-1. (Continued)

Approach for Sediment Assessment	Data Requirements	Issues
Interstitial Water Toxicity Identification Evaluation (TIE)	• interstitial water toxicity • toxicity of chemical fractions of interstitial water • data for validation (Does not lend itself to use of existing data)	• Pore water toxicity tests and TIE procedures are insufficiently validated • Interstitial water may not be the primary route of exposure for organisms ingesting sediments or compounds with high K_{ow}s
Apparent Effects Threshold	• bulk chemistry • field-collected biological effects data (results of more than one bioassay type preferable) • organic carbon (not absolutely necessary but preferable) (Requires individual monitoring data if sediment toxicity is used; may perhaps be used with summary data if animals that traverse the entire site, such as fish, are used)	• Requires data showing a wide range in chemical concentrations and biological effects • Requires use of a reference site having negligible measured biological effects • Cannot determine which chemicals are causing the biological effects • Cannot distinguish the harm caused by individual chemicals in mixtures • Does not address bioaccumulation
Spiked Sediment Toxicity	• toxicity tests on a range of test sediment concentrations where the test sediment was created by taking sediment from a reference site and adding chemical to form a range of sediment concentrations (Cannot be used with existing monitoring data)	• Requires establishment of a reference sediment • Results depend on sediment aging, i.e., the elapsed time between spiking and testing • Results may depend on the amount of carrier compound used to dissolve the chemical in the spiking solution • Does not test field conditions and in situ organisms; may not mimic natural conditions

Table 6-1. (Continued)

Approach for Sediment Assessment	Data Requirements	Issues
Tissue Residue Approach	• either WQC or no-observed-effects level from bioassay and BCF or criteria for fish tissue residues • sediment organic carbon content • chemistry in water column, sediment, and biota • food chain structure • ratio of dry to wet weight for animals in food chain • respiration rate as a function of water temperature and organism mass • lipid content of the animals and K_{ow} to calculate a BCF • growth rate of animals (Can be used with summary data, although additional parameters in the summary database would be required)	• Approach is most suitable for contaminants with high K_{ow}s and slow metabolism • The relationship between contaminant concentrations in sediments and tissue concentrations is poorly understood • Thermodynamic and toxicokinetic bioaccumulation models have been tested for only a few compounds • Causal relationships between tissue residues and biological effects are not well understood • Requires FDA action levels or state standards, which can vary considerably by state • Requires literature search or laboratory analysis of respiration rates
Screening-Level Concentration	• species composition • sediment chemistry • organic carbon content (Requires extensive detailed monitoring data)	• Results can be confounded by changes in the habitat, sediment properties, and surface water quality • Has received limited application to compounds other than nonpolar organics • Requires large sets of detailed monitoring data • Cannot determine which chemicals are causing the effects
Long and Morgan (1990) or NS&T	• matched chemistry and biological effects data for many species and sites • spiked sediment bioassay data from literature (Requires detailed monitoring data)	• Cannot determine which chemicals or other factors are causing the effects • Requires large sets of detailed monitoring data • Results may be confounded by the effects of mixtures • Does not consider differences in bioavailability for different sediments

Table 6-1. (Continued)

Approach for Sediment Assessment	Data Requirements	Issues
MacDonald (1992)	• matched chemistry and biological effects data for many species and sites (Requires detailed monitoring data)	• Cannot determine which chemicals or other factors are causing the effects • Requires large sets of detailed monitoring data • Results may be confounded by the effects of mixtures • Does not consider differences in bioavailability for different sediments

applied to all types of sediments and chemicals, provides a direct assessment of sediment quality, can use existing detailed monitoring data, and can be used to empirically derive Sediment Quality Criteria (SQC) for many chemicals. Three categories of individual monitoring data are normalized to values collected at a monitoring station designated as the reference site by dividing the value of the specific variable measured by its value measured at the reference site. In this manner a ratio-to-reference (RTR) value is calculated for chemical concentration, various toxicity test results, and parameters measuring benthic community structure or function. (A complete set of data for each monitoring station is necessary.) The

RTR values for each station are summarized by combining them, for each category of data, into an average. Average values are used to divide sediments into three categories: contaminant concentrations at which there are no biological effects, contaminant concentrations at or above which biological effects are always high, and a range of chemical concentrations with intermediate levels of biological effects.

Bulk Sediment Toxicity

In the Bulk Sediment Toxicity approach, a number of bioassays are performed using field-collected bulk sediment to determine whether the sediments produce adverse effects on the growth, survival, or behavior of test organisms. The method provides a direct measure of biological effects in total for whatever mixtures of chemicals may be present. This method is routinely used to assess disposal opportunities for dredged material and to assess the quality of sediments below discharge points or in the vicinity of waste disposal sites (Adams et al., 1992). The advantages of the approach are that it is relatively inexpensive to perform, it can be performed on species from a nearby reference site, and it can integrate the effects of mixtures of contaminants. This method cannot distinguish the chemical

agent responsible for the observed toxicity. Like the Sediment Quality Triad approach, this method may be used to define boundaries of problem areas based on relative sediment toxicity.

