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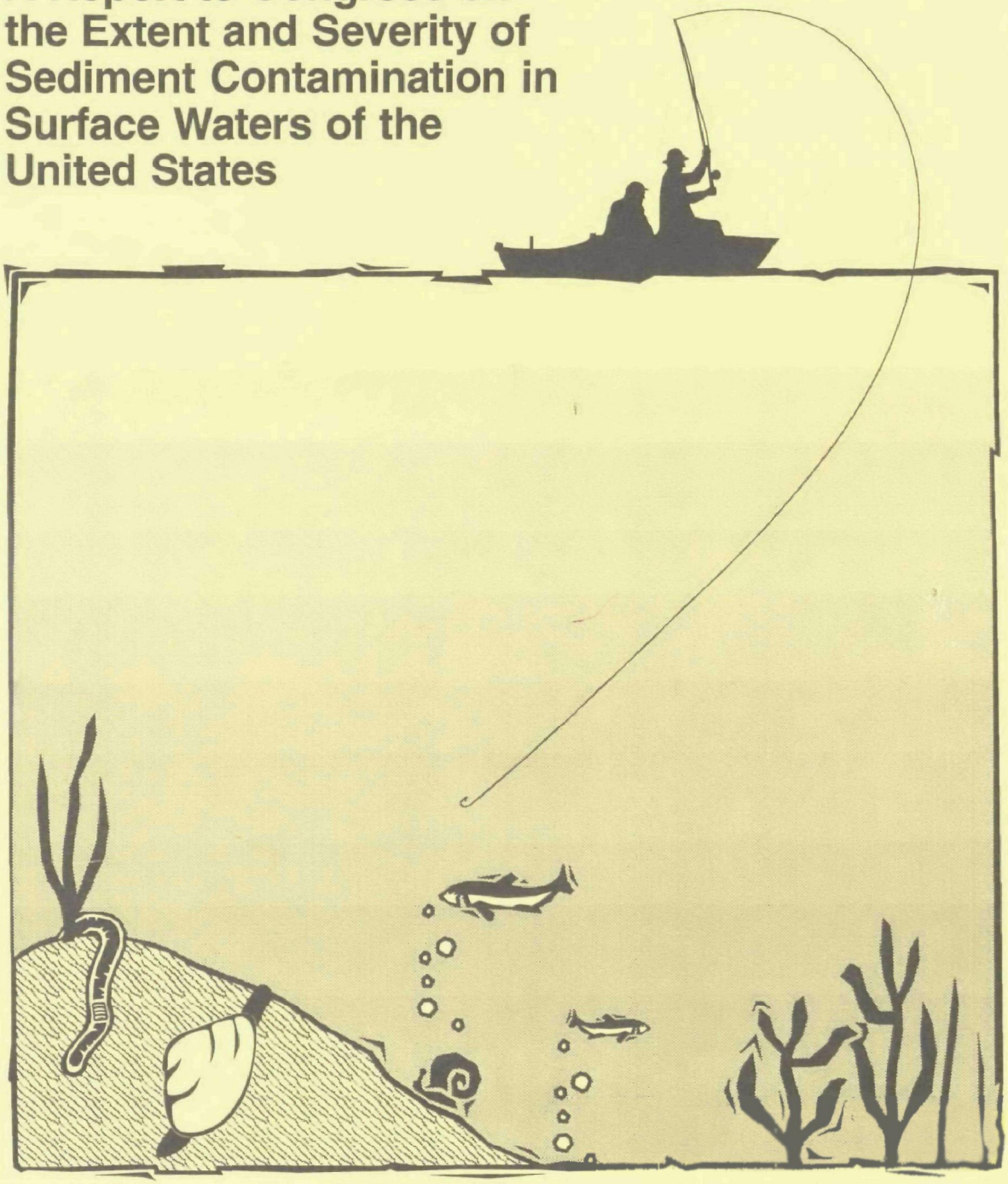
The National Sediment Quality Survey:

A Report to Congress on the Extent and Severity of Sediment Contamination in Surface Waters of the United States



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The National Sediment Quality Survey:

A Report to Congress on the Extent and Severity of Sediment Contamination in Surface Waters of the United States

DRAFT

July 1996

United States Environmental Protection Agency
Office of Science and Technology
Standards and Applied Science Division
Washington, DC

The National Sediment Quality Survey is a screening-level assessment of sediment quality which compiles and evaluates sediment chemistry data and related biological data taken from existing databases. The data and information contained in this document could be used in various EPA regulatory programs for priority setting or other purposes after further evaluation for program-specific criteria. However, this document has no immediate or direct regulatory consequence. It does not in itself establish any legally binding requirements, establish or affect legal rights or obligations, or represent a determination of any party's liability.

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Executive Summary

The National Sediment Quality Survey is the first United States Environmental Protection Agency (EPA) analysis of sediment chemistry and related biological data from across the country to identify the national extent and severity of sediment contamination. This report to Congress was prepared in response to requirements set forth in the Water Resources Development Act (WRDA) of 1992, which directed 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 the quality of aquatic sediments in the United States. WRDA specifically directs EPA to compile existing information on the quality, chemical and physical composition, and geographic location of pollutants in aquatic sediment, including the probable source of such pollutants and identification of those sediments which are contaminated. To comply with this mandate, EPA's Office of Science and Technology (OST) developed the National Sediment Inventory (NSI), and compiled sediment chemistry and related biological data stored in existing regional and national databases. EPA also developed a screening-level assessment method to analyze the NSI data.

This report presents the results of the evaluation of the NSI data, including the screening level identification of sampling stations across the country where contaminated sediments pose a potential threat to aquatic life and human health, as well as watersheds across the country that might have widespread sediment contamination problems. The majority 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 may not have, enabling them to compare their sites to others throughout the region or country, and allowing researchers to draw upon a large data set of information to conduct new analyses that ultimately will be relevant for local assessments and responses.

Description of the NSI

The NSI is the largest set of sediment chemistry and related biological data ever compiled by EPA. It includes approximately 2 million records for more than 21,000 monitoring stations across the country. To be efficient in collecting usable data of similar types for inclusion in the NSI, EPA sought data that were available in electronic format, represented broad geographic coverage, and represented specific sampling locations identified by latitude and longitude coordinates. The minimum data requirements for inclusion of computerized data in the NSI were locational information, sampling date, latitude and longitude coordinates, and measured units. Additional data fields such as sampling method and other quality assurance/quality control information were retained in the NSI if available, but were not required for a database to be included in the NSI.

The NSI includes data from the following data storage systems and monitoring programs:

- Selected data from EPA's Storage and Retrieval System (STORET)
- NOAA's Coastal Sediment Inventory (COSED)
- EPA's Ocean Data Evaluation System (ODES)
- EPA Region 4's Sediment Quality Inventory
- Gulf of Mexico Program's Contaminated Sediment Inventory
- EPA Region 10/COE Seattle District's Sediment Inventory
- EPA Region 9's Dredged Material Tracking System (DMATS)
- EPA's Great Lakes Sediment Inventory
- EPA's Environmental Monitoring and Assessment Program (EMAP)
- USGS (Massachusetts Bay) Data

In addition to sediment chemistry data, the NSI includes tissue residue, toxicity, benthic abundance, histopathology, and fish abundance data. The sediment chemistry, tissue residue, and toxicity data were evalu-

ated for this report to Congress. Data from 1980 to 1993 were used in the NSI data evaluation, but older data also are maintained in the NSI.

Evaluation Approach

The approach utilized chemical-specific screening values and an evaluation methodology developed and reviewed by national experts to assess contaminated sediment. The evaluation methodology is meant to be used *for screening purposes only*, the screening values are not regulatory criteria, site-specific cleanup standards, or remediation goals. The screening levels are set to be appropriately conservative, so sites which pass through the screen would not be expected to exhibit adverse effects; exceeding the screening levels does not indicate the level or type of risk at a particular site, but can be used to target additional investigations. Thus, these tools and the evaluation results improve the ability to identify and address contaminated sediment problems.

The following measurement parameters and techniques were used alone or in combination to evaluate the probability of adverse effects to aquatic life and human health from exposure to sediment contaminants:

(1) Comparison of sediment chemistry measurements to

- Draft sediment quality criteria (SCQs)
- Other sediment quality screening values
  - Sediment quality advisory levels (SQALs)
  - Effects range-median (ERM) and effects range-low (ERL) values
  - Probable effects levels (PELs) and threshold effects levels (TELs)
  - Apparent effects thresholds (AETs)

(2) Comparison of theoretical bioaccumulation potential (TBP) of measured sediment contaminants to

- EPA cancer and noncancer risk levels
- Food and Drug Administration (FDA) tolerance, action, or guidance values

(3) Comparison of the molar concentration of acid volatile sulfides ([AVS]) in sediment to the molar concentration of simultaneously extracted metals ([SEM]) in sediment

(4) Comparison of fish tissue contaminant levels to

- EPA cancer and noncancer risk levels
- FDA tolerance, action, or guidance values

(5) Acute effects based on sediment toxicity data

Based on the evaluation of these measurement parameters, EPA categorized NSI monitoring stations into "probability of adverse effects" categories, or tiers:

- Tier 1: higher probability of adverse effects
- Tier 2: intermediate probability of adverse effects
- Tier 3: no indication of adverse effects (any station not meeting the requirements for classification as Tier 1 or Tier 2; includes stations for which substantial data were available without evidence of adverse effects, as well as stations for which limited data were available to determine potential for adverse effects)

In addition to the analysis of potential adverse effects on aquatic life and human health, EPA also conducted a separate analysis of potential wildlife effects from exposure to contaminated sediment based on a comparison of sediment chemistry TBP values and fish tissue concentrations to EPA wildlife criteria.

EPA also developed a method to identify areas of potential widespread sediment contamination (APCs). For the purpose of the NSI data evaluation, APCs were defined as watersheds in which 10 or more sampling stations were categorized as Tier 1 and in which at least 75 percent of all sampling stations were categorized as either Tier 1 or Tier 2.

Findings

EPA evaluated more than 21,000 sampling stations nationwide as part of the NSI data evaluation. Of the sampling stations evaluated, 5,521 stations (26 percent) were categorized as Tier 1 for potential aquatic life or human health effects, 10,401 (49 percent) were categorized as Tier 2, and 5,174 (25 percent) were categorized as Tier 3. If the wildlife assessment had been included with the aquatic life and human health assessment, 619 stations classified as Tier 3 for the aquatic life and human health assessment would have been classified as Tier 2, and 16 stations classified as Tier 2 would have been classified as Tier 1.

Most of the NSI data were compiled from nonrandom monitoring programs. Such monitoring programs focus their sampling efforts on areas where contamination is known or suspected to occur. As a result, assuming all other factors are the same, the frequency of Tier 1 or Tier 2 classification based on the NSI data evaluation is probably greater than that which would result from purely random sampling.

The NSI sampling stations were located in 6,744 individual river reaches (or water body segments) across the contiguous United States, or approximately 11 percent of all river reaches in the country (based on EPA's River Reach File 1). Thirty-five percent of all river reaches evaluated had at least one station categorized as Tier 1, and 42 percent had at least one station categorized as Tier 2 (but none as Tier 1). In 23 percent of the reaches evaluated, all of the stations were categorized as Tier 3.

The NSI data evaluation identified 96 watersheds throughout the United States as APCs (Figure 1). These watersheds represent about 5 percent of all watersheds in the country. In addition, 39 percent of all watersheds in the country include at least one Tier 1 station, 15 percent include at least one Tier 2 station but no Tier 1 stations, and about 6 percent include only Tier 3 stations (Figure 2). Within the 96 APCs, 57 individual river reaches were identified as having 10 or more Tier 1 sampling stations.

More stations were categorized as either Tier 1 or Tier 2 based on potential aquatic life effects than on potential human health effects. About 40 percent more stations were categorized as Tier 1 for potential aquatic life effects (3,287 stations) than for potential human health effects (2,327 stations). About 60 percent more stations were categorized as Tier 2 due to potential aquatic life effects (9,921 stations) than for potential human health effects (6,196 stations).

Data related to more than 230 different chemicals or chemical groups were included in the NSI evaluation. Approximately 40 percent of these chemicals or chemical groups (97) were present at levels that indicated risks and resulted in stations being classified as Tier 1 or Tier 2. PCBs, mercury, and DDT were the chemicals most often responsible for stations being categorized as Tier 1. The chemicals most often responsible for stations being categorized as either Tier 1 or Tier 2 were copper (7,172 stations), nickel (6,284), lead (5,681), and PCBs (5,454).

Because PCBs were the contaminants most often responsible for Tier 1 classifications in the NSI evaluation, and because EPA took a conservative approach in evaluating the effects of PCB exposure, the Agency conducted two separate analyses of PCB data to determine the impact of the conservative approach on the overall classification of NSI sampling stations. EPA first examined the effect of excluding PCBs entirely from the NSI evaluation. If PCBs were excluded, the number of Tier 1 stations would be reduced by 42 percent, from 5,521 to 3,209 stations. The number of Tier 2 stations would be increased by 18 percent, from 10,401 to 11,957 stations. This increase reflects the movement of stations formerly classified as Tier 1 into Tier 2. In the second PCB evaluation, EPA evaluated the effect on the overall results of using a less conservative noncancer screening value (rather than the cancer screening value) for predicting human health risk associated with PCB sediment contamination. When the noncancer screening value was used, the number of Tier 1 stations decreased by 12 percent, from 5,521 to 4,844 stations, and the number of Tier 2 stations increased by 4 percent, from 10,401 to 10,802 stations.

Conclusions and Recommendations

EPA's evaluation of the NSI data was the most geographically extensive investigation of sediment contamination ever performed in the United States. The evaluation was based on state-of-the-art risk-based procedures to address the probability of adverse effects to human health, aquatic life, and wildlife. The results verify that sediment contamination is widespread and is an important national concern. This was the first large-scale assessment of sediment quality to go beyond "hot spot" identification. Through closer inspection of the thousands of potentially contaminated locations, EPA distinguished 96 watersheds where contamination is likely to be most severe and extensive.

The Agency and its state and federal partners can address sediment contamination problems through watershed management approaches. Watershed management programs focus on hydrologically defined drainage basins rather than areas defined by political boundaries. These programs recognize that conditions of land areas and activities within the watershed affect the water resource. Local management, stakeholder involvement, and holistic assessments of water quality are characteristics of the watershed approach. The National Estuary Program is one example of the watershed approach that has led to specific actions to address contaminated sediment problems. Specifically, the Narragansett (RI) Bay, Long Island Sound, New York/New Jersey Harbor, and San Francisco Bay Estuary Programs have all recommended actions to reduce sources of toxic contaminants to sediment. Numerous other examples of watershed management programs are summarized in *The Watershed*

Figure 1. Areas of Potential Widespread Sediment Contamination (APCs).

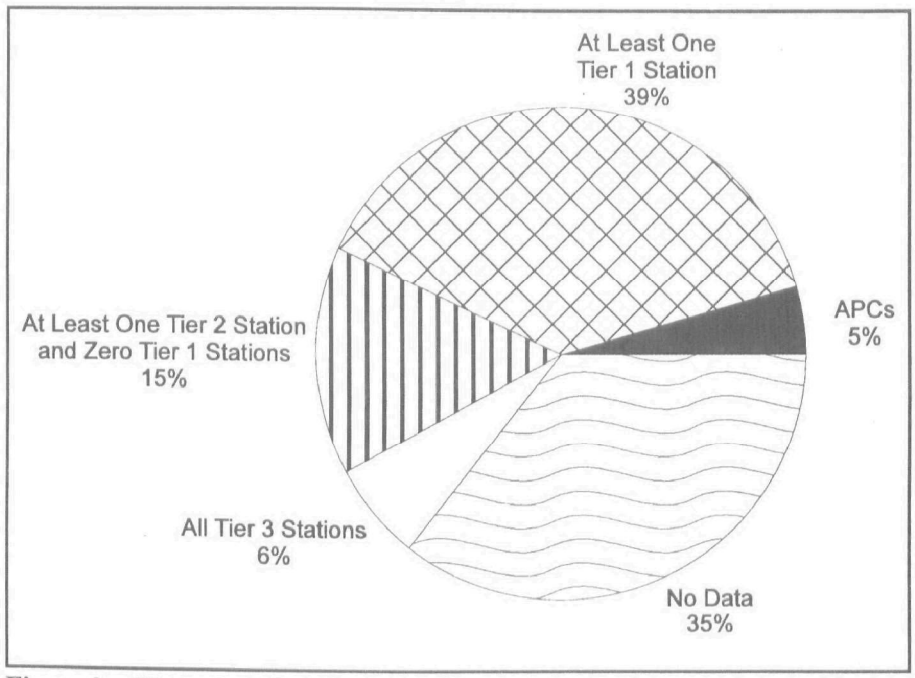


Figure 2. Watershed Classifications Based on Potential Aquatic Life or Human Health Effects.

Approach 1993/94 Activity Report (USEPA, 1994g) and *A Phase I Inventory of Current EPA Efforts to Protect Ecosystems* (USEPA, 1995b).

The results of the NSI data evaluation confirm that sediment contamination poses potential risks to aquatic life, human health, and wildlife and is widespread in many watersheds of the country. Based on the analysis of the NSI data, potential sediment contamination exists in all regions and states of the country. The water bodies affected include streams, lakes, harbors, near-shore areas, and oceans. Metals and persistent organic chemicals are the contaminants most often associated with sediment contamination.

The evaluation methodology was designed for the purpose of a screening-level assessment of sediment quality; further evaluation would be required to confirm that sediment contamination poses actual risks to aquatic life, human health, or wildlife for any given site or watershed. Uncertainty is associated with site-specific measures, assessment techniques, exposure scenarios, and default parameter selections. In addition, some potentially contaminated sediment sites across the country have been missed in the NSI data evaluation because the NSI does not provide complete national coverage of sediment quality data. Also, some data that were included in the NSI were not evaluated because of questions concerning data quality or a lack of locational information. On the other hand, data in the inventory were collected between 1980 and 1993 and any single measurement of a chemical at a site, taken any point in time during that period, could result in the categorization of the site in Tier 1 or Tier 2. The evaluation approach is conservative. Therefore, sites appearing in Tier 1 or Tier 2 may not cause unacceptable impacts. Limitations and uncertainties are discussed in detail in Chapter 5 and elsewhere in the report.

Some of the most significant sources of persistent and toxic chemicals have been eliminated or reduced as the result of environmental controls put into place during the past 10 to 20 years. For example, the commercial use of PCBs and the pesticides DDT and chlordane has been restricted or banned in the United States. In addition, effluent controls on industrial and municipal point source discharges and best management practices for the control of nonpoint sources have greatly reduced contaminant loadings to many of our rivers and streams.

Because of the enormous cost of remediation, the preferred means for reducing health and environmental risks from contaminated sediment is natural recovery through continuing deposition of clean sediment. The feasibility of natural recovery, as well as the long-term success of expensive remediation projects, depends on the effective control of pollutant sources. Although most active sources of PCBs are controlled, past disposal and use continue to result in evaporation from some landfills and leaching from soils. The predominant continuing sources of organochlorine pesticides are runoff and atmospheric deposition from past applications on agricultural land. For other classes of sediment contaminants, active sources continue to contribute substantial environmental releases. For example, liberation of inorganic mercury from fuel burning and other incineration operations continues, as do urban runoff and atmospheric deposition of metals and polynuclear aromatic hydrocarbons (PAHs). In addition, discharge limits for municipal and industrial point sources are based on either technology-based limits or state-adopted standards for protection of the water column, not necessarily for downstream protection of sediment quality. Determining the local and far-field effects of individual point and nonpoint sources on sediment quality usually requires site-specific in-depth study.

The primary recommendation resulting from the NSI data evaluation is that the states, in cooperation with EPA and other federal agencies, should proceed with further evaluations of the 96 watersheds identified as APCs. If active watershed management programs are in place, these evaluations should be coordinated within the context of current or planned actions. Future efforts should focus in particular on the 57 water body segments located within the 96 APCs that had 10 or more stations categorized as Tier 1. The purpose of these efforts should be, as appropriate, to gather additional sediment chemistry and related biological data, and to conduct further assessments of data to determine human health and ecological risk, determine temporal trends, identify potential sources of sediment contamination and determine whether potential sources are adequately controlled, and determine whether natural recovery is a feasible option for risk reduction.

Other recommendations resulting from the NSI evaluation include the following:

- Federal, state, and local government agencies should pool their resources and coordinate their efforts to address their common sediment contamination issues. These activities should support efforts such as the selection of future monitoring sites, the setting of priorities for reissuance of National Pollutant Discharge Elimination System (NPDES) permits and permit synchronization, pollutant trading between nonpoint and point sources, and total maximum daily load (TMDL) development.

- EPA should design future evaluations of NSI data to determine the temporal trends of contamination, and identify where and why conditions are improving or worsening. The NSI should expand to provide more complete national coverage of sediment quality data, both in terms of the number of water bodies evaluated and the suite of biological and chemical information available to evaluate each site.

- EPA should continue its efforts to make the NSI data and evaluation results more accessible to other agencies' programs and to States.

- EPA should continue to develop sediment quality criteria (SQCs), especially for metals. In the absence of SQCs for additional nonionic organic chemicals, EPA should also continue to develop additional sediment quality advisory levels (SQALs).

- Future monitoring programs should specify collection of AVS and SEM measurements where metals are a concern and site-specific total organic carbon (TOC) measurements where organic chemicals are a concern.

- Future sediment monitoring programs should also collect tissue residue, biological effects, and biological community measurements as well as sediment chemistry measurements.

- EPA should continue to update the NSI evaluation methodology as new assessment tools become available and the state of the science evolves.

- EPA and other federal agencies should fund or otherwise support the development of tools to better characterize the sources, fate, and effects of sediment contaminants.

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 aquatic sediments in the United States. The statute specifically instructs EPA to compile all existing information on the quantity, chemical and physical composition, and geographic location of pollutants in aquatic sediment, including the probable source 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. In addition, WRDA 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 extent and severity of sediment contamination nationwide. The *National Sediment Quality Survey* 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 continually updated, centralized assemblage of sediment quality measurements and state-of-the-art assessment techniques. EPA anticipates that products and services generated through the NSI will provide managers at the federal, state, and local levels with relevant, valuable information.

For this first report to Congress, OST has compiled and analyzed historical data collected from 1980 to 1993 from across the country that 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. 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 in the future.

This report presents the results of a screening-level assessment of the NSI data. For this assessment, OST examined sediment chemistry data, associated fish tissue residue levels, and acute toxicity bioassay test results. The purpose was to determine whether potential contamination 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 cause adverse effects to aquatic life and/or human health. However, because this analysis is based only on readily available electronic data, contamination problems likely 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, nor does it identify uncontaminated sediment sites. This analysis serves as a baseline for future assessments, which will incorporate additional monitoring locations, as well as supplementary data.

The National Sediment Quality Survey is presented as a single report summarizing 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 the potential sources of sediment contamination, including point and nonpoint

sources. A discussion of the results is provided in Chapter 5. Chapter 6 presents recommendations for improving the NSI for future evaluations of sediment quality. 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. Currently, over 1,500 water bodies in the United States have fish consumption advisories in place, affecting all but 4 states. Water supplies also have been shut down because of contaminated sediments, and in some places swimming is no longer allowed.

How extensive 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; Power and Chapman, 1992). The USEPA (1993a) summarizes other recent assessment studies. However, there is still no national-scale assessment of the extent and severity of sediment contamination, particularly in freshwater areas. This report is the result of EPA's first assessment to determine how widespread 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.

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; 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.

Chapter 2

Methodology

EPA faced two primary challenges to achieving the short-term goals of the National Sediment Inventory (NSI) and fulfilling the mandate of the Water Resources Development Act (WRDA) of 1992, as described in the introduction to this report. The first challenge was to compile a database of consistent sediment quality measures suitable for all regions of the country. The second challenge was to identify scientifically sound methods to determine whether a particular sediment is "contaminated," according to the definition set forth in the statute.

In many known areas of contamination, visible and relatively easy-to-recognize evidence of harmful effects to resident biota is concurrent with elevated concentrations of contaminants in sediment. In most cases, however, less obvious effects on biological communities and ecosystems are much more difficult to identify and are frequently associated with varying concentrations of sediment contaminants. In other words, bulk sediment chemistry measures are not always indicative of toxic effect levels. Similar concentrations of a chemical can produce widely different biological effects in different sediments. This discrepancy occurs because toxicity is influenced by the extent to which chemical contaminants bind to other constituents in sediment. These other sediment constituents, such as organic ligands and inorganic oxides and sulfides, are said to control the *bioavailability* of accumulated contaminants. Toxicant binding, or sorption, to sediment particles suspends the toxic mode of action in biological systems. Because the binding capacity of sediment varies, the degree of toxicity exhibited also varies for the same total quantity of toxicant.

The five general categories of sediment quality measurements are sediment chemistry, sediment toxicity, community structure, tissue chemistry, and pathology (Power and Chapman, 1992). Each of these categories has strengths and limitations for a national-scale sediment quality assessment. To be efficient in collecting usable data of similar types, EPA sought data that were available in electronic format, represented broad geographic coverage, and represented specific sampling locations identified by latitude and longitude coordinates. EPA found sediment chemistry and tissue chemistry to be the most widely available sediment quality measures.

As described above, sediment chemistry measures might not accurately reflect risk to the environment. However, EPA has recently developed assessment methods that combine contaminant concentration with measures of the primary binding phase to address bioavailability for certain chemical classes, under assumed conditions of thermodynamic equilibrium (USEPA, 1993d). Other methods exist that rely on statistical correlations of contaminant concentrations with incidence of adverse biological effects (Barrick et al., 1988; FDEP, 1994; Long et al., 1995). In addition, fish tissue levels can be predicted using sediment contaminant concentrations, along with independent field measures of chemical partitioning behavior and other known or assigned fish tissue and sediment characteristics. EPA can evaluate risk to consumers from predicted and field-measured tissue chemistry data using established dose-response relationships and standard consumption patterns. Evaluations based on tissue chemistry circumvent the bioavailability issue while also accounting for other mitigating factors such as metabolism. The primary difficulty in using field-measured tissue chemistry is relating chemical residue levels to a specific sediment, especially for those fish species which typically forage across great distances.

Sediment toxicity, community structure, and pathology measures are less widely available than sediment chemistry and fish tissue data in the broad-scale electronic format EPA sought for the NSI. Sediment toxicity data are typically in the form of percent survival, compared to control mortality, for indicator organisms exposed to the field-sampled sediment in laboratory bioassays. Although these measures account for bioavailability and the antagonistic and synergistic effects of pollutant mixtures, they do not address possible long-term reproductive or growth effects, nor do they identify specific contaminants responsible for observed acute toxicity. Indicator organisms also might not represent the most sensitive species. Community structure measures, such as fish abundance and benthic diversity, and pathology measures are potentially indicative of long-term adverse effects, yet there are a

multitude of mitigating physical, hydrologic, and biological factors that might not relate in any way to chemical contamination.

The ideal assessment methodology would be based on matched data sets of all five types of sediment quality measures to take advantage of the strengths of each measurement type and to minimize their collective weaknesses. Unfortunately, such a database does not exist on a national scale, nor is it typically available on a smaller scale. Based on the statutory definition of contaminated sediment in WRDA, EPA can identify locations where sediment chemistry measures exceed "appropriate geochemical, toxicological, or sediment quality criteria or measures." Again based on the statutory definition, EPA can also use tissue chemistry and sediment toxicity measures to identify aquatic sediments that "otherwise pose a threat to human health or the environment" because there are either screening values (e.g., EPA risk levels for fish tissue consumption) or control samples for comparison. It is unclear, however, how EPA could evaluate community structure or pathology measures to identify contaminated sediment, based on the statutory definition, without first identifying appropriate reference conditions to which measured conditions could be compared.

For this analysis, EPA evaluated sediment chemistry, tissue chemistry, and sediment toxicity data, taken at the same sampling station (or site), individually and in combination using a variety of assessment methods. Because of the limitations of the available sediment quality measures and assessment methods, EPA characterizes this identification of contaminated sediment sites as a *screening-level* analysis. Similar to a potential human illness screen, a screening-level analysis should pick up all potential problems and note them for further study. Thus, designation as a potentially contaminated site in this analysis is not meant to be definitive, but is intended to be inclusive of all potential problems. For this reason, EPA elected to evaluate data collected from 1980 to 1993 and to evaluate each chemical or biological measurement taken at a given site individually. A single measurement of a chemical at a site, taken at any point in time over the past 15 years, could be sufficient to categorize the site as posing a potential threat to aquatic life or human health.

EPA recognizes that sediment is dynamic and that great temporal and spatial variability in sediment quality exists. This variability can be a function of sampling (e.g., a contaminated area might be sampled one year, but not the next) or a function of natural events (e.g., floods can move contaminated sediment from one area to another, or can bury contaminated sediment). Therefore, EPA describes sites in terms of their "probability of adverse effects to aquatic life or human health." Each site falls into one of three categories (tiers): higher probability of adverse effects (Tier 1), intermediate probability of adverse effects (Tier 2), or no indication of adverse effects (Tier 3). Recognizing the imprecise nature of the numerical assessment parameters, Tier 1 sites are distinguished from Tier 2 sites based on the magnitude of a sediment chemistry measure or the degree of corroboration among the different types of sediment quality measures.

The remainder of this chapter presents a short history of how EPA developed the NSI, a brief description of the NSI data, and an explanation of the NSI data evaluation approach.

Background

EPA initiated work several years ago on the development of the NSI through pilot inventories in EPA Regions 4 and 5 and the Gulf of Mexico Program. Based on lessons learned from these three pilot inventories, the Agency developed a document entitled *Framework for the Development of the National Sediment Inventory* (USEPA, 1993a), which describes the general format for compiling sediment-related data and provides a brief summary of sediment quality evaluation techniques. The format and overall approach were then presented, modified slightly, and agreed upon at an interagency workshop held in March 1993 in Washington, D.C. Following the workshop, EPA began compiling and evaluating data for the NSI. Data from several national and regional databases were included as part of the effort.

In the spring of 1994, EPA conducted a preliminary evaluation of NSI sediment chemistry data only. The purpose of the assessment was to identify water bodies throughout the United States where measured values of sediment pollutants exceeded sediment chemistry levels of concern. The results of that assessment were then distributed to the EPA Regional offices for their review. The Regional offices were asked to review the preliminary evaluation and to:

- Verify sites targeted as areas of concern.
- Identify sites that might be incorrectly targeted as areas of concern.
- Identify potential areas of concern that were not targeted, but should have been.

- Inform EPA Headquarters of additional sediment quality data that should be included in the NSI to make the inventory more accurate and complete.

The EPA Regional offices completed their review of the preliminary evaluation during the winter of 1994-95. Regional comments on the results of the preliminary evaluation were incorporated into the NSI database. EPA will add new data sets identified by the Regions to the NSI and include them in the national assessment for future reports to Congress.

In April 1994, EPA Headquarters held the Second National Sediment Inventory Workshop (USEPA, 1994c). The purpose of this workshop was to bring together experts in the field of sediment quality assessment to recommend an approach for integrating and evaluating the sediment chemistry and biological data contained in the NSI. The final approach recommended by workshop participants provided the basis for the final approach adopted to evaluate NSI data for this report to Congress. Appendix I of this report provides a brief description of the workshop approach and a list of attendees.

Description of NSI Data

The NSI includes data from the following data storage systems and monitoring programs:

- Selected data sets from EPA's Storage and Retrieval System (STORET)
  - U.S. Army Corps of Engineers (COE)
  - U.S. Geological Survey (USGS)
  - EPA
  - States
- NOAA's Coastal Sediment Inventory (COSED)
- EPA's Ocean Data Evaluation System (ODES)
- EPA Region 4's Sediment Quality Inventory
- Gulf of Mexico Program's Contaminated Sediment Inventory
- EPA Region 10/COE Seattle District's Sediment Inventory
- EPA Region 9's Dredged Material Tracking System (DMATS)
- EPA's Great Lakes Sediment Inventory
- EPA's Environmental Monitoring and Assessment Program (EMAP)
- USGS (Massachusetts Bay) Data
- EPA's National Point Source Inventory

Although EPA elected to evaluate data collected since 1980 (i.e., 1980-93), data from before 1980 are still maintained in the NSI. At a minimum, EPA required that electronically available data include locational information, sampling date, latitude and longitude coordinates, and measured units for inclusion in the NSI. Additional data fields providing details such as sampling method or other quality assurance/quality control information were retained in the NSI if available. Additional information about available data fields and NSI component databases is presented in Appendix A of this report.

The types of data contained in the NSI include the following:

- *Sediment chemistry*: Measurement of the chemical composition of sediment-associated contaminants.
- *Tissue residue*: Measurement of chemical contaminants in the tissues of organisms.
- *Benthic abundance*: Measurement of the number and types of organisms living in or on sediments.
- *Toxicity*: Measurement of the lethal or sublethal effects of contaminants in environmental media on various test organisms.
- *Histopathology*: Observation of abnormalities or diseases in tissue (e.g., tumors).
- *Fish abundance*: Measurement of the number and types of fish found in a water body.

The NSI represents a compilation of environmental monitoring data from a variety of sources. Most of the component databases are maintained under known and documented quality assurance and quality control procedures. However, EPA's STORET database is intended to be a broad-based repository of data. Consequently, the quality of the data in STORET, both in terms of database entry and analytical instrument error, is unknown and probably varies a great deal depending on the quality assurance management associated with specific data submittals.

Inherent in the diversity of data sources are contrasting monitoring objectives and scope. Component sources contain data derived from different spatial sampling plans, sampling methods, and analytical methods. For example, data from EPA's EMAP program represent sampling stations that lie on a standardized grid over a given geographic area, whereas data in EPA's STORET most likely represent state monitoring data sampled from locations near known discharges or thought to have elevated contaminant levels. In contrast, many of the data in NOAA's COSED database represent sampling stations purposely selected because they are removed from known discharges. From an assessment point of view, STORET data might be useful for developing a list of contaminated sediment locations, but might overstate the general extent of contaminated sediment in the Nation by focusing largely on areas most likely to be problematic. On the other hand, analysis of EMAP data might result in a more balanced assessment in terms of the mix of contaminated sites and uncontaminated sites. Approximately 45 percent of monitoring records in the NSI originate from the STORET database. Reliance on these data is consistent with the stated objective of this survey: to identify those sediments which are contaminated. However, one cannot accurately make inferences regarding the overall condition of the Nation's sediment, or characterize the "percent contamination," using all the data in the NSI because uncontaminated areas are most likely underrepresented.

Table 2-1. Number of Stations Evaluated in the NSI by State

Region 1	Connecticut	98	Region 6	Arkansas	107
	Maine	55		Louisiana	460
	Massachusetts	895		New Mexico	101
	New Hampshire	7		Oklahoma	286
	Rhode Island	42		Texas	662
	Vermont	5			
Region 2	New Jersey	448	Region 7	Iowa	228
	New York	618		Kansas	203
	Puerto Rico	30		Missouri	327
				Nebraska	253
Region 3	Delaware	218	Region 8	Colorado	202
	District of Columbia	4		Montana	38
	Maryland	206		North Dakota	161
	Pennsylvania	311		South Dakota	43
	Virginia	1,051		Utah	47
	West Virginia	120		Wyoming	44
Region 4	Alabama	477	Region 9	Arizona	124
	Florida	1,776		California	1,443
	Georgia	318		Hawaii	36
	Kentucky	249		Nevada	96
	Mississippi	318			
	North Carolina	612			
	South Carolina	563			
	Tennessee	646			
Region 5	Illinois	1,669	Region 10	Alaska	267
	Indiana	108		Idaho	95
	Michigan	402		Oregon	291
	Minnesota	438		Washington	2,225
	Ohio	970			
	Wisconsin	703			

NSI data do not evenly represent all geographic regions in the United States, nor do the data represent a consistent set of monitored chemicals. For example, several of the databases are targeted toward marine environments or other geographically focused areas. Table 2-1 presents the number of stations evaluated per state. More than 50 percent of all stations evaluated in the NSI are located in Washington, Florida, Illinois, California, Virginia, Ohio, Massachusetts, and Wisconsin. Each of these states has more than 700 monitoring stations. Other states of similar or larger size (e.g., Georgia, Pennsylvania) have far fewer sampling stations with data for evaluation. Figures 2-1, 2-2, and 2-3 depict the location of monitoring stations with sediment chemistry, tissue residue, and toxicity data, respectively. Individual stations may vary considerably in terms of the number of chemicals monitored. Some stations have data that represent a large number of organic and inorganic contaminants, whereas others have measured values for only a few chemicals. Thus, the inventory cannot be considered comprehensive even for locations with sampling data. The reliance on readily available electronic data has undoubtedly led to exclusions of a vast amount of information available from sources such as local and state governments and published reports. Other limitations, including data quality issues, are discussed in Chapter 5 of this report.

NSI Data Evaluation Approach

The methodology developed for classifying sampling stations according to the probability of adverse effects on aquatic life and human health from sediment contamina-

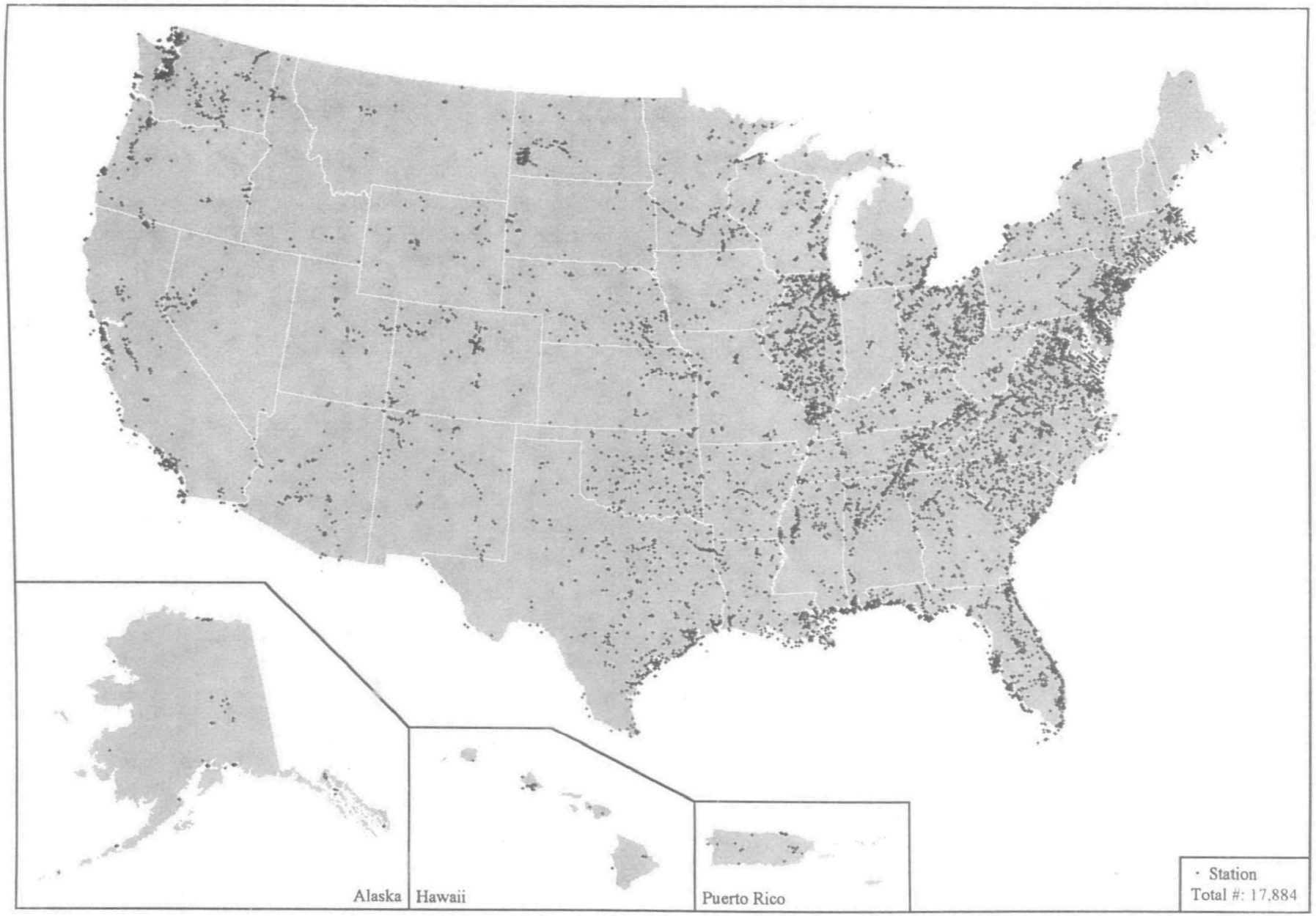


Figure 2-1. NSI Sediment Sampling Stations Evaluated.

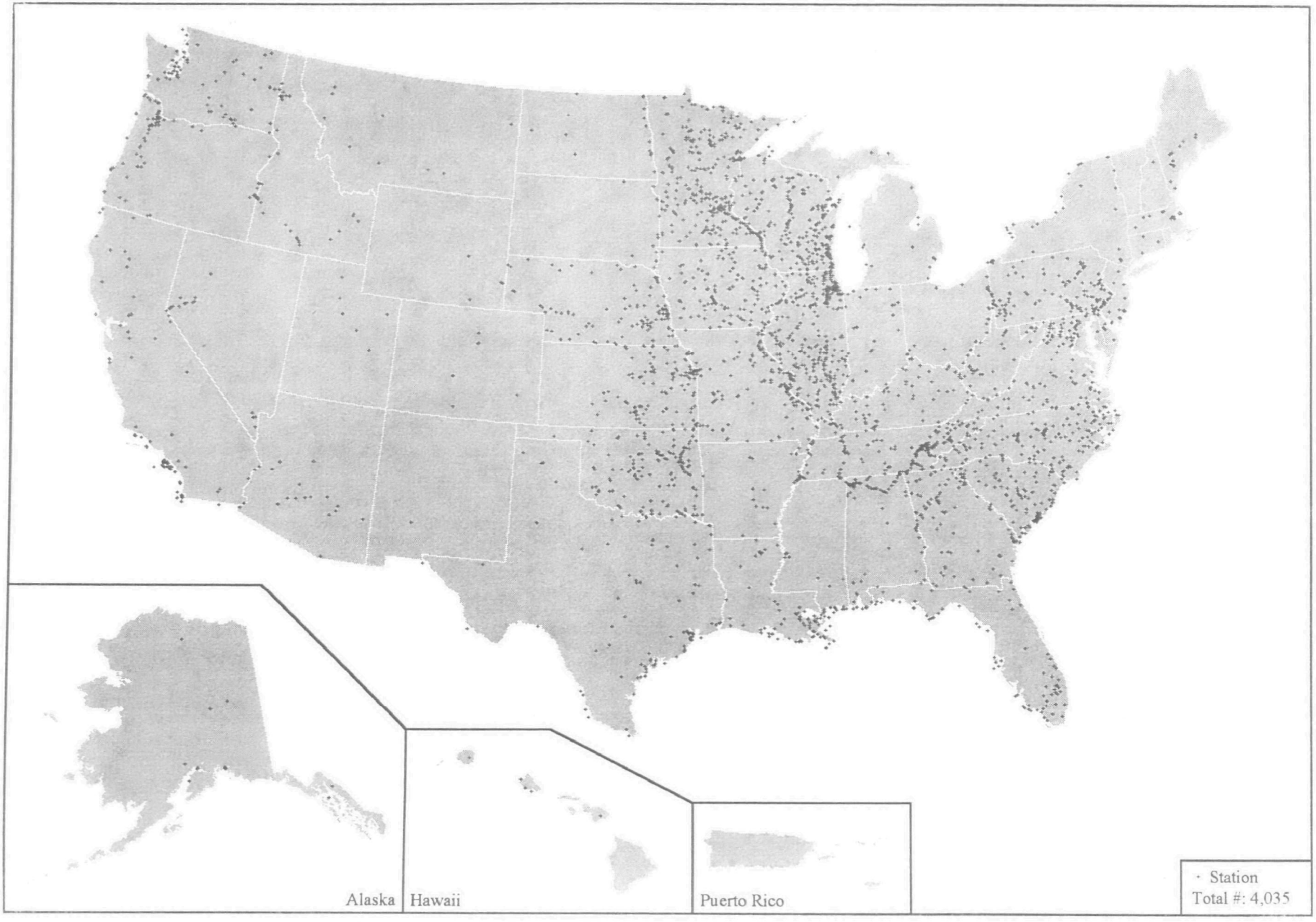


Figure 2-2. NSI Tissue Residue Sampling Stations Evaluated.

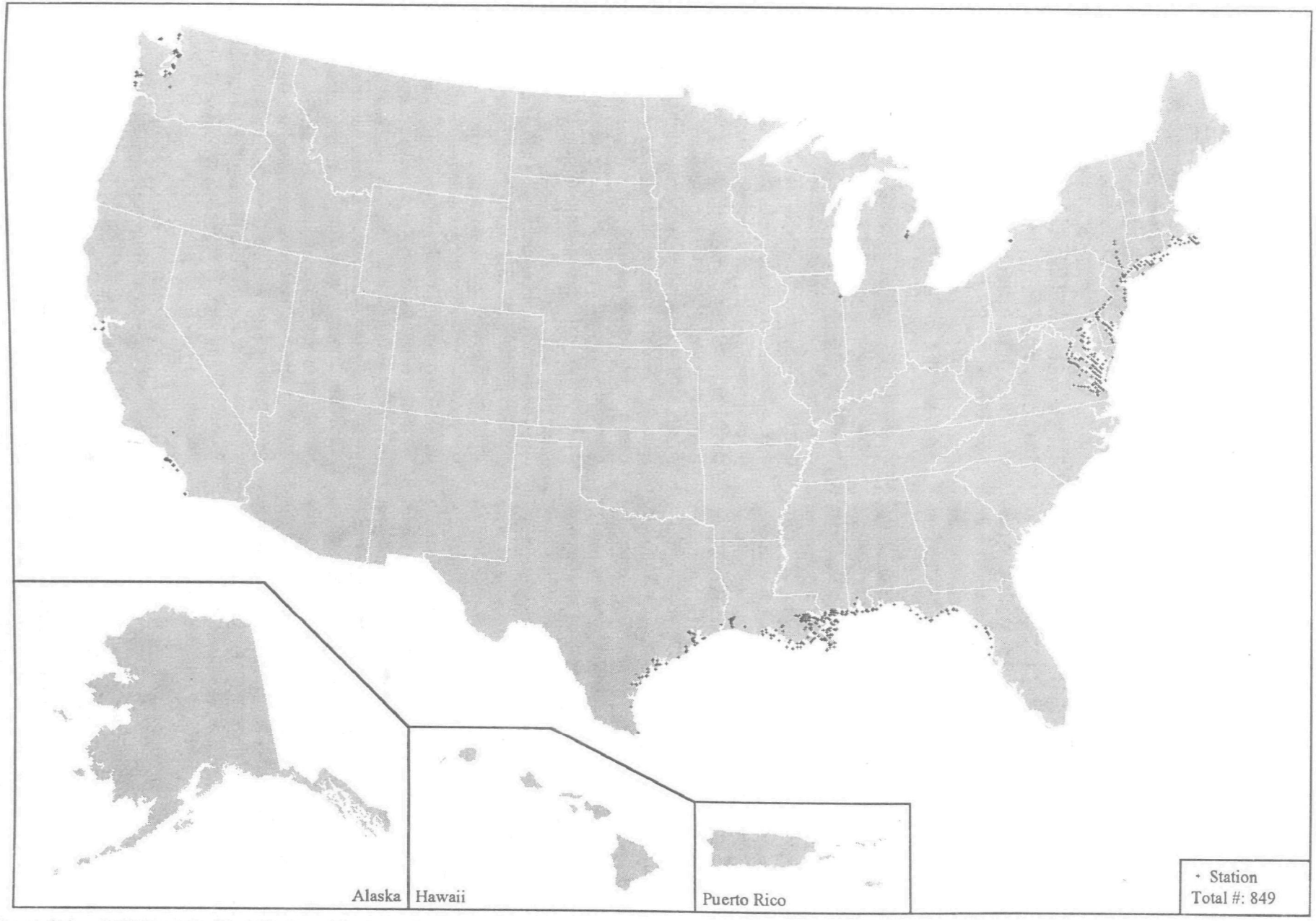


Figure 2-3. NSI Toxicity Test Stations Evaluated.

tion relies on measures of sediment chemistry, sediment toxicity, and contaminant residue in tissue. Although the NSI also contains benthic abundance, histopathology, and fish abundance data, these types of data were not used in the evaluation. Benthic and fish abundance cannot be directly associated with sediment contamination based on the statutory definition and currently available assessment tools, and available fish liver histopathology data were very limited.

The approach used to evaluate the NSI data focuses on the protection of benthic organisms from exposure to contaminated sediments and the protection of humans from the consumption of fish that bioaccumulate contaminants from sediment. In addition, potential effects on wildlife from fish consumption were also evaluated. The wildlife results were not included in the overall results of the NSI data evaluation; however, they are presented separately. Table 2-2 presents the classification scheme used in the evaluation of the NSI data. Each component, or evaluation parameter, of the classification scheme is numbered on Table 2-2. Each evaluation parameter is discussed under a section heading that refers to these numbers. Figures 2-4 through 2-8 depict the evaluation parameters and site classifications in flowchart format.

EPA analyzed the NSI data by evaluating each parameter in Table 2-2 on a station-by-station and sample-by-sample basis. Each station was classified into a "probability of adverse effects" category by combining parameters as shown in Table 2-2 and Figures 2-4 through 2-8. Because each individual measurement was considered independently (except for divalent metals, whose concentrations were summed), a single observation of elevated concentration could place a site into Tier 1, the higher probability category. In general, the methodology was constructed such that a site classified as Tier 1 must be represented by a relatively large set of data or by a highly elevated sediment concentration of a chemical whose effects threshold level is well characterized based on multiple assessment techniques. Fewer data were required to classify a site as Tier 2. Any station not meeting the requirements to be classified as Tier 1 or Tier 2 was classified as Tier 3. Stations in this category include those for which substantial data were available without evidence of adverse effects, as well as stations for which limited data were available to determine potential for adverse effects.

Individual evaluation parameters, applied to various measurements independently, could lead to different site classifications. If one evaluation parameter indicated a higher probability of adverse effects, but other evaluation parameters indicated an intermediate probability or did not indicate adverse effects, a Tier 1 classification was assigned to the station. For example, if a site was categorized as Tier 2 based on all sediment chemistry data, but was categorized as Tier 1 based on toxicity data, the site was placed in Tier 1. This principle also applies to evaluating multiple contaminants within the same evaluation parameter. For example, if the evaluation of sediment chemistry data placed a site in Tier 1 for metals and in Tier 2 for PCBs, the site was placed in Tier 1.

The numbered evaluation parameters used in the NSI data evaluation are briefly described below. A detailed description of the evaluation parameters is presented in Appendix B.

Sediment Chemistry Data

Sediment chemistry screening values are reference values above which sediment contaminant concentrations could pose a significant threat to aquatic life. The sediment chemistry screening values used to evaluate the NSI data for potential adverse effects of sediment contamination on aquatic life include both theoretically and empirically based values. The theoretically based values rely on the physical/chemical properties of sediment and chemicals to predict the level of contamination that would protect against an adverse effect to aquatic life. The empirically based, or correlative, screening values rely on paired field and laboratory data to relate incidence of observed biological effects to the dry-weight sediment concentration of a specific chemical.

The theoretically based screening values used as parameters in the evaluation of NSI data include the draft sediment quality criteria, sediment quality advisory levels, and comparison of simultaneously extracted metals to acid-volatile sulfide concentrations. Empirically based, correlative screening values used in the NSI evaluation include the effects range-median/effects range-low values, probable effects levels/threshold effects levels, and apparent effects thresholds. The use of each of these screening values in the evaluation of the NSI data is described below. Another theoretically based evaluation parameter, the theoretical bioaccumulation potential (which was used for human health assessments), is also described below. The limitations associated with the use of these screening values are discussed in Chapter 5.

Sediment Chemistry Values Exceed EPA Draft Sediment Quality Criteria [1]

This evaluation parameter was used to assess the potential effects of sediment contamination on benthic species. EPA has developed draft sediment quality criteria (SQCs) for the following five nonionic organic chemicals:

Table 2-2. NSI Data Evaluation Approach (with numbered parameters)

Category of Site Classifications	Data Used to Determine Classifications				
	Sediment Chemistry		Tissue Residue		Toxicity
Tier 1: Higher Probability of Adverse Effects to Aquatic Life or Human Health	Sediment chemistry values exceed draft sediment quality criteria for any one of the five chemicals for which criteria have been developed by EPA (must have measured TOC) 1	OR	Tissue levels of dioxin or PCBs in resident species exceed EPA risk levels 8	OR	Toxicity demonstrated by two or more nonmicrobial acute toxicity tests using two different species (one of which must be a solid-phase test) 11
	OR [SEM]-[AVS]>5 for the sum of molar concentrations of Cd, Cu, Ni, Pb, and Zn[a] 2				
	OR Sediment chemistry values exceed two or more of the relevant upper screening values (ERMs, AETs (high), PELs, SQALs, SQCs) for any one chemical (other than Cd, Cu, Ni, Pb, and Zn) (can use default TOC) 3				
	OR Sediment chemistry TBP exceeds FDA action levels or EPA risk levels 4	AND	Tissue levels in resident species exceed FDA action levels or EPA risk levels 9	—	—
Tier 2: Intermediate Probability of Adverse Effects to Aquatic Life or Human Health	[SEM]-[AVS] = 0 to 5 for the sum of molar concentrations of Cd, Cu, Ni, Pb, and Zn 5	OR	Tissue levels in resident species exceed FDA action levels or EPA risk levels 10	OR	Toxicity demonstrated by a single-species nonmicrobial toxicity test 12
	OR Sediment chemistry values exceed any one of the relevant lower screening values (ERLs, AETs (low), TELs, SQALs, SQCs) for any one chemical (can use default TOC) 6				
	OR Sediment chemistry TBP exceeds FDA action levels or EPA risk levels 7				
Tier 3: No indication of adverse effects	Any station not categorized as Tier 1 or Tier 2. Available data (which may be very limited or quite extensive) do not indicate a likelihood of adverse effects to aquatic life or human health.				

[a]Metals: Cd = cadmium, Cu = copper, Ni = nickel, Pb = lead, Zn = zinc.

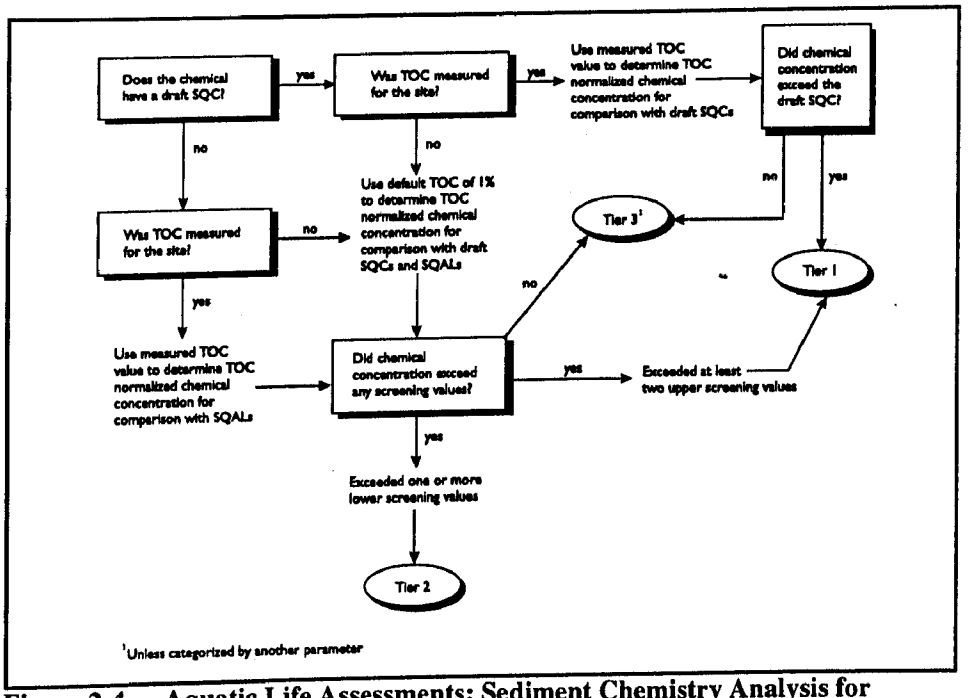


Figure 2-4. Aquatic Life Assessments: Sediment Chemistry Analysis for Organic Chemicals and Metals Not Included in the AVS Analysis.

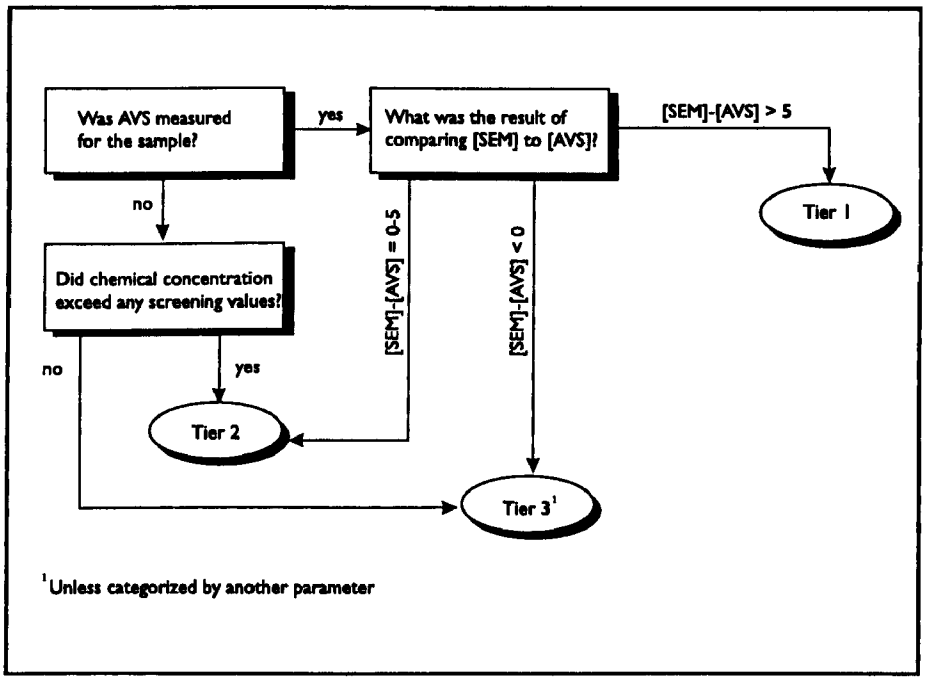


Figure 2-5. Aquatic Life Assessments: Sediment Chemistry Analysis for Divalent Metals.

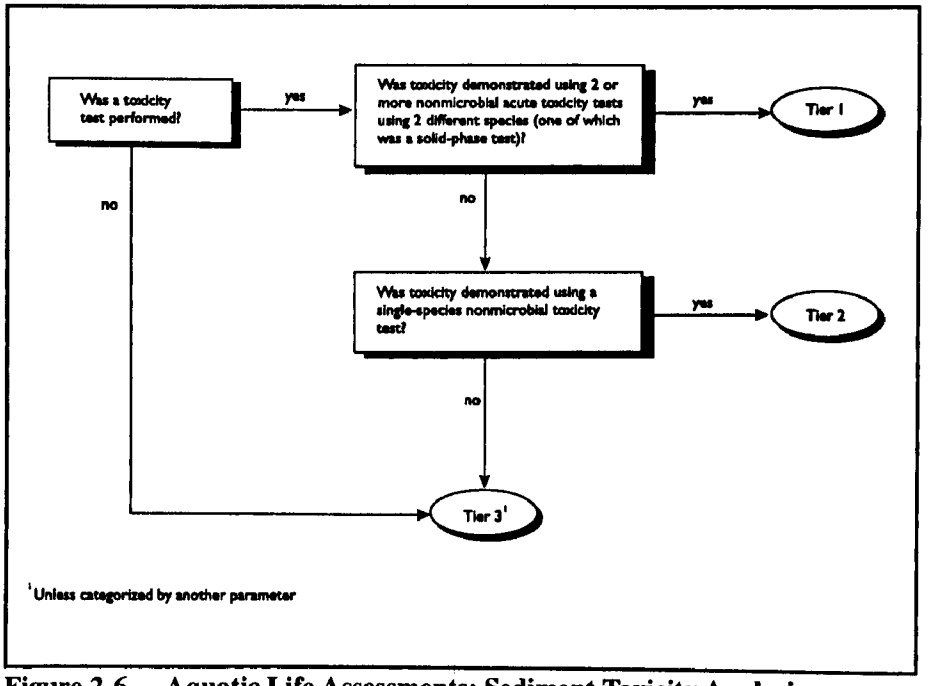


Figure 2-6. Aquatic Life Assessments: Sediment Toxicity Analysis.

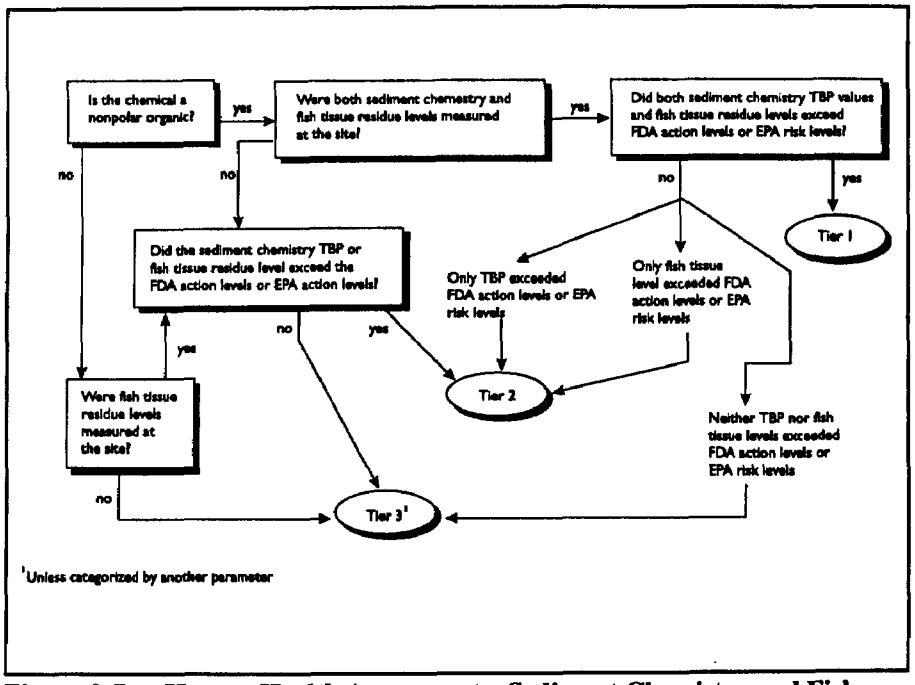


Figure 2-7. Human Health Assessments: Sediment Chemistry and Fish Tissue Residue Analysis (excluding dioxins and PCBs).

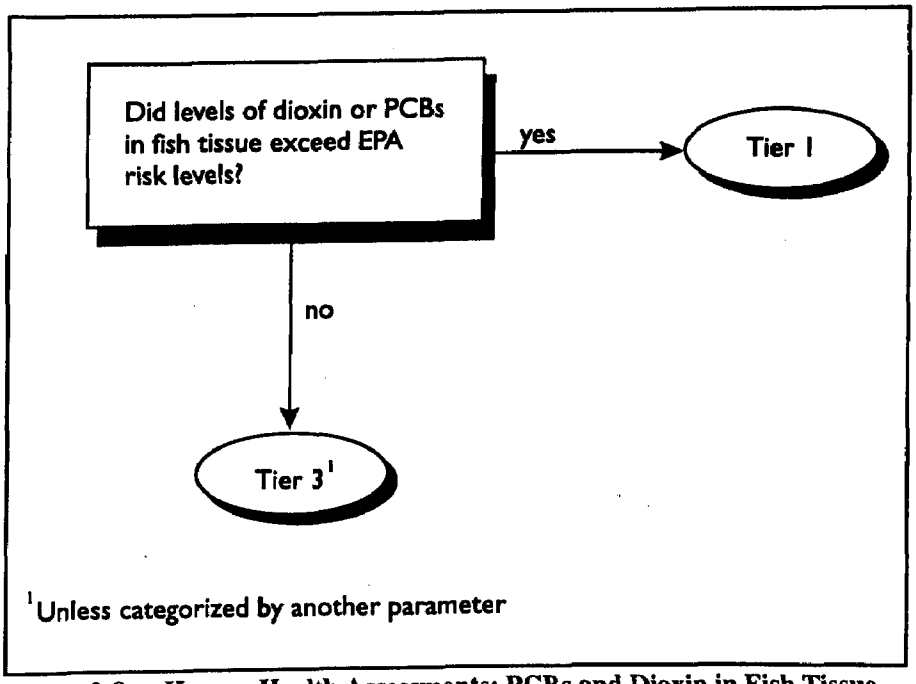


Figure 2-8. Human Health Assessments: PCBs and Dioxin in Fish Tissue Analysis.

- Acenaphthene (polynuclear aromatic hydrocarbon, PAH)
- Dieldrin (pesticide)
- Endrin (pesticide)
- Fluoranthene (PAH)
- Phenanthrene (PAH)

EPA developed these draft criteria using the equilibrium partitioning (EqP) approach (described in detail in Appendix B) for linking bioavailability to toxicity. The EqP approach involves predicting the dry-weight concentration of a contaminant in sediment that is in equilibrium with a pore water concentration that is protective of aquatic life. It combines the water-only effects concentration (the chronic water quality criteria) and the organic carbon partitioning coefficient of the chemical normalized to the organic carbon content of the sediment. The draft criterion is compared to the measured dry-weight sediment concentration of the chemical normalized to sediment organic carbon content. If the organic-carbon-normalized concentration of the contaminant does not exceed the draft sediment quality criterion, adverse effects should not occur to at least 95 percent of benthic organisms. The draft SQCs are based on the highest quality data available, which have been reviewed extensively.

For the NSI data evaluation, sediment chemistry measurements with accompanying measured total organic carbon (TOC) values can place a site in Tier 1 based exclusively on a comparison with a draft SQC. The amount of TOC in sediment is one of the factors that determines the extent to which a nonionic organic chemical is bound to the sediment and, thus, the availability for uptake by organisms (bioavailability). If draft SQCs based on measured TOC were not exceeded, or if none of the five nonpolar organic chemicals that have been assigned draft SQC values were measured, the site was classified as Tier 3 unless otherwise categorized by another parameter. If a sample for any of the five contaminants for which draft SQCs have been developed did not have accompanying TOC data, the measured concentration was compared to the draft SQC based on a default TOC value of 1 percent. In these instances, the draft SQC was treated like other sediment quality screening values described later in this section.

Comparison of AVS to SEM Molar Concentrations [2, 5]

The use of the total concentration of a trace metal in sediment as a measure of its toxicity and its ability to bioaccumulate is problematic because different sediments exhibit different degrees of bioavailability for the same total quantity of metal (Di Toro et al., 1990; Luoma, 1983). These differences have recently been reconciled by relating organism toxic response (mortality) to the metal concentration in the sediment interstitial water (Adams et al., 1985; Di Toro et al., 1990). Acid-volatile sulfide (AVS) is one of the major chemical components that control the activities and availability of metals in interstitial waters of anoxic (lacking oxygen) sediments (Meyer et al., 1994).

A large reservoir of sulfide exists as iron sulfide in anoxic sediment. Sulfide will react with several divalent transition metal cations (cadmium, copper, mercury, nickel, lead, and zinc) to form highly insoluble compounds that are not bioavailable (Allen et al., 1993). It follows in theory, and with verification (Di Toro et al., 1990), that divalent transition metals will not begin to cause toxicity in anoxic sediment until the reservoir of sulfide is used up (i.e., the molar concentration of metals exceeds the molar concentration of sulfide), typically at relatively high dry-weight metal concentrations. This observation has led to a laboratory measurement technique of calculating the difference between simultaneously extracted metal (SEM) concentration and acid volatile sulfide concentration from field samples to determine potential toxicity.

To evaluate the potential effects of metals on benthic species, the molar concentration of AVS ([AVS]) was compared to the sum of SEM molar concentrations ([SEM]) for five metals: cadmium, copper, nickel, lead, and zinc. Mercury was excluded from AVS comparison because other important factors play a major role in determining the bioaccumulation potential of mercury in sediment. Specifically, under certain conditions mercury binds to an organic methyl group and is readily taken up by living organisms.

Sediment with measured [SEM] in excess of [AVS] does not necessarily exhibit toxicity. This is because other binding phases can tie up metals. However, research indicates that sediment with [AVS] in excess of [SEM] will not be toxic from metals, and the greater the [SEM]-[AVS] difference, the greater the likelihood of toxicity from metals. Analysis of toxicity data for freshwater and saltwater sediment amphipods (crustaceans) from EPA's Environmental Research Laboratory in Narragansett, Rhode Island, revealed that 80 to 90 percent of the sediments were toxic at [SEM]-[AVS] = 5 (Hansen, 1995). Thus, EPA selected [SEM]-[AVS] = 5 as the demarcation line between Tier 1 and Tier 2. For the purpose of this evaluation, where [SEM]-[AVS] was greater than 5, the site was categorized as Tier 1. If [SEM]-[AVS] was be-

tween zero and 5, the site was categorized as Tier 2. If [SEM]-[AVS] was less than zero, or if AVS or the five AVS metals were not measured at the site, the site was categorized as Tier 3 unless otherwise categorized by another parameter.

Sediment Chemistry Values Exceed Screening Values [3, 6]

Several sets of sediment contaminant screening values, developed using different methodologies, are available to assess potential adverse effects on benthic species. The screening values selected for comparison with measured sediment levels are the draft SQCs using a default TOC of 1 percent (for those samples which do not have accompanying TOC data), sediment quality advisory levels (SQALs) for freshwater aquatic life (developed using the equilibrium partitioning approach discussed previously for the development of draft SQCs), the effects range-median (ERM) and effects range-low (ERL) values developed by Long et al. (1995), the probable effects levels (PELs) and threshold effects levels (TELs) developed for the Florida Department of Environmental Protection (FDEP, 1994), and the apparent effects thresholds (AETs) developed by Barrick et al. (1988). The assumptions and approaches used to develop these screening values are discussed in detail in Appendix B.

Although the draft SQCs and SQALs were both developed using the EqP approach, the data used to derive sediment SQALs came from limited sources and have undergone limited peer review. Toxicity values used for SQAL development include final chronic values from EPA ambient freshwater quality criteria and secondary chronic values derived using EPA's Great Lakes Water Quality Initiative "Tier II" water quality criteria methodology. The data used to develop the latter values were taken primarily from quality-screened studies in published literature. The development of SQALs is discussed in further detail in Appendix B of this report.

The ERLs/ERMs, PELs/TELs, and AETs relate the incidence of adverse biological effects to the sediment concentration of a specific chemical at a specific site using paired field and laboratory data. The developers of the ERLs/ERMs define sediment concentrations below the ERL as being in the "minimal-effects range," values between the ERL and ERM in the "possible-effects range," and values above the ERM in the "probable-effects range." In the FDEP (1994) approach, the lower of the two guidelines for each chemical (the TEL) is assumed to represent the concentration below which toxic effects rarely occur. In the range of concentrations between the TEL and PEL, effects occasionally occur. Toxic effects usually or frequently occur at concentrations above the upper guideline (the PEL). In the Barrick et al. (1988) approach, two thresholds were recognized, when possible, based on different indicator species. The AET-low was the lowest concentration for which a particular indicator showed an effect, and the AET-high was the highest concentration at which effects were observed for another indicator.

For the NSI data evaluation, the upper screening values were considered to be the ERM, PEL, draft SQC (when using default TOC), SQAL, and AET-high for a given chemical. The lower screening values were considered to be the ERL, TEL, draft SQC (when using default TOC), SQAL, and AET-low for a given chemical. Because they are not based on ranges of effects, the single freshwater aquatic life draft SQC and SQAL values for a given chemical served as both the high and low screening values.

For a site to be classified as Tier 1, a chemical measurement must have exceeded at least two of the upper screening values. If a sediment chemistry measurement exceeded any one of the lower screening values, the site was classified as Tier 2. If sediment concentrations at a site did not exceed any screening values or there were no data for chemicals that have assigned screening values, the site was categorized as Tier 3 unless otherwise categorized by another parameter.

Under this approach a site could be classified as Tier 1 from elevated concentrations of cadmium, copper, lead, nickel, or zinc based only on a comparison of [SEM] to [AVS] (that is, sites could not be classified as Tier 1 based on an exceedance of two upper screening values for any of the five metals). However, sites were classified as Tier 2 for these five metals based on an exceedance of one of the lower screening values if AVS data were not available.

Sediment Chemistry TBPs Exceed Screening Criteria [4, 7]

This evaluation parameter addresses the risk to human consumers of organisms exposed to sediment contaminants. The theoretical bioaccumulation potential (TBP) is an estimate of the equilibrium concentration (concentration that does not change with time) of a contaminant in tissues if the sediment in question were the only source of contamination to the organism. At present, the TBP calculation can be performed only for nonpolar organic chemicals. The TBP is estimated from the concentration of contaminant in the sediment, the organic carbon content of the sediment, the lipid content of the organism, and the relative affinity of the chemical for sediment

organic carbon and animal lipid content. This relative affinity is measured in the field and is called a biota-sediment accumulation factor (BSAF, as discussed in detail in Appendix C).

In the evaluation of NSI data, if a calculated sediment chemistry TBP value exceeded a screening value derived using standard EPA risk assessment methodology or the Food and Drug Administration (FDA) tolerance/action or guidance level, and if a corresponding tissue residue level for the same chemical for a resident species at the same station also exceeded one of those screening values, the station was classified as Tier 1. Individual chemical risk levels were considered separately; that is, risks from multiple contaminants were not added. Both sediment chemistry and tissue residue samples must have been taken from the same sampling location. If tissue residue levels for the same chemical for a resident species at the same station did not exceed EPA risk levels or FDA levels or there were no corresponding tissue data, the station was classified as Tier 2. If neither TBP values nor fish tissue residue levels exceeded EPA risk levels or FDA levels, or if no chemicals with TBP values, EPA risk levels, or FDA levels were measured, the site was categorized as Tier 3 unless otherwise categorized by another parameter. A detailed description of the methods used to develop TBP values and to determine the EPA risk levels used in this comparison is presented in Appendix B.

Tissue Residue Data [8, 9, 10]

Tissue residue data were used to assess potential adverse effects to humans from the consumption of fish that become contaminated through exposure to contaminated sediment. Only those species considered benthic, nonmigratory (resident), and edible by human populations were included in human health assessments. A list of species included in the NSI and their characteristics is presented in Appendix F.

Sampling stations at which human health screening values for dioxin and PCBs were exceeded in fish tissues were categorized as Tier 1. For these chemicals, corroborating sediment chemistry data was not required. If human health screening values for dioxin or PCBs in fish tissue were not exceeded or if neither chemical was measured, the site was categorized as Tier 3 unless otherwise categorized by another parameter.

For other chemicals, a tissue residue level exceeding an FDA tolerance/action or guidance level or EPA risk level, and a sediment chemistry TBP value exceeding that level for the same chemical were required to classify a sampling station as Tier 1. If tissue residue levels exceeded FDA levels or EPA risk levels but corresponding TBP values were not exceeded at the same station (or there were no sediment chemistry data from that station), the sampling location was categorized as Tier 2. If neither fish tissue levels nor TBP values exceeded EPA risk levels or FDA levels, or if no chemicals with TBP values, EPA risk levels, or FDA levels were measured, the site was categorized as Tier 3 unless otherwise categorized by another parameter.

Toxicity Data [11, 12]

Toxicity data were used to classify sediment sites based on their demonstrated adverse effects to aquatic life. Acute nonmicrobial sediment toxicity tests with a mortality endpoint were evaluated. Toxicity test results that lacked control data, or with control data that indicated greater than 20 percent mortality (less than 80 percent survival), were excluded from further consideration. A review of the American Society for Testing and Materials' protocols and other protocols for sediment toxicity tests suggests that mortality in controls can range from 10 to 30 percent, depending on the species, to be considered an acceptable test result (API, 1994). Current amphipod test requirements indicate that controls should have less than 10 percent mortality (API, 1994; USEPA, 1994b).

For the NSI data evaluation, EPA considers significant toxicity as a 20 percent difference in survival from control survival. For example, significant toxicity occurs if control survival was 80 percent and experimental survival was 60 percent or less.

For this evaluation parameter, corroboration of multiple tests was considered more indicative of a higher probability of adverse effects than the magnitude of the effect in a single test. Toxicity demonstrated by two or more single-species tests using two different test species (at least one of which had to be a solid-phase test) placed a site in Tier 1. A sampling station was categorized as Tier 2 if toxicity was demonstrated by one single-species nonmicrobial toxicity test. If toxicity was not demonstrated by a nonmicrobial toxicity test, or if toxicity test data were not available, the site was categorized as Tier 3 unless otherwise categorized by another parameter.

Incorporation of Regional Comments on the Preliminary Evaluation of Sediment Chemistry Data

Several reviewers from different EPA Regions and states provided comments on the May 16, 1994, preliminary evaluation of sediment chemistry data. These com-

ments included more than 150 specific comments identifying additional sites with contaminated sediment that had not been identified in the preliminary evaluation. Since the preliminary evaluation, the final NSI methodology has been developed and implemented. The updated methodology has been refined significantly to include tissue residue and toxicity data as well as revised screening values. Data corresponding to any additional comments that required further review were divided into two categories: (1) data that reviewers stated represented false positives and (2) data for additional water bodies that reviewers stated represented areas of potentially higher levels of contamination.

The false positives noted by the reviewers were identified in the NSI database by water body and chemical listed in the comment. If stations on the specified water bodies were categorized in the NSI evaluation as Tier 1 based only on the specific chemical(s) identified by the reviewer, those stations were removed from Tier 1 and placed in Tier 3. Stations that were identified in the NSI evaluation as Tier 1 from other chemicals not identified by the reviewer or because of toxicity data were not removed from Tier 1.

Data for additional water bodies that reviewers identified as potential areas of significant contamination were evaluated to determine whether stations along those water bodies had already been categorized as Tier 1 based on the NSI data evaluation Those stations which were identified by the Regions as potential areas of significant contamination but had not been categorized as Tier 1 as a result of the NSI evaluation are discussed separately in the results (Chapter 3).

Evaluation Using EPA Wildlife Criteria

In addition to the evaluation parameters described above and presented in Table 2-2, EPA conducted an assessment of NSI data based on a comparison of sediment chemistry TBP values and fish tissue values to EPA wildlife criteria. This evaluation, however, was not included with the results of evaluating the NSI data based on the other parameters. The results of evaluating NSI data based on wildlife criteria are presented in a separate section of Chapter 3. Wildlife criteria based on fish tissue concentrations were derived using methods similar to those employed for deriving EPA wildlife criteria, as presented in the proposed *Great Lakes Water Quality Initiative Criteria Documents for the Protection of Wildlife* (USEPA, 1995a). EPA has proposed wildlife criteria for four contaminants: DDT, mercury, 2,3,7,8-TCDD, and PCBs. The method used to develop wildlife criteria for the NSI data evaluation is explained in detail in Appendix B.

Chapter 3

Findings

This chapter presents the results of the evaluation of NSI data based on the methodology described in Chapter 2. This discussion includes a summary of the results of national, regional, and state assessments.

National Assessment

EPA evaluated a total of 21,096 sampling stations nationwide as part of the NSI data evaluation (Figure 3-1). Of the sampling stations evaluated, 5,521 stations (26 percent) were categorized as having a higher probability of adverse effects (Tier 1), 10,401 (49 percent) were categorized as having an intermediate probability of adverse effects (Tier 2), and 5,174 (25 percent) were categorized as having no indication of adverse effects (Tier 3). (See Table 3-1.) The national distribution of Tier 1 stations is illustrated in Figure 3-2. The distribution of Tier 1 stations depicted in Figure 3-2 must be viewed in the context of the distribution of all sampling stations depicted in Figure 3-1. Table 3-1 presents the number of stations in each tier by EPA Region. The greater number of Tier 1 and Tier 2 stations in some Regions is to some degree a function of a larger set of available data. Although there are 17 times more Tier 1 stations in EPA Region 4 (southeastern states) than in EPA Region 8 (mountain states), there are also 13 times more Tier 3 stations. The large percentages of stations in Tier 1 and Tier 2 in all Regions most likely reflect that sampling often takes place at locations where contamination problems are known or suspected.

The NSI sampling stations were located in 6,744 individual river reaches throughout the contiguous United States (based on EPA's River Reach File 1; Bondelid et al., 1990). A river reach can be part of a coastal shoreline, a lake, or a length of stream between two major tributaries ranging from approximately 1 to 10 miles long. NSI sampling stations were located in approximately 11 percent of all river reaches identified in the contiguous United States (Table 3-1 and Figure 3-3). Thirty-five percent of all river reaches evaluated in the United States had at least one station categorized as Tier 1. Forty-two percent of all reaches evaluated had at least one station categorized as Tier 2 (but none as Tier 1). In 23 percent of the reaches evaluated, all of the stations were categorized as Tier 3. EPA has not yet catalogued river reaches outside the contiguous United States (e.g., Alaska, Hawaii, Puerto Rico), and some sampling stations in the ocean were not linked to a specific reach. Again, the large percentages of river reaches with at least one Tier 1 or Tier 2 station probably reflect monitoring strategies targeted toward contaminated areas. In most cases, the smaller the percentage of reaches with available data, the greater the percentage of river reaches with at least one Tier 1 or Tier 2 station.

Not all sampling programs target only sites of known or suspected contamination. The NSI includes the National Oceanic and Atmospheric Administration's (NOAA's) National Status and Trends Program, which is part of the COSED database, and EPA's Environmental Monitoring and Assessment Program (EMAP). These are examples of sampling programs that do not target sites of known or suspected contamination. Based on these data alone, the percentage of stations placed in each tier differs considerably from the percentage of stations in each tier based on an evaluation of all the data in the NSI. Smaller percentages of COSED and EMAP stations are categorized as Tier 1 (18 percent for COSED and 14 percent for EMAP compared to 26 percent for all NSI stations), greater percentages are categorized as Tier 2 (75 percent for COSED and 68 percent for EMAP compared to 49 percent for all NSI stations), and smaller percentages are categorized as Tier 3 (7 percent for COSED and 18 percent for EMAP compared to 25 percent for all NSI stations). This may reflect the lower detection limits of more sensitive analytical chemistry techniques, the sensitivity of Tier 2 evaluation parameters, and the nearly ubiquitous presence of intermediate levels of contamination in areas sampled by these programs.

Data describing environmental concentrations of more than 230 different chemicals or chemical groups were included in the NSI evaluation. Approximately 40 percent of these chemicals or chemical groups (97) were present at some location at levels that indicated risks to human health or the environment (Tier 1 or Tier 2). Table 3-2 presents the chemicals or chemical groups that resulted in more than 1,000 stations being classified as Tier

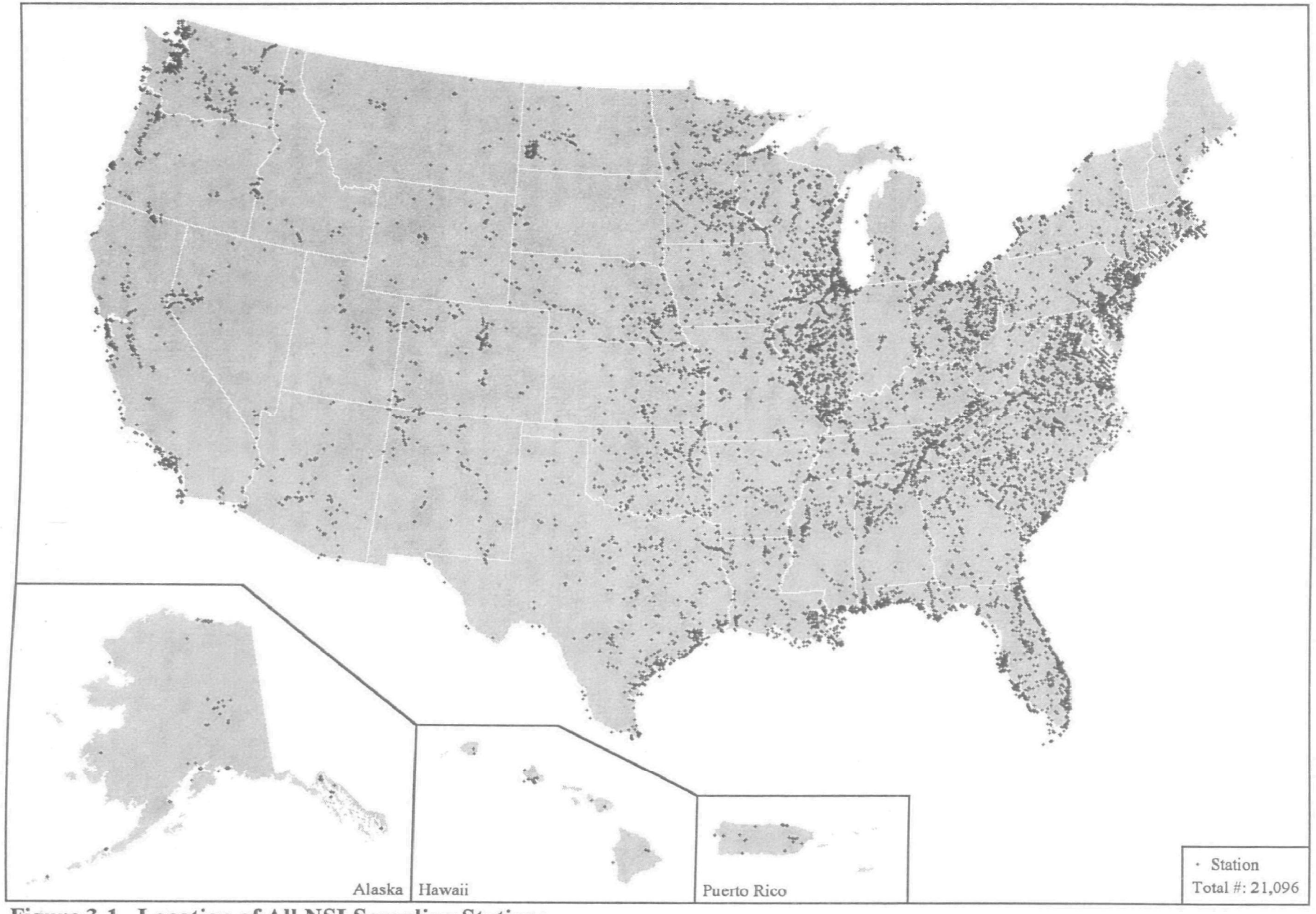


Figure 3-1. Location of All NSI Sampling Stations.

