Chapter 1

Introduction

What Is The National Sediment Quality Survey?

The Water Resources Development Act (WRDA) of 1992 directed the U.S. Environmental Protection Agency (EPA), in consultation with the National Oceanic and Atmospheric Administration (NOAA) and the U.S. Army Corps of Engineers, to conduct a comprehensive national survey of data regarding the quality of sediments in the United States. The Act required EPA to compile all existing information on the quantity, chemical and physical composition, and geographic location of pollutants in aquatic sediment, including the probable sources of such pollutants and identification of those sediments which are contaminated. The statute defines contaminated sediment as aquatic sediment that contains chemical substances in excess of appropriate geochemical, toxicological, or sediment quality criteria or measures, or is otherwise considered to pose a threat to human health or the environment. The Act further required EPA to report to the Congress the findings, conclusions, and recommendations of such survey, including recommendations for actions necessary to prevent contamination of aquatic sediments and to control sources of contamination. In addition, the Act requires EPA to establish a comprehensive and continuing program to assess aquatic sediment quality. As part of this continuing program, EPA must report to Congress every 2 years on the assessment's findings.

To comply with the WRDA mandate, EPA's Office of Science and Technology (OST) initiated the National Sediment Inventory (NSI). The goals of the NSI are to compile sediment quality information from available electronic databases, gather information from available electronic databases and published reports on sediment contaminant sources, develop screening-level assessment protocols to identify potentially contaminated sediment, and produce biennial reports to Congress on the incidence and severity of sediment contamination nationwide. *The Incidence and Severity of Sediment Contamination in Surface Waters of the United States* is the first of these reports to Congress. To ensure that future reports to Congress accurately reflect contemporary conditions of the Nation's sediment as science evolves, the NSI will develop into a regularly updated, centralized assemblage of sediment quality measurements and assessment techniques.

The Incidence and Severity of Sediment Contamination in Surface Waters of the United States is presented as a four-volume series. This volume, *Volume 1: The National Sediment Quality Survey,* presents a national baseline screening-level assessment of contaminated sediment over a time period of the past 15 years using a weight-of-evidence approach. The purpose of *The National Sediment Quality Survey* is to depict and characterize the incidence and severity of sediment contamination based on the *probability* of adverse effects to human health and the environment. Information contained in this volume may be used to further investigate sediment contamination on a national, regional, and site-specific scale. Volume 2 of this series presents data summaries for watersheds that have been identified in this volume as containing areas of probable concern for sediment contamination. Volume 3 presents a screening analysis to identify probable point source contributors of sediment pollutants. Volume 4 presents a screening analysis to identify probable nonpoint contributors of sediment pollutants (in preparation for subsequent biannual reports).

For *The National Sediment Quality Survey*, OST compiled and analyzed historical data that were collected from 1980 to 1993 from across the country and are currently stored in large electronic databases. This effort required a substantial synthesis of multiple formats and the coordinated efforts of many federal and state environmental information programs that maintain relevant data. Published data that have not been entered into databases, or are not readily available to EPA, are not included in the NSI at this time and thus were not evaluated for this report to Congress. As data management systems and access capabilities continue to improve, EPA anticipates that a greater amount of data will be readily available in electronic form.

This report presents the results of the screening-level assessment of the NSI data. For this assessment, OST examined sediment chemistry data, associated fish tissue residue levels, and sediment toxicity test results. The purpose was to determine whether potential contamina-

tion problems either exist currently or existed over the past 15 years at distinct monitoring locations. This report identifies locations where available data indicate that direct or indirect exposure to the sediment could be associated with adverse effects to aquatic life or human health. However, because this analysis is based on readily available electronic data, contamination problems exist at some locations where data are lacking. Furthermore, because the data analyzed were collected over a relatively long period of time, conditions might have improved or worsened since the sediment was sampled. Consequently, this report does not definitively assess the current overall condition of all sediments across the country, but serves as a baseline for future assessments, which will include additional sampling stations, incorporate contemporary data, and examine trends.

In addition to this and future reports to Congress, EPA anticipates that products generated through the NSI will provide managers at the federal, state, and local levels with information. Many of the NSI data were obtained by local watershed managers from monitoring programs targeted toward areas of known or suspected contamination. NSI data and evaluation results can assist local watershed managers by providing additional data that they might not have, demonstrating the application of a weight-of-evidence approach for identifying and screening contaminated sediment locations, and allowing researchers to draw upon a large data set of information to conduct new analyses that ultimately will be relevant for local assessments.