Interstitial Water Toxicity Identification Evaluation

The Interstitial Water Toxicity Identification Evaluation (TIE) approach is a multistage procedure for evaluating the toxicity of sediment-associated chemicals to aquatic organisms by exposing organisms to interstitial water, i.e., aqueous solutions extracted by centrifugation or syringe from sediments. Interstitial water is used based on the assumption that contact with interstitial water is the primary route of exposure for organisms living in sediment. Once the degree of toxicity to interstitial water has been evaluated, toxicity identification and evaluation procedures are used to identify the contaminant(s) responsible for the toxicity and to quantify the degree of biological response. The final and most important stage of the Interstitial Water TIE approach is the confirmation of the suspected contaminants using correlation of toxicity with contaminant concentrations, spiked sediment bioassays, or observation of signs of intoxication among different species.

Apparent Effects Threshold

In the Apparent Effects Threshold (AET) approach, field data on biological effects are compared with sediment concentrations of individual chemicals. The AET is defined as the concentration above which biological effects are always observed (based on statistical significance, $P \leq 0.05$). Paired sediment chemistry and biological effects data spanning a wide range in chemical concentration and biological response are required. "Impacted" and "nonimpacted" sites are identified based on whether the biological response of test organisms exposed to sediments from the site is statistically different from the biological response measured for sediment from a reference site. Unimpacted sites are selected and sorted by the concentrations of each chemical of interest. The highest chemical concentration in the sediments not causing biological effects is the AET value for that chemical based on a specific biological response. Several different biological endpoints may be used to obtain a range of AET values. The AET may be used to discriminate contaminated sediments and to develop numerical SQC.

Spiked Sediment Toxicity

The Spiked Sediment Toxicity method is used to establish the safe sediment concentration of a chemical by using a dose-response relationship developed from sediment spike toxicity tests. The toxicity to one or more benthic organisms is

measured by exposing them to test sediments to which a range of chemical concentrations has been added. This method establishes an unequivocal relationship between individual chemicals and toxicity, may be used to examine the joint action of several chemicals, has regulatory and scientific precedence, and can be applied to all chemicals and sediments. This method assumes that exposure conditions in the laboratory approximate conditions in the field. It may be used to develop site-specific SQC by using organisms and sediments from a given site.

Tissue Residue

Sediment Quality Criteria for specific chemicals are established by defining a critical pathway for exposure between contaminants in sediments and the organism of interest. The critical pathway considers the exposure of benthic organisms to contaminants through ingestion of sediments and phytoplankton. Bioaccumulation and subsequent trophic transfer of the chemicals is modeled, taking into account the growth and energy expenditure of the organism. The uptake of contaminant across the gills is assumed to be proportional to the respiration rate of the organism, which must be determined experimentally for all organisms in the food chain as a function of water temperature and body weight. Safe concentrations of contaminants in sediments are then back-calculated from acceptable tissue residue concentrations. Acceptable tissue residues can be based on sublethal effects on benthos or human health risk as determined from FDA action limits, state standards, or cancer models. This method is protective of human health and aquatic life because it takes into account bioaccumulation in fish tissue. The method accounts for uptake of contaminants due to ingestion of sediments, prey, and passage of water over the gills. It may be used for more than one class of chemicals provided that values for the bioconcentration factor (BCF) of that chemical are available. Without BCF values, however, this method can be applied only to nonpolar, nonionic compounds. It can provide a site-specific SQC based on sediment properties and types of organisms present.

Screening-Level Concentration

The Screening-Level Concentration (SLC) approach is a statistical method for estimating the highest concentration of a chemical in sediment that will not be expected to produce an effect on benthic infaunal composition. Synoptic observations of organic carbon-normalized chemical concentration and naturally occurring benthic macroinvertebrate fauna are used to evaluate the quality of sediments at a particular location. Co-occurrence analysis is used to link biological effects at each site with the chemicals potentially contributing to these effects. For each organism, a species screening-level concentration (SSLC) is estimated as the highest concentration of a given contaminant that the organism can tolerate based

on the record of its presence or absence at the various monitoring stations for that site. This concentration is estimated by plotting a cumulative frequency distribution of the total number of stations where the organism is present versus the organic carbon normalized concentration in the sediment of those stations. The 90th percentile concentration for the chemical becomes the species' SSLC. The SLC is calculated for the chemical by plotting SSLCs obtained for a large number of species as a frequency distribution. The SLC is defined as the concentration above which 95 percent of the SSLCs are found. The method can be used to derive site-specific SQC.