Table 3-1. National Assessment: Number of NSI Sampling Stations in Each Probability of Adverse Effects Category and Number of River Reaches Where NSI Sampling Stations Are Located

	Station Evaluation						River Reach Evaluation[a]							
	Tier 1		Tier 2		Tier 3									
State	#	%[b]	#	%[b]	#	%[b]	Number of Stations Not Identified by an RF1 Reach[c]	Reaches w/at Least 1 Station in Tier 1	Reaches w/at Least 1 Station in Tier 2[d]	Reaches w/all Stations in Tier 3	Total # Reaches w/at Least 1 Station Evaluated	Total Reaches in Region	% of all Reaches in Region w/at Least 1 Station Evaluated	% of Reaches Evaluated w/at Least 1 Tier 1 or Tier 2 Station
Region 1	298	27	646	59	158	14	361	59	65	7	131	2,648	5	95
Region 2	355	32	559	51	182	17	173	116	147	29	292	1,753	17	90
Region 3	318	17	934	49	658	34	92	209	453	226	888	3,247	27	75
Region 4	1,157	23	1,930	39	1,872	38	343	566	684	520	1,770	9,749	18	71
Region 5	1,418	33	2,137	50	735	17	108	594	570	268	1,432	6,025	24	81
Region 6	382	24	837	52	397	24	124	266	341	192	799	7,293	11	76
Region 7	330	33	393	39	288	28	N/A	246	182	88	516	4,857	11	83
Region 8	68	13	327	61	140	26	N/A	61	153	91	305	13,492	2	70
Region 9	468	28	942	55	289	17	794	119	92	43	254	4,601	6	83
Region 10	727	25	1,696	59	455	16	497	147	174	72	393	10,178	4	82
Total for U.S.[e]	5,521	26	10,401	49	5,174	25	2,492	2,371	2,843	1,530	6,744	62,742	11	77

[a]River reaches based on EPA River Reach File 1 (RF1).
[b]Percent of all stations evaluated in the NSI in the Region.
[c]Stations not identified by an RF1 reach were located in coastal or open water areas.
[d]No stations in these reaches were included inTier 1.
[e]Because some reaches occur in more than one Region, the total number of reaches in each cateogry for the country might not equal the sum of reaches in the Regions.

Figure 3-2. NSI Stations Categorized as Having a Higher Probability of Adverse Effects (Tier 1).

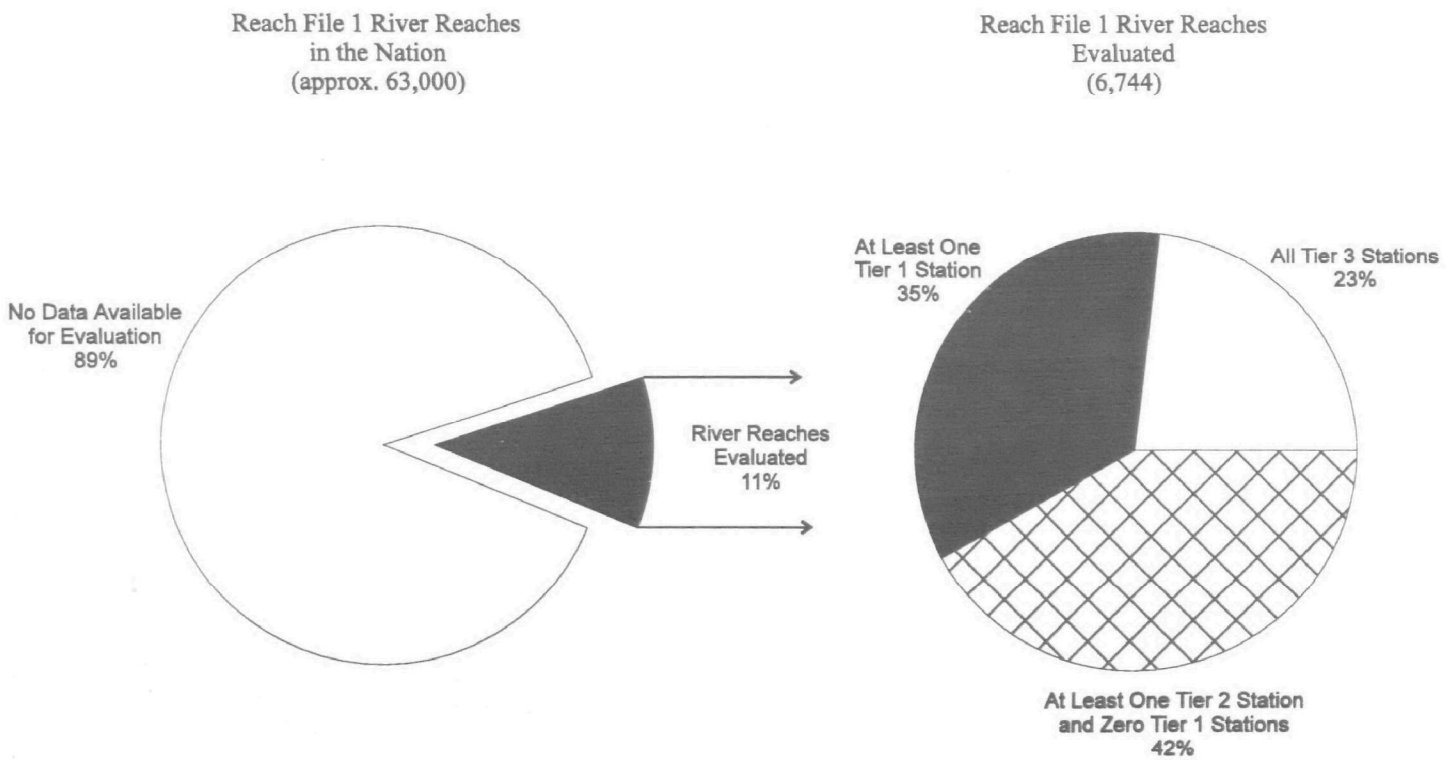


Figure 3-3. National Assessment: Percent of River Reaches That Include Tier 1, Tier 2, and Tier 3 Stations.

Table 3-2. Chemicals or Chemical Groups Most Often Responsible for Sampling Stations Being Categorized as Tier 1 or Tier 2

Chemical or Chemical Group	Number of Stations							
	Total # of Stations Evaluated	Based on All Measurement Parameters			Based on Aquatic Life Parameters		Based on Human Health Parameters	
		Combined Tiers 1 & 2	Tier 1	Tier 2	Tier 1	Tier 2	Tier 1	Tier 2
Copper	16,161	7,172	-	7,172	-	7,167	-	5
Nickel	12,447	6,284	-	6,284	-	6,284	-	-
Lead	16,791	5,681	-	5,681	-	5,415	-	328
Polychlorinated biphenyls	12,276	5,454	3,175	2,279	963	1,219	2,256	3,198
Arsenic	13,200	5,392	182	5,210	182	4,658	-	605
Cadmium	16,010	4,808	-	4,808	-	4,773	-	41
Mercury	15,649	4,333	1,122	3,211	1,122	3,127	-	103
Zinc	15,160	3,468	-	3,468	-	3,451	-	17
DDT (and metabolites)	11,462	3,422	803	2,619	798	2,203	21	1,402
Chromium	15,222	3,070	278	2,792	278	2,786	-	7
Dieldrin	10,284	2,597	58	2,539	49	1,006	9	2,456
Chlordane	10,697	2,169	11	2,158	-	1,303	11	1,697
Benzo(a)pyrene	5,435	1,993	287	1,706	287	1,051	-	1,990
Pyrene	5,798	1,920	431	1,489	431	1,489	-	10
Chrysene	5,300	1,427	166	1,261	166	1,261	-	30
Dibenzo(a,h)anthracene	4,896	1,383	337	1,046	337	1,018	-	1,092
Benzo(a)anthracene	5,120	1,366	214	1,152	214	1,106	-	847
Bis(2-ethylhexyl)phthalate	3,559	1,190	347	843	347	823	-	406
Naphthalene	5,246	1,186	254	932	254	932	-	5
Fluoranthene	5,814	1,114	210	904	210	904	-	11
Fluorene	5,175	1,107	201	906	201	906	-	5
Silver	8,022	1,096	302	794	302	794	-	-
Total for all chemicals in the NSI database	21,096	15,922	5,521	10,401	3,287	9,921	2,327	6,196

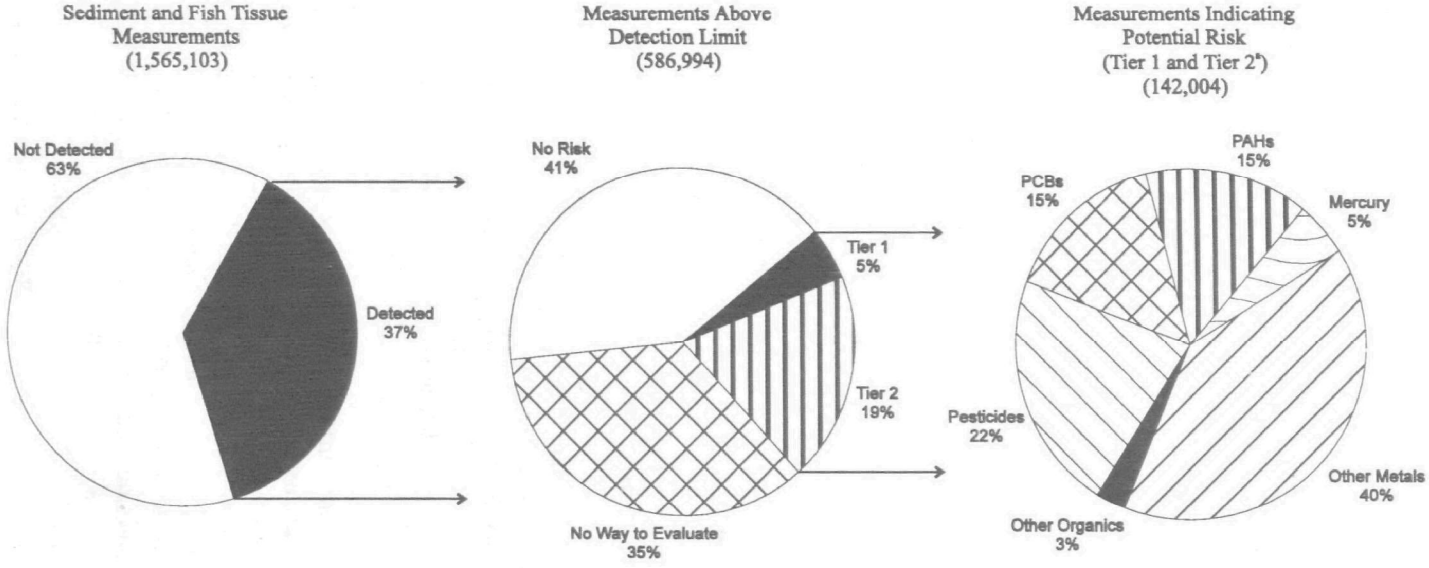
1 or Tier 2. Table 3-2 also separately identifies the number of stations categorized as Tier 1 or Tier 2 for aquatic life effects and for human health effects. Evaluation parameters indicative of aquatic life effects included:

- Comparison of sediment chemistry measurements to EPA draft sediment quality criteria (SQCs).
- Comparison of sediment chemistry measurements to other screening values (draft SQCs when percent organic carbon is not reported, SQALs, ERL/ERMs, PEL/TELs, and AETs).
- Comparison of [SEM] to [AVS].
- Results of toxicity tests.

Human health evaluation parameters included:

- Comparison of sediment chemistry TBP to EPA risk levels or FDA tolerance/action or guideline levels.
- Comparison of fish tissue levels of PCBs and dioxin to EPA risk levels. (A station can be classified as Tier 1 without corroborating sediment chemistry data.)
- Comparison of fish tissue levels to EPA risk levels and FDA tolerance/action or guideline levels.

Stations are reported more than once in Table 3-2 because it is common for a station to have elevated concentration levels for multiple chemicals. Of the 5,521 stations identified as Tier 1, 3,175 stations were placed in Tier 1 because of elevated levels of PCBs, 1,122 were placed in Tier 1 because of elevated levels of mercury, and 803 were placed in Tier 1 because of elevated levels of DDT. Metals other than mercury, silver, and arsenic are notably absent from Tier 1 in Table 3-2 since the method for evaluating cadmium, copper, nickel, lead, and zinc required the simultaneous measurement of AVS, which was rarely available. The [SEM]-[AVS] methodology for sediment assessment is relatively new, and AVS measurements have not commonly been made during sediment analyses. It should be noted that the total number of stations classified as Tier 1 or Tier 2 for a given chemical as presented in Table 3-2 may not be representative of the potential risk posed by that chemical. This is because, although there may be few overall observations for some chemicals, the frequency of detection in sediment and tissue and the frequency with which those chemicals result in Tier 1 or Tier 2 risk may be high (see Appendix D, Table D-2). Figure 3-4 illustrates the percent of sediment chemistry and fish tissue residue measurements included in the NSI that were above the detection limit for the chemicals



*For most chemical groups, the percent of measurements in Tier 1 and Tier 2 was similar to the percent of measurements in Tier 1 and Tier 2 for all classes of contaminants. However, for PCBs, approximately 80 percent of the measurements were categorized as Tier 1 and for other metals, only 2 percent of the measurements were categorized as Tier 1.

Figure 3-4. National Assessment: Percent of NSI Measurements That Include Potential Risk.

analyzed, the fraction of those measurements above detection levels that indicate potential risk (Tier 1 or Tier 2), and the distribution of measurements indicating risk by chemical class.

More stations exhibit potential aquatic life effects than potential human health effects. About 40 percent more stations were categorized as Tier 1 for potential aquatic life effects (3,287 stations) than for potential human health effects (2,327 stations). Furthermore, about 60 percent more stations were categorized as Tier 2 for potential aquatic life effects (9,921 stations) than were categorized as Tier 2 for potential human health effects (6,196 stations). The locations of stations categorized as Tier 1 or Tier 2 for potential aquatic life effects are illustrated in Figure 3-5, and the locations of those categorized as Tier 1 or Tier 2 for human health effects are illustrated in Figure 3-6.

EPA also analyzed the results to determine which evaluation parameters were most sensitive; that is, which parameters most often caused stations to be categorized as either Tier 1 or Tier 2 (see Table 3-3). Most of the stations categorized as Tier 1 (3,283 stations) or Tier 2 (9,882 stations) were placed in those categories because measured sediment contaminant levels exceeded screening values. The comparison of fish tissue levels of PCBs and dioxins to EPA risk levels triggered placement of the second highest number of stations in Tier 1 (2,313 stations). The comparison of sediment chemistry TBP values to FDA action levels and EPA risk levels triggered placement of the second highest number of stations in Tier 2 (5,671 stations). The AVS and toxicity parameters triggered placement of the fewest stations in Tier 1 (8 stations each) and Tier 2 (146 stations for AVS and 183 stations for toxicity). These results reflect both data availability and evaluation parameter sensitivity.

For a number of reasons, known contaminated sediment sites in the United States might not have been categorized as Tier 1 or Tier 2 based on the evaluation of NSI data. The NSI does not presently include data describing every sampled location in the Nation. Therefore, numerous sampling sites were not evaluated for this first report to Congress. However, additional databases will be added to the NSI and more sampling stations will be evaluated for future reports to Congress.

During an initial screening of the NSI data, EPA noted data quality problems that might have affected all or many of the data reported in a given database (e.g., the Virginia State Water Control Board organic chemical data reported in STORET). Databases with obvious quality problems were not included in the NSI data evaluation. Also, if a database included in the NSI did not have associated locational information (latitude/longitude), data in that database were not included in the NSI data evaluation (e.g., EPA's Great Lakes Sediment Quality Database). To reduce the chances of overlooking sampling sites that have obvious sediment contamination problems, EPA sent a preliminary evaluation of sediment chemistry data to each EPA Region so knowledgeable staff would have an opportunity to list additional contaminated sediment sites not identified in the NSI evaluation. The locations of these sites are presented at the end of this chapter. Despite these efforts, some sediment sampling sites known to have contamination problems still have not been listed in this first report to Congress.

Watershed Analysis

Although sampling stations are an important unit of assessment, the most significant sediment contamination problems exist where multiple contaminated locations are in close proximity or are distributed throughout a discrete hydrologic unit. A single "hot spot" may not affect a benthic community or accumulation of contaminants in resident fish tissue to a great extent. However, widespread contamination is more likely to adversely affect benthic communities and lead to a greater extent of contaminant accumulation in resident fish.

The NSI data evaluation identified 96 watersheds throughout the United States as areas of potential widespread sediment contamination (APCs) (Figure 3-7). APCs are watersheds that contain 10 or more Tier 1 stations and in which at least 75 percent of all stations have been categorized as Tier 1 or Tier 2. These dual criteria are based on empirical observation of the data. Expert reviewers indicated that this was a reasonable approach to obtaining a qualitative ranking. These watersheds constitute 5 percent of all watersheds in the country (Figure 3-8). The watershed analysis also indicated that 39 percent of all watersheds in the country contain at least one Tier 1 station, 15 percent contain at least one Tier 2 station but no Tier 1 stations, and 6 percent contain all Tier 3 stations. Thirty-five percent of all watersheds in the country could not be evaluated because of a lack of data.

Contaminated areas may be concentrated in specific river reaches in a watershed. Within the 96 APCs across the country, 57 individual river reaches or water body segments have 10 or more Tier 1 stations (Table 3-4). These are localized areas within the watershed for which an abundance of evidence indicates potentially severe contamination. Because EPA's Reach File 1 was used to index the location of NSI sampling stations, some sta-

Figure 3-5. Stations Categorized as Tier 1 or Tier 2 Due to Potential Aquatic Life Effects.

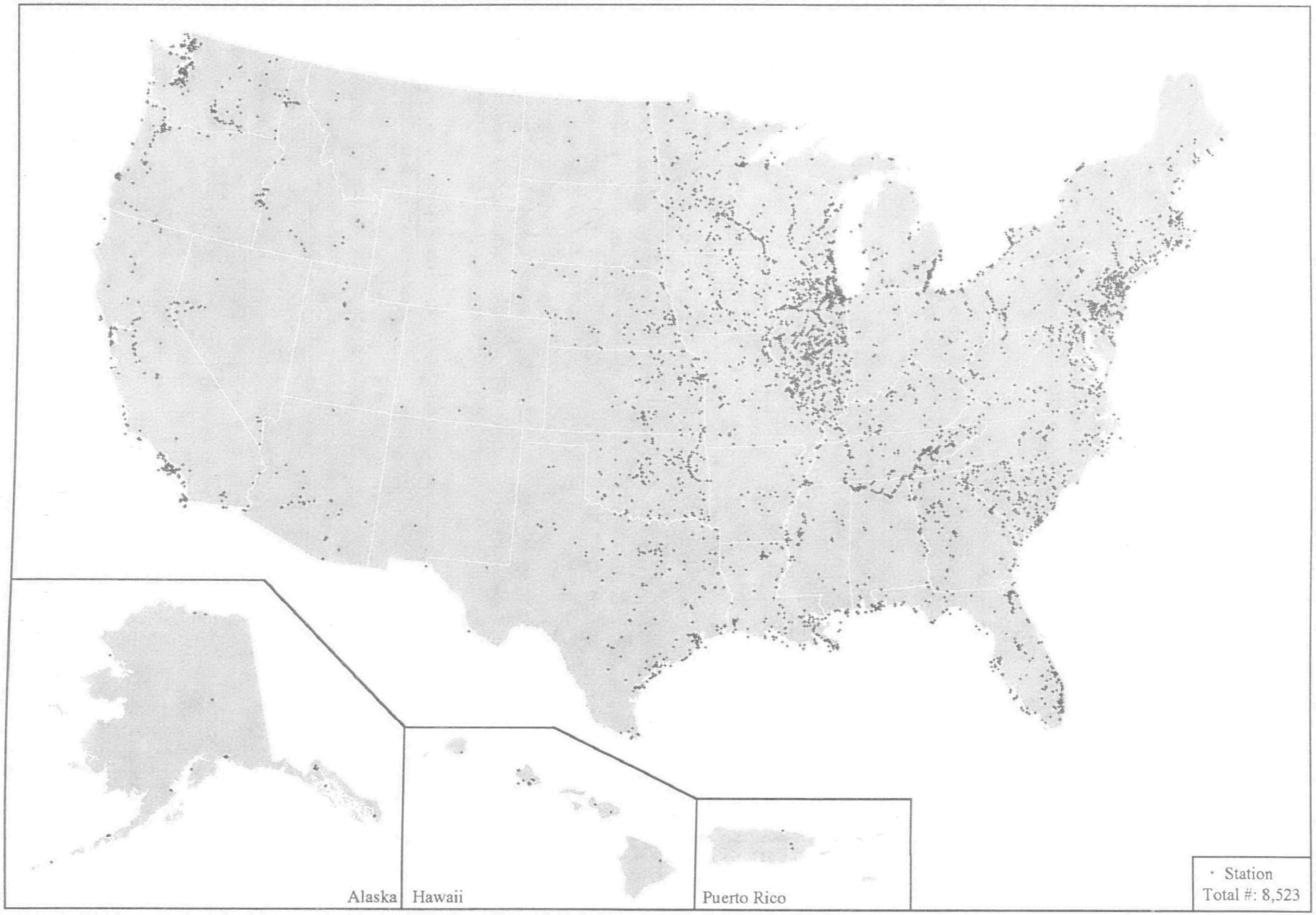


Figure 3-6. Stations Categorized as Tier 1 or Tier 2 Due to Potential Human Health Effects.

Table 3-3. Number of Stations Placed in Tier 1 and Tier 2 Based on Each Component of the Evaluation Approach (see Table 2-2)

Measurement Parameter	Number of Stations in Tier 1	Number of Stations in Tier 2
Sediment chemistry values exceed draft sediment quality criteria	97	NA
[SEM]-[AVS] comparison	8	146
Sediment chemistry values exceed screening values	3,283	9,882
Sediment chemistry TBP and fish tissue levels exceed risk levels or action levels	126	NA
Sediment chemistry TBP exceeds risk levels or action levels	NA	5,671
Fish tissue levels exceed risk levels or action levels	NA	2,789
Tissue levels of PCBs or dioxins exceed risk levels	2,313	NA
Toxicity parameters	8	183

tions might not actually occur on the identified Reach File 1 stream, but on a smaller stream that is hydrologically linked or is relatively close to the Reach File 1 stream.

Wildlife Assessment

As mentioned in Chapter 2, EPA conducted a separate analysis of the NSI data to determine the number of stations where chemical concentrations of DDT, mercury, dioxin, and PCBs exceeded levels predicted to be protective of wildlife (i.e., EPA wildlife criteria). The wildlife criteria used in this evaluation were derived using methods similar to those presented in the proposed *Great Lakes Water Quality Initiative Criteria Documents for the Protection of Wildlife* (USEPA, 1995a). The only assumed route of exposure of exposure for this evaluation was the consumption of contaminated fish tissue by wildlife.

Data were available to evaluate a total of 7,796 NSI stations using the wildlife criteria. Table 3-5 presents a comparison of the stations categorized as Tier 1 or Tier 2 with and without the use of wildlife criteria. If wildlife criteria had been used to complete the national assessment, 619 stations classified as Tier 3 would have been classified as Tier 2 and 16 stations classified as Tier 2 would have been classified as Tier 1. Most of the change in station classification is due to the increase in Tier 2 stations classified for DDT (from 2,619 to 4,276) and mercury (from 3,211 to 5,199). Figure 3-9 presents all 16,541 stations classified as Tier 1 and Tier 2 when wildlife criteria are used for the assessment.

Use of wildlife criteria resulted in the different classification for two reasons: (1) the wildlife criteria for DDT and mercury are significantly lower (8 and 19 times lower, respectively) than the EPA risk levels used in the corresponding human health evaluations; (2) the lipid content used in the wildlife TBP analysis (10.31 percent for whole body) exceeded the lipid content used in the human health TBP analysis (3.0 percent for fillet).

No additional stations were categorized as Tier 1 for mercury or dioxins as a result of using wildlife criteria. For a station to be categorized as Tier 1, both sediment chemistry TBP and measured fish tissue concentrations taken from that station had to exceed the wildlife criteria. At very few stations in the NSI were both sediment chemistry and fish tissue levels for dioxin measured. In those few cases where contaminants in both media were measured, there were no additional stations (stations not already classified as Tier 1) where both the sediment chemistry TBP and fish tissue levels exceeded the wildlife dioxin criteria. No additional stations were classified as Tier 1 due to exceedance of the wildlife criteria for mercury since sediment chemistry TBPs cannot be calculated for metals.

Regional and State Assessment

The remainder of this chapter presents more detailed results from the evaluation of NSI data for stations located in each of the EPA Regions and each state. The

Figure 3-7. Areas of Potential Widespread Sediment Contamination (APCs).

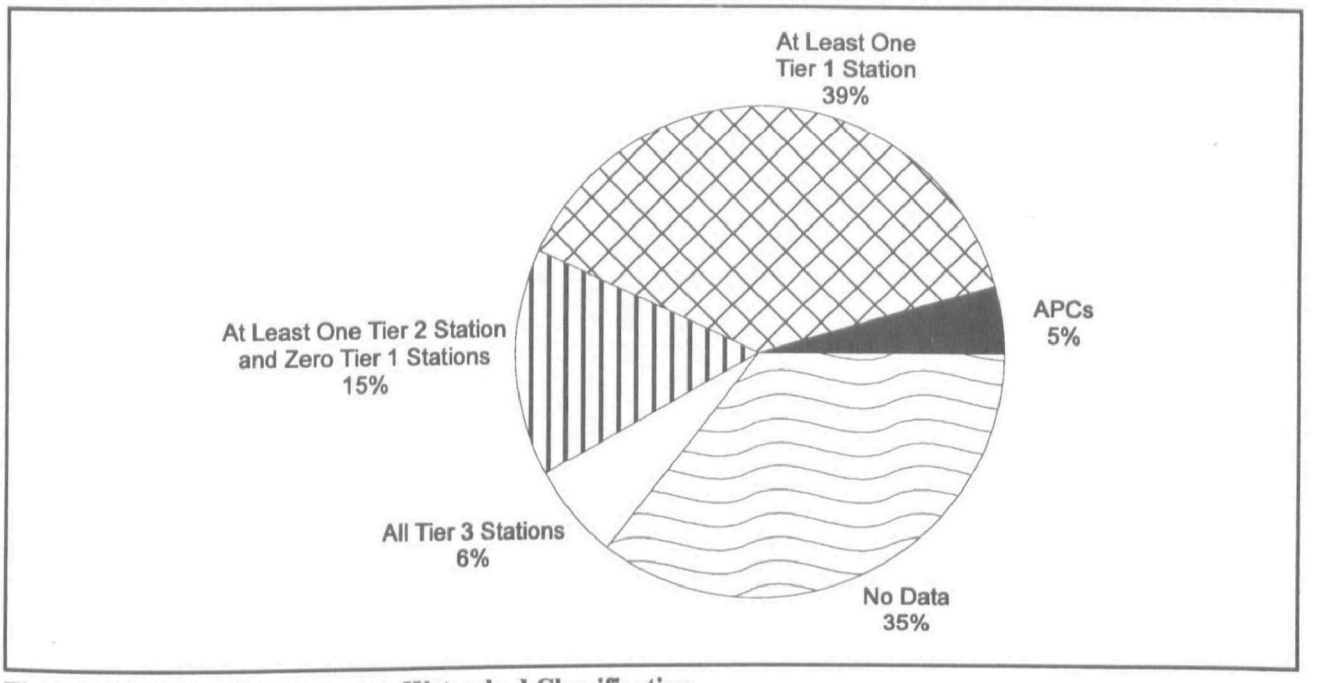


Figure 3-8. National Assessment: Watershed Classification.

sections that follow present the number of sampling stations in each Region and state that have been categorized as Tier 1, Tier 2, and Tier 3 and the chemicals that were most often responsible for Tier 1 and Tier 2 classifications. Tables and figures similar to those presented in the national assessment of station evaluation results and river reach evaluation results are included. For each Region, maps that identify the location of sampling stations categorized as Tier 1 and Tier 2 are provided. Areas of potential widespread sediment contamination in each Region have also been identified. The presentation format is identical for each Region.

Table 3-4. River Reaches Located in Areas of Potential Widespread Sediment Contamination That Have 10 or More Tier 1 Sampling Stations

EPA Region	Cataloging Unit Number	Cataloging Unit Name	RF1 Reach ID	RF1 Reach Name	Number of Tier 1 Stations	Total Number of Stations in Reach
1	01090001	Charles	01090001022	Boston Bay	72	146
			01090001015	Boston Bay	42	149
			01090001013	Atlantic Ocean	37	58
			01090001024	Boston Bay	16	45
1	01090004	Narragansett	01090004023	Seekonk River	16	17
2	02030103	Hackensack-Passaic	02030103023	Rockaway River	26	56
2	02030104	Sandy Hook-Staten Island	02030104003	Arthur Kill	10	10
2	04120103	Buffalo-Eighteenmile	04120103007	Buffalo Creek	26	42
			04120103001	Lake Erie, U.S. Shore	17	22
2	04120104	Niagara	04120104007	Niagara River	12	20
2	04130001	Oak Orchard-Twelvemile	04130001001	Lake Ontario, U.S. Shore	14	27
4	03060106	Middle Savannah	03060106047	Horse Creek	10	11
4	03080103	Lower St. Johns	03080103017	St. Johns River	10	27
4	06010201	Watts Bar Lake	06010201026	Little River	15	23
			06010201035	Tennessee River	10	12
4	06010207	Lower Clinch	06010207022	Poplar Creek	19	25
			06010207021	Poplar Creek, Brushy Fork	17	23
			06010207003	Clinch River	16	20
4	06020001	Middle Tennessee-Chickamauga	06020001003	Lookout Creek	29	41
4	06030005	Pickwick Lake	06030005046	Wilson Lake	22	25
5	04030108	Menominee	04030108001	Menominee River	10	12
5	04030204	Lower Fox	04030204001	Fox River	13	13
			04030204010	Fox River	12	13
			04030204004	Fox River	10	10
5	04040001	Little Calumet-Galien	04040001010	Indiana Harbor	15	15
			04040001006	Calumet River	12	20
5	04040002	Pike-Root	04040002002	Lake Michigan	15	33
5	04040003	Milwaukee	04040003001	Milwaukee River	48	64
5	04090004	Detroit	04090004006	Detroit River	27	38
			04090004014	River Rouge	12	12
			04090004011	Detroit River	11	11
			04090004004	Detroit River	10	12
5	04100002	Raisin	04100002001	River Raisin	16	32

Table 3-4. (Continued)

EPA Region	Cataloging Unit Number	Cataloging Unit Name	RF1 Reach ID	RF1 Reach Name	Number of Tier 1 Stations	Total Number of Stations in Reach
5	07010206	Twin Cities	07010206001	Mississippi River	10	15
5	07120003	Chicago	07120003001	Chicago Sanitary Ship Canal	35	36
			07120003006	Little Calumet River	13	42
5	07120004	Des Plaines	07120004011	Des Plains River	11	20
6	08040207	Lower Ouachita	08040207005	Bayou De Siard	11	11
6	08080206	Lower Calcasieu	08080206033	Calcasieu River	13	40
			08080206034	Bayou D'Inde	11	30
6	08090100	Lower Mississippi-New Orleans	08090100004	Mississippi River	13	23
9	18030012	Tulare-Buena Vista Lakes	18030012014	Kings River	10	12
9	18050004	San Francisco Bay	18050004001	San Francisco Bay	11	27
9	18070104	Santa Monica Bay	18070104003	Pacific Ocean	20	37
9	18070105	Los Angeles	18070105001	Los Angeles River	12	31
9	18070201	Seal Beach	18070201001	Pacific Ocean	18	47
9	18070204	Newport Bay	18070204002	San Diego Creek	11	22
9	18070304	San Diego	18070304014	San Diego Bay	30	46
10	17110002	Strait Of Georgia	17110002019	Bellingham Bay	13	26
10	17110013	Duwamish	17110013003	Elliot Bay	41	100
10	17110019	Puget Sound	17110019086	Puget Sound	119	232
			17110019085	Puget Sound	105	264
			17110019068	Budd Inlet	41	112
			17110019084	Puget Sound	32	57
			17110019087	Puget Sound	32	164
			17110019020	Bainbridge Island	31	88
			17110019022	Sinclair Inlet	25	44

Table 3-5. Increased Number of Sampling Stations Identified as Tier 1 and Tier 2 if Wildlife Criteria Are Used in the National Assessment[a]

Chemical or Chemical Group	Number of Stations Excluding Wildlife Assessment		Number of Stations Including Wildlife Assessment	
	Tier 1	Tier 2	Tier 1	Tier 2
DDT (and metabolites)	803	2,619	868	4,276
Dioxin	311	33	311	60
Mercury	1,122	3,211	1,122	5,199
PCBs	3,175	2,279	3,181	2,289
All Data	5,521	10,401	5,537	11,004

[a]The wildlife assessment used a default lipid content of 10.31 percent to compute the sediment chemistry TBP.

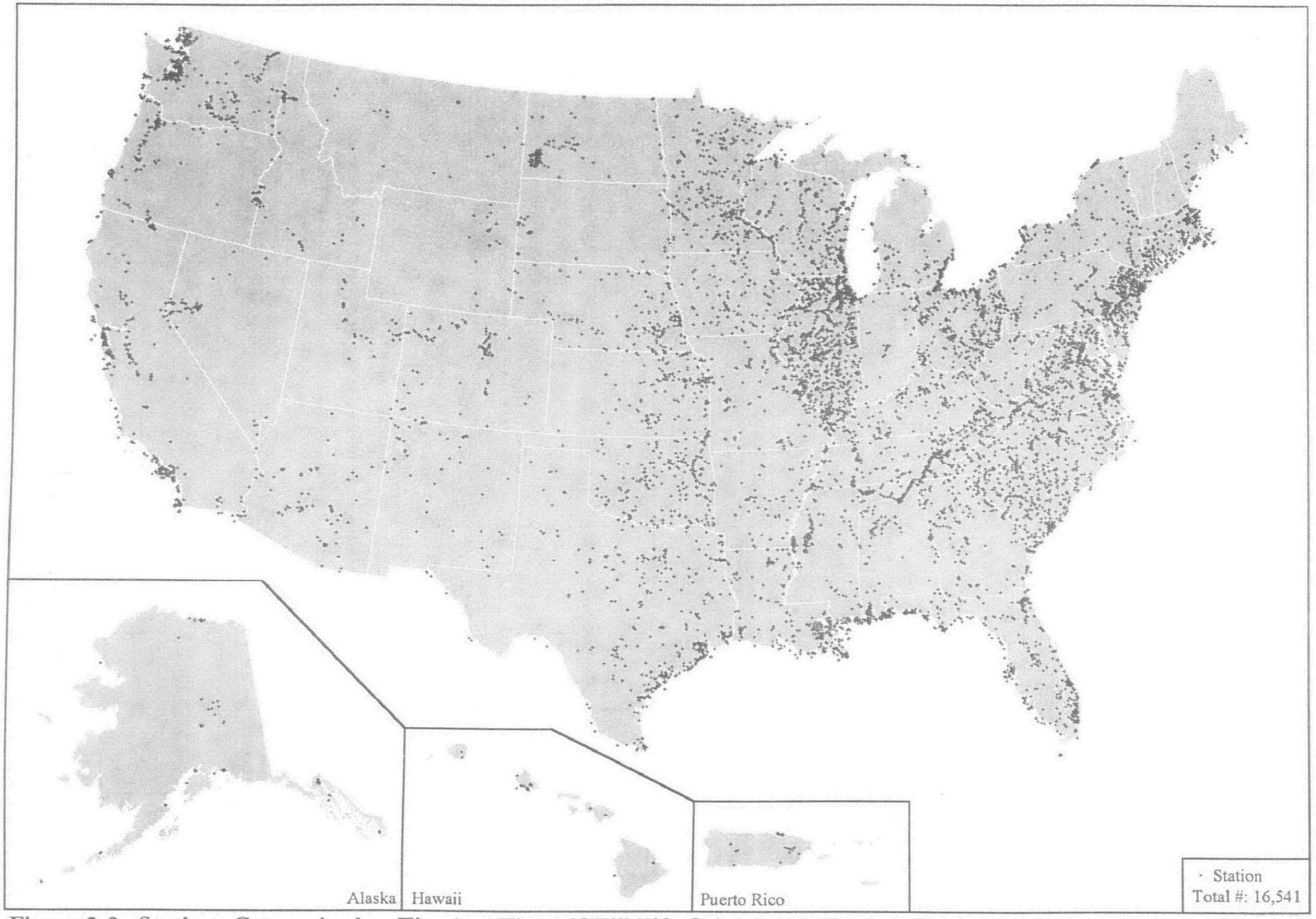


Figure 3-9. Stations Categorized as Tier 1 or Tier 2 if Wildlife Criteria are Used to Complete the Analysis.

EPA Region 1

EPA evaluated 1,102 sampling stations in Region 1 as part of the NSI evaluation. This evaluation resulted in 298 stations (27 percent) in Region 1 being categorized as Tier 1, 646 (59 percent) as Tier 2, and 158 (14 percent) as Tier 3 (Table 3-6). Figure 3-10 identifies the stations in Region 1 that were categorized as Tier 1 or Tier 2 due to potential aquatic life effects and those categorized as Tier 1 or Tier 2 due to potential human health effects.

The NSI sampling stations in Region 1 were located in 131 separate river reaches, or 5 percent of all reaches in the Region (Table 3-6). Of all river reaches evaluated in Region 1, 45 percent included at least one Tier 1 station, 50 percent included at least one Tier 2 station but no Tier 1 stations, and 5 percent had only Tier 3 stations (Figure 3-11).

Out of a total of 61 watersheds located in Region 1, 3 (5 percent) were identified as APCs (Figure 3-12). In addition, 39 percent of all watersheds in the Region had at least one Tier 1 station but were not categorized as APCs, 11 percent had at least one Tier 2 station but no Tier 1 stations, and less than 2 percent had only Tier 3 stations. Forty-three percent of the watersheds in Region 1 could not be evaluated because of a lack of data. The locations of the APCs and the Tier 1 and Tier 2 stations in Region 1 are illustrated in Figure 3-13.

Within the 3 watersheds in Region 1 identified as APCs (Table 3-7), 14 water bodies have at least 1 sampling station that has been categorized as Tier 1; 3 water bodies have 10 or more sampling stations categorized as Tier 1 (Table 3-8). The Massachusetts Bay area appears to have the most significant potential widespread sediment contamination problem in Region 1. The waterbodies listed on Table 3-8 are not inclusive of all locations containing a Tier 1 or Tier 2 station because only waterbodies within APC watersheds are listed. These summary results are also not inclusive of locations with contaminated sediment not identified in this survey. The data compiled for the NSI are primarily from large national electronic databases. Data from many sampling and testing studies have not yet been incorporated into the NSI. Thus, there may be additional locations with sediment contamination that do not appear in this summary. On the other hand, data in the inventory were collected between 1980 and 1993 and any single measurement of a chemical at a site, taken any point in time during that period, could result in the categorization of the site in Tier 1 or Tier 2. The evaluation approach is conservative. Therefore sites appearing in Tier 1 or Tier 2 may not cause unacceptable impacts. It is also important to note that management programs may already exist to address identified sediment contamination problems.

The chemicals most often responsible for stations being categorized as Tier 1 or Tier 2 in Region 1 overall and in each state in Region 1 are presented in Table 3-9.

Table 3-6. Region 1: Number of NSI Sampling Stations in Each Probability of Adverse Effects Category and Number of River Reaches Where NSI Sampling Stations Are Located

	Station Evaluation						River Reach Evaluation[a]							
	Tier 1		Tier 2		Tier 3									
State	#	%	#	%	#	%	Number of Stations Not Identified by an RF1 Reach[b]	Reaches w/at Least 1 Station in Tier 1	Reaches w/at Least 1 Station in Tier 2[c]	Reaches w/all Stations in Tier 3	Total # Reaches w/at Least 1 Station Evaluated	Total Reaches in State	% of all Reaches in State w/at Least 1 Station Evaluated	% of Reaches Evaluated w/at Least 1 Tier 1 or Tier 2 Station
Connecticut	20	20	67	68	11	11	8	16	24	4	44	215	21	91
Maine	13	24	37	67	5	9	28	9	7	2	18	1,583	1	89
Massachusetts	242	27	516	58	137	15	316	25	27	-	52	270	19	100
New Hampshire	4	57	1	14	2	29	-	2	-	2	4	279	1	-
Rhode Island	16	38	24	57	2	5	9	6	7	-	13	56	23	100
Vermont	3	60	1	20	1	20	-	3	-	-	3	355	1	-
REGION 1[d]	298	27	646	59	158	14	361	59	65	7	131	2,648	5	95

[a]River reaches based on EPA River Reach File 1 (RF1).
[b]Stations not identified by an RF1 reach were located in coastal or open water areas.
[c]No stations in these reaches were included in Tier 1.
[d]Because some reaches occur in more than one state, the total number of reaches in each category for the Region might not equal the sum of reaches in the states.

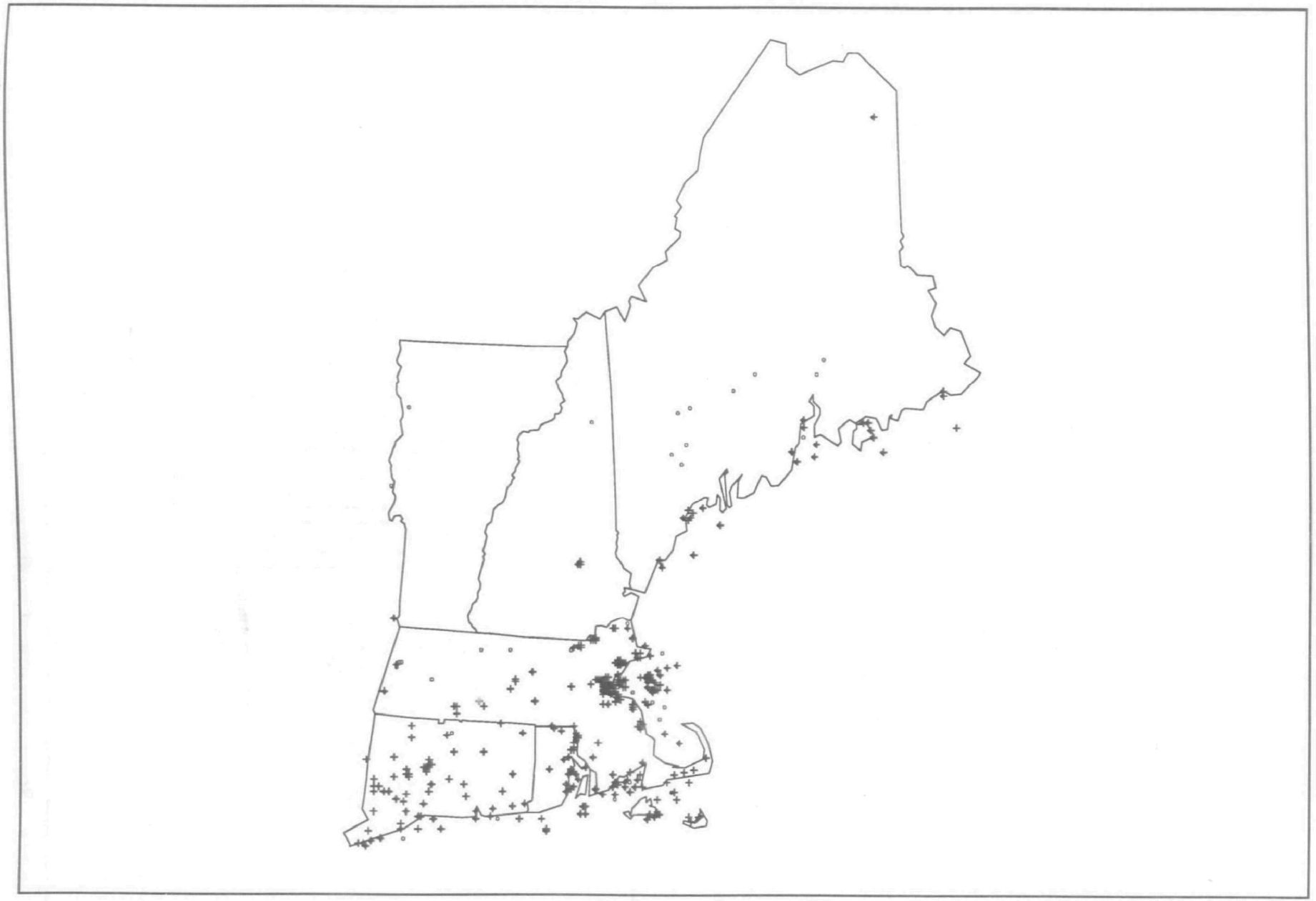


Figure 3-10. Region 1: Stations Categorized as Tier 1 or Tier 2 Due to Potential Aquatic Life Effects (+) and Potential Human Health Effects (o).

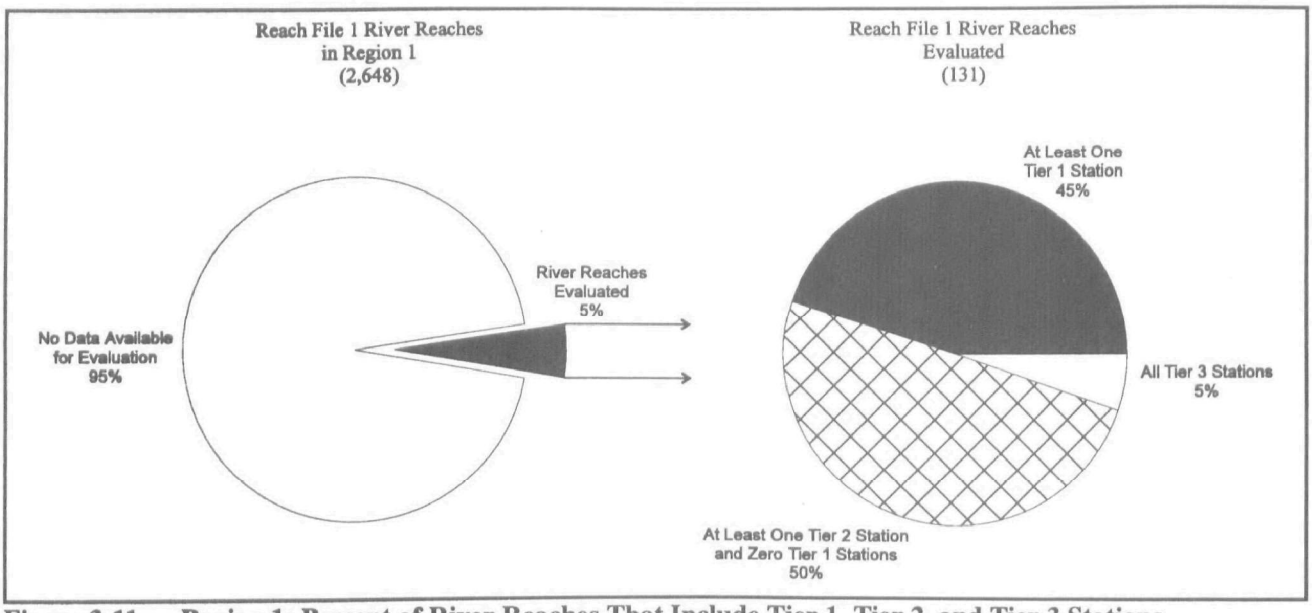


Figure 3-11. Region 1: Percent of River Reaches That Include Tier 1, Tier 2, and Tier 3 Stations.

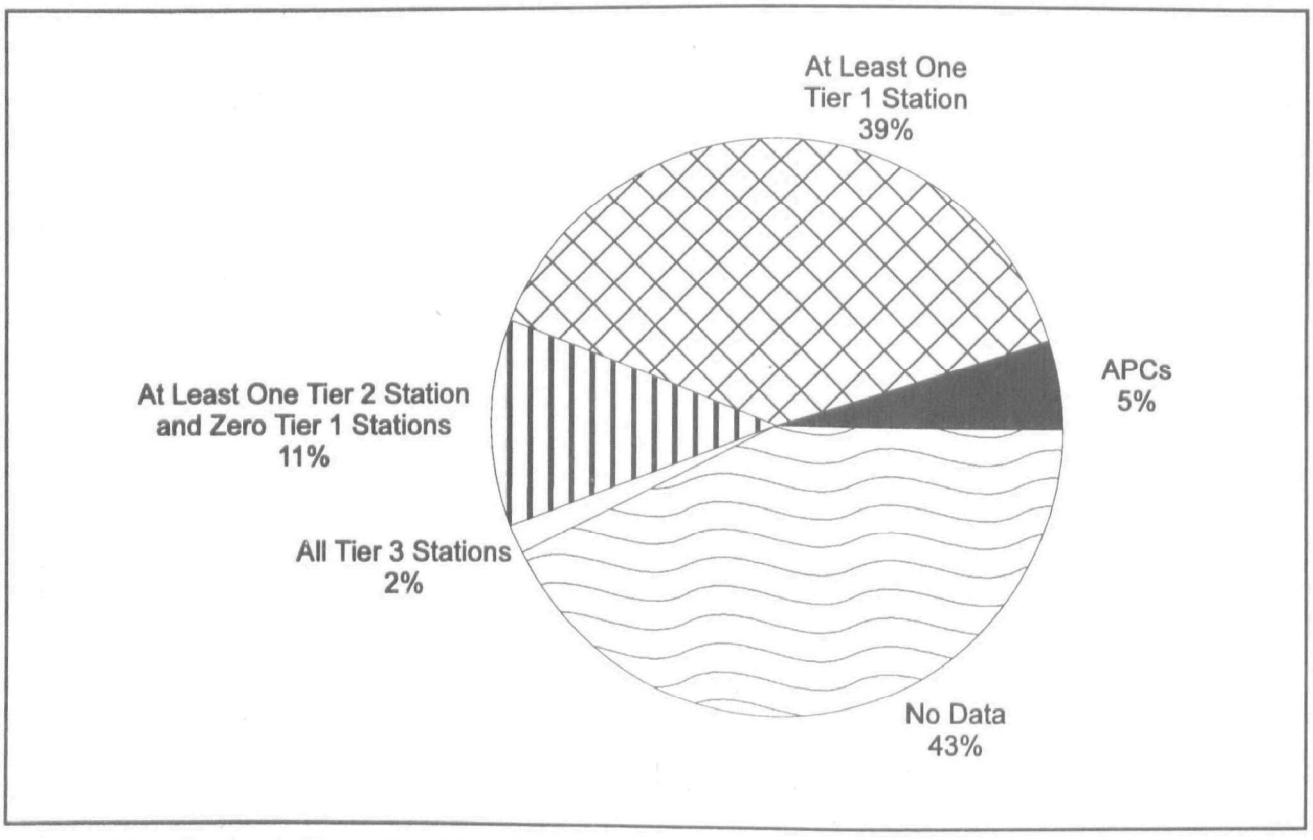


Figure 3-12. Region 1: Watershed Classifications.

Figure 3-13. Region 1: Location of Sampling Stations Categorized as Tier 1 or Tier 2 and Watersheds Identified as Areas of Potential Widespread Sediment Contamaination (APCs).

Table 3-7. Region 1: Watersheds Identified as Areas of Potential Widespread Sediment Contamination

Cataloging Unit Number	Name	State(s)[a]	Number of Stations			Percent of Stations in Tier 1 or Tier 2
			Tier 1	Tier 2	Tier 3	
01090001	Charles	MA	195	402	111	84
01090004	Narragansett	MA, RI	28	20	0	100
01090002	Cape Cod	MA, (RI)	15	73	20	81

[a] No data were available for states listed in parenthesis.

Table 3-8. Region 1: Water Bodies With Sampling Stations Categorized as Tier 1 That Are Located in Areas of Potential Widespread Sediment Contamination

Water Body	# of Tier 1 Stations	Water Body	# of Tier 1 Stations
Boston Bay	141	Bass River	3
Atlantic Ocean	46	Potowomut River	3
Seekonk River	16	Conanicut Island	2
Boston Harbor and Mystic River Area	9	Pawtuxet River	2
Buzzards Bay	5	Acushnet River	1
Martha's Vineyard	4	Charles River	1
Narragansett Bay	4	Taunton River	1

Table 3-9. Region 1: Chemicals Most Often Responsible for Stations Being Categorized as Tier 1 or Tier 2[a]

	Chemical	# Tier 1 & Tier 2 Stations	# Tier 1 Stations	# Tier 2 Stations
Region 1 Overall	Copper	625	--	625
	Lead	623	--	623
	Chromium	497	59	438
	Nickel	491	--	491
	Mercury	488	176	312
	Arsenic	387	14	373
	Zinc	376	--	376
	Cadmium	339	--	339
	Polychlorinated biphenyls	231	74	157
	Benzo(a)pyrene	179	5	174
	DDT	133	17	116
	Dibenzo(a,h)anthracene	132	13	119
	Benzo(a)anthracene	128	8	120
	Pyrene	122	7	115
	Chrysene	120	2	118
Connecticut	Copper	71	--	71
	Nickel	55	--	55
	Lead	49	--	49
	Cadmium	45	--	45
	Zinc	40	--	40
	Mercury	39	11	28
	Chromium	32	--	32
	Benzo(a)pyrene	28	1	27
	Chrysene	24	--	24
	Polychlorinated biphenyls	23	4	19
Maine	Arsenic	31	--	31
	Polychlorinated biphenyls	30	7	23
	Chromium	30	2	28
	Nickel	29	--	29
	Benzo(a)pyrene	25	--	25
	Lead	23	--	23
	DDT	16	--	16
	Copper	15	--	15
	Mercury	13	--	13
	Dibenzo(a,h)anthracene	12	1	11
Massachusetts	Lead	513	--	513
	Copper	504	--	504
	Mercury	416	162	254
Massachusetts (continued)	Chromium	411	53	358
	Nickel	377	--	377
	Arsenic	317	14	303
	Zinc	314	--	314
	Cadmium	278	--	278
	Polychlorinated biphenyls	149	54	95
	Benzo(a)pyrene	98	2	96
New Hampshire	DDT	4	3	1
	Anthracene	3	2	1
	Benzo(a)anthracene	3	2	1
	Benzo(a)pyrene	3	2	1
	Phenanthrene	3	2	1
	Acenaphthylene	3	--	3
	Benzo(b)fluoranthene	3	--	3
	Fluoranthene	3	--	3
	Chrysene	2	1	1
	Acenaphthene	2	--	2
Rhode Island	Lead	35	--	35
	Copper	32	--	32
	Nickel	28	--	28
	Polychlorinated biphenyls	25	5	20
	Benzo(a)pyrene	25	--	25
	Chromium	23	3	20
	DDT	23	3	20
	Arsenic	22	--	22
	Benzo(a)anthracene	21	--	21
	Dibenzo(a,h)anthracene	20	2	18
Vermont	Polychlorinated biphenyls	3	3	--
	Dioxins	1	1	--
	Aldrin	1	--	1
	Arsenic	1	--	1
	Cadmium	1	--	1
	Copper	1	--	1
	Dieldrin	1	--	1
	Lead	1	--	1
	Mercury	1	--	1
	Nickel	1	--	1

[a]Stations may be listed for more than one chemical.

EPA Region 2

EPA evaluated 1,096 sampling stations in Region 2 as part of the NSI evaluation. This evaluation resulted in 355 stations (32 percent) in Region 2 being categorized as Tier 1, 559 (51 percent) as Tier 2, and 182 (17 percent) as Tier 3 (Table 3-10). Figure 3-14 identifies the stations in Region 2 that were categorized as Tier 1 or Tier 2 due to potential aquatic life effects and those categorized as Tier 1 or Tier 2 due to potential human health effects.

The NSI sampling stations in Region 2 were located in 292 separate river reaches, or 17 percent of all reaches in the Region (Table 3-10). Of all river reaches evaluated in Region 2, 40 percent included at least one Tier 1 station, 50 percent included at least one Tier 2 station but no Tier 1 stations, and 10 percent had only Tier 3 stations (Figure 3-15).

Out of a total of 63 watersheds located in Region 2, 12 (19 percent) were identified as APCs (Figure 3-16). In addition, 41 percent of all watersheds in the Region had at least one Tier 1 station but were not categorized as APCs, 30 percent had at least one Tier 2 station but no Tier 1 stations, and none of the watersheds evaluated had only Tier 3 stations. Less than 10 percent percent of the watersheds in Region 2 could not be evaluated because of a lack of data. The locations of the APCs and the Tier 1 and Tier 2 stations in Region 2 are illustrated in Figure 3-17.

Within the 12 watersheds in Region 2 identified as APCs (Table 3-11), 52 water bodies have at least 1 sampling station that has been categorized as Tier 1; 9 water bodies have 10 or more sampling stations categorized as Tier 1 (Table 3-12). Several areas in Region 2 appear to have potential significant, widespread sediment contamination problems. They include the Niagara River, Buffalo Creek, and Lake Erie near Buffalo, New York; Lake Ontario between Rochester, New York, and the Niagara River; the St. Lawrence River in the northern part of New York; Arthur Kill in New York and New Jersey; the Hackensack/Passaic watershed in New York and New Jersey; the Atlantic Ocean beyond Staten Island; and others. The waterbodies listed on Table 3-12 are not inclusive of all locations containing a Tier 1 or Tier 2 station because only waterbodies within APC watersheds are listed. These summary results are also not inclusive of locations with contaminated sediment not identified in this survey. The data compiled for the NSI are primarily from large national electronic databases. Data from many sampling and testing studies have not yet been incorporated into the NSI. Thus, there may be additional locations with sediment contamination that do not appear in this summary. On the other hand, data in the inventory were collected between 1980 and 1993 and any single measurement of a chemical at a site, taken any point in time during that period, could result in the categorization of the site in Tier 1 or Tier 2. The evaluation approach is conservative. Therefore sites appearing in Tier 1 or Tier 2 may not cause unacceptable impacts. It is also important to note that management programs may already exist to address identified sediment contamination problems.

The chemicals most often responsible for stations being categorized as Tier 1 or Tier 2 in Region 2 overall and in each state in Region 2 are presented in Table 3-13.

Table 3-10. Region 2: Number of NSI Sampling Stations in Each Probability of Adverse Effects Category and Number of River Reaches Where NSI Sampling Stations Are Located

	Station Evaluation						River Reach Evaluation[a]							
	Tier 1		Tier 2		Tier 3									
State	#	%	#	%	#	%	Number of Stations Not Identified by an RF1 Reach[b]	Reaches w/at Least 1 Station in Tier 1	Reaches w/at Least 1 Station in Tier 2[c]	Reaches w/all Stations in Tier 3	Total # Reaches w/at Least 1 Station Evaluated	Total Reaches in State	% of all Reaches in State w/at Least 1 Station Evaluated	% of Reaches Evaluated w/at Least 1 Tier 1 or Tier 2 Station
New Jersey	142	32	228	51	78	17	62	59	56	14	129	285	45	89
New York	208	34	310	50	100	16	81	58	93	15	166	1,488	11	91
Puerto Rico	5	17	21	70	4	13	30	-	-	-	-	-	-	-
REGION 2[d]	355	32	559	51	182	17	173	116	147	29	292	1,753	17	90

[a]River reaches based on EPA River Reach File 1 (RF1).
[b]Stations not identified by an RF1 reach were located in coastal or open water areas.
[c]No stations in these reaches were included in Tier 1.
[d]Because some reaches occur in more than one state, the total number of reaches in each category for the Region might not equal the sum of reaches in the states.

Figure 3-14. Region 2: Categorized as Tier 1 or Tier 2 Due to Potential Aquatic Life Effcects (+) and Potential Human Health Effects (o).

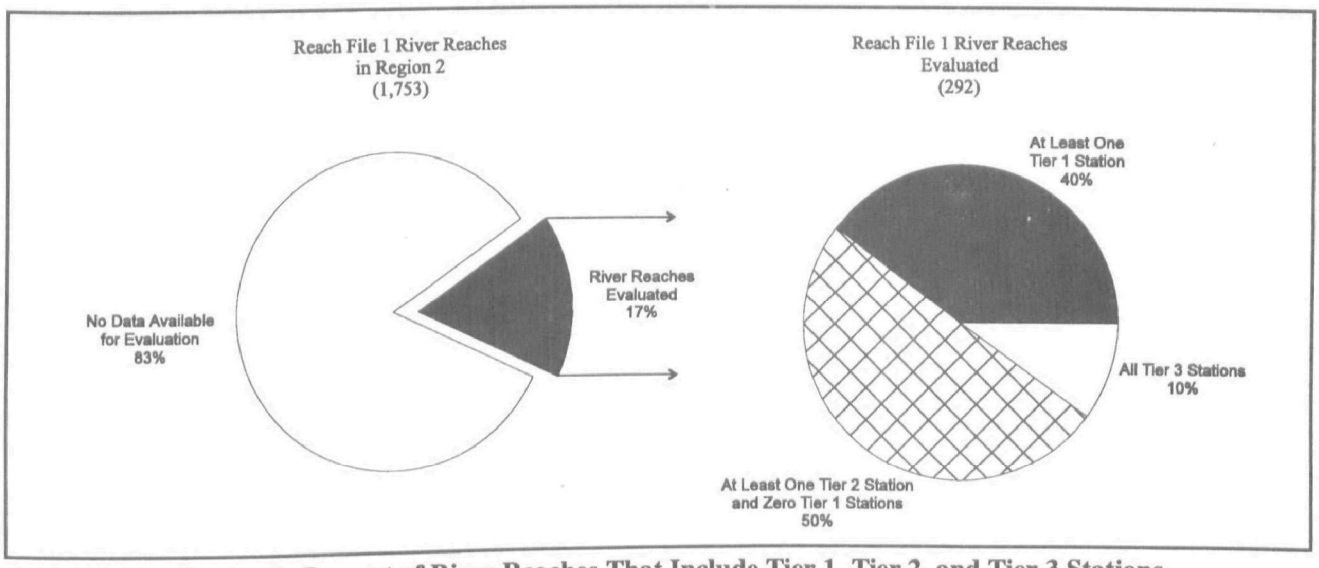


Figure 3-15. Region 2: Percent of River Reaches That Include Tier 1, Tier 2, and Tier 3 Stations.

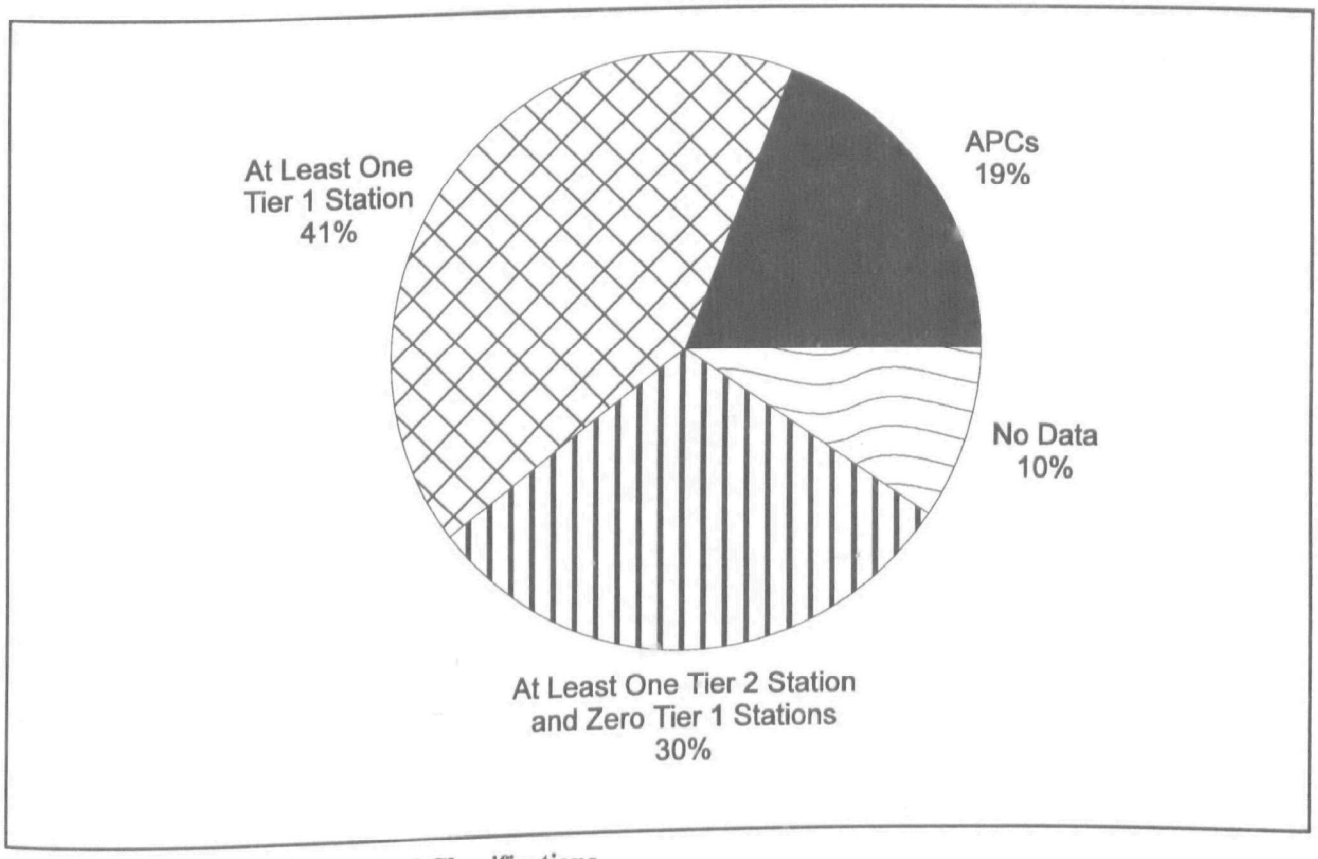


Figure 3-16. Region 2: Watershed Classifications.

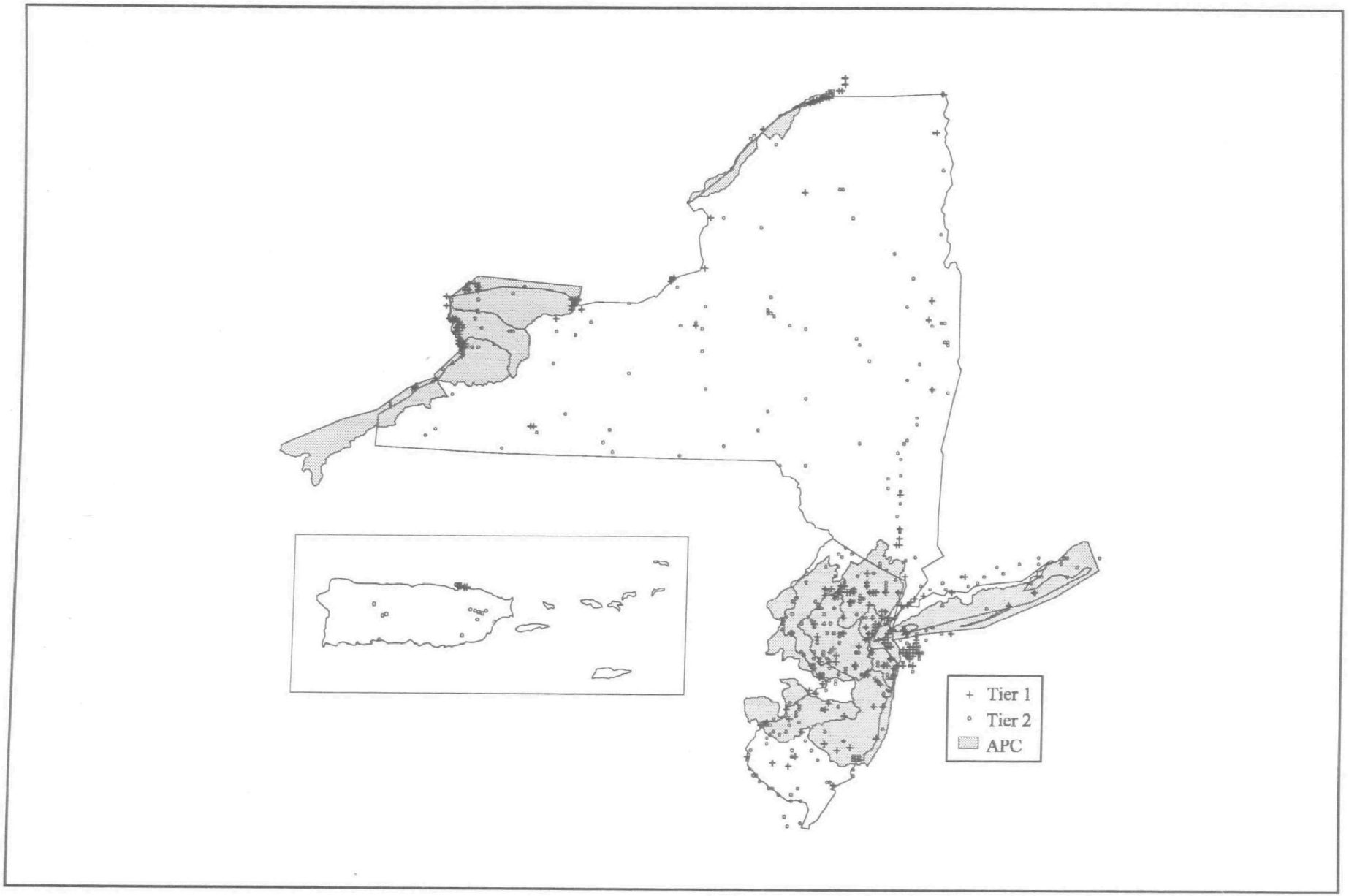


Figure 3-17. Region 2: Location of Sampling Stations Categorized as Tier 1 or Tier 2 and Watersheds Identified as Areas of Potential Widespread Sediment Contamination (APCs).

Table 3-11. Region 2: Watersheds Identified as Areas of Potential Widespread Sediment Contamination

Cataloging Unit Number	Name	State(s)*	Number of Stations			Percent of Stations in Tier 1 or Tier 2
			Tier 1	Tier 2	Tier 3	
02030104	Sandy Hook-Staten Island	NY, NJ	60	21	19	81
04120103	Buffalo-Eighteenmile	NY	59	33	9	91
02030103	Hackensack-Passaic	NY, NJ	43	58	2	98
04130001	Oak Orchard-Twelvemile	NY	39	46	1	99
04120104	Niagara	NY	24	16	1	98
04120101	Chautauqua-Conneaut	NY, PA, OH	21	86	3	97
04150301	Upper St. Lawrence	NY	21	5	5	84
02040202	Lower Delaware	PA, NJ	18	29	10	82
02030105	Raritan	NJ	13	37	15	77
02030202	Southern Long Island	NY	11	24	8	81
02040105	Middle Delaware-Musconetcong	PA, NJ	11	26	11	77
02040301	Mullica-Toms	NJ	10	22	10	76

Table 3-12. Region 2: Water Bodies With Sampling Stations Categorized as Tier 1 That Are Located in Areas of Potential Widespread Sediment Contamination

Water Body	# of Tier 1 Stations	Water Body	# of Tier 1 Stations
Lake Ontario, U.S. Shore	31	Shrewsbury River	2
Buffalo Creek	30	Stony Bk.	2
Rockaway River	26	Bass River	1
Lake Erie, U.S. Shore	24	Beden Brook	1
Atlantic Ocean	22	Big Timber Creek	1
Niagara River	21	Cazenovia Creek	1
St. Lawrence River	21	Cooper River	1
Arthur Kill	10	Cranbury Bk.	1
Staten Island	10	Great South Bay	1
Sandy Hook Bay	8	Green Bk.	1
Delaware River	8	Hammonton Creek	1
Newark Bay	6	Matchaponix Bk.	1
Smoke Creek	6	Millstone River	1
Passaic River	6	Mullica River	1
Hackensack River	5	Rahway River	1
Manasquan River	4	Rancocas Creek, N. Br.	1
Musconetcong River	3	Raritan Bay	1
Tonawanda Creek	3	Raritan River, N. Br.	1
Barnegat Bay	2	Raritan River, S. Br.	1
Eighteenmile Creek	2	SB Rockaway Creek	1
Lower Bay	2	Shinnecock Bay	1
Manalapan Bk.	2	South River	1
Moriches Bay	2	Toms River	1
Pompton Creek	2	Wanaque Reservoir	1
Rancocas Creek, S. Br.	2	Whippany River	1
Saddle River	2	Yellow Brook	1

Table 3-13. Region 2: Chemicals Most Often Responsible for Stations Being Categorized as Tier 1 or Tier 2[a]

	Chemical	# Tier 1 & Tier 2 Stations	# Tier 1 Stations	# Tier 2 Stations
Region 2 Overall	Copper	546	--	546
	Lead	467	--	467
	Nickel	443	--	443
	Polychlorinated biphenyls	442	151	291
	Mercury	388	144	244
	Cadmium	360	--	360
	Zinc	358	--	358
	DDT	351	114	237
	Arsenic	282	6	276
	Chromium	247	26	221
	Chlordane	229	--	229
	Pyrene	214	64	150
	Benzo(a)pyrene	180	36	144
	Naphthalene	155	30	125
	Fluoranthene	151	41	110
New Jersey	DDT	195	48	147
	Copper	192	--	192
	Lead	191	--	191
	Polychlorinated biphenyls	181	43	138
	Mercury	158	70	88
	Arsenic	151	6	145
	Zinc	143	--	143
	Chlordane	139	--	139
New Jersey (continued)	Cadmium	128	--	128
	Chromium	119	22	97
New York	Copper	332	--	332
	Nickel	321	--	321
	Lead	268	--	268
	Polychlorinated biphenyls	261	108	153
	Cadmium	230	--	230
	Mercury	224	70	154
	Zinc	210	--	210
	DDT	155	66	89
	Pyrene	147	52	95
	Chromium	126	4	122
Puerto Rico	Copper	22	--	22
	Nickel	10	--	10
	Arsenic	9	--	9
	Lead	8	--	8
	Mercury	6	4	2
	Zinc	5	--	5
	Silver	4	1	3
	Bis(2-ethylhexyl)phthalate	2	1	1
	Diethyl phthalate	2	1	1
	Cadmium	2	--	2

[a]Stations may be listed for more than one chemical.

EPA Region 3

EPA evaluated 1,910 sampling stations in Region 3 as part of the NSI evaluation. This evaluation resulted in 318 stations (17 percent) in Region 3 being categorized as Tier 1, 934 (49 percent) as Tier 2, and 658 (34 percent) as Tier 3 (Table 3-14). Figure 3-18 identifies the stations in Region 3 that were categorized as Tier 1 or Tier 2 due to potential aquatic life effects and those categorized as Tier 1 or Tier 2 due to potential human health effects.

The NSI sampling stations in Region 3 were located in 888 separate river reaches, or 27 percent of all reaches in the Region (Table 3-14). Of all river reaches evaluated in Region 3, 24 percent included at least one Tier 1 station, 51 percent included at least one Tier 2 station but no Tier 1 stations, and 25 percent had only Tier 3 stations (Figure 3-19).

Out of a total of 128 watersheds located in Region 3, 8 (6 percent) were identified as APCs (Figure 3-20). In addition, 63 percent of all watersheds in the Region had at least one Tier 1 station but were not categorized as APCs, 22 percent had at least one Tier 2 station but no Tier 1 stations, and 5 percent had only Tier 3 stations. Four percent of the watersheds in Region 3 could not be evaluated because of a lack of data. The locations of the APCs and the Tier 1 and Tier 2 stations in Region 3 are illustrated in Figure 3-21.

Within the 8 watersheds in Region 3 identified as APCs (Table 3-15), 27 water bodies have at least 1 sampling station that has been categorized as Tier 1; 4 water bodies have 10 or more sampling stations categorized as Tier 1 (Table 3-16). The Delaware River; the Schuykill River in Pennsylvania (near Philadelphia); coastal areas of Lake Erie near Erie, Pennsylvania; and the Ohio River near Pittsburgh appear to have some of the most significant potential widespread sediment contamination problems in Region 3. The waterbodies listed on Table 3-16 are not inclusive of all locations containing a Tier 1 or Tier 2 station because only waterbodies within APC watersheds are listed. These summary results are also not inclusive of locations with contaminated sediment not identified in this survey. The data compiled for the NSI are primarily from large national electronic databases. Data from many sampling and testing studies have not yet been incorporated into the NSI. Thus, there may be additional locations with sediment contamination that do not appear in this summary. On the other hand, data in the inventory were collected between 1980 and 1993 and any single measurement of a chemical at a site, taken any point in time during that period, could result in the categorization of the site in Tier 1 or Tier 2. The evaluation approach is conservative. Therefore sites appearing in Tier 1 or Tier 2 may not cause unacceptable impacts. It is also important to note that management programs may already exist to address identified sediment contamination problems.

The chemicals most often responsible for stations being categorized as Tier 1 or Tier 2 in Region 3 overall and in each state in Region 3 are presented in Table 3-17.

Table 3-14. Region 3: Number of NSI Sampling Stations in Each Probability of Adverse Effects Category and Number of River Reaches Where NSI Sampling Stations Are Located

	Station Evaluation						River Reach Evaluation[a]							
	Tier 1		Tier 2		Tier 3									
State	#	%	#	%	#	%	Number of Stations Not Identified by an RF1 Reach[b]	Reaches w/at Least 1 Station in Tier 1	Reaches w/at Least 1 Station in Tier 2[c]	Reaches w/all Stations in Tier 3	Total # Reaches w/at Least 1 Station Evaluated	Total Reaches in State	% of all Reaches in State w/at Least 1 Station Evaluated	% of Reaches Evaluated w/at Least 1 Tier 1 or Tier 2 Station
Delaware	21	10	35	16	162	74	13	10	7	22	39	77	51	44
District of Columbia	3	75	1	25	-	-	-	3	-	-	3	11	27	-
Maryland	50	24	68	33	88	43	29	31	36	30	97	400	24	69
Pennsylvania	127	41	106	34	78	25	4	78	27	34	139	677	21	76
Virginia	73	7	691	66	287	27	46	61	362	112	535	1279	42	79
West Virginia	44	37	33	27	43	36	-	30	23	31	84	993	9	63
REGION 3[d]	318	17	934	49	658	34	92	209	453	226	888	3247	27	75

[a]River reaches based on EPA River Reach File 1 (RF1).
[b]Stations not identified by an RF1 reach were located in coastal or open water areas.
[c]No stations in these reaches were included in Tier 1.
[d]Because some reaches occur in more than one state, the total number of reaches in each category for the Region might not equal the sum of reaches in the states.

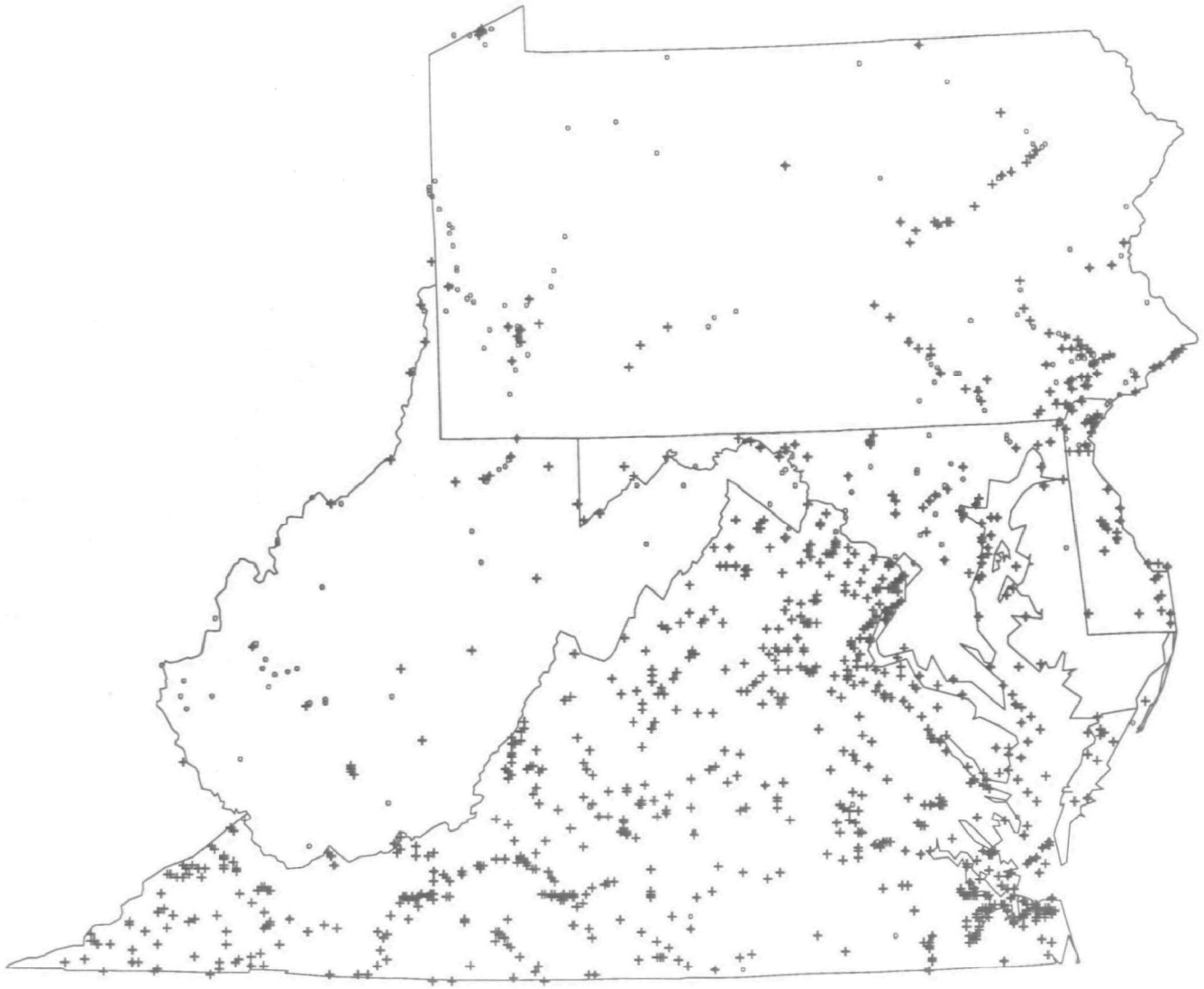


Figure 3-18. Region 3: Stations Categorized as Tier 1 or Tier 2 Due to Potential Aquatic Life Effects (+) and Potential Human Health Effects (o).

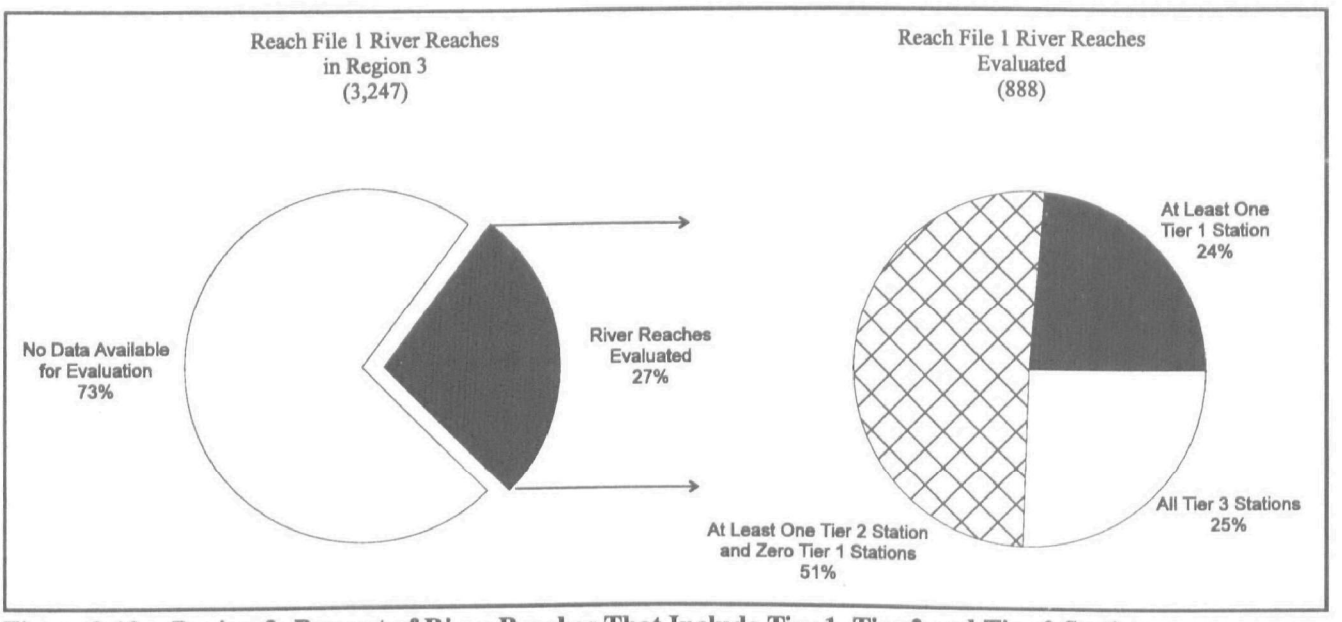


Figure 3-19. Region 3: Percent of River Reaches That Include Tier 1, Tier 2 and Tier 3 Stations.