The National Sediment Quality Survey summarizes national, regional, and state results from the evaluation of NSI data. Chapter 1 provides background information about sediment quality issues. Chapter 2 is an overview of the assessment methods used to evaluate the NSI data. Chapter 3 contains the evaluation results on a national, regional, and state basis. Chapter 4 presents information on probable sources of sediment contamination, including point and nonpoint sources. A discussion of the results is provided in Chapter 5. Chapter 6 presents recommendations for evaluating and managing contaminated sediments. Several appendices present detailed descriptions of both the NSI data and the approach used to evaluate the data:

A: Detailed Description of NSI Data

B: Description of Evaluation Parameters Used in the NSI Data Evaluation

C: Method for Selecting Biota-Sediment Accumulation Factors and Percent Lipids in Fish Tissue Used for Deriving Theoretical Bioaccumulation Potentials

D: Screening Values for Chemicals Evaluated

E: Cancer Slope Factors and Noncancer Reference Doses Used to Develop EPA Risk Levels

F: Species Characteristics Related to NSI Bioaccumulation Data

G: Notes on the Methodology for Evaluating Sediment Toxicity Tests

H: Additional Analyses for PCBs and Mercury

I: NSI Data Evaluation Approach Recommended by the National Sediment Inventory Workshop, April 26-27, 1994

Why Is Contaminated Sediment An Important National Issue?

Sediment provides habitat for many aquatic organisms and functions as an important component of aquatic ecosystems. Sediment also serves as a major repository for persistent and toxic chemical pollutants released into the environment. In the aquatic environment, chemical waste products of anthropogenic (human) origin that do not easily degrade can eventually accumulate in sediment. In fact, sediment has been described as the "ultimate sink," or storage place, for pollutants (Salomons et al., 1987). If that were entirely true, however, we would not need to be concerned about potential adverse effects from these "stored" pollutants. Unfortunately, sediment can function as both a sink and a source for contaminants in the aquatic environment.

Adverse effects on organisms in or near sediment can occur even when contaminant levels in the overlying water are low. Benthic (bottom-dwelling) organisms can be exposed to contaminants in sediment through direct contact, ingestion of sediment particles, or uptake of dissolved contaminants present in the interstitial (pore) water. In addition, natural and human disturbances can release contaminants to the overlying water, where pelagic (open-water) organisms can be exposed. Evidence from laboratory tests shows that contaminated sediment can cause both immediate lethality (acute toxicity) and long-term deleterious effects (chronic toxicity) to benthic organisms. Field studies have revealed other effects, such as tumors and other lesions, on bottom-feeding fish. These effects can reduce or eliminate species of recreational, commercial, or ecological importance (such as crabs, shrimp, and fish) in water bodies either directly or

by affecting the food supply that sustainable populations require. Furthermore, sediment contaminants might not kill the host organism, but might accumulate in edible tissue to levels that cause health risks to wildlife and human consumers.

In summary, environmental managers and others are concerned about sediment contamination and the assessment of sediment quality for the following reasons (adapted from Power and Chapman in "Assessing Sediment Quality," 1992):

- Various toxic contaminants found only in barely detectable amounts in the water column can accumulate in sediments to much higher levels.
- Sediments serve as both a reservoir for contaminants and a source of contaminants to the water column and organisms.
- Sediments integrate contaminant concentrations over time, whereas water column contaminant concentrations are much more variable and dynamic.
- Sediment contaminants (in addition to water column contaminants) affect bottom-dwelling organisms and other sediment-associated organisms, as well as both the organisms that feed on them and humans.
- Sediments are an integral part of the aquatic environment that provide habitat, feeding, spawning, and rearing areas for many aquatic organisms.

Contaminated sediments can affect aquatic life in a number of ways. Areas with high sediment contaminant levels can be devoid of sensitive species and, in some cases, all species. For example, benthic amphipods were absent from contaminated waterways in Commencement Bay, Washington (Swartz et al., 1982). In Rhode Island, the number of species of benthic molluscs was reduced near an outfall where raw electroplating wastes and other wastes containing high levels of toxic metals were discharged into Narragansett Bay (Eisler, 1995). In California, pollution-tolerant oligochaete worms dominate the sediment in the lower portion of Coyote Creek, which receives urban runoff from San Jose (Pitt, 1995).