Long and Morgan (1990)

Long and Morgan (1990) used a weight-of-evidence approach for establishing informal guidelines for assessing the sediments sampled within the NOAA NS&T program. In this method, available site-specific sediment criteria, which were developed using all available methods, were collected for each compound for harbors, bays, and rivers in coastal marine and estuarine environments throughout the United States (although most data are from the northeast and west coasts). Frequently, SQC used were obtained from the equilibrium partitioning approach, the apparent effects threshold, screening-level concentrations, and spiked sediment bioassays. The study involved collecting matched individual monitoring chemical and biological data for areas showing a gradient in concentration and effects. The data were used to calculate various types of SQC. Spiked sediment bioassay data were obtained from the literature. The SQC obtained for various sites and by various methods were ranked from lowest to highest, and the values corresponding to the 10th and 50th percentiles were described as the effects range low (ER-L) and effects range medium (ER-M), respectively. Informal SQC were developed for 43 chemicals or mixtures of chemicals including metals, PCBs, and pesticides.

MacDonald (1992)

MacDonald (1992) built upon the Long and Morgan (1990) approach used to develop NS&T guidelines by including extensive data from the southeastern United States and by incorporating data that demonstrated uncertain, or no, biological effects, as well as those that demonstrated definite effects. The guidelines developed by MacDonald (1992) are designed to be indicators of the general relationship between contaminant concentrations and effects, not absolute indicators of effects. Both the Region 4 and Gulf of Mexico sediment inventories described in Chapter 3 of this document employed the MacDonald (1992) guidelines for evaluating data.

The two effects levels generated by the MacDonald (1992) analysis are defined as the Threshold Effects Level (TEL) and the Probable Effects Level (PEL). The two effects levels are determined using both the Biological Effects Data Set (BEDS), which consists of those data associated with definite biological effects, and the No Biological Effects Data Set (NBEDS), which consists of those data associated with no significant effects. The TEL is loosely defined as the level below which no biological effects would be expected due to the single contaminant being considered. The PEL is loosely defined as that level above which biological effects would nearly always be expected. It is important to note the TELs and PELs are single chemical guideline levels that by themselves do not take into account possible effects due to the presence of chemicals for which there are no guidelines or the effects of multiple chemicals, which may have additive or synergistic effects. One drawback of the MacDonald effects levels compared to those determined by Long and Morgan (1990) is that the additional quality assurance constraints imposed by MacDonald have resulted in effects levels being determined for fewer chemicals (USEPA, 1992a).

CONCLUSIONS AND RECOMMENDATIONS

The final output from the activities described in the previous chapters will be two-fold. First, the National Sediment Inventory (NSI), which will include an actual evaluation of detailed monitoring data from several sources, will be developed. The NSI will also include biological and other data that were the basis for classifying the contaminated sediment sites. The second output will be an evaluation of data housed in the NSI and will include a listing of all those locations across the country which are potentially severely contaminated and those for which sufficient data exist to classify them as posing a significant risk to human health and aquatic life.

The evaluation of data in the NSI will represent a snapshot of sediment contamination problems across the country. It will provide a near-term screening assessment of the national extent and severity and potential sources of sediment contamination, thereby fulfilling the mandates of the Water Resources Development Act of 1992 and contributing to meeting the objectives of EPA's Contaminated Sediment Management Strategy. Any site included on the list of potential or probable contaminated sites should be a target for future, more intensive study, either to justify and recommend remedial or regulatory actions for those sites which pose an obvious risk to the environment or to gather additional information for those sites which appear to be severely contaminated but for which there are insufficient data to reach a definitive conclusion.

By linking contaminated sites with potential sources, the data in the NSI could also be used to evaluate the contribution to sediment contamination from various contaminant sources, including point and nonpoint sources, thereby assisting managers in assessing the need for stricter effluent controls and best management practices. The Inventory could also help managers prioritize future remediation, regulatory, or assessment activities; guide decisions regarding the appropriate type and scale of regulatory action needed to reduce contaminant inputs; and evaluate the effectiveness of existing technology-based effluent guidelines, water quality-based controls, and nonpoint source controls. The Inventory could also be used to identify and prioritize on a local, state, Regional, or national level those specific chemicals in need of stricter regulation.

EPA recommends that the NSI be developed in a coordinated effort with a modernized STORET. This approach will facilitate future updating and future assessments of sediment quality.

EPA also recommends that efforts be made to ensure that future sediment quality monitoring programs include additional information and parameter measurements (which may currently be missing from many data sets), which can be used to more

accurately assess the potential environmental impacts of sediment contamination during future assessments. For example, sediment sampling programs should include the measurement of total or percent organic carbon content, sediment particle size, sediment reductive capacity, and salinity. The data should also meet certain minimum data quality objectives, and the results of data quality evaluations should be reported with the data or, at a minimum, the QA/QC samples and procedures used should be identified. Ensuring that ongoing and future data collections contain these minimum data elements should result in the use of less time and effort to locate relevant data, evaluate their utility for contaminant assessment, and evaluate conditions at a particular site.

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