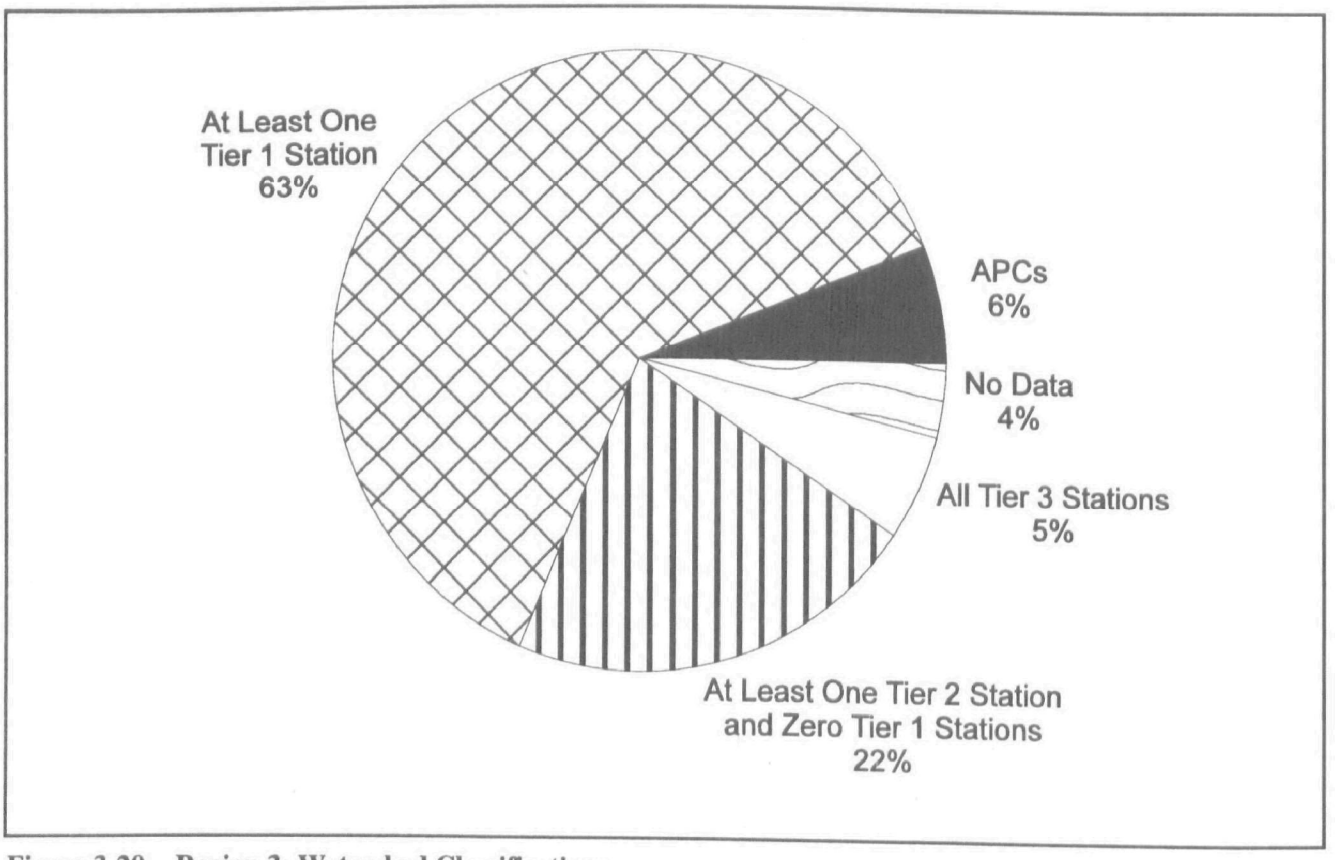


Figure 3-20. Region 3: Watershed Classifications.

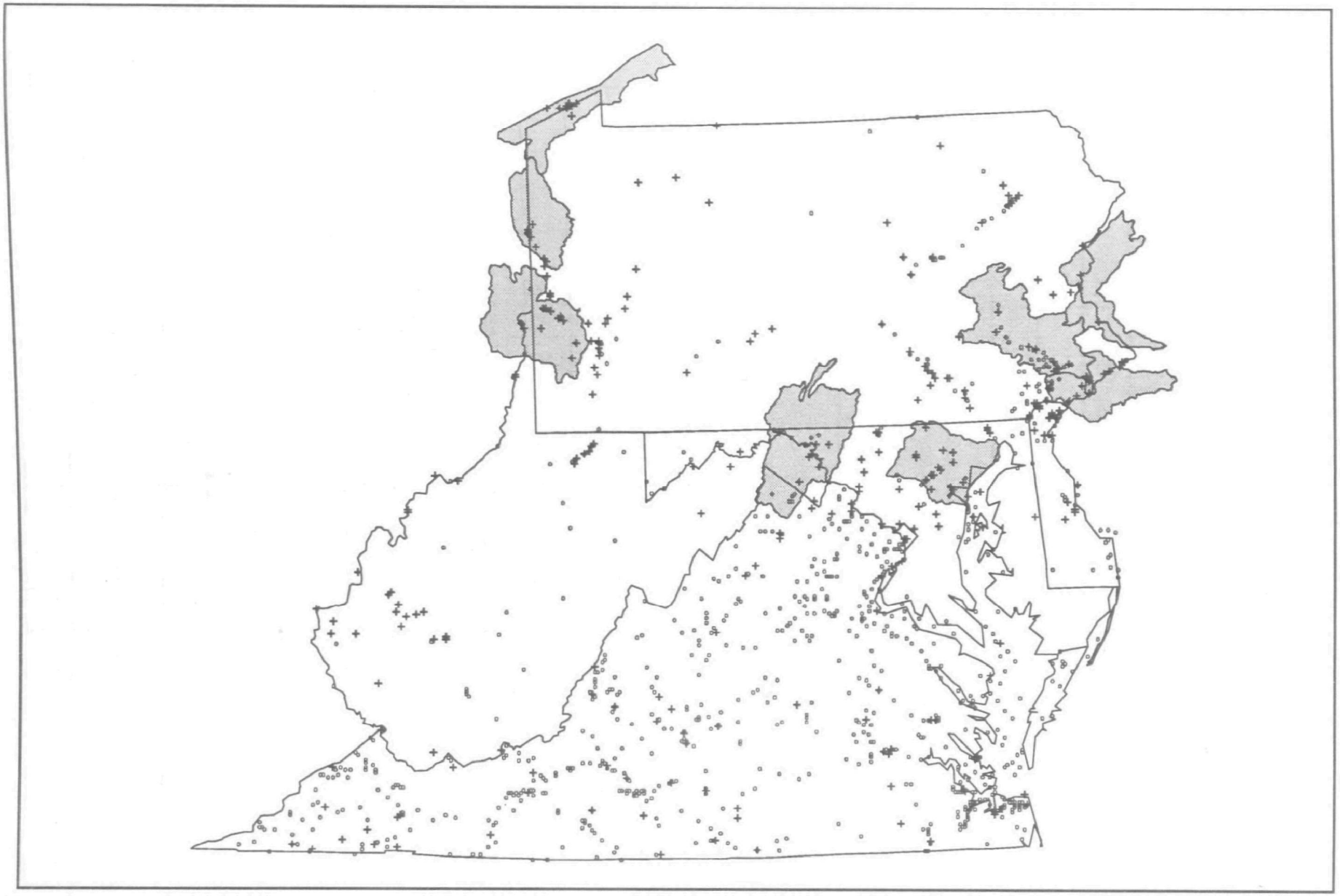


Figure 3-21. Region 3: Location of Sampling Stations Categorized as Tier 1 of Tier 2 and Watersheds Identified as Areas of Potential Widespread Sediment Contamination (APCs).

Table 3-15. Region 3: Watersheds Identified as Areas of Potential Widespread Sediment Contamination

Cataloging Unit Number	Name	State(s)[a]	Number of Stations			Percent of Stations in Tier 1 or Tier 2
			Tier 1	Tier 2	Tier 3	
04120101	Chautauqua-Conneaut	NY,PA,OH	21	86	3	97
02040202	Lower Delaware	PA,NJ	18	29	10	82
02060003	Gunpowder-Patapsco	MD,(PA)	17	7	5	83
02040203	Schuylkill	PA	12	23	9	80
05030101	Upper Ohio	WV,PA,OH	12	29	12	77
02040105	Middle Delaware-Musconetcong	PA,NJ	11	26	11	77
02070004	Conococheague-Opequon	WV,VA,MD,-(PA)	11	12	6	79
05030102	Shenango	OH,PA	11	1	3	80

[a]No data were available for states listed in parentheses.

Table 3-16. Region 3: Water Bodies With Sampling Stations Categorized as Tier 1 That Are Located in Areas of Potential Widespread Sediment Contamination

Water Body	# of Tier 1 Stations	Water Body	# of Tier 1 Stations
Delaware River	13	Patapsco River	2
Lake Erie, U.S. Shore	10	Patapsco River, N. Br.	2
Schuylkill River	10	Raccoon Creek	2
Shenango River	10	Back River	1
Ohio River	7	Chesapeake Bay	1
Gunpowder Falls	4	Crum Creek	1
Potomac River	4	Darby Creek	1
Opequon Creek	3	Little Chartiers Creek	1
Antietam Creek	2	Little Gunpowder Falls	1
Chartiers Creek	2	Neshannock Creek	1
Conococheague Creek	2	Tulpehocken Creek	1
Curtis Bay	2	Walnut Creek	1
Gwynns Falls	2	Wassahickon Creek	1
Herring Run	2		

Table 3-17. Region 3: Chemicals Most Often Responsible for Stations Being Categorized as Tier 1 or Tier 2[a]

	Chemical	# Tier 1 & Tier 2 Stations	# Tier 1 Stations	# Tier 2 Stations
Region 3 Overall	Nickel	634	--	634
	Copper	626	--	626
	Lead	626	--	626
	Arsenic	529	1	528
	Zinc	371	--	371
	Polychlorinated biphenyls	353	243	110
	Cadmium	346	--	346
	Mercury	320	42	278
	Chromium	249	12	237
	Chlordane	161	--	161
	DDT	135	9	126
	Dieldrin	116	--	116
	Benzo(a)pyrene	106	6	100
	BHC	69	2	67
	Dibenzo(a,h)anthracene	64	4	60
Delaware	Polychlorinated biphenyls	33	14	19
	DDT	27	3	24
	Lead	24	--	24
	Chromium	19	2	17
	Arsenic	18	--	18
	Nickel	15	--	15
	BHC	13	--	13
	Mercury	12	3	9
	Benzo(a)pyrene	12	--	12
	Copper	8	--	8
District of Columbia	Polychlorinated biphenyls	4	2	2
	Dioxins	2	2	--
	Benzo(a)pyrene	2	--	2
	Chlordane	2	--	2
	Copper	2	--	2
	Dieldrin	2	--	2
	Nickel	2	--	2
	Silver	1	1	--
	Arsenic	1	--	1
	Benzo(a)anthracene	1	--	1
Maryland	Polychlorinated biphenyls	71	44	27
	Arsenic	70	--	70
	Lead	68	--	68
Maryland (continued)	Nickel	50	--	50
	Copper	42	--	42
	Chromium	41	4	37
	DDT	35	--	35
	Chlordane	33	--	33
	Zinc	32	--	32
	Benzo(a)pyrene	31	--	31
Pennsylvania	Polychlorinated biphenyls	141	112	29
	Lead	87	--	87
	Chlordane	81	--	81
	Nickel	63	--	63
	Cadmium	56	--	56
	Dieldrin	55	--	55
	Copper	46	--	46
	Zinc	44	--	44
	DDT	38	6	32
	Mercury	25	3	22
Virginia	Copper	520	--	520
	Nickel	497	--	497
	Arsenic	412	--	412
	Lead	411	--	411
	Zinc	279	--	279
	Mercury	260	34	226
	Cadmium	255	--	255
	Chromium	167	3	164
	Polychlorinated biphenyls	62	30	32
	Benzo(a)pyrene	48	4	44
West Virginia	Polychlorinated biphenyls	42	41	--
	Lead	35	--	35
	Chlordane	29	--	29
	Dieldrin	16	--	16
	Cadmium	12	--	12
	Copper	8	--	8
	Zinc	8	--	8
	Heptachlor epoxide	7	--	7
	Nickel	7	--	7
	Aldrin	6	--	6

[a]Stations may be listed for more than one chemical.

EPA Region 4

EPA evaluated 4,959 sampling stations in Region 4 as part of the NSI evaluation. This evaluation resulted in 1,157 stations (23 percent) in Region 4 being categorized as Tier 1, 1,930 (39 percent) as Tier 2, and 1,872 (38 percent) as Tier 3 (Table 3-18). Figure 3-22 identifies the stations in Region 4 that were categorized as Tier 1 or Tier 2 due to potential aquatic life effects and those categorized as Tier 1 or Tier 2 due to potential human health effects.

The NSI sampling stations in Region 4 were located in 1,770 separate river reaches, or 18 percent of all reaches in the Region (Table 3-18). Of all river reaches evaluated in Region 4, 32 percent included at least one Tier 1 station, 39 percent included at least one Tier 2 station but no Tier 1 stations, and 29 percent had only Tier 3 stations (Figure 3-23).

Out of a total of 308 watersheds located in Region 4, 19 (6 percent) were identified as APCs (Figure 3-24). In addition, 59 percent of all watersheds in the Region had at least one Tier 1 station but were not categorized as APCs, 17 percent had at least one Tier 2 station but no Tier 1 stations, and 8 percent had only Tier 3 stations. Ten percent of the watersheds in Region 1 could not be evaluated because of a lack of data. The locations of the APCs and the Tier 1 and Tier 2 stations in Region 4 are illustrated in Figure 3-25.

Within the 19 watersheds in Region 4 identified as APCs (Table 3-19), 65 water bodies have at least 1 sampling station that has been categorized as Tier 1; 15 water bodies have 10 or more sampling stations categorized as Tier 1 (Table 3-20). Several areas in Region 4 appear to have potential widespread sediment contamination problems. The most significant of these appear to be along the Tennessee River, Lookout Creek in Tennessee and Georgia, Wilson Lake and Mobile Bay in Alabama, the St. Johns River in Florida, and other locations. It is important to emphasize here that Region 4 has significantly more data in the NSI than do most other Regions, which would to some degree account for the relatively large number of Region 4 sampling stations categorized as Tier 1. The waterbodies listed on Table 3-20 are not inclusive of all locations containing a Tier 1 or Tier 2 station because only waterbodies within APC watersheds are listed. These summary results are also not inclusive of locations with contaminated sediment not identified in this survey. The data compiled for the NSI are primarily from large national electronic databases. Data from many sampling and testing studies have not yet been incorporated into the NSI. Thus, there may be additional locations with sediment contamination that do not appear in this summary. On the other hand, data in the inventory were collected between 1980 and 1993 and any single measurement of a chemical at a site, taken any point in time during that period, could result in the categorization of the site in Tier 1 or Tier 2. The evaluation approach is conservative. Therefore sites appearing in Tier 1 or Tier 2 may not cause unacceptable impacts. It is also important to note that management programs may already exist to address identified sediment contamination problems.

The chemicals most often responsible for stations being categorized as Tier 1 or Tier 2 in Region 4 overall and in each state in Region 4 are presented in Table 3-21.

Table 3-18. Region 4: Number of NSI Sampling Stations in Each Probability of Adverse Effects Category and Number of River Reaches Where NSI Sampling Stations Are Located

State	Station Evaluation						River Reach Evaluation[a]							
	Tier 1		Tier 2		Tier 3									
	#	%	#	%	#	%	Number of Stations Not Identified by an RF1 Reach[b]	Reaches w/at Least 1 Station in Tier 1	Reaches w/at Least 1 Station in Tier 2[c]	Reaches w/all Stations in Tier 3	Total # Reaches w/at Least 1 Station Evaluated	Total Reaches in State	% of all Reaches in State w/at Least 1 Station Evaluated	% of Reaches Evaluated w/at Least 1 Tier 1 or Tier 2 Station
Alabama	160	34	178	37	139	29	65	68	57	57	182	1,531	12	69
Florida	211	12	672	38	893	50	190	70	115	126	311	855	36	60
Georgia	115	36	100	32	103	32	3	75	57	54	186	1,658	11	71
Kentucky	69	28	131	52	49	20	-	49	60	26	135	1,247	11	81
Mississippi	54	17	142	45	122	38	61	21	47	35	103	984	11	66
North Carolina	71	12	294	48	247	40	22	50	156	107	313	1,415	22	66
South Carolina	161	29	254	45	148	26	2	105	138	28	271	1,055	26	90
Tennessee	316	49	159	25	171	26	-	132	63	97	292	1,417	21	67
REGION 4[d]	1,157	23	1,930	39	1,872	38	343	566	684	520	1,770	9,749	18	71

[a]River reaches based on EPA River Reach File 1 (RF1).
[b]Stations not identified by an RF1 reach were located in coastal or open water areas.
[c]No stations in these reaches were included in Tier 1.
[d]Because some reaches occur in more than one state, the total number of reaches in each category for the Region might not equal the sum of reaches in the states.

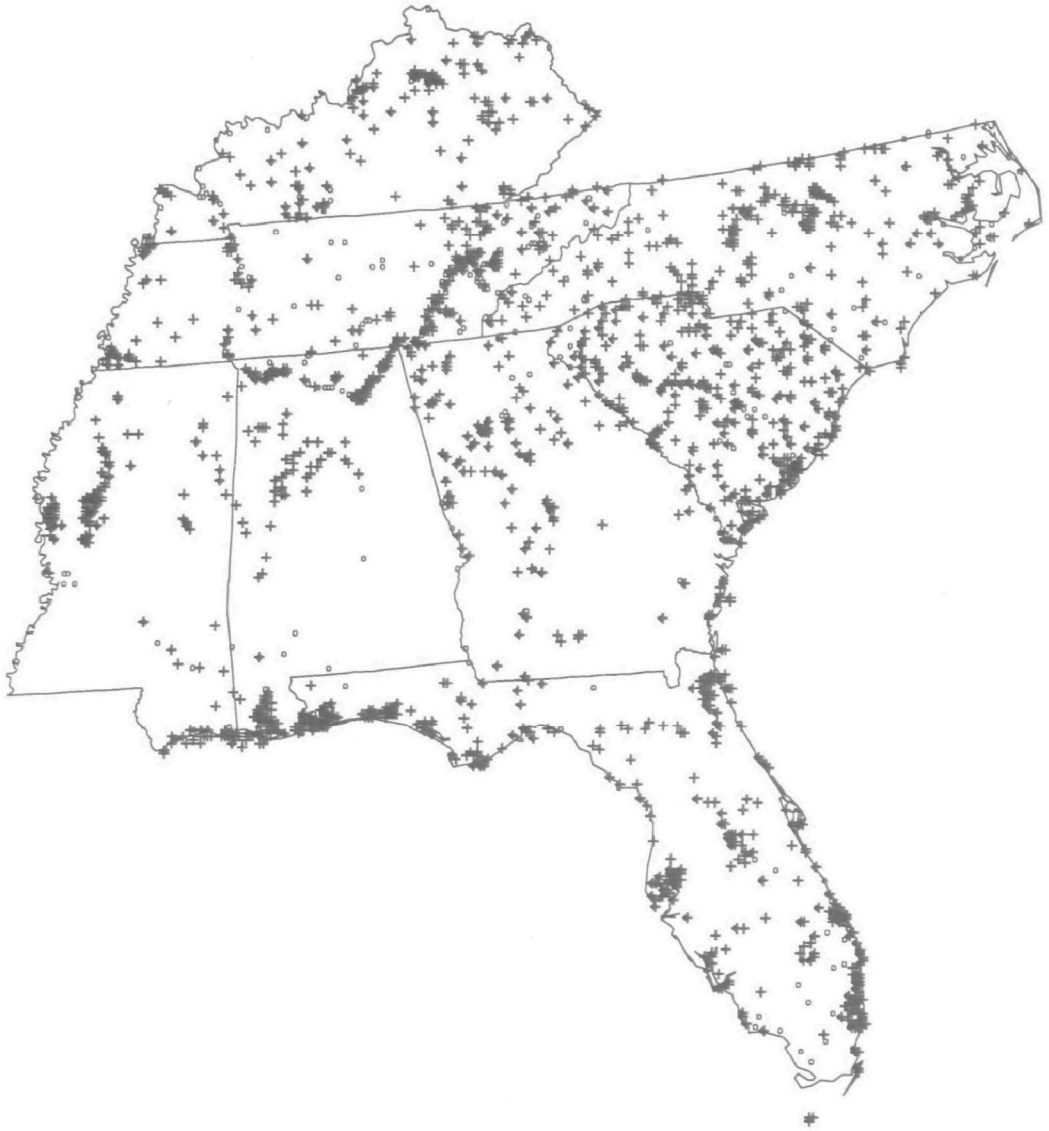


Figure 3-22. Region 4: Stations Categorized as Tier 1 or Tier 2 Due to Potential Aquatic Life Effects (+) and Potential Human Health Effects (o).

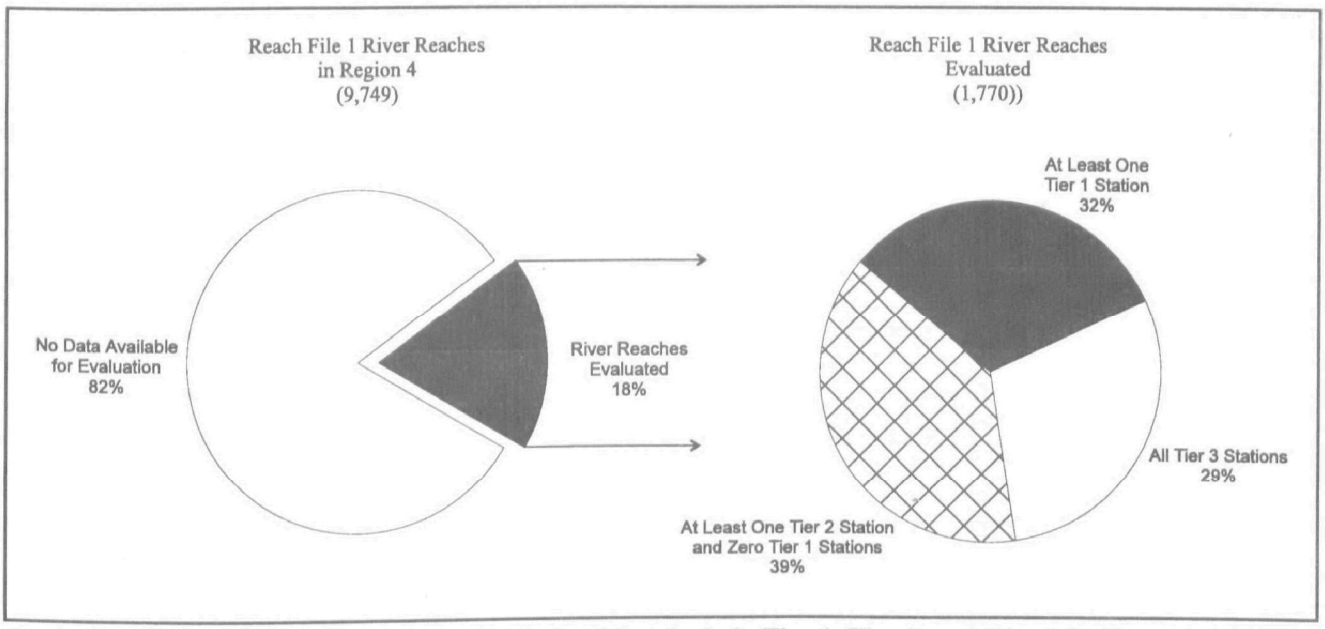


Figure 3-23. Region 4: Percent of River Reaches That Include Tier 1, Tier 2, and Tier 3 Stations.

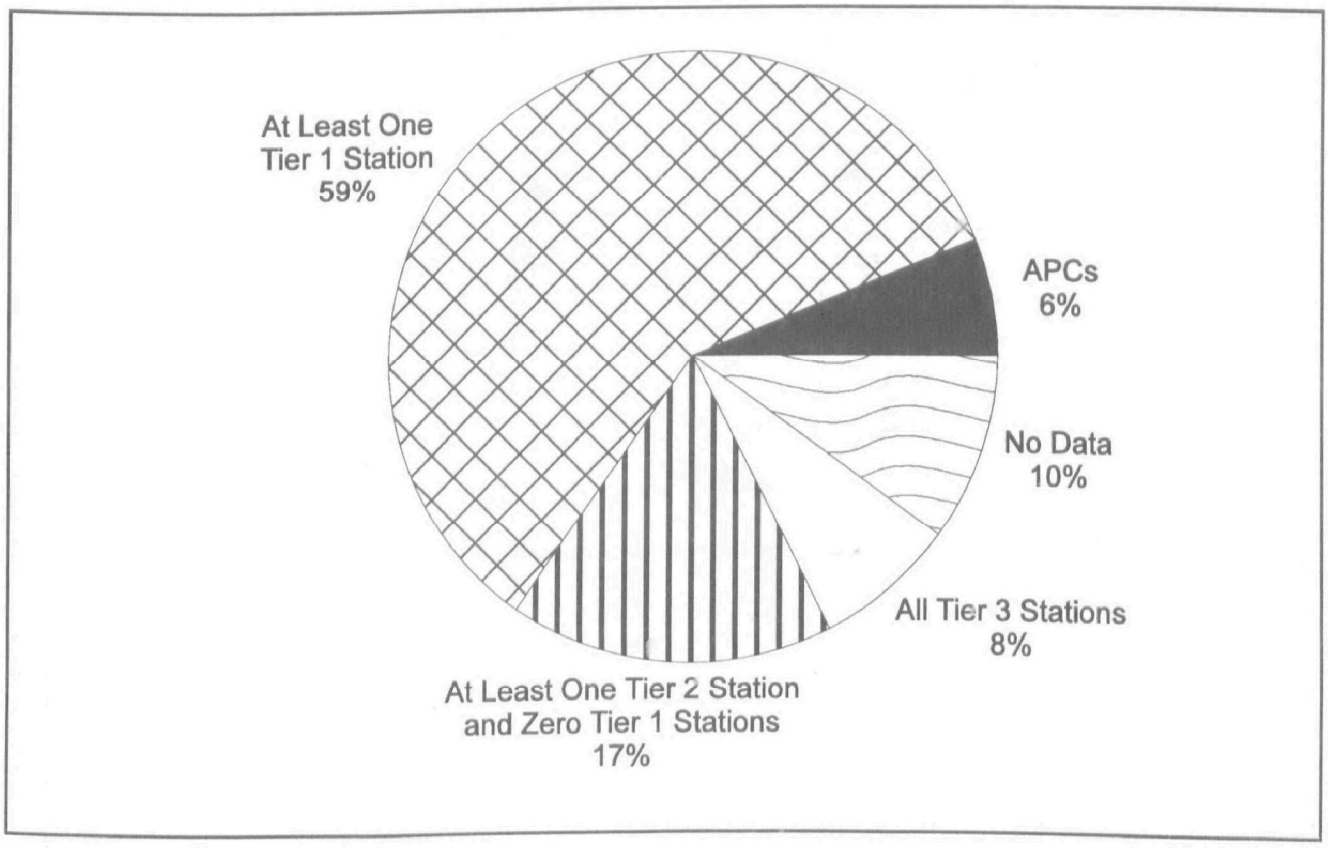


Figure 3-24. Region 4: Watershed Classifications.

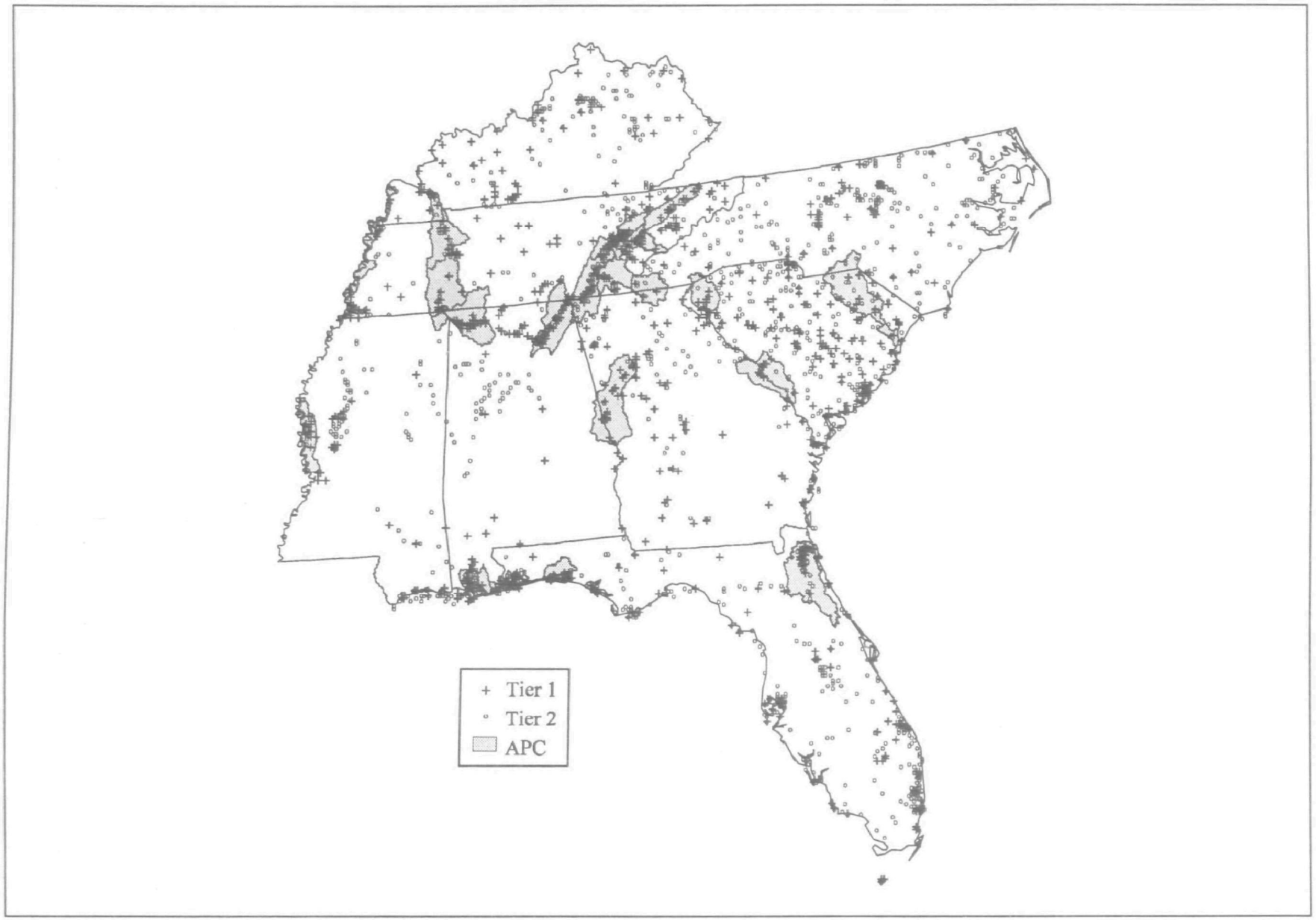


Figure 3-25. Region 4: Location of Sampling Stations Categorized as Tier 1 or Tier 2 and Watersheds Identified as Areas of Potential Widespread Contamination (APCs).

Table 3-19. Region 4: Watersheds Identified as Areas of Potential Widespread Sediment Contamination

Cataloging Unit Number	Name	State(s)[a]	Number of Stations			Percent of Stations in Tier 1 or Tier 2
			Tier 1	Tier 2	Tier 3	
06010201	Watts Bar Lake	TN	63	7	19	79
06010207	Lower Clinch	TN	61	14	4	95
06030005	Pickwick Lake	TN, AL, (MS)	49	9	11	84
06020001	Middle Tennessee- Chickamauga	GA, TN, (AL)	47	29	18	81
03080103	Lower St. Johns	FL	32	111	45	76
03160205	Mobile Bay	AL	31	43	7	91
06030001	Guntersville Lake	TN, AL, (GA)	25	46	21	77
03130002	Middle Chattahoochee-Lake Harding	GA, (AL)	21	4	2	93
03060106	Middle Savannah	GA, SC	20	11	5	86
03140102	Choctawhatchee Bay	FL	19	23	9	82
06040001	Lower Tennessee-Beech	TN, (MS)	15	6	4	84
06040005	Kentucky Lake	KY, TN	15	14	1	97
08010100	Lower Mississippi-Memphis	AR, MS, KY, MO, TN	14	3	3	85
06020002	Hiwassee	GA, NC, TN	13	17	3	91
06010104	Holston	TN	12	2	1	93
03040201	Lower Pee Dee	NC, SC	11	20	3	91
08030209	Deer-Steele	MS, (LA)	11	10	0	100
03060101	Seneca	NC, SC	10	3	3	81
03140107	Perdido Bay	FL, AL	10	24	4	89

[a]No data were available for states listed in parentheses.

Table 3-20. Region 4: Water Bodies With Sampling Stations Categorized as Tier 1 That Are Located in Areas of Potential Widespread Sediment Contamination

Water Body	# of Tier 1 Stations	Water Body	# of Tier 1 Stations
Tennessee River	80	Cypress Creek	2
St. Johns River	30	Deer River	2
Lookout Creek	29	Long Cane Creek	2
Mobile Bay	29	Seneca River	2
Wilson Lake	27	Shoal Creek	2
Poplar Creek	21	Spring Creek	2
Clinch River	18	Twelvemile Creek	2
Choctawhatchee Bay	17	West Pont Lake	2
Guntersville Lake	17	Beech Creek	1
Poplar Creek, Brushy Fork	17	Big Black Creek	1
Little River	16	Big Sandy Creek	1
Chattahoochee River	14	Chatugue Lake	1
Watts Bar Lake	14	Conecross Creek	1
Mississippi River	12	Coon Creek	1
Horse Creek	10	Elevenmile Creek	1
Black Bayou	9	Golden Creek	1
Holston River	9	Hiwassee Lake	1
Kentucky Lake	9	Jeffries Creek	1
Savannah River	9	Lake Harding	1
Hiwassee River	8	Lake Keowee	1
Perdido Bay	7	Lake Washington	1
Melton Hill Lake	5	Lafayette Creek	1
Cherokee Lake	3	Little Horse Creek	1
Fort Loudoun Lake	3	Mountain Creek	1
Gulf Of Mexico	3	Mud Creek	1
Hartwell Reservoir	3	Nottely Lake	1
Lake Chickamauga	3	Oostanaula Creek	1
Pee Dee River	3	Pottsburg Creek	1
Pickwick Lake	3	Rogers Creek	1
Big Nance Creek	2	Sinking Creek	1
Black Creek	2	Steele Bayou	1
Catfish Creek	2	Sweetwater Creek	1
Crooked Creek	2		

Table 3-21. Region 4: Chemicals Most Often Responsible for Stations Being Categorized as Tier 1 or Tier 2[a]

	Chemical	# Tier 1 & Tier 2 Stations	# Tier 1 Stations	# Tier 2 Stations
Region 4 Overall	Polychlorinated biphenyls	1034	669	365
	Lead	989	–	989
	Copper	935	–	935
	Mercury	923	235	688
	Nickel	820	–	820
	DDT	751	157	594
	Cadmium	751	–	751
	Arsenic	734	37	697
	Chromium	459	26	433
	Zinc	438	–	438
	Chlordane	374	7	367
	Benzo(a)pyrene	289	28	261
	Pyrene	279	62	217
	Dieldrin	252	9	243
	Fluoranthene	207	34	173
Alabama	Mercury	125	42	83
	Arsenic	118	4	114
	Polychlorinated biphenyls	114	98	16
	Cadmium	103	–	103
	Nickel	97	–	97
	Copper	94	–	94
	Lead	85	–	85
	DDT	76	8	68
	Zinc	76	–	76
	Chromium	69	1	68
Florida	Mercury	302	52	250
	Polychlorinated biphenyls	293	82	211
	Lead	291	–	291
	Copper	283	–	283
	DDT	242	48	194
	Cadmium	208	–	208
	Benzo(a)pyrene	193	19	174
	Pyrene	176	30	146
	Arsenic	171	7	164
	Chlordane	169	–	169
Georgia	Polychlorinated biphenyls	111	82	29
	Arsenic	62	–	62
	Cadmium	60	–	60
	Copper	60	–	60
	Lead	46	–	46
	Chlordane	45	4	41
	Mercury	43	12	31
	Nickel	38	–	38
	DDT	36	11	25
	Chromium	33	2	31
Kentucky	Nickel	105	–	105
	Lead	76	–	76
	Cadmium	69	–	69
Kentucky (continued)	Arsenic	65	3	62
	Copper	55	–	55
	Polychlorinated biphenyls	50	48	2
	Zinc	43	–	43
	Chlordane	41	3	38
	Dieldrin	40	3	37
	Mercury	35	5	30
Mississippi	DDT	99	31	68
	Nickel	66	–	66
	Arsenic	63	1	62
	Polychlorinated biphenyls	44	15	29
	Cadmium	33	–	33
	Chromium	32	–	32
	Lead	28	–	28
	Dieldrin	24	–	24
	Copper	22	–	22
	Benzo(a)pyrene	13	–	13
North Carolina	Copper	150	–	150
	Mercury	133	30	103
	Lead	128	–	128
	Nickel	99	–	99
	Arsenic	75	–	75
	Chromium	72	2	70
	Cadmium	62	–	62
	Polychlorinated biphenyls	60	28	32
	Zinc	45	–	45
	DDT	27	1	26
South Carolina	Lead	198	–	198
	DDT	188	48	140
	Mercury	144	19	125
	Copper	141	–	141
	Polychlorinated biphenyls	132	93	39
	Nickel	131	–	131
	Cadmium	129	–	129
	Chromium	63	12	51
	Arsenic	62	18	44
	Zinc	58	–	58
Tennessee	Polychlorinated biphenyls	230	223	7
	Nickel	164	–	164
	Lead	137	–	137
	Mercury	134	75	59
	Copper	130	–	130
	Arsenic	118	4	114
	Cadmium	87	–	87
	Zinc	83	–	83
	DDT	57	6	51
	Dieldrin	52	3	49

[a]Stations may be listed for more than one chemical.

EPA Region 5

EPA evaluated 4,290 sampling stations in Region 5 as part of the NSI evaluation. This evaluation resulted in 1,418 stations (33 percent) in Region 5 being categorized as Tier 1, 2,137 (50 percent) as Tier 2, and 735 (17 percent) as Tier 3 (Table 3-22). Figure 3-26 identifies the stations in Region 5 that were categorized as Tier 1 or Tier 2 due to potential aquatic life effects and those categorized as Tier 1 or Tier 2 due to potential human health effects. It should be noted that the NSI includes sampling data from the Great Lakes Sediment Inventory that, because of a lack of latitude and longitude data, were not included in the NSI evaluation. Had those data been included in the NSI evaluation, an additional 221 stations would have been categorized as Tier 1, 392 as Tier 2, and 84 as Tier 3.

The NSI sampling stations in Region 5 were located in 1,432 separate river reaches, or 24 percent of all reaches in the Region (Table 3-22). Of all river reaches evaluated in Region 5, 41 percent included at least one Tier 1 station, 40 percent included at least one Tier 2 station but no Tier 1 stations, and 19 percent had only Tier 3 stations (Figure 3-27).

Out of a total of 278 watersheds located in Region 5, 36 (13 percent) were identified as APCs (Figure 3-28). In addition, 59 percent of all watersheds in the Region had at least one Tier 1 station but were not categorized as APCs, 7 percent had at least one Tier 2 station but no Tier 1 stations, and 3 percent had only Tier 3 stations. Eighteen percent of the watersheds in Region 5 could not be evaluated because of a lack of data. The locations of the APCs and the Tier 1 and Tier 2 stations in Region 5 are illustrated in Figure 3-29.

Within the 36 watersheds in Region 5 identified as APCs (Table 3-23), 102 water bodies have at least 1 sampling station that has been categorized as Tier 1; 18 water bodies have 10 or more sampling stations categorized as Tier 1 (Table 3-24). The Detroit River, Fox River, Milwaukee River, Mississippi River, Chicago Ship Canal, and several coastal areas of Lake Michigan and Lake Erie appear to have the most significant potential widespread sediment contamination problems in Region 5. It is important to emphasize here that, like Region 4, Region 5 has significantly more data in the NSI than do most other Regions, which to some degree explains the relatively large number of Region 5 sampling stations categorized as Tier 1. The waterbodies listed on Table 3-24 are not inclusive of all locations containing a Tier 1 or Tier 2 station because only waterbodies within APC watersheds are listed. These summary results are also not inclusive of locations with contaminated sediment not identified in this survey. The data compiled for the NSI are primarily from large national electronic databases. Data from many sampling and testing studies have not yet been incorporated into the NSI. Thus, there may be additional locations with sediment contamination that do not appear in this summary. On the other hand, data in the inventory were collected between 1980 and 1993 and any single measurement of a chemical at a site, taken any point in time during that period, could result in the categorization of the site in Tier 1 or Tier 2. The evaluation approach is conservative. Therefore sites appearing in Tier 1 or Tier 2 may not cause unacceptable impacts. It is also important to note that management programs may already exist to address identified sediment contamination problems.

The chemicals most often responsible for stations being categorized as Tier 1 or Tier 2 in Region 5 overall and in each state in Region 5 are presented in Table 3-25.

Table 3-22. Region 5: Number of NSI Sampling Stations in Each Probability if Adverse Effects Category and Number of River Reaches Where NSI Sampling Stations Are Located

	Station Evaluation						River Reach Evaluation[a]							
	Tier 1		Tier 2		Tier 3									
State	#	%	#	%	#	%	Number of Stations Not Identified by an RF1 Reach[b]	Reaches w/at Least 1 Station in Tier 1	Reaches w/at Least 1 Station in Tier 2[c]	Reaches w/all Stations in Tier 3	Total # Reaches w/at Least 1 Station Evaluated	Total Reaches in State	% of all Reaches in State w/at Least 1 Station Evaluated	% of Reaches Evaluated w/at Least 1 Tier 1 or Tier 2 Station
Illinois	428	26	1,075	64	166	10	8	182	255	30	467	920	51	94
Indiana	67	62	23	21	18	17	3	35	8	1	44	559	8	98
Michigan	219	54	144	36	39	10	20	64	41	11	116	1,145	10	91
Minnesota	220	50	65	15	153	35	-	140	34	90	264	1,355	20	66
Ohio	130	13	704	73	136	14	71	56	191	57	304	1,054	29	81
Wisconsin	354	50	126	18	223	32	6	130	47	82	259	1,174	22	68
REGION 5[d]	1,418	33	2,137	50	735	17	108	594	570	268	1,432	6,025	24	81

[a]River reaches based on EPA River Reach File 1 (RF1).
[b]Stations not identified by an RF1 reach were located in coastal or open water areas.
[c]No stations in these reaches were included in Tier 1.
[d]Because some reaches occur in more than one state, the total number of reaches in each category for the Region might not equal the sum of reaches in the states.

Figure 3-26. Region 5: Stations Categorized as Tier 1 or Tier 2 Due to Potential Aquatic Life Effects (+) and Potential Human Health Effects (o).

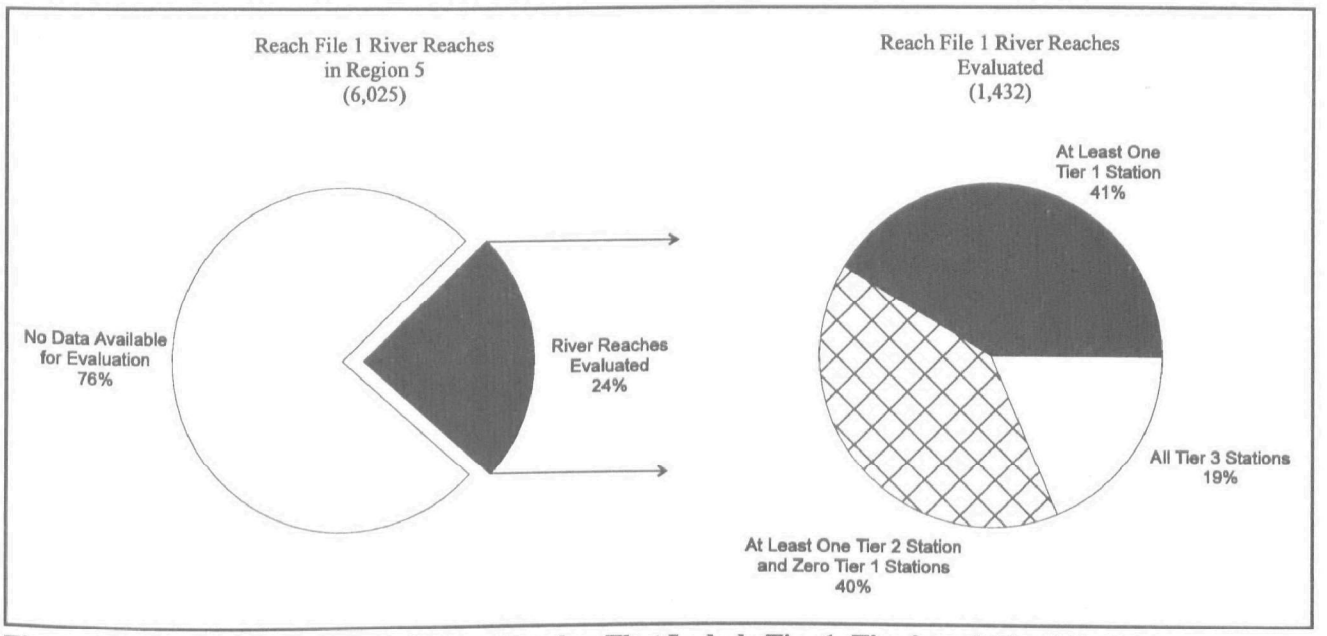


Figure 3-27. Region 5: Percent of River Reaches That Include Tier 1, Tier 2, and Tier 3 Stations.

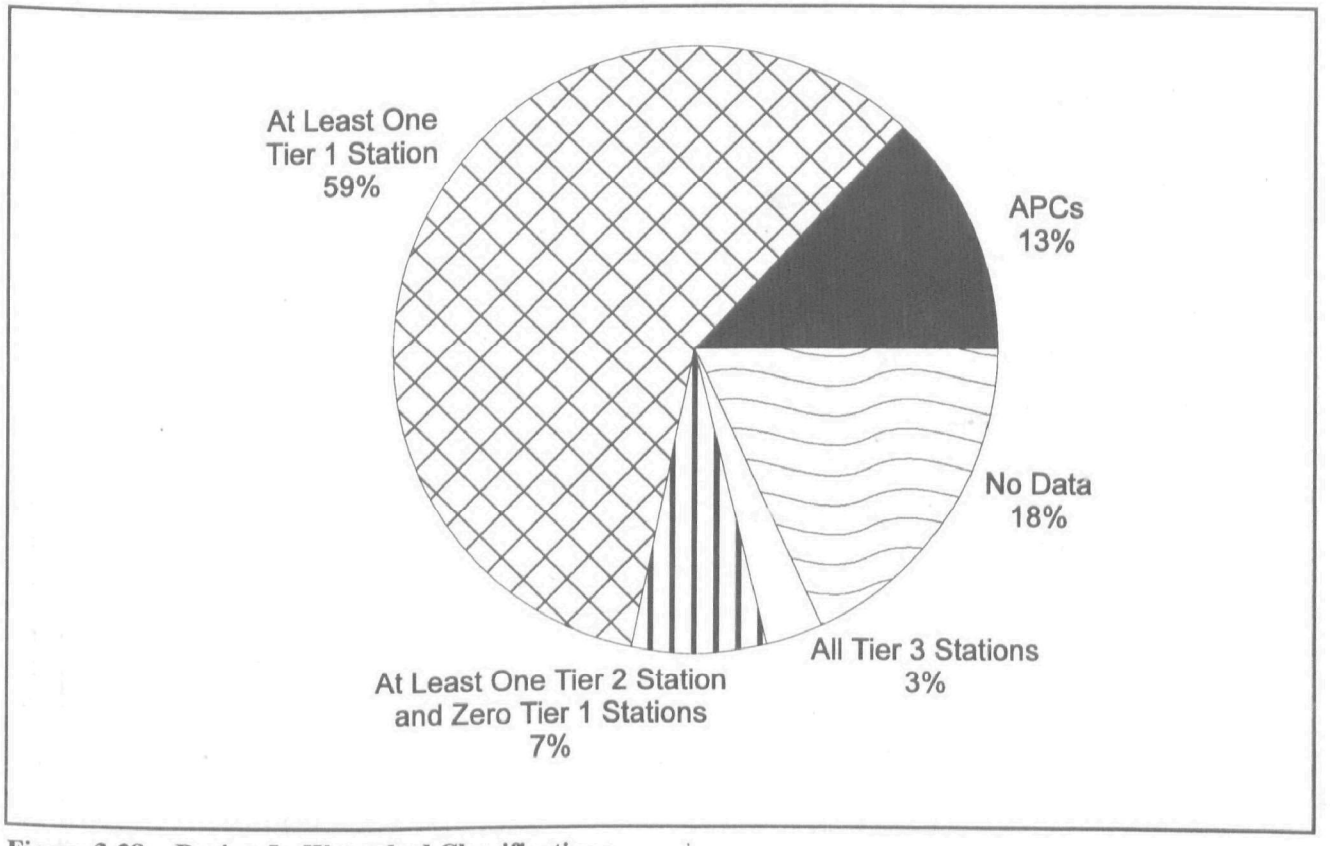


Figure 3-28. Region 5: Watershed Classifications.

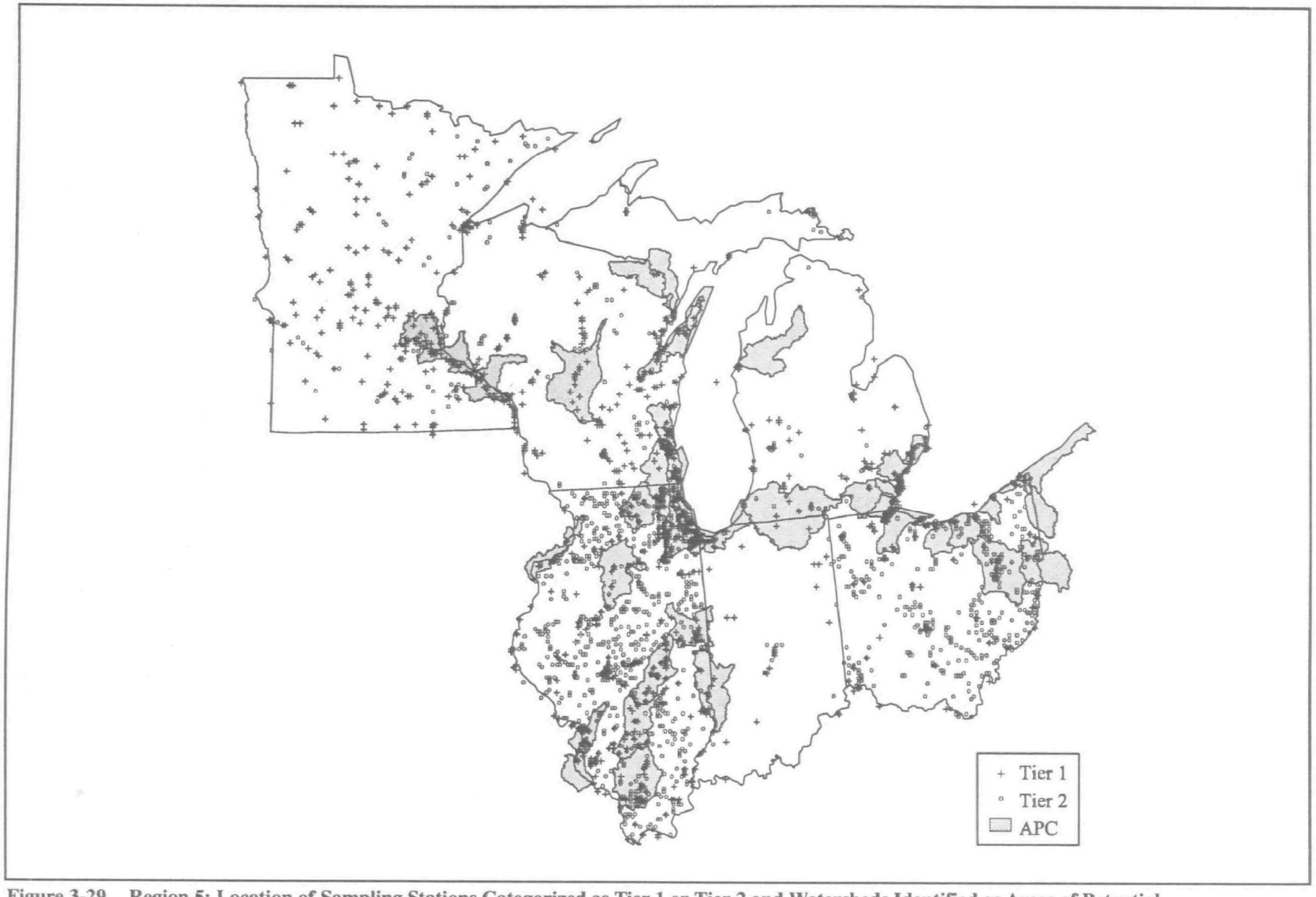


Figure 3-29. Region 5: Location of Sampling Stations Categorized as Tier 1 or Tier 2 and Watersheds Identified as Areas of Potential Widespread Sediment Contamination (APCs).

Table 3-23. Region 5: Watersheds Identified as Areas of Potential Widespread Sediment Contamination

Cataloging Unit Number	Name	State(s)*	Number of Stations			Percent of Stations in Tier 1 or Tier 2
			Tier 1	Tier 2	Tier 3	
04090004	Detroit	MI	85	29	1	99
07120003	Chicago	IN, IL	64	36	3	97
07120004	Des Plaines	WI, IL	61	43	6	95
04040003	Milwaukee	WI	60	16	14	84
04030204	Lower Fox	WI	49	2	0	100
04040001	Little Calumet-Galien	IL, IN, (MI)	45	26	18	80
04040002	Pike-Root	WI, IL	34	30	8	89
07140201	Upper Kaskaskia	IL	31	24	0	100
07010206	Twin Cities	WI, MN	26	2	7	80
04110001	Black-Rocky	OH	24	31	4	93
07140106	Big Muddy	IL	23	65	6	94
04120101	Chautauqua-Conneaut	NY, PA, OH	21	86	3	97
07070003	Castle Rock	WI	20	0	2	91
04100002	Raisin	MI, (OH)	18	19	1	97
07140101	Cahokia-Joachim	MO, IL	18	34	4	93
04050001	St. Joseph	IN, MI	17	9	6	81
07040003	Buffalo-Whitewater	WI, MN	17	3	6	77
07080101	Copperas-Duck	IL, IA	17	5	5	81
05120111	Middle Wabash-Busseron	IN, IL	15	17	1	97
07120006	Upper Fox	WI, IL	15	40	5	92
04090002	Lake St. Clair	MI	13	5	1	95
04100001	Ottawa-Stony	OH, MI	13	15	1	97
04100010	Cedar-Portage	MI, OH	13	39	4	93
07040001	Rush-Vermillion	WI, MN	13	1	0	100
07140202	Middle Kaskaskia	IL	13	22	3	92
04030102	Door-Kewaunee	WI	12	5	3	85
04030108	Menominee	MI, WI	12	6	3	86
05030101	Upper Ohio	WV, PA, OH	12	29	12	77
05120109	Vermilion	IL, (IN)	12	16	0	100
04060103	Manistee	MI	11	3	0	100
05030102	Shenango	OH, PA	11	1	3	80
07130001	Lower Illinois-Senachwine Lake	IL	11	10	0	100
04100012	Huron-Vermilion	OH	10	35	0	100
04110003	Ashtabula-Chagrin	OH	10	18	3	90
05040001	Tuscarawas	OH	10	53	15	81
07090006	Kishwaukee	IL, (WI)	10	24	0	100

*No data were available for states listed in parentheses.

Table 3-24. Region 5: Water Bodies With Sampling Stations Categorized as Tier 1 That Are Located in Areas of Potential Widespread Sediment Contamination

Water Body	# of Tier 1 Stations	Water Body	# of Tier 1 Stations
Detroit River	64	Becks Creek	2
Lake Erie, U.S. Shore	60	Castle Rock Flowage	2
Fox River	58	Coldwater River	2
Mississippi River	56	Crab Orchard Creek	2
Milwaukee River	55	Crooked Creek	2
Lake Michigan	45	Hickory Creek	2
Chicago Sanitary Ship Canal	41	Kaskaskia Creek, E. Fork	2
Des Plains River	27	Kaskaskia River, Lake Fork	2
Kaskaskia River	21	Lake Shelbyville	2
Calumet River	19	Little Creek	2
River Raisin	16	Portage River, E. Br.	2
Indiana Harbor	15	Ramsey Creek	2
Wisconsin River	15	Saline River	2
Wabash River	14	Vermilion River	2
Lake St. Clair	13	Barton Lake	1
Little Calumet River	13	Beaucoup Creek	1
River Rouge	13	Big Bureau Creek	1
Menominee River	12	Big Muddy River, M. Fork	1
Du Page River	9	Buffalo Creek	1
Illinois River	9	Burns Ditch	1
Cahokia Canal	8	Clark Lake	1
Manistee Lake	8	Coon River	1
Big Muddy River, Casey Fork	7	Deep River	1
Black River	7	East River	1
Crab Orchard Lake	7	Eliza Creek	1
Du Page River, E. Br.	7	Garvin Brook	1
Du Page River, W. Br.	7	Gilmore Creek	1
Grosse Isle	7	Grosse Isle	1
Lake Minnetonka	7	Hog Creek	1
St. Joseph River	7	Kaskaskia Creek, N. Fork	1
Tuscarawas River	7	Kilbourn Ditch	1
Lake Calumet	6	Killbuck Creek	1
Ashtabula River	5	Lake Creek	1
Cedar Creek	5	Lemonweir River	1
Fox Lake	5	Little Crooked Creek	1
Kishwaukee River, S. Br.	5	Little Roche A Cri Creek	1
Lake Michigan, Green Bay	5	Mill Creek	1
Chicago Ship Canal	4	Ottawa Creek	1
Root River	4	Petenwell Flowage	1
Salt Creek	4	Pigeon River	1
Vermilion River, Salt Fork	4	Piscasaw River	1
Big Muddy River	3	Rend Lake	1
Chicago River, N. Br.	3	Rocky River	1
Huron River	3	Sturgeon Bay	1
Kishwaukee River	3	Sugar Creek	1
Manistee River	3	Swan Creek	1
Nimishillen Creek	3	Upper Salt Fork Drainage Ditch	1
Ohnathan Creek	3	Vermilion River, M. Fork	1
Paw Paw River	3	W Bureau Creek	1
Vermilion River, N. Fork	3	Wall Town Drainage Ditch	1
W Okaw River	3	Whitewater River	1

Table 3-25. Region 5: Chemicals Most Often Responsible for Stations Being Categorized as Tier 1 or Tier 2[a]

	Chemical	# Tier 1 & Tier 2 Stations	# Tier 1 Stations	# Tier 2 Stations
Region 5 Overall	Copper	1,625	–	1,625
	Polychlorinated biphenyls	1,460	1,113	347
	Lead	1,326	–	1,326
	Dieldrin	1,318	36	1,282
	Nickel	1,260	–	1,260
	Cadmium	1,203	–	1,203
	Arsenic	1,019	32	987
	Zinc	915	–	915
	Mercury	761	197	564
	Chlordane	723	–	723
	DDT	668	177	491
	Chromium	414	81	333
	Heptachlor epoxide	338	–	338
	Pyrene	300	103	197
	Fluoranthene	290	59	231
Illinois	Dieldrin	1019	33	986
	Copper	616	–	616
	Chlordane	518	–	518
	Polychlorinated biphenyls	503	318	185
	Lead	464	–	464
	Cadmium	460	–	460
	Arsenic	380	18	362
	Nickel	342	–	342
	Mercury	330	72	258
	DDT	275	36	239
Indiana	Polychlorinated biphenyls	66	59	7
	Arsenic	53	3	50
	Dieldrin	51	3	48
	Chlordane	48	–	48
	Heptachlor epoxide	42	–	42
	Copper	36	–	36
	Lead	36	–	36
	BHC	33	7	26
	DDT	33	6	27
	Cadmium	29	–	29
Michigan	Polychlorinated biphenyls	250	151	99
	Copper	213	–	213
	Lead	213	–	213
Michigan (continued)	Nickel	198	–	198
	DDT	182	97	85
	Zinc	170	–	170
	Mercury	140	53	87
	Pyrene	140	50	90
	Cadmium	140	–	140
	Fluoranthene	133	20	113
Minnesota	Polychlorinated biphenyls	225	216	9
	Dieldrin	88	–	88
	Cadmium	66	–	66
	DDT	30	–	30
	Copper	24	–	24
	Lead	21	–	21
	Mercury	17	–	17
	Dioxins	10	10	–
	Chromium	9	–	9
	Aldrin	5	–	5
Ohio	Nickel	644	–	644
	Copper	577	–	577
	Lead	472	–	472
	Arsenic	459	2	457
	Cadmium	420	–	420
	Zinc	381	–	381
	Mercury	125	16	109
	Chromium	123	19	104
	Fluoranthene	108	17	91
	Polychlorinated biphenyls	97	65	32
Wisconsin	Polychlorinated biphenyls	319	304	15
	Copper	159	–	159
	Mercury	127	42	85
	Lead	120	–	120
	DDT	100	15	85
	Cadmium	88	–	88
	Dieldrin	76	–	76
	Pyrene	62	21	41
	Zinc	60	–	60
	Nickel	54	–	54

[a]Stations may be listed for more than one chemical.

EPA Region 6

EPA evaluated 1,616 sampling stations in Region 6 as part of the NSI evaluation. This evaluation resulted in 382 stations (24 percent) in Region 6 being categorized as Tier 1, 837 (52 percent) as Tier 2, and 397 (24 percent) as Tier 3 (Table 3-26). Figure 3-30 identifies the stations in Region 6 that were categorized as Tier 1 or Tier 2 due to potential aquatic life effects and those categorized as Tier 1 or Tier 2 due to potential human health effects.

The NSI sampling stations in Region 6 were located in 799 separate river reaches, or 11 percent of all reaches in the Region (Table 3-26). Of all river reaches evaluated in Region 6, 33 percent included at least one Tier 1 station, 43 percent included at least one Tier 2 station but no Tier 1 stations, and 24 percent had only Tier 3 stations (Figure 3-31).

Out of a total of 403 watersheds located in Region 6, 8 (2 percent) were identified as APCs (Figure 3-32). In addition, 36 percent of all watersheds in the Region had at least one Tier 1 station but were not categorized as APCs, 21 percent had at least one Tier 2 station but no Tier 1 stations, and 10 percent had only Tier 3 stations. Thirty-one percent of the watersheds in Region 6 could not be evaluated because of a lack of data. The locations of the APCs and the Tier 1 and Tier 2 stations in Region 6 are illustrated in Figure 3-33.

Within the 8 watersheds in Region 6 identified as APCs (Table 3-27), 17 water bodies have at least 1 sampling station that has been categorized as Tier 1; 4 water bodies have 10 or more sampling stations categorized as Tier 1 (Table 3-28). The Calcasieu River and Mississippi River in Louisiana appear to have some of the most significant, potential widespread sediment contamination problems in Region 6. The waterbodies listed on Table 3-28 are not inclusive of all locations containing a Tier 1 or Tier 2 station because only waterbodies within APC watersheds are listed. These summary results are also not inclusive of locations with contaminated sediment not identified in this survey. The data compiled for the NSI are primarily from large national electronic databases. Data from many sampling and testing studies have not yet been incorporated into the NSI. Thus, there may be additional locations with sediment contamination that do not appear in this summary. On the other hand, data in the inventory were collected between 1980 and 1993 and any single measurement of a chemical at a site, taken any point in time during that period, could result in the categorization of the site in Tier 1 or Tier 2. The evaluation approach is conservative. Therefore sites appearing in Tier 1 or Tier 2 may not cause unacceptable impacts. It is also important to note that management programs may already exist to address identified sediment contamination problems.

The chemicals most often responsible for stations being categorized as Tier 1 or Tier 2 in Region 6 overall and in each state in Region 6 are presented in Table 3-29.

Table 3-26. Region 6: Number of NSI Sampling Stations in Each Probability of Adverse Effects Category and Number of River Reaches Where NSI Sampling Stations Are Located

State	Station Evaluation						River Reach Evaluation[a]							
	Tier 1		Tier 2		Tier 3									
	#	%	#	%	#	%	Number of Stations Not Identified by an RF1 Reach[b]	Reaches w/at Least 1 Station in Tier 1	Reaches w/at Least 1 Station in Tier 2[c]	Reaches w/all Stations in Tier 3	Total # Reaches w/at Least 1 Station Evaluated	Total Reaches in State	% of all Reaches in State w/at Least 1 Station Evaluated	% of Reaches Evaluated w/at Least 1 Tier 1 or Tier 2 Station
Arkansas	18	17	39	36	50	47	-	17	31	40	88	855	10	55
Louisiana	111	24	270	59	79	17	57	45	68	29	142	840	17	80
New Mexico	4	4	40	40	57	56	-	4	28	28	60	919	7	53
Oklahoma	122	43	95	33	69	24	-	97	59	41	197	1,308	15	79
Texas	127	19	393	59	142	22	67	104	160	56	320	3,588	9	83
REGION 6[d]	382	24	837	52	397	24	124	266	341	192	799	7,293	11	76

[a]River reaches based on EPA River Reach File 1 (RF1).
[b]Stations not identified by an RF1 reach were located in coastal or open water areas.
[c]No stations in these reaches were included in Tier 1.
[d]Because some reaches occur in more than one state, the total number of reaches in each category for the Region might not equal the sum of reaches in the states.

Figure 3-30. Region 6: Stations Categorized as Tier 1 or Tier 2 Due to Potential Aquatic Life Effects (+) and Potential Human Health Effects (o).

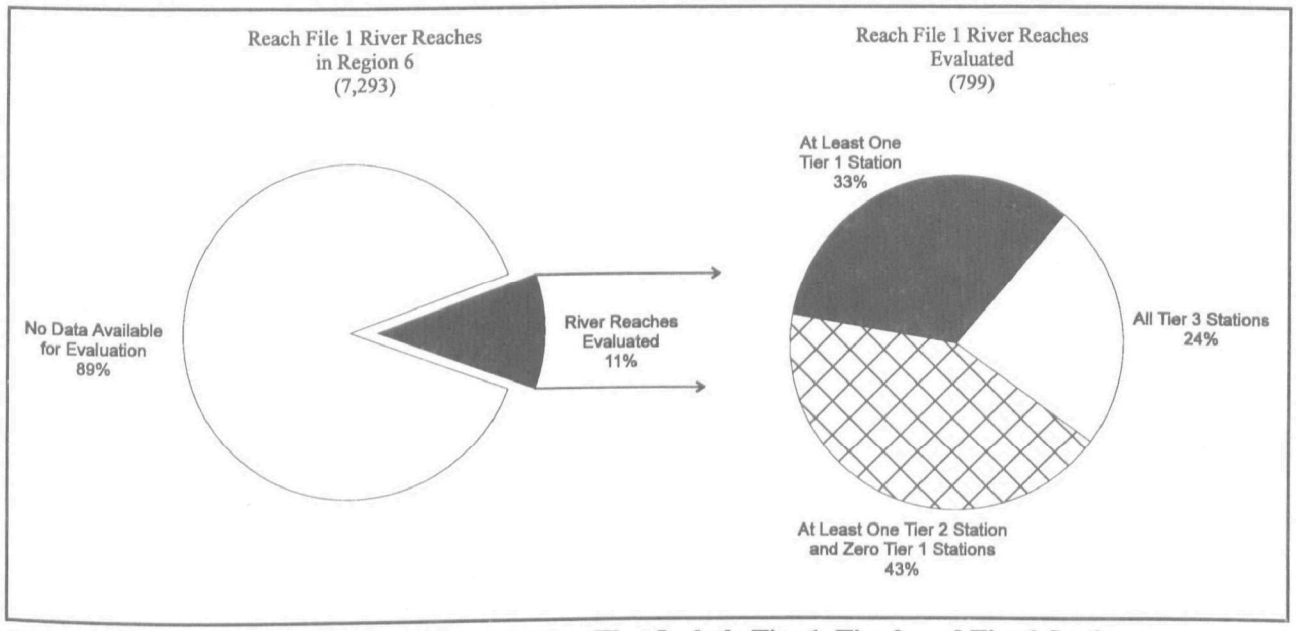


Figure 3-31. Region 6: Percent of River Reaches That Include Tier 1, Tier 2, and Tier 3 Stations.

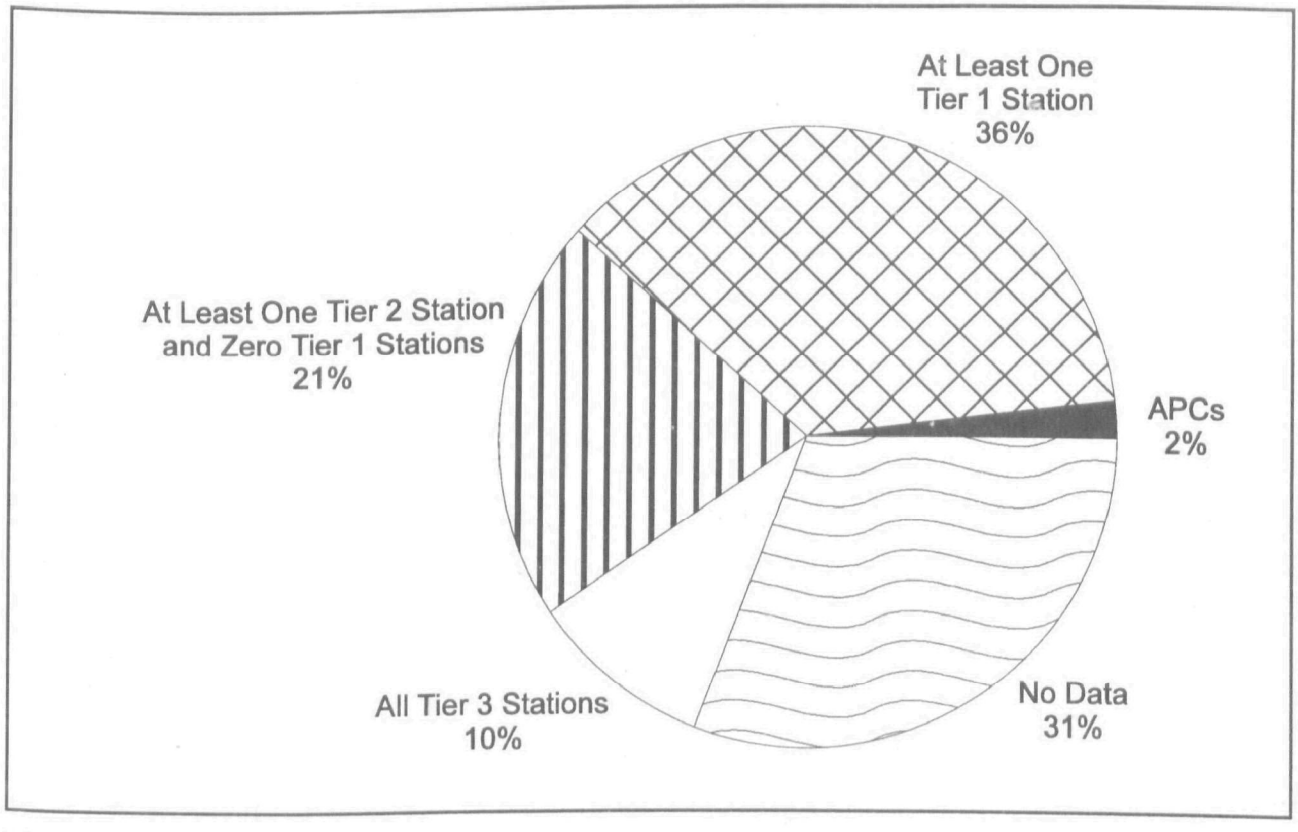


Figure 3-32. Region 6: Watershed Classifications.

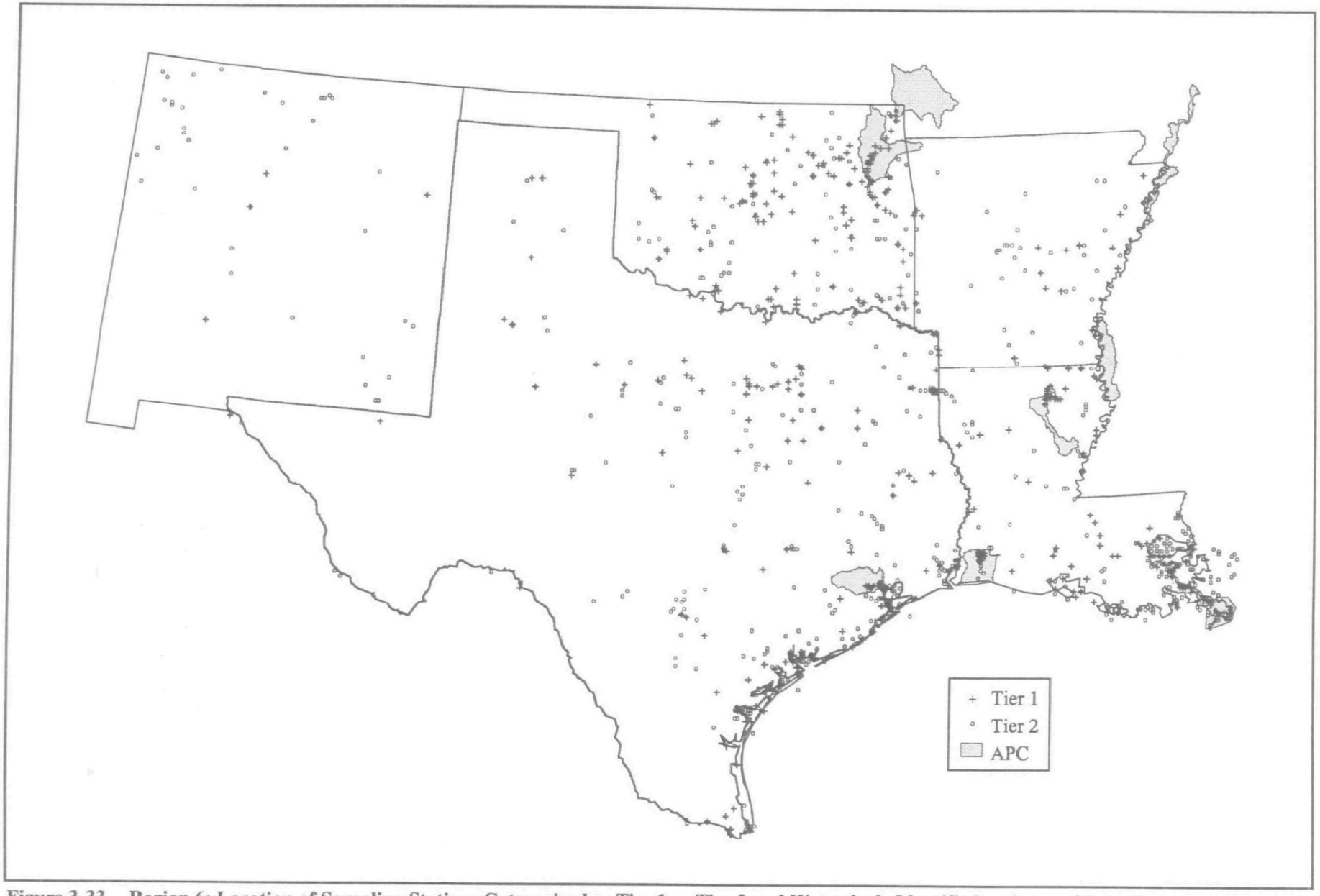


Figure 3-33. Region 6: Location of Sampling Stations Categorized as Tier 1 or Tier 2 and Watersheds Identified as Areas of Potential Widespread Sediment Contamination (APCs).

Table 3-27. Region 6: Watersheds Identified as Areas of Potential Widespread Sediment Contamination

Cataloging Unit Number	Name	State(s)*	Number of Stations			Percent of Stations in Tier 1 or Tier 2
			Tier 1	Tier 2	Tier 3	
08080206	Lower Calcasieu	LA	26	52	22	78
08090100	Lower Mississippi-New Orleans	LA	16	34	1	98
08010100	Lower Mississippi-Memphis	AR, MS, KY, MO, TN	14	3	3	85
11070209	Lower Neosho	OK, (AR)	13	3	4	80
08040207	Lower Ouachita	LA	12	0	0	100
08030209	Deer-Steele	MS, (LA)	11	10	0	100
11070207	Spring	OK, MO, KS	10	25	6	85
12040104	Buffalo-San Jacinto	TX	10	23	3	92

*No data were available for states listed in parentheses.

Table 3-28. Region 6: Water Bodies With Sampling Stations Categorized as Tier 1 That Are Located in Areas of Potential Widespread Sediment Contamination

Water Body	# of Tier 1 Stations	Water Body	# of Tier 1 Stations
Calcasieu River	15	Neosho River	2
Mississippi River	15	Pryor Creek	2
Bayou D'Inde	11	Greens Bayou	1
Bayou De Siard	11	Lake Eucha	1
Buffalo Bayou	5	Mississippi River, Grand Pass	1
Fort Gibson Lake	4	Mississippi River, Pass Loutre	1
Lake Hudson	3	Ouachita River	1
Busch Island	2	Spavinaw Lake	1
Galveston Bay	2		

Table 3-29. Region 6: Chemicals Most Often Responsible for Stations Being Categorized as Tier 1 or Tier 2[a]

	Chemical	# Tier 1 & Tier 2 Stations	# Tier 1 Stations	# Tier 2 Stations
Region 6 Overall	Nickel	460	–	460
	Polychlorinated biphenyls	434	216	218
	Arsenic	429	3	426
	Copper	350	–	350
	DDT	327	70	257
	Cadmium	325	–	325
	Lead	297	–	297
	Chromium	290	9	281
	Mercury	235	47	188
	Chlordane	189	4	185
	Silver	144	32	112
	Zinc	133	–	133
	Dieldrin	132	10	122
	BHC	123	16	107
	Dibenzo(a,h)anthracene	122	2	120
Arkansas	Arsenic	25	–	25
	DDT	23	6	17
	Mercury	15	3	12
	Polychlorinated biphenyls	14	7	7
	Lead	13	–	13
	Dieldrin	7	–	7
	Dioxins	6	6	–
	Chlordane	6	–	6
	Cadmium	4	–	4
	Copper	3	–	3
Louisiana	Nickel	178	–	178
	Arsenic	141	1	140
	Chromium	132	3	129
	Polychlorinated biphenyls	119	44	75
	Copper	111	–	111
	DDT	110	26	84
	SEM (est)[b]	75	–	75
	Mercury	71	21	50
Louisiana (continued)	Dibenzo(a,h)anthracene	59	1	58
	Lead	57	–	57
New Mexico	Copper	24	–	24
	Cadmium	23	–	23
	Arsenic	17	–	17
	Nickel	12	–	12
	Lead	8	–	8
	Zinc	6	–	6
	Mercury	5	3	2
	Chromium	4	–	4
	Polychlorinated biphenyls	2	2	–
	Chlordane	2	–	2
Oklahoma	Polychlorinated biphenyls	135	118	17
	Arsenic	78	1	77
	Chlordane	73	3	70
	Cadmium	60	–	60
	DDT	58	7	51
	Lead	43	–	43
	Dieldrin	35	1	34
	Copper	27	–	27
	Mercury	26	3	23
	Toxaphene	20	–	20
Texas	Nickel	259	–	259
	Copper	185	–	185
	Cadmium	182	–	182
	Lead	176	–	176
	Arsenic	168	1	167
	Polychlorinated biphenyls	164	45	119
	Chromium	152	6	146
	DDT	135	31	104
	Silver	135	30	105
	Mercury	118	17	101

[a]Stations may be listed for more than one chemical.
[b]Simultaneously extracted metals.

EPA Region 7

EPA evaluated 1,011 sampling stations in Region 7 as part of the NSI evaluation. This evaluation resulted in 330 stations (33 percent) in Region 7 being categorized as Tier 1, 393 (39 percent) as Tier 2, and 288 (28 percent) as Tier 3 (Table 3-30). Figure 3-34 identifies the stations in Region 7 that were categorized as Tier 1 or Tier 2 due to potential aquatic life effects and those categorized as Tier 1 or Tier 2 due to potential human health effects.

The NSI sampling stations in Region 7 were located in 516 separate river reaches, or 11 percent of all reaches in the Region (Table 3-30). Of all river reaches evaluated in Region 7, 48 percent included at least one Tier 1 station, 35 percent included at least one Tier 2 station but no Tier 1 stations, and 17 percent had only Tier 3 stations (Figure 3-35).

Out of a total of 239 watersheds located in Region 7, 5 (2 percent) were identified as APCs (Figure 3-36). In addition, 49 percent of all watersheds in the Region had at least one Tier 1 station but were not categorized as APCs, 16 percent had at least one Tier 2 station but no Tier 1 stations, and 5 percent had only Tier 3 stations. Twenty-eight percent of the watersheds in Region 7 could not be evaluated because of a lack of data. The locations of the APCs and the Tier 1 and Tier 2 stations in Region 7 are illustrated in Figure 3-37.

Within the 5 watersheds in Region 7 identified as APCs (Table 3-31), 12 water bodies have at least 1 sampling station that has been categorized as Tier 1; 1 water body has 10 or more sampling stations categorized as Tier 1 (Table 3-32). The waterbodies listed on Table 3-32 are not inclusive of all locations containing a Tier 1 or Tier 2 station because only waterbodies within APC watersheds are listed. These summary results are also not inclusive of locations with contaminated sediment not identified in this survey. The data compiled for the NSI are primarily from large national electronic databases. Data from many sampling and testing studies have not yet been incorporated into the NSI. Thus, there may be additional locations with sediment contamination that do not appear in this summary. On the other hand, data in the inventory were collected between 1980 and 1993 and any single measurement of a chemical at a site, taken any point in time during that period, could result in the categorization of the site in Tier 1 or Tier 2. The evaluation approach is conservative. Therefore sites appearing in Tier 1 or Tier 2 may not cause unacceptable impacts. It is also important to note that management programs may already exist to address identified sediment contamination problems.

The chemicals most often responsible for stations being categorized as Tier 1 or Tier 2 in Region 7 overall and in each state in Region 7 are presented in Table 3-33.

Table 3-30. Region 7: Number of NSI Sampling Stations in Each Probability of Adverse Effects Category and Number of River Reaches Where NSI Sampling Stations Are Located

	Station Evaluation						River Reach Evaluation[a]							
	Tier 1		Tier 2		Tier 3									
State	#	%	#	%	#	%	Number of Stations Not Identified by an RF1 Reach[b]	Reaches w/at Least 1 Station in Tier 1	Reaches w/at Least 1 Station in Tier 2[c]	Reaches w/all Stations in Tier 3	Total # Reaches w/at Least 1 Station Evaluated	Total Reaches in State	% of all Reaches in State w/at Least 1 Station Evaluated	% of Reaches Evaluated w/at Least 1 Tier 1 or Tier 2 Station
Iowa	75	33	104	46	49	21	-	61	50	19	130	1,198	11	85
Kansas	76	38	98	48	29	14	-	64	48	13	125	1,184	11	90
Missouri	124	38	98	30	105	32	-	76	32	18	126	1,364	9	86
Nebraska	55	22	93	37	105	41	-	45	62	39	146	1,265	12	73
REGION 7[d]	330	33	393	39	288	28	-	246	182	88	516	4,857	11	83

[a]River reaches based on EPA River Reach File 1 (RF1).
[b]Stations not identified by an RF1 reach were located in coastal or open water areas.
[c]No stations in these reaches were included in Tier 1.
[d]Because some reaches occur in more than one state, the total number of reaches in each category for the Region might not equal the sum of reaches in the states.

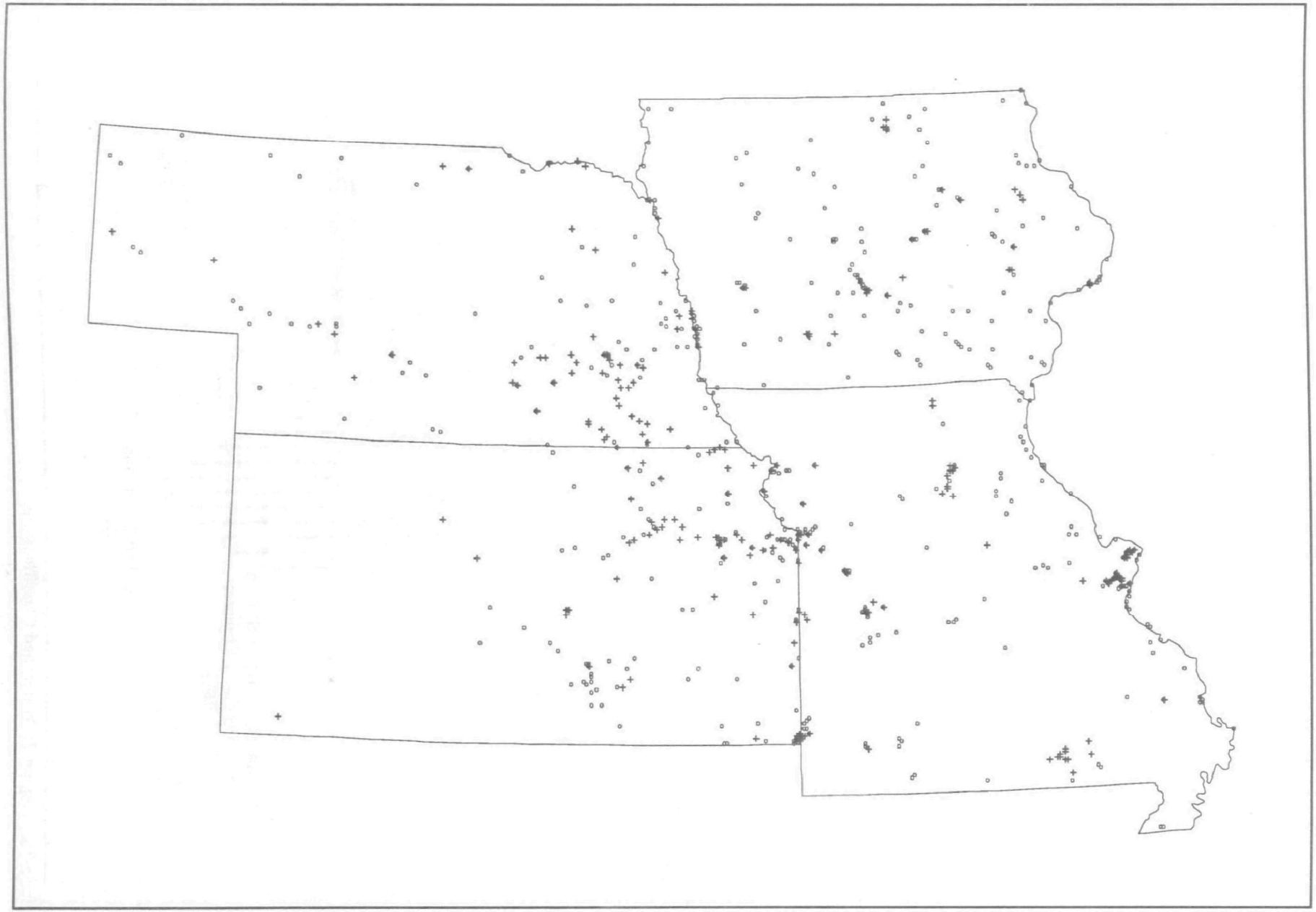


Figure 3-34. Region 7: Stations Categorized as Tier 1 or Tier 2 Due to Potential Aquatic Life Effects (+) and Potential Human Health Effects (o).