Sediment contamination can also adversely affect the health of organisms and provide a source of contaminants to the aquatic food chain (Lyman et al., 1987). For example, fin rot and a variety of tumors have been found in fish living above sediments contaminated by polycyclic aromatic hydrocarbons (PAHs) located near a creosote plant on the Elizabeth River in Virginia. These impacts have been correlated with the extent of sediment contamination in the river (Van Veld et al., 1990). Liver tumors and skin lesions have occurred in brown bullheads from the Black River in Ohio, which is contaminated by PAHs from a coke plant. The authors of the Black River study established a cause-and-effect relationship between the presence of PAHs in sediment and the occurrence of liver cancer in native fish populations (Baumann et al., 1987). Examples of risks to fish-eating birds and mammals posed by contaminated food chains include reproductive problems in Forster's terns on Lake Michigan near Green Bay (Kubiak et al., 1989) and on mink farms where mink were fed Great Lakes fish (Auerlich et al., 1973). In both cases, high levels of polchlorinated biphenyls (PCBs) in fish were identified as the cause of the reproductive failures. Contaminated sediments can also affect the food chain base by eliminating food sources and, in some cases, altering natural competition, which can impact the population dynamics of higher trophic levels (Burton et al., 1989; Landis and Yu, 1995).

The accumulation of contaminants in fish tissue (called bioaccumulation) and contamination of the food chain are also important human health and wildlife concerns because people and wildlife eat finfish and shellfish. In fact, the consumption of fish represents the most significant route of aquatic exposure of humans to many metals and organic compounds (USEPA, 1992a). Most sediment-related human exposure to contaminants is through indirect routes that involve the transfer of pollutants out of the sediments and into the water column or aquatic organisms. 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. In 1995, over 1,500 water bodies in the United States had fish consumption advisories in place, affecting all but four states. Water supplies also have been shut down because of contaminated sediments, and in some places swimming is no longer allowed.

How Significant Is The Problem?

Puget Sound was one of the first areas in the country to be studied extensively for sediment contamination. Early studies from the 1980s demonstrated fairly extensive sediment contamination, especially near major industrial embayments (Dexter et al., 1981; Long, 1982; Malins et al., 1980; Riley et al., 1981). These early assessments demonstrated that Puget Sound sediments were contaminated by many organic and inorganic chemicals, including PCBs, PAHs, and metals. Although contaminant

concentrations in sediment tended to decrease rapidly with distance from the nearshore sources, researchers also documented widespread low-level contamination in the deepwater sediments of the main basin of Puget Sound (Ginn and Pastorok, 1982). Also in the 1980s, several kinds of biological effects, including cancerous tumors, were reported in organisms from contaminated areas of Puget Sound (Becker et al., 1987).

Several recent studies conducted in other parts of the country further illustrate the significance of sediment contamination and its potential widespread impact. For example, Myers et al. (1994) investigated the relationships between hepatic lesions (liver tumors) and stomach contents, liver tissue, and bile in three species of bottom-dwelling fish captured from 27 urban and nonurban sites on the Pacific Coast from Alaska to southern California, as well as the relationship of such lesions to associated chemical concentrations in sediments. In general, the authors found that lesions were more likely to occur in fish from sites with higher concentrations of chemical contaminants in sediments. Certain lesions had a significantly higher relative risk of occurrence at urban sites in Puget Sound, San Francisco Bay, the vicinity of Los Angeles, and San Diego Bay (Myers et al., 1994). The results of this study provide strong evidence for the involvement of sediment contaminants in causing hepatic lesions in bottom fish and clearly indicate the usefulness of these lesions as indicators of contaminant-induced effects in fish (Myers et al., 1994).

Several recent assessments of existing data on the Nation's marine (saltwater) and freshwater sediments (e.g., NRC, 1989) indicate potentially widespread and serious contamination problems. The NOAA National Status and Trends Program has monitored coastal sediment contamination since the mid-1980s and has linked elevated pollutant concentrations to the potential for adverse biological effects in many urban areas, including the Hudson-Raritan estuary, Boston Harbor, western Long Island, and the Oakland estuary of San Francisco Bay (Long and Morgan, 1990; Power and Chapman, 1992). The U.S. and Canadian governments have also identified widespread contaminated sediments in the Great Lakes (IJC, 1987; Fox and Tuchman, 1996; Power and Chapman, 1992). The USEPA (1993a) summarizes other recent assessment studies. However, there is still no national-scale assessment of the incidence and severity of sediment contamination, particularly in freshwater areas. This report is the result of EPA's first assessment to determine how significant the problem of sediment contamination is on a national basis.