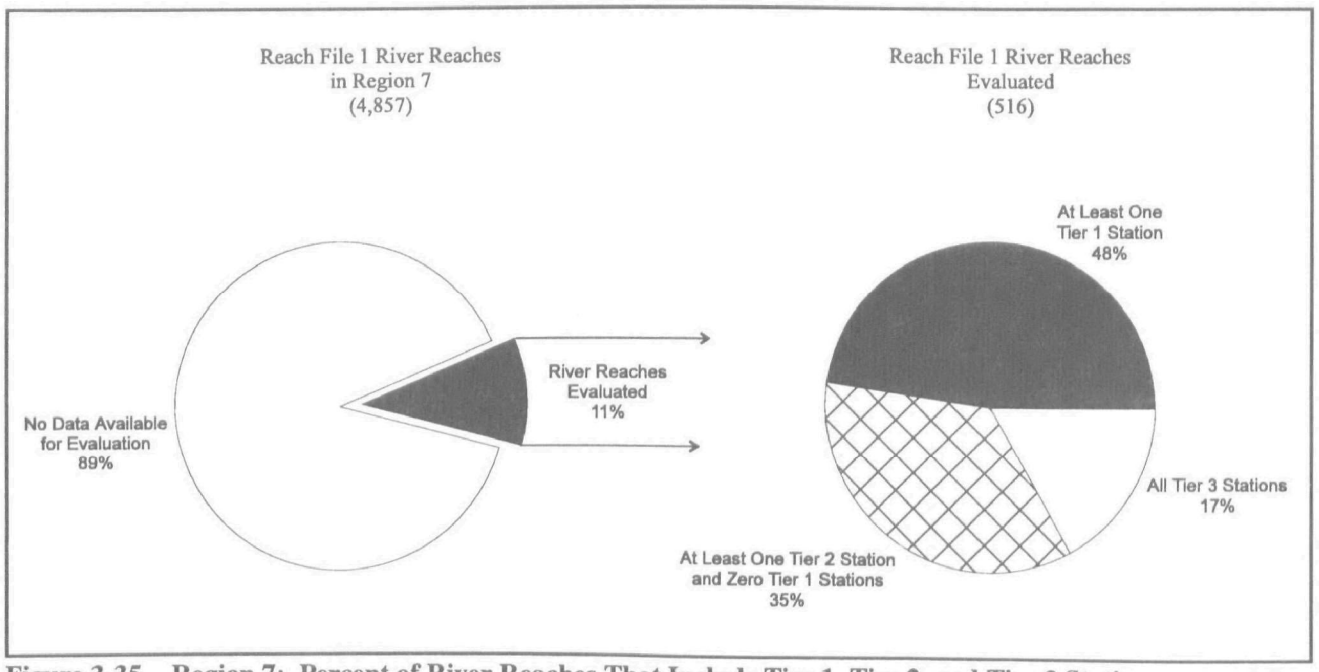


Figure 3-35. Region 7: Percent of River Reaches That Include Tier 1, Tier 2, and Tier 3 Stations.

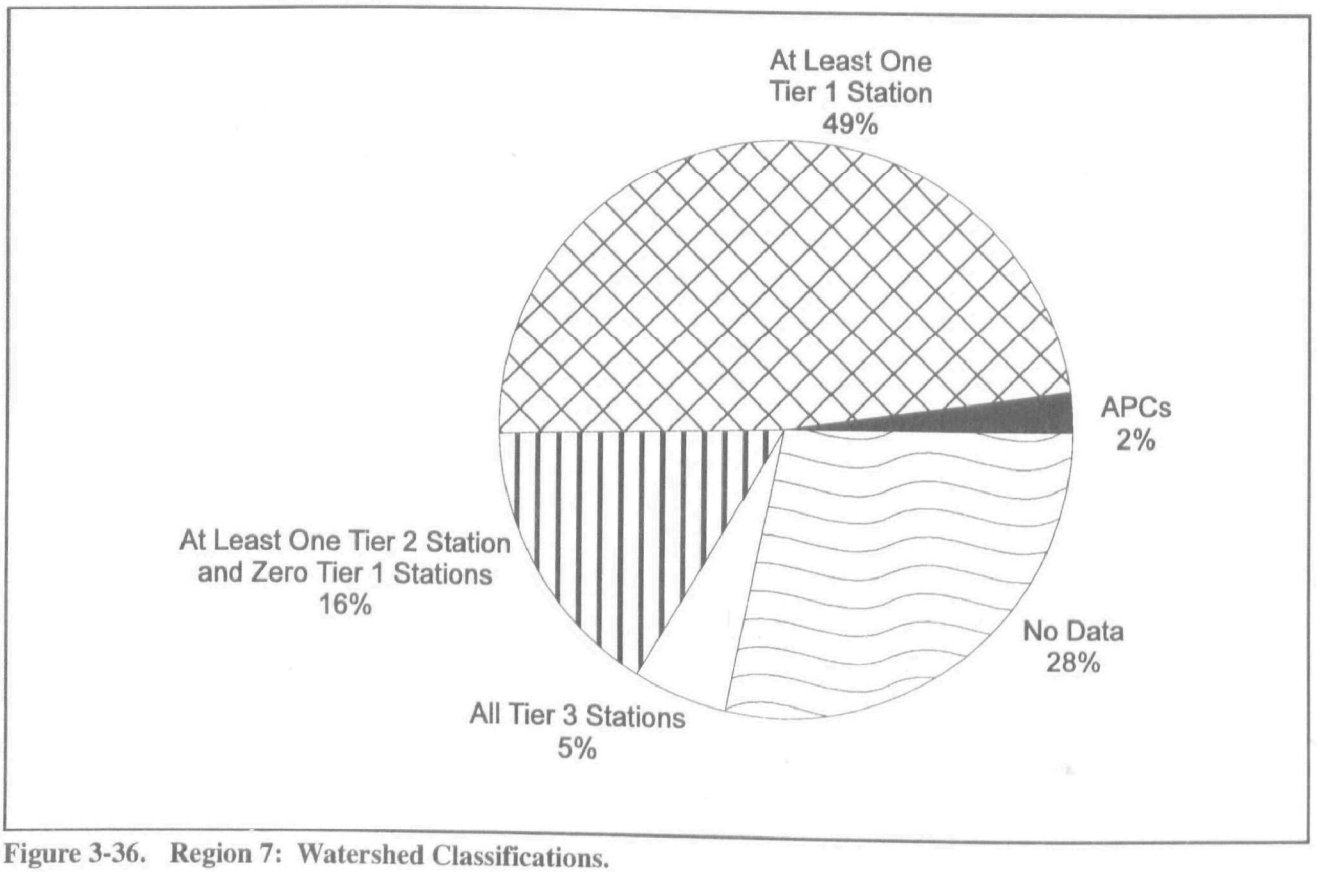


Figure 3-36. Region 7: Watershed Classifications.

Figure 3-37. Region 7: Locations of Sampling Stations Categorized as Tier 1 or Tier 2 and Watersheds Identified as Areas of Potential Widespread Sediment Contamination (APCs).

Table 3-31. Region 7: Watersheds Identified as Areas of Potential Widespread Sediment Contamination

Cataloging Unit Number	Name	State(s)	Number of Stations			Percent of Stations in Tier 1 or Tier 2
			Tier 1	Tier 2	Tier 3	
07140101	Cahokia-Joachim	MO, IL	18	34	4	93
07080101	Copperas-Duck	IL, IA	17	5	5	81
08010100	Lower Mississippi-Memphis	AR, MS, KY, MO, TN	14	3	3	85
10270104	Lower Kansas	MO, KS	12	15	2	93
11070207	Spring	OK, MO, KS	10	25	6	85

Table 3-32. Region 7: Water Bodies With Sampling Stations Categorized as Tier 1 That Are Located in Areas of Potential Widespread Sediment Contamination

Water Body	# of Tier 1 Stations	Water Body	# of Tier 1 Stations
Mississippi River	17	Duck Creek	1
Kansas River	7	Joachim Creek	1
Spring River	5	Kill Creek	1
Center Creek	3	Stranger Creek	1
Cedar Creek	2	Turkey Creek	1
Cow Creek	1	Wakarusa River	1

Table 3-33. Region 7: Chemicals Most Often Responsible for Stations Being Categorized as Tier 1 or Tier 2[a]

	Chemical	# Tier 1 & Tier 2 Stations	# Tier 1 Stations	# Tier 2 Stations
Region 7 Overall	Dieldrin	336	2	334
	Chlordane	329	–	329
	Polychlorinated biphenyls	305	291	14
	Arsenic	171	–	171
	Heptachlor epoxide	138	–	138
	Nickel	121	–	121
	Cadmium	115	–	115
	Lead	84	–	84
	Copper	74	–	74
	Chromium	50	5	45
	Dioxins	44	42	2
	Zinc	43	–	43
	Bis(2-ethylhexyl)phthalate	37	9	28
	DDT	33	–	33
	Aldrin	31	–	31
Iowa	Dieldrin	126	2	124
	Chlordane	91	–	91
	Polychlorinated biphenyls	71	71	–
	Heptachlor epoxide	54	–	54
	Arsenic	34	–	34
	Copper	17	–	17
	Cadmium	14	–	14
	Nickel	14	–	14
	DDT	12	–	12
	Lead	10	–	10
Kansas	Polychlorinated biphenyls	68	68	–
	Chlordane	67	–	67
	Dieldrin	62	–	62
Kansas (continued	Arsenic	52	–	52
	Nickel	49	–	49
	Cadmium	36	–	36
	Lead	34	–	34
	Chromium	27	1	26
	Zinc	23	–	23
	Copper	20	–	20
Missouri	Chlordane	119	–	119
	Polychlorinated biphenyls	116	102	14
	Dieldrin	76	–	76
	Heptachlor epoxide	53	–	53
	Arsenic	43	–	43
	Cadmium	36	–	36
	Lead	33	–	33
	Dioxins	31	29	2
	Nickel	29	–	29
	Copper	27	–	27
Nebraska	Dieldrin	72	–	72
	Chlordane	52	–	52
	Polychlorinated biphenyls	50	50	–
	Arsenic	42	–	42
	Cadmium	29	–	29
	Nickel	29	–	29
	Chromium	17	2	15
	Aldrin	13	–	13
	Heptachlor epoxide	12	–	12
	Bis(2-ethylhexyl)phthalate	10	4	6

[a]Stations may be listed for more than one chemical.

EPA Region 8

EPA evaluated 535 sampling stations in Region 8 as part of the NSI evaluation. This evaluation resulted in 68 stations (13 percent) in Region 8 being categorized as Tier 1, 327 (61 percent) as Tier 2, and 140 (26 percent) as Tier 3 (Table 3-34). Figure 3-38 identifies the stations in Region 8 that were categorized as Tier 1 or Tier 2 due to potential aquatic life effects and those categorized as Tier 1 or Tier 2 due to potential human health effects.

The NSI sampling stations in Region 8 were located in 305 separate river reaches, or 2 percent of all reaches in the Region (Table 3-34). Of all river reaches evaluated in Region 8, 20 percent included at least one Tier 1 station, 50 percent included at least one Tier 2 station but no Tier 1 stations, and 30 percent had only Tier 3 stations (Figure 3-39).

Out of a total of 385 watersheds located in Region 8, none were identified as APCs. Fourteen percent of all watersheds in the Region had at least one Tier 1 station, 12 percent had at least one Tier 2 station but no Tier 1 stations, and 9 percent had only Tier 3 stations (Figure 3-40). Sixty-five percent of the watersheds in Region 8 could not be evaluated because of a lack of data. The locations of the Tier 1 and Tier 2 stations in Region 8 are illustrated in Figure 3-41.

Lack of multiple sampling site data did not allow identification of any watersheds in Region 8 as APCs. Therefore, specific waterbodies with Tier 1 stations are not listed in a separate table, as for other Regional summaries. The data compiled for the NSI are primarily from large national electronic databases. Data from many sampling and testing studies have not yet been incorporated into the NSI. Thus, there may be additional locations with sediment contamination that do not appear in this summary. On the other hand, data in the inventory were collected between 1980 and 1993 and any single measurement of a chemical at a site, taken any point in time during that period, could result in the categorization of the site in Tier 1 or Tier 2. The evaluation approach is conservative. Therefore sites appearing in Tier 1 or Tier 2 may not cause unacceptable impacts. It is also important to note that management programs may already exist to address identified sediment contamination problems.

The chemicals most often responsible for stations being categorized as Tier 1 or Tier 2 in Region 8 overall and in each state in Region 8 are presented in Table 3-35.

Table 3-34. Region 8: Number of NSI Sampling Stations in Each Probability of Adverse Effects Category and Number of River Reaches Where NSI Sampling Stations Are Located

State	Station Evaluation						River Reach Evaluation[a]							
	Tier 1		Tier 2		Tier 3		Number of Stations Not Identified by an RF1 Reach[b]	Reaches w/at Least 1 Station in Tier 1	Reaches w/at Least 1 Station in Tier 2[c]	Reaches w/all Stations in Tier 3	Total # Reaches w/at Least 1 Station Evaluated	Total Reaches in State	% of all Reaches in State w/at Least 1 Station Evaluated	% of Reaches Evaluated w/at Least 1 Tier 1 or Tier 2 Station
	#	%	#	%	#	%								
Colorado	11	6	140	69	51	25	—	8	73	34	115	2,178	5	70
Montana	9	24	18	47	11	29	—	9	10	8	27	5,490	1	70
North Dakota	24	15	112	70	25	15	—	22	36	9	67	992	7	87
South Dakota	13	30	21	49	9	21	—	11	6	7	24	1,611	2	71
Utah	7	15	24	51	16	34	—	7	16	10	33	1,034	3	70
Wyoming	4	9	12	27	28	64	—	4	12	25	41	2,421	2	39
REGION 8[d]	68	13	327	61	140	26	—	61	153	91	305	13,492	2	70

[a]River reaches based on EPA River Reach File 1 (RF1).
[b]Stations not identified by an RF1 reach were located in coastal or open water areas.
[c]No stations in these reaches were included in Tier 1.
[d]Because some reaches occur in more than one state, the total number of reaches in each category for the Region might not equal the sum of reaches in the states.

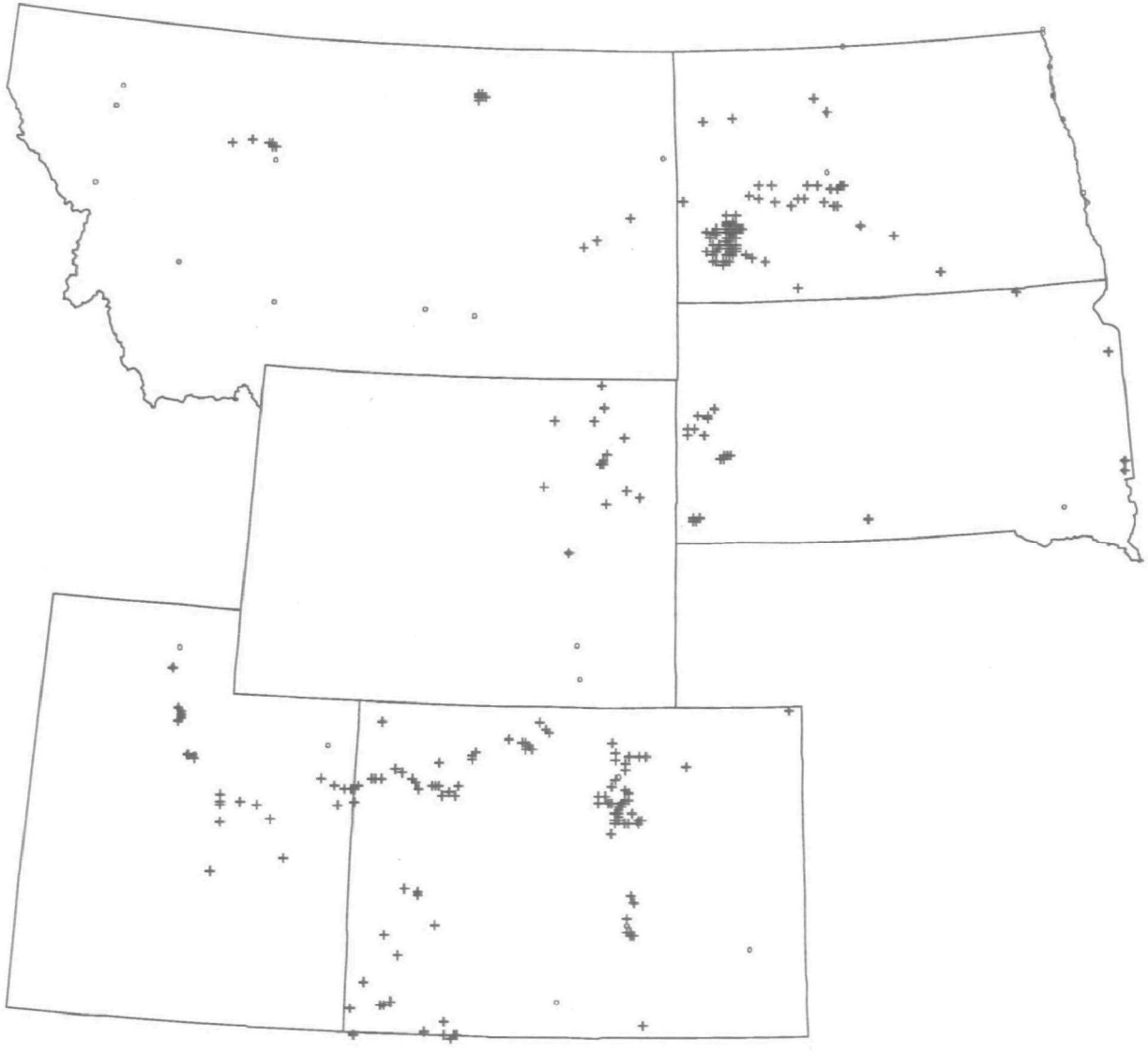


Figure 3-38. Region 8: Stations Categorized as Tier 1 or Tier 2 Due to Potential Aquatic Life Effects (+) and Potential Human Health Effects (o).

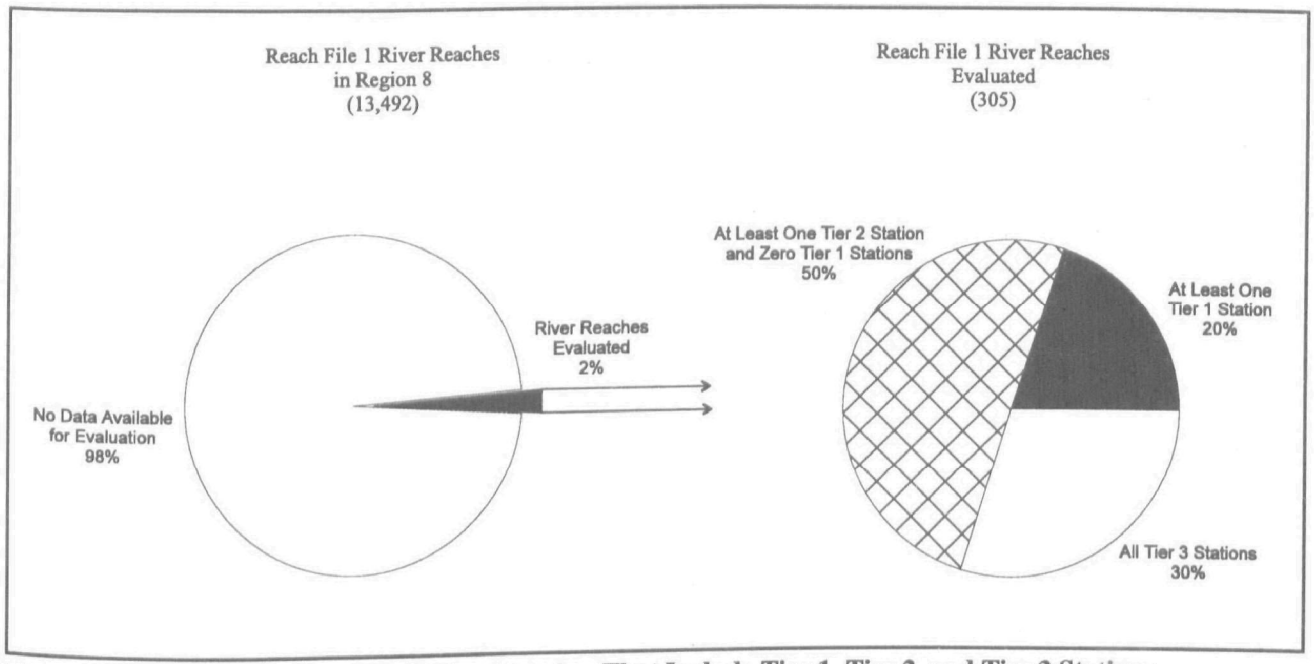


Figure 3-39. Region 8: Percent of River Reaches That Include Tier 1, Tier 2, and Tier 3 Stations.

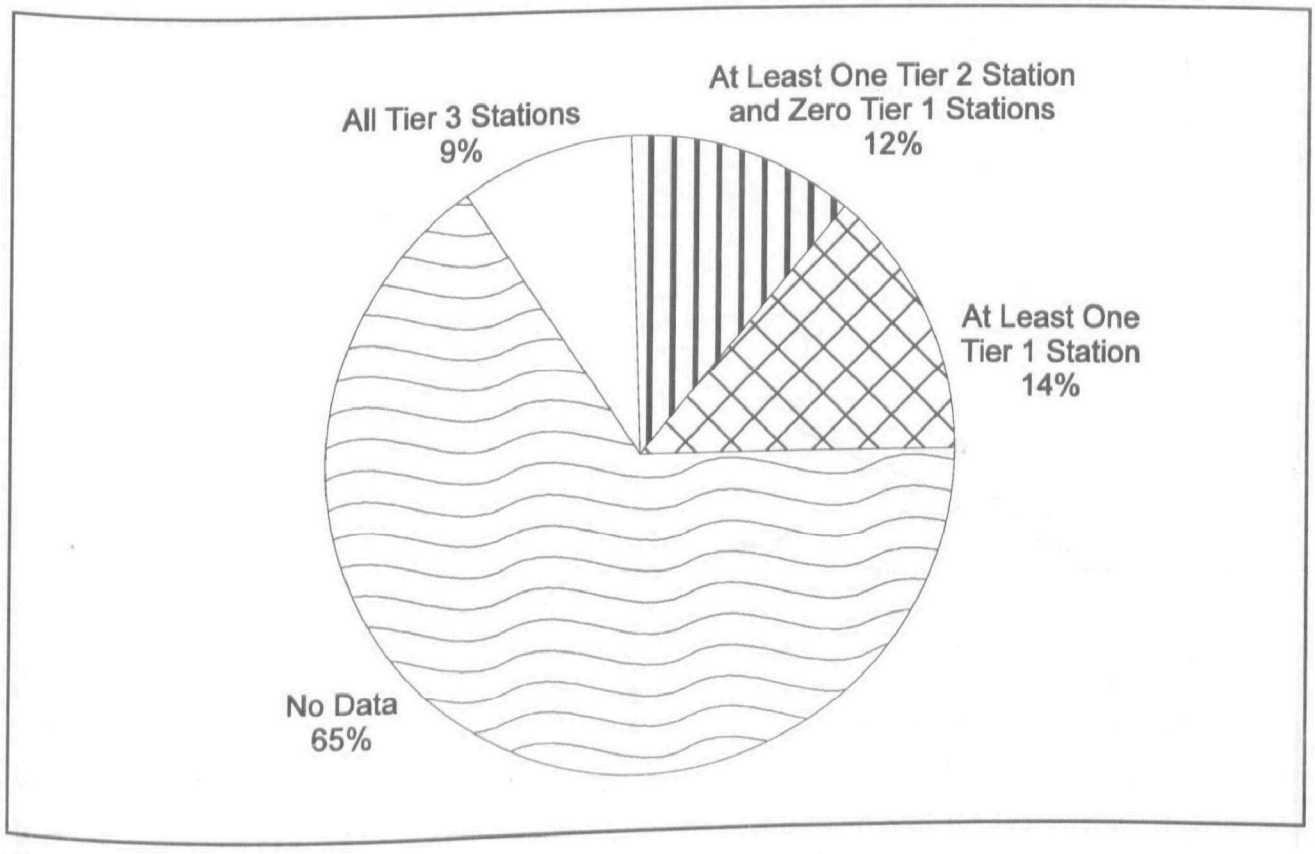


Figure 3-40. Region 8: Watershed Classifications.

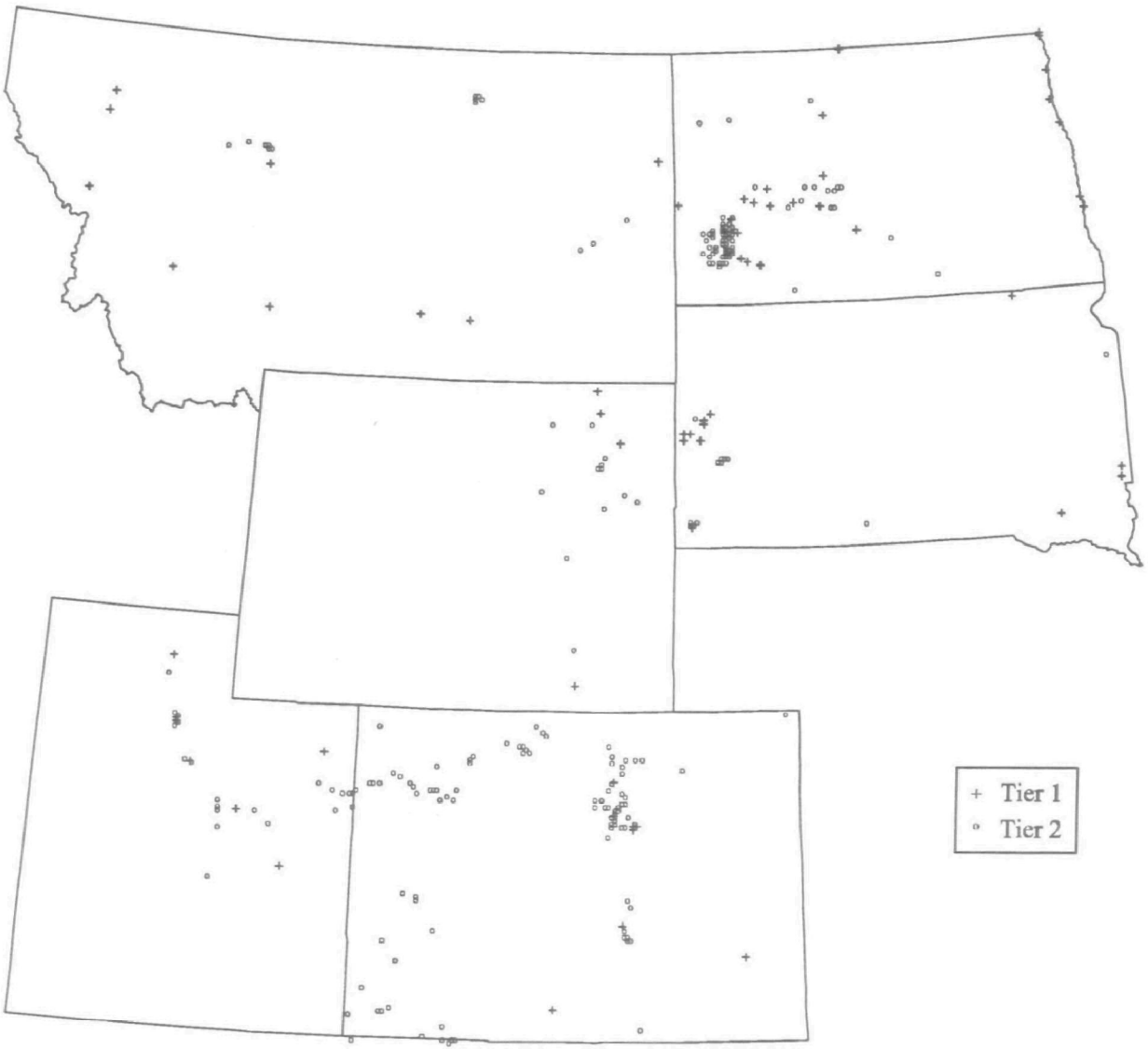


Figure 3-41. Region 8: Locations of Sampling Stations Categorized as Tier 1 or Tier 2.

Table 3-35. Region 8: Chemicals Most Often Responsible for Stations Being Categorized as Tier 1 or Tier 2[a]

	Chemical	# Tier 1 & Tier 2 Stations	# Tier 1 Stations	# Tier 2 Stations
Region 8 Overall	Copper	195	--	195
	Nickel	192	--	192
	Cadmium	169	--	169
	Arsenic	155	22	133
	Lead	74	--	74
	Zinc	56	--	56
	Chromium	53	1	52
	Polychlorinated biphenyls	40	29	11
	Mercury	35	12	23
	Dieldrin	20	--	20
	Aldrin	12	--	12
	Toxaphene	12	--	12
	Silver	11	1	10
	Bis(2-ethylhexyl)phthalate	10	4	6
	Chlordane	9	--	9
Colorado	Cadmium	109	--	109
	Copper	71	--	71
	Arsenic	59	--	59
	Nickel	53	--	53
	Lead	50	--	50
	Zinc	43	--	43
	Mercury	18	6	12
	Chromium	10	--	10
	Polychlorinated biphenyls	7	4	3
	Dieldrin	5	--	5
Montana	Arsenic	18	--	18
	Copper	12	--	12
	Nickel	12	--	12
	Polychlorinated biphenyls	9	9	--
	Chromium	6	--	6
	Dieldrin	5	--	5
	Aldrin	4	--	4
	Toxaphene	4	--	4
	Cadmium	3	--	3
	Dioxins	2	2	--
North Dakota	Nickel	110	--	110
	Copper	93	--	93
North Dakota (continued)	Chromium	34	--	34
	Arsenic	33	12	21
	Cadmium	16	--	16
	Polychlorinated biphenyls	10	10	--
	Mercury	6	2	4
	Dieldrin	4	--	4
	Aldrin	2	--	2
	Bis(2-ethylhexyl)phthalate	2	--	2
	Lead	2	--	2
South Dakota	Arsenic	23	7	16
	Lead	16	--	16
	Nickel	15	--	15
	Cadmium	9	--	9
	Copper	9	--	9
	Zinc	6	--	6
	Bis(2-ethylhexyl)phthalate	3	2	1
	Mercury	3	2	1
	Chromium	3	1	2
	Benzo(a)pyrene	2	--	2
Utah	Cadmium	21	--	21
	Arsenic	14	--	14
	Polychlorinated biphenyls	11	4	7
	Chlordane	8	--	8
	Copper	8	--	8
	Mercury	7	2	5
	Lead	6	--	6
	Dieldrin	5	--	5
	Silver	5	--	5
	Zinc	5	--	5
Wyoming	Cadmium	11	--	11
	Arsenic	8	3	5
	Polychlorinated biphenyls	2	1	1
	Copper	2	--	2
	Bis(2-ethylhexyl)phthalate	1	--	1
	Mercury	1	--	1
	Nickel	1	--	1
	Silver	1	--	1

[a]Stations may be listed for more than one chemical.

EPA Region 9

EPA evaluated 1,699 sampling stations in Region 9 as part of the NSI evaluation. This evaluation resulted in 468 stations (28 percent) in Region 9 being categorized as Tier 1, 942 (55 percent) as Tier 2, and 289 (17 percent) as Tier 3 (Table 3-36). Figure 3-42 identifies the stations in Region 9 that were categorized as Tier 1 or Tier 2 due to potential aquatic life effects and those categorized as Tier 1 or Tier 2 due to potential human health effects.

The NSI sampling stations in Region 1 were located in 254 separate river reaches, or 6 percent of all reaches in the Region (Table 3-36). Of all river reaches evaluated in Region 9, 47 percent included at least one Tier 1 station, 36 percent included at least one Tier 2 station but no Tier 1 stations, and 17 percent had only Tier 3 stations (Figure 3-43).

Out of a total of 279 watersheds located in Region 9, 10 (less than 4 percent) were identified as APCs (Figure 3-44). In addition, 22 percent of all watersheds in the Region had at least one Tier 1 station but were not categorized as APCs, 10 percent had at least one Tier 2 station but no Tier 1 stations, and 5 percent had only Tier 3 stations. Fifty-nine percent of the watersheds in Region 9 could not be evaluated because of a lack of data. The locations of the APCs and the Tier 1 and Tier 2 stations in Region 9 are illustrated in Figure 3-45.

Within the 10 watersheds in Region 9 identified as APCs (Table 3-37), 19 water bodies have at least 1 sampling station that has been categorized as Tier 1; 7 water bodies have 10 or more sampling stations categorized as Tier 1 (Table 3-38). San Diego Bay, San Francisco Bay, and offshore areas around San Diego and Los Angeles appear to have the most significant potential widespread sediment contamination problems in Region 9. The waterbodies listed on Table 3-38 are not inclusive of all locations containing a Tier 1 or Tier 2 station because only waterbodies within APC watersheds are listed. These summary results are also not inclusive of locations with contaminated sediment not identified in this survey. The data compiled for the NSI are primarily from large national electronic databases. Data from many sampling and testing studies have not yet been incorporated into the NSI. Thus, there may be additional locations with sediment contamination that do not appear in this summary. On the other hand, data in the inventory were collected between 1980 and 1993 and any single measurement of a chemical at a site, taken any point in time during that period, could result in the categorization of the site in Tier 1 or Tier 2. The evaluation approach is conservative. Therefore sites appearing in Tier 1 or Tier 2 may not cause unacceptable impacts. It is also important to note that management programs may already exist to address identified sediment contamination problems.

The chemicals most often responsible for stations being categorized as Tier 1 or Tier 2 in Region 9 overall and in each state in Region 9 are presented in Table 3-39.

Table 3-36. Region 9: Number of NSI Sampling Stations in Each Probability of Adverse Effects Category and Number of River Reaches Where NSI Sampling Stations Are Located

	Station Evaluation						River Reach Evaluation[a]							
	Tier 1		Tier 2		Tier 3									
State	#	%	#	%	#	%	Number of Stations Not Identified by an RF1 Reach[b]	Reaches w/at Least 1 Station in Tier 1	Reaches w/at Least 1 Station in Tier 2[c]	Reaches w/all Stations in Tier 3	Total # Reaches w/at Least 1 Station Evaluated	Total Reaches in State	% of all Reaches in State w/at Least 1 Station Evaluated	% of Reaches Evaluated w/at Least 1 Tier 1 or Tier 2 Station
Arizona	44	35	58	47	22	18	—	30	33	11	74	1,146	7	85
California	392	27	822	57	229	16	758	75	44	26	145	2,606	6	82
Hawaii	8	22	23	64	5	14	36	—	—	—	—	—	—	—
Nevada	24	25	39	41	33	34	—	16	15	6	37	916	4	84
REGION 9[d]	468	28	942	55	289	17	794	119	92	43	254	4,601	6	83

[a]River reaches based on EPA River Reach File 1 (RF1).
[b]Stations not identified by an RF1 reach were located in coastal or open water areas.
[c]No stations in these reaches were included in Tier 1.
[d]Because some reaches occur in more than one state, the total number of reaches in each category for the Region might not equal the sum of reaches in the states.

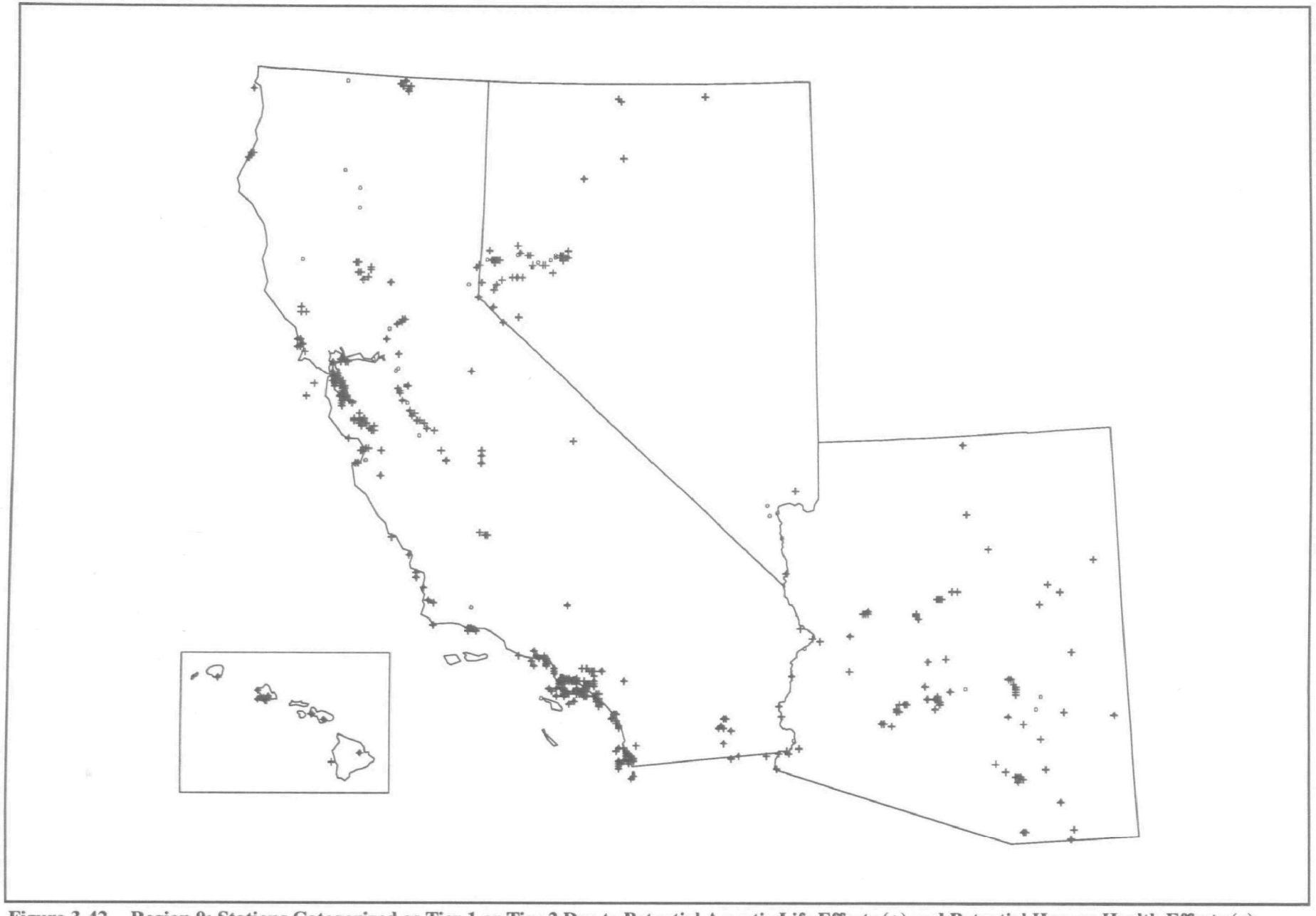


Figure 3-42. Region 9: Stations Categorized as Tier 1 or Tier 2 Due to Potential Aquatic Life Effects (+) and Potential Human Health Effects (o).

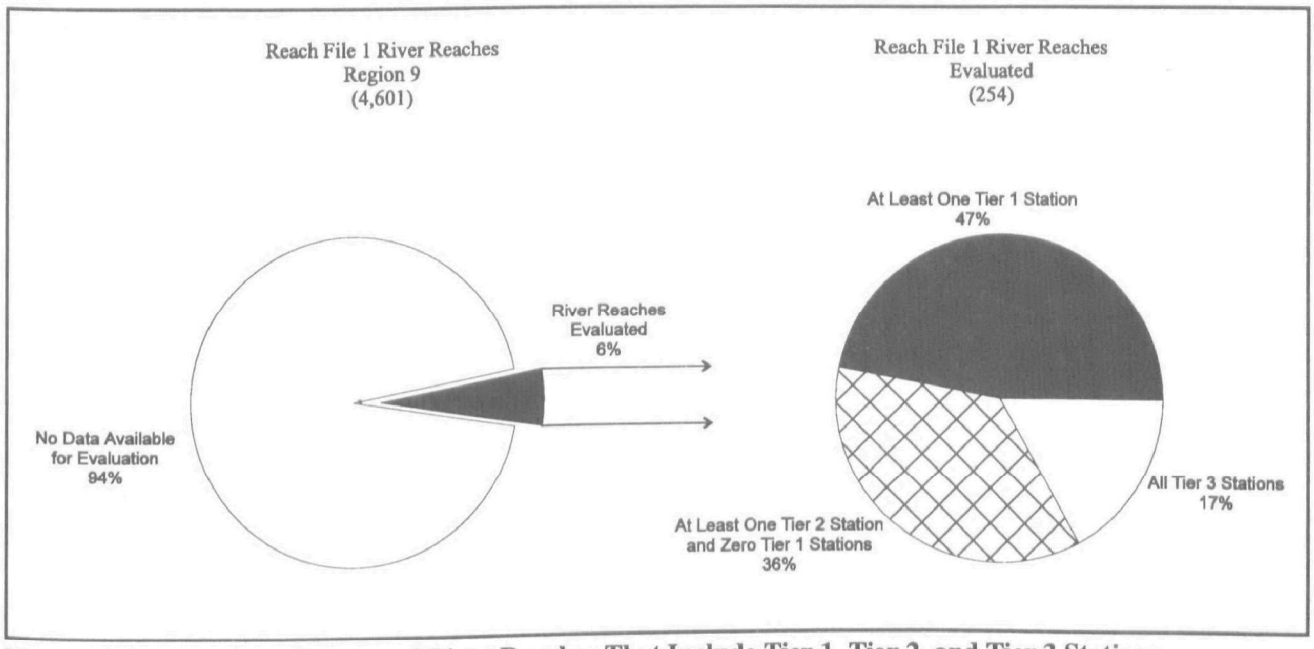


Figure 3-43. Region 9: Percent of River Reaches That Include Tier 1, Tier 2, and Tier 3 Stations.

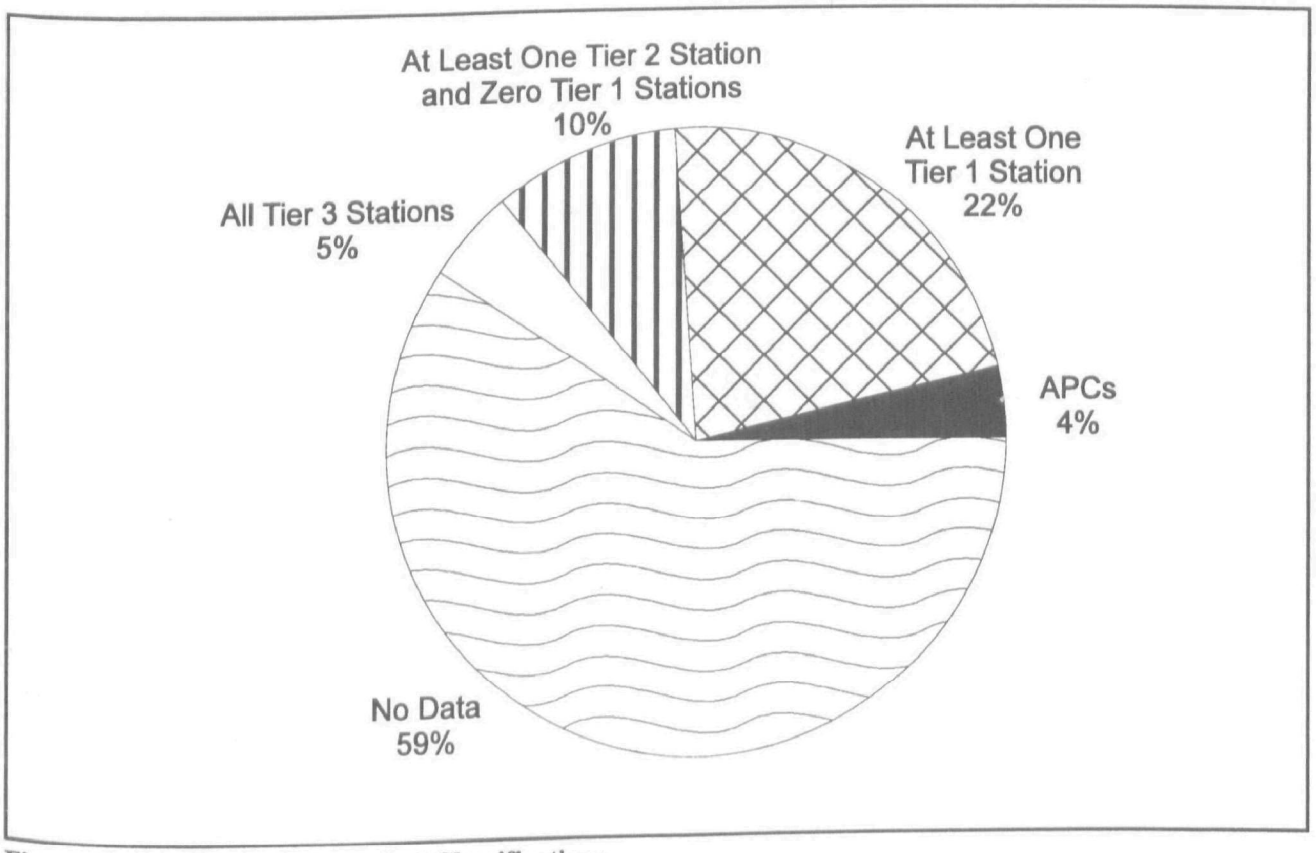


Figure 3-44. Region 9: Watershed Classifications.

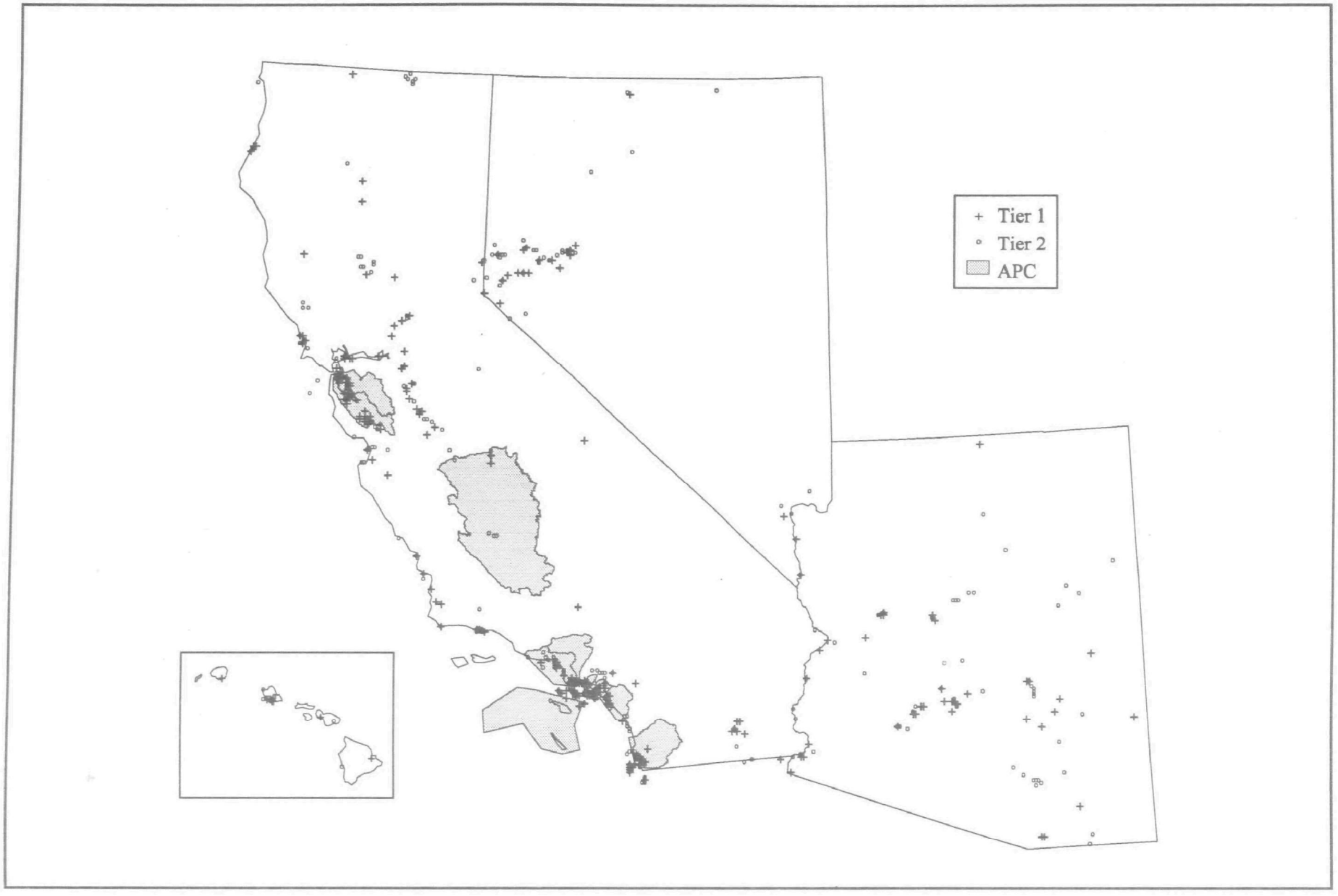


Figure 3-45. Region 9: Location of Sampling Stations Categorized as Tier 1 or Tier 2 and Watersheds Identified as Areas of Potential Widespread Sediment Contamination (APCs).

Table 3-37. Region 9: Watersheds Identified as Areas of Potential Widespread Sediment Contamination

Cataloging Unit Number	Name	State(s)	Number of Stations			Percent of Stations in Tier 1 or Tier 2
			Tier 1	Tier 2	Tier 3	
18070104	Santa Monica Bay	CA	79	31	22	83
18070201	Seal Beach	CA	63	339	40	91
18070304	San Diego	CA	53	51	3	97
18070204	Newport Bay	CA	24	68	16	85
18050004	San Francisco Bay	CA	19	37	8	88
18050003	Coyote	CA	18	6	0	100
18070105	Los Angeles	CA	14	19	4	89
18070107	San Pedro Channel Islands	CA	14	10	1	96
18030012	Tulare-Buena Vista Lakes	CA	10	5	5	75
18070301	Aliso-San Onofre	CA	10	22	0	100

Table 3-38. Region 9: Water Bodies With Sampling Stations Categorized as Tier 1 That Are Located in Areas of Potential Widespread Sediment Contamination

Water Body	# of Tier 1 Stations	Water Body	# of Tier 1 Stations
Pacific Ocean	178	Corte Madera Creek	2
San Diego Bay	32	Los Gatos Creek	2
San Francisco Bay	19	Coyote Creek	1
Los Angeles River	14	Lexington Reservoir	1
Santa Catalina Island	14	Oso Creek	1
San Diego Creek	12	Peters Canyon Wash	1
Kings River	10	San Diego River	1
Alamitos Creek	8	San Juan Creek	1
Calero Reservoir	4	Sweetwater River	1
Aliso Creek	2		

Table 3-39. Region 9: Chemicals Most Often Responsible for Stations Being Categorized as Tier 1 or Tier 2[a]

	Chemical	# Tier 1 & Tier 2 Stations	# Tier 1 Stations	# Tier 2 Stations
Region 9 Overall	Copper	678	--	678
	DDT	675	179	496
	Arsenic	455	12	443
	Nickel	454	--	454
	Cadmium	446	--	446
	Polychlorinated biphenyls	445	100	345
	Mercury	403	134	269
	Lead	314	--	314
	Bis(2-ethylhexyl)phthalat	302	69	233
	Chromium	265	42	223
	Zinc	238	--	238
	Silver	209	23	186
	BHC	164	9	155
	Benzo(a)pyrene	158	6	152
	Dieldrin	125	--	125
Arizona	Copper	72	--	72
	Arsenic	55	8	47
	Nickel	50	--	50
	Lead	37	--	37
	Zinc	28	--	28
	Bis(2-ethylhexyl)phthalat	26	15	11
	Cadmium	24	--	24
	DDT	23	9	14
	Mercury	22	12	10
	Silver	15	7	8
California	DDT	640	168	472
	Copper	573	--	573
	Polychlorinated biphenyls	418	87	331
California (continued)	Cadmium	406	--	406
	Nickel	373	--	373
	Arsenic	357	3	354
	Mercury	336	103	233
	Bis(2-ethylhexyl)phthalat	264	48	216
	Lead	253	--	253
	Chromium	239	40	199
Hawaii	Nickel	20	--	20
	Copper	19	--	19
	Mercury	16	4	12
	Arsenic	16	1	15
	Lead	14	--	14
	Zinc	13	--	13
	DDT	10	2	8
	Chromium	10	1	9
	Polychlorinated biphenyls	8	3	5
	Cadmium	8	--	8
Nevada	Mercury	29	15	14
	Arsenic	27	--	27
	Copper	14	--	14
	Nickel	11	--	11
	Zinc	11	--	11
	Lead	10	--	10
	Polychlorinated biphenyls	9	4	5
	Bis(2-ethylhexyl)phthalat	8	4	4
	Cadmium	8	--	8
	Chlordane	8	--	8

[a]Stations may be listed for more than one chemical.

EPA Region 10

EPA evaluated 2,878 sampling stations in Region 10 as part of the NSI evaluation. This evaluation resulted in 727 stations (25 percent) in Region 10 being categorized as Tier 1, 1,696 (59 percent) as Tier 2, and 455 (16 percent) as Tier 3 (Table 3-40). Figure 3-46 identifies the stations in Region 10 that were categorized as Tier 1 or Tier 2 due to potential aquatic life effects and those categorized as Tier 1 or Tier 2 due to potential human health effects.

The NSI sampling stations in Region 10 were located in 393 separate river reaches, or 4 percent of all reaches in the Region (Table 3-40). Of all river reaches evaluated in Region 10, 38 percent included at least one Tier 1 station, 44 percent included at least one Tier 2 station but no Tier 1 stations, and 18 percent had only Tier 3 stations (Figure 3-47).

Out of a total of 219 watersheds located in Region 10, 7 (3 percent) were identified as APCs (Figure 3-48). In addition, 28 percent of all watersheds in the Region had at least one Tier 1 station but were not categorized as APCs, 14 percent had at least one Tier 2 station but no Tier 1 stations, and 6 percent had only Tier 3 stations. Forty-nine percent of the watersheds in Region 10 could not be evaluated because of a lack of data. The locations of the APCs and the Tier 1 and Tier 2 stations in Region 10 are illustrated in Figure 3-49.

Within the 7 watersheds in Region 10 identified as APCs (Table 3-41), 34 water bodies have at least 1 sampling station that has been categorized as Tier 1; 8 water bodies have 10 or more sampling stations categorized as Tier 1 (Table 3-42). Puget Sound appears to have the most significant potential widespread sediment contamination problem in Region 10. The waterbodies listed on Table 3-42 are not inclusive of all locations containing a Tier 1 or Tier 2 station because only waterbodies within APC watersheds are listed. These summary results are also not inclusive of locations with contaminated sediment not identified in this survey. The data compiled for the NSI are primarily from large national electronic databases. Data from many sampling and testing studies have not yet been incorporated into the NSI. Thus, there may be additional locations with sediment contamination that do not appear in this summary. On the other hand, data in the inventory were collected between 1980 and 1993 and any single measurement of a chemical at a site, taken any point in time during that period, could result in the categorization of the site in Tier 1 or Tier 2. The evaluation approach is conservative. Therefore sites appearing in Tier 1 or Tier 2 may not cause unacceptable impacts. It is also important to note that management programs may already exist to address identified sediment contamination problems.

The chemicals most often responsible for stations being categorized as Tier 1 or Tier 2 in Region 10 overall and in each state in Region 10 are presented in Table 3-43.

Table 3-40. Region 10: Number of NSI Sampling Stations in Each Probability of Adverse Effects Category and Number of River Reaches Where NSI Sampling Stations Are Located

	Station Evaluation						River Reach Evaluation[a]							
	Tier 1		Tier 2		Tier 3									
State	#	%	#	%	#	%	Number of Stations Not Identified by an RF1 Reach[b]	Reaches w/at Least 1 Station in Tier 1	Reaches w/at Least 1 Station in Tier 2[c]	Reaches w/all Stations in Tier 3	Total # Reaches w/at Least 1 Station Evaluated	Total Reaches in State	% of all Reaches in State w/at Least 1 Station Evaluated	% of Reaches Evaluated w/at Least 1 Tier 1 or Tier 2 Station
Alaska	21	8	191	71	55	21	267	—	—	—	—	—	—	—
Idaho	43	45	36	38	16	17	—	30	16	7	53	3,227	2	87
Oregon	81	28	158	54	52	18	2	45	43	25	113	4,203	3	78
Washington	582	26	1,311	59	332	15	228	75	115	40	230	2,924	8	83
REGION 10[d]	727	25	1,696	59	455	16	497	147	174	72	393	10,178	4	81

[a]River reaches based on EPA River Reach File 1 (RF1).

[b]Stations not identified by an RF1 reach were located in coastal or open water areas.

[c]No stations in these reaches were included in Tier 1.

[d]Because some reaches occur in more than one state, the total number of reaches in each category for the Region might not equal the sum of reaches in the states.

Figure 3-46. Region 10: Stations Categorized as Tier 1 or Tier 2 Due to Potential Aquatic Life Effects (+) and Potential Human Health Effects (o).

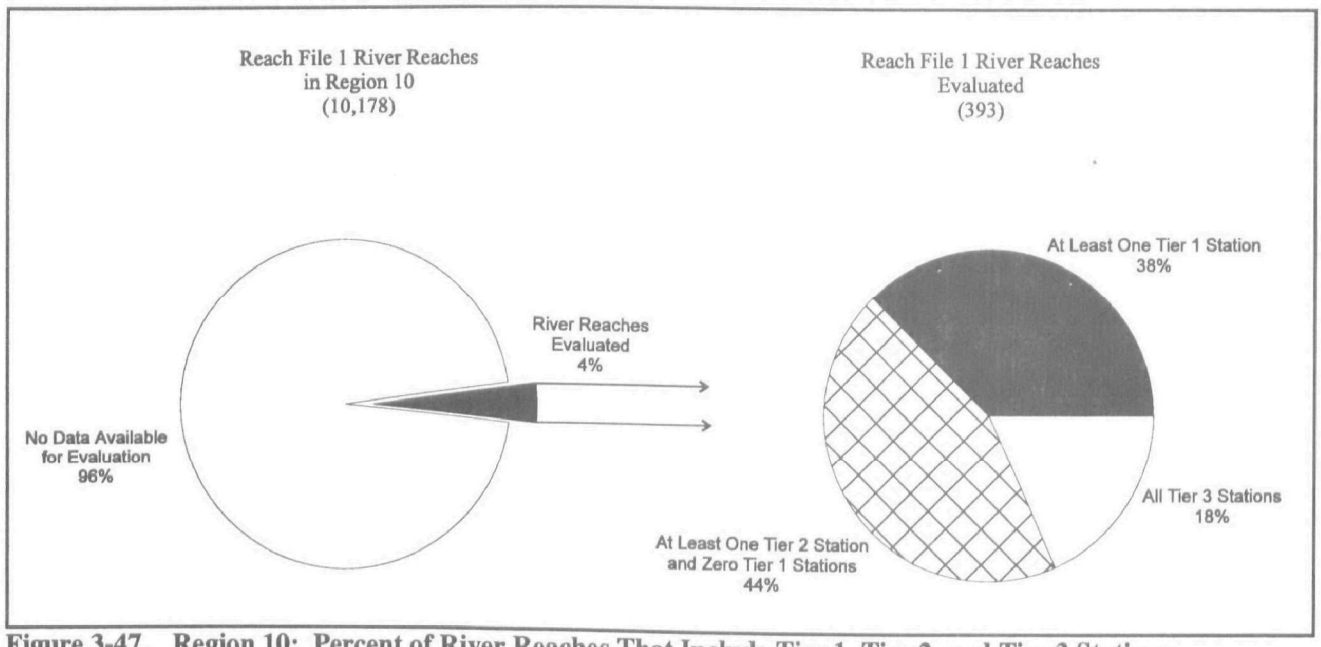


Figure 3-47. Region 10: Percent of River Reaches That Include Tier 1, Tier 2, and Tier 3 Stations.

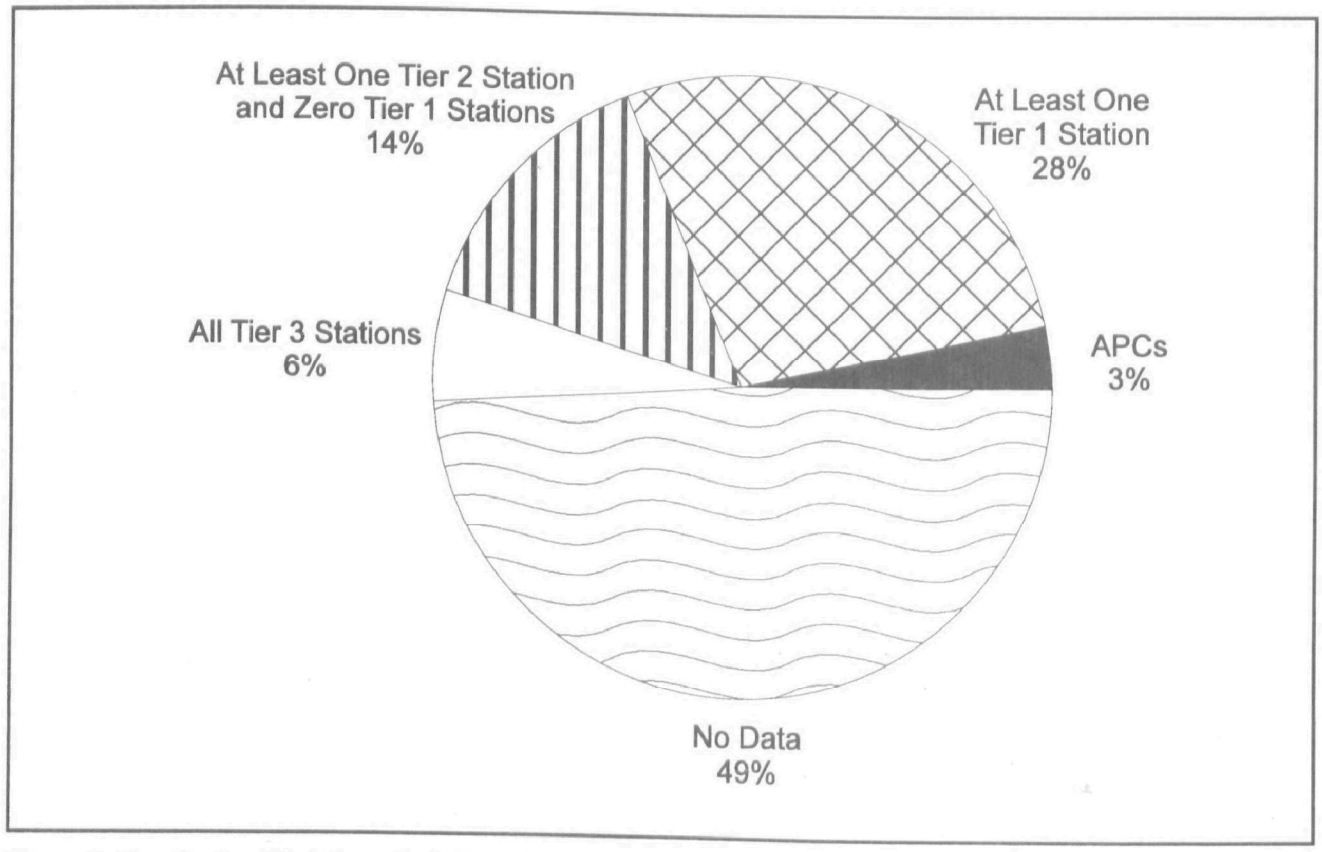


Figure 3-48. Region 10: Watershed Classifications.

Figure 3-49. Region 10: Location of Sampling Stations Categorized as Tier 1 or Tier 2 and Watersheds Identified as Areas of Potential Widespread Sediment Contamination (APCs).

Table 3-41. Region 10: Watersheds Identified as Areas of Potential Widespread Sediment Contamination

Cataloging Unit Number	Name	State(s)*	Number of Stations			Percent of Stations in Tier 1 or Tier 2
			Tier 1	Tier 2	Tier 3	
17110019	Puget Sound	WA	418	851	114	92
17110013	Duwamish	WA	48	69	10	92
17110002	Strait Of Georgia	WA	32	168	63	76
17030003	Lower Yakima	WA	23	19	5	89
17090012	Lower Willamette	OR	21	51	4	95
17110014	Puyallup	WA	12	6	1	95
17010303	Coeur D'Alene Lake	ID, (WA)	10	13	0	100

*No data were available for states listed in parentheses.

Table 3-42. Region 10: Water Bodies With Sampling Stations Categorized as Tier 1 That Are Located in Areas of Potential Widespread Sediment Contamination

Water Body	# of Tier 1 Stations	Water Body	# of Tier 1 Stations
Puget Sound	306	Lake Whatcom	2
Budd Inlet	41	Sammish Bay	2
Elliot Bay	41	Sammish River	2
Bainbridge Island	31	Whidbey Island	2
Sinclair Inlet	28	Spring Creek	2
Bellingham Bay	22	Thompson Lake	2
Yakima River	19	Ahtanum Creek	1
Willamette River	10	Camano Island	1
Carbon River	8	Duwamish Waterway	1
Columbia Slough	8	Fidalgo Island	1
Green River	6	Padden Lake	1
Coeur D'alene Lake	4	Port Orchard	1
Dyes Inlet	4	Port Susan	1
Puyallup River	4	Spanaway Lake	1
Coeur D'alene River	3	Toppenish Creek	1
Johnson Creek	3	White Hall Creek	1
Chambers Creek	2	Wolf Lodge Creek	1

Table 3-43. Region 10: Chemicals Most Often Responsible for Stations Being Categorized as Tier 1 or Tier 2[a]

	Chemical	# Tier 1 & Tier 2 Stations	# Tier 1 Stations	# Tier 2 Stations
Region 10 Overall	Copper	1,518	--	1,518
	Nickel	1,409	--	1,409
	Arsenic	1,231	55	1,176
	Lead	881	--	881
	Benzo(a)pyrene	803	103	700
	Pyrene	770	160	610
	Mercury	760	133	627
	Cadmium	754	--	754
	Polychlorinated biphenyls	710	289	421
	Dibenzo(a,h)anthracene	709	245	464
	Chrysene	704	86	618
	Benzo(a)anthracene	669	107	562
	Naphthalene	589	104	485
	Fluorene	547	77	470
	Chromium	546	17	529
Alaska	Chromium	135	12	123
	Arsenic	89	--	89
	Copper	50	--	50
	Nickel	41	--	41
	Cadmium	35	--	35
	Naphthalene	31	2	29
	Polychlorinated biphenyls	29	2	27
	Zinc	29	--	29
	Phenanthrene	26	--	26
	Fluorene	22	--	22
Idaho	Arsenic	39	13	26
	Polychlorinated biphenyls	32	28	4
	Lead	32	--	32
Idaho (continued)	Cadmium	29	--	29
	Copper	28	--	28
	Zinc	28	--	28
	DDT	25	--	25
	Dieldrin	21	--	21
	Toxaphene	14	--	14
	Silver	11	8	3
Oregon	Copper	125	--	125
	Nickel	107	--	107
	Arsenic	86	1	85
	Polychlorinated biphenyls	84	46	38
	DDT	73	19	54
	Zinc	59	--	59
	Mercury	53	7	46
	Cadmium	51	--	51
	Chromium	46	3	43
	Lead	44	--	44
Washington	Copper	1,315	--	1,315
	Nickel	1,256	--	1,256
	Arsenic	1,017	41	976
	Lead	788	--	788
	Benzo(a)pyrene	754	101	653
	Pyrene	735	156	579
	Mercury	683	121	562
	Chrysene	682	83	599
	Dibenzo(a,h)anthracene	681	240	441
	Benzo(a)anthracene	646	104	542

[a]Stations may be listed for more than one chemical.

Potentially Highly Contaminated Sites Not Identified by the NSI Evaluation

Several Regions and states provided comments on the May 16, 1994, preliminary evaluation of sediment chemistry data contained in the NSI. They identified receiving streams that should have been but were not identified as locations of potential adverse effects, based on the NSI data evaluation. The specific waterbodies that reviewers of the preliminary evaluation identified as potentially contaminated, but which are not presently included in the NSI because data are inadequate to categorize stations as Tier 1, are presented in Table 3-44 and Figure 3-50. If a water body had previously been identified as having at least one Tier 1 sampling station using the NSI evaluation methodology, it was not included in Table 3-34 or Figure 3-50.

Table 3-44. Potentially Highly Contaminated Sites Not Identified in the NSI Evaluation

Water Body	EPA Region	State	Chemicals Potentially Present
Onandaga Lake	2	NY	pesticides, metals, PAHs, PCBs
Ley Creek	2	NY	mercury
Kill van Kull	2	NY	metals, dioxin
Newtown Creek	2	NY	PAHs
Scajaquada Creek	2	NY	metals, PCBs
Skaneateles Creek	2	NY	PCBs
Hudson River	2	NY	PCBs
Southern reaches of the Maurice River	2	NJ	arsenic
Elizabeth River	3	VA	PAHs
James River	3	VA	kepone
Anacostia River	3	DC	chlordane, PCBs
Lake O' the Pines	6	TX	lead, zinc
Linneville Bayou	6	TX	lead, chromium
Humboldt River Basin	9	NV	selenium
Dry Lake	9	AZ	dioxin

Figure 3-50. Location of Potentially Highly Contaminated Sites Not Identified in the NSI Evaluation.

Chapter 4

Pollutant Sources

Toxic chemicals that accumulate in sediment and are associated with contamination problems enter the environment from a variety of sources. These sources can be broadly differentiated as point sources and nonpoint sources. The term "point source" is defined in the Clean Water Act (CWA) and generally refers to any specific outlet, such as a pipe or ditch, from which pollutants are discharged. In contrast, nonpoint sources do not have a single point of origin and generally include diffuse sources, such as urban areas or agricultural fields, that tend to deliver pollutants to surface water during and after rainfall events. Some sources, such as landfills and mining sites, are difficult to categorize as either a point or nonpoint source. Although they represent discrete sources, pollution from such land areas tends to result from rainfall runoff and leaching. Likewise, atmospheric deposition of pollutants, generally considered to be a nonpoint source of water pollution, arises from the emission of chemicals from discrete stationary and mobile source points of origin. The CWA specifies water vessels and other floating craft as point sources although, taken as a whole, they function as a diffuse source.

Many point and nonpoint pollutant sources have been the subject of federal and other action over the past 25 years. The direct discharge of pollutants to waterways from municipal sewage treatment and industrial facilities requires a federal permit under the CWA. Permitting authority, however, has been delegated to many states. These permits often contain technology-based or water quality-based pollutant discharge limits and monitoring requirements. More recently, replacement of aging combined sewer systems and other storm water control measures has addressed the discharge of pollutants from urban areas through municipal facilities. The dredging of sediment to maintain navigation channels is managed under both the CWA and the Marine Protection, Research, and Sanctuaries Act (MPRSA) to ensure that unacceptable degradation from chemical pollutants in the dredged material does not occur at the disposal location. Emission standards and controls on stationary and mobile sources of air pollutants have also been established in federal regulations promulgated under the authority of the Clean Air Act (CAA). These actions have reduced emissions of gaseous compounds such as inorganic oxides, as well as pollutants that eventually enter water bodies and accumulate in sediment. The Toxic Substances Control Act (TSCA) and Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) have greatly reduced the toxic pollutant input to the environment through bans and use restrictions on many pesticides and industrial-use chemicals.

Federal, state, and local laws have also addressed land-based pollutant sources. Under the Resource Conservation and Recovery Act (RCRA), the movement and disposal of pollutants in landfills and other repositories of hazardous waste are tracked and controlled. At sites where past disposal practices, either purposeful or accidental, have resulted in severe contamination, remediation has been undertaken under the federal Superfund laws. Where applicable, land development projects are approved contingent on an assessment of the environmental impact conducted under National Environmental Policy Act (NEPA) authority. Under the authority of the Coastal Zone Management Act (CZMA), EPA has developed nonregulatory management measures to reduce pollutant delivery via nonpoint sources, such as runoff from urban and agricultural areas.

The combined impact of these actions has yielded improvements in water quality. In at least some documented cases, pollutant levels in sediment are also decreasing. (For example, see the discussion of the Palos Verdes case study presented in Chapter 5.) However, improvement in sediment quality might lag behind improvement in overlying water because of the persistent nature of many pollutants, as well as the storage and sink functions of sediment, and because the most toxic bioaccumulative pollutants are difficult to monitor and regulate. It is beyond the scope of this baseline assessment to determine the temporal trends of pollutant concentrations in sediment on a national scale. Future reports to Congress will address that issue. This baseline assessment demonstrates that, at least from the perspective of the past 15 years, sediment contamination remains a significant and widespread problem.

Because of the high cost of remediation, the preferred solution to reducing health and environmental risks from contaminated sediment problems is natural recovery of contaminated sites through source reduction, contaminant degradation, and continuing deposition of clean

sediment. The feasibility of natural recovery, as well as the long-term success of expensive remediation projects, depends on the effective control of pollutant sources. For some classes of sediment contaminants, such as PCBs and organochlorine pesticides, use and manufacture bans or severe restrictions have been in place for many years. Past disposal and use of PCBs continue to result in evaporation of this contaminant from some landfills and leaching from soils, but most active PCB sources have been controlled. The predominant sources of organochlorine pesticides are runoff and atmospheric deposition from past applications on agricultural land, and occasional discharge from municipal treatment facilities. For other classes of sediment contaminants, active sources continue to contribute substantial environmental releases. For example, liberation of inorganic mercury from fuel burning and other incineration operations continues, as do urban runoff and atmospheric deposition of metals and PAHs. In addition, discharge limits for municipal and industrial point sources are based on either technology-based limits or state-adopted standards for protection of the water column, not necessarily for downstream protection of sediment quality. Understanding the local and far-field effects of individual point and nonpoint sources on sediment quality usually requires site-specific study.

The purposes of this chapter are to:

- Present by chemical class the extent of sediment contamination in the 96 watersheds identified as areas of potential widespread sediment contamination (APCs).
- Identify the major source categories of these chemical classes and summarize key studies that link these source categories to sediment contamination.
- Analyze land use patterns and the extent of sediment contamination by chemical class in the 96 APCs.
- Briefly describe current EPA efforts to further characterize point and nonpoint sources of sediment contaminants.

Extent of Sediment Contamination by Chemical Class

The individual chemicals evaluated for this report can be grouped into six chemical classes: metals, PCBs, pesticides, mercury, PAHs, and other organic chemicals. Pesticides include the organochlorine pesticide compounds assessed in this report, such as DDT and metabolites, dieldrin, and chlordane. PAHs include both low- and high-molecular-weight polynuclear aromatic hydrocarbons, and other organics include all organics not otherwise classified. Mercury is grouped separately from other metals because of its unique behavior in the environment (e.g., methylation and bioaccumulation potential) and because of recent attention focused on its impact as a primary sediment and fish contaminant of concern.

Figure 4-1 presents, by chemical class, the average percent of stations that are contaminated in the 96 APCs. For this analysis, the percent contamination is derived by taking the number of stations where an individual chemical constituent of a particular chemical class places a station into Tier 1 or Tier 2 and dividing by the total number of stations in the watershed. Each constituent, or any constituent representative of a chemical class, might not have been measured at all stations in the watershed. In addition, the total number of stations in each watershed varies extensively, as does the spatial extent of sampling within the watershed. The resulting percent contamination by chemical class varies a great deal—from 0 percent to 100 percent for each class—among the watersheds. Figure 4-1 presents the average value at both Tier 1 and combined Tier 1 and Tier 2 contamination levels.

Figure 4-1 indicates that at the Tier 1 level of contamination, PCBs are the dominant chemical class with an average extent of contamination of 29 percent. Among Tier 1 stations, all other classes of contaminants account for contamination at a lower percent of the stations on the average (6 to 10 percent). The relative importance of PCBs reflects, in part, the fact that a station can be designated Tier 1 for human health effects based on elevated fish tissue concentrations alone for this chemical class, whereas elevated levels in fish tissue and corresponding elevated levels in sediment are required for all other classes. At the combined Tier 1 and Tier 2 level of contamination, metals are the dominant chemical class measured by average extent of contamination (59 percent), followed by PCBs and pesticides (both at 43 percent), mercury (29 percent), and PAHs and other organics (19 and 14 percent, respectively). The very large increase in the relative importance of metals from Tier 1 to combined Tier 1 and Tier 2 also reflects the evaluation methodology because a divalent transition metal concentration cannot place a station into Tier 1 without an accompanying acid-volatile sulfide concentration ([AVS]) measurement, which is typically not available.

Figure 4-1 graphically displays the relative differences in certainty of assessing the probable effects of

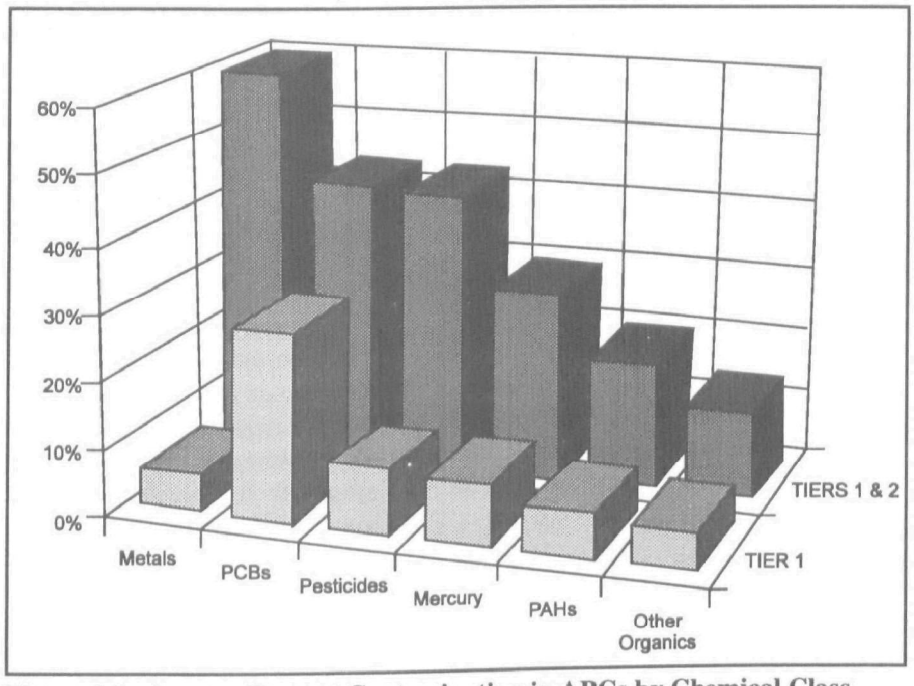


Figure 4-1. Average Percent Contamination in APCs by Chemical Class

metals versus assessing the effects of PCBs. More confidence can be placed in the assertion that PCBs exhibit a "higher probability of adverse effects" than in making this assertion for metals. The relatively high percent of PCB contamination at the Tier 1 level reflects the relative certainty that elevated PCB levels in fish are associated with elevated levels in sediment. The relatively low percent of metal contamination at the Tier 1 level primarily reflects the lack of confirming data (i.e., AVS) regarding important binding phases and bioavailability, not necessarily the lack of significance of metal contamination. In fact, the very high percent contamination indicated at the combined Tier 1 and Tier 2 level demonstrates the potential importance of this chemical class.

This analysis does not imply that certain chemical classes are always dominant, nor that other chemical classes can be dismissed altogether. In fact, contamination from constituents in any class may be of paramount importance in a given watershed or location. The differences in extent of chemical class contamination on the average in the 96 APCs is intended to provide some perspective to the ensuing sections of this chapter.

Major Sediment Contaminant Source Categories

To identify the important sources of sediment contaminants, EPA searched the scientific and technical literature for studies that link specific pollutant sources to evidence of sediment contamination. EPA focused this review on studies appearing in peer-reviewed journals and government reports published after 1980. The majority of studies related sediment contamination to a source through qualitative means, including associations of land use or specific activity with the types of contaminants detected, and spatial analyses. For example, organochlorine pesticide contamination is associated with agricultural land use where past application practices and hydrologic routes of rainfall runoff are known. Some researchers made the association with contamination source by more quantitative means such as loadings measurements, runoff or deposition estimates, or mass balance models of contaminant inputs. Most research has focused on the chemicals or chemical classes listed above. The studies reviewed attributed sediment contamination from the six classes of chemicals to four general nonpoint source categories and two general point source categories. Table 4-1 summarizes the correlations of source category to chemical class documented in literature.

Table 4-1 does not specifically list some important sources that are difficult to categorize as a point or nonpoint source. These sources include leachate from landfills, direct inputs from recreational and commercial boating, and disposal of contaminated dredged material. As mentioned at the beginning of this chapter, landfills are not easily classified as a point or nonpoint source. Evaporation and subsequent deposition of moderately volatile contaminants from landfills represent an atmospheric source, yet leachate is typically considered as neither "urban runoff" nor a controlled point source. Nonetheless, leachate from landfills is an important documented source of sediment contaminants. For example, landfill leachate and past effluent discharges from electronics manufacturers have contaminated New Bedford Harbor in Massachusetts with PCBs and heavy metals (Garton et al., 1996). Boating and shipping activities can be important sources of a variety of contaminants, including PAHs and anti-fouling paint additives such as tributyl tin and copper. As for dredged material disposal, past dredging operations to maintain navigation channels could be responsible for contaminated sediment at specifically designated dump sites. Dredging practices are currently managed under federal, state, and local authority to ensure that appropriate testing and safe dis-

Table 4-1. Correlations Among Sources and Chemical Class of Sediment Contaminants

Source/Chemical Class	Mercury	PCBs	PAHs	Metals	Pesticides	Other Organics
Harvested Croplands					★	
Inactive and Abandoned Mine Sites	●			●		
Atmospheric Deposition	●	●	●	●	●	●
Urban Sources	●		●	●	★	●
Industrial Discharges	●	★	●	●	★	●
Municipal Discharges	●	●	●	●	●	●

● Ongoing source
★ Source from past activities

posal occur. In addition to these sources, uncontrollable and accidental point source releases, such as improper disposal practices and spills, have occurred and continue to occur.

A notable feature of Table 4-1 is the extent to which multiple sources can be associated with each chemical class. This is the primary factor in making source assessment and effective source control such difficult tasks. The table does not provide any indication of which sources are the most significant. The significance of any given source depends on the areal extent of the source and intensity of the activity in the watershed. Because a variety of sources are present (or were present in the past) in most watersheds, and the extent and intensity of each source vary, the most important source of a particular chemical or class of chemical contaminants at a given location also varies. In addition, there is typically overlap among source categories. The most obvious overlap is between atmospheric deposition and urban sources. For example, fuel combustion in urban areas releases PAHs to the atmosphere, which are subsequently deposited in various parts of the watershed or transported to other areas.

Despite these cautions, the results of EPA's literature review allow some broad assertions regarding source associations. For harvested croplands, organochlorine pesticides are the major contaminants of concern. Inactive and abandoned mine sites contribute mercury and other heavy metals to sediment. Atmospheric deposition is a primary contributor of mercury, PCBs, and PAHs. Urban sources are most closely associated with metals and PAHs. Although permit monitoring records and industry-supplied release estimates, as well as specific spatial analysis studies, indicate that municipal and industrial discharges of sediment contaminants (particularly metals and other organics) continue, the relative contribution compared to nonpoint sources is an open question and undoubtedly varies substantially by watershed. A brief summary of the literature review for major source categories follows.

At many sites, elevated levels of pesticides in the Nation's sediment can be attributed to past agricultural practices. Crop growers deliberately apply pesticides to protect their yield from insects, fungus, and weeds. In the past, organochlorine compounds such as DDT and chlordane were used without restriction to rid harvested croplands of a broad range of unwanted species. These compounds tend to be persistent in the environment, adsorptive to soil and sediment particles, highly bioaccumulative in living tissue, and lethal to many non-target organisms. As these effects became apparent and regulatory authorities began restricting or banning the use of persistent pesticides in the United States, chemical manufacturers developed newer organophosphate pesticides that may be more easily degradable and, in some cases, more narrowly targeted to specific organisms. In addition, modern pesticides must undergo federal registration procedures designed to protect human health and the environment before they can be approved for intended new uses.

Although the current-use pesticides are applied throughout the country in large amounts, they are not frequently analyzed in routine sediment monitoring, nor are they frequently detected in sediment when included in monitoring studies (Pereira et al., 1994). Because of the lack of monitoring data, and the absence of available levels of concern in sediment, current-use pesticides were not included in this evaluation of sediment quality. However, these compounds exhibit toxicity to non-target organisms. Furthermore, although these compounds have shorter half-lives and greater water solubility than organochlorines in general, the chemical and physical properties of these compounds indicate significant bioconcentration potential (Willis and McDowell, 1983). Thus, further assessment of the presence of current-use pesticides in fish and sediment is warranted.

The discharge of pollutants from agricultural lands to surface water is largely driven by precipitation. Contaminants also reach the aquatic ecosystem via irrigation return flows through interflow or ground water seepage.

Most of the literature reviewed identifies agriculture as the source of pesticides in sediment because of upstream land use, chemical use, and the nature of the chemicals detected in sediments. Contamination of sediment associated with major agricultural areas of the United States has been reported in numerous studies. For example, the San Joaquin River, in the highly agricultural central valley of California, has bed-sediment concentrations of the pesticides DDT and dieldrin among the highest of all major rivers in the United States (Gilliom and Clifton, 1990). Researchers have also found continued elevated levels of highly persistent organochlorines in bottom-feeding fish, a condition that is often a consequence of sediment contamination. In the Yakima River in Washington, which drains a largely agricultural region, concentrations of DDT in fish for the years 1989-90 were found to be similar to concentrations for the years 1970-76 (USGS, 1993).

Contaminant contributions from past mining activities are so significant that several former mining sites in the United States have been included on the EPA Superfund Program's National Priorities List of sites for remediation, including the Clark Fork River Basin in Montana, the Bunker Hill Complex in Idaho, Whitewood Creek and the Belle Fourche River in South Dakota, Tar Creek in Oklahoma, Iron Mountain in California, and the Arkansas River and tributaries near Leadville, Colorado. The persistence and mobility of heavy metals have resulted in concentrations in sediments up to 65 miles downstream of discharge similar to the elevated concentrations found in the mine tailings themselves (Henny et al., 1994). Based on information provided by the states, the Bureau of Mines estimated that abandoned coal and metal mines and their associated wastes adversely affect more than 12,000 miles of rivers and streams and more than 180,000 acres of lakes and reservoirs (Kleinman, 1989).

The primary sediment contaminants of concern associated with mining are heavy metals such as lead, mercury, zinc, cadmium, copper, manganese, and silver. These metals are primarily associated with historical mining of silver, gold, lead, and zinc. A literature review of studies related to mining pollution provided publications describing the effects of mining on water quality; however, few researchers have directly addressed the effects of mining on sediments. A monitoring study performed on Idaho's Lake Coeur d'Alene surface sediment found that ores and wastes from a mining district were the source of elevated sediment concentrations of several heavy metals via transport down the Coeur d'Alene River (Horowitz et al., 1993). Moore et al. (1991) performed an integrated sediment-water-biota monitoring study on the effects of acid mine effluent on the Blackfoot River in Montana. These researchers found elevated levels of heavy metals in sediment from tributaries with known historical mine effluent input that were higher than levels in nonaffected tributaries. In another study from the gold mining region of northern Georgia, elevated mercury concentrations decreased as distance of the sampling sites from the mining district increased (Leigh, 1994). The author further suggests that similar occurrences of mercury contamination could exist throughout the gold mining region of the Southern Piedmont because of the historical amalgamation processes used by gold miners.

Atmospheric deposition is often identified as a major source of mercury, PCBs, and PAHs to aquatic systems. Studies have also implicated atmospheric sources as an important contributor of metals. Sources that emit large amounts of many toxic chemicals to the atmosphere include industrial point sources, fuel combustion in motor vehicles, volatilization of compounds from landfills and open water, combustion of wood and other fuels to produce heat, and waste incineration. In addition, long-range atmospheric transport of organochlorine pesticides from countries where their use is still permitted contributes these compounds to aquatic environments in this country (Keeler et al., 1993).

Atmospheric sources of mercury include coal combustion, waste incineration, and paint application. Sorensen et al. (1990) compared mercury levels in sediment cores from lakes in northern Minnesota with precipitation loadings from monitoring and concluded that, on the average, direct wet atmospheric deposition accounts for 60 percent of the mercury in lake sediment. A 1994 EPA report to Congress entitled *Deposition of Air Pollutants to the Great Waters* also describes mass balance studies from Wisconsin and Sweden indicating that atmospheric deposition is responsible for most of the mercury in lakes (USEPA, 1994a). The Swedish study also points out that mercury deposited onto forest soils is stored, for potentially long periods of time, before it enters the lake through storm water runoff. This further illustrates the relationship between atmospheric deposition and runoff.

Important sources of PCBs to the atmosphere include transformer leakage, electric power generation, industrial fuel combustion, landfills, sewage sludge combustion, and waste oil combustion. Researchers have developed a mass balance for PCBs in Lake Superior that indicates that approximately 77 to 89 percent of the annual PCB input to the lake is from atmospheric deposition (Baker et al., 1993, cited in USEPA, 1994a). These

researchers have also estimated the percent contribution of PCBs from atmospheric deposition for other Great Lakes, keeping track of the fraction contributed from atmospheric deposition to upstream lakes. For example, about 63 percent of PCB input to Lake Huron is from direct atmospheric deposition, an additional 15 percent is from atmospheric deposition to the upstream Lakes Superior and Michigan, and the remaining 22 percent is from other sources. Lakes Erie and Ontario receive only about 13 percent and 7 percent, respectively, of their annual PCB load from atmospheric sources.

Sources of atmospheric PAHs include stationary fuel combustion, industrial production facilities, transportation, solid waste incineration, and forest and prairie fires. Routine installation of catalytic converters in motor vehicles, as well as other combustion emission controls, have decreased PAH releases to the atmosphere. Atmospheric transport of PAHs generated during fuel combustion has often been inferred to account for the appearance of PAHs in soils and sediments in regions distant from known combustion sources, but quantification of this process is scarce in the literature (Prahl et al., 1984). Researchers typically state that the types of PAHs detected in sediments at a particular study site are indicative of combustion sources, thereby implying that atmospheric deposition is probably the primary source to the aquatic environment (Helfrich and Armstrong, 1986; Rice et al., 1993). In a rare attempt to quantify this contribution, Prahl et al. (1984) studied atmospheric particulate matter and surface sediment in Washington State coastal sediments and estimated that atmospheric transport accounted for about 10 percent of the PAHs in sediment. However, unlike the examination of PCBs in the Great Lakes described above, the authors did not account for the atmospheric contribution to upstream waterborne inputs.

Metals are released to the atmosphere from sources such as primary and secondary metal production and, in the past, use of leaded gasoline. Mass balance studies of metal inputs to the aquatic environment have identified atmospheric deposition as an important contributor, but less significant than riverine and upstream sources. As was the case with the PAH mass balance in Washington, these studies do not identify the atmospheric portion of riverine or upstream sources. In one study, estimates of loadings to Narragansett Bay, Rhode Island, indicated that atmospheric deposition contributes 2 percent of copper and zinc and 33 percent of lead in sediment (Bricker, 1993). Based on a mass balance study on Delaware Bay, direct atmospheric deposition accounts for 7 percent of the cadmium loading to the bay; rivers (72 percent) and salt marshes (21 percent) account for the remaining cadmium input. Some portion of the riverine input originates from the air (USEPA, 1994a).

Atmospheric deposition is a significant source of dioxins and furans found in sediment. These highly persistent compounds are grouped with "other organics" in Figure 4-1. A recent review indicated that incineration of industrial and municipal waste, residential and industrial wood combustion, and electric power generation may be the most important sources of dioxins and furans in the environment (Johnson et al., 1992).

The category "urban sources" refers broadly to runoff from roadways, residential and commercial areas, construction sites, and marinas and shipyards. According to EPA's National Urban Runoff Program (NURP) studies, the principal toxic pollutants found in urban runoff are metals, oil and grease, PAHs, and petroleum hydrocarbons (USEPA, 1992b). Much of the pollution in urban runoff is associated with atmospheric deposition, particularly for mercury and PAHs. Other classes of chemicals, such as metals and petroleum hydrocarbons, have many land-based sources. Lead was formerly contributed by car exhaust, but most contributions now come from exterior paints and industrial runoff. Cadmium is also associated with paints. Zinc is associated with weathering and abrasion of galvanized iron and steel. Car brake linings and leaching and abrasion of copper pipes and brass fittings contribute copper to runoff. Chromium is contributed to runoff through car and machinery corrosion (Cohn-Lee and Cameron, 1991). Sources of petroleum hydrocarbons include disposal of automobile and industrial lubricants, spillage from oil storage facilities, and leakage from motor vehicles (Brown et al., 1985). In addition to agricultural uses, organochlorine pesticides were also used extensively in urban and residential areas for a variety of pest control purposes.

The association of urban sources and metal enrichment of sediment is well documented in the literature. For example, a study of storm water detention ponds in Florida, Virginia, Maryland, and Minnesota found that metal concentrations in surface sediments were typically 5 to 30 times higher than those in the parent soils (Schueler, 1994). This study also reported the highest metal concentrations in ponds associated with industrial land use, followed by those associated with roads and commercial land use, then those associated with residential land use. In contrast to atmospheric transport, which can carry pollutants far from their original source, runoff of metals tends to affect areas in close proximity to the source. For example, Yousef et al. (1985) sampled water and sediments in detention ponds in Florida and found that metals from highway runoff are retained by

bottom sediments close to the point of entry to the waterway.

Hydrocarbons, PAHs, and mercury are also frequently associated with urban sources. Using analytical chemistry techniques, Brown et al. (1985) discovered that crankcase oil was a primary contributor to sediment hydrocarbon contamination in Tampa, Florida. Gas chromatograms of used crankcase oil, storm water runoff, and sediment samples all showed similar peaks, indicating that the type of petroleum found in sediment very closely resembled that found in storm water runoff. Sources of PAHs that are concentrated in urban areas include emissions from commercial and residential fuel-burning furnaces and vehicular emissions. An inventory of sediment contamination in Casco Bay, Maine, showed that the highest PAH concentrations occurred at locations closest to the city of Portland (Kennicutt et al., 1994). Mastran et al. (1994) found that sediments from urban areas tend to have lower fluoranthene/pyrene ratios than those from remote areas. These ratios are indicative of pollution caused by gas exhaust residues in urban runoff. A study of ambient air in the southern Lake Michigan basin revealed that mercury concentrations, both gaseous and particulate, are significantly higher (approximately 5 times higher) in the Chicago urban/industrial area than levels measured at the same time in surrounding areas (Keeler, 1994, as reported in USEPA, 1994a).

In addition to the nonpoint source categories discussed above, municipal and industrial point sources have been associated with sediment contaminated by each of the chemical classes examined in this report. Much of this contamination has been caused by past industrial and municipal discharges. For example, sediment core samples from southwestern Long Island, New York, revealed levels of metals that increased to several times the preindustrial concentrations, then decreased approximately 50 percent between the mid-1960s and late 1980s. PCBs, chlordane, and other chlorinated organics in sediment also decreased between the late 1960s and the late 1980s. Local improvements in wastewater treatment and national efforts to restrict the use of specific chemicals are cited as explanations for the declines (Bopp et al., 1993). As previously mentioned, past effluent discharges from electronics manufacturers are linked to PCB contamination in New Bedford Harbor, Massachusetts (Garton et al., 1996; Lake et al., 1992). Perhaps the best example of pesticide contamination in sediment from past industrial activity is kepone in the James River, Virginia. Kepone escaped undetected from a manufacturing site for over 9 years and contaminated miles of the James (Nichols, 1990).

A well-documented case of the effects of point sources on sediment quality is the Newark Bay estuary in New Jersey, which encompasses the Passaic River, Hackensack River, Kill van Kull, and Arthur Kill. Wenning et al. (1994) examined sediment core samples from the lower Passaic River in New Jersey and concluded that the sediment is heavily contaminated with PCBs, PAHs, and metals from recent and historical municipal and industrial discharges from local and upstream sources. The authors identify industrial effluent, either directly discharged or released through combined sewer overflows, as the most likely primary source. Researchers have also measured high levels of dioxin in sediment in the estuary adjacent to an industrial site in Newark where chlorinated phenols had been produced (Bopp et al., 1991). In a recent study, researchers determined that the magnitude of current loading estimates for metals and organics from major sources, such as industrial and municipal discharges and combined sewer overflows, likely exceeds the capacity of the Newark Bay estuary to absorb and dilute the various waste streams (Crawford et al., 1995).

EPA has conducted an inventory and analysis of point source releases of sediment contaminants in the United States. This inventory includes examination of data from effluent monitoring required by discharge permits and chemical release estimates provided by industry under the community right-to-know provision of the Superfund Amendments and Reauthorization Act of 1986 (SARA). Permit monitoring data indicate that municipal sewage treatment plants and major industrial facilities discharge all chemical classes of sediment contaminants. Metals are monitored at the greatest number of facilities and released in the largest amounts. Mercury, PAHs, and other organics are also released from many facilities. PCBs and pesticides are less frequently monitored, and a relatively small number of records indicate positive detections. Industry-supplied release estimates provided under SARA indicate that manufacturing facilities transfer the majority of their sediment contaminants, primarily metals and other organics, to municipal sewage treatment plants. The analysis of these data addresses the hazard potential, but does not indicate whether these discharges actively contribute to documented cases of sediment contamination.

Land Use Patterns and Sediment Contamination

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). The previous section of this chapter provided numerous examples of these relationships from published studies. For this report, EPA examined the relationship between the extent of sediment contamination by chemical class and patterns of land use in the 96 areas of potential widespread sediment contamination (APCs). EPA identified individual watersheds where land use appears to provide important information concerning the types of contaminants present, and summarized general trends that emerge by looking at the percent of urban and agricultural land areas in watersheds.

This analysis was based on a comparison of the extent of contamination by chemical class (described earlier in this chapter) within each watershed to the percent of land area developed for certain uses within the watershed. EPA used the Agency's modeling tool, Better Assessment Science Integrating Point and Nonpoint Sources (BASINS), for spatial analysis to quickly obtain land use data originally compiled by the U.S. Geological Survey (USGS) on a watershed basis. Although these land use data might be as much as 20 years old, the data compiled for the NSI have also been collected over the past 15 years. The original land use data are divided into 10 categories. EPA combined residential, commercial/industrial, and other urban land uses in the "total urban" land use category for this analysis. EPA also combined cropland and other agricultural land/rangeland in a "total agricultural" land use category. This allowed comparison of attributes such as the percent of stations with pesticide contamination and the percent total agricultural land use.

Several difficulties are associated with this approach to comparing land use to the evaluation of NSI sampling stations. First, the frequency and spatial extent of sampling data in the NSI vary by watershed. A greater amount of sampling in areas thought to be contaminated will yield a larger number, and larger percentage, of Tier 1 and Tier 2 sites. Second, acreage of a land use activity is not indicative of the *intensity* of that use. For example, a small amount of land in a watershed might be devoted to an industrial activity that contributes a large amount of pollution. Most watersheds contain at least a small fraction of each land use activity. There are also problems of scale. Localized problems in specific reaches might be caused by land use activity in the immediate vicinity of the reach rather that the overall land use in the watershed. Lastly, many individual pollutants and chemical classes are associated with multiple types of sources. Some classes of pollutants, like the highly persistent PCBs, have been cycled in the environment for many years and transported far from their original source. These chemicals could not be expected to be associated with any general land use category.

Table 4-2 lists each of the 96 APCs with the number of Tier 1 and Tier 2 stations by chemical class and the percent land use information. In general, EPA found that a diversified set of land uses yields a diversified set of pollutants. However, in some cases a preponderance of one land use type is associated with expected chemical classes of sediment contaminants. For example, the Lower Yakima watershed in Washington, an intensive fruit and vegetable growing region, is approximately 81 percent agricultural and only 2 percent urban. In this watershed, nearly 90 percent of the sampling stations were contaminated with pesticides, whereas no stations exhibited mercury contamination and less than 10 percent exhibited contamination from metals or PAHs. These percentages were substantially different from the average values presented in Figure 4-1. Similar findings were evident in other highly agricultural watersheds, such as the Tulare-Buena Vista Lakes in California.

In some cases, the absence of a particular land use in a watershed can provide clues about the source of in-place contaminants. Some watersheds, such as the Lower Mississippi-New Orleans in Louisiana and the Hackensack-Passaic in New Jersey, have very low agricultural land usage, yet a high percentage of contamination from pesticides. High levels of contaminants in recent sediment deposition may indicate upstream delivery of contaminants, whereas high levels in buried sediment may be indicative of pesticide manufacture/formulation or urban applications in the past. In the Coeur D'Alene watershed in Idaho, there is very little agricultural land use and almost no urban land use. In this watershed, where mining is a known source of contamination, over 90 percent of the stations exhibited metal contamination, whereas none indicated PAH or pesticide contamination. In other watersheds with very low percent urbanization, there was substantial contamination from all chemical classes except PAHs. This phenomenon was evident in several nonurbanized watersheds in the Southeast and upper Midwest, such as Pickwick Lake and Guntersville Lake. Further examination of percent agricultural and urban land use revealed some general trends that are illustrated by these examples.

A high percentage of agricultural land use in a watershed tended to correspond with a markedly higher percent contamination from pesticides and lower percent contamination from metals, mercury, and PAHs. This phenomenon is presented graphically in Figure 4-2 and in tabular form on Table 4-3. For this analysis, EPA grouped watersheds into quartiles based on percent total

Table 4-2. Tier 1 and Tier 2 Station Classification by Chemical Class and Land Uses in Areas of Potential Widespread Sediment Contamination (APCs)

			Number of Stations With a Probability of Adverse Effects									Percent of Total Area in Each Watershed									
EPA Reg.	Cataloging Unit #	Name	Tier	Mercury	Other Metals	PCBs	Pesticides	PAHs	Other	All Chemicals*	Total # of Stations	Residential	Commercial/ Industrial	Other Urban	Cropland	Other Agricultural	Forestland	Bays & Estuaries	Other Water	Other	Missing/ Unknown
1	01090001	Charles	TIER1	146	68	35	8	11	1	195	708	25.43%	5.95%	4.56%	3.06%	0.04%	39.57%	7.82%	5.86%	1.47%	6.23%
			TIER2	216	486	54	50	50	0	402											
1	01090004	Narragansett	TIER1	8	18	4	3	2	0	28	48	13.74%	3.58%	4.61%	7.41%	0.86%	51.56%	9.96%	6.27%	1.14%	0.88%
			TIER2	20	27	17	18	22	0	20											
1	01090002	Cape Cod	TIER1	6	3	8	1	5	0	15	108	5.90%	0.81%	1.77%	1.84%	4.12%	22.90%	35.05%	4.26%	1.37%	21.98%
			TIER2	27	60	33	33	34	0	73											
2	04120103	Buffalo-Eighteenmile	TIER1	20	7	29	29	43	29	59	101	8.27%	3.54%	3.20%	42.85%	0.10%	30.94%	10.31%	0.35%	0.43%	0.02%
			TIER2	45	79	31	31	17	15	33											
2	02030103	Hackensack-Passaic	TIER1	21	12	13	23	10	4	43	103	33.33%	7.24%	5.65%	2.62%	0.26%	38.99%	0.00%	6.94%	1.33%	3.64%
			TIER2	39	75	34	42	15	19	58											
2	04130001	Oak Orchard-Twelvemile	TIER1	10	20	4	8	4	2	39	86	2.25%	44.43%	1.25%	10.48%	3.29%	8.42%	26.77%	2.78%	0.29%	0.04%
			TIER2	30	61	15	20	12	13	46											
2	02030104	Sandy Hook-Staten Island	TIER1	53	40	19	17	12	20	60	100	30.58%	10.23%	7.70%	6.99%	0.49%	7.83%	13.66%	7.27%	2.22%	13.03%
			TIER2	11	30	9	19	29	5	21											
2	04120104	Niagara	TIER1	5	0	17	13	19	16	24	41	9.35%	32.02%	3.91%	31.59%	0.24%	17.47%	0.02%	3.61%	0.92%	0.87%
			TIER2	16	29	9	11	9	16	16											
2	04150301	Upper St. Lawrence	TIER1	5	0	21	3	8	9	21	31	1.51%	0.85%	1.29%	36.31%	0.75%	28.47%	0.06%	26.73%	0.21%	3.82%
			TIER2	8	17	5	11	6	5	5											
2	02030105	Raritan	TIER1	1	1	4	5	1	1	13	65	15.15%	4.87%	2.99%	25.86%	0.49%	26.55%	0.00%	2.65%	1.01%	20.43%
			TIER2	11	39	25	27	4	3	37											
2	02040301	Mullica-Toms	TIER1	2	0	2	2	1	5	10	42	8.54%	1.71%	1.18%	6.04%	0.52%	43.11%	7.97%	20.75%	2.32%	7.86%
			TIER2	10	24	10	11	15	4	22											
2	02040105	Middle Delaware-Musconetcong	TIER1	1	1	8	1	1	0	11	48	5.49%	1.53%	1.26%	38.02%	0.16%	33.98%	0.00%	2.68%	0.67%	16.22%
			TIER2	3	19	13	20	2	0	26											
2	02030202	Southern Long Island	TIER1	7	4	1	4	1	2	11	43	23.38%	5.03%	5.06%	4.29%	0.74%	10.73%	19.75%	3.26%	1.88%	25.88%
			TIER2	12	25	8	8	14	2	24											
3	02060003	Gunpowder-Patapsco	TIER1	2	3	15	0	1	0	17	29	13.47%	5.10%	4.32%	40.80%	0.11%	26.70%	4.62%	4.11%	0.76%	0.01%
			TIER2	6	19	4	21	7	4	7											
3	02040203	Schuylkill	TIER1	0	1	11	0	0	2	12	44	9.17%	2.68%	2.78%	41.37%	0.26%	25.81%	0.00%	0.65%	2.46%	14.82%
			TIER2	5	16	6	14	0	0	23											
3	05030101	Upper Ohio	TIER1	0	0	12	0	0	0	12	53	13.08%	2.52%	2.18%	35.26%	0.34%	43.13%	0.00%	1.07%	2.42%	0.00%
			TIER2	0	29	0	9	0	1	29											
3	02070004	Conococheague-Opequon	TIER1	0	0	11	0	0	1	11	29	1.88%	0.98%	0.89%	50.58%	1.55%	43.24%	0.00%	0.51%	0.34%	0.02%
			TIER2	2	17	1	13	0	0	12											
3	02040202	Lower Delaware	TIER1	1	1	12	5	1	5	18	57	26.68%	13.51%	6.47%	21.76%	1.90%	18.45%	0.18%	9.61%	1.17%	0.27%
			TIER2	7	23	20	33	2	0	29											
3	05030102	Shenango	TIER1	0	0	11	0	0	0	11	15	3.93%	0.76%	2.20%	74.41%	0.02%	12.85%	0.00%	5.36%	0.44%	0.02%
			TIER2	0	2	0	8	0	0	1											
3	04120101	Chautauqua-Conneaut	TIER1	1	0	18	0	3	4	21	110	4.07%	1.13%	2.05%	38.07%	0.21%	21.58%	31.10%	0.18%	0.21%	1.40%
			TIER2	22	101	15	20	29	13	86											
4	06010201	Watts Bar Lake	TIER1	5	0	58	0	0	1	63	89	9.71%	1.84%	1.29%	27.72%	0.06%	52.32%	0.00%	5.20%	1.87%	0.01%
			TIER2	5	10	2	14	0	1	7											
4	06010207	Lower Clinch	TIER1	46	19	24	0	4	3	61	79	11.76%	1.74%	1.24%	24.98%	0.04%	56.28%	0.00%	2.16%	1.63%	0.16%
			TIER2	11	33	0	7	14	20	14											
4	06030005	Pickwick Lake	TIER1	8	1	45	1	0	0	49	69	1.93%	0.60%	0.33%	40.73%	0.07%	44.51%	0.00%	4.07%	1.35%	6.41%
			TIER2	11	24	2	23	0	2	9											
4	06020001	Middle Tennessee-Chickamauga	TIER1	14	1	16	1	26	7	47	94	8.14%	1.58%	1.19%	19.50%	0.04%	64.76%	0.00%	3.34%	1.44%	0.00%
			TIER2	15	57	1	12	0	9	29											
4	03080103	Lower St. Johns	TIER1	7	0	5	3	22	2	32	188	6.99%	1.71%	1.57%	9.03%	1.72%	51.60%	0.00%	25.04%	1.98%	0.36%
			TIER2	35	76	18	48	57	1	111											

Table 4-2. (Continued)

			Number of Stations With a Probability of Adverse Effects									Percent of Total Area in Each Watershed									
EPA Reg.	Cataloging Unit #	Name	Tier	Mercury	Other Metals	PCBs	Pesticides	PAHs	Other	All Chemicals*	Total # of Stations	Residential	Commercial/ Industrial	Other Urban	Cropland	Other Agricultural	Forestland	Bays & Estuaries	Other Water	Other	Missing/ Unknown
4	06030001	Guntersville Lake	TIER1	7	1	15	3	0	0	25	92	0.97%	0.33%	0.23%	40.41%	0.05%	52.24%	0.00%	5.18%	0.55%	0.05%
			TIER2	36	60	0	11	0	0	46											
4	03130002	Middle Chattahoochee-Lake Harding	TIER1	0	1	19	4	0	7	21	27	4.86%	0.77%	0.95%	15.41%	0.12%	75.59%	0.00%	0.98%	1.27%	0.05%
			TIER2	3	8	3	14	2	2	4											
4	03060106	Middle Savannah	TIER1	11	11	19	3	2	6	20	36	3.75%	1.78%	0.81%	16.90%	0.18%	62.67%	0.00%	12.10%	1.80%	0.00%
			TIER2	6	10	3	13	2	2	11											
4	03140102	Choctawhatchee Bay	TIER1	0	7	2	9	2	0	19	51	3.04%	4.94%	1.10%	3.03%	0.01%	61.80%	17.57%	3.14%	1.25%	4.13%
			TIER2	14	32	9	11	15	0	23											
4	06040005	Kentucky Lake	TIER1	0	0	14	0	0	1	15	30	1.25%	0.33%	0.26%	25.78%	0.00%	58.59%	0.00%	13.00%	0.76%	0.03%
			TIER2	9	25	0	2	0	2	14											
4	06040001	Lower Tennessee-Beech	TIER1	1	0	14	0	0	1	15	25	0.38%	0.12%	0.20%	28.06%	0.01%	65.47%	0.00%	3.01%	1.82%	0.94%
			TIER2	1	11	0	13	0	0	6											
4	06020002	Hiwassee	TIER1	1	0	12	0	0	2	13	33	2.65%	0.51%	0.58%	18.99%	0.11%	58.13%	0.00%	1.63%	1.77%	15.63%
			TIER2	6	18	0	6	0	0	17											
4	08010100	Lower Mississippi-Memphis	TIER1	1	1	12	0	0	4	14	20	0.57%	0.88%	0.35%	49.87%	0.06%	21.07%	0.00%	25.08%	2.09%	0.03%
			TIER2	0	3	2	15	0	0	3											
4	06010104	Holston	TIER1	3	1	10	0	0	2	12	15	4.73%	1.14%	0.45%	44.35%	0.01%	43.72%	0.00%	5.29%	0.30%	0.00%
			TIER2	3	6	1	4	0	0	2											
4	03040201	Lower Pee Dee	TIER1	1	0	7	5	0	2	11	34	2.02%	0.55%	0.47%	32.03%	0.20%	54.90%	0.01%	9.43%	0.38%	0.01%
			TIER2	16	16	1	16	1	0	20											
4	03160205	Mobile Bay	TIER1	11	13	2	1	4	0	31	81	4.22%	0.91%	0.97%	2.68%	0.43%	9.60%	18.20%	1.97%	0.33%	60.70%
			TIER2	14	38	6	16	21	0	43											
4	08030209	Deer-Steele	TIER1	0	0	0	11	0	0	11	21	1.29%	0.57%	0.77%	74.35%	0.91%	18.66%	0.00%	3.34%	0.03%	0.08%
			TIER2	0	7	0	10	0	0	10											
4	03140107	Perdido Bay	TIER1	8	0	1	0	1	1	10	38	8.04%	2.35%	1.12%	2.59%	0.16%	14.87%	8.08%	4.77%	1.61%	56.39%
			TIER2	8	15	3	0	9	0	24											
4	03060101	Seneca	TIER1	1	1	9	3	0	0	10	16	0.54%	0.02%	0.02%	0.12%	0.00%	13.24%	0.00%	0.58%	0.36%	85.13%
			TIER2	1	8	2	1	0	0	3											
5	04090004	Detroit	TIER1	42	21	74	42	53	38	85	115	42.87%	12.65%	8.99%	24.55%	0.18%	5.95%	0.78%	2.29%	1.74%	0.00%
			TIER2	27	90	31	7	19	17	29											
5	07120003	Chicago	TIER1	21	23	34	18	0	0	64	103	36.16%	19.12%	8.10%	20.63%	0.00%	4.45%	8.76%	1.14%	1.63%	0.00%
			TIER2	27	52	16	37	0	0	36											
5	07120004	Des Plaines	TIER1	12	4	54	11	0	1	61	110	21.71%	9.97%	6.61%	48.40%	0.31%	7.47%	0.00%	2.04%	3.48%	0.00%
			TIER2	18	53	24	76	0	0	43											
5	04040003	Milwaukee	TIER1	5	6	43	6	20	14	60	90	11.83%	5.78%	4.20%	66.30%	0.08%	6.64%	0.10%	4.68%	0.41%	0.00%
			TIER2	22	38	3	32	6	15	16											
5	04030204	Lower Fox	TIER1	21	3	41	8	5	5	49	51	8.94%	5.28%	2.88%	76.15%	0.04%	3.43%	0.11%	2.19%	0.98%	0.00%
			TIER2	5	27	1	16	14	19	2											
5	04040001	Little Calumet-Galien	TIER1	10	14	40	9	7	10	45	89	7.34%	6.16%	2.59%	37.11%	0.22%	12.87%	30.51%	2.12%	1.08%	0.00%
			TIER2	24	48	6	12	0	3	26											
5	04040002	Pike-Root	TIER1	5	4	28	3	1	1	34	72	12.02%	5.19%	4.10%	33.68%	0.04%	0.93%	43.58%	0.18%	0.29%	0.00%
			TIER2	16	40	11	16	3	3	30											
5	07140201	Upper Kaskaskia	TIER1	0	0	23	14	0	0	31	55	1.19%	0.39%	0.69%	90.79%	0.02%	5.83%	0.00%	1.05%	0.04%	0.00%
			TIER2	4	8	6	38	0	0	24											
5	07010206	Twin Cities	TIER1	0	0	26	0	0	0	26	35	21.99%	5.24%	5.12%	48.03%	0.03%	4.39%	0.00%	14.24%	0.95%	0.00%
			TIER2	1	2	0	5	0	1	2											
5	07140106	Big Muddy	TIER1	2	2	20	0	0	0	23	94	1.96%	0.91%	0.66%	70.37%	0.51%	20.43%	0.00%	3.60%	1.56%	0.00%
			TIER2	14	61	13	39	0	0	65											
5	07070003	Castle Rock	TIER1	0	0	20	0	0	2	20	22	1.05%	0.53%	0.55%	40.77%	0.05%	37.43%	0.00%	18.97%	0.64%	0.00%
			TIER2	2	1	0	5	0	0	0											

Table 4-2. (Continued)

			Number of Stations With a Probability of Adverse Effects									Percent of Total Area in Each Watershed									
EPA Reg.	Cataloging Unit #	Name	Tier	Mercury	Other Metals	PCBs	Pesticides	PAHs	Other	All Chemicals[a]	Total # of Stations	Residential	Commercial/ Industrial	Other Urban	Cropland	Other Agricultural	Forestland	Bays & Estuaries	Other Water	Other	Missing/ Unknown
5	04100002	Raisin	TIER1	1	0	17	7	1	0	18	38	2.25%	1.00%	0.74%	87.13%	0.15%	5.46%	0.01%	2.90%	0.35%	0.00%
			TIER2	2	7	17	13	2	6	19											
5	04050001	St. Joseph	TIER1	0	1	3	7	7	3	17	32	3.08%	1.42%	1.02%	79.21%	1.25%	9.23%	0.03%	4.45%	0.31%	0.00%
			TIER2	0	18	0	5	2	6	9											
5	07040003	Buffalo-Whitewater	TIER1	0	0	17	0	0	0	17	26	0.74%	0.29%	0.40%	54.93%	0.05%	37.00%	0.00%	6.50%	0.08%	0.00%
			TIER2	1	2	0	6	0	0	3											
5	04110001	Black-Rocky	TIER1	2	0	12	7	21	9	24	59	11.18%	2.79%	4.40%	66.45%	0.20%	11.11%	3.20%	0.38%	0.29%	0.00%
			TIER2	23	54	7	4	2	1	31											
5	07120006	Upper Fox	TIER1	0	0	15	0	0	0	15	60	10.36%	2.44%	2.38%	63.18%	0.61%	10.84%	0.00%	7.42%	2.77%	0.00%
			TIER2	12	37	14	27	0	0	40											
5	05120111	Middle Wabash-Busseron	TIER1	7	0	9	0	0	0	15	33	2.49%	0.92%	1.02%	79.64%	0.09%	13.31%	0.00%	1.50%	1.03%	0.00%
			TIER2	9	23	8	30	0	0	17											
5	07140202	Middle Kaskaskia	TIER1	1	0	5	8	0	0	13	38	1.21%	0.40%	0.60%	78.52%	0.09%	16.06%	0.00%	3.01%	0.10%	0.00%
			TIER2	4	16	6	22	0	0	22											
5	07040001	Rush-Vermillion	TIER1	0	0	13	0	0	1	13	14	1.38%	0.59%	0.44%	80.68%	0.06%	9.43%	0.00%	7.07%	0.34%	0.00%
			TIER2	2	3	0	3	0	0	1											
5	05120109	Vermilion	TIER1	8	0	4	0	0	0	12	28	3.92%	1.00%	0.73%	90.08%	0.10%	3.51%	0.00%	0.15%	0.50%	0.00%
			TIER2	2	19	1	26	0	0	16											
5	04030108	Menominee	TIER1	5	4	5	0	2	1	12	21	0.55%	0.17%	0.29%	10.13%	0.01%	67.58%	0.01%	20.94%	0.31%	0.01%
			TIER2	8	7	1	2	7	0	6											
5	04090002	Lake St. Clair	TIER1	1	2	10	8	5	9	13	19	18.44%	3.81%	2.35%	28.70%	0.00%	3.60%	38.06%	4.87%	0.17%	0.00%
			TIER2	10	13	6	8	8	5	5											
5	07140101	Cahokia-Joachim	TIER1	4	1	11	2	0	5	18	56	10.64%	4.50%	4.32%	42.42%	0.11%	33.25%	0.00%	3.85%	0.92%	0.00%
			TIER2	8	25	11	41	0	0	34											
5	04100010	Cedar-Portage	TIER1	3	0	3	3	3	3	13	56	1.85%	1.28%	1.44%	73.80%	0.07%	1.56%	17.41%	2.10%	0.49%	0.00%
			TIER2	24	46	0	4	15	9	39											
5	04100001	Ottawa-Stony	TIER1	0	1	12	3	4	3	13	29	6.73%	2.43%	2.93%	75.57%	0.30%	6.19%	3.84%	1.12%	0.89%	0.00%
			TIER2	5	16	3	10	3	7	15											
5	07130001	Lower Illinois-Senachwine Lake	TIER1	3	0	8	0	0	0	11	21	2.04%	1.04%	0.51%	82.55%	0.04%	8.96%	0.00%	4.04%	0.82%	0.00%
			TIER2	6	12	9	15	0	0	10											
5	04030102	Door-Kewaunee	TIER1	0	0	12	0	0	0	12	20	0.77%	0.35%	0.46%	38.47%	0.87%	10.63%	42.55%	5.63%	0.25%	0.00%
			TIER2	0	8	0	6	2	0	5											
5	04060103	Manistee	TIER1	2	1	3	2	10	0	11	14	0.45%	0.20%	0.30%	17.77%	0.14%	73.75%	0.00%	6.82%	0.57%	0.00%
			TIER2	7	11	11	12	4	7	3											
5	05040001	Tuscarawas	TIER1	0	8	1	2	0	0	10	78	10.00%	1.64%	1.71%	53.74%	0.04%	30.05%	0.00%	0.97%	1.85%	0.00%
			TIER2	0	55	0	4	2	4	53											
5	07090006	Kishwaukee	TIER1	0	0	10	0	0	0	10	34	2.25%	1.05%	0.99%	91.45%	0.38%	2.99%	0.00%	0.30%	0.58%	0.00%
			TIER2	1	12	4	34	0	0	24											
5	04100012	Huron-Vermilion	TIER1	0	0	5	0	0	5	10	45	1.63%	0.54%	0.91%	85.38%	0.17%	6.86%	3.93%	0.27%	0.27%	0.04%
			TIER2	21	45	3	0	17	5	35											
5	04110003	Ashtabula-Chagrin	TIER1	5	5	9	1	2	7	10	31	18.31%	3.14%	5.37%	39.91%	0.06%	27.41%	4.86%	0.63%	0.30%	0.01%
			TIER2	5	23	5	5	6	7	18											
6	08080206	Lower Calcasieu	TIER1	12	2	4	2	11	10	26	100	2.75%	2.01%	0.44%	30.87%	0.21%	4.37%	0.00%	54.19%	0.50%	4.67%
			TIER2	18	35	5	6	15	13	52											
6	08090100	Lower Mississippi-New Orleans	TIER1	3	0	9	1	3	1	16	51	3.09%	2.26%	0.73%	1.70%	0.03%	1.54%	16.26%	39.49%	0.53%	34.37%
			TIER2	11	48	30	40	34	1	34											
6	11070209	Lower Neosho	TIER1	0	0	13	0	0	0	13	20	0.34%	0.02%	0.05%	4.48%	0.01%	3.35%	0.00%	1.08%	0.02%	90.65%
			TIER2	0	2	0	13	0	0	3											
6	08040207	Lower Ouachita	TIER1	0	0	1	11	0	1	12	12	3.38%	0.53%	0.51%	30.43%	0.12%	52.72%	0.00%	8.96%	3.36%	0.00%
			TIER2	5	11	0	0	0	0	0											

Table 4-2. (Continued)

			Number of Stations With a Probability of Adverse Effects									Percent of Total Area in Each Watershed									
EPA Reg.	Cataloging Unit #	Name	Tier	Mercury	Other Metals	PCBs	Pesticides	PAHs	Other	All Chemicals[a]	Total # of Stations	Residential	Commercial/ Industrial	Other Urban	Cropland	Other Agricultural	Forestland	Bays & Estuaries	Other Water	Other	Missing/ Unknown
6	12040104	Buffalo-San Jacinto	TIER1	0	1	9	3	1	3	10	36	23.31%	7.07%	6.32%	45.96%	0.06%	13.38%	0.04%	2.97%	0.80%	0.08%
			TIER2	14	26	15	14	11	3	23											
7	10270104	Lower Kansas	TIER1	0	1	11	0	0	1	12	29	3.70%	1.82%	1.83%	82.75%	0.91%	7.67%	0.00%	0.92%	0.40%	0.00%
			TIER2	1	14	0	22	1	3	15											
7	11070207	Spring	TIER1	0	0	8	0	1	2	10	41	1.84%	0.67%	0.79%	80.42%	0.12%	14.27%	0.00%	0.19%	1.70%	0.01%
			TIER2	1	29	1	7	0	1	25											
7	07080101	Copperas-Duck	TIER1	1	1	17	0	0	1	17	27	5.40%	2.53%	1.58%	68.60%	0.18%	9.58%	0.00%	9.04%	0.54%	2.55%
			TIER2	1	7	0	18	1	2	5											
9	18070304	San Diego	TIER1	18	4	33	13	7	2	53	107	11.02%	4.09%	2.72%	6.92%	54.85%	9.62%	1.36%	0.86%	1.98%	6.60%
			TIER2	26	93	45	47	39	4	51											
9	18070104	Santa Monica Bay	TIER1	15	6	22	66	4	1	79	132	17.03%	7.90%	2.86%	1.18%	20.81%	0.68%	0.41%	0.20%	0.96%	47.95%
			TIER2	33	94	34	22	18	3	31											
9	18070201	Seal Beach	TIER1	5	0	8	23	2	32	63	442	41.18%	22.80%	4.68%	4.98%	0.12%	0.00%	0.75%	1.15%	1.27%	23.05%
			TIER2	38	211	142	288	30	182	339											
9	18050003	Coyote	TIER1	14	8	0	0	0	0	18	24	20.29%	9.69%	9.13%	6.07%	23.27%	27.93%	1.58%	1.38%	0.66%	0.01%
			TIER2	8	12	1	0	1	0	6											
9	18070204	Newport Bay	TIER1	10	0	1	11	0	2	24	108	19.51%	13.49%	6.60%	18.96%	28.16%	0.25%	1.09%	0.91%	3.33%	7.69%
			TIER2	13	62	19	48	8	25	68											
9	18050004	San Francisco Bay	TIER1	10	9	1	0	5	0	19	64	12.06%	7.21%	3.48%	4.43%	27.36%	28.64%	14.20%	1.98%	0.65%	0.00%
			TIER2	33	41	18	19	21	0	37											
9	18070105	Los Angeles	TIER1	4	0	2	8	3	0	14	37	38.36%	13.78%	6.51%	1.31%	31.59%	6.65%	0.02%	0.30%	1.46%	0.01%
			TIER2	16	33	4	10	5	1	19											
9	18030012	Tulare-Buena Vista Lakes	TIER1	0	0	1	10	1	1	10	20	1.76%	1.53%	0.70%	55.36%	38.72%	0.90%	0.00%	0.74%	0.26%	0.03%
			TIER2	1	5	4	5	0	0	5											
9	18070107	San Pedro Channel Islands	TIER1	7	2	2	10	0	0	14	25	0.00%	0.08%	0.01%	0.00%	2.59%	0.00%	0.02%	0.00%	0.18%	97.12%
			TIER2	3	22	6	3	4	3	10											
9	18070301	Aliso-San Onofre	TIER1	5	2	0	5	0	0	10	32	3.18%	1.26%	1.22%	4.37%	60.80%	5.39%	0.03%	0.26%	1.49%	22.01%
			TIER2	7	29	9	7	2	0	22											
10	17110019	Puget Sound	TIER1	98	52	146	37	296	32	418	1383	12.36%	2.12%	2.05%	3.75%	0.32%	41.35%	34.95%	2.62%	0.48%	0.00%
			TIER2	449	1116	317	106	490	317	851											
10	17110013	Duwamish	TIER1	0	3	34	3	12	6	48	127	12.99%	2.97%	4.23%	6.82%	0.55%	70.85%	0.00%	0.96%	0.63%	0.00%
			TIER2	27	107	10	17	58	23	69											
10	17110002	Strait of Georgia	TIER1	16	1	1	4	12	4	32	263	4.22%	0.75%	1.22%	10.95%	0.46%	28.13%	51.38%	2.61%	0.20%	0.07%
			TIER2	51	180	15	34	73	28	168											
10	17030003	Lower Yakima	TIER1	0	0	5	19	0	1	23	47	1.13%	0.52%	0.26%	25.97%	55.06%	15.65%	0.00%	1.23%	0.17%	0.01%
			TIER2	0	4	0	23	1	10	19											
10	17090012	Lower Willamette	TIER1	1	0	13	10	5	4	21	76	31.21%	6.41%	4.69%	13.32%	0.97%	39.03%	0.00%	3.77%	0.61%	0.00%
			TIER2	12	51	24	18	11	15	51											
10	17110014	Puyallup	TIER1	0	3	1	0	8	1	12	19	5.85%	0.55%	0.79%	3.78%	4.44%	81.43%	0.00%	0.68%	2.47%	0.01%
			TIER2	0	8	6	1	9	6	6											
10	17010303	Coeur D'Alene Lake	TIER1	1	8	2	0	0	0	10	23	0.73%	0.13%	0.42%	12.68%	0.65%	75.10%	0.00%	10.14%	0.14%	0.00%
			TIER2	1	13	0	0	0	0	13											

[a]Because of the numerous chemicals monitored at each station, the total in this column is not equal to the sum of the numbers in the columns for the different chemical classes.

[b]Adapted from USGS land use and land cover classification system for use with remote sensor data.

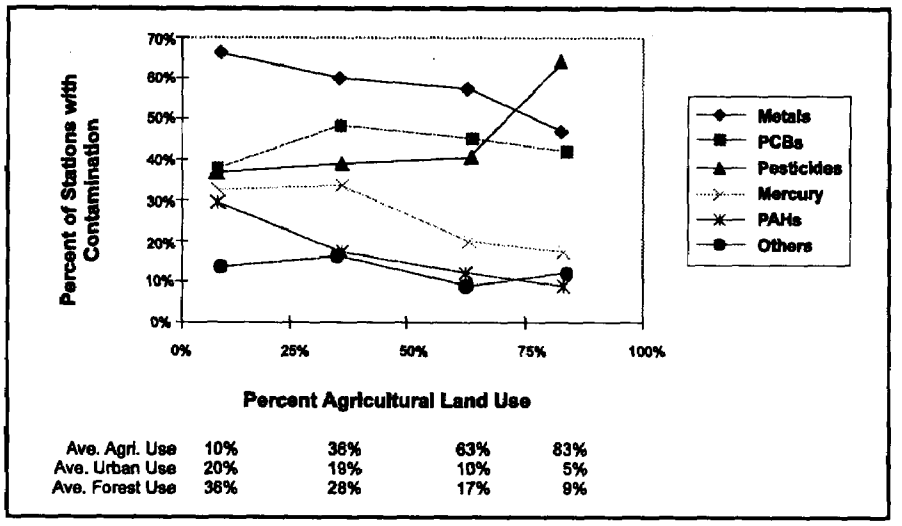


Figure 4-2. Percent Tier 1 and Tier 2 Stations vs. Agricultural Land Use in APCs.

Table 4-3. Comparison of Percent APC Agricultural Land Use to Percent of Tier 1 and Tier 2 Stations by Chemical Class

	Percent Total Agricultural Land Area				
	<25%	25-50%	50-75%	>75%	Overall Average
Average Percent Agricultural Land Area in Group	10%	36%	63%	83%	39%
Number of Watersheds in Group	32	34	13	17	
Metals	66%	60%	58%	47%	59%
PCBs	38%	48%	45%	42%	43%
Pesticides	37%	39%	40%	64%	43%
Mercury	32%	34%	20%	18%	29%
PAHs	30%	17%	12%	9%	19%
Others	13%	16%	9%	12%	14%

agricultural land use and calculated the average percent contaminant by chemical class for each group. Some general trends that would be expected were clearly evident. In watersheds with greater than 75 percent of the land devoted to agriculture, pesticide contamination jumped from under 40 percent of all stations to 64 percent. In contrast, metals, mercury, and PAH contamination all steadily decreased, with all three classes exhibiting a percent contamination in the over 75 percent agriculture group at least 10 percentage points under the overall average for each class. PCBs and other organics did not exhibit any trend and never varied more than 5 percentage points from the overall average.

In contrast, increasingly higher percentages of urban land use in watersheds correlated with steadily increasing contamination from most chemical classes. Figure 4-3 and Table 4-4 present the results of a trend analysis for total urban land use. For this analysis, EPA placed watersheds into groups of under 5 percent urban area, 5 to 10 percent urban area, 10 to 20 percent urban area, and greater than 20 percent urban area to best illustrate trends. The percent PAH and metal contamination were both 10 percentage points under the overall average for the least urbanized watershed group, then rose sharply as the proportion of urban area crossed the 5 percent threshold. The extent of metal contamination rose to an average of 71 percent, more than 10 percentage points above the overall average of 59 percent, in watersheds with more than 20 percent total urban land use. Mercury contamination rose steadily and reached a peak of 40 percent in the most heavily urbanized watersheds. The mercury and PAH trends perhaps illustrate the effect of atmospheric deposition from local urban sources. Contamination from other organics also rose steadily, but never varied more than 6 percentage points from the overall average. Pesticide contamination initially decreased as percent urbanization increased, but it rose more than 10 percentage points from the 10 to 20 percent urban group to the over 20 percent urban group. As mentioned previously, this may reflect upstream delivery of contaminants, pesticide manufacture or formulation, or urban applications in the past. As was the case with the agriculture analysis, the average percent PCB contamination for the urban groups showed no trend and never varied substantially from the overall average.

EPA's Point and Nonpoint Source Sediment Contaminant Inventories

As part of the National Sediment Inventory (NSI) and mandate under the Water Resources Development Act (WRDA) of 1992, EPA is conducting inventories of point and nonpoint sources of sediment contaminants.

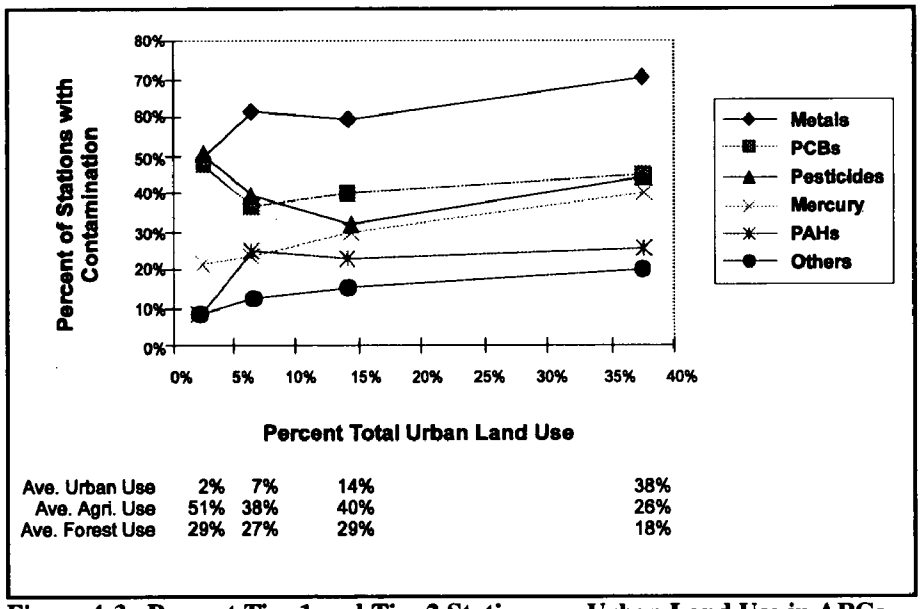


Figure 4-3. Percent Tier 1 and Tier 2 Stations vs. Urban Land Use in APCs.

Table 4-4. Comparison of Percent APC Urban Land Use to Percent of Tier 1 and Tier 2 Stations by Chemical Class

	Percent Total Urban Land Area				
	<5%	5-10%	10-20%	>20%	Overall Average
Average Percent Urban Land Area in Group	2%	7%	14%	38%	16%
Number of Watersheds in Group	32	18	19	27	
Metals	49%	61%	59%	71%	59%
PCBs	47%	37%	40%	45%	43%
Pesticides	50%	39%	32%	44%	43%
Mercury	21%	24%	30%	40%	29%
PAHs	9%	25%	23%	25%	19%
Others	8%	12%	15%	20%	14%

The objective of the point source assessment component of the NSI is to compile available data regarding the purposeful discharge of sediment contaminants from industrial facilities and municipal sewage treatment plants and to determine the sediment hazard potential by chemical class, watershed, and industrial category. EPA has produced a July 1996 draft *National Sediment Contaminant Point Source Inventory: Analysis of Facility Release Data* based on 1994 permit monitoring records in EPA's Permit Compliance System (PCS) and chemical release estimates in the 1993 Toxic Release Inventory (TRI). The report presents a sediment hazard analysis based on release amount, chemical toxicity, and inherent physical/chemical properties of the contaminant. The report serves as Volume II of the complete report to Congress on the extent and severity of sediment contamination in surface waters of the United States. As previously stated, discharge limits for point sources are not necessarily protective of downstream sediment quality. The Agency believes an effective source control strategy should focus on areas at greatest risk on a watershed scale. The report identifies 29 watersheds among the 96 areas of potential widespread potential sediment contamination (APCs) where the potential for point source contribution to sediment contamination is the greatest.

The objective of the nonpoint source assessment component of the NSI is to prepare a nationwide assessment of annual nonpoint source contributions of selected sediment contaminants on a watershed basis. Given the number and diversity of nonpoint sources, the Agency is focusing initial efforts on four major categories: harvested croplands, urban areas, atmospheric deposition, and inactive and abandoned mine sites (where information is available). Although these nonpoint sources do not constitute the full range of sediment contaminant sources, they are frequently cited in the scientific literature as significant sources of mercury, PCBs, PAHs, metals, pesticides, and other organic compounds.

The nonpoint source assessment is intended to be a screening-level study that begins to correlate contaminated sediment sites with suspected sources of these contaminants. As part of this assessment, EPA is compiling data from the Bureau of the Census, the U.S. Department of Agriculture, the U.S. Department of the Interior's U.S. Geological Survey and Bureau of Mines, and others. EPA will compile information and data concerning these nonpoint source activities to identify watersheds for further investigation and assessment.

Given the breadth of nonpoint sources, EPA anticipates that the process of conducting future assessments

will be iterative. Additional nonpoint sources will be added to the inventory to more fully discriminate between contaminant types and known sources and to characterize their proximity to known or suspected contaminated sediment sites. This iterative process will allow EPA to identify regions of the country where nonpoint sources are known to exist, but data on sediment quality are either limited or lacking.

Chapter 5

Conclusions and Discussion

The National Sediment Inventory (NSI) is EPA's largest compilation of sediment chemistry data and related biological data. It includes approximately 2 million records for more than 21,000 monitoring stations across the country. EPA's evaluation of the NSI data was the most geographically extensive investigation of sediment contamination ever performed in the United States. The evaluation was based on state-of-the-art risk-based procedures to address the probability of adverse effects to human health, aquatic life, and wildlife. The results verify that sediment contamination is widespread and is an important national concern. This was the first large-scale assessment of sediment quality to go beyond "hot spot" identification. Through closer inspection of the thousands of potentially contaminated locations, EPA distinguished 96 watersheds where contamination is likely to be most severe and extensive.

The Agency and its state and federal partners can address sediment contamination problems through watershed management approaches. Watershed management programs focus on hydrologically defined drainage basins rather than areas defined by political boundaries. These programs recognize that conditions of land areas and activities within the watershed affect the water resource. Local management, stakeholder involvement, and holistic assessments of water quality are characteristics of the watershed approach. The National Estuary Program is one example of the watershed approach that has led to specific actions to address contaminated sediment problems. Specifically, the Narragansett (RI) Bay, Long Island Sound, New York/New Jersey Harbor, and San Francisco Bay Estuary Programs have all recommended actions to reduce sources of toxic contaminants to sediment. Numerous other examples of watershed management programs are summarized in *The Watershed Approach 1993/94 Activity Report* (USEPA, 1994g) and *A Phase I Inventory of Current EPA Efforts to Protect Ecosystems* (USEPA, 1995b).

This chapter presents some general conclusions about the extent of sediment contamination in the United States and sources of sediment contaminants. It also includes comparisons to other national studies that address the extent of sediment contamination and to a national survey of state-issued fish consumption advisories. In addition, this chapter presents the results of an analysis of the sensitivity of parameters used to evaluate potential human health effects from exposure to PCBs and mercury, which was performed to show how the use of different screening values affect the results. The chapter concludes with a discussion of the strengths and limitations of the NSI data and evaluation method.

Extent of Sediment Contamination

The results of the NSI data evaluation confirm that sediment contamination is an important national concern and poses potential risks to aquatic life, human health, and wildlife. The data further confirm that sediment contamination is widespread in many watersheds of the country. The analysis of the NSI data indicates that potential sediment contamination exists in all regions and states of the country. The water bodies affected include streams, lakes, harbors, nearshore areas, and oceans. A number of specific locations in the United States had large numbers of stations that indicate a higher probability of adverse effects (Tier 1 stations). Puget Sound, Boston Harbor, the Detroit River, San Diego Bay, and portions of the Tennessee River were among those locations. Several U.S. harbors (e.g., Boston Harbor, Puget Sound, Los Angeles, Chicago, Detroit) appear to have some of the most severely contaminated sediments in the country. This finding is not surprising since major U.S. harbors have been affected throughout the years by large volumes of boat traffic, contaminant loadings from upstream sources, and many local point and nonpoint sources.

Thousands of other water bodies in hundreds of watersheds throughout the country contain sampling stations classified as Tier 1. Many of these sampling stations may represent isolated "hot spots" rather than widespread sediment contamination, although insufficient data were available in the NSI to make such a determination. EPA's River Reach File 1 (RF1) delineates the Nation's rivers and waterways into segments, or reaches, of approximately 1 to 10 miles in length. Based on RF1, approximately 11 percent of all river reaches in the United States contained NSI sampling

stations. More than 5,000 sampling stations in approximately 2,400 river reaches across the country (35 percent of all reaches evaluated) were classified as Tier 1. Another 10,000 sampling stations were classified as Tier 2. In total, over 5,000 river reaches in the United States—approximately 75 percent of all river reaches evaluated—include at least one Tier 1 or Tier 2 station. However, EPA cannot estimate the areal extent or number of river miles of contaminated sediment because the NSI does not provide complete coverage for the entire nation, sampling locations are largely based on a nonrandom sampling design, and sediment quality can vary greatly within very short distances.

Most of the NSI data were compiled from nonrandom monitoring programs. Such monitoring programs focus sampling efforts on areas where contamination is known or suspected to occur. As a result, assuming all other factors are the same, the frequency of Tier 1 or Tier 2 classification based on the NSI data evaluation is probably greater than that which would result from purely random sampling. Swartz et al. (1995) demonstrated the effects of nonrandom sampling design on the frequency of detecting contaminated sites. They compared the percent of sediment sites that exceeded PAH screening effects levels (ERL, SQC, AET) based on random site selection (Virginian Province EMAP stations) to the percent of sites that exceeded those levels based on site selection on the basis of known PAH contamination (creosote-contaminated Eagle Harbor, Washington). They found that the frequency of exceeding a sediment guideline in sites known to be contaminated was 5 to 10 times greater than that for randomly selected sites.

The results of the NSI data evaluation must be interpreted in the context of data availability. Many states and EPA Regions appear to have a much greater extent of sediment contamination than others. To some degree, this appearance reflects the relative extent of readily available electronic data, not necessarily the relative extent of sediment contamination. For example, 182 of the 920 river reaches in Illinois contain a Tier 1 station, whereas only 9 of the 5,490 reaches in Montana contain a Tier 1 station. However, the NSI includes sampling station data for over 50 percent of the river reaches in Illinois but less than 1 percent of the river reaches in Montana. Therefore, although the absolute number of Tier 1 and Tier 2 stations in each state is important, relative comparisons of the extent of sediment contamination between states is not possible because the extent of sampling and data availability vary widely.

The lack of important assessment parameters hampered EPA's efforts to determine the full extent and severity of sediment contamination. For example, a Tier 1 classification based on divalent metal concentrations in sediment required an associated acid-volatile sulfide (AVS) measurement. Also, a Tier 1 classification for potential human health effects required both sediment chemistry and fish tissue residue data for all chemicals except PCBs and dioxins. These data combinations frequently were not available. Table A-2 in Appendix A presents the total number of NSI stations where sediment chemistry data, related biological data, and matched data (i.e., sediment chemistry and biological data taken at the same station) were collected. AVS measurements were available at only 1 percent of the evaluated stations. Likewise, matched sediment chemistry and fish tissue data were available at only 8 percent of the evaluated stations. Toxicity data were also limited: bioassay results were available at only 6 percent of the evaluated stations.

The potential risk of adverse effects to aquatic life and human health is greater in areas with a multitude of contaminated locations. The assessment of individual monitoring stations is useful for estimating the number and distribution of contaminated spots and overall magnitude of sediment contamination in the United States. However, a single "hot spot" might not pose a great threat to either the benthic community at large or consumers of resident fish because the spatial extent of exposure could be small. On the other hand, if many contaminated spots are located in close proximity, the spatial extent and probability of exposure are much greater. EPA examined sampling station classifications within watersheds to identify areas of potential widespread sediment contamination (APCs), where the exposure of benthic organisms and resident fish to contaminated sediment would be frequent. These are watersheds that include at least 10 Tier 1 sampling stations and in which at least 75 percent of all sampling stations were categorized as either Tier 1 or Tier 2. Approximately 5 percent of the watersheds in the United States (96 of 2,111) were classified as APCs based on this assessment. In many of these watersheds, the risk might be concentrated on certain water bodies or river reaches. Within the 96 APCs, 57 river reaches include 10 or more Tier 1 stations.

Although the APCs were selected by means of a screening exercise, EPA believes that they represent the highest priority for further risk analysis, temporal trend assessment, contaminant source evaluation, and management action because of the preponderance of evi-

dence in these areas. The uncertainties and limitations of this assessment leave some doubt about the classification of any given sampling station. However, the probability of making an erroneous classification of all 10 Tier 1 stations and 75 percent of all stations in a watershed is low. EPA chose the watershed as the unit of spatial analysis because many state and federal water and sediment quality management programs, as well as data acquisition efforts, are centered around this unit. This choice reflects the growing recognition that activities taking place in one part of a watershed can greatly affect other parts of the watershed, and that management efficiencies are achieved when viewing the watershed holistically. Watershed management is a vital component of community-based environmental protection.

Although only 11 percent of all river reaches in the United States were evaluated as part of this study, it is likely that the results identified most of the severely contaminated areas in the country. This is because most of the NSI data were obtained from monitoring programs targeted toward areas of known or suspected contamination. For a number of reasons, however, some potentially contaminated sediment sites were missed. The most obvious reason is that the NSI does not include all sediment quality data that have ever been collected. For example, the NSI does not include many EPA Superfund Program data and therefore sampling stations in the vicinity of hazardous waste sites might not have been included in the NSI evaluation. Additional data sets will be added to the NSI for future evaluations to provide better national coverage. In addition, some data in the NSI were not evaluated because of questions concerning data quality or because no locational information (latitude and longitude) was available.

Sources of Sediment Contamination

Some of the most significant sources of persistent and toxic chemicals have been eliminated or reduced as the result of environmental controls put into place during the past 10 to 20 years. For example, the commercial use of PCBs and the pesticides DDT and chlordane has been restricted or banned in the United States. In addition, effluent controls on industrial and municipal point source discharges and best management practices for the control of nonpoint sources have greatly reduced contaminant loadings to many of our rivers and streams.

The results of better controls over releases of sediment contaminants are evident from studies such as that conducted by Swartz et al. (1991) on the Palos Verdes Shelf. These researchers examined sediment cores collected at two sites on the Palos Verdes Shelf near the Los Angeles County Sanitation District's municipal wastewater outfalls, and at two reference sites in Santa Monica. They found that the vertical distribution of sediment toxicity near the outfalls was significantly correlated with profiles of total organic carbon and sediment chemical contamination. Dating of core horizons showed that sediment toxicity also was significantly correlated with historical records of the mass emission rate of suspended solids from the outfalls. The vertical profiles showed that the toxicity of surficial sediments increased after the initiation of the discharge in the 1950s, remained relatively high until the early 1970s, and then decreased after the implementation of source controls and improved effluent treatment (Swartz et al., 1991).

Based on the NSI data evaluation, metals and persistent organic chemicals are the contaminants most often associated with sediment contamination. Despite recent progress in controlling sediment contaminant releases to the environment, active sources of these contaminants still exist. These include nonpoint source loadings such as surface water runoff and atmospheric deposition, point source loadings, and resuspension of in-place sediment contaminants from historical sources.

Some correlations between land use and sediment contamination caused by specific classes of chemicals were identified in Chapter 4. Agricultural land use was correlated with the extent of sediment contaminated with organochlorine pesticides in APC watersheds, especially those with more than 75 percent of land area devoted to crop production or rangeland. In contrast, the extent of sediment contaminated with PAHs, mercury, and other metals in APC watersheds correlated with the extent of urban land use. Land use did not appear to be associated with the extent of PCB contamination.

Comparison of NSI Evaluation Results to Results of Previous Sediment Contamination Studies

The results of this study are consistent with the findings of other national assessments of sediment contamination. For example, in EPA's 1992 *National Water Quality Inventory* report, 27 states identified 770 known contaminated sediment sites (USEPA, 1994d). The identified "sites" probably best correlate to river reaches from this analysis in terms of areal extent. The NSI evaluation identified approximately 2,400 river reaches in 50 states that contain a Tier 1 site. In the *National Water Quality Inventory* report, the states frequently listed metals (e.g.,

mercury, cadmium, and zinc), PCBs, DDT (and its by-products), chlordane, and priority organic chemicals as the cause of sediment contamination. They identified industrial and municipal discharges (past and present), landfills, resource extraction, abandoned hazardous waste disposal sites, and combined sewer overflows as the most important sources of sediment contamination.

In a 1987 overview of sediment contamination (which was based on a limited amount of national data), EPA estimated that hundreds of sites located in all regions of the United States have in-place sediment contaminants at concentrations of concern (USEPA, 1987). The study identified harbor areas, both freshwater and marine, as some of the most severely impacted areas in the country. The study identified municipal and industrial point source discharges, urban and agricultural runoff, combined sewer overflows, spills, mine drainage, and atmospheric deposition as frequently cited sources of sediment contamination.

In 1994, the National Oceanic and Atmospheric Administration (NOAA) released its *Inventory of Chemical Concentrations in Coastal and Estuarine Sediments* (NOAA, 1994). This study categorized 2,800 coastal sites as either "high" or "hot" based on the contaminant concentrations found at the sampling locations. NOAA did not use risk-based screening values for its analysis. Using the National Status and Trends Mussel Watch data set, "high" values were defined as the mean concentration for a specific chemical plus one standard deviation. High values corresponded to about the 85th percentile of contaminant concentration. "Hot" concentrations were defined as those exceeding five times the "high" values. Most of the "hot" sites were in locations with high ship traffic, industrial activity, and relatively poor flushing, such as harbors, canals, and intracoastal waterways (NOAA, 1994). Mercury and cadmium exceeded the NOAA "hot" thresholds at a greater percentage of sites where they were measured (about 7 percent each) than other sediment contaminants.

Comparison of NSI Evaluation Results to Fish Consumption Advisories

EPA recently published a National Listing of Fish Consumption Advisories issued by state governments. As of 1994, 1,532 specific water bodies (each of which might include several water body segments, or reaches, as defined in this study) in 46 states had fish consumption advisories in place. Mercury was the contaminant most often associated with fish consumption advisories; 1,119 water bodies had advisories that included mercury. States also issued a large number of advisories because of high levels of chlordane, PCBs, and dioxins in fish tissue.

A direct comparison of the fish advisory contaminants and NSI contaminants is not possible because states often issue advisories for groups of chemicals. Nevertheless, five of the top six contaminants associated with fish advisories (PCBs, DDT, dieldrin, chlordane, and dioxins) are also among the contaminants most often responsible for the Tier 1 classification of water bodies based on potential human health effects (Table 5-1). As illustrated in Figure 5-1, many water bodies with fish advisories are also located in the same areas where sampling stations are classified as Tier 1 or Tier 2 based on potential human health effects. Tier 1 and Tier 2 stations are located predominantly where data have been collected and compiled for the NSI, whereas fish consumption advisories are located predominantly in states with active fish advisory programs. Unlike the NSI data evaluation, which is applied consistently to available data, each state may employ different methods for risk analysis. A water body-by-water body comparison is not possible at this time because there are no common geographic identifier codes. OST is currently adding common codes (river reach numbers) to the National Fish Advisory Listing.

Although there is good agreement for other chemicals, mercury is notably absent from the Tier 1 category in Table 5-1. Using the NSI evaluation methodology, mercury cannot place a site in Tier 1 for potential human health effects. For chemicals other than PCBs and dioxins, sediment chemistry and fish tissue data must both indicate human health risk for Tier 1 assignment. Unfortunately, the bioaccumulation potential of mercury based on concentrations in sediment cannot be assessed because the biota sediment accumulation factors (BSAFs) used for this study apply only to nonionic organic compounds. In addition, available fish tissue data for mercury did not place a large number of sampling stations in Tier 2 for potential human health effects, compared to the number of issued fish advisories.

There are three possible explanations for the relatively small number of stations categorized as Tier 2 for mercury in comparison to the number of fish advisories in place for mercury. The first explanation is that the NSI evaluation was limited to data from resident demersal species, whereas data used in support of issuing state fish advisories probably included pelagic and migratory species. The second possible explanation is that the evaluation parameters used in the analysis were not as stringent as the ones used to support fish advisory issuance. The third explanation is that the NSI does not include the actual data used by the states.

Table 5-1. Comparison of Contaminants Most Often Associated With Fish Consumption Advisories and Those Which Most Often Cause Stations to Be Placed in Tier 1 or Tier 2 Based on the NSI Data Evaluation

		Number of River Reaches That Include at Least One Tier 1 or Tier 2 Station Based on the NSI Data Evaluation of Human Health Fish Consumption Advisories Parameters[d]		
Chemical[a]	# of Waterbodies with Fish Advisories[c]	Tier 1	Tier 2[e]	Total
Mercury	1,119	0	89	89
PCBs	387	1,498	732	2,230
Chlordane	114	11	1,026	1,037
Dioxins	53	242	8	250
DDT and metabolites	28	19	656	675
Dieldrin	15	9	1,296	1,305
Selenium	12	0	4	4
Mirex	10	0	15	15
PAHs	5	0	529	529
Toxaphene	4	0	183	183
Hexachlorobenzene	3	0	53	53
Lead	2	0	259	259
Hexachlorobutadiene	2	0	6	6
Creosote[b]	2	-	-	-
Chromium	1	0	6	6
Copper	1	0	4	4
Zinc	1	0	14	14

[a]Other chemical groups responsible for fish consumption advisories (i.e., pesticides [24 water bodies], "multiple" [4 water bodies], "not specified" [4 water bodies], and metals [6 water bodies]) could not be directly compared to NSI chemicals.
[b]No reference values were available for creosote; therefore, it was not evaluated in the NSI data evaluation.
[c]Does not include statewide advisories
Mercury: New York, New Jersey, Maine, Massachusetts, Michigan, coastal Florida
Chlordane: Missouri
PCBs: New York
Dioxin: coastal Maine
[d]A water body can be composed of numerous river reaches.
[e]River reaches that include at least one Tier 2 station but no Tier 1 stations.

To examine these possible explanations, EPA performed additional analyses of mercury fish tissue data included in the NSI. The current evaluation, using a fish tissue screening value of 1 part per million (ppm), yields 103 Tier 2 stations (4 percent of all stations with detectable levels). If data from all edible pelagic and migratory species are included in the analysis, there are 374 Tier 2 stations (9 percent of all stations with detectable levels). A fish tissue threshold of 0.6 ppm, derived using the more stringent reference dose (0.00006 mg/kg-day) recommended to states for issuing fishing advisories to protect against developmental effects among infants (USEPA, 1994e), yields 821 Tier 2 stations (20 percent of all stations with detectable levels) when applied to all edible species using the consumption rate for an average consumer of 6.5 grams per day. However, fish advisories are often issued for more exposed populations, such as recreational or subsistence fishers. The 0.2 ppm Canadian guideline limit for mercury in fish that are part of a subsistence diet yields 2,308 Tier 2 stations (56 percent of all stations with detectable levels) when applied to all edible species in the NSI database. Further details of the additional mercury analyses are provided in Appendix H.

The conclusion resulting from these additional analyses is that all three explanations probably have an effect. Most fish advisories are issued to protect infants from developmental effects for populations where exposure is greater than 6.5 grams of fish per day. It is also likely that many of the data used to develop state fish advisories are not included in the NSI, or are not evaluated for sediment contamination because they are measurements in pelagic or migratory fish.

Sensitivity to Selected PCB Evaluation Parameters

Because PCBs and dioxin are extremely hydrophobic chemicals commonly associated with sediment, and because of their toxicity to humans, EPA believes that elevated levels of PCBs and dioxins in fish tissue of resident, demersal species are sufficient evidence to indicate a potential sediment contamination problem and to place a site in the Tier 1 category for those contaminants. Based on the NSI data evaluation, PCBs were responsible for the Tier 1 classification of more stations than any other chemical. Therefore, EPA conducted a sensitivity analysis of some PCB evaluation parameters to determine the effect on the number of stations classified as Tier 1 or Tier 2.

In the NSI evaluation, EPA selected a conservative approach for the analysis of PCBs. The approach is conservative because it does not require matching sediment chemistry

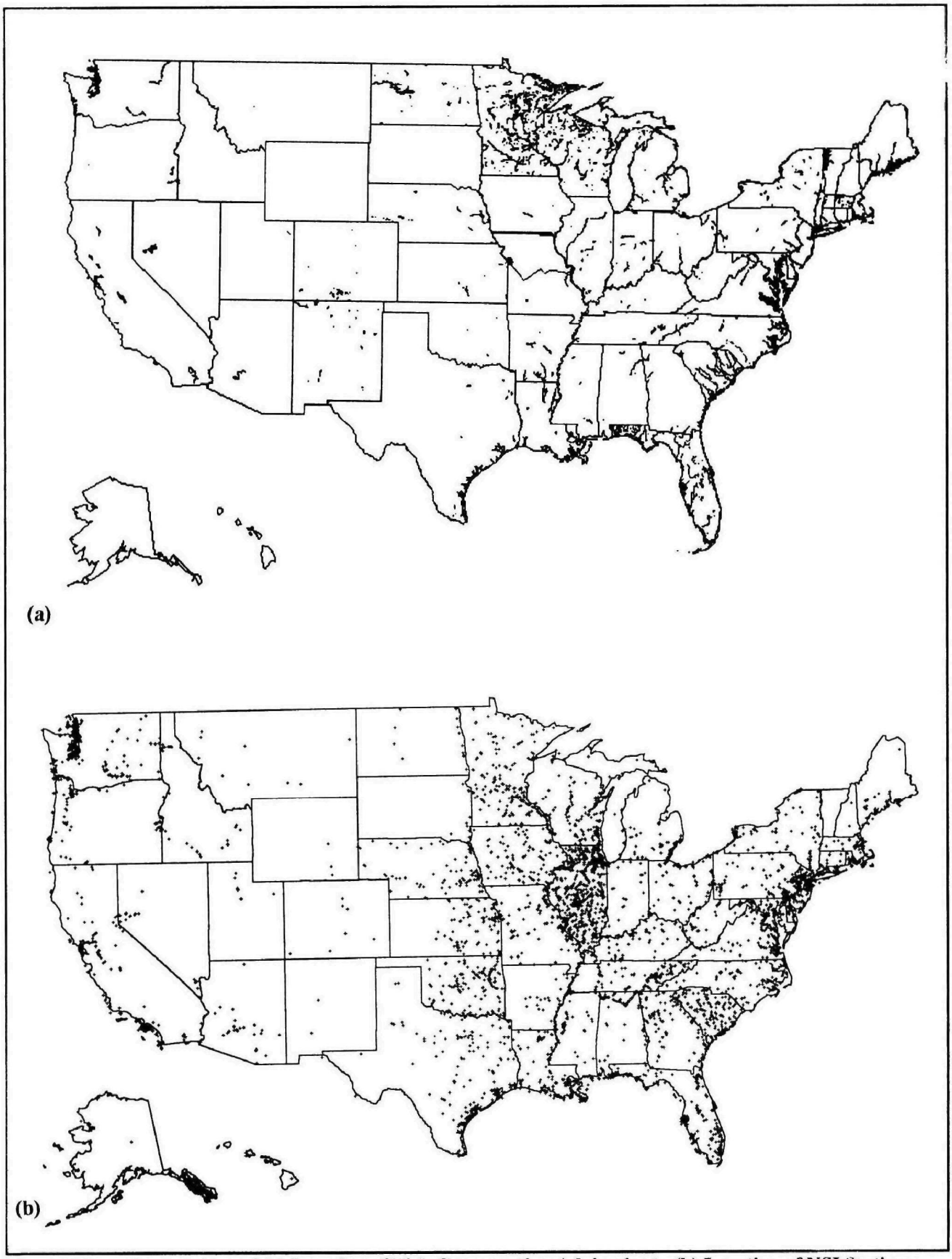


Figure 5-1. Comparison of (a) Location of Fish Consumption Advisories to (b) Location of NSI Stations Categorized as Tier 1 or Tier 2 Due to Potential Human Health Effects.

and tissue residue data for PCB, and it is based on a cancer risk level of 10^{-5} (i.e., a 1 in 100,000 extra chance of cancer over a lifetime of 70 years) applied to all PCBs congeners or total PCB measurements. Some PCB congeners, measured individually or as a part of total PCBs, are considered a greater threat for noncancer effects than for cancer. The evaluation currently places 3,198 sediment stations and 2,256 tissue stations in Tier 1 based on human health protection using the 10^{-5} cancer risk level. Only 542 stations included matching sediment and tissue data for PCBs. The number of stations classified as Tier 1 would have decreased significantly if this match had been required.

EPA performed additional evaluations to determine the number of stations that exceed other screening values, less conservative than those selected for the PCB evaluation used in this study. The complete results are presented in Appendix H, which includes a comparison of the number of sediment and fish tissue sampling stations with detectable levels of PCBs that exceed various evaluation parameters for both aquatic life and human health. The number of sediment stations that exceed the respective levels is approximate because the additional analyses were performed using default organic carbon content.

Site evaluation based on PCB contamination is quite sensitive to the selection of evaluation parameters. For protection of fish consumers, there are essentially three distinct levels of protection. Using an EPA cancer risk of 10^{-5} or greater, 85 percent or more of the stations with detectable PCB levels are classified as Tier 1. About one-half to two-thirds of the stations are classified as Tier 1 for exceedances of PCB levels protective of noncancer health effects, cancer risk at a 10^{-4} risk level, or levels exceeding the wildlife criterion. Less than one-third of the stations are classified as Tier 1 using the FDA level of protection. As documented in Appendix H, these percentages vary depending on use of a BSAF safety factor, and whether one is examining the set of fish tissue data or sediment chemistry data. These three levels of protection vary within two orders of magnitude, a range that covers most of the distribution of PCB measurements.

Although station classification for PCB contamination is quite sensitive to selection of evaluation parameters, overall station classification using the complete NSI evaluation for all chemicals is more robust. Using the selected PCB evaluation parameters, there are 15,922 total Tier 1 and Tier 2 stations. If PCBs are dropped from the analysis entirely, the total number of Tier 1 and Tier 2 stations remains about the same (less than a 5 percent decrease), but the number of Tier 1 stations decreases by approximately 40 percent. If PCBs are evaluated using a noncancer human health threshold, the total number of Tier 1 and Tier 2 stations decreases by less than 2 percent and the number of Tier 1 stations decreases by approximately 12 percent. Figure 5-2 shows the location of Tier 1 and Tier 2 stations that exhibit potential human health risks for all chemicals other than PCBs for comparison to Figure 3-6 in the results section.

Strengths of the NSI Data Evaluation

The National Sediment Quality Survey is the first EPA analysis of sediment chemistry and related biological data from numerous databases to identify the national extent and severity of sediment contamination. In future surveys, EPA will include data from additional databases, thereby providing more complete geographic coverage of the country. This first evaluation of the NSI data, however, provides a baseline screening assessment of sediment contamination problems throughout the country.

In the evaluation of NSI data, EPA has used the most widely accepted sediment assessment techniques, which were recommended by national experts in sediment quality assessment. These experts included persons from federal and state governments as well as the private sector. Because of the complex nature of the reactions between different chemicals in different sediment types, in water, and in tissues, no single sediment assessment technique can be used to adequately evaluate potential adverse effects due to exposure to all contaminants. Uncertainties and limitations are associated with each of the evaluation techniques. To compensate for those limitations, EPA has used multiple assessment techniques, alone and in combination, to evaluate the NSI data. For example, EPA developed draft SQCs based on the best scientific data available and extensive peer review. Therefore, EPA believes that the draft SQCs are highly reliable benchmarks for protecting sediment quality and with measured TOC can indicate a higher probability for adverse effects to aquatic life. In addition, EPA believes that other sediment chemistry screening values (ERMs/ERLs, PELs/TELs, AETs, and SQALs) are also reliable indicators of probability for aquatic life impacts. The Agency applied a weight-of-evidence approach for evaluating contaminant levels using these screening values, requiring the exceedance of multiple upper sediment chemistry screening values (i.e., ERM, PEL, AET-high, or SQAL) for classification of Tier 1 sites.

The screening values used to evaluate the NSI data include both theoretical and correlative ap-

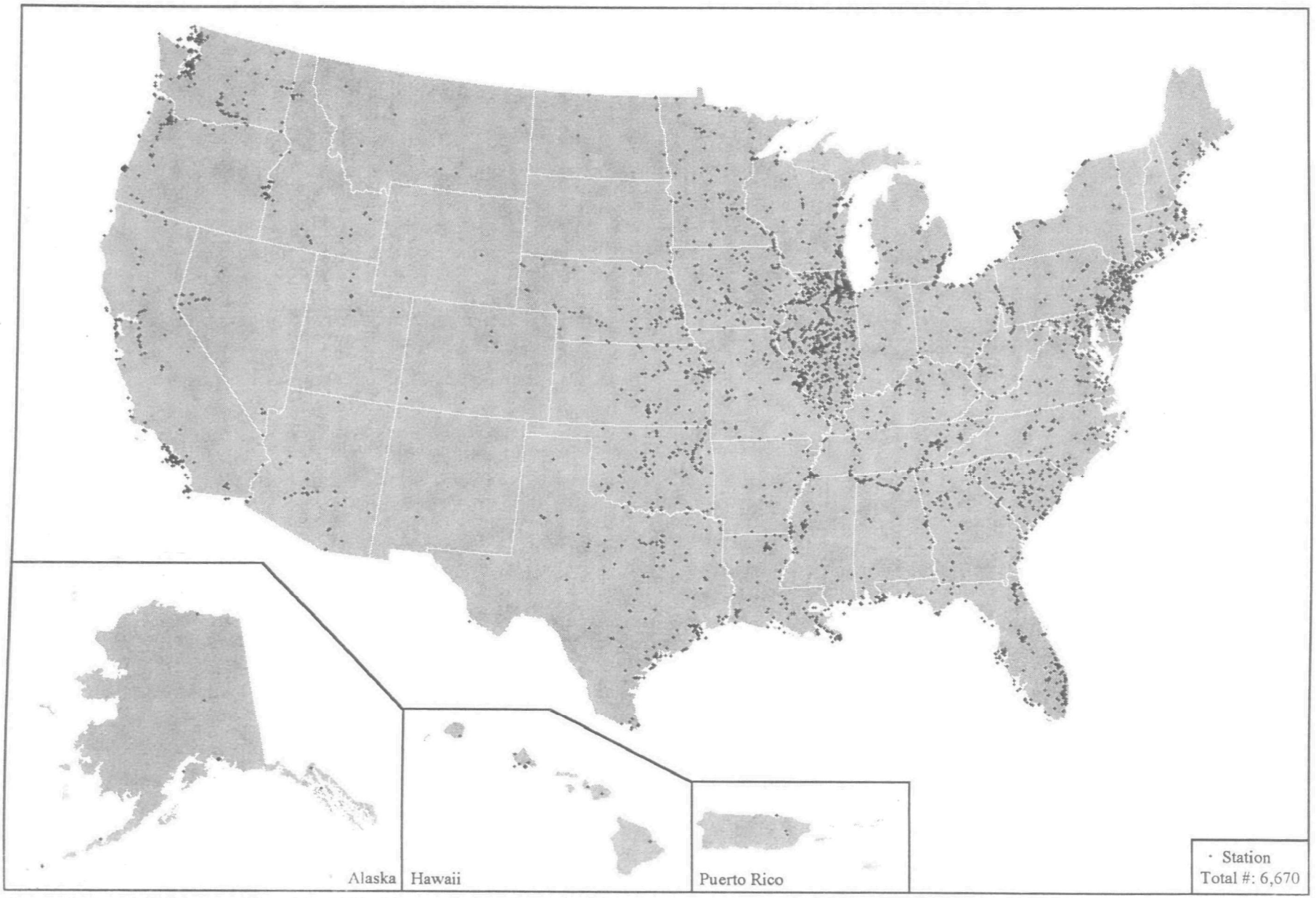


Figure 5-2. NSI Stations That Would Be Categorized as Tier 1 or Tier 2 Based on Potential Human Health Effects Without PCBs.

proaches. The theoretical approaches (e.g., draft SQCs, SQALs, and TBPs) are based on the best information available concerning how chemicals react in sediments and organisms and how organisms react to those chemicals. The correlative approaches (i.e., ERMs/ERLs, PELs/TELs, and AETs) are based on matched sediment and biological data gathered in the field and in the laboratory, and they provide substantial evidence of actual biological effects from sediments contaminated with specific concentrations of the chemicals of concern.

The NSI evaluation approach includes assessments of potential impacts to both human health and aquatic life. Some chemicals pose a greater risk to human health than to aquatic life; for others, the reverse is true. By evaluating both potential human health and aquatic life impacts, EPA has ensured that the most sensitive endpoint is used to assess environmental impacts.

Because sediment chemistry data are not the only indicators of potential environmental degradation due to sediment contamination, the NSI data evaluation approach also includes evaluations of fish tissue residue and toxicity data. If high levels of PCBs or dioxins (which are highly hydrophobic organic chemicals commonly found associated with sediments) were measured in fish tissue at a given site, the site could be categorized as Tier 1 with no corroborating sediment chemistry data. For other chemicals, high concentrations in tissues alone were not sufficient to categorize a site as Tier 1; corroborating sediment chemistry data were also required. For a site to be categorized as Tier 1 based on toxicity data alone, multiple toxicity tests with positive results using two different test species were required. One of the tests had to be a solid-phase test.