What Are The Potential Sources Of Sediment Contamination?

Water bodies usually receive discharges of pollutants as a result of the various human activities, past and present, that take place nearby. The cumulative effect of historical, nonpoint, and point sources can contribute to sediment contamination. A point source is a single, identifiable source of pollution such as a pipe from a factory or a wastewater treatment plant. Nonpoint source pollution is usually carried off the land by stormwater runoff and includes pollutants from agriculture, urban areas, mining, marinas and boating, construction and other land modifications, and atmospheric deposition. Many of the current suspected and documented cases of sediment contamination are caused by past industrial and agricultural uses of highly persistent and toxic chemicals, such as PCBs and chlordane. While the use of such chemicals has since been banned or tightly restricted, monitoring programs continue to study the extent and severity of their accumulation in sediment, and subsequently in the tissues of fish and shellfish. Other potential sediment contaminants, including heavy metals, PAHs, some pesticides, and existing and new industrial chemicals, continue to appear in point and nonpoint source releases. However, significant progress over the past 10 to 15 years, achieved through industry pollution prevention initiatives, National Pollutant Discharge Elimination System (NPDES) permits, and national technology-based effluent guideline limitations, has substantially reduced the discharge of toxic and persistent chemicals. Surficial sediments are often less contaminated than deeper sediments indicating improved sediment conditions with reduced discharges over the past 10 to 15 years.

The characteristics of local sediment contamination are usually related to the types of land use activities that take place or have taken place within the area that drains into the water body (the watershed). For example, harbors, streams, and estuaries bordered by industrialized or urbanized areas tend to have elevated levels of the metals and organic compounds typically associated with human activities in these land use areas. Sometimes the contamination is localized beneath an outfall of industrial or municipal waste; in other cases, natural mixing processes and dredging disperse the pollutants. In addition, rivers and streams can carry pollutants from upstream sources into larger downstream water bodies, where they can contribute further to the problem of sediment contamination. Drifting atmospheric pollutants that are eventually deposited in water bodies also contribute to sediment contamination. For example, EPA estimates

that 76 to 89 percent of PCB loadings to Lake Superior have come from air pollution (USEPA, 1994a).

Point source releases, including accidental or deliberate discharges, have resulted in elevated localized sediment 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 have contributed a wide variety of contaminants to sediments. Municipal point sources include sewage treatment plants and overflows from combined sewers (which mix the contents of storm sewers and sanitary sewers). Industrial point sources include manufacturing plants and power-generating operations.

The pervasiveness of 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 contaminant contributions from nonpoint sources like atmospheric deposition and land drainage. For example, mining is a significant source of sediment contamination in some regions, as are runoff and seepage from landfills and Superfund sites, and urban and agricultural runoff (Baudo and Muntau, 1990; Canfield et al., 1994; Hoffman, 1985; Livingston and Cox, 1985; Ryan and Cox, 1985). Agricultural runoff can contribute selenium, arsenic, and mercury and a wide variety of pesticides. Urban runoff is a frequently mentioned source of heavy metals and PAHs. Atmospheric deposition can be one of the major sources of lead, arsenic, cadmium, mercury, PAHs, DDT and other organochlorine pesticides, and PCBs in many aquatic environments (USEPA, 1993c). However, it is often difficult to determine the portion of these contaminants contributed by nonpoint versus point source discharges because the same contaminants can come from both (Baudo and Muntau, 1990).

Kepone contamination in the James River in Virginia is an example of historical sediment contamination. Kepone is a very stable organic compound formerly used in pesticides. Although active discharges of kepone at the production site in Hopewell, Virginia, terminated in 1980, high levels of kepone can still be found in the sediment and finfish and shellfish of the James River downstream from the original discharge site (Huggett and O'Conner, 1988; Nichols, 1990). In fact, a fish advisory exists on portions of the James River because of high levels of kepone in tissues of fish taken from the river. Historical sediment contamination problems such as those on the James River are often further complicated by ongoing discharge sources. Such historical sediment contamination problems can also slow the natural recovery of aquatic systems because of the stable nature of the chemicals responsible for the contamination. Historical sediment contamination can also cause new problems. For example, during heavy storms contaminated sediments can be uncovered, resuspended, and carried downstream, where they cause problems in areas that were previously uncontaminated.