Although EPA has developed proposed SQCs for only five nonionic organic chemicals, the Agency has developed similar values, the SQALs, for an additional 35 chemicals as part of the NSI data evaluation. The SQALs have allowed EPA to evaluate more chemicals using multiple assessment techniques, thereby adding more weight of evidence to the results of this evaluation.

Limitations of the NSI Data Evaluation

This methodology was designed for the purpose of a screening-level assessment of sediment quality. A considerable amount of uncertainty is associated with the site-specific measures, assessment techniques, exposure scenarios, and default parameter selections. Therefore, the results of evaluating particular sites based on this methodology should be followed up with more intensive assessment efforts, when appropriate (e.g., for water bodies with multiple Tier 1 sites located in APCs). Two types of limitations are associated with the evaluation of the NSI data: limitations associated with the data themselves and limitations associated with the evaluation of the data.

Limitations of Data

The NSI is a multimedia compilation of environmental monitoring data obtained from a variety of sources, including state and federal program offices. Inherent in the diversity of data sources are contrasting monitoring objectives and scopes, which make comparison of data from different data sets difficult. For example, several of the databases contain only information from marine environments or other geographically focused areas. The potential for inconsistencies in measured concentrations of contaminants at different stations exists for samples taken from different monitoring programs. For example, sampling different age profiles in sediments, applying different sampling and analysis methods, and sampling for different objectives can affect the results of the NSI evaluation. Although numerous data sets identified sampling and laboratory methods, most data did not have this information. In addition, some data sets included in the NSI were not peer-reviewed (i.e., Region 4's Sediment Quality Inventory, the Gulf of Mexico Program's Contaminated Sediment Inventory, and some data sets from EPA's STORET). Furthermore, each monitoring program used unique sampling and analysis protocols. For example, PCBs, the chemical group most often responsible for placing sites in Tier 1, were measured by nearly all of the programs but were analyzed and reported as aroclor-specific data, congener-specific data, total PCBs, or a combination of these.

The only quality assurance/quality control (QA/QC) information required for data to be included in the NSI was information on the source of the data and the location of the sampling station. Available information on several types of QA/QC procedures that can influence the quality of the data and can be used to check the quality of data was included in the NSI. None of this information, however, was required before a data set could be included in the NSI. Evaluation of such information can provide an indication of the quality of the data used to target a specific site. Table 5-2 presents a summary of the known QA/QC information associated with each of the data sets included in the NSI.

Table 5-2. National Sediment Inventory Database: Summary of QA/QC Information

Database	Are There QA/QC Reports to Accompany the Data?	Were the Data Peer-Reviewed?	Are the Sampling and Analytical Methods Identified in the Database?	Are the Detection Limits for the Analytes Included in the Database?	Comments
ODES	Yes	Yes, 301(h) data	Yes	Yes	Data Qualifiers
EMAP (VA and LA Provinces)	Yes	Yes	Yes	Yes	Data Qualifiers
Seattle; U.S. Army Corps of Engineers	Yes	Yes	Yes	Yes	Data Qualifiers
Region 4	Some	No	Some	Yes	Data Qualifiers
Gulf of Mexico	Some	No	Some	Yes	Data Qualifiers
COSED	Yes	Yes	Yes	Some	
Great Lakes	Yes	Yes	Yes	Yes	
DMATS	Some	Yes	Yes	Yes	Data Qualifiers
STORET	Unknown	Unknown	No	Yes	Data Qualifiers
Massachusetts Bay (USGS)	Some	Yes	Yes	Yes	

Data reporting was also inconsistent among the different data sources. Inconsistencies that required resolution included the lack or inconsistent use of Chemical Abstract Service (CAS) numbers, analyte names, species names, and other coding conventions, as well as the lack of detection limits and associated data qualifiers (remark codes). The evaluation of toxicity data required the presence of control data. Control data were not often initially reported with the data, and significant follow-up work was required to acquire such data. In addition, 4 of the 11 sources of toxicity test data used in the NSI evaluation did not report the use of laboratory replicates.

Some of the data included in the NSI were compiled as early as 1980 (the data cover the period of 1980-93) and might not reflect current conditions. The analysis did not include a temporal assessment of trends in sediment contaminant levels. Emissions of many prominent contaminants declined during the 1980s, and significant remediation efforts have taken place at many sites since that time. In addition, dredging, burial, and scouring might have removed contaminants from some sampling sites. The lack of a trend analysis in sediment contamination over time is an important limitation of this study and will be investigated in future NSI evaluations.

Some data parameters are consistently absent throughout the NSI database. (Refer to Appendix A, Tables A-1 and A-2, for information on the number of NSI stations at which the various types of data were collected.) For example, very few site-specific TOC or AVS data are available, and toxicity data or matched sediment chemistry and biological data were available at relatively few stations. For many of the fish tissue data included in the NSI, the species was not identified.

The lack of AVS data in the NSI was a significant limitation for the evaluation of metals data. The NSI includes a relatively large amount of metals data, and the data indicate that metals concentrations in sediment are elevated in many areas. At some stations the elevated metals concentrations might indicate a potential problem; however, no stations in the NSI could be placed in Tier 1 solely from measured concentrations of cadmium, copper, nickel, lead, or zinc. This reflects in large part the absence of AVS data, which are required to place sites contaminated with those metals in Tier 1.

The unavailability of matching sediment chemistry and tissue residue data also limited the NSI data evaluation. In several instances, fish tissue was not analyzed for the same suite of chemicals for which sediment was analyzed. Spatial and temporal limitations of the data might have directly affected the analysis. Although some sediment chemistry and tissue residue data might have been collected in the same or very similar locations, if the station names were not identical, the data could not be treated as if they were collected from the same location. This very

likely resulted in an underestimate of the number of Tier 1 stations identified based on potential human health effects. The underestimate occurred because exceedances of sediment TBP and tissue levels (EPA risk levels and FDA levels) at the same station were required to categorize stations as Tier 1.

The lack of consistency among the different monitoring programs in the suite of chemicals analyzed also represents an area of uncertainty in the NSI data evaluation. Certain databases contain primarily information describing concentrations of metals or pesticides, whereas others (e.g., STORET and ODES) contain data describing concentrations of nearly every chemical monitored in all of the NSI data. Many monitoring programs use a screening list of chemicals that are indicator pollutants for contaminated sediments. Thus, many of the specific chemicals assessed in the NSI data evaluation are not always measured in samples. In addition, certain classes of in-place sediment contaminants might not be recognized as causing significant impacts and thus are not routinely measured.

Information describing local background levels of sediment contaminants was usually not presented with the data included in the NSI and thus was not considered when the significance of elevated contaminant concentrations in sediment was evaluated. Background conditions can be important in an evaluation of potential adverse effects on aquatic life because ecosystems can adapt to their ambient environmental conditions. For example, high metals concentrations in samples collected from a particular station might occur from natural geological conditions at that location, as opposed to the effects of human activities.

Most data are associated with a specific location. As a result, establishing the percent of waters with contaminated sediment is not possible because it is difficult to assess the extent to which a monitoring station represents a larger segment of a water body. Furthermore, the NSI data are geographically biased. More than 50 percent of all stations evaluated in the NSI are located in 8 states (Washington, Florida, Illinois, California, Virginia, Ohio, Massachusetts, and Wisconsin), which have more than 700 monitoring stations each. Finally, EPA did not verify reported latitude and longitude coordinates for each site.

Limitations of Approach

Sediment Chemistry Screening Values

There are significant gaps in our knowledge concerning sediment-pollutant chemistry (especially bioavailability) and direct and indirect effects on aquatic biota. The certainty with which sediment toxicity can be predicted for each chemical using the various screening values included in the NSI evaluation can vary significantly based on the quality of the available data and the appropriateness of exposure assumptions. For example, draft SQCs and SQALs are not equivalent, even though they were developed using the same methodology. EPA has proposed SQCs for five chemicals based on the highest quality toxicity and octanol/water partitioning data, which have been reviewed extensively. The draft SQCs have also undergone extensive field validation experiments. However, data used to derive SQALs for additional chemicals have undergone only limited peer review. The AET values used in this evaluation were based on empirical data from Puget Sound. Direct application of values from Puget Sound to a specific site or region in another part of the country might be overprotective or underprotective of the resources in that area. Extensive collection of data and additional analyses would be required to develop AETs for other sites.

The bioavailability of metals in sediment is addressed by the comparison of the molar concentration of sulfide anions (i.e., acid-volatile sulfide [AVS]) to the molar concentration of metals (i.e., simultaneously extracted metals [SEM]). The [SEM]-[AVS] difference is most applicable as an indicator of when metals are not bioavailable. If [AVS] exceeds [SEM], there is sufficient binding capacity in the sediment to preclude metal bioavailability. However, if [SEM] exceeds [AVS], metals might be bioavailable or other non-measured phases might bind up the excess metals. To apply the [SEM]-[AVS] difference to indicate positive bioavailability and toxicity for this evaluation, EPA used laboratory data that indicated the probability of observed toxic effects at various [SEM]-[AVS] levels. Based on these data, EPA defined the Tier 1 level as [SEM]-[AVS]>5. Thus, this use of [SEM]-[AVS] represents a hybrid of a theoretical approach and a correlative approach.

Only those chemicals for which sediment chemistry screening values (i.e., draft SQCs, SQALs, ERLs/ERMs, PELs/TELs, and AETs) are available were evaluated in the analysis of NSI data. Therefore, the methodology could not identify contamination associated with chemical classes such as ionic organic compounds (e.g., alkyl phenols) and organometallic complexes (e.g., tributyl tin).

Biological effects correlation approaches are based on the evaluation of paired field and laboratory data to relate incidence of adverse biological effects to the dry-weight sediment concentration of a specific chemical at a particular site. Researchers use these data sets to identify level-of-concern chemical concentrations based on the

probability of observing adverse effects. Exceedance of the identified level-of-concern concentrations is associated with a likelihood of adverse organism response, but it does not demonstrate that a particular chemical is solely responsible. In fact, a given site typically contains a mixture of chemicals that contribute to observed adverse effects to some degree. Therefore, these correlative approaches tend to result in screening values that are lower than the theoretical draft SQCs and SQALs, which address the effects of a single contaminant. The effects range approaches to assessing sediment quality also do not account for such factors as organic matter content, AVS, and particle size distribution, which can mitigate the bioavailability and, therefore, the toxicity of contaminants in sediment.

Another concern is the application of screening values based on freshwater data (draft SQCs and SQALs) and those based on saltwater data alone (ERLs/ERMs, PELs/TELs, and AETs) to evaluate sediment contaminant concentrations in the NSI from both freshwater and saltwater habitats. Freshwater organisms exhibit tolerance to toxic chemicals similar to that of saltwater species when tested in their respective water; however, estuarine organisms might be less tolerant if osmotically stressed (Rand and Petrocelli, 1985). Thus, the relative toxicity of a chemical in water (i.e., its chronic threshold water concentration) is usually within an order of magnitude for saltwater and freshwater species, although final chronic values and draft sediment quality criteria values are usually slightly higher for saltwater species. Because of limitations of time and resources, sampled sites in the NSI were not classified by salinity regime, and further site-specific evaluations are required to more definitively assess the toxicity at the sites. However, the application of several different screening values should provide a reasonable estimate of potential risks to aquatic life in freshwater, estuarine, and marine habitats.

Additional false positive and false negative classifications of potential risk to aquatic life from sediment contaminant concentrations could occur when a default value for organic carbon content is applied. Draft SQCs and SQALs are based on the partitioning of a chemical between organic carbon in the sediment and pore water at equilibrium. Because the organic carbon content of most sediment samples in the NSI is unknown, these sediment samples were assumed to contain 1 percent organic carbon. Total organic carbon (TOC) can range from 0.1 percent in sandy sediments to 1 to 4 percent in silty harbor sediments and 10 to 20 percent in navigation channel sediments (Clarke and McFarland, 1991). Long et al. (1995) reported an overall mean TOC concentration of 1.2 percent from data compiled from 350 publications for their biological effects database for sediments. Sediments that have an organic carbon content higher or lower than 1 percent TOC might be classified incorrectly.

Uncertainty associated with the equilibrium partitioning theory for developing draft SQCs and SQALs includes the degree to which the equilibrium partitioning model explains the available sediment toxicity data (USEPA, 1993d). An analysis of variance using freshwater and saltwater organisms in water-only and sediment toxicity tests (using different sediments) was conducted to support development of the draft sediment criteria. This analysis indicated that varying the exposure medium (i.e., water or sediment) resulted in an estimate of variability that should be used for computing confidence limits for the draft SQCs. The methodology used to derive the octanol/water partitioning coefficient and the final chronic value can also influence the degree of uncertainty associated with the draft SQCs. Differences in the response of water column and benthic organisms, and limitations in understanding the relationship of individual and population effects to community-level effects, have also been noted (Mancini and Plummer, 1994). Site-specific modifications to screening values derived using the equilibrium partitioning model have been recommended to better address chemical bioavailability and species sensitivities (USEPA, 1993b). Sediment chemistry screening values developed using the equilibrium partitioning approach also do not address possible synergistic, antagonistic, or additive effects of contaminants.

Based on the theoretical calculations used to compute SQAL values, it is possible that SQALs might be orders of magnitude larger or smaller than other screening values used for the analysis (ERLs/ERMs, PELs/TELs, and AETs). This might be a result of the limited aquatic toxicity data used to develop SQAL values for some of the contaminants for which water quality criteria are unavailable. EPA did not use SQALs for this analysis in most cases. The approach used to develop SQALs, and to choose chemicals for which SQALs could not be developed, is presented in Appendix B.

Fish Tissue Screening Values

The approach used to assess sediment chemistry data for the potential to accumulate in fish tissue also represents a theoretical approach with field-measured components. In addition to applying a site-specific or default organic carbon content, the theoretical bioaccumulation potential (TBP) calculation includes a field-measured biota sediment accumulation factor (BSAF) to account for the relative affinity of a chemical for fish tissue lipids or sediment organic carbon. The BSAF will account for

the effects of metabolism and biomagnification in the organism in which it is measured. The primary limitation of this approach is the applicability of a field-measured BSAF, or a percentile from a distribution of values, at a variety of sites where the conditions may vary.

TBPs were assumed to be equivalent to levels detectable in fish tissue. However, this approach might not completely account for biomagnification in the food chain, especially when using a BSAF derived from a benthic organism. In addition, it is assumed that sediment does not move, that contaminant sources other than sediment are negligible, that fish migration does not occur, and that exposure is consistent. The TBP calculation assumes that various lipids in different organisms and organic carbon in different sediments are similar and have distributional properties similar to the field-measured values used to derive BSAFs. Other simplifying assumptions are that chemicals are similarly exchanged between the sediments and tissues and that compounds behave alike, independent of site conditions other than organic carbon content. In reality, physical-chemical processes (e.g., diffusion through porous media and sediment mixing) can vary and limit the rate at which chemicals can exchange with bottom sediments. Uptake of contaminants by aquatic organisms is also a kinetic (rate-controlled) process that can vary and be slowed, for example, by awkward passage of a bulky molecule across biological membranes. Also, a BSAF of 1 (thermodynamic equilibrium) was used to estimate TBPs for many nonpolar organics. This BSAF might overestimate or underestimate the bioaccumulative potential for certain nonpolar organics because it is assumed that there is no metabolic degradation or biotransformation of the chemical. Site-specific organic carbon content was often not available, which leads to additional uncertainty concerning the comparability of BSAFs among different locations. In addition, development of the BSAFs used in the TBP evaluation relied on a large amount of data that have not been published or peer-reviewed. Because of these factors, actual residue levels in fish resulting from direct and/or indirect exposure to contaminated sediment might be higher or lower. There is therefore uncertainty regarding site classifications based on comparison of estimated TBPs with FDA tolerance/action and guideline levels and EPA risk levels.

TBPs could not be calculated for polar organic compounds or heavy metals. Therefore, sites could not be classified using FDA levels or EPA risk levels for those chemicals using a TBP approach (although fish tissue monitoring data are often available for many sites).

Uncertainties and numerous assumptions are associated with exposure parameters and toxicity data used to derive EPA risk levels and FDA tolerance/action and guideline levels. For example, the derivation of EPA risk levels is based on the assumption that an individual consumes on average 6.5 g/day of fish caught from the same site over a 70-year period. Also, the TBP calculation for human health assessments assumes fish tissue contains 3 percent lipid. This value is intended to be indicative of the fillet rather than the whole body. Generally, the exposure assumptions and safety factors incorporated into toxicity assessments might overestimate risks to the general population associated with sediment contamination, but might underestimate risks to populations of subsistence or recreational fishers.

Other Limitations

Because a numerical score was not assigned to each sampling station to indicate the level of contamination associated with that station, it is not possible to determine which of the stations in Tier 1 should be considered the "most" contaminated. Such a numerical ranking system was intentionally not used for the NSI data evaluation because EPA does not believe that such ranking is appropriate for a screening-level analysis such as this, given the level of uncertainty.

Chapter 6

Recommendations

The following discussion presents EPA's recommendations for addressing current sediment contamination problems throughout the country and for improving the ability to conduct sediment assessments. These recommendations relate to six activities or information needs:

1. Further investigate conditions in the 96 targeted watersheds.
2. Coordinate efforts to address sediment quality through watershed management programs.
3. Expand the National Sediment Inventory's (NSI's) coverage and capabilities.
4. Provide better access to information in the NSI.
5. Develop better monitoring and assessment tools.
6. Address basic science needs.

Recommendation 1: Further Investigate Conditions in the 96 Targeted Watersheds

To characterize the extent and severity of sediment contamination problems in the United States, EPA has performed a screening-level analysis of the information in the NSI, the results of which are presented in Chapter 3. As mentioned previously, the results of the NSI data evaluation alone should not be used as justification for taking corrective actions at potentially contaminated sites. The initial evaluation of NSI data was performed as a means of screening and targeting. Additional, site-specific data and information should be gathered to verify the NSI evaluation results and to support a comprehensive assessment of the extent and severity of sediment contamination problems.

The primary recommendation resulting from the NSI data analysis is that the states, in cooperation with EPA and other federal agencies, should proceed with further evaluations of the 96 watersheds identified as areas of potential widespread sediment contamination (APCs). If active watershed management programs are in place, these evaluations should be coordinated within the context of current or planned actions. Future monitoring and assessment efforts should focus in particular on the 57 water body segments (or river reaches) located within the 96 APCs that had 10 or more stations categorized as Tier 1. The purpose of these efforts should be, as appropriate, to gather additional sediment chemistry data and related biological data and conduct further assessments of the data to determine human health and ecological risk, determine temporal trends, identify potential sources of sediment contamination and determine whether potential sources are adequately controlled, and determine whether natural recovery is a feasible option for risk reduction. Additional monitoring and analysis of data from the 96 APCs will also be used to track and document the effectiveness of management actions taken to address sediment contamination problems over time. Trends in sediment contamination in the 96 APCs over time will be reported in future reports to Congress.

It should be noted that many state and federal government monitoring programs already do a good job of gathering data at sites with known contamination problems (including some of the 96 APCs), and additional monitoring at those locations will probably not be necessary. However, for other locations not previously targeted for focused monitoring, additional data might be required to adequately assess potential sediment contamination problems, especially in areas where significant human health exposures occur. In addition, in some cases it might be necessary to conduct baseline studies to determine where to focus monitoring activities.

Further investigation might reveal that risks are minimal or that natural recovery has diminished risk or will diminish risk in an acceptable time period, or it might verify that current contamination is widespread and unlikely to sufficiently improve under existing conditions. Following verification of sediment contamination problems based on these additional assessments, appropriate actions (e.g., remediation, permit review, TMDL assessment, best management practices for nonpoint sources, or "no action") should be taken to address the problem. In many cases, the mechanisms for corrective actions are already in place (e.g., permit review, TMDL assessments) and responsible parties have already been identified. In

other cases, the states should work with EPA to determine the best course of action.

Recommendation 2: Coordinate Efforts to Address Sediment Quality Through Watershed Management of Programs

The watershed approach is a community-based water resource management framework that requires a high level of interprogram coordination to consider all factors contributing to water and sediment quality problems and to develop integrated, science-based, cost-effective solutions that involve all stakeholders. It is within the watershed framework, therefore, that EPA recommends that federal, state, and local government agencies pool their resources and coordinate their efforts to address their common sediment contamination issues. These activities should support efforts such as selection of future monitoring sites, setting of priorities for reissuance of NPDES permits, permit synchronization, total maximum daily load (TMDL) development, and pollutant trading between nonpoint and point sources.

The NSI provides an important tool for targeting efforts to further investigate the 96 APCs. It is also useful for screening additional potential areas of concern where there are known data gaps. In addition, the targeting technique used for identifying the APCs is directly applicable to local-level analysis because it uses site-specific information. As the NSI is expanded, it will provide further information to help environmental managers better understand which of the Nation's watersheds have sediment contamination problems that pose the greatest risk to aquatic life and human health, and track progress in addressing those problems.

There are many active watershed management efforts. EPA recommends strengthening and expanding these efforts, as appropriate, to better address sediment contamination issues. The majority 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 may not have, enabling them to compare their sites to others throughout the region or country, and allowing researchers to draw upon a large data set of information to conduct new analyses that ultimately will be relevant for local assessments and responses.

An important component of watershed management is to educate and engage all stakeholders in government, industry, and the community. The NSI can help explain the need to establish pollution prevention initiatives for point sources and nonpoint sources that might go beyond current practices. For example, chemical use practices in industry and by landowners, homeowners, and local governments might need to be changed to prevent, reduce, or eliminate potential sources of sediment contaminants.

Recommendation 3: Expand the NSI's Coverage and Capabilities

The NSI is currently limited in terms of the number of data sets it includes and the national coverage it provides. Over 50 percent of the monitoring stations evaluated in the NSI are located in eight states (Washington, Florida, Illinois, California, Virginia, Ohio, Massachusetts, and Wisconsin). In addition, only 11 percent of all river reaches in the United States include one or more sampling stations that were assessed as part of the NSI data evaluation.

EPA should continue compiling sediment chemistry data and related biological data in the NSI to:

- Obtain a greater breadth of coverage across the United States.
- Increase the number of water bodies evaluated.
- Include additional data for more chemicals of concern.
- Provide more recent data for evaluation for future reports to Congress.

Commentors on the preliminary evaluation of NSI data identified several additional databases that should be included in the NSI for future evaluations. Those databases and others should be evaluated and added to the NSI in the future as appropriate. EPA plans to obtain the most recent data from databases currently in the NSI (e.g., STORET and ODES) and add new data from recent monitoring efforts targeted at specific water bodies, states, or other areas that are currently underrepresented in the NSI.

Although some historical trend information is available, a comprehensive assessment of temporal trends is not presented in the current report to Congress. Future evaluations of the NSI data should be designed to determine where and why sediment quality conditions are improving or worsening. EPA plans to develop an approach for assessing temporal trends that might include, for example, a statistical analysis of recent and older data from national databases that are updated on a regular basis, such as STORET, ODES,

and the National Oceanic and Atmospheric Administration's NS&T database. In addition, in the search for additional databases for use in future NSI data evaluations, EPA should focus on obtaining sediment core data, which can provide valuable information concerning historical trends in sediment contamination. An assessment of temporal trends in sediment contamination will provide valuable information concerning the effectiveness of measures taken to control the release of sediment contaminants.

Recommendation 4: Provide Better Access to Information in the NSI

The NSI can be a powerful tool for water resource managers at the national, regional, state, watershed, and water body levels. It provides in a single place a wealth of information that could be very useful, especially with improved access and availability. Multiple agencies should have access to the same data for decision makers in regional management, state-level management, and watershed-level management.

Plans are under development to make this happen. By September 1996 the NSI data, organized by watershed and including maps and summary tables, should be available on EPA's mainframe computer for on-screen viewing and download. In addition, near future plans are to make this information available on EPA's World Wide Web site. EPA has also included the NSI data in its comprehensive GIS/modeling system, BASINS (Better Assessment Science Integrating Point and Nonpoint Sources). Future activities should include the addition of the NSI evaluation tools to BASINS to allow users to query the NSI evaluation results. For managers, this could be useful for identifying watersheds, water bodies, or sampling stations where various sediment chemistry and/or biological screening values have been exceeded. Identifying potential point and nonpoint sources of sediment contaminants is also critical.

Increased access to data and information in the NSI has many implications. At the national level, the data and information can:

- Demonstrate the need and provide impetus for increased pollution prevention efforts.
- Demonstrate the need for safer or biodegradable chemicals.
- Determine relative risk compared to other problems.

At the state and watershed level, better access to NSI information can help in:

- Educating and involving the public.
- Setting goals and prioritizing activities and expenditures.
- Evaluating the adequacy and effectiveness of control actions, clean-up activities, and other management actions.

Related to source identification are plans under way at the Agency for one-stop reporting of and access to integrated information about the environmental performance and emissions of major industrial facilities and other pollution sources. States and EPA will give every major industrial facility and other type of facility generating, storing, and disposing of hazardous and toxic wastes a unique identifying number. This number will be used by states and EPA to link all environmental information related to the facility. NSI development will be linked to these Agency-level efforts.

Interagency and intergovernmental cooperation is essential for enhancing NSI information, coverage, and comprehensiveness. Reporting of water quality information and environmental indicator development at the Office of Water are important ongoing efforts related to the collection of information from state agencies (through 305(b) reporting), other federal agencies, and the private sector. Efforts for future data collection for the NSI should be integrated into these related initiatives.

Recommendation 5: Develop Better Monitoring and Assessment Tools

During the evaluation of information in the NSI, analysts continually came up against the limitations of available tools and techniques to assess the sediment contaminant information. For example, many contaminants included in the NSI, such as kepone and tributyl tin, could not be evaluated due to a lack of appropriate screening values for comparison with measured values. Although screening values were adopted or developed for the NSI data evaluation wherever feasible, many data for some potentially harmful contaminants were not evaluated. To address this issue, EPA should continue to develop sediment quality criteria (SQCs), especially for metals. In the absence of SQCs for additional nonionic organic chemicals, EPA should continue to develop additional sediment quality advisory levels (SQALs). The development of additional SQCs and SQALs will improve

assessment capabilities both for identifying potential problems and planning appropriate response actions.

The limitations associated with a lack of screening values were most apparent in the evaluation of sediment metals data. As noted in the previous chapter, a large number of stations had elevated concentrations of metals. However, many of these stations could not be categorized as Tier 1 because of a lack of acid volatile sulfiide (AVS) and simultaneously extracted metals (SEM) data, which were required to place stations in the Tier 1 category based on sediment contamination from cadmium, copper, nickel, lead, or zinc. AVS and SEM provide information necessary to assess the bioavailability of metals in sediment, and future sediment monitoring programs should specify collection of AVS and SEM measurements where metals are a concern.

Total organic carbon (TOC) data were also lacking for many monitoring stations with data in the NSI. TOC, like AVS and SEM, provides information related to the bioavailability of contaminants—in this case, nonionic organic chemicals. Because of the lack of site-specific TOC data, a default TOC value was used in the NSI evaluation in the comparison of measured sediment chemistry values to screening values. This approach resulted in the possible overestimation or underestimation of potential impacts. Therefore, EPA recommends that future monitoring programs also include TOC measurements where organic chemicals are a concern.

EPA also recommends that future sediment monitoring programs collect tissue residue, biological effects (i.e., toxicity, histopathology), and biological community (e.g., benthic abundance and diversity) measurements. These types of data are necessary to better assess actual effects resulting from exposure to contaminated sediment. In areas where aquatic life effects are a concern, monitoring programs should collect matched sediment chemistry and biological effects data and biological community measurements. Matched sediment chemistry and tissue residue data should be collected where human exposures are a concern.

The sediment quality evaluation tools used for the current NSI data evaluation should be used as the basis for further methods development. As sediment quality data become more available and the state of the science for sediment assessment evolves, assessment methods will also evolve. For example, new and better screening values will be developed. EPA should incorporate new sediment assessment techniques into future NSI data evaluations as they are developed, tested, and proven reliable. For example, although biological community data were included in the NSI, the data were not evaluated for this report to Congress because there is little agreement among sediment assessment experts concerning biological community conditions that can be directly related to sediment quality problems. EPA should work to develop these and other sediment assessment tools for future assessments.

Recommendation 6: Address Basic Science Needs

The National Sediment Quality Survey is the first attempt to analyze sediment chemistry and biological data from numerous databases from across the country in an effort to identify the national extent and severity of sediment contamination. Because the data were not generated by a single monitoring program designed at the outset to provide this national picture, numerous hurdles had to be overcome to analyze the data with as little bias and as much scientific validity as possible. This exercise itself provided an opportunity to assess the needs to develop better basic science with respect to sediment chemistry data and related biological data. These needs are in addition to those identified under Recommendations 3, 4, and 5.

Identified below are the relevant issues and science needs that should be addressed to better characterize the sources, fate, and effects of sediment contaminants:

- Methods to better predict the fate and transport of sediment contaminants.
- Methods to predict or track atmospheric sources and cross-media transfers of sediment contaminants such as mercury, pesticides, PCBs, and PAHs.
- Bioavailability of compounds other than nonionic organics.
- Estimates of land use impacts on sediment conditions (predictive capabilities).
- Methods for fingerprinting chemicals for source identification.

Glossary

Acid-volatile sulfide (AVS): Reactive solid-phase sulfide fraction that can be extracted by cold hydrochloric acid. Appears to control the bioavailability of most divalent metal ions because of the sulfide ions' high affinity for divalent metals, resulting in the formation of insoluble metal sulfides in anaerobic (anoxic) sediments.

Acute toxicity: Immediate or short-term response of an organism to a single dose of a chemical substance through various routes of exposure. Refers to generalized toxic response with lethality usually being the observed endpoint.

Apparent Effects Thresholds (AETs): Sediment quality screening levels based on a biological effects correlation approach. Designed to identify concentrations of contaminants that are associated exclusively with sediments exhibiting statistically significant biological effects relative to reference sediments. Two screening levels are recognized when possible based on different indicators: (1) AET-L, the lowest concentration for which a particular indicator showed an effect, and (2) AET-H, the highest concentration at which effects were observed for another indicator. Based on empirical data from Puget Sound. Developed by Barrick et al. (1988).

Benthic abundance: The quantity or relative degree of plentifulness of organisms living in or on the bottom of streams, rivers, or oceans.

Benthic organisms: Species living in or on the bottom of streams, rivers, or oceans.

Bioavailability: The fraction of chemical present that is available for uptake by aquatic organisms.

Biological community: An assemblage of organisms that are associated in a common environment and interact with each other in a self-sustaining and self-regulating relationship.

Biological effects correlation approach: A method for relating the incidence of adverse biological effects to the dry-weight sediment concentration of a specific chemical at a particular site based on the evaluation of paired field and laboratory data. Exceedance of the identified level of concern concentration is associated with a likelihood of adverse organism response, but does not demonstrate that a particular chemical is solely responsible.

Chronic toxicity: Response of an organism to repeated, long-term exposure to a chemical substance.

Combined sewer overflow: A discharge of a mixture of storm water and untreated domestic wastewater that occurs when the flow capacity of a sewer system is exceeded during a rainstorm.

Contaminated sediment: Sediment that contains chemical substances at concentrations that pose a known or suspected threat to aquatic life, wildlife, or human health.

Contaminated sediment site: A monitoring station that has been categorized as having a higher probability of causing adverse effects to aquatic life, wildlife, or human health based on an evaluation of monitoring data contained in the NSI.

Demersal species: Swimming organisms that prefer to spend the majority of their time on or near the bottom of a water body.

Divalent metals: Metals that exist and are available for reaction in a valence state of two (i.e., carrying an electric charge of two units).

Ecosystem: An ecological unit consisting of both the biotic communities and the nonliving (abiotic) environment, which interact to produce a stable system.

Effects range-median (ERM) and effects range-low (ERL) values: Sediment quality screening levels based on a biological effects correlation approach. Represent chemical concentration ranges that are rarely (i.e., below the ERL), sometimes (i.e., between ERL and ERM), and usually (i.e., above the ERM) associated with toxicity for marine and estuarine sediments. Developed by Long et al. (1995).

Elutriate phase toxicity test: Toxicity test in which sediments are mixed with test water for a fixed period of

time, the sediments are then removed, and test organisms are introduced to the test water (the elutriate) in the absence of sediments. Useful for representing the exposure to chemicals that can occur after sediments have been resuspended into the water column or after they have passed through the water column as part of dredged material disposal operations.

Equilibrium concentration: The concentration at which a system is in balance due to equal action by opposing forces within the system. When the partitioning of a nonionic organic chemical between organic carbon and pore water and partitioning of a divalent metal between solid and solution phases are assumed to be at equilibrium, an organism in the sediment is assumed to receive an equivalent exposure to the contaminant from water only or from any equilibrated phase. The pathway of exposure might include pore water (respiration), sediment carbon (ingestion), sediment organism (ingestion), or a combination of routes.

Equilibrium partitioning (EqP) approach: Approach used to relate the dry-weight sediment concentration of a particular chemical that causes an adverse biological effect to the equivalent free chemical concentration in pore water and to that concentration sorbed to sediment organic carbon or bound to sulfide. Based on the theory that the partitioning of a nonionic organic chemical between organic carbon and pore water and the partitioning of a divalent metal between the solid and solution phases are at equilibrium.

Histopathology: The study of diseases associated with tissue changes or effects.

Hydrology: A science dealing with the properties, distribution, and circulation of water on the surface of the land, in the soil, and in the atmosphere.

Interstitial water: Water in an opening or space, as between rock, soil, or sediment (i.e., pore water).

Microbial toxicity test: Type of toxicity test in which members of the microbial community (i.e., bacteria) are used as the test organism. Microbial responses in toxicity tests have been recommended as early warning indicators of ecosystem stress. However, questions have been raised concerning the sensitivity of sediment microbial toxicity testing.

Molar concentration: The ratio of the number of moles (chemical unit referring to the amount of an element having a mass in grams numerically equal to its atomic weight) of solute (the substance being dissolved or that present in the smaller proportion) in a solution divided by the volume of the solution expressed in liters.

National Sediment Inventory (NSI): A national repository for sediment quality data and related biological data. Results of the evaluation of data from the NSI serve as the basis for the report to Congress on the extent and severity of sediment contamination across the country (i.e., the National Sediment Quality Survey). Eventually all compiled NSI data will be incorporated into the new, modernized STORET, where they will be permanently stored.

Nonionic organic chemicals: Compounds that do not form ionic bonds (bonds in which the electrical charge between bonded atoms in the compound is unequally shared). Nonionic compounds do not break into ions when dissolved in water and therefore are more likely to remain in contact with and interact with sediment compounds or other compounds in water.

Nonpoint source pollution: Pollution from diffuse sources without a single point of origin or pollution not introduced into a receiving stream from a specific outlet. Such pollutants are generally carried off the land by storm water runoff. Sources of nonpoint source pollution include atmospheric deposition, agriculture, silviculture, urban runoff, mining, construction, dams and channels, inappropriate land disposal of waste, and saltwater intrusion.

Nonpolar organic chemicals: Compounds that do not exhibit a strong dipole moment (there is little difference between the electrostatic forces holding the chemical together). Nonpolar compounds tend to be less soluble in water. In aquatic systems, nonpolar chemicals are more likely to be associated with sediments or other nonpolar compounds than with the surrounding water.

Point source pollution: Pollution contributed by any discernible, confined, and discrete conveyance including, but not limited to, any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, or vessel or other floating craft, from which pollutants are or may be discharged.

Pore water: See Interstitial water.

Probable Effects Levels (PELs) and Threshold Effects Levels (TELs): Biological effects correlation-based sediment quality screening levels similar to ERMs/ERLs. Used to develop similar effects-based guidelines for the State of Florida. The lower of the two guidelines

for each chemical (i.e., the TEL) is assumed to represent the concentration below which toxic effects rarely occur. In the range of concentrations between the two guidelines, effects occasionally occur. Toxic effects usually or frequently occur at concentrations above the upper guideline value (i.e., the PEL).

Sediment quality advisory levels (SQALs): Equilibrium partitioning-based sediment quality screening values. Derived using the same approach used to develop sediment quality criteria; however, SQALs are based on data from limited sources and have undergone only limited review.

Sediment quality criteria (SQCs): Published draft sediment quality criteria for the protection of aquatic life. Based on the equilibrium partitioning-based approach using the highest quality toxicity and octanol/water partitioning data, which have been reviewed extensively. Draft SQCs have been developed by EPA for five nonionic organic chemicals: acenaphthalene, dieldrin, endrin, fluoranthene, and phenanthrene.

Simultaneously extracted metals (SEM): Metal concentrations that are extracted during the same analysis in which the acid-volatile sulfide (AVS) content of the sediment is determined.

Solid-phase toxicity test: Toxicity test in which test organisms are exposed directly to sediments. Sediments are carefully placed in the exposure chamber and the chamber is then filled with clean water. Resuspended particles are allowed to settle before initiation of exposure. Solid-phase toxicity tests integrate multiple exposure routes, including chemical intake from dermal contact with sediment particles as well as ingestion of sediment particles, interstitial water, and food organisms.

Theoretical bioaccumulation potential (TBP): An estimate of the equilibrium concentration of a contaminant in tissues if the sediment in question were the only source of contamination to the organism. TBP is estimated from the organic carbon content of the sediment, the lipid content of the organism, and the relative affinities of the chemical for sediment organic carbon and animal lipid content.

Total organic carbon (TOC): Measure of organic carbon content of sediment expressed as a percent. Used to normalize the dry-weight sediment concentration of a chemical to the organic carbon content of the sediment.

U.S. Environmental Protection Agency (EPA) risk levels: Levels of contaminant concentrations in an exposure medium that pose a potential carcinogenic risk (e.g., 10^{-5}, or a 1 in 100,000 extra chance of cancer over a lifetime) and/or noncancer hazard (i.e., exceeds a reference dose). Used in this document to estimate human health risk associated with the consumption of chemically contaminated fish tissue.

U.S. Food and Drug Administration (FDA) tolerance/action or guideline levels: FDA has prescribed levels of contaminants that will render a food "adulterated." The establishment of action levels (informal judgments about the level of a food contaminant to which consumers can be safely exposed) or tolerances (regulations having the force of law) is the regulatory procedure employed by FDA to control environmental contaminants in food.

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Appendix A

Detailed Description of NSI Data

Sources of the NSI Data

The scope of the data compilation component of the NSI was to collect, review, and compile readily available data that could be used to evaluate the extent of sediment contamination throughout the United States. As a result, emphasis was placed on gathering data sets with sediment chemistry data since those were the most prevalent data available on a national basis. The minimum data elements for inclusion in the NSI were date of sample collection, latitude/longitude, reliable units (e.g., mg/kg), and source of data. The electronic data sources used for the NSI are listed below.

- EPA's Storage and Retrieval System (STORET)
- EPA's Ocean Data Evaluation System (ODES)
- NOAA's Coastal Sediment Inventory (COSED)
- EPA Region 4's Sediment Quality Inventory
- EPA Gulf of Mexico Program's Contaminated Sediment Inventory
- EPA Region 10/COE Seattle District Sediment Inventory
- EPA's Great Lakes Data Base
- EPA's Environmental Monitoring and Assessment Program (EMAP)
- EPA Region 9 Dredged Material Tracking System (DMATS)
- USGS Massachusetts Bay Data (metals only)
- National Source Inventory (PCS and TRI)

In several cases, the readily available data sources for the NSI were compilations of existing data. For example, the EPA Gulf of Mexico Program's Contaminated Sediment Inventory included data from ODES, STORET, and EMAP. Since those data sources had been reviewed independently, they were deleted from the Gulf of Mexico Inventory before that data set was added to the NSI. A similar screening of data was conducted for the other data sets included in the NSI. Below is a summary of the remaining contributors to the individual data sets:

STORET	Numerous federal and state agencies	
ODES	Boston Harbor	Tennessee
	Masschusetts Bay	Kentucky
	Cape Arundel	Florida
	City of Gloucester	GLNPO/ARCS
	Mile 106	Galveston Bay
	South Carolina	San Diego Pre-301(h)
	Alabama	Orange County 301(h)
	Mississippi	Oxnard 301(h)
	Georgia	Los Angeles 301(h)
	North Carolina	Thums Ocean Dumping
	Encina 301(h)	Puget Sound
	Morro Bay 301(h)	Anchorage
	Hyperion 301(h)	Endicott 403(c)
	Goleta 301(h)	Kuparuk STP 403(c)

	San Francisco NEP LA2 Ocean Dumping LA5 Ocean Dumping	Prudhoe Bay 403(c) Port Valdez 403(c)
COSED	NOAA NS&T	Ed Long
Region 4	City of Tampa Dept of Navy EPA Region 4 FL DER S FL Water Mgmt Dist. USACE	USACE, Jacksonville USACE, Mobile USACE, Savannah USACE, Wilmington USFWS
Gulf of Mexico	ADEM (Mobile) Army Corps Eng. EPA-Houston ERL-N GCRL, Mississippi	TVA USACE (Mobile) USEPA Region 6 USGS
Seattle COE	Department of Social and Health Services Department of Ecology U.S. Fish and Wildlife Service Puget Sound Water Quality Authority Tetra Tech, Inc. Department of Fisheries Department of Natural Resources Department of Wildlife EPA Region 10 Batelle Northwest Sequim Laboratory Environmental Systems Corporation Department of Health College of Ocean and Fisheries Science PTI Environmental Services National Oceanic and Atmospheric Admin. Fish and Wildlife Health Consultants City of Bellingham U.S. Army Corps of Engineers, Seattle Columbia Northwest, Inc. Hulbert Mill King County Municipality of Metropolitan Seattle Wildlife Health Consultants U.S. Navy City of Olympia, LOTT treatment plant Port of Bellingham Port of Everett Port of Olympia Port of Port Townsend Thurston County Dept of Public Health U.S. Coast Guard	Department of Parks and Recreation Environmental Information Consultants South. CA Coastal Water Research Proj., Army Corps of Engineers, San Francisco Environmental Science Associates, Inc. E.V.S. Consultants, Sausalito, CA Marine Bioassay Labs, Watsonville, CA MEC Analytical Systems, Watsonville, CA San Francisco Port Commission ToxScan, Inc., Watsonville, CA Tetra Tech, Inc., Lafayette, CA Port of Grays Harbor Port of Tacoma Tristar Marine Morton Marine Port of Seattle South Park Marina U.S. Oil and Refining Company Weyerhauser Day Island Yacht Club Shell Oil Capital Regional District, Victoria, BC Environment Canada Greater Vancouver Regional District E.V.S. Consultants, Seattle, WA E.V.S. Consultants, Vancouver, BC British Petroleum Oil Company American Petroleum Institute
Great Lakes	Heidelberg College, Tiffin, Ohio Illinois EPA Michigan Tech. Univ., Houghton, MI Univ. of Wisconsin-Superior,WI Michigan Dept. Natural Resources	US Army COE, Buffalo District Beak Consultants, Inc Ontario Ministry of the Environment Aqua Tech, Melmore, OHEG&G Bionomics/Aqua Tech Environ. Cnstlt.

	Ohio EPA Illinois Geological Survey USEPA-GLNPO USEPA-ERL-Duluth	Applied Biology, Inc., Decatur, GA Recra Research, Inc., Tonawanda, NY USFWS, Columbia, MO - ARCS Michigan State University
EMAP	Louisianian Province	Virginian Province
DMATS	USEPA Region 9	
USGS Massachusetts Bay	A.D. Little, 1990 ACE_NED permit file #29-91-00473E ACE_NED permit file 199102068 ACE_NED permit file 09-89-2777 ACE_NED permit file 09-89-530 ACE_NED permit file 1989-2911 ACE_NED permit file 199101096 ACE_NED permit file 20-87-2002 ACE_NED permit file 20-89-2206 ACE_NED permit file 22-87-927 ACE_NED permit file 23-198902070 ACE_NED permit file 24-87-912 ACE_NED permit file 24-89-1180 ACE_NED permit file 25-81-374 ACE_NED permit file 25-86-1007 ACE_NED permit file 25-86-290E ACE_NED permit file 25-86-641 ACE_NED permit file Boston Harbor ACE_NED permit file Bridge marine- Salisbury, MA ACE_NED permit file CENED-OR (1145-2-303b) ACE_NED permit file HULL-72-CHA30 ACE_NED permit file Long Wharf Boston	ACE_NED permit file Navigation Improvement Study Feasibility Report and Environmental Assessment; Mystic RI ACE_NED permit file Navigation Improvement Study Dredge Material Disposal Plan Supplement to Feasibility Rep BOEHM, 1983 Bajek, 1983 Battelle, 1984; 1987 a, b Boehm & Farrington, 1984 Boehm et al., 1984 CDM, 1980 Cudmore, 1988 Enseco, 1987a Enseco, 1987b GCA Corp., 1982 Gardner et al., 1986 Gardner et al., 1988 Hubbard, 1987 Jason M. Cortell & Assoc., 1982
USGS Massachusetts Bay	ACE_NED permit file MA DPW Beverly-Salem Bridge and By-Pass Project ACE_NED permit file MA-HULL-81-180 ACE_NED permit file MA-HULL-84-210 ACE_NED permit file MWRA- Stoney Brook Conduit ACE_NED permit file Massport Bird Island Flats - Harborwalk phase III ACE_NED permit file Navigation Improvement Study Dredge Material Disposal Plan Supplement to Feasibility Rep USACOE,1981 Wong, 1983 USEPA MBDS, 1989 USACOE, 1990b (DAMOS)	Jason Cortell, 1990 MA DEQE, 1985 MA DEQE, 1986MA DPW, 1991 MA DEQE, 1982 MacDonald, 1991 NET Atlantic, 1990 Nolan et al., 1981 Penney et al., 1981 Phillips, 1985 Pruell et al., 1989 Ryan et al., 1982 Robinson et al., 1990 Shea et al., 1991 Shiaris et al., 1986

Types of Data Included in the NSI

In addition to sediment chemistry data, tissue residue, benthic abundance, toxicity (solid-phase and elutriate), histopathology, and fish abundance data have been gathered and included in the NSI, although only the sediment chemistry, tissue residue, and toxicity data have been evaluated for this report to Congress. The NSI also includes loadings data from the Permit Compliance System (PCS) and the Toxic Release Inventory (TRI). EPA recently released an updated version of the National Fish Advisories database, which was not available for this analysis. A summary of the types of data available in the NSI is provided below.

Sediment chemistry. Sediment chemistry data include detailed analytical results, analyte sampled, remark codes, sampling methods, analytical methods, sample weight, core depths, and grain size information. Percent organic carbon and acid-volatile sulfide content of sediments are also included when available.

Tissue residue. Tissue residue data include detailed analytical results, analyte sampled, remark codes, sampling methods, clean-up procedures, analytical methods, species, sex, anatomy sampled, life stage, and wet/dry reporting basis.

Toxicity. Toxicity data include test conditions (DO, pH, flushing hardness, feeding, salinity, etc.), test species, dilution, endpoints (e.g., mortality), and test duration. Solid-phase and elutriate data are provided when available.

Benthic abundance. Benthic abundance data include enumeration of species collected and numerous community-level summaries/indices.

Histopathology. Histopathology data include the number of fish with body, branchial, and buccal pathologies; number of species; and abundance.

Fish abundance. Fish abundance data include mean and standard deviation of fish length and abundance of species.

For each data set included in the NSI, Table A-1 identifies the number of stations at which the following parameters were measured:

- Sediment chemistry
- Tissue residue
- Benthic abundance
- Toxicity
- Histopathology
- Matched data
  - sediment chemistry and tissue residue
  - sediment chemistry and benthic abundance
  - sediment chemistry and toxicity
  - sediment chemistry and histopathology
  - sediment chemistry, tissue residue, and toxicity
  - sediment chemistry, benthic abundance, and toxicity

Table A-2 presents the total number of stations at which each of these parameters was measured and the number of stations for which coordinates (i.e., latitude/longitude) were available. Only data from stations with coordinates could be used to identify sites of potential concern.

The only quality assurance/quality control (QA/QC) information required for the data before they could be included in the NSI was information on the source of the data and the location of the sampling station. If available, information on the field and laboratory samples and methods used was included with the data.

How the Data Are Organized

The NSI data are contained in a series of tables that correspond to the different types of data described above. In some cases multiple tables were created for one type of data. The primary table in the NSI is the station table. Each record in the table corresponds to a unique sampling station. The records in the station table can be related to tables for each type of data, such as sediment chemistry data, tissue residue data, etc. These tables can then be related to additional look-up tables that include ancillary information such as chemical or species names. Figure A-1 illustrates the relationship between the station, sediment chemistry, tissue residue, toxicity, and related look-up tables.

Table A-1. Number of Stations at Which Various Types of Data Were Collected

Data Set	Number of Stations Where Measured										
	Sediment Chemistry	Tissue Residue	Benthic Abundance	Toxicity	Histopath-ology	Sediment Chemistry and Tissue Residue	Sediment Chemistry and Benthic Abundance	Sediment Chemistry and Toxicity	Sediment Chemistry and Histopath-ology	Sediment Chemistry, Tissue Residue, and Toxicity	Sediment Chemistry, Benthic Abundance, and Toxicity
STORET	12,907	6,057				1,533					
Region 4	1,024										
ODES	1,317	1,722	2,592	296		37	664	70		2	49
COSED	1,104										
Gulf of Mexico	210			82				6			
Great Lakes	761	26	476	373		26	449	369		26	68
DMATS	213	202		245		169		188		163	
Mass. Bay	979										
EMAP										198	259
LA Prov.	260	199	259	259	259	198	259	259	259		202
VA Prov.	202		212	212			202	202			
Seattle USCOE	2,116		365	876			365	707			270
Total	21,093	8,206	3,904	2,343	259	1,963	1,939	1,801	259	389	848

Table A-2. Number of Stations With Data Included in the NSI

Measurement Parameters	Total Number of Stations	Stations with Coordinates	
		Number	% of Total Number of Stations w/Coordinates[a]
Sediment Chemistry	21,093	19,546	76
TOC	6,170	5,335	21
AVS	425	371	1
Tissue Residue	8,206	7,208	28
Toxicity	2,343	1,523	6
Elutriate Phase	630	—	—
Solid Phase	1,865	—	—
Benthic Abundance	3,904	1,844	7
Histopathology	259	259	1
Sediment Chemistry & Tissue	1,963	1,930	8
Sediment Chemistry & Toxicity	1,801	1,263	5
Sediment Chemistry & Abundance	1,939	1,340	5
Sediment Chemistry & Histopathology	259	259	1
Sediment Chemistry, Tissue, & Toxicity	389	359	1
Sediment Chemistry, Toxicity, & Abundance	848	733	3

[a]Total number of stations with coordinates = 25,555.

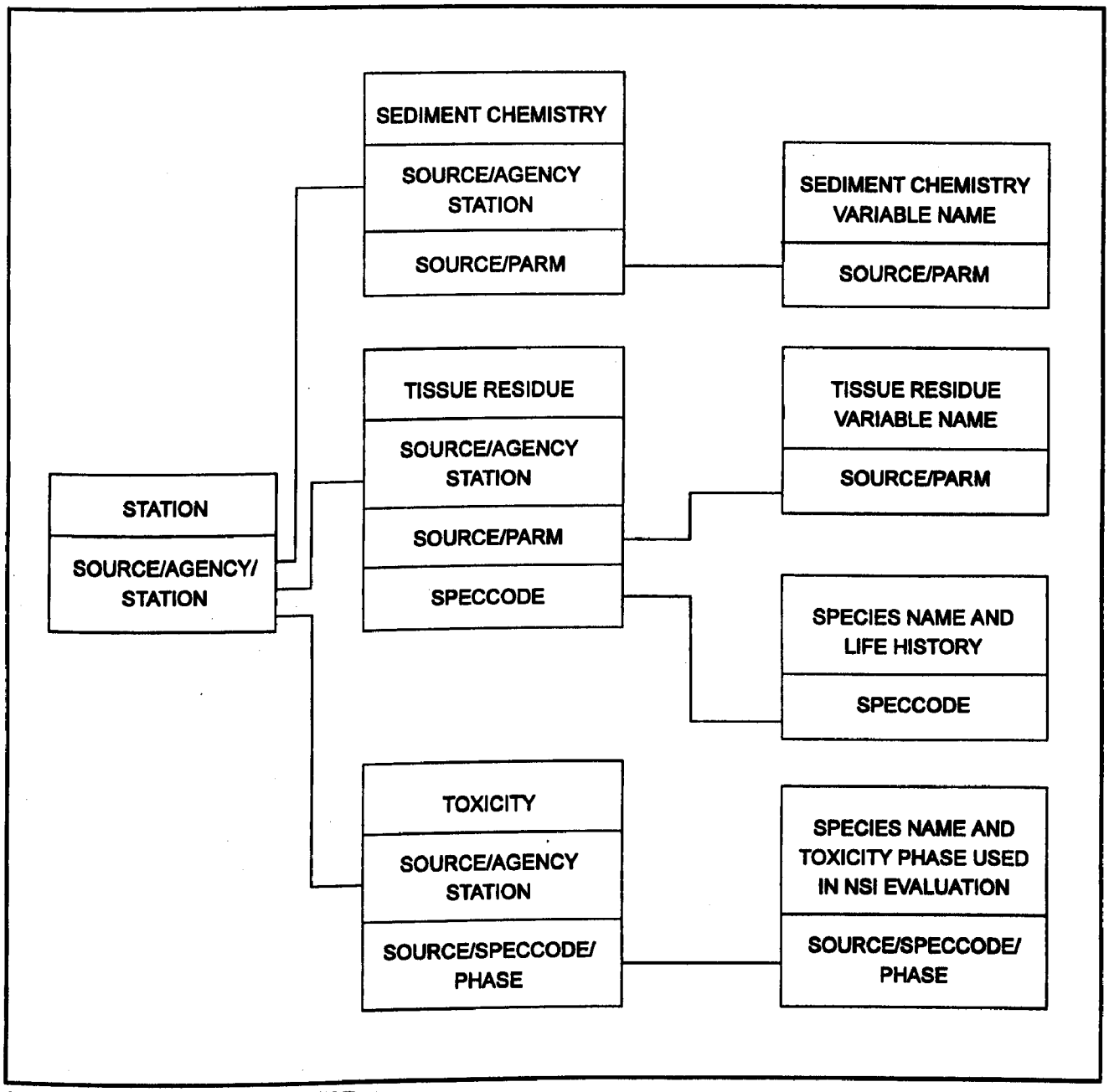

Figure A-1. Organization of NSI Data.

Table A-3 summarizes the tables that are available in version 1.1 of the NSI (the current version). Some of these tables have not required updating since version 1.0 of the NSI (the version used to prepare the preliminary evaluation of sediment chemistry data described in Chapter 2). Key changes to the data set from version 1.0 include the following:

- Inclusion of Regional/state review codes. (See data element NSIREVCD in tables ALLSEDI and ALLTISS.)
- Resolution of species codes for tissue residue data.
- Inclusion of biotoxicity control data for EMAP programs.
- Revised loadings data from Permit Compliance System (PCS) and Toxic Release Inventory (TRI). Facilities with no loadings data are included as a separate table.
- Inclusion of species information and toxicity phase for purposes of the NSI evaluation methodology.

The remainder of this section contains a listing of the field names and descriptions associated with each table in the NSI.

ALLSTAT.DBF	**Station**
SOURCE	Identification of data origin (e.g., REG4 is the Region 4 Pilot Study)
AGENCY	Identification of group responsible for collecting data (e.g., NS&T is NOAA's National Status and Trends Program)
STATION	Monitoring station identification code. (ODES NOTE: STATION = *STN_CD* || ' ' || *STATION* || DATE. DMATS NOTE: STATION = *ID* || ' ' || *STATIONI* || ' ' || *SERIES* || ' ' || *SCAN*.)
COUNTY	County
DEPTH	Water depth (m)
DEPT_MAX	Maximum water depth (m)
DEPT_MIN	Minimum water depth (m)
DREDGESI	Dredged site
DRWATERB	Dredged water body
GEOCODE	Geologic code
INSTIT	Institution
LAT	Latitude (decimal degrees)
LAT_2	Latitude #2 forming a rectangle (decimal degrees)
LNG	Longitude (decimal degrees)
LNG_2	Longitude #2 forming a rectangle (decimal degrees)
LOCATION	Location
LOC_CODE	Location code
NSIREACH	Reach File 1 reach
ORIGIN	Origin
ORG_NAME	Organization name
REFER	Reference, literature citation
SR_SCI	Senior scientist
STATE	State
WATERBOD	Waterbody
EPA_REG	EPA Region
FIPS	FIPS code
FIPS_DIS	Distance to nearest FIPS (mile)
HUC_DIS	Distance to nearest catologic unit (mile)
RF1_DIS	Distance to RF1 reach (mile)

Table A-3. Data Tables Available in the NSI

Table Name	Table Description
ALLSTAT.DBF	Station
ALLSEDI.DBF	Sediment chemistry
ALLTISS.DBF	Tissue residue
ALLBIOT.DBF	Biotoxicity
ALLSEDM.DBF	Sediment grain size and miscellaneous sediment chemistry
ALLTISM.DBF	Miscellaneous tissue residue
ALLELUT.DBF	Elutriate
LOADD.DBF	PCS/TRI loadings
LOADS.DBF	PCS/TRI facilities (have loadings data)
LOADO.DBF	Other PCS/TRI facilities (no associated loadings data)
BIOTCODE.DBF	Toxicity phase for biotoxicity table (ALLBIOT)
ELUTPARM.DBF	List of analytes for elutriate table (ALLELUT)
SED_PARM.DBF	List of analytes for sediment tables (ALLSEDI, ALLSEDM)
TIS_CODE.DBF	List of species for tissue tables (ALLTISS, ALLTISM)
TIS_PARM.DBF	List of analytes for tissue tables (ALLTISS, ALLTISM)
SEACOE.DBF	EPA Region 10/COE Seattle District's Sediment Inventory Code file (important for interpreting a large number of codes unique to this data source)
REMARK.WP	Text file on remark codes (important for remark codes other than "K" or "U")
ALLSUPR.DBF	Superfund facilities
ALLBENA.DBF	Benthic species abundance
ALLBENC.DBF	Benthic community
ALLHIST.DBF	Histopathology
ALLFISA.DBF	Fish abundance
SPEC-CD.DBF	Species codes for benthic data
FISH-CD.DBF	Species codes for fish abundance data

EXT_MTHO	Extraction method code to indicate the method used to extract or digest the sample matrix and remove or isolate the chemical of concern
INSTRUME	Instrument code to identify the final chemical analysis method(s) used for analyzing the sample
MEAS_BAS	Result is wet or dry weight basis (see also P)
NSIREVCD	Preliminary evluation code (A=Reviewed in QA/QC of Preliminary Evaluation, U=Only one (1) observation of this chemical in source, X=Deleted based on QA/QC of Preliminary Evaluation (first run), Y=Duplicate Data, Z=Deleted based on QA/QC of Preliminary Evaluation (second run))
P	Result associated with PARM (µg/kg, ppb)
PARM	Analyte measured (see also P and R)
R	Remark code associated with PARM and P
SAMP_DTL	Depth to bottom of sample interval (m)
SAMP_DTU	Depth to top of sample interval (m)
SMP_EQP	Sampling equipment code
SPHERE	Sphere (i.e., environment) code from which the sample came
WET_WGT	Total wet weight of sample (g)

ALLTISS.DBF	**Tissue residue**
SOURCE	Identification of data origin (e.g., REG4 is the Region 4 Pilot Study)
AGENCY	Identification of group responsible for collecting data (e.g., NS&T is NOAA's National Status and Trends Program)
STATION	Monitoring station identification code. (ODES NOTE: STATION = *STN_CD* ‖ ' ' ‖ *STATION* ‖ DATE. DMATS NOTE: STATION = *ID* ‖ ' ' ‖ *STATIONI* ‖ ' ' ‖ *SERIES* ‖ ' ' ‖ *SCAN*.)
DATE	Date of sample collection
SAMPLE	Unique sample identifier code
SEQ	Computer-generated sequence number when multiple samples were taken; SOURCE, AGENCY, STATION, and DATE were identical; and no SAMPLE, SUBSAMPL, or REPLICAT codes were provided
REPLICAT	Unique replicate identifier code
ANATOMY	Organ/tissue sampled
ANAT_CD	Organ/tissue sampled code
CAS	CAS number for analyte
CLEANUP	Sample cleanup code to indicate an additional step taken to further purify the sample extracts or digestates
COMPOSIT	A unique identifier to indicate a sample created by compositing tissues from several individuals
DRY_WGT	Percent of total sample remaining after drying
EXT_MTHO	Extraction method code to indicate the method used to extract or digest the sample matrix and remove or isolate the chemical of concern
INSTRUME	Instrument code to identify the final chemical analysis method(s) used for analyzing the sample
NSIREVCD	Preliminary evluation code (F=Field test, L=Lab test, W=Species cannot be resolved, Y=Duplicate Data)
LENGTH	Length of specimen
LIFE_STA	Life stage code to identify the life stage of the sample
MEAS_BAS	Result is wet or dry weight basis (see also P)
NUMB_IND	Number of organisms in sample
P	Result associated with PARM
PARM	Analyte measured (see also P and R)
P_STD	Standard deviation of P associated with repeated measurements of PARM
R	Remark code associated with PARM and P

SAMPTYPE	Sample type
SEX	Sex code used to identify sex of sample
SMP_EQP	Sampling equipment code
SPECCODE	Species code
SPECIMEN	Unique identifier for the individual organism being analyzed
TOT_REP	Number of replicates
WEIGHT	Weight of organism
WET_WGT	Total weight of sample
LIPIDS	% Extractable lipids
SPEC_BIO	STORET taxonomic code

ALLBIOT.DBF	**Biotoxicity**
SOURCE	Identification of data origin (e.g., REG4 is the Region 4 Pilot Study)
AGENCY	Identification of group responsible for collecting data (e.g., NS&T is NOAA's National Status and Trends Program)
STATION	Monitoring station identification code. (ODES NOTE: STATION = *STN_CD* ‖ ' ' ‖ *STATION* ‖ DATE. DMATS NOTE: STATION = *ID* ‖ ' ' ‖ *STATIONI* ‖ ' ' ‖ *SERIES* ‖ ' ' ‖ *SCAN*.)
DATE	Date of sample collection
SAMPLE	Unique sample identifier code
REPLICAT	Unique replicate identifier code
SEQ	Computer-generated sequence number when multiple samples were taken; SOURCE, AGENCY, STATION, and DATE were identical; and no SAMPLE, SUBSAMPL, or REPLICAT codes were provided
AMMONIA	Ammonia concentration (mg/L)
ABNORMAL	Abnormality
BIOASS_DA	Bioassay date
BIOASSAY	Type of bioassay reported
BIOMASS	Biomass
COMMENTS	Comments
COM_NAME	Common name
DIL_UNIT	Concentration/Dilution units
DILUTION	Concentration/Dilution
DOX	Dissolved oxygen (mL/L)
ENDPOIN2	Endpoint #2 of bioassay test
ENDPOINT	Endpoint of bioassay test
E_QUALIF	EMERGENC qualifier
EMERGENC	Emergence after 10 days
EXT_MTHO	Extraction method code to indicate the method used to extract or digest the sample matrix and remove or isolate the chemical of concern
FEEDING	Feeding of species tested
FLUSH	Flushing rate in percent of chamber volume exchanged/24 hours
GENUS	Organism genus
HARDNESS	Hardness
HOLD_TIM	Holding time of sample prior to analysis (weeks)
LFSTG_EN	Life stage end—for bioassays that span more than one life stage, record predominant life stage at the end of the bioassay
LFSTG_ST	Life stage start—for bioassays that span more than one life stage, record predominant life stage at the start of the bioassay
MEASURED	Measured (Y/N)
NAME	Genus and species name (linked to PHASE)
NUM_ORGA	Number of organisms

P	Result associated with ENDPOINT
P_CC	Control-corrected analytical result associated with P
P2	Result associated with ENDPOIN2
PH	pH
PHASE	Phase code to indicate the phase (i.e., medium) in which the bioassay organisms are housed
PHOTO_PE	Photoperiod: Number of light hours vs. number of dark hours (e.g., 1608 = 16 hours light, 8 hours dark)
QASAMP1	Control sample no. 1
QASAMP2	Control sample no. 2
QASAMP3	Control sample no. 3
RENEWAL	Renewal (Y/N)
R	Remark code associated with ENDPOINT and P
REBURIAL	ET50 (mean reburial time)
RESPO_TY	Type of bioassay response
SALINITY	Salinity of water in test chamber (ppt)
SAMP_DTL	Depth to bottom of sample interval (m)
SAMP_DTU	Depth to top of sample interval (m)
SERIES	Bioassay series number
SIGNIF	Significant difference from control
SMP_EQP	Sampling equipment code
SPECCODE	Species code
SPECIES	Organism species
SPHERE	Sphere (i.e., environment) code from which the sample came
STD_TOX	Standard Toxicant Result code to indicate whether the results of the standard toxicant bioassay were acceptable
TEMP	Water temperature (deg C)
TESTDUR	Test duration (days)
TESTTYPE	Test used
TESTEXP	Test exposure periods
UNITS	Units associated with ENDPOINT and P
UNITS2	Units associated with ENDPOIN2 and P2
WATERTYP	Water type
YOUNG	Number of young produced per adult female over 4 weeks

ALLSEDM.DBF	**Sediment grain size and miscellaneous sediment chemistry**
SOURCE	Identification of data origin (e.g., REG4 is the Region 4 Pilot Study)
AGENCY	Identification of group responsible for collecting data (e.g., NS&T is NOAA's National Status and Trends Program)
STATION	Monitoring station identification code. (ODES NOTE: STATION = *STN_CD* ‖ ' ' ‖ *STATION* ‖ DATE. DMATS NOTE: STATION = *ID* ‖ ' ' ‖ *STATIONI* ‖ ' ' ‖ *SERIES* ‖ ' ' ‖ *SCAN*.)
DATE	Date of sample collection
SAMPLE	Unique sample identifier code
SUBSAMPL	Unique subsample identifier code
REPLICAT	Unique replicate identifier code
SEQ	Computer-generated sequence number when multiple samples were taken; SOURCE, AGENCY, STATION, and DATE were identical; and no SAMPLE, SUBSAMPL, or REPLICAT codes were provided
CAS	CAS number for analyte
CLEANUP	Sample cleanup code to indicate an additional step taken to further purify the sample extracts or digestates

COARSE_M	Method of analysis for analysis of coarse particles. Left blank if sample was not split into fractions.
COMMENTS	Comments
DRY_WGT	Percent of total sample remaining after drying
EXT_MTHO	Extraction method code to indicate the method used to extract or digest the sample matrix and remove or isolate the chemical of concern
FINE_MTH	Method of analysis for analysis of fine particles. Left blank if sample was not split into fractions.
INSTRUME	Instrument code to identify the final chemical analysis method(s) used for analyzing the sample
MEAS_BAS	Result is wet or dry weight basis (see also P)
P	Result associated with PARM
PARM	Analyte measured (see also P and R)
PHI_B	Phi boundaries in phi units, between the coarse and fine fractions
PHI_MAX	Phi boundary maximum at the fine end of the analyzed range
PHI_MIN	Phi boundary minimum at the coarse end of the analyzed range
R	Remark code associated with PARM and P
SAMP_DTL	Depth to bottom of sample interval (m)
SAMP_DTU	Depth to top of sample interval (m)
SMP_EQP	Sampling equipment code
SPHERE	Sphere (i.e., environment) code from which the sample came
TOT_WGT	Total weight of sample (g)
UNITS	Units associated with PARM, P, and R
WET_WGT	Total wet weight of sample (g)
P_ALP	Nonnumeric result associated with PARM

ALLTISM.DBF	**Miscellaneous tissue residue**
SOURCE	Identification of data origin (e.g., REG4 is the Region 4 Pilot Study)
AGENCY	Identification of group responsible for collecting data (e.g., NS&T is NOAA's National Status and Trends Program)
STATION	Monitoring station identification code. (ODES NOTE: STATION = *STN_CD* ‖ ' ' ‖ *STATION* ‖ DATE. DMATS NOTE: STATION = *ID* ‖ ' ' ‖ *STATIONI* ‖ ' ' ‖ *SERIES* ‖ ' ' ‖ *SCAN*.)
DATE	Date of sample collection
SAMPLE	Unique sample identifier code
SEQ	Computer-generated sequence number when multiple samples were taken; SOURCE, AGENCY, STATION, and DATE were identical; and no SAMPLE, SUBSAMPL, or REPLICAT codes were provided
REPLICAT	Unique replicate identifier code
ANAT_CD	Organ/tissue sampled code
CAS	CAS number for analyte
CLEANUP	Sample cleanup code to indicate an additional step taken to further purify the sample extracts or digestates
COMPOSIT	A unique identifier to indicate a sample created by compositing tissues from several individuals.
DRY_WGT	Percent of total sample remaining after drying
EXT_MTHO	Extraction method code to indicate the method used to extract or digest the sample matrix and remove or isolate the chemical of concern
INSTRUME	Instrument code to identify the final chemical analysis method(s) used for analyzing the sample
LENGTH	Length of specimen
LIPIDS	Lipids (%)

LIFE_STA	Life stage code to identify the life stage of sample
MEAS_BAS	Result is wet or dry weight basis (see also P)
NUMB_IND	Number of organisms in sample
P	Result associated with PARM
PARM	Analyte measured (see also P and R)
R	Remark code associated with PARM and P
SEX	Sex code used to identify sex of sample
SMP_EQP	Sampling equipment code
SPECCODE	Species code
SPEC_SCI	Species scientific name
SPECIMEN	Unique identifier for the individual organism being analyzed
UNITS	Units associated with PARM, P, and R
WET_WGT	Total weight of sample
P_ALP	Nonnumeric result associated with PARM

ALLELUT.DBF	**Elutriate**
SOURCE	Identification of data origin (e.g., REG4 is the Region 4 Pilot Study)
AGENCY	Identification of group responsible for collecting data (e.g., NS&T is NOAA's National Status and Trends Program)
STATION	Monitoring station identification code. (ODES NOTE: STATION = *STN_CD* ‖ ' ' ‖ *STATION* ‖ DATE. DMATS NOTE: STATION = *ID* ‖ ' ' ‖ *STATIONI* ‖ ' ' ‖ *SERIES* ‖ ' ' ‖ *SCAN*.)
DATE	Date of sample collection
SAMPLE	Unique sample identifier code
SEQ	Computer-generated sequence number when multiple samples were taken; SOURCE, AGENCY, STATION, and DATE were identical; and no SAMPLE, SUBSAMPL, or REPLICAT codes were provided.
SUBSAMPL	Unique subsample identifier code
REPLICAT	Unique replicate identifier code
CAS	CAS number for analyte
EXT_MTHO	Extraction method code to indicate the method used to extract or digest the sample matrix and remove or isolate the chemical of concern
INSTRUME	Instrument code to identify the final chemical analysis method(s) used for analyzing the sample
P	Result associated with PARM (μg/L)
PARM	Analyte measured (see also P and R)
R	Remark code associated with PARM and P
SAMP_DTL	Depth to bottom of sample interval (m)
SAMP_DTU	Depth to top of sample interval (m)
SAMP_EQP	Sampling equipment code

LOADD.DBF	**PCS/TRI loadings**
ID	Facility identification number
CAS	CAS number for analyte
CHEMICAL	Analyte name
SIC	SIC code for facility
E3KGY0	PCS loadings using below detection limit (dl) equal to 0.0 assumption
E3KGYE	PCS loadings using below detection limit equal to 0.5·dl assumption
E3KGY1	PCS loadings using below detection limit equal to dl assumption
E3FLO0	PCS flow using below detection limit equal to 0.0 assumption
E3FLOE	PCS flow using below detection limit equal to 0.5·dl assumption

E3FLO1	PCS flow using below detection limit equal to dl assumption
E6KGYE	TRI POTW transfers
E6KGY75	75 percent of TRI POTW transfers

LOADS.DBF	**PCS/TRI facilities (have loadings data)**
ID	Facility identification number
CODE	"PCS" or "TRI"
SPC	State postal code
LAT	Latitude (decimal degrees)
LNG	Longitude (decimal degrees)
NSIREACH	Reach File 1 Reach

LOADO.DBF	**Other PCS/TRI facilities (no associated loadings data)**
ID	Facility identification number
SPC	State postal code
LAT	Latitude (decimal degrees)
LNG	Longitude (decimal degrees)
NSIREACH	Reach File 1 Reach

BIOTCODE.DBF	**Toxicity phase for biotoxicity table (ALLBIOT)**
NAME	Genus and species name
PHASE	Toxicity phase listed in source of data (when available)
SOURCE	Identification of data origin (e.g., REG4 is the Region 4 Pilot Study)
NSIPHASE	Toxicity phase used by NSI

ELUTPARM.DBF	**List of analytes for elutriate table (ALLELUT)**
SOURCE	Identification of data origin (e.g., REG4 is the Region 4 Pilot Study)
PARM	Analyte measured (see also P and R)
CAS	CAS number for analyte
LNAME	Analyte long name

SED_PARM.DBF	**List of analytes for sediment tables (ALLSEDI, ALLSEDM)**
SOURCE	Identification of data origin (e.g., REG4 is the Region 4 Pilot Study)
PARM	Analyte measured (see also P and R)
CAS	CAS number for analyte
LNAME	Analyte long name

TIS_CODE.DBF	**List of species for tissue tables (ALLTISS, ALLTISM)**
SPECCODE	Species code
SPEC_SCI	Species scientific name
SPEC_COM	Species common name
RES_MIG	Species resident, migratory, or either
BOT_PEL	Species benthic, pelagic, or either
EDIBLE	Species considered edible by humans

TIS_PARM.DBF	List of analytes for tissue tables (ALLTISS, ALLTISM)
SOURCE	Identification of data origin (e.g., REG4 is the Region 4 Pilot Study)
PARM	Analyte measured (see also P and R)
CAS	CAS number for analyte
LNAME	Analyte long name

ALLSUPR.DBF	Superfund facilities
STATE	State postal code
ID	Superfund identification
NAME	Facility name
COUNTY	County name
CNTY_FIP	3-digit county FIPS code
C0305	C0305
C0326	C0326
LAT	Latitude (decimal degrees)
LNG	Longitude (decimal degrees)
NSIREACH	Reach File 1 Reach

ALLBENA.DBF	Benthic Species Abundance
SOURCE	Identification of data origin (e.g., REG4 is the Region 4 Pilot Study)
AGENCY	Identification of group responsible for collecting data (e.g., NS&T is NOAA's National Status and Trends Program)
STATION	Monitoring station identification code. (ODES NOTE: STATION = *STN_CD* ‖ ' ' ‖ *STATION* ‖ DATE. DMATS NOTE: STATION = *ID* ‖ ' ' ‖ *STATIONI* ‖ ' ' ‖ *SERIES* ‖ ' ' ‖ *SCAN*.)
DATE	Date of sample collection
SAMPLE	Unique sample identifier code
REPLICAT	Unique replicate identifier code
BOTTOM	Bottom type
AREA_BAS	Area basis for reported data
COMM_BAS	Basis for community abundance measurements
EXT_MTHO	Extraction method code to indicate the method used to extract or digest the sample matrix and remove or isolate the chemical of concern
GENUS	Organism genus
MESH_SZ	Seive mesh size
N_REP	Number of replicate samples
NUMB_IND	Total number of individuals
NUMB_SPE	Total number of unique species
ORDER	Organism order
P	Result associated with PARM
PARM	Analyte measured (see also P and R)
P_MEAN	Mean P
P_STD	Standard deviation of P
R	Remark code associated with P and PARM
SAMP_DTL	Depth to bottom of sample interval (m)
SAMP_DTU	Depth to top of sample interval (m)
SPECIES	Organism species
SPECCODE	Species code
UNITS	Units associated with PARM, P, and R

ALLBENC.DBF	**Benthic Community**
SOURCE	Identification of data origin (e.g., REG4 is the Region 4 Pilot Study)
AGENCY	Identification of group responsible for collecting data (e.g., NS&T is NOAA's National Status and Trends Program)
STATION	Monitoring station identification code. (ODES NOTE: STATION = *STN_CD* ‖ ' ' ‖ *STATION* ‖ DATE. DMATS NOTE: STATION = *ID* ‖ ' ' ‖ *STATIONI* ‖ ' ' ‖ *SERIES* ‖ ' ' ‖ *SCAN*.)
DATE	Date of sample collection
SAMPLE	Unique sample identifier code
AMPHIPOD	Number of amphipod
AMPHMABN	Mean abundance of amphipods
AREA_BAS	Area basis for reported data
ARTHROPO	Number of arthropods in the sample
BIOM_TOT	Total biomass (g)
BIOMMEAN	Mean biomass per grab (g)
BIV_MABN	Mean abundance of bivalves (g)
BSPINDEX	Benthic species index
BSP_GRAB	Number of grabs
BSP_MABN	Mean abundance per grab
BSP_MDIV	Mean Shannon-Wiener diversity index
BSP_MEAN	Mean number of species per grab
BSP_MEXP	Expected mean number of species
BSP_TABN	Total abundance
BSP_TDIV	Pooled Shannon-Wiener diversity index
BSP_TOT	Total number of species
CAPIMABN	Mean abundance of capitellids
COMM_BAS	Basis for community abundance measurements
CRUSTACE	Number of crustaceans in the sample
DECAMABN	Mean abundance of decapods
DOMINANC	Numeric dominance in the sample
ECHINODE	Number of echinoderms in the sample
EVENESS	Eveness
ITI	ITI
MED_DIAM	50% quartile diameter (phi)
MISC_TAX	Number of miscellaneous taxa in sample
MOIST_M	Sediment moisture content (%)
MOLLUSCS	Number of molluscs in the sample
NEMATODE	Number of nematodes in the sample
OLIGOCHA	Number of oligochaetes in the sample
PABN_AMP	Percent abundance amphipods
PABN_BIV	Percent abundance bivalves
PABN_GAS	Percent abundance gastropods
PABN_TUB	Percent abundance tubificids
PLYC_MWT	Mean biomass per polychaete (g)
PLYCMABN	Mean abundance of polychaetes
P_SENSIT	Abundance of pollution sensitive organisms (%)
P_TOLERA	Abundance of pollution tolerant organisms (%)
POLYCHAE	Number of polychaetes in the sample
QUARDVTM	Phi quartile deviation
Q1_PHI	25% quartile diameter (phi)
Q3_PHI	75% quartile diameter (phi)
RPDDEP_M	Mean RPD in mm

SICL_B_M	Mean silt/clay content (%)
SKEWNESS	Phi quartile skewness
TUBIMABN	Mean abundance of tubificids

ALLHIST.DBF	**Histopathology**
SOURCE	Identification of data origin (e.g., REG4 is the Region 4 Pilot Study)
AGENCY	Identification of group responsible for collecting data (e.g., NS&T is NOAA's National Status and Trends Program)
STATION	Monitoring station identification code. (ODES NOTE: STATION = *STN_CD* ‖ ' ' ‖ *STATION* ‖ DATE. DMATS NOTE: STATION = *ID* ‖ ' ' ‖ *STATIONI* ‖ ' ' ‖ *SERIES* ‖ ' ' ‖ *SCAN*.)
DATE	Date of sample collection
BODYPATH	Number of fish with body pathologies
BRNCPATH	Number of fish with branchial pathologies
BUCCPATH	Number of fish with buccal pathologies
FSP_ABN	Abundance (number/trawl)
FSP_TOT	Number of species
MNMDTRSH	Manmade trash (Y/N)

ALLFISA.DBF	**Fish abundance**
SOURCE	Identification of data origin (e.g., REG4 is the Region 4 Pilot Study)
AGENCY	Identification of group responsible for collecting data (e.g., NS&T is NOAA's National Status and Trends Program)
STATION	Monitoring station identification code. (ODES NOTE: STATION = *STN_CD* ‖ ' ' ‖ *STATION* ‖ DATE. DMATS NOTE: STATION = *ID* ‖ ' ' ‖ *STATIONI* ‖ ' ' ‖ *SERIES* ‖ ' ' ‖ *SCAN*.)
DATE	Date of sample collection
LEN_MEAN	Mean length (in)
LEN_STD	Standard deviation length (in)
P	Result associated with PARM
PARM	Analyte measured (see also P)
SPECCODE	Species code
UNITS	Units associated with PARM and P

SPEC-CD.DBF	**Species codes for benthic data**
SPECCODE	Species code
SPEC_SCI	Species scientific name
SPEC_COM	Species common name

FISH-CD.DBF	**Species codes for fish abundance data**
SPECCODE	Species code
SPEC_SCI	Species scientific name
SPEC_COM	Species common name

Appendix B

Description of Evaluation Parameters Used in the NSI Data Evaluation

Chapter 2 of this document presented the methodology used in the evaluation of the NSI data. This appendix describes in greater detail the screening values and other parameters used in the NSI data evaluation. The actual parameter values used are presented in Appendix D. For the purpose of discussion, the sediment evaluation parameters have been placed into three groups: (1) those used to assess potential impacts to aquatic life, (2) those used to assess potential impacts to human health, and (3) those used to assess potential impacts to wildlife. The uncertainties associated with the use of these parameters in the NSI data evaluation are discussed in Chapter 5.

Aquatic Life Assessments

To evaluate the potential threat to aquatic life from chemical contaminants detected in sediments, measured concentrations of contaminants were compared to sediment chemistry screening levels. The results of toxicity tests to indicate the actual toxicity of sediment samples to species of aquatic organisms, when available, were also evaluated for the NSI.

Sediment chemistry screening levels are reference values above which sediment contaminant concentrations could pose a significant threat to aquatic life. Several different approaches, based on causal or empirical correlative methodologies, have been developed for deriving screening levels of sediment contaminants. Each of these approaches attempts to predict contaminant concentration levels that could result in adverse effects to benthic species, which are extrapolated to represent the entire aquatic community for this evaluation. For the purpose of this analysis, the screening levels selected include the following:

- EPA's draft sediment quality criteria (SQCs) for five nonionic organic chemicals, developed using an equilibrium partitioning approach (USEPA, 1992a, 1993a).
- Sediment quality advisory levels (SQALs) for selected nonionic organic chemicals, developed using an equilibrium partitioning approach (USEPA, 1992a, 1993a).
- The sum of simultaneously extracted divalent transition metals concentrations minus the acid-volatile sulfide concentration ([SEM]-[AVS]), also based on an equilibrium partitioning approach.
- Effects range-median (ERM) and effects range-low (ERL) values for selected nonionic organics and metals developed by Long et al. (1995).
- Probable effects levels (PELs) and threshold effects levels (TELs) for selected nonionic organics and metals developed for the Florida Department of Environmental Protection (FDEP, 1994).

- Apparent effects thresholds (AETs) for selected nonionic organics and metals developed by Barrick et al. (1988).

The principles behind the development of each of these sediment chemistry screening values are discussed below. The sediment toxicity tests are also briefly described in this section.

Equilibrium Partitioning Approaches

The potential toxicity of sediment-associated nonionic organic chemicals and divalent metals is indicated by the amount of the contaminant that is uncomplexed or freely available in the interstitial (pore) water. The bioavailability and toxicity of nonionic organic chemicals and divalent metals in sediments are mediated by several physical, chemical, and biological factors, including sediment grain size, particulate and dissolved organic carbon, and sulfide produced by sulfate-reducing bacteria (Di Toro et al., 1991, 1992; Howard and Evans, 1993). For nonionic organic chemicals, sorption to the organic carbon dissolved in the interstitial water and bound to sediment particles is the most important factor affecting bioavailability. Sulfide, specifically the reactive solid-phase sulfide fraction that can be extracted by cold hydrochloric acid (acid-volatile sulfide, or AVS), appears to control the bioavailability of most divalent metal ions because of the sulfide ions' high affinity for divalent metals, resulting in the formation of insoluble metal sulfides in anaerobic sediments.

When the concentrations of nonionic organic chemicals and divalent metals were measured in pore water extracted from spiked sediment used in toxicity tests, the biological effects observed in those tests occurred at similar pore water concentrations, even when different types of sediments were used, typically within a factor of 2 (Di Toro et al., 1991, 1992). Biological effects also occurred at similar concentrations in tests with different sediment types containing different amounts of organic carbon (OC) when (1) the dry weight sediment concentrations of nonionic organic chemicals were normalized for organic carbon content (i.e., μg chemical/g_{oc}) and (2) when the difference between molar concentrations of simultaneously extracted metals ([SEM]) in the sediment exceeded the molar concentration of AVS ([AVS]) in the sediments by similar amounts (the mortality of sensitive species increases in the range of 1.5 to 12.5 : mol of SEM per : mol of AVS). Most importantly, the effects concentrations in the sediment could be predicted from the effects concentrations determined in water-only exposures to these chemicals. Most measurements of sediment chemical concentrations are made from whole sediment samples and converted to units of chemical per dry-weight of sediment, because of the difficulties in extracting the pore water. However, when dry-weight concentrations of nonionic organics and metals were used to plot concentration-response curves of the toxicity of different sediments, biological effects occurred at different dry-weight concentrations when measured in different sediments (Luoma, 1983; USEPA, 1993a). To develop criteria or advisory levels for comparing the toxicity of different chemicals in different sediments, it was necessary to examine the role of organic carbon and other complexing factors in the bioavailability of chemicals in sediment.

In sediment, the partitioning of a nonionic organic chemical between organic carbon and pore water and the partitioning of a divalent metal between the solid and solution phases are assumed to be at equilibrium. The fugacity (activity) of the chemical in each of these phases is the same at equilibrium. Fugacity describes mathematically the rates at which chemicals diffuse or are transported between phases (Mackay, 1991). Hence, an organism in the sediment is assumed to receive an equivalent exposure from water only or from any equilibrated phase. The pathway of exposure might include pore water (respiration), sediment carbon (ingestion), sediment organism (ingestion), or a mixture of routes. The biological effect is produced by the chemical activity of the single phase or the equilibrated system (Di Toro et al., 1991). The equilibrium partitioning approach uses this partitioning theory to relate the dry-weight sediment concentration of a particular chemical that causes an adverse biological effect to the equivalent free chemical concentration in pore water and to the concentration sorbed to sediment organic carbon or bound to sulfide. The theoretical causal resolution of chemical bioavailability in relation to chemical toxicity in different sediments differen-

tiates equilibrium partitioning approaches from purely empirical correlative assessment methods (described later in this section).

The processes that govern the partitioning of chemical contaminants among sediments, pore water, and biota are better understood for some kinds of chemicals than for others. Partitioning of nonionic hydrophobic organic compounds between sediments and pore water is highly correlated with the organic carbon content of sediments, but it does not account for all of the toxicity variation observed between sediment and water-only experimental exposures. Other factors that can affect biological responses are not considered in the model. The equilibrium partitioning approach has been tested using only nonionic organic chemicals with octanol/water partition coefficients (log K_{ow}s) between 3.8 and 5.3. However, because the theory should be applicable to nonionic organic chemicals with log K_{ow}s from 2.0 to 5.5 (Dave Hansen, EPA/ORD-Narragansett, pers. commun., April 17, 1995), nonionic organic chemicals with log K_{ow}s in this range were evaluated for the analysis of NSI data. For trace metals, concentrations of sulfides and organic carbon have been identified as important factors that control the phase associations and, therefore, the bioavailability of trace metals in anoxic sediments. However, models that can use these factors to predict the bioavailability of trace metals in sediments are not fully developed (see below). Mechanisms that control the partitioning of nonionic and nonpolar organic compounds with log K_{ow}s of less than 2.0 or greater than 5.5 and polar organic compounds in sediments, and affect their toxicity to benthic organisms, are less well understood. Models for predicting biological effects from concentrations of such compounds have not yet been developed; therefore, these chemicals have not been evaluated using equilibrium partitioning approaches.

Draft Sediment Quality Criteria

The equilibrium partitioning model was selected for the development of sediment quality criteria because it can be applied to predict sediment contaminant concentrations below which biological effects are not expected to occur based on the toxicity of individual nonionic organic chemicals—and hence can protect benthic aquatic life in bedded, permanently inundated, or intertidal sediments—while accounting for sediment characteristics that affect the bioavailability of the chemical (Di Toro et al., 1991; USEPA, 1993a). The predominant phase for sorption of nonionic organic chemicals to sediment particles appears to be organic carbon, for sediments in which the fraction of organic carbon (f_{oc}) is greater than 0.2 percent.

The partitioning of a chemical between the interstitial water and sediment organic carbon is explained by the sediment/pore water partition coefficient for a chemical, K_p, which is equal to the organic carbon content of the sediment (f_{oc}) multiplied by the sediment particle organic carbon partition coefficient (K_{oc}). K_p is the ratio of the concentration of the chemical in the sediment to the concentration of the chemical in the pore water. Normalizing the dry-weight concentration of the chemical in sediment to organic carbon is better than using the interstitial water concentration of the chemical because organic carbon in the sediment can also bind the chemical and affect its bioavailability and toxicity. The particle organic carbon partition coefficient (K_{oc}) is related to the chemical's octanol/water partition coefficient (K_{ow}) by the following equation (Di Toro et al., 1991):

$$\log K_{oc} = 0.00028 + 0.983(\log K_{ow})$$

The octanol/water partition coefficient for each chemical, which represents the likelihood of the chemical to complex or sorb to organic carbon, must be measured with modern experimental techniques to provide the most accurate estimate of this parameter. The concentration of the chemical on sediment particles (C_s) is then equal to the dissolved concentration of chemical (C_d) multiplied by the organic carbon content of the sediment (f_{oc}) and the particle organic carbon partition coefficient (K_{oc}), when f_{oc} is greater than 0.2 percent (USEPA, 1993a), thus normalizing the dry-weight sediment concentration of the chemical to the organic carbon content of the sediment.

$$C_s = C_d f_{oc} K_{oc}$$

The criterion threshold sediment concentration is derived from the final chronic value (FCV) of EPA's water quality criteria (USEPA, 1985). Freshwater and saltwater FCVs are based on the results of acceptable laboratory tests conducted to determine the toxicity of a chemical in water to a variety of species of aquatic organisms, and they represent the highest levels of a chemical to which organisms can be exposed without producing toxic effects. This level is predicted to protect approximately 95 percent of aquatic life under certain conditions. An evaluation of data from the water quality criteria documents and benthic colonization experiments demonstrated that benthic species have chemical sensitivities similar to those of water column species (Di Toro et al., 1991). Thus, if the concentration of a chemical in sediment, measured with respect to the sediment organic carbon content, does not exceed the sediment quality criterion, then no adverse biological effects from that chemical would be expected (USEPA, 1992a, 1993a).

EPA has developed and published draft freshwater sediment quality criteria (SQCs) for the protection of aquatic life for five contaminants: acenaphthene, dieldrin, endrin, fluoranthene, and phenanthrene. These draft SQCs are based on the equilibrium partitioning approach (USEPA 1993b, 1993c, 1993d, 1993e, 1993f) using the aquatic life water quality criterion final chronic value (FCV, in µg/L) and the partition coefficient between sediment and pore water (K_p, in L/g sediment) for the chemical of interest (Di Toro et al., 1991; USEPA, 1993a). Thus, SQC = K_p FCV. On a sediment organic carbon basis, the sediment quality criterion, SQC_{oc}, is:

$$SQC_{oc}(\mu g / g_{oc}) = FCV(\mu g / L)\ \chi\ K_{oc}(L / kg)\ \chi\ (10^{-3} kg_{oc} / g_{oc})$$

where:

FCV	=	EPA aquatic life water quality criterion final chronic value and
K_{oc}	=	organic carbon-water partitioning coefficient.

K_{oc} is presumed to be independent of sediment type for nonionic organic chemicals, so that the SQC_{oc} is also independent of sediment type. Using a site-specific organic carbon fraction, f_{oc} (g_{oc}/g sediment), the SQC_{oc} can be expressed as a sediment-specific value, the SQC:

$$SQC = (SQC_{oc})(f_{oc})$$

Sediment Quality Advisory Levels

EPA intends to develop sediment quality criteria for additional chemicals in the future. In the interim, EPA's Office of Science and Technology developed equilibrium partitioning-based sediment quality advisory levels (SQALs) using the following equation:

$$SQAL_{oc}(\mu g / g_{oc}) = [FCV,\ SCV(\mu g / L)]\ \chi\ K_{oc}(L / kg)\ \chi\ (10^{-3} kg_{oc} / g_{oc})$$

where:

$SQAL_{oc}$	=	calculated sediment quality advisory level;
FCV, SCV	=	EPA aquatic life chronic criterion (final chronic value, FCV), or other chronic threshold water concentration (secondary chronic value, SCV); and
K_{oc}	=	organic carbon-water partitioning coefficient.

As noted in Chapter 2, EPA has proposed sediment quality criteria (SQCs) for five chemicals based on the highest quality toxicity and octanol/water partitioning (K_{ow}) data, which have been reviewed extensively. However, data used to derive SQALs for additional chemicals came from limited sources and have undergone only limited peer review. This section describes the sources of data used to calculate the values used in the SQAL equations: log K_{ow}s (used to derive K_{oc}s) and

chronic threshold water concentrations. A detailed description of the methods and data used to develop SQALs for specific chemicals using the equilibrium partitioning approach will be published by EPA as a separate document.

SQALs for use in the NSI data evaluation were developed in conjunction with other programs at EPA (established under the Resource Conservation and Recovery Act, RCRA, and the Superfund Amendments and Authorization Act, SARA) to provide the same values for conducting screening-level evaluations of sediment toxicity for these programs. The SQALs are meant to be used *for screening purposes only*, the screening values are not regulatory criteria, site-specific cleanup standards, or remediation goals. The screening levels are set to be appropriately conservative, so sites which pass through the screen would not be expected to exhibit adverse effects; exceeding the screening levels does not indicate the level or type of risk at a particular site, but can be used to target additional investigations. EPA's Office of Research and Development (ORD), including staff from Environmental Research Laboratory, Athens, Georgia; Environmental Research Laboratory, Duluth, Minnesota; and Environmental Research Laboratory, Narragansett, Rhode Island, provided guidance and assisted in the development of the necessary values.

Method for Determination of Log K_{ow}s. Log K_{ow} values were initially identified in summary texts on physical-chemical properties, such as Howard (1990) and Mackay et al. (1992a,b) and accompanying volumes. Additional compendia of log K_{ow} values were also evaluated, including De Kock and Lord (1987), Douchette and Andren (1988), Klein et al. (1988), De Bruijn et al. (1989), Isnard and Lambert (1989), Leo (1993), Noble (1993), and Stephan (1993). To supplement these sources, on-line database searches were conducted in ChemFate, TOXLINE, and Hazardous Substances Data Bank (HSDB) (National Library of Medicine); Internet databases such as CARL UNCOVER; and EPA databases such as ASTER, OLS, and the ORD BBS. Original references were identified for the values, and additional values were identified. In cases where log K_{ow} values varied over several orders of magnitude or measured values could not be identified, detailed on-line searches were conducted using TOXLIT, Chemical Abstracts, and DIALOG. Values identified from all of these sources and the method used to obtain each log K_{ow} value were compiled for each chemical. A few chemicals lacked experimentally measured log K_{ow}s, and no log K_{ow} data were available from any source for butachlor, DCPA/Dacthal, and Ethion/Bladen.

The determination of K_{ow} values was based on experimental measurements taken primarily by the slow-stir, generator-column, and shake-flask methodologies. The SPARC Properties Calculator model was also used to generate K_{ow} values, when appropriate, for comparison with the measured values. Values that appeared to be considerably different from the rest were considered to be outliers and were not used in the calculation.

For each chemical, the available value based on one of these methods was given preference. If more than one such value was available, the log K_{ow} value was calculated as the arithmetic mean of those values (USEPA, 1994). Recommended log K_{ow}s were finalized by ORD-Athens based on recommended criteria, and the justification for selection of each value was included in the report (Karickhoff and Long, April 10, 1995, draft report).

Selection of Chronic Toxicity Values. A hierarchy of sources for chronic toxicity values to develop the SQALs was prepared. The following sources were identified and ranked from most to least confidence in the chronic values to be used:

1. Sediment quality criteria (SQCs).
2. Final chronic values from the Great Lakes Initiative (USEPA, 1995c).
3. Final chronic values from the National Ambient Water Quality Criteria documents.
4. Final chronic values from draft freshwater criteria documents.
5. Final chronic values developed from data in EPA's Aquatic Toxicity Information Retrieval database (AQUIRE) and other sources.

6a. Secondary chronic values developed from data in AQUIRE and other sources.
6b. Secondary chronic values from Suter and Mabrey (1994)

EPA draft SQCs were available for five chemicals: acenapthene, dieldrin, endrin, fluoranthene, and phenanthrene. There were no final chronic values (FCVs) obtained by the aquatic life criteria methodology (referred to as "Tier I") described in USEPA (1995c) available for the remaining chemicals in the NSI. Two SQALs were based on the FCVs from National Ambient Water Quality Criteria documents, for gamma-BHC/Lindane and toxaphene. No FCVs were available from draft criteria documents.

Thirteen SQALs were based on work conducted by Oak Ridge National Laboratories (Suter and Mabrey 1994) using the USEPA (1995c) methodology for obtaining secondary chronic values ("Tier II"). This methodology was developed to obtain whole-effluent toxicity screening values based on all available data, but the SCVs could also be calculated with fewer toxicity data than are required for the criteria methodology. The SCVs are generally more conservative than those which can be produced by the FCV methodology, reflecting greater uncertainty in the absence of additional toxicity data. The minimum requirement for deriving an SCV is toxicity data from a single taxonomic family (Daphnidae), provided the data are acceptable. Only those values from Suter and Mabrey (1994) which included at least one daphnid test result in the calculation of the SCV were included for the NSI. SCVs from Suter and Mabrey (1994) were used to develop SQALs for the following chemicals:

benzene
BHC, delta-
chlorobenzene
dibenzofuran
diethyl phthalate
di-n-butyl phthalate
ethylbenzene
napthalene
1,1,2,2-tetrachloroethane
tetrachloroethene
toluene
1.1.1-trichloroethane
trichloroethene

A preliminary search of data records in EPA's AQUIRE database indicated that the following chemicals might have sufficient toxicity data for the development of SCVs:

biphenyl
4-bromophenyl phenyl ether
butyl benzyl phthalate
diazinon
1,2-dichlorobenzene
1,3-dichlorobenzene
1,4-dichlorobenzene
endosulfan mixed isomers
alpha-endosulfan
beta-endosulfan
fluorene
hexachlorethane
malathion
methoxychlor
pentachlorobenzene
tetrachloromethane
tribromomethane
1,2,4-trichlorobenzene
trichloromethane
m-xylene

Insufficient toxicity test data were found in AQUIRE for acenapthylene, endosulfan sulfate, heptachlor epoxide, and trichlorofluoromethane. In addition, review of AQUIRE data records indicated that no daphnid acute toxicity tests had been conducted for hexachlorobutadiene. These chemicals were dropped from further development of SQALS.

Acid-Volatile Sulfide Concentration

The use of the total concentration of a trace metal in sediment as a measure of its toxicity and its ability to bioaccumulate is not supported by field and laboratory studies because different sediments exhibit different degrees of bioavailability for the same total quantity of metal (Di Toro et al., 1990;

Luoma, 1983). These differences have been reconciled by relating organism toxic response (mortality) to the metal concentration in the sediment pore water (Adams et al., 1985; Di Toro et al., 1990). Metals form insoluble complexes with the reactive pool of solid-phase sulfides in sediments (iron and manganese sulfides), restricting their bioavailability. The metals that can bind to these sulfides have sulfide solubility parameters smaller than those of iron sulfide and include nickel, zinc, cadmium, lead, copper, and mercury. Acid-volatile sulfide (AVS) is one of the major chemical components that control the activities and availability of metals in the pore waters of anoxic sediments (Meyer et al., 1994).

AVS is operationally defined as the sulfide liberated from a sediment sample to which hydrochloric acid has been added at room temperature under anoxic conditions (Meyer et al., 1994). The metals concentrations that are extracted during the same analysis are termed the simultaneously extracted metals (SEM). SEM is operationally defined as those metals which form less soluble sulfides than do iron or manganese (i.e., the solubility products of these sulfides are lower than that of iron or manganese sulfide) and that are at least partially soluble under the same test conditions in which the AVS content of the sediment is determined (Allen et al., 1993; Di Toro et al., 1992; Meyer et al., 1994).

Laboratory studies using spiked sediments and field-collected metal-contaminated sediments demonstrated that when the molar ratio of SEM to AVS [SEM]/[AVS] was less than 1 (excess AVS remained), no acute toxicity (mortality greater than 50 percent) was observed in any sediment for any benthic test organism. When [SEM]/[AVS] was greater than 1 (excess metal remained), the mortality of sensitive species (e.g., amphipods) increased in the range of 1.5 to 2.5 μmol of SEM per μmol AVS (Casas and Crecelius, 1994; Di Toro et al., 1992).

Experimental studies indicate that the lower limit of applicability for AVS is approximately 1 μmol AVS/g sediment and possibly lower; other sorption phases, such as organic carbon, probably become important for sediments with smaller AVS concentrations and for metals with large partition coefficients and large chronic water quality criteria (Di Toro et al., 1990). In addition, studies indicate that copper, as well as mercury, might be associated with another phase in sediments, such as organic carbon, and AVS alone might not be the appropriate partitioning phase for predicting its toxicity. Pore-water concentrations of metals should also be evaluated (Allen et al., 1993; Ankley et al., 1993; Casas and Crecelius, 1994).

The AVS approach requires that all toxic SEMs present in amounts that would contribute significantly to the [SEM] sum be measured to correctly predict only acute toxicity, so incomplete analyses of metals would compromise the results (Di Toro et al., 1992); however, mercury presents special problems and is not included in this evaluation. If the AVS content of sediment is low, as in fully oxidized sediments, the metal-binding capacity of the sediment decreases and the method will not work (Adams et al., 1992; Zhuang et al., 1994). Most benthic macroorganisms, including those used in toxicity tests, survive in sediments that have a thin oxidized surface layer and then an anoxic layer. The anoxic layer can have significant AVS concentrations that would reduce the metal activity to which these organisms are exposed (Di Toro et al., 1992). AVS varies spatially in sediment—vertically with depth and horizontally where patches of an appropriate carbon source occur under low oxygen conditions for the sulfate-reducing bacteria. AVS can also vary when sediments are oxgenated during physical disturbance and seasonally as changes in the productivity of the aquatic ecosystem alter the oxidation state of sediment and oxidize metal sulfides, so that the toxicity of the metals present in the sediment changes over time (Howard and Evans, 1993). However, the AVS approach can be used to predict when a sediment contaminated with metals is not acutely toxic (Ankley et al., 1993; Di Toro et al., 1992).

Selection of an [SEM]-[AVS] difference sufficiently high to place a sediment in the Tier 1 category requires careful consideration because the relationship between organism response and the [SEM]-[AVS] difference of sediment depends on the amount and kinds of other binding phases

present. Using freshwater and saltwater sediment amphiod toxicity data, researchers at EPA's Environmental Research Laboratory in Narragansett, Rhode Island, plotted [SEM]-[AVS] versus the percentage of sediments with a higher [SEM]-[AVS] value that were toxic. For this analysis, the researchers defined toxicity as greater than 24 percent mortality. Analysis of these data reveals that between 80 percent and 90 percent of the sediments were toxic at [SEM]-[AVS] = 5. The running average mortality at this level was between 44 percent and 62 percent (Hansen, 1995). EPA's Office of Science and Technology selected [SEM]-[AVS] = 5 as the demarcation line between the higher (Tier 1) and intermediate (Tier 2) probability categories.

Biological Effects Correlation Approaches

Biological effects correlation approaches are based on the evaluation of paired field and laboratory data to relate incidence of adverse biological effects to the dry-weight sediment concentration of a specific chemical at a particular site. Researchers use these data sets to identify level-of-concern chemical concentrations based on the probability of observing adverse effects. Exceedance of the identified level-of-concern concentrations is associated with a likelihood of adverse organism response, but it does not demonstrate that a particular chemical is solely responsible. Consequently, correlative approaches do not indicate direct cause-and-effect relationships. In fact, a given site typically contains a mixture of chemicals that contribute to observed adverse effects to some degree. These and other potentially mitigating factors tend to make screening values based on correlative approaches conservative.

Effects Range-Medians and Effects Range-Lows

The effects range approach for deriving sediment quality guidelines involves matching dry-weight sediment contaminant concentrations with associated biological effects data. Long and Morgan (1990) originally developed informal guidelines using this approach for evaluation of NOAA's National Status and Trends (NS&T) data. Data from equilibrium partitioning modeling, laboratory, and field studies conducted throughout North America were used to determine the concentration ranges that are rarely, sometimes, and usually associated with toxicity for marine and estuarine sediments (Long et al., 1995). Effects range-low (ERL) and effects range-median (ERM) values were derived by Long et al. (1995) for 28 chemicals or classes of chemicals: 9 trace metals, total PCBs, 13 individual polynuclear aromatic hydrocarbons (PAHs), 3 classes of PAHs (total low molecular weight, total high molecular weight, and total PAH), and 2 pesticides (p,p'-DDE and total DDT). For each chemical, sediment concentration data with incidence of observed adverse biological effects were identified and ordered. Data entered into this biological effects database for sediments (BEDS) were expressed on a dry-weight basis.

The authors identified the lower 10th-percentile concentration as the ERL and the 50th-percentile concentration as the ERM. In terms of potential biological effects, sediment contaminant concentrations below the ERL are said to be in the "minimal-effects range," values between the ERL and ERM are in the "possible-effects range," and values above the ERM are in the "probable-effects range."

The accuracy of these guidelines was evaluated based on the data in the database by noting whether the incidence of effects was less than 25 percent in the minimal-effects range, increased consistently with increasing chemical concentrations, and was greater than 75 percent in the probable-effects range. Long et al. (1995) reported that these sediment quality guidelines were most accurate for copper, lead, silver, and all classes of PAHs and most of the individual PAHs; however, accuracy was low for nickel, chromium, mercury, total PCBs, and DDE and DDT. The guidelines generally agreed within factors of 2 to 3 with other guidelines, including the national sediment quality criteria and freshwater effects-based criteria from Ontario. The authors attributed variability in the database to differences in sensitivities of different taxa and physical factors that affect bioavailability, but they argued that because of the synergistic effects of multiple toxicants, the inclu-

sion of data from many field studies in which mixtures of chemicals were present in sediments could make the guidelines more protective than guidelines based on a single chemical. The authors also emphasized that ERLs and ERMs were intended to be used as informal screening tools only.

Probable Effects Levels and Threshold Effects Levels

A method slightly different from that used by Long et al. (1995) to develop ERMs and ERLs was used by the Florida Department of Environmental Protection (FDEP, 1994) to develop similar weight-of-evidence, effects-based guidelines for Florida's coastal waters. Modifications to the Long et al. (1995) approach increased the relevance of the resultant guidelines to Florida's coastal sediments by making information in the database more consistent and by expanding the information used to derive sediment quality assessment guidelines with additional data from other locations in the United States and Canada, particularly Florida and the southeastern and Gulf of Mexico regions (FDEP, 1994). Three effects ranges were developed with a method that used both the chemical concentrations associated with biological effects (the "effects" data) and those associated with no observed effects (the "no-effects" data). In this method, a threshold effects level (TEL) was calculated first as the square root of the product of the lower 15th-percentile concentration associated with observations of biological effects (the ERL) and the 50th-percentile concentration of the no-observed-effects data (the NER-M). A safety factor of 0.5 was applied to the TEL to define a no-observable-effects level (NOEL). Next, a probable-effects level (PEL) was calculated as the square root of the product of the 50th-percentile concentration of the effects data (the ERM) and the 85th-percentile concentration of the no-observed-effects data (the NER-M). TELs and PELs were developed for 33 chemicals: 9 trace metals, total PCBs, 13 individual polynuclear aromatic hydrocarbons (PAHs), 3 classes of PAHs (total low molecular weight, total high molecular weight, and total PAH), 6 pesticides (chlordane, dieldrin, p,p' -DDD, p,p' -DDE, p,p' -DDT), and total DDT.

As was the case with the Long et al. (1995) approach, in the FDEP (1994) approach the lower of the two guidelines for each chemical (i.e., the TEL) was assumed to represent the concentration below which toxic effects rarely occurred. In the range of concentrations between the TEL and PEL, effects occasionally occurred. Toxic effects usually or frequently occurred at concentrations above the upper guideline value (i.e., the PEL). TEL and PEL values were developed on a sediment dry-weight basis.

Although the extensive database and evaluation of effects data make this approach applicable to many areas of the country, the available data still have limitations. FDEP (1994) also noted that there is a potential for underprotection or overprotection of aquatic resources if the bioavailability of sediment-associated contaminants and other factors affecting toxicity are not included. Most of the TELs and PELs were within a factor of 2 to 3 of other sediment quality guideline values. Most were deemed reliable (PELs having a lower reliability than TELs) for evaluating sediment quality in Florida's coastal waters, with less confidence in the values for mercury, nickel, total PCBs, chlordane, lindane, and total DDT. The abilities of the TELs and PELs to correctly predict the toxicity of sediment, based on an evaluation of independent sets of field data from Florida, the Gulf of Mexico, California, and New York that were not included in the expanded database, were 86 percent and 85 percent, respectively. These limitations should be considered in the application of TELs and PELs.

Apparent Effects Thresholds

The AET approach is another empirical data evaluation approach similar to the effects range approaches developed by Long et al. (1995) and FDEP (1994). Barrick et al. (1988) reported that AETs can be developed for any measured chemical (organic or inorganic) that spans a wide concentration range in the data set used to generate the AET. The AET concept was applied to matched field data for sediment chemistry and any observable biological effects (e.g., bioassay responses, infaunal abundances at various taxonomic levels, bioaccumulation). By using these different biological indicators, application of the resulting sediment quality values enabled a wide range of bio-

logical effects to be addressed in the management of contaminated sediments. Using sediment samples from Puget Sound in Washington State, AET values were determined for 52 chemicals: 10 trace metals, 15 individual polynuclear aromatic hydrocarbons (PAHs), 3 pesticides (p,p' -DDD, p,p' -DDE, p,p' -DDT), 6 halogenated organics, and 18 other compounds.

The focus of the AET approach is to identify concentrations of contaminants that are associated exclusively with sediments exhibiting statistically significant biological effects relative to reference sediments. AET values were based on measured chemical concentrations per dry weight of sediment. AETs for each chemical and biological indicator were developed using the following steps (Barrick et al., 1988).

1. Collected "matched" chemical and biological effects data—Conducted chemical and biological effects testing on subsamples of the same field sample.

2. Identified "impacted" and "nonimpacted" stations—Statistically tested the significance of adverse biological effects relative to suitable reference conditions for each sediment sample and biological indicator.

3. Identified the AET using only "nonimpacted" stations—For each chemical, the AET was identified for a given biological indicator as the highest *detected* concentration among sediment samples that did not exhibit statistically significant effects.

4. Checked for a preliminary AET—Verified that statistically significant biological effects were observed at a chemical concentration higher than the AET; otherwise, the AET was only a preliminary minimum estimate.

5. Repeated steps 1-4 for each biological indicator.

For a given data set, the AET value for a chemical is the sediment concentration above which a particular adverse biological effect for individual biological indicators (amphipod bioassay, oyster larvae bioassay, Microtox bioassay, and benthic infaunal abundance) is always significantly different statistically relative to appropriate reference conditions. Two thresholds were recognized, when possible, based on the different indicators. AET-L was the lowest concentration for which a particular indicator showed an effect, and AET-H was the highest concentration at which effects were observed for another indicator. AET values based on Microtox bioassays were not used for the NSI evaluation.

Sediment Toxicity Approaches

Methods for testing the acute and chronic toxicity of sediment samples to benthic freshwater and marine organisms have been developed (see reviews in Burton et al., 1992, Lamberson et al., 1992; API, 1994) and used primarily for dredged material evaluation (USEPA and USACOE, 1994). The NSI data contain acute sediment toxicity results from tests in which organisms were exposed to potentially contaminated field-collected sediments and mortality or sublethal effects on the organisms were recorded. Results of whole sediment and elutriate toxicity tests were used in the evaluation of the NSI.

Variations in sediment toxicity observed in tests of the same sediment sample may be attributed to the relative sensitivities of the species used in the tests; disruption of geochemistry and kinetic activity of bedded sediment contaminants during sampling, handling, and bioturbation; and laboratory-related confounding factors (Lamberson et al., 1992). Recent studies indicate that aqueous representations of whole sediment (e.g., elutriate) do not accurately predict the bioavailability of some contaminants compared to whole-sediment exposures (Harkey et al., 1994). Acute sediment

toxicity tests have been widely accepted by the scientific and regulatory communities and the results can be readily interpreted, although more work is needed on chronic testing (Thomas et al., 1992). Sediment toxicity tests provide important information on the effects of multiple chemical exposures to assist in the evaluation of sediment quality.

Human Health Assessments

In the evaluation of NSI data, two primary evaluation parameters were used to assess potential human health impacts from sediment contamination: (1) sediment chemistry theoretical bioaccumulation potential and (2) tissue levels of contaminants in demersal, nonmigratory species. Each of these evaluation parameters is described below.

Theoretical Bioaccumulation Potential

The theoretical bioaccumulation potential (TBP) is an estimate of the equilibrium concentration of a contaminant in tissues if the sediment in question were the only source of contamination to the organism (USEPA and USACOE, 1994). The TBP calculation is used as a screening mechanism to represent the magnitude of bioaccumulation likely to be associated with nonpolar organic contaminants in the sediment. At present, the TBP calculation can be performed only for nonpolar organic chemicals; however, methods for TBP calculations for metals and polar organic chemicals are under development (USEPA and USACOE, 1994).

The environmental distribution of nonpolar organic chemicals is controlled largely by their solubility in various media. Therefore, in sediments they tend to occur primarily in association with organic matter (Karickhoff, 1981) and in organisms they are found primarily in the body fats or lipids (Bierman, 1990; Geyer et al., 1982; Konemann and van Leeuwen, 1980; Mackay, 1982). Bioaccumulation of nonpolar organic compounds from sediment can be estimated from the organic carbon content of the sediment, the lipid content of the organism, and the relative affinities of the chemical for sediment organic carbon and animal lipid content (USEPA and USACOE, 1994). It is possible to relate the concentration of a chemical in one phase of a two-phase system to the concentration in the second phase when the system is in equilibrium. The TBP calculation focuses on the equilibrium distribution of a chemical between the sediment and the organism. By normalizing nonpolar organic chemical concentration data for lipid in organisms, and for organic carbon in sediment, it is possible to estimate the preference of a chemical for one phase or the other (USEPA and USACOE, 1994).

The TBP can be calculated relative to the biota-sediment accumulation factor (BSAF), as in the following equation (USEPA and USACOE, 1994):

$$TBP = BSAF(C_s / f_{oc})f_l$$

where TBP is expressed on a whole-body basis in the same units of concentration as C_s and

TBP	=	theoretical bioaccumulation potential (ppm);
C_s	=	concentration of nonpolar organic chemical in sediment (ppm);
BSAF	=	biota-sediment accumulation factor (ratio of the concentration of a chemical in tissue, normalized to lipid, to the concentration of the chemical in surface sediment, normalized to organic carbon (in kg sediment organic carbon/kg lipid));
f_{oc}	=	total organic carbon (TOC) content of sediment expressed as a decimal fraction (i.e., 1 percent = 0.01); and
f_l	=	organism lipid content expressed as a decimal fraction (i.e., 3 percent = 0.03) of fillet or whole-body dry weight.

BSAF values used in the TBP evaluation are discussed in Appendix C. If TOC measurements were not available at a site, f_{oc} was assumed to be 0.01 (1 percent).

For the evaluation of NSI data, EPA selected a 3 percent lipid content in fish fillets for the TBP calculation for assessing human health effects from the consumption of contaminated fish. Lipid normalization is now part of the EPA guidance on bioaccumulation, and the current national methodology uses a 3 percent value for human health assessments. The *Great Lakes Water Quality Initiative Technical Support Document for the Procedure to Determine Bioaccumulation Factors* (USEPA, 1995b) uses a 3.10 percent lipid value for trophic level 4 fish and 1.82 percent for trophic level 3 fish in its human health assessments.

As part of the NSI TBP evaluation, EPA also evaluated percent lipid measurements included in the STORET database, the *National Study of Chemical Residues in Fish* (NSCRF) (USEPA, 1992b), and other published sources and compared those values to the value selected for the NSI evaluation (Appendix C). The mean fillet percent lipid content for various groups of fish species in the STORET database ranged from 0.753 to 4.49 percent; in the NSCRF, mean fillet values ranged from 1.6 to 4.9 percent. The mean whole-body percent lipid content for various groups of fish species in the STORET database ranged from 3.757 to 6.33 percent; in the NSCRF, mean whole-body values ranged from 4.6 to 8.8 percent.

In the NSI data evaluation approach, TBP values were compared to U.S. Food and Drug Administration tolerance/action/guidance levels and EPA risk levels. These parameters are discussed below.

FDA Tolerance/Action/Guidance Levels

The U.S. Food and Drug Administration (FDA) is responsible for the safety of the Nation's foods, including fish and shellfish, for human consumption. Under the authority of the Federal Food, Drug and Cosmetic Act (FFDCA), FDA ensures that regulated products are safe for use by consumers. The FFDCA authorizes FDA to conduct assessments of the safety of ingredients in foods. The key element of the FFDCA, and the source of FDA's main tools for enforcement, is the prohibition of the "adulteration" of foods. FDA can prescribe the level of contaminant that will render a food adulterated and, therefore, can initiate enforcement action based on scientific data. The establishment of guidance and action levels (informal judgments about the level of a food contaminant to which consumers can be safely exposed) or tolerances (regulations having the force of law) is the regulatory procedure employed by FDA to control environmental contaminants in food.

FDA established levels for several pesticides before they were banned. At the time (i.e., during the 1970s), the available detection limits were considered to demonstrate elevated contamination and were used as action levels. Since that time, FDA has focused on developing risk-based standards. These standards have been derived by individually considering each chemical and the species of fish it is likely to contaminate. FDA also considered (1) the amount of potentially contaminated fish eaten and (2) the average concentrations of contaminants consumed. FDA has established action levels in fish for 10 pesticides and methylmercury, tolerance levels for polychlorinated biphenyls (PCBs), and guidance for 5 metals.

EPA Risk Levels

Potential impacts on humans are evaluated by estimating potential carcinogenic risks and noncarcinogenic hazards associated with the consumption of chemically contaminated fish tissue. In this assessment it was assumed that the only source of contamination to fish is contaminated sediment. The procedures for estimating human health risks due to the consumption of chemically contaminated fish tissue are based on *Risk Assessment Guidance for Superfund* (USEPA, 1989) and

Guidance for Assessing Chemical Contamination Data for Use in Fish Advisories, Volume II: Development of Risk-Based Intake Limits (USEPA, 1994).

EPA human health risk assessment methods were used in this assessment to determine the levels of contamination in fish that might result in a 10^{-5} (1 in 100,000 extra chance of cancer over a lifetime) cancer risk or a noncancer hazard in humans. A 10^{-5} risk level exceeds the lower bound (i.e., 10^{-6}) but is lower than the upper bound (i.e., 10^{-4}) of the risk range accepted by EPA (USEPA, 1990).

Human health cancer risks and noncancer hazards are based on the calculation of the chronic daily intake (CDI) of contaminants of concern:

$$CDI = \frac{(EPC)(IR)(EF)(ED)}{(BW)(AT)}$$

where:

CDI	=	chronic daily intake (mg/kg/day);
EPC	=	exposure point concentration (contaminant concentration in fish);
IR	=	ingestion rate (6.5 g/day);
EF	=	exposure frequency (365 days/year);
ED	=	exposure duration (70 years);
BW	=	body weight (70 kg); and
AT	=	averaging time (70 years x 365 days/year).

These are the same parameter values used by EPA to develop human health water quality criteria. Carcinogenic risks are then quantified using the equation below:

$$\text{Cancer risk}_i = CDI_i \chi SF_i$$

where:

Cancer risk$_i$	=	the potential carcinogenic risk associated with exposure to chemical *i* (unitless);
CDI$_i$	=	chronic daily intake for chemical *i* (mg/kg/day); and
SF$_i$	=	slope factor for chemical *i* (mg/kg/day)$^{-1}$.

The hazard quotient, which is used to quantify the potential for an adverse noncarcinogenic effect to occur, is calculated using the following equation:

$$HQ_i = \frac{CDI_I}{RfD_I}$$

where:

HQ$_i$	=	hazard quotient for chemical *i* (unitless);
CDI$_i$	=	chronic daily intake for chemical *i* (mg/kg/day); and
RfD$_i$	=	reference dose for chemical *i* (mg/kg/day).

If the hazard quotient exceeds unity (i.e., 1), an adverse health effect might occur. The higher the hazard quotient, the more likely that an adverse noncarcinogenic effect will occur as a result of exposure to the chemical. If the estimated hazard quotient is less than unity, an adverse noncarcinogenic effect is highly unlikely to occur.

Using these formulas, the fish tissue concentration (EPC) of a contaminant that equates to a cancer risk of 10^{-5} or a hazard quotient that exceeds unity can be back-calculated.

Cancer risk:

$$EPC = \frac{(10^{-5})(BW)(AT)(C_1)}{(IR)(EF)(ED)(SF_i)}$$

Noncancer hazard:

$$EPC = \frac{(BW)(AT)(RfD_i)(C_1)}{(IR)(EF)(ED)}$$

where:

C_1 = conversion factor (10^3 g/kg).

Tissue Levels of Contaminants

In addition to sediment chemistry TBP values, measured levels of contaminants in the tissues of resident aquatic species were used to assess potential human health risk. As was the case with the evaluation of TBP values, the NSI evaluation approach compared contaminant tissue levels to FDA tolerance/action/guidance levels and EPA risk levels. Each of these parameters was discussed in the previous section. In such a comparison it is assumed that contaminant concentrations in tissue are due to bioaccumulation from contaminants in the sediment.

Wildlife Assessments

In addition to the evaluation parameters described above for the assessment of potential aquatic life and human health impacts, EPA also conducted a separate analysis of potential wildlife impacts resulting from exposure to sediment contaminants.

Wildlife criteria based on fish tissue concentrations were derived using methods similar to those employed for deriving EPA wildlife criteria, as presented in the proposed *Great Lakes Water Quality Initiative Criteria Documents for the Protection of Wildlife* (USEPA, 1995a). EPA has developed Great Lakes Water Quality Wildlife Criteria for four chemicals: DDT, mercury, 2,3,7,8-TCDD, and PCBs. A Great Lakes Water Quality Wildlife Criterion (GLWC) is the concentration in the water of a substance that, if not exceeded, protects avian and mammalian wildlife populations from adverse effects resulting from the ingestion of surface waters and aquatic prey (USEPA, 1995a). Wildlife values are calculated using the equation:

$$WV = \frac{(NOAEL \chi SSF) \chi Wt_A}{W_A + (F_A \chi BAF)}$$

where:

WV	=	wildlife value (mg/L);
NOAEL	=	no-observed-adverse-effect level, as derived from mammalian or avian studies (mg/kg-d);
Wt_A	=	average weight for the representative species identified for protection (kg);
W_A	=	average daily volume of water consumed by the representative species identified for protection (L/d);
SSF	=	species sensitivity factor, an extrapolation factor to account for the difference in toxicity between species;
F_A	=	average daily amount of food consumed by the representative species identified for protection (kg/d); and
BAF	=	bioaccumulation factor (L/kg), the ratio of the concentration of a chemical in tissue, normalized to lipid, to the concentration in ambient water. Chosen using guidelines for wildlife presented in appendix B to part 132,

Methodology for Development of Bioaccumulation Factors (*Federal Register*, Vol. 58, No. 72, April 16, 1993).

In the development of the four GLWCs, wildlife values for five representative Great Lakes basin wildlife species (bald eagle, herring gull, belted kingfisher, mink, and river otter) were calculated, and the geometric mean of these values within each taxonomic class (birds and mammals) was determined. The GLWC is the lower of two class-species means (USEPA, 1995a).

The wildlife values are considered to be generally protective of wildlife species. However, it should be noted that the approach is not based on the most sensitive wildlife species, but rather a typical class of either avian or mammalian piscivores. Despite this limitation, this approach is still considered appropriate and conservative because of the many conservative assumptions used to derive these wildlife values (e.g., species sensitivity factors, assumption that animals consume only contaminated fish).

Proposed EPA wildlife criteria are based on surface water contaminant levels protective of potential wildlife exposure. Thus, the proposed EPA wildlife criteria cannot be compared directly to the NSI fish tissue concentrations (either the derived TBPs or actual fish tissue monitoring data). Therefore, it was necessary to develop an approach for estimating wildlife criteria for fish tissue based on the same toxicity and exposure parameter assumptions that were used to derive the surface water wildlife criteria. First, wildlife values (i.e., fish tissue concentrations protective of wildlife) were derived for the most sensitive mammalian species (i.e., otter and mink) and avian species (i.e., kingfisher, herring gull, and eagle)—the same species used to derive the proposed EPA wildlife criteria. The equation used to estimate wildlife values for fish tissue is presented below. (Exposure assumptions used for each species are presented in USEPA, 1995a.)

$$WV_{fish} = \frac{[NOAEL \chi SSF] \chi Wt_A}{F_A}$$

where:

WV_{fish}	=	wildlife value for fish tissue (mg/kg);
NOAEL	=	no-observed-adverse-effect level (mg/kg-day);
SSF	=	species sensitivity factor
Wt_A	=	average weight of animal in kilograms (kg); and
F_A	=	average daily amount of food consumed (kg/day).

Secondly, the geometric mean of the wldlife values was calculated for the mammal group, as well as for the avian group. Finally, the lower of the two geometric mean values was considered the wildlife criterion for fish tissue for a given chemical.

It should be noted that direct ingestion of surface water was included when developing proposed EPA wildlife criteria for surface water. This exposure route, however, was not considered when evaluating NSI data, even though sediment contamination might result in contamination of surface water available for wildlife consumption. A sensitivity analysis was conducted to evaluate the impact of excluding the surface water ingestion exposure route. Based on this analysis, ingestion of surface water contributes less than 0.0001 percent of the total exposure (i.e., ingestion of fish and water). Therefore, excluding the water ingestion exposure route had no significant impact on the evaluation of NSI data with regard to potential wildlife impacts.

Wildlife criteria derived for DDT, mercury, 2,3,7,8-TCDD, and PCBs based on fish tissue concentration are presented below.

Chemical	Fish Tissue Criterion (mg/kg)
DDT	3.93E-2
Mercury	5.73E-2
2,3,7,8-TCDD	5.20E-7
PCBs	1.60E-1

The wildlife criteria were compared to actual fish tissue residue data contained in the NSI and to TBPs calculated for DDT, 2,3,7,-TCDD, and PCBs. Mercury is not a nonpolar organic chemical, and thus a TBP for mercury was not calculated. It should be noted that a whole-body lipid value of 10.31 was assumed for the TBP evaluation of potential wildlife impacts, based on the *Great Lakes Water Quality Technical Support Document for the Procedure to Determine Bioaccumulation Factors* (USEPA, 1995b).

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Appendix C

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

Theoretical bioaccumulation potentials (TBPs) are empirically derived potential concentrations that might occur in the tissues of fish exposed to contaminated sediments. TBPs are computed for nonpolar organic chemicals as a function of sediment concentrations, fish tissue lipid contents, and sediment organic carbon contents. Four separate pieces of information are required to compute the TBP for nonpolar organic chemicals:

1. Concentration of nonpolar organic compound in sediment.
2. Organic carbon content of the sediment.
3. Biota-sediment accumulation factor (BSAF).
4. Lipid content in fish tissue.

The details of the TBP calculations and related assumptions are found in Appendix B of this report to Congress. This appendix describes the approach used to develop the BSAFs used in the NSI TBP evaluation and to evaluate fish tissue lipid content data from selected information sources for comparison to the values used in the NSI TBP evaluation. The BSAF values used for each chemical evaluated are presented in Appendix D.

Chemicals considered for fish tissue residue evaluation as part of the NSI data evaluation have at least one screening value available, and the sum of positive sediment results and positive tissue results is greater than 20 observations.

Method for Selecting BSAFs

Biota-sediment accumulation factors (BSAFs) are transfer coefficients that relate concentrations in biota to concentrations in sediment. They are calculated as the ratio of the concentration of nonpolar organic chemical in fish tissue (normalized by lipid content) to the concentration of nonpolar organic chemical in sediment (normalized by organic carbon content). At equilibrium, BSAFs are in theory approximately 1.0. In practice, BSAFs can be greater than or less than 1.0 depending on the disequilibrium between fish and water, and that between water and sediment. Although the TBP calculation approach taken here addresses mainly the effects of chemical properties, BSAFs can differ depending on the biota, dynamics of chemical loadings to the water body, food chain effects, and rate of sediment-water exchange. Thus, actual BSAF values will depend on many site-specific variables including hydraulic, biological, chemical, and ecological factors that affect bioavailability.

BSAF values were assigned only to nonpolar chemicals in the NSI. This section describes how the actual BSAF values used for the TBP assessment were selected from recommended values for specific chemicals.

Sources of Recommended BSAFs

BSAFs used in the NSI TBP evaluation were obtained from the EPA Office of Research and Development (EPA/ORD) Environmental Research Laboratories at Duluth, Minnesota (Cook, 1995) and Narragansett, Rhode Island (Hansen, 1995). In some cases (i.e., EPA/ORD-Duluth), BSAFs were provided for specific chemicals; in other cases (i.e., EPA/ORD-Narragansett), BSAFs were provided by chemical class. Recommended BSAFs from each laboratory are described below.

EPA Environmental Research Laboratory, Duluth

BSAF recommendations obtained from EPA/ORD-Duluth included mainly chemical-specific values for:

- PCB congeners
- Pesticides
- Dioxins/Furans
- Chlorinated benzenes

The recommended values from EPA/ORD-Duluth were based on BSAF data compiled from various sites and studies. Data were selected based on the following criteria (Cook, 1995):

- The primary source of chemical exposure to food webs was through release of chemicals in sediments.
- The BSAF was derived for pelagic organisms (i.e., fish).
- Chemicals in sediments and biota were at roughly steady state with respect to environmental loadings of the chemical.

Few, if any, steady-state sites were available, however, because environmental loadings of many of the chemicals are variable or have declined since the 1960s. Barring this limitation, the BSAF data for Lake Ontario that were used to estimate bioaccumulation factors (BAFs) for the Great Lakes Water Quality Initiative were recommended (Cook, 1995; USEPA, 1994a). The Lake Ontario BSAFs (Cook et al., 1994) are the primary source of values used in NSI TBP assessments. Another source for BSAFs was the set of values reported for Lake Ontario salmonids (Oliver and Niimi, 1988). The Lake Ontario BSAFs are based on a large set of sediment and fish samples collected in 1987 (USEPA, 1990).

EPA Environmental Research Laboratory, Narragansett

EPA/ORD-Narragansett provided a second source of information for selecting BSAF values. Probability distribution curves for selecting BSAFs were presented by EPA/ORD-Narragansett for three chemical classes:

- PAHs
- PCBs
- Pesticides

EPA/ORD-Narragansett researchers developed cumulative probability curves for each chemical class from their database of BSAFs (Hansen, 1995). The database from which general BSAF recommendations were summarized included data from laboratory and field studies conducted with both freshwater and marine sediments. Data must be from species that directly contact sediments or feed on organisms that live in sediments, i.e., benthic invertebrates and benthically coupled fishes.

Overall the database contained more than 4,000 BSAF observations. Cumulative probability curves summarizing the BSAF data in the database were provided by Hansen (1995) for PAHs, PCBs, and pesticides. BSAF values were tabulated for several probability percentiles.

Approach for Selecting BSAFs from Recommended Values

The general approach for selecting a BSAF for a chemical follows:

- Use a chemical-specific value for the BSAF, if available.
- If no chemical-specific value is available, use a BSAF derived for a chemical category.
- For chemicals having no specific information on the BSAF, use a default value of 1.

The EPA/ORD-Narragansett values for the BSAF were selected to achieve the 50th percentile protection level (Table C-1). The BSAF values from EPA/ORD-Duluth were averages and were implemented in the analysis as such.

Since there was some overlap between the categories of chemicals for which BSAF values were recommended, the following approach was used to assign BSAFs to specific chemicals in the NSI (Table C-2). For dioxins and furans, chemical-specific values recommended by EPA/ORD-Duluth were applied; for PCBs, the value for total PCBs recommended by EPA/ORD-Duluth was used. When using BSAFs from USEPA (1994a), values from the study by Cook et al. (1994) were preferred over values reported by Oliver and Niimi (1988) unless the Oliver and Niimi values were all that were available, as recommended by Cook (1995).

Pesticides received recommendations from both laboratories. The BSAFs developed by EPA/ORD-Narragansett were for benthic organisms and demersal (bottom-dwelling) fishes. The BSAFs developed by EPA/ORD-Duluth, on the other hand, were for benthically coupled pelagic (open-water) fishes. BSAFs from EPA/ORD-Narragansett were used for pesticides having log K_{ow} values less than 5.5. For pesticides having log K_{ow} values greater than or equal to 5.5, the BSAF values from EPA/ORD-Duluth were used. BSAF values selected by this approach are expected to be more conservative because food web transfer to pelagic fishes is a more important process for chemicals having high log K_{ow} values. Exposure through environmental media, as in direct contact with sediments by benthic organisms, is a more important process for chemicals having low log K_{ow} values.

Chemicals having no BSAF values available included halogenated compounds; compounds containing nitrogen, sulfur, or phosphorus; and other compounds. These chemicals were assigned a default BSAF of 1.

BSAF values were assigned to all nonpolar organic chemicals in the NSI having available screening values. These screening values are risk-based concentrations (RBCs) developed either from carcinogenic potency slopes or from oral reference doses. Carcinogenic potency slopes and reference doses were obtained from IRIS (USEPA, 1995) and HEAST

Table C-1. EPA/ORD-Narragansett Data BSAF Distributions (kg sediment organic carbon/kg lipid)

Probability Percentile	Chemical Class		
	PAHs	PCBs	Pesticides
50	0.29	1.11	1.80
70	0.55	2.26	3.34
80	0.94	3.66	4.61
90	1.71	5.83	7.31
95	2.84	9.15	10.61
100	4.19	16.46	22.63

Table C-2. Conventions for Assigning BSAFs to Nonpolar Organic Compounds in NSI

Category of Chemical	Source of BSAF	BSAF Value Used in Evaluation
Dioxins	EPA/ORD-Duluth[a] "pelagic," risk-based, chemical-specific BSAF	0.059
PCBs	EPA/ORD-Duluth[a] "pelagic," risk-based BSAF for total PCBs	1.85
Pesticides	log K_{ow} < 5.5 EPA/ORD-Narragansett[b] "benthic" class-specific BSAF for 50th percentile protection level	1.80
	log K_{ow} ≥ 5.5 EPA/ORD-Duluth[a] "pelagic," risk-based, chemical-specific BSAF if available; otherwise, use EPA/ORD-Narragansett[b] value	See chemical-specific BSAF given in Appendix D
PAHs	EPA/ORD-Narragansett[b] "benthic," risk-based, class-specific BSAF for 50th percentile protection level	0.29
Halogenated and other compounds	Default value of 1 unless chemical-specific value available from EPA/ORD-Duluth[a]	1.0

[a]Cook, 1995.
[b]Hansen, 1995.

(USEPA, 1994b). Other screening values used for comparison to TBP values and tissue data are U.S. Food and Drug Administration (FDA) tolerance/action/guidance levels and EPA wildlife criteria. The BSAF values used in the analysis are presented in Appendix D along with the screening values discussed above.

Evaluation of Tissue Lipid Content

Fish tissue lipid content enters the risk screening assessment as the normalizing factor in the numerator of the TBP equation. Normalizing by organic carbon content removes much of the site-to-site variation in the sorption of nonpolar organic chemicals by sediments (Karickhoff et al., 1979). In a similar manner, normalizing by lipid content can eliminate much site and species variation in the tendency of organisms to bioaccumulate nonpolar organic compounds (Esser, 1986). Lipid contents can vary naturally with species, site, season, age and size of fish, and trophic level. In addition, reported lipid contents can vary significantly depending on the analytical method (Randall et al., 1991).

The purpose of this section is to evaluate the percent fish lipid content data from various sources and compare these values to those selected for use in the NSI evaluation (i.e., 3.0 percent for fillets for human health TBP evaluations and 10.31 for whole body wildlife TBP evaluations).

The remainder of this section describes the lipid data sources evaluated and analysis of the lipid content data.

Sources of Lipid Data

Lipid data used for comparison with the percent lipid values selected for the NSI evaluation were obtained from three major sources:

- EPA's water monitoring database, STORET.
- *National Study of Chemical Residues in Fish*, or NSCRF (USEPA, 1992).
- U.S. Department of Agriculture's (USDA's) *Composition of Foods* (Dickey, 1990).

Additional sources included examples of whole fish and fillet lipid contents taken from the recent literature.

Each of the three major sources is described in the following paragraphs.

STORET

The STORET database was the single largest source of reported data on fish tissue lipid contents. Data stored under various parameter codes for lipid content in STORET were converted into units of percentage. Some screening of the data was performed as follows:

- Records were retrieved from January 1990 to March 1995.
- Reported lipid contents greater than 35 percent were eliminated because they were significantly greater than the 90th percentile.
- Only records having an anatomy code of "whole organism" or "fillet" were included. Records with a code of "fillet/skin" or "edible portion" were excluded.
- Data that appeared to be reversed (i.e., fillet percent lipid was greater than whole organism lipid) were also not considered.
- Also not considered were records in which the minimum and maximum were equal, or very nearly equal, when the number of observations was large.

There is less consistency in the data obtained from STORET relative to the NSCRF data since the analyses in STORET were conducted by numerous laboratories around the Nation. Data reported under different parameter codes (i.e., different methods for lipids) were grouped for the analysis. Moreover, the quality of the data in STORET is unknown. STORET data are compiled by species in Table C-3. The fishes are divided by trophic level and habitat into four subtables (Tables C-3a through C-3d) for the combinations of trophic levels 3 and 4 and epibenthic (bottom-dwelling) and pelagic (water column-dwelling) habitat.

National Study of Chemical Residues in Fish

The second largest database on fish tissue lipid content was available from the NSCRF (USEPA, 1992) (Table C-3). This set of lipid analysis data was taken in conjunction with analyses for dioxins/furans. An advantage of this database is that all of the lipid measurements were performed by the same laboratory using the same method. The data were screened to exclude data for fish species for which two or fewer observations were made.

USDA Report on Composition of Foods

A summary of a relatively small database on the composition of fish and shellfish foods and food products was available from USDA (Dickey, 1990). The section on fish and shellfish in the report coordinated by Dickey (1990) came from an earlier USDA report by Exler (1987). Data presented by Exler (1987) for various fish species were summarized from the USDA's Nutrient Data Bank (NDB). Records in the NDB are based primarily on published scientific reports and technical journal articles. To a lesser extent, the NDB contains unpublished data from industrial, government, and academic institutions under contract with the Human Nutrition Information Service. Lipids data are given in percentage of edible portion, where "edible portion" is the part of food customarily considered edible in the United States. Records were available for 32 fishes.

Table C-3a. Lipid Contents of Trophic Level 3, Epibenthic Fishes

Species Name	Common Name	Whole Fish Lipid Content, Percent (size)	Fillet Lipid Content, Percent (size)	Reference, Comments
Aplodinotus grunniens	freshwater drum		mean = 1.9 (1.3 to 2.5, 3 obs)	EPA (1992)
Aplodinotus grunniens	freshwater drum		mean = 4.93, standard (error = 0.103, 905 obs)	Exler (1987)
Carpoides carpio	river carpsucker	mean = 5.8 (0.5 to 15.0, 3865 obs)	mean = 4.4 (1.8 to 9.2, 184 obs)	STORET
Carpoides cyprinus	quillback	mean = 5.1 (0.3 to 13.0, 780 obs)	mean = 3.2 (0.4 to 4.89, 78 obs)	STORET
Catostomus ardens	Utah sucker	mean = 3.5 (1.1 to 8.2, 356 obs)	mean = 1.6 (0.1 to 6.7, 695 obs)	STORET
Catostomus catostomus	longnose sucker (FW)		0.8 to 3.8 (not given)	Owens et al. (1994)
Catostomus catostomus	longnose sucker	mean = 3.9 (2.5 to 7.2, 298 obs)	mean = 7.05 (6.4 to 7.7, 32 obs)	STORET
Catostomus columbianus	bridgelip sucker	mean = 4.6 (0.7 to 10.4, 309 obs)		STORET
Catostomus commersoni	white sucker		5.41 ± 1.18 1.07 ± 0.23 1.36 ± 0.17 0.99 ± 0.22 2.25 ± 0.65 (not given)	Servos et al. (1994)
Catostomus commersoni	white sucker	mean = 6.1 (1.4 to 21.8, 39 obs)		USEPA (1992)
Catostomus commersoni	white sucker	mean = 4.3 (0.2 to 12.0, 4102 obs)	mean = 1.7 (0.2 to 9.1, 586 obs)	STORET
Catostomus commersoni	white sucker		mean = 2.32 (standard error = 0.069, 157 obs)	Exler (1987)
Catostomus macrocheilus	largescale sucker	mean = 6.7 (0.3 to 13.0, 752 obs)	mean = 1.6 (0.1 to 5.26, 482 obs)	STORET
Catostomus occidentalis	Sacramento sucker	mean = 9.8 (1.7 to 18.5, 3 obs)		USEPA (1992)
Cottus cognatus	sculpin (FW)	8 (5.4 g)		USEPA (1994)
Cyprinus carpio	carp	9 (15 g)		Cook et al. (1991)
Cyprinus carpio	carp	18.7 (69.5 g) 15.7 (56.0 g) 13.0 (37.5 g) 16.6 (36.5 g) 17.5 (29.0 g)		Kuehl et al. (1987)

Table C-3a. (Continued)

Species Name	Common Name	Whole Fish Lipid Content, Percent (size)	Fillet Lipid Content, Percent (size)	Reference, Comments
Cyprinus carpio	carp	18.7 (69.5 g) 15.7 (56.0 g) 13.0 (37.5 g) 16.6 (36.5 g) 17.5 (29.0 g)		Kuehl et al.(1987)
Cyprinus carpio	carp	mean = 9.3 (0.5 to 25.1, 145 obs)	mean = 9.0 (2.0 to 19.6, 6 obs)	USEPA (1992)
Cyprinus carpio	carp	mean = 6.5 (0.3 to 17.0, 70002 obs)	mean = 4.3 (0.02 to 21.6, 16139 obs)	STORET
Cyprinus carpio	carp		mean = 5.60 (standard error = 0.207, 163 obs)	Exler (1987)
Ctenophyaryngodon idella	grass carp		mean = 5.2 (3 obs)	USEPA (1992)
Erimyzon oblongus	creek chubsucker	mean = 3.9 (3.9 to 4.0, 3 obs)		USEPA (1992)
Hypentelium nigricans	northern hogsucker	mean = 4.4 (0.8 to 8.98, 637 obs)	mean = 0.7 (0.5 to 0.99, 70 obs)	STORET
Ictalurus furcatus	blue catfish	mean = 7.3 (5.3 to 10.4, 5 obs)	mean = 2.7 (2.0 to 3.0, 4 obs)	USEPA (1992)
Ictalurus furcatus	blue catfish		mean = 6.0 (1.5 to 12.0, 56 obs)	STORET
Ictalurus melus (Ameiurus melas)	black bullhead	mean = 2.9 (0.9 to 6.2, 911 obs)	mean = 1.4 (0.15 to 5.1, 573 obs)	STORET
Ictalurus natalis (Ameiurus natalis)	yellow bullhead	mean = 2.8 (0.5 to 7.5, 235 obs)	mean = 0.96 (0.1 to 3.2, 294 obs)	STORET
Ictalurus nebulosus (Ameiurus nebulosus)	brown bullhead	mean = 2.2 (1.3 to 4.1, 133 obs)	mean = 1.5 (0.4 to 3.3, 107 obs)	STORET
Ictalurus punctatus	channel catfish	mean = 9.8 (3.4 to 23.0, 22 obs)	mean = 5.1 (1.1 to 11.5, 17 obs)	USEPA (1992)
Ictalurus punctatus	channel catfish	mean = 7.1 (0.3 to 15.0, 7512 obs)	mean = 5.1 (0.2 to 17.3, 20655 obs)	STORET
Ictalurus punctatus	channel catfish		mean = 4.26 (standard error = 0.417, 59 obs)	Exler (1987)
Ictiobus bubalus	smallmouth buffalo	mean = 5.7 (2.2 to 11.9, 6 obs)		USEPA (1992)

Table C-3a. (Continued)

Species Name	Common Name	Whole Fish Lipid Content, Percent (size)	Fillet Lipid Content, Percent (size)	Reference, Comments
Ictiobus bubalus	smallmouth buffalo	mean = 9.7 (2.8 to 17.3, 886 obs)	mean = 4.8 (0.2 to 14.5, 595 obs)	STORET
Ictiobus cyprinellus	bigmouth buffalo	mean = 15.1 (5.7 to 22.6, 3 obs)		USEPA (1992)
Ictiobus cyprinellus	bigmouth buffalo	mean = 5.8 (0.4 to 16.2, 675 obs)	mean = 4.1 (0.3 to 15, 1678 obs)	STORET
Ictiobus niger	black buffalo		mean = 3.5 (1.2 to 7.1, 42 obs)	STORET
Minytrema melanops	spotted sucker	mean = 4.5 (0.9 to 7.4, 9 obs)		USEPA (1992)
Minytrema melanops	spotted sucker	mean = 3.7 (0.7 to 5.9, 188 obs)	mean = 1.5 (0.9 to 3.2, 197 obs)	STORET
Moxostoma anisurum	silver redhorse	mean = 8.2 (6.2 to 8.5, 180 obs)	mean = 2.1 (1.3 to 2.7, 7 obs)	STORET
Moxostoma carinatum	river redhorse	mean = 5.1 (1.9 to 5.9, 193 obs)	mean = 1.3 (0.5 to 2.4, 170 obs)	STORET
Moxostoma duquesnei	black redhorse	mean = 5.0 (0.3 to 9.7, 1774 obs)	mean = 0.97 (0.7 to 1.8, 58 obs)	STORET
Moxostoma erythrurum	golden redhorse	mean = 6.0 (0.8 to 16.1, 2018 obs)	mean = 1.8 (0.6 to 2.8, 154 obs)	STORET
Moxostoma macrolepidotum	shorthead redhorse	mean = 19.8 (10.8 to 31.9, 4 obs)		USEPA (1992)
Moxostoma macrolepidotum	shorthead redhorse	mean = 6.5 (0.4 to 10.9, 683 obs)	mean = 3.0 (1.4 to 13.5, 342 obs)	STORET
Mugil cephalus	striped mullet		mean = 3.79 (standard error = 0.357, 43 obs)	Exler (1987)
Mylocheilus caurinus	peamouth	mean = 11.0 (9.36 to 12.91, 162 obs)		STORET
Ptychocheilus oregoni	northern squawfish	mean = 5.6 (0.8 to 12.0, 812 obs)	mean = 1.3 (0.7 to 3.0, 117 obs)	STORET
Ptychocheilus	squawfish		mean = 2.2 (0.5 to 3.0, 7 obs)	USEPA (1992)
Scaphirhynchus platorhynchus	shovelnose sturgeon		mean = 7.4 (1.1 to 20.3, 392 obs)	STORET

Table C-3b. Lipid Contents of Trophic Level 3, Pelagic Fishes

Species Name	Common Name	Whole Fish Lipid Content, Percent (size)	Fillet Lipid Content, Percent (size)	Reference, Comments
Acipenser sp.	sturgeon (unknown)		mean = 4.04 (7 obs)	Exler (1987)
Acrocheilus alutaceus	chiselmouth	mean = 5.0 (3.2 to 6.8, 47 obs)	mean = 0.55 (0.19 to 1.00, 91 obs)	STORET
Alosa pseudoharengus	alewife	7 (32 g)		USEPA (1994)
Alosa pseudoharengus	alewife	mean = 8.9 (3.7 to 15.2, 128 obs)		STORET
Alosa sapidissima	American shad	mean = 6.55 (5.9 to 7.6, 270 obs)		STORET
Alosa sapidissima	American shad		mean = 13.77 (standard error = 1.00, 11 obs)	Exler (1987)
Anguilla rostrata	American eel		mean = 11.66 (standard error = 0.885, 14 obs)	Exler (1987)
Aplodinotus grunniens	freshwater drum	mean = 5.5 (1.0 to 19.7, 574 obs)	mean = 4.8 (0.3 to 21.2, 459 obs)	STORET
Archosargus probatocephalus	sheepshead		mean = 2.41 (standard error = 0.040, 5 obs)	Exler (1987)
Coregonus artedii	cisco (lake herring)		mean = 1.91 (standard error = 0.149, 69 obs)	Exler (1987)
Coregonus clupeaform	lake whitefish		mean = 5.86 (standard error = 0.451, 68 obs)	Exler (1987)
Coregonus hoyi	bloater	mean = 21.1 (16 to 25.5, 52 obs)	mean = 8.3 (3.2 to 17.0, 98 obs)	STORET
Dorosoma cepedianum	gizzard shad	mean = 7.4 (1.3 to 18.0, 189 obs)		STORET
Dorosoma petenense	threadfin shad	mean = 3.0 (0.5 to 18.0, 9 obs)		STORET
Gadus macrocephalus	true or Pacific cod		mean = 0.63 (standard error = 0.031, 18 obs)	Exler (1987)
Hiodon alosoides	goldeye	mean = 3.2 (3.5 to 2.8, 74 obs)		STORET

Table C-3b. (Continued)

Species Name	Common Name	Whole Fish Lipid Content, Percent (size)	Fillet Lipid Content, Percent (size)	Reference, Comments
Platygobia (Hybopsis in database) *gracilis*	flathead chub		mean = 3.3 (0.68 to 8.14, 75 obs)	STORET
Lepomis auritis	redbreast sunfish	mean = 3.6 (1.3 to 8.1, 550 obs)		STORET
Lepomis cyanellus	green sunfish	mean = 3.2 (2.2 to 7.8, 376 obs)		STORET
Lepomis gibbosus	pumpkinseed	mean = 3.9 (2.2 to 7.7, 126 obs)		STORET
Lepomis gibbosus	pumpkinseed		mean = 0.70 (standard error = 0.071, 8 obs)	Exler (1987)
Lepomis megalotis	longear sunfish	mean = 2.8 (1.0 to 7.2, 536 obs)		STORET
Osmerus mordax	rainbow smelt	4 (16 g)		USEPA (1994)
Osmerus mordax	rainbow smelt		mean = 2.42 (standard error = 0.107, 52 obs)	Exler (1987)
Pimephales promelas	fathead minnow	19 (1 g)		Cook et al. (1991)
Lepomis macrochirus	bluegill sunfish	mean = 3.5 (2.4 to 4.6, 4 obs)		USEPA (1992)
Lepomis macrochirus	bluegill sunfish	mean = 4.4 (0.1 to 8.7, 1034 obs)		STORET
Lota lota	burbot		0.35 to 0.7	Owens et al. (1994)
Lota lota	burbot		mean = 0.2 (0.1 to 0.3, 18 obs)	STORET
Lota lota	burbot		mean = 0.81 (standard error = 0.059, 13 obs)	Exler (1987)
Oryzias latipes	medaka	8 (0.175 g)		Schmieder et al. (1992)
Phoxinus erythrogaster	southern redbelly dace	mean = 5.6 (2.2 to 10.0, 762 obs)		STORET

Table C-3b. (Continued)

Species Name	Common Name	Whole Fish Lipid Content, Percent (size)	Fillet Lipid Content, Percent (size)	Reference, Comments
Pomoxis annularis	white crappie		mean = 1.0 (0.5 to 2.0, 7 obs)	USEPA (1992)
Pomoxis annularis	white crappie	mean = 2.1 (0.4 to 5.8, 622 obs)	mean = 0.4 (0.08 to 2.6, 936 obs)	STORET
Pomoxis nigromaculatus	black crappie		mean = 1.1 (0.5 to 1.5, 3 obs)	USEPA (1992)
Pomoxis nigromaculatus	black crappie	mean = 2.7 (0.7 to 8.4, 457 obs)	mean = 1.4 (0.13 to 5.3, 118 obs)	STORET
Prosopium williamsoni	mountain whitefish	mean = 8.5 (0.5 to 13.8, 327 obs)	mean = 1.6, (0.2 to 4.1, 532 obs)	STORET
Prosopium williamsoni	mountain whitefish		3.4 to 11.8 (not given)	Owens et al. (1994)
Richardsonius balteatus	redside shiner		mean = 0.9 (0.85 to 0.96, 50 obs)	STORET
Sebastes auriculatus	brown rockfish		mean = 1.57 (81 obs)	Exler (1987)
Sebastes marinus	redfish		mean = 1.63 (standard error = 0.092, 208 obs)	Exler (1987)
Semotilus atromacula	creek chub	mean = 3.9 (1.0 to 5.0, 815 obs)		STORET
Semotilus corporalis	fallfish	mean = 1.9 (0.25 to 3.9, 100 obs)		STORET

Table C-3c. Lipid Contents of Trophic Level 4, Epibenthic Fishes

Species Name	Common Name	Whole Fish Lipid Content, Percent (size)	Fillet Lipid Content, Percent	Reference, Comments
Pylodictis olivaris	flathead catfish	mean = 3.1 (0.5 to 8.1, 829 obs)	mean = 3.0 (0.2 to 21.1, 1315 obs)	STORET
Pylodictis olivaris	flathead catfish	mean = 6.0 (1.6 to 8.7, 3 obs)	mean = 1.9 (0.6 to 3.1, 4 obs)	USEPA (1992)

Table C-3d. Lipid Contents of Trophic Level 4, Pelagic Fishes

Species Name	Common Name	Whole Fish Lipid Content, Percent (size)	Fillet Lipid Content, Percent (size)	Reference, Comments
Ambloplites rupestris	rock bass		mean = 1.0 (0.8 to 1.2, 3 obs)	USEPA (1992)
Ambloplites rupestris	rock bass	mean = 2.3 (0.6 to 4.4, 759 obs)	mean = 0.7 (0.4 to 0.98, 129 obs)	STORET
Amia calva	bowfin		mean = 0.5 (0.04 to 1.4, 230 obs)	STORET
Centropristis striata	black sea bass		mean = 2.00 (standard error = 0.221, 40 obs)	Exler (1987)
Esox lucius	northern pike		mean = 1.4 (0.6 to 2.6, 5 obs)	USEPA (1992)
Esox lucius	northern pike	mean = 1.9 (0.1 to 9.8, 810 obs)		STORET
Esox lucius	northern pike		mean = 0.69 (standard error = 0.005, 224 obs)	Exler (1987)
Esox niger	chain pickerel		mean = 1.3 (0.6 to 2.0, 5 obs)	USEPA (1992)
Leiostomus xanthurus	spot	mean = 5.2 (3.3 to 7.9, 300 obs)		STORET
Leiostomus xanthurus	spot		mean = 4.90 (standard error = 2.93, 10 obs)	Exler (1987)
Lutjanus campechanus	red snapper		1.34 (55 obs)	Exler (1987)
Micropogonias undulatus	Atlantic croaker		3.17 (standard error = 0.529, 8 obs)	Exler (1987)
Micropterus dolomieu	smallmouth bass		mean = 1.6 (0.8 to 4.4, 19 obs)	USEPA (1992)
Micropterus dolomieu	smallmouth bass	mean = 3.4 (0.3 to 8.8, 1166 obs)	mean = 0.6 (0.01 to 2.3, 848 obs)	STORET
Micropterus punctulatus	spotted bass		mean = 2.8 (0.9 to 4.5, 4 obs)	USEPA (1992)
Micropterus punctualtus	spotted bass	mean = 2.4 (0.6 to 4.9, 322 obs)	mean = 0.7 (0.1 to 1.8, 353 obs)	STORET

Table C-3d. (Continued)

Species Name	Common Name	Whole Fish Lipid Content, Percent (size)	Fillet Lipid Content, Percent (size)	Reference, Comments
Micropterus salmoides	largemouth bass		mean = 1.6 (0.4 to 7.6, 54 obs)	USEPA (1992)
Micropterus salmoides	largemouth bass	mean = 4.1 (0.3 to 10.6, 2924 obs)	mean = 0.7 (0.04 to 9.2, 4548 obs)	STORET
Morone americana	white perch	mean = 4.5 (2.6 to 7.1, 249 obs)		STORET
Morone chrysops	white bass		mean = 2.7 (0.7 to 4.8, 11 obs)	USEPA (1992)
Morone chrysops	white bass	mean = 4.6 (0.3 to 15.4, 615 obs)	mean = 3.9 (0.01 to 8.1, 847 obs)	STORET
Morone saxatilis	striped bass		mean = 2.33 (standard error = 0.381, 14 obs)	Exler (1987)
Oncorhynchus gorbuscha	pink salmon		mean = 3.45 (standard error = 0.141, 144 obs)	Exler (1987)
Oncorhynchus kisutch	coho salmon		mean = 2.7 (0.4 to 10.7, 383 obs)	STORET
Oncorhynchus kisutch	coho salmon		mean = 5.92 (standard error = 0.162, 217 obs)	Exler (1987)
Oncorhynchus mykiss	rainbow trout	11 (35 g)		Branson et al. (1985)
Oncorhynchus mykiss	rainbow trout		mean = 5.0 (4.1 to 5.6, 3 obs)	USEPA (1992)
Oncorhynchus nerka	sockeye salmon		mean = 8.56 (standard error = 0.392, 48 obs)	Exler (1987)
Oncorhynchus tshawytscha	chinook salmon	mean = 3.7 (2.4 to 5.1, 52 obs)	mean = 2.2 (0.04 to 17.7, 1957 obs)	STORET
Oncorhynchus tshawytscha	chinook salmon		mean = 10.44 (standard error = 1.692, 10 obs)	Exler (1987)
Perca flavescens	yellow perch	mean = 3.6 (1.2 to 9.1, 112 obs)	mean = 0.5 (0.1 to 4.6, 280 obs)	STORET
Pomatomus saltatrix	bluefish		mean = 4.27 (3 obs)	Exler (1987)

Table C-3d. (Continued)

Species Name	Common Name	Whole Fish Lipid Content, Percent (size)	Fillet Lipid Content, Percent (size)	Reference, Comments
Salmo clarki (Onchorhynchus clarki)	cutthroat trout		mean = 1.0 (0.2 to 1.7, 378 obs)	STORET
Salmo gairdneri (Onchorhynchus mykiss)	rainbow trout		mean = 3.36 (standard error = 0.256, 24 obs)	Exler (1987)
Salmo salar	Atlantic salmon		mean = 6.34 (standard error = 1.72, 7 obs)	Exler (1987)
Salmo trutta	brown trout		mean = 4.0 (1.6 to 8.1, 6 obs)	USEPA (1992)
Salmo trutta	brown trout	mean = 6.0 (1.5 to 8.9, 112 obs)	mean = 5.0 (0.14 to 14.8, 741 obs)	STORET
Salvelinus namaycush, Oncorhynchus mykiss, Oncorhynchus spp.	salmonids	11 (2410 g)		USEPA (1994)
Salvelinus malma	Dolly Varden	mean = 7.1 (2.1 to 9.9, 3 obs)		USEPA (1992)
Salvelinus namaycush	lake trout	mean = 15.9 (12.6 to 18.3, 42 obs)	mean = 7.8 (2.5 to 20.0, 1883 obs)	STORET
Scomberomorus cavall	king mackerel		mean = 2.00 (standard error = 0.188, 6 obs)	Exler (1987)
Scomberomorus macula	Spanish mackerel		mean = 6.30 (standard error=3.810, 3 obs)	Exler (1987)
Stizostedion canadense	sauger	mean = 6.0 (0.8 to 16.3, 139 obs)	mean = 1.7 (0.3 to 10.0, 195 obs)	STORET
Stizostedion vitreum	walleye		0.6 to 0.7	Owens et al. (1994)
Stizostedion vitreum	walleye	mean = 6.2 (0.3 to 15, 1089 obs)	mean = 1.3 (0.3 to 6.0, 440 obs)	STORET
Stizostedion vitreum	walleye		mean = 1.22 (standard error = 0.162, 14 obs)	Exler (1987)
Stizostedion vitreum vitreum	walleye		mean = 1.6 (0.7 to 2.6, 13 obs)	USEPA (1992)

Analysis of Lipids Data

Lipids data were analyzed for comparison with the screening value selected for the NSI evaluation by computing averages. Eight averages of data for fishes of the following categories for data in STORET (Table C-4a) and the NSCRF (Table C-4b) were computed (and labeled A-H):

A. Trophic levels 3 and 4, whole body
B. Trophic levels 3 and 4, whole body, excluding migratory and saltwater fishes
C. Trophic level 4, pelagic, fillet
D. Trophic level 4, pelagic, fillet, excluding migratory and saltwater fishes
E. Resident, freshwater, demersal fishes, whole body
F. Resident, freshwater, pelagic fishes, whole body
G. Resident, freshwater, demersal fishes, fillet
H. Resident, freshwater, pelagic fishes, fillet.

Data for fillets and whole fish were evaluated separately. All analysis except "A" were of fishes in the NSI exclusively. Summary statistics reported include the mean, standard error, range, and number of observations. The matrices in Tables C-4a and C4-b indicate the categories of fishes averaged. The average of edible portions from USDA data was 4.1 percent lipid.

The mean fillet percent lipid content for various groups of fish species in the STORET database ranged from 0.753 to 4.49 percent; in the NSCRF, mean fillet values ranged from 1.6 to 4.9 percent. The mean whole-body percent lipid content for various groups of fish species in the STORET database ranged from 3.757 to 6.33 percent; in the NSCRF, mean whole-body values ranged from 4.6 to 8.8 percent.

Table C-4a. Lipid Analysis - STORET

Analysis	Matrix of Fishes Included in Average								Tissue/ Organ	Lipid Content, %			
	Trophic Level		Position in Water Column		Mobility		Habitat						
	3	4	Demersal	Pelagic	Resident	Migratory	Freshwater	Saltwater		Mean	Standard Error	Number of Observations	Range
A	●	●	●	●	●	●	●	●	whole	5.97		113,978	0.1-26.7
B	●	●	●	●	●		●		whole	5.97	0.010	110,998	0.1-26.7
C		●		●	●	●	●	●	fillet	2.5		13,293	0.01-20
D		●		●	●		●		fillet	0.753	0.010	6793	0.01-10
E	●	●	●		●		●		whole	6.33	0.011	91867	0.22-26.7
F	●	●		●	●		●		whole	3.757	0.020	13025	0.10-16.3
G	●	●	●		●		●		fillet	4.49	0.018	42687	0.02-24
H	●	●		●	●		●		fillet	1.06	0.021	9378	0.01-21.07

Table C-4b. Lipid Analysis - NSCRF

Analysis	Matrix of Fishes Included in Average								Tissue/ Organ	Lipid Content, %			
	Trophic Level		Position in Water Column		Mobility		Habitat						
	3	4	Demersal	Pelagic	Resident	Migratory	Freshwater	Saltwater		Mean	Standard Error	Number of Observations	Range
A	●	●	●	●	●	●	●	●	whole	8.5		249	0.5-31.9
B	●	●	●	●	●		●		whole	8.6	0.328	246	0.5-31.9
C		●		●	●	●	●	●	fillet	1.9		122	0.4-8.1
D		●		●	●		●		fillet	1.6	0.116	103	0.4-7.6
E	●	●	●		●		●		whole	8.8	0.338	233	0.5-31.9
F	●	●		●	●		●		whole	4.6	1.02	7	1.6-8.7
G	●	●	●		●		●		fillet	4.9	0.697	34	0.5-19.6
H	●	●		●	●		●		fillet	1.6	0.106	117	0.4-7.6

Data for fillets and whole fish were evaluated separately. All analyses except "A" were of fishes in the NSI exclusively. Summary statistics reported include the mean, standard error, range, and number of observations. The matrices in Tables C-4a and C-4b indicate the categories of fishes averaged. The average of edible portions from USDA data was 4.1 percent lipid.

The mean fillet percent lipid content for various groups of fish species in the STORET database ranged from 0.753 to 4.49 percent; in the NSCRF, mean fillet values ranged from 1.6 to 4.9 percent. The mean whole-body percent lipid content for various groups of fish species in the STORET database ranged from 3.757 to 6.33 percent; in the NSCRF, mean whole-body values ranged from 4.6 to 8.8 percent.

References

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Appendix D

Screening Values for Chemicals Evaluated

Sediment Concentrations

Table D-1 presents the screening values used in the evaluation of NSI sediment chemistry data. Values listed in this table are in parts per million (ppm) except for the values for EPA draft sediment quality criteria (SQC_{oc}) and sediment quality advisory levels ($SQAL_{oc}$), which are in micrograms per gram (µg/g) organic carbon. These values were multiplied by the organic carbon content (f_{oc}) of the sediment sample, when known, or the default value if unknown (f_{oc} = 0.01). SQALs used in this analysis were calculated specifically for use in the screening analysis of NSI data and are currently under technical review. These values were not developed for regulatory purposes and should be used with caution (if at all) for purposes other than the evaluation of NSI data. Effects range-low (ERL) and effects range-median (ERM) values were taken from Long et al. (1995). Apparent effects threshold-low (AET-L) and apparent effects threshold-high (AET-H) values listed are values that have been normalized to dry weight. AET-Ls and AET-Hs were taken from Barrick et al. (1988). Threshold effects levels (TELs) and probable effects levels (PELs) were taken from FDEP (1994).

Fish Tissue Concentrations

Fish tissue concentrations are presented in the right columns of Table D-1. EPA risk levels were calculated for both a human health cancer risk of 10^{-5} and a noncancer hazard quotient of 1 (USEPA, 1995a, 1995b). Other available EPA sources were consulted as necessary for risk-based concentrations to be used in a screening analysis, including the Environmental Criteria and Assessment Office (as cited in USEPA, 1995c). FDA guidance/action/tolerance levels were obtained from the FDA Office of Seafood (DHHS 1994; 40 CFR 180.213a and 180.142; USFDA 1993a,b,c,d,e).

Biota-Sediment Accumulation Factors

The final column in Table D-1 presents the biota-sediment accumulation factors (BSAFs) used in the analysis. The BSAFs were adopted for use in the theoretical bioaccumulation potential (TBP) calculations that represent potential concentrations that might occur in tissues of fish exposed to contaminated sediments. The methodology used in deriving BSAFs and other parameters used in the TBP calculations are described in Appendix C of this document.

Methodology for Combining Chemical Data Using a Risk-Based Approach

Several screening values, as provided in the original source documents, refer to groups of chemicals. The majority of the data included in the NSI exist as specific chemicals. To perform a screening analysis that accommodates the way the data exist in the NSI and provides a reasonably conservative risk-based approach, chemical data were combined in particular cases.

Two of the chemical groups affected by this approach are polychlorinated biphenyls (PCBs) and dioxin compounds. The data for PCBs in the NSI occur in three ways: (1) total PCBs, (2) PCB congeners, and (3) PCB aroclors. The data for the PCB congeners were summarized (excluding as appropriate the lower chlorinated homologs that may be present as laboratory artifacts) to provide a total PCB value where one was not provided by the original database. This summarization enabled comparisons to the screening values available for total PCBs. Aroclor-specific data were

Table D-1. Screening Values for Chemicals Evaluated

GUIDELINE VALUES INTENDED ONLY FOR SCREENING LEVEL HAZARD COMPARISON AMONG CHEMICALS
May Be Over- or Underprotective of Sediment at a Given Location Depending on Site-Specific Conditions

			Sediment Concentration								Fish Tissue Concentration (ppm)			
CAS Number	Chemical Name	Code	SQC_{sc} ($\mu g/g_{sc}$)	ER-L (ppm)	ER-M (ppm)	AET-L (ppm)	AET-H (ppm)	$SQAL_{sc}$ ($\mu g/g_{sc}$)	TEL (ppm)	PEL (ppm)	Concen. = EPA Risk 10^{-6}	EPA Non Cancer Hazard Quotient = 1	FDA Guidance/ Action/ Tolerance Level	BSAF (unitless)
83329	Acenaphthene	1	130	.016	.5	.5[c]	2[a]	130	0.00671	0.0889		650		0.29[b]
208968	Acenaphthylene	1		.044	.64	1.3[a,b]	1.3[a,b]		0.00587	0.128				
67641	Acetone	1										1100		1.0
98862	Acetophenone	1										1100		
107028	Acrolein	1										220		
107131	Acrylonitrile	1									0.2	11		1.0
15972608	Alachlor/Lasso	1									1.3	110		
116063	Aldicarb/Temik											11		
309002	Aldrin	1,3									0.0063	0.32	0.3	1.80[b]
62533	Aniline										19			
120127	Anthracene	1		.0853	1.1	.96[c]	13[a]		0.0469	0.245		3200		0.29[b]
999999933	Anthracene&Phenanthrene	1	180	.0853	1.1	.96[c]	6.9[a]	180	0.0469	0.245		3200		0.29[b,e]
7440360	Antimony					150[b]	200[a]					4.3		
7440382	Arsenic	2		8.2	70	57[b]	700[c]		7.24	41.6	0.062	3.2	68	
1912249	Atrazine										0.49	380		
7440393	Barium											750		
92875	Benzidine										0.00047	32		
71432	Benzene	1,6						5.7			3.7			1.0
56553	Benzo(a)anthracene	1		.261	1.6	1.6[c]	5.1[a,b]		0.0748	0.693	0.15			0.29[b]
999999955	Benzo(a)anthracene/Chrysene	1		.261	1.6	1.6[c]	5.1[a,b]		0.0748	0.693	0.15			0.29[b,e]
50328	Benzo(a)pyrene	1		.43	1.6	1.6[c]	3.6[b]		0.0888	0.763	0.015			0.29[b]
205992	Benzo(b)fluoranthene	1				3.6[c]	9.9[b]				0.15			0.29[b]
191242	Benzo(ghi)perylene	1				.72[c]	2.6[b]							
207089	Benzo(k)fluoranthene	1				3.6[c]	9.9[b]				1.5			0.29[b]
65850	Benzoic acid					.65[a,b]	.76[a]					43000		
98077	Benzotrichloride	1									0.0083			

Table D-1. (Continued)

GUIDELINE VALUES INTENDED ONLY FOR SCREENING LEVEL HAZARD COMPARISON AMONG CHEMICALS
May Be Over- or Underprotective of Sediment at a Given Location Depending on Site-Specific Conditions

			Sediment Concentration								Fish Tissue Concentration (ppm)			
CAS Number	Chemical Name	Code	SQC_{oc} ($\mu g/g_{oc}$)	ER-L (ppm)	ER-M (ppm)	AET-L (ppm)	AET-H (ppm)	$SQAL_{oc}$ ($\mu g/g_{oc}$)	TEL (ppm)	PEL (ppm)	Concen. = EPA Risk 10^{-6}	EPA Non Cancer Hazard Quotient = 1	FDA Guidance/ Action/ Tolerance Level	BSAF (unitless)
100516	Benzyl alcohol					.073[b]	.87[a,b]					3200		
100447	Benzyl chloride	1									0.63			
7440417	Beryllium										.025	54		
319846	BHC, alpha-	1,3							0.00032	0.00099	0.017		0.3	1.80[b]
319857	BHC, beta-	1,3							0.00032	0.00099	0.060		0.3	1.80[b]
319868	BHC, delta-	1,3,6						13	0.00032	0.00099	0.060		0.3	1.80[b]
58899	BHC, gamma- (Lindane)	1,3,6						0.37	0.00032	0.00099	0.083	3.2	0.3	1.80[b]
608731	BHC, technical grade	1,3						0.37	0.00032	0.00099	0.060	3.2	0.3	1.80[b]
92524	Biphenyl	1,6						110				540		0.29[b]
111444	Bis(2-chloroethyl)ether	1									0.098			
108601	Bis(2-chloroisopropyl)ether	1									1.5	430		
117817	Bis(2-ethylhexyl)phthalate	1,6				1.3[b]	1.9[a]		0.182	2.65	7.7	220		1.0
542881	Bis(chloromethyl)ether										0.00049			
7440428	Boron											970		
75274	Bromodichloromethane	1									1.7	220		
74839	Bromomethane	1										15		
101553	Bromophenyl phenyl ether, 4-	1,6						130				620		1.0
1689845	Bromoxynil											220		
85687	Butyl benzyl phthalate	1,6				.9[a,b]	.9[a,b]	1100				2200		1.0
7440439	Cadmium	2		1.2	9.6	5.1[b]	9.6[a]		0.676	4.21		5.4	3	
63252	Carbaryl/Sevin											1100		
1563662	Carbofuran/furadan											54		
75150	Carbon disulfide											1100		
133904	Chloramben											160		
57749	Chlordane	1,3							0.00226	0.00479	0.083	0.65	0.3	4.77[c]
5103719	Chlordane, alpha(cis)-	1,3							0.00226	0.00479	0.083	0.65	0.3	4.77[c]

Table D-1. (Continued)

GUIDELINE VALUES INTENDED ONLY FOR SCREENING LEVEL HAZARD COMPARISON AMONG CHEMICALS
May Be Over- or Underprotective of Sediment at a Given Location Depending on Site-Specific Conditions

			Sediment Concentration								Fish Tissue Concentration (ppm)			
CAS Number	Chemical Name	Code	SQC_{oc} ($\mu g/g_{oc}$)	ER-L (ppm)	ER-M (ppm)	AET-L (ppm)	AET-H (ppm)	$SQAL_{oc}$ ($\mu g/g_{oc}$)	TEL (ppm)	PEL (ppm)	Concen. = EPA Risk 10^{-6}	EPA Non Cancer Hazard Quotient = 1	FDA Guidance/ Action/ Tolerance Level	BSAF (unitless)
5103742	Chlordane, beta(trans)-	1,3							0.00226	0.00479	0.083	0.65	0.3	2[a]
5566347	Chlordane, gamma(trans)-	1,3							0.00226	0.00479	0.083	0.65	0.3	2.22[a]
999999247	Chlordane-Nonachlor(cis)-	1,3							0.00226	0.00479	0.083	0.65	0.3	4.77[a]
999999248	Chlordane-Nonachlor(trans)-	1,3							0.00226	0.00479	0.083	0.65	0.3	4.77[a]
108907	Chlorobenzene	1,6						82				220		1.0
510156	Chlorobenzilate										0.40	220		
75003	Chloroethane	1										4300		
75014	Chloroethene	1									0.057			
110758	Chloroethylvinyl ether, 2-	1										270		
74873	Chloromethane	1									8.3			
91587	Chloronaphthalene, 2-	1										860		
95578	Chlorophenol, 2-											54		
2921882	Chlorpyrifos/Dursban	1										32		1.80[b]
7440473	Chromium	2		81	370	260[b]	270[a]		52.3	160		54	11	
218019	Chrysene	1		.384	2.8	2.8[e]	9.2[a,b]		0.108	0.846	15			0.29[b]
7440508	Copper			34	270	390[e]	1300[a]		18.7	108		400		
108394	Cresol, m-					.63[a,o]	.72[b]					540		
95487	Cresol, o-					.63[a,o]	.72[b]					540		
106445	Cresol, p-					.67[a,m]	3.6[a]					54		
1319773	Cresols					.63[a,o]	.72[b]					54		
98828	Cumene	1										430		
21725462	Cyanazine										0.13	22		
57125	Cyanide											220		
1861321	DCPA/Dacthal	1										110		1.80[b]
53190	DDD, o,p'-	1,3		.00158	.027	.016[b]	.043[a]		0.00122	0.00781	0.45		5	0.28[a]
72548	DDD, p, p'-	1,3		.00158	.027	.016[b]	.043[a]		0.00122	0.00781	0.45		5	0.28[a]

Table D-1. (Continued)

GUIDELINE VALUES INTENDED ONLY FOR SCREENING LEVEL HAZARD COMPARISON AMONG CHEMICALS May Be Over- or Underprotective of Sediment at a Given Location Depending on Site-Specific Conditions														
			Sediment Concentration								Fish Tissue Concentration (ppm)			
CAS Number	Chemical Name	Code	SQC_{oc} ($\mu g/g_{oc}$)	ER-L (ppm)	ER-M (ppm)	AET-L (ppm)	AET-H (ppm)	$SQAL_{oc}$ ($\mu g/g_{oc}$)	TEL (ppm)	PEL (ppm)	Concen. = EPA Risk 10^{-5}	EPA Non Cancer Hazard Quotient = 1	FDA Guidance/ Action/ Tolerance Level	BSAF (unitless)
3424826	DDE, o,p'-	1,3		.0022	.027	.009[b]	.015[a]		0.00207	0.374	0.32		5	7.7[a]
72559	DDE, p, p'-	1,3		.0022	.027	.009[b]	.015[a]		0.00207	0.374	0.32		5	7.7[a]
789026	DDT, o,p'-	1,3		.00158	.027	.034[b]	.034[b]		0.00119	0.00477	0.32	5.4	5	1.67[a]
50293	DDT, p, p'-	1,3		.00158	.027	.034[b]	.034[b]		0.00119	0.00477	0.32	5.4	5	1.67[a]
999999300	DDT (Total)	1,3		.00158	.0461	.009[b]	.015[a]		0.00389	0.0517	0.32	5.4	5	7.7[a]
1163195	Decabromodiphenyl oxide	1										110		
84742	Di-n-butyl phthalate	1,6				1.4[a,o]	1.4[a,o]	1100				1100		1.0
117840	Di-n-octyl phthalate	1				6.2[b]	6.2[b]					220		1.0
333415	Diazinon/Spectracide	1,6						.019				9.7		1.80[b]
53703	Dibenzo(a,h)anthracene	1		.0634	.26	.23[o]	.97[b]		0.00622	0.135	0.015			0.29[b]
132649	Dibenzofuran	1,6				.54[o]	1.7[a]	200				43		1.0
96128	Dibromo-3-chloropropane, 1,2-	1									0.077			
124481	Dibromochloromethane	1									1.3	220		1.0
1918009	Dicamba											320		
95501	Dichlorobenzene, 1,2-	1,6				0.05[a,b]	0.05[a,b]	34				970		1.0
541731	Dichlorobenzene, 1,3-	1,6						170				960		1.0
106467	Dichlorobenzene, 1,4-	1,6				.11[b]	.12[a,o]	35			4.5			1.0
25321226	Dichlorobenzenes	1				0.05[a,b]	0.05[a,b]	34			4.5	960		1.0
91941	Dichlorobenzidine, 3,3'-										0.24			
75718	Dichlorodifluoromethane	1										2200		
75343	Dichloroethane 1,1-	1										1100		1.0
107062	Dichloroethane 1,2-	1									1.2			1.0
75354	Dichloroethene, 1,1-	1									0.18	97		
156605	Dichloroethene, trans-1,2-	1										220		1.0
156592	Dichloroethylene, cis-1,2-	1										110		
75092	Dichloromethane	1									14	650		1.0

Table D-1. (Continued)

GUIDELINE VALUES INTENDED ONLY FOR SCREENING LEVEL HAZARD COMPARISON AMONG CHEMICALS
May Be Over- or Underprotective of Sediment at a Given Location Depending on Site-Specific Conditions

CAS Number	Chemical Name	Code	Sediment Concentration								Fish Tissue Concentration (ppm)			BSAF (unitless)
			SQC_{oc} ($\mu g/g_{oc}$)	ER-L (ppm)	ER-M (ppm)	AET-L (ppm)	AET-H (ppm)	$SQAL_{oc}$ ($\mu g/g_{oc}$)	TEL (ppm)	PEL (ppm)	Concen. = EPA Risk 10^{-5}	EPA Non Cancer Hazard Quotient = 1	FDA Guidance/ Action/ Tolerance Level	
120832	Dichlorophenol, 2,4-											32		
94757	Dichlorophenoxyacetic acid, 2,4-	5										110	1	
94826	Dichlorophenoxybutanoic acid, 2,4-											86		
78875	Dichloropropane, 1,2-	1									1.6			1.0
542756	Dichloropropene, 1,3-	1									0.62	3.2		
62737	Dichlorvos	1									0.37	5.4		
115322	Dicofol/Kelthane										0.24			
60571	Dieldrin	1,3,6	11					11	7.15E-4	0.0043	.0067	.54	.3	1.80[b]
84662	Diethyl phthalate	1,6				0.2[b]	0.2[b]	63				8600		1.0
119904	Dimethoxybenzidine,3,3'-										7.7			
131113	Dimethyl phthalate	1				0.16[a]	0.16[a]					110000		1.0
105679	Dimethylphenol, 2,4-					.029[a]	.21[b]					220		
528290	Dinitrobenzene, 1,2-											4.3		
99650	Dinitrobenzene, 1,3-											1.1		
100254	Dinitrobenzene, 1,4											4.3		
51285	Dinitrophenol, 2,4-											22		
121142	Dinitrotoluene, 2,4-											22		
606202	Dinitrotoluene, 2,6-											11		
88857	Dinoseb/DNBP											11		
122667	Diphenylhydrazine, 1,2-										0.13			
298044	Disulfoton	1										0.43		
959988	Endosulfan, alpha-	1,6						.29				65		1.80[b]
33213659	Endosulfan, beta-	1,6						1.4				65		1.80[b]
115297	Endosulfan mixed isomers	1,6						.54				65		1.80[b]
72208	Endrin	1,6	4.2					4.2				3.2		1.80[b]
563122	Ethion/Bladen	1										5.4		1.80[b]

Table D-1. (Continued)

GUIDELINE VALUES INTENDED ONLY FOR SCREENING LEVEL HAZARD COMPARISON AMONG CHEMICALS
May Be Over- or Underprotective of Sediment at a Given Location Depending on Site-Specific Conditions

			Sediment Concentration								Fish Tissue Concentration (ppm)			
CAS Number	Chemical Name	Code	SQC_{oc} ($\mu g/g_{oc}$)	ER-L (ppm)	ER-M (ppm)	AET-L (ppm)	AET-H (ppm)	$SQAL_{oc}$ ($\mu g/g_{oc}$)	TEL (ppm)	PEL (ppm)	Concen. = EPA Risk 10^{-5}	EPA Non Cancer Hazard Quotient = 1	FDA Guidance/ Action/ Tolerance Level	BSAF (unitless)
141786	Ethyl acetate	1										9700		
100414	Ethylbenzene	1,6				.01[b]	.037[a]	480				1100		1.0
106934	Ethylene dibromide	1									.0013			
206440	Fluoranthene	1	620	.6	5.1	2.5[a]	30[a]	620	0.113	1.494		430		0.29[b]
86737	Fluorene	1,6		.019	.54	.54[a]	3.6[a]	54	0.0212	0.144		430		0.29[b]
944229	Fonofos	1										22		
76448	Heptachlor	1,3									0.024	5.4	.3	1.80[b]
1024573	Heptachlor epoxide	1,3									0.012	0.14	.3	1.80[b]
118741	Hexachlorobenzene	1				.022[b]	.23[a]				0.067	8.6		0.09[a]
87683	Hexachlorobutadiene	1				.011[b]	.27[a]				1.4	2.2		1.0
77474	Hexachlorocyclopentadiene	1										75		
67721	Hexachloroethane	1,6						100			7.7	11		1.0
51235042	Hexazinone	1										360		
123319	Hydroquinone											430		
193395	Indeno(1,2,3-cd)pyrene	1				.69[a]	2.6[b]				0.15			0.29[b]
78591	Isophorone	1									110	2200		1.0
33820530	Isopropalin											160		
7439921	Lead	2		46.7	218	450[b]	660[a,c]		30.2	112			1.3	
121755	Malathion	1,6						.067				220		1.80[b]
108316	Maleic anhydride											1100		
7439965	Manganese											54		
7439976	Mercury			.15	.71	.59[a]	2.1[a,b]		0.13	0.696		1.1	1	
72435	Methoxychlor	1,6						1.9				54		1.80[b]
78933	Methyl ethyl ketone	1										6500		1.0
108101	Methyl isobutyl ketone	1										860		
22967926	Methyl Mercury	3										1.1	1	

Table D-1. (Continued)

GUIDELINE VALUES INTENDED ONLY FOR SCREENING LEVEL HAZARD COMPARISON AMONG CHEMICALS
May Be Over- or Underprotective of Sediment at a Given Location Depending on Site-Specific Conditions

CAS Number	Chemical Name	Code	Sediment Concentration								Fish Tissue Concentration (ppm)			BSAF (unitless)
			SQC_{oc} ($\mu g/g_{oc}$)	ER-L (ppm)	ER-M (ppm)	AET-L (ppm)	AET-H (ppm)	$SQAL_{oc}$ ($\mu g/g_{oc}$)	TEL (ppm)	PEL (ppm)	Concen. = EPA Risk 10^{-6}	EPA Non Cancer Hazard Quotient = 1	FDA Guidance/ Action/ Tolerance Level	
91576	Methylnaphthalene, 2-	1		.07	.67	.67[a]	1.9[a]		0.0202	0.201				
21087649	Metribuzin											270		
2385855	Mirex/Dechlorane	1,3									0.060	2.2	0.1	1.31[a]
7439987	Molybdenum											54		
91203	Naphthalene	1,6		.16	2.1	2.1[a]	2.7[b]	47	0.0346	0.391		430		0.29[b]
91598	Naphthylamine, 2-										0.00083			
7440020	Nickel	2		20.9	51.6				15.9	42.8		220	70	
98953	Nitrobenzene											5.4		
100027	Nitrophenol, 4											670		
924163	Nitrosodi-n-butylamine, N-										0.020			
621647	Nitrosodi-n-propylamine, N-										0.015			
55185	Nitrosodmiethylamine, N-										0.0021			
86306	Nitrosodiphenylamine, N-					.028[b]	.13[a]				22			
999999484	PAHs (high molecular weight)			1.7	9.6	17[a,b,c]	69[a,b,c]		0.655	6.676				
999999502	PAHs (low molecular weight)			.552	3.16	5.2[a,b]	24[a,b]		0.312	1.442				
56382	Parathion ethyl											65		
12674112	PCB(Aroclor-1016)	1,4		.0227	.180	1.0[b]	3.1[a]		0.0216	0.189	0.014	0.75	2	1.85[a]
11104282	PCB(Aroclor-1221)	1,4		.0227	.180	1.0[b]	3.1[a]		0.0216	0.189	0.014	0.22	2	1.85[a]
11141165	PCB(Aroclor-1232)	1,4		.0227	.180	1.0[b]	3.1[a]		0.0216	0.189	0.014	0.22	2	1.85[a]
53469219	PCB(Aroclor-1242)	1,4		.0227	.180	1.0[b]	3.1[a]		0.0216	0.189	0.014	0.22	2	1.85[a]
12672296	PCB(Aroclor-1248)	1,4		.0227	.180	1.0[b]	3.1[a]		0.0216	0.189	0.014	0.22	2	1.85[a]
11097691	PCB(Aroclor-1254)	1,4		.0227	.180	1.0[b]	3.1[a]		0.0216	0.189	0.014	0.22	2	1.85[a]
11096825	PCB(Aroclor-1260)	1,4		.0227	.180	1.0[b]	3.1[a]		0.0216	0.189	0.014	0.22	2	1.85[a]
608935	Pentachlorobenzene	1,6						69				8.6		0.04[a]
82688	Pentachloronitrobenzene/Quintozo										0.41	32		
87865	Pentachlorophenol					.36[a]	.69[b]				0.90	320		

Table D-1. (Continued)

GUIDELINE VALUES INTENDED ONLY FOR SCREENING LEVEL HAZARD COMPARISON AMONG CHEMICALS
May Be Over- or Underprotective of Sediment at a Given Location Depending on Site-Specific Conditions

CAS Number	Chemical Name	Code	Sediment Concentration								Fish Tissue Concentration (ppm)			BSAF (unitless)
			SQC_{oc} ($\mu g/g_{oc}$)	ER-L (ppm)	ER-M (ppm)	AET-L (ppm)	AET-H (ppm)	$SQAL_{oc}$ ($\mu g/g_{oc}$)	TEL (ppm)	PEL (ppm)	Concen. = EPA Risk 10^{-5}	EPA Non Cancer Hazard Quotient = 1	FDA Guidance/ Action/ Tolerance Level	
85018	Phenanthrene	1	180	0.240	1.5	1.5[a]	6.9[a]	180	0.0867	0.544				
108952	Phenol					.42[b]	1.2[a,b]					6500		
298022	Phorate/Famophos/Thimet	1										2.2		
85449	Phthalic anhydride											22000		
1336363	Polychlorinated biphenyls	1,4		0.0227	0.180	1.0[b]	3.1[a]		0.0216	0.189	0.014	0.22	2	1.85[a]
1610180	Prometon/Pramitol											160		
7287196	Prometym/Caparol											43		
23950585	Pronamide											810		
1918167	Propachlor											140		
129000	Pyrene	1		.665	2.6	3.3[a]	16[a,b]		0.153	1.398		320		0.29[c]
91225	Quinoline	1									0.009			
7782492	Selenium											54		
7440224	Silver			1	3.7	6.1[a]	6.1[a]		0.733	1.77		54		
122349	Simazine	5									0.90	54	12	
7440246	Strontium											6500		
100425	Styrene	1										2200		
13071799	Terbufos/Counter	1										0.27		
886500	Terbutryn											11		
95943	Tetrachlorobenzene, 1,2,4,5-	1										3.2		1.0
1746016	Tetrachlorodibenzo-p-dioxin,2,3,7,8-	1									6.9E-7			0.059[a]
79345	Tetrachloroethane, 1,1,2,2-	1,6						160			0.54			1.0
127184	Tetrachloroethene	1,6				.057[b]	.14[a]	53			2.1	110		1.0
56235	Tetrachloromethane	1,6						120			0.83	7.5		1.0
58902	Tetrachlorophenol, 2,3,4,6-											320		
961115	Tetrachlorvinphos/Gardona/Stirof	1									4.5	320		
7440315	Tin											6500		

Table D-1. (Continued)

GUIDELINE VALUES INTENDED ONLY FOR SCREENING LEVEL HAZARD COMPARISON AMONG CHEMICALS
May Be Over- or Underprotective of Sediment at a Given Location Depending on Site-Specific Conditions

CAS Number	Chemical Name	Code	Sediment Concentration								Fish Tissue Concentration (ppm)			BSAF (unitless)
			SQC_{oc} ($\mu g/g_{oc}$)	ER-L (ppm)	ER-M (ppm)	AET-L (ppm)	AET-H (ppm)	$SQAL_{oc}$ ($\mu g/g_{oc}$)	TEL (ppm)	PEL (ppm)	Concen. = EPA Risk 10^{-5}	EPA Non Cancer Hazard Quotient = 1	FDA Guidance/ Action/ Tolerance Level	
108883	Toluene	1,6						89				2200		1.0
8001352	Toxaphene	1,6						10			.098			1.80[b]
75252	Tribromomethane (Bromoform)	1,6						65			14	220		1.0
120821	Trichlorobenzene, 1,2,4-	1,6				.051[a]	.064[b]	920				110		1.0
71556	Trichloroethane, 1,1,1-	1,6						17				970		1.0
79005	Trichloroethane, 1,1,2-	1									1.9	43		1.0
79016	Trichloroethene	1,6						210			9.8	65		1.0
75694	Trichlorofluoromethane	1										3200		1.0
67663	Trichloromethane (Chloroform)	1									18	110		1.0
95954	Trichlorophenol, 2,4,5-											1100		
88062	Trichlorophenol, 2,4,6-										9.8			
93765	Trichlorophenoxyacetic acid, 2,4,5-											110		
93721	Trichlorophenoxypropionic acid, 2,4,5-											86		
1582098	Trifluralin/Treflan										14	81		
95636	Trimethylbenzene, 1,2,4-	1										5.4		
118967	Trinitrotoluene										3.6	5.4		
7440622	Vanadium											75		
108054	Vinyl acetate	1										11000		
108383	Xylene, m-	1,5				.04[b]	.12[c]	2.5				22000		1.0
95476	Xylene, o-	1				.04[b]	.12[c]	2.5				22000		1.0
106423	Xylene, p-	1				.04[b]	.12[c]	2.5						1.0
1330207	Xylenes	1				.04[b]	.12[c]	2.5				22000		1.0
7440666	Zinc			150	410	410[b]	1600[c]		124	271		3200		
888888881	Dioxin-toxic equivalents	1									6.9E-7			0.025[a]

Table D-1. (Continued)

Codes:

1. Chemical is a nonpolar organic.
2. FDA criterion is a guideline.
3. FDA criterion is an action level.
4. FDA criterion is a tolerance level, with the force of law.
5. Fish tissue action level set by USEPA, 40CFR180.
6. Preliminary $SQAL_{oc}$ developed for this chemical is under technical review.

AET Criteria:

[a] Sediment concentration based on amphipods.
[b] Sediment concentration based on benthic organisms.
[c] Sediment concentration based on oysters.

BSAF Sources:

[a] Cook 1995.
[b] Hansen 1995.

analyzed separately. In addition, the dioxin congeners were evaluated using the toxicity equivalence factor (TEF) approach (USEPA, 1989). This approach involves summarizing specific dioxin congeners based on their toxicity as compared to 2,3,7,8-tetrachlorodibenzo-p-dioxin, for which screening values are available. PCBs and dioxin represent the only cases where chemical data were actually combined for the NSI evaluation.

Because EPA typically performs risk-based screening by analyzing closely related chemicals with the same risk-based concentrations, this methodology was applied to the NSI evaluation. If no screening values were available for a certain chemical, but were available for a closely related chemical or group of chemicals, the lower or more conservative screening values of the closely related chemicals were used in analyzing the chemicals without screening values. This methodology was applied only for chemicals or chemical groups with more than 20 positive results. The following chemicals and chemical groups were affected by this methodology: BHCs, chlordanes, cresols, DDT and metabolites, dichlorobenzenes, endosulfans, methylmercury, anthracene and phenanthrene, benzo(a)anthracene/chrysene, xylenes, and PCBs (in applying screening values to aroclors with no available screening values).

Frequency of Detection

The frequency at which a given chemical or chemical group is responsible for sites in the NSI being categorized as Tier 1 or Tier 2 is often a reflection of the number of times that chemical is measured and detected in sediment samples. Thus, chemicals that are measured and detected less frequently might not often be identified as posing a potential risk to aquatic life or human health, even though the chemical is highly toxic. Table D-2 lists the number of times each chemical included in the NSI evaluation was measured and detected (i.e., a positive result) in sediment and fish tissue and the number of times each chemical was responsible for a station being categorized as Tier 1 or Tier 2.

Table D-2. Frequency of Detection of Chemicals in Sediment and Fish Tissue and Number of Detections Resulting in Risk (Tier 1 or Tier 2)[a, b]

CAS Number	Chemical Name	Number of Times Measured in Sediment	Number of Positive Sediment Results	Number of Times Measured in Tissue[c]	Number of Positive Tissue Results[c]	Tier 1 Level Results	Tier 2 Level Results
83329	Acenaphthene	6126	1567	777	41	144	359
208968	Acenaphthylene	5774	1286	-	-	74	958
67641	Acetone	547	48	22	16	-	-
107028	Acrolein	-	-	464	-	-	-
107131	Acrylonitrile	1034	9	464	-	-	7
15972608	Alachlor/Lasso	-	-	976	1	-	-
309002	Aldrin	14311	658	8029	612	2	712
62533	Aniline	-	-	10	-	-	-
120127	Anthracene	5211	1798	748	63	168	728
999999933	Anthracene&Phenanthrene	260	199	4	-	82	95
7440360	Antimony	5923	2980	1275	99	-	56
7440382	Arsenic	22281	18791	5528	2113	189	8613
1912249	Atrazine	-	-	880	-	-	-
7440393	Barium	-	-	986	837	-	-
71432	Benzene	2248	136	976	90	-	16
92875	Benzidine	-	-	537	-	-	-
56553	Benzo(a)anthracene	6718	3236	820	153	241	1540
999999955	Benzo(a)anthracene/Chrysene	272	243	-	-	146	76
50328	Benzo(a)pyrene	7011	3263	831	58	317	2292
205992	Benzo(b)fluoranthene	4179	1249	717	26	-	441
191242	Benzo(ghi)perylene	6034	2016	-	-	-	259
207089	Benzo(k)fluoranthene	4192	1093	651	21	-	113
65850	Benzoic acid	1724	247	121	5	-	41
100516	Benzyl alcohol	1910	90	120	-	-	13
7440417	Beryllium	-	-	1301	81	-	39
92524	Biphenyl	1215	873	564	138	-	2
542881	Bis(chloromethyl)ether	-	-	76	-	-	-
111444	Bis(2-chloroethyl)ether	-	-	636	3	-	3
108601	Bis(2-chloroisopropyl)ether	-	-	34	1	-	-
117817	Bis(2-ethylhexyl)phthalate	4606	1998	647	91	401	1109
7440428	Boron	-	-	44	21	-	-
75274	Bromodichloromethane	-	-	560	4	-	-
74839	Bromomethane	-	-	491	3	-	-
101553	Bromophenyl phenyl ether, 4-	2698	20	656	1	-	7
85687	Butyl benzyl phthalate	4069	333	634	4	1	51
319846	BHC, alpha-	9109	219	8148	1670	11	461
319857	BHC, beta-	6761	241	3060	209	-	257
319868	BHC, delta-	4891	99	2156	65	1	94

Table D-2. (Continued)

CAS Number	Chemical Name	Number of Times Measured in Sediment	Number of Positive Sediment Results	Number of Times Measured in Tissue[c]	Number of Positive Tissue Results[c]	Tier 1 Level Results	Tier 2 Level Results
58899	BHC, gamma-/Lindane	14442	999	8750	1391	101	527
608731	BHC, technical grade	169	166	115	31	3	66
7440439	Cadmium	27919	15176	6743	3321	-	7206
75150	Carbon disulfide	-	-	24	21	-	-
57749	Chlordane	12432	2170	7316	4568	116	4228
999999247	Chlordane-Nonachlor(cis)-	1476	9	4468	2101	-	268
999999248	Chlordane-Nonachlor(trans)-	1992	31	4569	2764	-	556
5103719	Chlordane, alpha(cis)-	4416	1516	6092	3659	3	1157
5103742	Chlordane, beta(trans)-	2833	443	5841	3045	3	847
5566347	Chlordane, gamma(trans)-	967	334	85	19	-	207
108907	Chlorobenzene	2111	58	819	18	-	4
510156	Chlorobenzilate	-	-	22	-	-	-
75003	Chloroethane	-	-	557	1	-	-
75014	Chloroethene	-	-	706	2	-	2
110758	Chloroethylvinyl ether, 2-	-	-	534	-	-	-
74873	Chloromethane	-	-	744	12	-	-
91587	Chloronaphthalene, 2-	-	-	655	1	-	-
95578	Chlorophenol, 2-	-	-	629	1	-	-
2921882	Chlorpyrifos/Dursban	305	5	793	143	-	-
7440473	Chromium	27504	25216	5508	3283	426	4126
218019	Chrysene	6975	3580	893	149	185	1618
7440508	Copper	27956	25452	6284	5533	-	11213
108394	Cresol, m-	988	780	-	-	-	41
95487	Cresol, o	1993	745	51	-	-	22
106445	Cresol, p-	985	84	49	3	-	31
1319773	Cresols	18	1	-	-	-	1
21725462	Cyanazine	-	-	326	-	-	-
57125	Cyanide	-	-	14	3	-	-
84742	Di-n-butyl phthalate	4651	986	637	55	9	112
117840	Di-n-octyl phthalate	4179	435	650	6	-	23
333415	Diazinon/Spectracide	3712	249	172	-	-	188
53703	Dibenzo(a,h)anthracene	7564	2431	824	16	419	1732
132649	Dibenzofuran	2564	416	126	-	25	51
124481	Dibromochloromethane	2033	18	562	1	-	-
95501	Dichlorobenzene, 1,2-	4402	107	892	2	38	23
541731	Dichlorobenzene, 1,3-	4315	132	797	2	-	22
106467	Dichlorobenzene, 1,4-	4352	268	887	3	53	41
25321226	Dichlorobenzenes	27	12	-	-	6	3
91941	Dichlorobenzidine, 3,3'-	-	-	639	1	-	-

Table D-2. (Continued)

CAS Number	Chemical Name	Number of Times Measured in Sediment	Number of Positive Sediment Results	Number of Times Measured in Tissue[c]	Number of Positive Tissue Results[c]	Tier 1 Level Results	Tier 2 Level Results
75718	Dichlorodifluoromethane	-	-	174	-	-	-
75343	Dichloroethane 1,1-	1918	19	561	-	-	-
107062	Dichloroethane 1,2-	1981	20	972	8	-	-
156605	Dichloroethene, trans-1,2-	1393	33	793	2	-	-
75354	Dichloroethene, 1,1-	-	-	973	2	-	-
75092	Dichloromethane	2177	576	532	112	-	11
120832	Dichlorophenol, 2,4-	-	-	642	1	-	-
94757	Dichlorophenoxyacetic acid, 2,4-	-	-	39	-	-	-
78875	Dichloropropane, 1,2-	2015	15	563	2	-	-
542756	Dichloropropene, 1,3-	-	-	107	-	-	-
115322	Dicofol/Kelthane	-	-	400	26	-	-
60571	Dieldrin	14702	3113	10243	5583	89	6709
84662	Diethyl phthalate	4188	367	654	2	34	48
131113	Dimethyl phthalate	4118	135	653	-	-	38
105679	Dimethylphenol, 2,4-	4541	80	640	1	-	54
51285	Dinitrophenol, 2,4-	-	-	631	-	-	-
121142	Dinitrotoluene, 2,4-	-	-	636	1	-	-
606202	Dinitrotoluene, 2,6-	-	-	636	1	-	-
122667	Diphenylhydrazine, 1,2-	-	-	509	-	-	-
298044	Disulfoton	-	-	23	-	-	-
1861321	DCPA/Dacthal	129	76	827	586	-	3
53190	DDD, o,p'-	6349	977	3397	428	73	502
72548	DDD, p, p'-	15311	4411	6252	2481	572	2574
3424826	DDE, o,p'-	5434	632	3427	401	118	222
72559	DDE, p, p'-	15961	5980	7656	5715	823	3501
999999300	DDT (Total)	3710	736	5750	4183	122	860
789026	DDT, o,p'-	6056	567	3479	368	25	268
50293	DDT, p, p'-	16028	3268	5843	1677	371	1839
115297	Endosulfan mixed isomers	2606	80	49	12	-	20
959988	Endosulfan, alpha-	5581	84	2832	53	-	45
33213659	Endosulfan, beta-	5886	260	2157	10	-	42
72208	Endrin	12694	289	8192	893	-	8
563122	Ethion/Bladen	2953	38	170	-	-	-
100414	Ethylbenzene	2543	118	807	50	1	42
206440	Fluoranthene	7562	4563	953	216	234	1074
86737	Fluorene	6652	2280	797	14	231	1141
944229	Fonofos	-	-	288	-	-	-
76448	Heptachlor	11952	673	7369	1006	-	210
1024573	Heptachlor epoxide	12829	986	7480	2896	-	1431

Table D-2. (Continued)

CAS Number	Chemical Name	Number of Times Measured in Sediment	Number of Positive Sediment Results	Number of Times Measured in Tissue[c]	Number of Positive Tissue Results[c]	Tier 1 Level Results	Tier 2 Level Results
118741	Hexachlorobenzene	10044	1445	6970	1519	-	224
87683	Hexachlorobutadiene	4198	128	1161	14	-	81
67721	Hexachloroethane	3801	4	636	-	-	1
193395	Indeno(1,2,3-cd)pyrene	5874	1913	756	20	-	559
78591	Isophorone	3400	40	635	4	-	8
33820530	Isopropalin	-	-	392	15	-	-
7439921	Lead	29979	24971	6654	3008	-	8883
121755	Malathion	4041	38	500	1	-	26
108316	Maleic anhydride	-	-	2	-	-	-
7439965	Manganese	-	-	1000	971	-	5
7439976	Mercury	26142	16632	9752	8424	1951	5049
72435	Methoxychlor	9183	154	5912	63	-	33
78933	Methyl ethyl ketone	519	7	20	11	-	-
108101	Methyl isobutyl ketone	-	-	26	-	-	-
22967926	Methyl Mercury	-	-	9	8	-	-
91576	Methylnaphthalene, 2-	2629	973	-	-	71	522
21087649	Metribuzin	-	-	289	-	-	-
2385855	Mirex/Dechlorane	5794	544	4800	915	-	40
7439987	Molybdenum	-	-	707	169	-	-
91203	Naphthalene	6823	2820	803	22	291	1247
7440020	Nickel	21519	18550	3120	974	-	9260
98953	Nitrobenzene	-	-	635	-	-	-
100027	Nitrophenol, 4	-	-	606	1	-	-
621647	Nitrosodi-n-propylamine, N-	-	-	645	1	-	1
86306	Nitrosodiphenylamine, N-	3730	66	661	3	-	45
999999484	PAHs (high molecular weight)	1566	885	-	-	93	383
999999502	PAHs (low molecular weight)	1604	895	-	-	112	382
56382	Parathion ethyl	-	-	499	4	-	-
608935	Pentachlorobenzene	114	54	404	30	-	4
82688	Pentachloronitrobenzene/Quintozene	-	-	390	2	-	-
87865	Pentachlorophenol	5622	195	1756	149	-	26
85018	Phenanthrene	7067	4078	-	-	335	694
108952	Phenol	4595	864	647	12	-	155
1336363	Polychlorinated biphenyls	11296	4183	10642	7379	8151	2620
1610180	Prometon/Pramitol	-	-	289	-	-	-
1918167	Propachlor	-	-	1	-	-	-
129000	Pyrene	7558	4555	952	187	482	1896
12674112	PCB(Aroclor-1016)	5098	46	3161	12	19	39
11104282	PCB(Aroclor-1221)	5627	7	3568	2	4	5

Table D-2. (Continued)

CAS Number	Chemical Name	Number of Times Measured in Sediment	Number of Positive Sediment Results	Number of Times Measured in Tissue[c]	Number of Positive Tissue Results[c]	Tier 1 Level Results	Tier 2 Level Results
11141165	PCB(Aroclor-1232)	5417	13	3195	1	4	10
53469219	PCB(Aroclor-1242)	6375	435	4446	220	355	270
12672296	PCB(Aroclor-1248)	6314	559	4464	688	916	280
11097691	PCB(Aroclor-1254)	7178	1305	5871	3343	3664	765
11096825	PCB(Aroclor-1260)	6885	890	6035	3611	3866	531
7782492	Selenium	-	-	2559	2079	-	4
7440224	Silver	11082	6256	1739	515	350	1083
122349	Simazine	-	-	289	-	-	-
7440246	Strontium	-	-	45	45	-	-
100425	Styrene	-	-	191	-	-	-
888888882	SEM_est ([SEM]-[AVS])	335	335	-	-	8	161
95943	Tetrachlorobenzene, 1,2,4,5-	97	1	398	12	-	-
1746016	Tetrachlorodibenzo-p-dioxin, 2,3,7,8-	631	38	908	391	353	23
79345	Tetrachloroethane, 1,1,2,2-	1683	49	978	33	-	2
127184	Tetrachloroethene	2429	109	973	49	2	17
56235	Tetrachloromethane	2010	15	979	4	-	-
58902	Tetrachlorophenol, 2,3,4,6-	-	-	71	-	-	-
7440315	Tin	-	-	382	264	-	-
108883	Toluene	2338	325	814	116	-	28
8001352	Toxaphene	10912	75	6566	643	-	684
75252	Tribromomethane/Bromoform	2078	44	818	7	-	-
120821	Trichlorobenzene, 1,2,4-	4256	87	1082	46	6	49
71556	Trichloroethane, 1,1,1-	2083	63	815	23	-	10
79005	Trichloroethane, 1,1,2-	2035	14	879	7	-	-
79016	Trichloroethene	2494	75	975	19	-	1
75694	Trichlorofluoromethane	1096	9	288	15	-	-
67663	Trichloromethane/Chloroform	2277	76	972	37	-	-
95954	Trichlorophenol, 2,4,5-	-	-	73	-	-	-
88062	Trichlorophenol, 2,4,6-	-	-	658	-	-	-
93765	Trichlorophenoxyacetic acid, 2,4,5-	-	-	3	-	-	-
93721	Trichlorophenoxypropionic acid, 2,4,5	-	-	36	-	-	-
1582098	Trifluralin/Treflan	-	-	925	193	-	-
7440622	Vanadium	-	-	768	465	-	-
108054	Vinyl acetate	-	-	21	-	-	-
108383	Xylene, m-	55	31	-	-	4	6
95476	Xylene, o-	61	1	-	-	-	1
106423	Xylene, p-	14	2	-	-	-	2
1330207	Xylenes	922	48	22	13	5	11
7440666	Zinc	27065	26473	4580	4553	-	5176

Table D-2. (Continued)

CAS Number	Chemical Name	Number of Times Measured in Sediment	Number of Positive Sediment Results	Number of Times Measured in Tissue[c]	Number of Positive Tissue Results[c]	Tier 1 Level Results	Tier 2 Level Results
888888881	Dioxin toxic equilvalents	56	56	590	590	459	45

[a]Results presented at observation level. Multiple observations may have occurred at a given station.
[b]Observations recorded here correspond only to stations with available latitude/longitude coordinates.
[c]Fish tissue results are presented for demersal, resident, and edible species only.

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Appendix E

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

Table E-1 presents the cancer slope factors and noncancer reference doses that were used to calculate the EPA risk levels and hazard quotients used in the analysis. The calculations for the EPA risk levels and hazard quotients used in the analysis appear in Appendix B. The slope factors and reference doses were obtained from the following sources:

- *Health Effects Assessment Summary Tables FY 1995.* EPA/540/R-95/036. U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, Washington, DC.
- *Integrated Risk Information System (IRIS).* Online. U.S. Environmental Protection Agency, Office of Health and Environmental Assessment, Environmental Criteria and Assessment Office, Cincinnati, OH.
- Risk-Based Concentration Table, January-June 1995. U.S. Environmental Protection Agency, Region 3.

Table E-1. Cancer Slope Factors and Noncancer Reference Doses Used to Develop EPA Risk Levels

CAS Number	Chemical Name	Cancer Slope Factor(mg/kg/d)$^{-1}$ (Followed by source; see footnotes)	Noncancer ReferenceDose (mg/kg/d) (Followed by source; see footnotes)	Surrogate Chemical Used (if necessary)
83329	Acenaphthene		6.00E-2[i]	
67641	Acetone		1.00E-1[h]	
98862	Acetophenone		1.00E-1[i]	
107028	Acrolein		2.00E-2[h]	
107131	Acrylonitrile	5.40E-1[i]	1.00E-3[h]	
15972608	Alachlor/Lasso	8.00E-2[h]	1.00E-2[i]	
116063	Aldicarb/Temik		1.00E-3[i]	
309002	Aldrin	1.70E+1[i]	3.00E-5[i]	
62533	Aniline	5.70E-3[i]		
120127	Anthracene		3.00E-1[i]	
999999933	Anthracene & Phenanthrene		3.00E-1	anthracene
7440360	Antimony		4.00E-4[i]	
7440382	Arsenic	1.75E+0[j]	3.00E-4[i]	
1912249	Atrazine	2.22E-1[h]	3.50E-2[i]	
7440393	Barium		7.00E-2[i]	
92875	Benzidine	2.30E+2[i]	3.00E-3[i]	
71432	Benzene	2.90E-2[i]		
56553	Benzo(a)anthracene	7.30E-1[e]		
999999955	Benzo(a)anthracene/Chrysene	7.30E-1		benzo(a)anthracene
50328	Benzo(a)pyrene	7.30E+0[j]		
205992	Benzo(b)fluoranthene	7.30E-1[e]		
207089	Benzo(k)fluoranthene	7.30E-2[e]		
65850	Benzoic acid		4.00E+0[j]	
98077	Benzotrichloride	1.30E+1[i]		
100516	Benzyl alcohol		3.00E-1[h]	
100447	Benzyl chloride	1.70E-1[i]		
7440417	Beryllium	4.30E+0[j]	5.00E-3[i]	
319846	BHC, alpha-	6.30E+0[j]		
319857	BHC, beta-	1.80E+0[j]		
319868	BHC, delta-	1.80E+0		beta-BHC
58899	BHC, gamma- (Lindane)	1.30E+0[h]	3.00E-4[i]	
608731	BHC, technical grade	1.80E+0[j]		

Table E-1. (Continued)

CAS Number	Chemical Name	Cancer Slope Factor(mg/kg/d)$^{-1}$ (Followed by source; see footnotes)	Noncancer ReferenceDose (mg/kg/d) (Followed by source; see footnotes)	Surrogate Chemical Used (if necessary)
608731	BHC, technical grade	1.80E+0[i]		
92524	Biphenyl		5.00E-2[i]	
111444	Bis(2-chloroethyl)ether	1.10E+0[i]		
108601	Bis(2-chloroisopropyl)ether	7.00E-2[n]	4.00E-2[i]	
117817	Bis(2-ethylhexyl)phthalate	1.40E-2[i]	2.00E-2[i]	
542881	Bis(chloromethyl)ether	2.20E+2[i]		
7440428	Boron		9.00E-2[i]	
75274	Bromodichloromethane	6.20E-2[i]	2.00E-2[i]	
74839	Bromomethane		1.40E-3[i]	
101553	Bromophenyl phenyl ether, 4-		5.80E-2[r]	
1689845	Bromoxynil		2.00E-2[i]	
85687	Butyl benzyl phthalate		2.00E-1[i]	
7440439	Cadmium		5.00E-4[i]	
63252	Carbaryl/Sevin		1.00E-1[i]	
1563662	Carbofuran/furadan		5.00E-3[i]	
75150	Carbon disulfide		1.00E-1[i]	
133904	Chloramben		1.50E-2[i]	
57749	Chlordane	1.30E+0[i]	6.00E-5[i]	
5103719	Chlordane, alpha(cis)-	1.30E+0	6.00E-5	chlordane
5103742	Chlordane, beta(trans)-	1.30E+0	6.00E-5	chlordane
5566347	Chlordane, gamma(trans)-	1.30E+0	6.00E-5	chlordane
999999247	Chlordane-nonachlor(cis)-	1.30E+0	6.00E-5	chlordane
999999248	Chlordane-nonachlor(trans)-	1.30E+0	6.00E-5	chlordane
108907	Chlorobenzene		2.00E-2[i]	
510156	Chlorobenzilate	2.70E-1[h]	2.00E-2[i]	
75003	Chloroethane		4.00E-1[e]	
75014	Chloroethene	1.90E+0[h]		
110758	Chloroethylvinyl ether, 2-		2.50E-2[f]	
74873	Chloromethane	1.30E-2[h]		
91587	Chloronaphthalene, 2-		8.00E-2[i]	
95578	Chlorophenol, 2-		5.00E-3[i]	
2921882	Chlorpyrifos/Dursban		3.00E-3[i]	

Table E-1. (Continued)

CAS Number	Chemical Name	Cancer Slope Factor(mg/kg/d)$^{-1}$ (Followed by source; see footnotes)	Noncancer ReferenceDose (mg/kg/d) (Followed by source; see footnotes)	Surrogate Chemical Used (if necessary)
7440473	Chromium		5.00E-3[i]	
218019	Chrysene	7.30E-3[c]		
7440508	Copper		3.71E-2[h]	
108394	Cresol, m-		5.00E-2[i]	
95487	Cresol, o-		5.00E-2[i]	
106445	Cresol, p-		5.00E-3[h]	
1319773	Cresols		5.00E-3	p-Cresol
98828	Cumene		4.00E-2[i]	
21725462	Cyanazine	8.40E-1[h]	2.00E-03[h]	
57125	Cyanide		2.00E-2[i]	
1861321	DCPA/Dacthal		1.00E-2[i]	
53190	DDD, o,p'-	2.40E-1		p,p'-DDD
72548	DDD, p, p'-	2.40E-1[i]		
3424826	DDE, o,p'-	3.40E-1		p,p'-DDE
72559	DDE, p, p'-	3.40E-1[i]		
789026	DDT, o,p'-	3.40E-1	5.00E-4	p,p'-DDT
50293	DDT, p, p'-	3.40E-1[i]	5.00E-4i	
999999300	DDT (Total)	3.40E-1	5.00E-4	p,p'-DDT
1163195	Decabromodiphenyl oxide		1.00E-2[i]	
84742	Di-n-butyl phthalate		1.00E-1[i]	
117840	Di-n-octyl phthalate		2.00E-2[h]	
3334515	Diazinon/Spectracide		9.00E-4[h]	
53703	Dibenzo(a,h)anthracene	7.30E+0[c]		
132649	Dibenzofuran		4.00E-3[e]	
96128	Dibromo-3-chloropropane, 1,2-	1.40E+0[h]		
124481	Dibromochloromethane	8.40E-2[i]	2.00E-2[i]	
1918009	Dicamba		3.00E-2[i]	
95501	Dichlorobenzene, 1,2-		9.00E-2[i]	
541731	Dichlorobenzene, 1,3-		8.90E-2[i]	
106467	Dichlorobenzene, 1,4-	2.40E-2[h]		
25321226	Dichlorobenzenes	2.40E-2	8.90E-2	1,3-and 1,4-dichlorobenzene
91941	Dichlorobenzidine, 3,3'-	4.50E-1[i]		

Table E-1. (Continued)

CAS Number	Chemical Name	Cancer Slope Factor(mg/kg/d)$^{-1}$ (Followed by source; see footnotes)	Noncancer ReferenceDose (mg/kg/d) (Followed by source; see footnotes)	Surrogate Chemical Used (if necessary)
75718	Dichlorodifluoromethane		2.00E-1[i]	
75343	Dichloroethane 1,1-		1.00E-1[h]	
107062	Dichloroethane 1,2-	9.10E-2[i]		
75354	Dichloroethene, 1,1-	6.00E-1[i]	9.00E-3[i]	
156605	Dichloroethene, trans-1,2-		2.00E-2[i]	
156592	Dichloroethylene, cis-1,2-		1.00E-2[h]	
75092	Dichloromethane	7.50E-3[s]	6.00E-2[i]	
120832	Dichlorophenol, 2,4-		3.00E-3[i]	
94757	Dichlorophenoxyacetic acid, 2,4-		1.00E-2[i]	
94826	Dichlorophenoxybutanoic acid, 2,4-		8.00E-3[i]	
78875	Dichloropropane, 1,2-	6.80E-2[h]		
542756	Dichloropropene, 1,3-	1.75E-1[h]	3.00E-4[i]	
62737	Dichlorvos	2.90E-1[i]	5.00E-4[i]	
115322	Dicofol/Kelthane	4.40E-1[w]		
60571	Dieldrin	1.60E+1[i]	5.00E-5[i]	
84662	Diethyl phthalate		8.00E-1[i]	
119904	Dimethoxybenzidine,3,3'-	1.40E-2[h]		
131113	Dimethyl phthalate		1.00E+1[h]	
105679	Dimethylphenol, 2,4-		2.00E-2[i]	
528290	Dinitrobenzene, 1,2-		4.00E-4[h]	
99650	Dinitrobenzene, 1,3-		1.00E-4[i]	
100254	Dinitrobenzene, 1,4		4.00E-4[h]	
51285	Dinitrophenol, 2,4-		2.00E-3[i]	
121142	Dinitrotoluene, 2,4-		2.00E-3[i]	
606202	Dinitrotoluene, 2,6-		1.00E-3[h]	
88857	Dinoseb/DNBP		1.00E-3[i]	
122667	Diphenylhydrazine, 1,2-	8.00E-1[i]		
298044	Disulfoton		4.00E-5[i]	
959988	Endosulfan, alpha-		6.00E-3	endosulfan
33213659	Endosulfan, beta-		6.00E-3	endosulfan
115297	Endosulfan mixed isomers		6.00E-3[i]	
72208	Endrin		3.00E-4[i]	

Table E-1. (Continued)

CAS Number	Chemical Name	Cancer Slope Factor(mg/kg/d)$^{-1}$ (Followed by source; see footnotes)	Noncancer ReferenceDose (mg/kg/d) (Followed by source; see footnotes)	Surrogate Chemical Used (if necessary)
563122	Ethion/Bladen		5.00E-4[i]	
141786	Ethyl acetate		9.00E-1[i]	
100414	Ethylbenzene		1.00E-1[i]	
106934	Ethylene dibromide	8.50E+1[i]		
206440	Fluoranthene		4.00E-2[i]	
86737	Fluorene		4.00E-2[i]	
944229	Fonofos		2.00E-3[i]	
76448	Heptachlor	4.50E+0[i]	5.00E-4[i]	
1024573	Heptachlor epoxide	9.10E+0[i]	1.30E-5[i]	
118741	Hexachlorobenzene	1.60E+0[i]	8.00E-4[i]	
87683	Hexachlorobutadiene	7.80E-2[i]	2.00E-4[h]	
74474	Hexachlorocyclopentadiene		7.00E-3[i]	
67721	Hexachloroethane	1.40E-2[i]	1.00E-3[i]	
51235042	Hexazinone		3.30E-2[i]	
123319	Hydroquinone		4.00E-2[h]	
193395	Indeno(1,2,3-cd)pyrene	7.30E-1[e]		
78591	Isophorone	9.50E-4[i]	2.00E-1[i]	
33820530	Isopropalin		1.50E-2[i]	
121755	Malathion		2.00E-2[i]	
108316	Maleic anhydride		1.00E-1[i]	
7439965	Manganese		5.00E-3[i]	
7439976	Mercury		1.00E-4	methyl mercury
72435	Methoxychlor		5.00E-3[i]	
78933	Methyl ethyl ketone		6.00E-1[i]	
108101	Methyl isobutyl ketone		8.00E-2[h]	
22967926	Methyl Mercury		1.00E-4[i]	
21087649	Metribuzin		2.50E-2[i]	
2385855	Mirex/Dechlorane	1.80E+0[w]	2.00E-4[i]	
7439987	Molybdenum		5.00E-3[i]	
91203	Naphthalene		4.00E-2[w]	
91598	Naphthylamine, 2-	1.30E+2[e]		
7440020	Nickel		2.00E-2[i]	

Table E-1. (Continued)

CAS Number	Chemical Name	Cancer Slope Factor(mg/kg/d)$^{-1}$ (Followed by source; see footnotes)	Noncancer ReferenceDose (mg/kg/d) (Followed by source; see footnotes)	Surrogate Chemical Used (If necessary)
98953	Nitrobenzene		5.00E-4[i]	
100027	Nitrophenol, 4		6.20E-2[r]	
924163	Nitrosodi-n-butylamine, N-	5.40E+0[j]		
621647	Nitrosodi-n-propylamine, N-	7.00E+0[j]		
55185	Nitrosodiethylamine, N-	1.50E+2[i]		
86306	Nitrosodiphenylamine, N-	4.90E-3[i]		
56382	Parathion ethyl		6.00E-3[h]	
12674112	PCB(Aroclor-1016)	7.70E+0	7.00E-5[i]	PCBs
11104282	PCB(Aroclor-1221)	7.70E+0	2.00E-5[i]	PCBs
11141165	PCB(Aroclor-1232)	7.70E+0	2.00E-5	PCBs/Aroclor 1254
53469219	PCB(Aroclor-1242)	7.70E+0	2.00E-5	PCBs/Aroclor 1254
12672296	PCB(Aroclor-1248)	7.70E+0	2.00E-5	PCBs/Aroclor 1254
11097691	PCB(Aroclor-1254)	7.70E+0	2.00E-5	PCBs/Aroclor 1254
11096825	PCB(Aroclor-1260)	7.70E+0	2.00E-5	PCBs/Aroclor 1254
608935	Pentachlorobenzene		8.00E-4[i]	
82688	Pentachloronitrobenzene/Quintoze		2.60E-1[h]	3.00E-3[i]
87865	Pentachlorophenol	1.20E-1[i]	3.00E-2[i]	
108952	Phenol		6.00E-1[i]	
298022	Phorate/Famophos/Thimet		2.00E-4[h]	
85449	Phthalic anhydride		2.00E+0[j]	
1336363	Polychlorinated biphenyls	7.70E+0[j]	2.00E-5	Aroclor 1254 (RfD)
1610180	Prometon/Pramitol		1.50E-2[i]	
7287196	Prometym/Caparol		4.00E-3[i]	
23950585	Pronamide		7.50E-2[i]	
1918167	Propachlor		1.30E-2[i]	
129000	Pyrene		3.00E-2[i]	
91225	Quinoline	1.20E+1[h]		
7782492	Selenium		5.00E-3[i]	
7440224	Silver		5.00E-3[i]	
122349	Simazine	1.20E-1[h]	5.00E-3[i]	
122349	Strontium		6.00E-1[i]	
100425	Styrene		2.00E-1[i]	

Table E-1. (Continued)

CAS Number	Chemical Name	Cancer Slope Factor(mg/kg/d)$^{-1}$ (Followed by source; see footnotes)	Noncancer ReferenceDose (mg/kg/d) (Followed by source; see footnotes)	Surrogate Chemical Used (if necessary)
13071799	Terbufos/Counter		2.50E-5[h]	
886500	Terbutryn		1.00E-3[i]	
95943	Tetrachlorobenzene, 1,2,4,5-		3.00E-4[i]	
1746016	Tetrachlorodibenzo-p-dioxin, 2,3,7,8-	1.56E+5[h]		
79345	Tetrachloroethane, 1,1,2,2-	2.00E-1[i]		
127184	Tetrachloroethene	5.20E-2[e]	1.00E-2[i]	
56235	Tetrachloromethane	1.30E-1[i]	7.00E-4[i]	
58902	Tetrachlorophenol, 2,3,4,6-		3.00E-2[i]	
961115	Tetrachlorvinphos/Gardona/Stirof	2.40E-2[h]	3.00E-2[i]	
7440315	Tin		6.00E-1[h]	
108883	Toluene		2.00E-1[i]	
8001352	Toxaphene	1.10E+0[i]		
75252	Tribromomethane (Bromoform)	7.90E-3[i]	2.00E-2[i]	
120821	Trichlorobenzene, 1,2,4-		1.00E-2[i]	
71556	Trichloroethane, 1,1,1-		9.00E-2[w]	
79005	Trichloroethane, 1,1,2-	5.70E-2[i]	4.00E-3[i]	
79016	Trichloroethene	1.10E-2[w]	6.00E-3[e]	
75694	Trichlorofluoromethane		3.00E-1[i]	
67663	Trichloromethane (Chloroform)	6.10E-3[i]	1.00E-2i	
95954	Trichlorophenol, 2,4,5-		1.00E-1[i]	
88062	Trichlorophenol, 2,4,6-	1.10E-2[i]		
93765	Trichlorophenoxyacetic acid, 2,4,5-		1.00E-2[i]	
93721	Trichlorophenoxypropionic acid, 2,4,5-		8.00E-3[i]	
1582098	Trifluralin/Treflan	7.70E-3[i]	7.50E-3[i]	
95636	Trimethylbenzene, 1,2,4-		5.00E-4[e]	
118967	Trinitrotoluene	3.00E-2[i]	5.00E-4[i]	
7440622	Vanadium		7.00E-3[h]	
108054	Vinyl acetate		1.00E+0[h]	
108383	Xylene, m-		2.00E+0[h]	
95476	Xylene, o-		2.00E+0[h]	
1330207	Xylenes		2.00E+0[i]	
7440666	Zinc		3.00E-1[i]	

Codes:

[i]Integrated Risk Information System (IRIS).
[h]Health Effects Assessment Summary Tables (HEAST).
[e]Environmental Criteria and Assessment Office (ECAO, as cited in Risk-Based Concentration Table).
[w]Withdrawn from HEAST, but use continued for screening assessments (USEPA, Risk-Based Concentration Table).

Appendix F

Species Characteristics Related to NSI Bioaccumulation Data

Table F-1 presents the species used in tissue residue analyses whose results are included in the NSI. For each species listed, Table F-1 identifies the species as being resident or migratory (or either) and demersal or pelagic (or either) and specifies whether the species might be consumed by humans (i.e., recreational or subsistence anglers). A species is considered either resident or migratory if it stays predominately in one location as long as food and habitat are available but is capable of traveling long distances to find food and suitable habitat. A species is considered either demersal or pelagic if it spends much of its time in the water column but is likely to feed off the bottom.

If a species is identified as either resident or migratory, it is considered resident for the purpose of this analysis. If a species is identified as either demersal or pelagic, it is considered demersal.

Table F-1. Species Characteristics Related to Tissue Residue Data

Species Code	Scientific Name	Common Name	Resident/Migratory[a]	Demersal/Pelagic[b]	Potentially Eatable
615301010400	Acanthomysis macropsis	Mysid shrimp	E	E	
611829010000	Acartia spp.	Copepod (unknown species)	M	P	
872901010000	Acipenser spp.	Sturgeon (unknown Species)	M	D	Y
872901010600	Acipenser fulvescens	Lake sturgeon	R	D	Y
872901010500	Acipenser oxyrhynchus	Atlantic sturgeon	M	D	Y
872901010300	Acipenser transmontanus	White sturgeon	M	D	Y
877601200100	Acrocheilus alutaceus	Chiselmouth	R	P	
875503060100	Allosmerus elongatus	Whitebait smelt	M	P	Y
874701010200	Alosa aestivalis	Blueback herring	M	P	Y
874701010600	Alosa chrysochloris	Skipjack herring	M	P	Y
874701010300	Alosa mediocris	Hickory shad	M	P	Y
874701010500	Alosa pseudoharengus	Alewife	M	P	Y
874701010100	Alosa sapidissima	American shad	M	P	Y
883516020200	Ambloplites cavifrons	Roanoke bass	R	P	Y
883516020100	Ambloplites rupestris	Rock bass	R	P	Y
877702060100	Ameiurus brunneus	Snail bullhead	R	D	Y
877702060200	Ameiurus catus	White catfish	R	D	Y
877702060300	Ameiurus melas	Black bullhead	R	D	Y
877702060400	Ameiurus natalis	Yellow bullhead	R	D	Y
877702060500	Ameiurus nebulosus	Brown bullhead	R	D	Y
877702060600	Ameiurus platycephalus	Flat bullhead	R	D	Y
877702060700	Ameiurus serracanthus	Spotted bullhead	R	D	Y
873401010100	Amia calva	Bowfin	R	E	Y
884202010200	Anarhichas denticulatus	Northern wolffish	R	D	Y
874101010100	Anguilla rostrata	American eel	M	P	Y
883544260100	Aplodinotus grunniens	Freshwater drum	M	E	Y
883516090100	Archoplites interruptus	Sacramento perch	R	P	Y
883543030100	Archosargus probatocephalus	Sheepshead	M	P	Y
551539010100	Arctica islandica	Ocean quahog	R	D	Y
877718020200	Arius felis	Hardhead catfish	M	D	Y
883102040500	Artedius notospilotus	Bonehead sculpin	R	D	
618102000000	Astacidae	Crayfish (family)	R	D	Y

Table F-1. (Continued)

Species Code	Scientific Name	Common Name	Resident/Migratory[a]	Demersal/Pelagic[b]	Potentially Eatable
551519010000	*Astarte spp.*	Astarte clam (Unknown species)	R	D	
551519011300	*Astarte undata*	Waved astarte	R	D	
883561010100	*Astronotus ocellatus*	Oscar	R	P	Y
810601051100	*Astropecten verrilli*	Margined seastar	R	D	
877718010100	*Bagre marinus*	Gafftopsail catfish	M	E	Y
883544030100	*Bairdiella chrysoura*	Silver perch	M	P	Y
550000000000	*Bivalvia*	Class of molluscs	R	D	Y
550701160100	*Brachiodontes recurvus*	Hooked mussel	R	D	Y
874701040000	*Brevoortia spp.*	Menhaden (unknown species)	M	P	Y
874701040100	*Brevoortia tyrannus*	Atlantic menhaden	M	P	Y
618901030100	*Callinectes sapidus*	Blue crab	M	D	Y
618105010600	*Cambarus bartoni*	Crayfish	R	D	Y
877601140100	*Campostoma anomalum*	Central stoneroller	R	E	
618803010400	*Cancer magister*	Dungeness crab	M	D	Y
883528030300	*Caranx hippos*	Crevalle jack	M	P	Y
877601030100	*Carassius auratus*	Goldfish	R	E	
870802050100	*Carcharhinus obscurus*	Dusky shark	M	E	Y
870802050300	*Carcharhinus plumbeus*	Brown shark (sandbar)	M	E	Y
877604020000	*Carpiodes spp.*	Carpsucker (unknown species)	R	D	Y
877604020200	*Carpiodes carpio*	River carpsucker	R	D	Y
877604020100	*Carpiodes cyprinus*	Quillback	R	D	Y
877604020300	*Carpiodes velifer*	Highfin carpsucker	R	D	Y
877604010000	*Catostomus spp.*	Sucker (unknown sp)	R	D	Y
877604010500	*Catostomus ardens*	Utah sucker	R	D	Y
877604010100	*Catostomus catostomus*	Longnose sucker	R	D	Y
877604010400	*Catostomus columbianus*	Bridgelip sucker	R	D	Y
877604010200	*Catostomus commersoni*	White sucker	R	D	Y
877604011200	*Catostomus latipinnis*	Flannelmouth sucker	R	D	Y
877604010300	*Catostomus macrocheilus*	Largescale sucker	R	D	Y
877604011500	*Catostomus occidentalis*	Sacramento sucker	R	D	Y
877604011600	*Catostomus platyrhynchus*	Mountain sucker	R	D	Y
877604012000	*Catostomus snyderi*	Klamath largescale sucker	R	D	Y

Table F-1. (Continued)

Species Code	Scientific Name	Common Name	Resident/Migratory[a]	Demersal/Pelagic[b]	Potentially Eatable
877604012100	*Catostomus tahoensis*	Tahoe sucker	R	D	Y
883516000000	*Centrarchidae*	Sunfish family	R	P	Y
883516030100	*Centrarchus macropterus*	Flier	R	P	Y
883501010500	*Centropomus undecimalis*	Common snook	M	P	Y
883502030100	*Centropristis striata*	Black sea bass	M	P	Y
900201010100	*Chelydra serpentina*	Snapping turtle	R	E	Y
648933000000	*Chironomidae*	Midge family	R	D	
648960063300	*Chironomus riparius*	Midge	R	D	
883561090100	*Cichla ocellaris*	Peacock cichlid	R	P	Y
885703010100	*Citharichthys sordidus*	Pacific sanddab	E	D	
885703011100	*Citharichthys xanthostigma*	Longfin sanddab	E	D	
877712010200	*Cichla Clarias fuscus*	Whitespotted clarias	M	D	Y
877601070100	*Clinostomus funduloides*	Rosyside dace	R	P	
551545020100	*Corbicula manilensis*	Asiatic clam	R	D	Y
875501010800	*Coregonus artedii*	Cisco (lake herring)	M	P	Y
875501010600	*Coregonus clupeaformis*	Lake whitefish	M	P	Y
875501010900	*Coregonus hoyi*	Bloater	M	P	Y
883102000000	*Cottidae*	Sculpin family	R	D	Y
883102080000	*Cottus spp.*	Sculpin (unknown species)	R	D	
883102080100	*Cottus aleuticus*	Coastrange sculpin	R	D	
883102080700	*Cottus bairdi*	Mottled sculpin	R	D	
883102080900	*Cottus carolinae*	Banded sculpin	R	D	
883102080200	*Cottus cognatus*	Slimy sculpin	R	D	
551002010000	*Crassostrea spp.*	Oysters (unknown species)	R	D	Y
551002010100	*Crassostrea gigas*	Pacific oyster	R	D	Y
551002010200	*Crassostrea virginica*	Eastern oyster	R	D	Y
877601230100	*Ctenopharyngodon idella*	Grass carp	R	E	Y
877604060100	*Cycleptus elongatus*	Blue sucker	M	D	Y
883544010200	*Cynoscion nebulosus*	Spotted sea trout	R	P	Y
883544010300	*Cynoscion nothus*	Silver sea trout	M	P	Y
883544010400	*Cynoscion regalis*	Weakfish	M	P	Y
877601761400	*Cyprinella lutrensis*	Red shiner	R	P	

Table F-1. (Continued)

Species Code	Scientific Name	Common Name	Resident/Migratory[a]	Demersal/Pelagic[b]	Potentially Eatable
877601761900	*Cyprinella spiloptera*	Spotfin shiner	R	P	
877601000000	*Cyprinidae*	Carp/goldfish (hybrid)	R	E	Y
877601010100	*Cyprinus carpio*	Common carp	R	D	Y
871305010500	*Dasyatis sabina*	Atlantic stingray	M	D	Y
874701050100	*Dorosoma cepedianum*	Gizzard shad	M	P	
874701050200	*Dorosoma petenense*	Threadfin shad	M	P	
551202030100	*Elliptio complanata*	Freshwater clam	?	D	Y
885704040300	*Eopsetta exilis*	Slender sole	E	D	Y
883544120500	*Equetus punctatus*	Spotted drum	R	D	
877604030000	*Erimyzon spp.*	Chubsucker (unknown species)	R	E	
877604030200	*Erimyzon oblongus*	Creek chubsucker	R	E	
877604030100	*Erimyzon sucetta*	Lake chubsucker	R	E	
875801000000	*Esocidae*	Pike	R	P	Y
875801010201	*Esox americanus americanus*	Redfin pickerel	R	P	Y
875801010202	*Esox americanus vermiculatus*	Grass pickerel	R	P	Y
875801010100	*Esox lucius*	Northern pike	R	P	Y
875801010400	*Esox masquinongy*	Muskellunge	R	P	Y
875801010300	*Esox niger*	Chain pickerel	R	P	Y
883520016700	*Etheostoma radiosum*	Orangebelly darter	R	D	
883520010900	*Etheostoma spectabile*	Orangethroat darter	R	D	
883520017600	*Etheostoma stigmaeum*	Speckled darter	R	D	
883520018700	*Etheostoma whipplei*	Redfin darter	R	D	
883520018800	*Etheostoma zonale*	Banded darter	R	D	
880404021000	*Fundulus zebrinus*	Plains killifish	R	P	
880404021100	*Fundulus olivaceus*	Blackspotted topminnow	R	P	
879103040100	*Gadus macrocephalus*	Pacific cod	M	E	Y
870802020100	*Galeocerdo cuvier*	Tiger shark	M	E	Y
880408010100	*Gambusia affinis*	Western mosquitofish	R	P	
883544020100	*Genyonemus lineatus*	White croaker	M	E	Y
877601260000	*Gila spp.*	Chub (unknown species)	R	E	
877601261500	*Gila robusta*	Roundtail chub	R	E	
883551020100	*Girella nigricans*	Opaleye	M	P	

Table F-1. (Continued)

Species Code	Scientific Name	Common Name	Resident/Migratory[a]	Demersal/Pelagic[b]	Potentially Eatable
885704350100	*Glyptocephalus zachi*	Rex sole	E	D	
551202060100	*Gonidea angulata*	Freshwater mussel	R	D	Y
874701000000	*Glupeidae*	Herring family	M	P	Y
622003030000	*Hexagenia spp.*	Burrowing mayfly (unknown species)	R	D	
622003030700	*Hexagenia limbata*	Mayfly	R	D	
875101010100	*Hiodon alosoides*	Goldeye	M	P	Y
875101010200	*Hiodon tergisus*	Mooneye	M	P	Y
885703110200	*Hippoglossina stomata*	Bigmouth sole	M	D	Y
885704060100	*Hippoglossoides elas*	Flathead sole	M	D	Y
885704060300	*Hippoglossoides platessoides*	American plaice	M	D	Y
616923040100	*Hyalella azteca*	Freshwater amphipod	R	E	
877601050300	*Hybognathus placitus*	Plains minnow	R	P	
871602010100	*Hydrolagus colliei*	Spotted rat fish	M	D	
877604050100	*Hypentelium nigricans*	Northern hog sucker	R	D	Y
875503010100	*Hypomesus pretiosus*	Surf smelt	M	P	Y
885704220100	*Hypsopsetta guttulata*	Diamond turbot	?	D	Y
877702000000	*Ictaluridae*	Bullhead catfish family	R	D	Y
877702010000	*Ictalurus spp.*	Catfish (unknown species)	R	D	Y
877702010200	*Ictalurus furcatus*	Blue catfish	R	D	Y
877702010500	*Ictalurus punctatus*	Channel catfish	R	D	Y
877604070100	*Ictiobus bubalus*	Smallmouth buffalo	R	E	Y
877604070200	*Ictiobus cyprinellus*	Bigmouth buffalo	R	E	Y
877604070300	*Ictiobus niger*	Black buffalo	R	E	Y
883543020100	*Lagodon rhomboides*	Pinfish	E	P	
870600000000	*Lamniformes*	Shark	M	P	Y
877601300100	*Lavinia exilicauda*	Hitch	R	P	
883544040100	*Leiostomus xanthurus*	Spot	M	P	Y
884701030100	*Lepidogobius lepidus*	Bay goby	R	P	
873201010000	*Lepisosteus spp.*	Gar (unknown species)	E	P	Y
873201010200	*Lepisosteus oculatus*	Spotted gar	E	P	Y
873201010100	*Lepisosteus osseus*	Longnose gar	E	P	Y
873201010300	*Lepisosteus platostomus*	Shortnose gar	E	P	Y

Table F-1. (Continued)

Species Code	Scientific Name	Common Name	Resident/Migratory[a]	Demersal/Pelagic[b]	Potentially Eatable
873201010400	*Lepisosteus spatula*	Alligator gar	E	P	Y
883516050000	*Lepomis spp.*	Sunfish (unknown species)	R	P	Y
883516050100	*Lepomis auritus*	Redbreast sunfish	R	P	Y
883516050200	*Lepomis cyanellus*	Green sunfish	R	P	Y
883516050500	*Lepomis gibbosus*	Pumpkinseed	R	P	Y
883516050300	*Lepomis gulosus*	Warmouth	R	P	Y
883516050600	*Lepomis humilis*	Orangespotted sunfish	R	P	Y
883516050400	*Lepomis macrochirus*	Bluegill	R	P	Y
883516050700	*Lepomis marginatus*	Dollar sunfish	R	P	Y
883516050800	*Lepomis megalotis*	Longear sunfish	R	P	Y
883516050900	*Lepomis microlophus*	Redear sunfish	R	P	Y
883516051000	*Lepomis punctatus*	Spotted sunfish	R	P	Y
879103080100	*Lota lota*	Burbot	M	E	Y
618701150200	*Loxorhynchus grandis*	Decorator crab	R	D	
500501010300	*Lumbriculus variegatus*	Aqauatic worm	R	D	
883536010700	*Lutjanus campechanus*	Red snapper	M	D	Y
877601780400	*Luxilus chrysocephalus*	Striped shiner	R	P	
877601780600	*Luxilus cornutus*	Common shiner	R	P	
885704110100	*Lyopsetta exilis*	Slender sole	M	D	Y
814802010600	*Lytechinus anamesus*	Little gray sea urchin	R	D	
551531013600	*Macoma irus*	Clam (macoma)	R	D	Y
551531011400	*Macoma nasuta*	Bent-nosed macoma	R	D	
877601800200	*Macrhybopsis gelida*	Sturgeon chub	R	E	
551202430300	*Megalonaias gigantea*	Washboard mussel	R	D	Y
551547110100	*Mercenaria mercenaria*	Quahog	R	D	Y
883544070100	*Micropogonias undulats*	Atlantic croaker	M	P	Y
883516060000	*Micropterus spp.*	Bass (unknown species)	R	P	Y
883516060500	*Micropterus coosae*	Redeye bass	R	P	Y
883516060100	*Micropterus dolomieu*	Smallmouth bass	R	P	Y
883516060600	*Micropterus notius*	Swannee bass	R	P	Y
883516060300	*Micropterus punctulatus*	Spotted bass	R	P	Y
883516060200	*Micropterus salmoides*	Largemouth Bass	R	P	Y

Table F-1. (Continued)

Species Code	Scientific Name	Common Name	Resident/Migratory[a]	Demersal/Pelagic[b]	Potentially Eatable
877604080100	*Minytrema melanops*	Spotted sucker	E	D	Y
883502010000	*Morone spp.*	Temperate bass (unknown species)	E	P	Y
883502010100	*Morone americana*	White perch	M	P	Y
883502010400	*Morone chrysops*	White bass	M	P	Y
883502010300	*Morone chrysops x saxatilis*	Hybrid striped bass (white/striped)	E	P	Y
883502010500	*Morone mississippiensis*	Yellow bass	M	P	Y
883502010200	*Morone saxatilis*	Striped bass	M	P	Y
877604040000	*Moxostoma spp.*	Redhorse (unknown species)	R	D	Y
877604040400	*Moxostoma anisurum*	Silver redhorse	R	D	Y
877604040700	*Moxostoma carinatum*	River redhorse	R	D	Y
877604040200	*Moxostoma congestum*	Gray redhorse	R	D	Y
877604040900	*Moxostoma duquesnei*	Black redhorse	R	D	Y
877604041000	*Moxostoma erythrurum*	Golden redhorse	R	D	Y
877604040100	*Moxostoma macrolepidotum*	Shorthead redhorse	R	D	Y
877604041400	*Moxostoma pappillosum*	V-lip redhorse	R	D	Y
877604040300	*Moxostoma poecilurum*	Blacktail redhorse	R	D	Y
877604041700	*Moxostoma rupiscartes*	Striped jumprock	R	D	Y
883601010100	*Mugil cephalus*	Striped mullet	M	E	Y
883601010200	*Mugil curema*	White mullet	M	E	Y
870802040100	*Mustelus canis*	Smooth dogfish	M	E	Y
551701020100	*Mya arenaria*	Soft clam	R	D	Y
877601170100	*Mylocheilus caurinus*	Peamouth	R	E	
877601350100	*Mylopharodon conocephalus*	Hardhead	R	E	
550701010000	*Mytilus spp.*	Mussel (unknown species)	R	D	Y
550701010200	*Mytilus californianus*	California mussel	R	D	Y
550701010100	*Mytilus edulis*	Blue mussel	R	D	Y
500124030500	*Neanthes arenaceodentata*	Sand worm	R	D	
500168040100	*Neoamphitrite robusta*	Terrebellid worm	R	D	
500125011900	*Nephtys caecoides*	Sand worm	R	D	
500168040100	*Neoamphitrite robusta*	Terrebellid worm	R	D	
500125011900	*Nephtys caecoides*	Sand worm	R	D	
500125011500	*Nephtys incisa*	Red-lined worm	R	D	

Table F-1. (Continued)

Species Code	Scientific Name	Common Name	Resident/Migratory[a]	Demersal/Pelagic[b]	Potentially Eatable
877601100300	*Nocomis asper*	Redspot chub	R	E	
877601100200	*Nocomis leptocephalus*	Bluehead chub	R	E	
877601100100	*Nocomis micropogon*	River chub	R	E	
877601060100	*Notemigonus crysoleucas*	Golden shiner	M	P	
877601501000	*Notropis amblops*	Bigeye chub	R	E	
877601114100	*Notropis boops*	Bigeye shiner	R	P	
877601111400	*Notropis buchanani*	Ghost shiner	R	P	
877601110600	*Notropis hudsonius*	Spottail shiner	R	P	
877601118100	*Notropis nubilus*	Ozark minnow	R	E	
877601112300	*Notropis stramineus*	Sand shiner	R	P	
877702020200	*Noturus insignis*	Margined madtrom	R	D	
877702021800	*Noturus miurus*	Brindled madtom	R	D	
877702022000	*Noturus phaeus*	Brown madtom	R	D	
870703010100	*Odontaspis taurus*	Sand tiger	M	E	Y
500300000000	*Oligochaetes*	Aquatic worms	R	D	
875501020800	*Oncorhynchus clarki*	Cutthroat trout	E	P	Y
875501020100	*Oncorhynchus gorbuscha*	Pink salmon	M	P	Y
875501021100	*Oncorhynchus mykiss*	Rainbow trout	E	P	Y
875501020300	*Oncorhynchus kisutch*	Coho salmon	M	P	Y
875501020500	*Oncorhynchus nerka*	Sockeye salmon	M	E	Y
875501020600	*Oncorhynchus tshawytscha*	Chinook salmon	M	E	Y
878301020000	*Opsanus spp.*	Toadfish (unknown species)	R	D	
618105030000	*Orconectes spp.*	Crayfish	R	D	Y
877601360100	*Orthodon microlepidotus*	Sacramento blackfish	R	P	
883540020100	*Orthopristis chrysoptera*	Pigfish	R	P	Y
875503000000	*Osmeridae*	Smelt (species unknown)	M	P	Y
875503030200	*Osmerus mordax*	Rainbow smelt	M	P	Y
618102020100	*Pacifastacus leniusculus*	Crayfish	R	D	Y
617918010100	*Pandalus borealis*	Maine shrimp	R	D	
883502160400	*Paralabrax nebulifer*	Barred sand bass	E	D	Y
885703030900	*Paralichthys californicus*	California halibut	M	D	Y
885703030100	*Paralichthys dentatus*	Summer flounder (fluke)	M	D	Y

Table F-1. (Continued)

Species Code	Scientific Name	Common Name	Resident/Migratory[a]	Demersal/Pelagic[b]	Potentially Eatable
885703030400	*Paralichthys lethostigma*	Southern flounder	M	D	Y
817502010100	*Parastichopus californicus*	California sea cucumber	R	D	
500166030400	*Pectinaria californiensis*	Sandworm	R	D	
617701010000	*Penaeus spp.*	Shrimp	R	D	Y
617701010100	*Penaeus aztecus*	Brown shrimp	R	E	Y
617701010300	*Penaeus setiferus*	White shrimp	R	E	Y
883520020100	*Perca flavescens*	Yellow perch	R	P	Y
883520030900	*Percina copelandi*	Channel darter	R	D	
883560050100	*Phanerodon furcatus*	White seaperch	R	P	Y
877601370300	*Phoxinus erythrogaster*	Southern redbelly dace	R	P	
877601160200	*Pimephales promelas*	Fathead minnow	R	P	
811703050100	*Pisaster brevispinus*	Starfish	R	D	
550905090100	*Placopecten magellanicus*	Atlantic deep-sea scallop	R	D	
885704140100	*Platichthys.stellatus*	Starry flounder	M	D	Y
877601840100	*Platygobio gracilis*	Flathead chub	R	E	
885704151000	*Pleuronectes bilineatus*	Rock sole	E	D	Y
885704130100	*Pleuronectes vetulus*	English sole	M	D	Y
885704000000	*Pleuronectidae*	Righteye flounder family	M	D	Y
885704160200	*Pleuronichthys decurrens*	Curlfin sole	M	D	Y
885704160400	*Pleuronichthys verticalis*	Hornyhead turbot	M	D	Y
880408110200	*Poecilia vittata*	Cuban limia	E	P	
883544080100	*Pogonias cromis*	Black drum	M	P	Y
872902010100	*Polyodon spathula*	Paddlefish	M	P	Y
883525010100	*Pomatomus saltatrix*	Bluefish	M	P	Y
883516070000	*Pomoxis spp.*	Crappie (unknown species)	R	P	Y
883516070100	*Pomoxis annularis*	White crappie	R	P	Y
883516070200	*Pomoxis nigromaculatus*	Black crappie	R	P	Y
882602010100	*Prionotus carolinus*	Northern searobin	R	D	Y
875501060100	*Prosopium cylindraceum*	Round whitefish	M	P	Y
875501060200	*Prosopium williamsoni*	Mountain whitefish	M	P	Y
551547070100	*Protothaca staminea*	Clam (Pacific littleneck)	R	D	Y
885704150400	*Pleuronectes americanus*	Winter flounder	M	D	Y

Table F-1. (Continued)

Species Code	Scientific Name	Common Name	Resident/Migratory[a]	Demersal/Pelagic[b]	Potentially Eatable
885704150400	*Pleuronectes americanus*	Winter flounder	M	D	Y
877601180000	*Ptychochellus spp.*	Squawfish	R	E	Y
877601180100	*Ptychocheilus oregonensis*	Northern squawfish	R	E	Y
877702030100	*Pylodictis olivaris*	Flathead catfish	R	E	Y
871304010300	*Raja binoculata*	Winter skate	M	D	Y
890302010600	*Rana catesbeiana*	Bullfrog	?	P	Y
551525040100	*Rangia cuneata*	Brackish water clam	R	D	Y
877601090000	*Rhinichthys spp.*	Dace (unknown species)	R	D	
877601190100	*Richardsonius balteatus*	Redside shiner	R	P	
875501030000	*Salmo spp.*	Trout (unknown species)	E	P	Y
875501030500	*Salmo salar*	Atlantic salmon	M	P	Y
875501030600	*Salmo trutta*	Brown trout	E	P	Y
875501000000	*Salmonidae*	Trout (family)	E	P	Y
875501040000	Salvelinus hybrid	Splake (hybrid)	E	P	Y
875501040400	*Salvelinus fontinalis*	Brook trout	E	P	Y
875501040100	*Salvelinus malma*	Dolly varden	E	P	Y
875501040300	*Salvelinus namaycush*	Lake trout	E	P	Y
551547020100	*Saxidomus giganteus*	Clam (smooth washington)	R	D	Y
872901020200	*Scaphirhynchus platorynchus*	Shovelnose sturgeon	M	D	Y
883544000000	*Sciaenidae*	Drum family	M	E	Y
883544090100	*Sciaenops ocellatus*	Red drum	M	E	Y
885003030100	*Scomber japonicus*	Chub mackerel	M	P	Y
885003050100	*Scomberomorus cavalla*	King mackeral	M	P	Y
885003050200	*Scomberomorus maculatus*	Spanish mackerel	M	P	Y
885703040100	*Scophthalmus aquosus*	Windowpane	M	D	Y
882601061600	*Scorpaena guttata*	California scorpionfish	R	D	Y
883102310100	*Scorpaenichthys marmoratus*	Cabezon	R	D	
882601010300	*Sebastes auriculatus*	Brown rockfish	M	P	Y
882601012000	*Sebastes maliger*	Quillback rockfish	M	P	Y
882601012100	*Sebastes melanops*	Black rockfish	M	P	Y
882601013900	*Sebastes norvegicus*	Golden redfish	M	P	Y
882601012700	*Sebastes pauclspinis*	Bocaccio	M	P	Y

Table F-1. (Continued)

Species Code	Scientific Name	Common Name	Resident/Migratory[a]	Demersal/Pelagic[b]	Potentially Eatable
882601012700	*Sebastes paucispinis*	Bocaccio	M	P	Y
882601013000	*Sebastes proriger*	Redstripe rockfish	M	P	Y
877601080200	*Semotilus atromaculatus*	Creek chub	R	E	
877601080100	*Semotilus corporalis*	Fallfish	R	E	
877601080300	*Semotilus lumbee*	Sandhills crab	R	E	
617704010900	*Sicyonia ingentis*	Rock shrimp	R	D	
551529020100	*Solen sicarius*	Razor clam	R	D	
871001020100	*Squalus acanthias*	Spiny dogfish	M	E	Y
883520040200	*Stizostedion canadense*	Sauger	R	P	Y
883520040100	*Stizostedion vitreum*	Walleye	R	P	Y
880302020100	*Strongylura marina*	Atlantic needlefish	M	P	
885703130300	*Syacium papillosum*	Dusky flounder	M	D	Y
885802011600	*Symphurus atricauda*	California tonguefish	M	D	
876202010100	Synodus foetens	Inshore lizardfish	R	D	
885003040400	*Thunnus atlanticus*	Blackfin tuna	M	P	Y
875501070100	*Thymallus arcticus*	Arctic grayling	E	P	Y
883561400100	*Tilapia mossambica*	Mozambique tilapia	R	E	Y
883561040500	*Tilapia zillii*	Redbelly tilapia	R	E	Y
551525020100	*Tresus capax*	Horse clam	R	D	Y
870802090200	*Triakis semifasciata*	Leopard shark	M	E	Y
884701300100	*Tridentiger trigonocephalus*	Chameleon goby	R	D	
885801010100	*Trinectes maculatus*	Hogchoker	M	D	
880302030200	*Tylosurus crocodilus*	Houndfish	M	E	Y
875802010200	*Umbra limi*	Central mudminnow	R	E	
050601010000	*Vaucheria*	Macroalgae	?	E	

[a]Fish species is considered: R = resident, M = migratory, E = either resident or migratory, ? = unknown.

[b]Fish speciees is considered: D = demersal, P = pelagic, E = either, ? = unknown.

Appendix G

Notes on the Methodology for Evaluating Sediment Toxicity Tests

Results of sediment toxicity tests conducted around the United States were submitted with several databases for evaluation in the NSI. Additional processing of records was required for most of the databases. Because test results were reported differently in each database, appropriate interpretation of the test results was sometimes confusing. This section explains how the toxicity test data were handled for the NSI evaluation with respect to issues related to sampling date, type of test, sample location identification, and results of control or reference tests conducted during the toxicity tests.

Sampling Date

Only those tests in the databases for which the sediment samples were obtained between January 1, 1980, and December 31, 1993, were evaluated. Tests before and after that period were eliminated.

Sample Location

Records were examined to determine whether the site from which the sediment sample was collected had been identified by latitude and longitude coordinates. Samples that were not properly identified were not analyzed. Tests from the Great Lakes Sediment Inventory (GLSI) database were eliminated because sample locations were not appropriately identified. Sediment samples in the EPA Region 10/U.S. Army Corps of Engineers Seattle District's Sediment Inventory (SEACOE) that were located in British Columbia were also excluded from the analysis.

Type of Test

Data from seven databases (Table G-1) were reviewed to determine whether they had reported the results of acute sediment (solid-phase) and elutriate nonmicrobial toxicity tests in which the endpoint was mortality. Records pertaining to chronic toxicity tests, microbial toxicity tests, tests that were not conducted with sediment or elutriate, and tests in which the endpoint was not percent mortality (or percent survival, which could be converted to percent mortality) were eliminated from further analysis.

Only the DMATS and GOM databases clearly reported the phase (solid, elutriate, particulate) of sediment sample used in the bioassays conducted; ODES provided this information for some of the tests. If the phase was not indicated, this information was obtained or best professional judgment was used to identify the phase used in the tests. For some species, comparison of species with those used in standard EPA test protocols or with species used in other sediment toxicity tests in the databases permitted assignment of phase with certainty. Other species might be used in sediment-, elutriate-, and particulate-phase tests, and the phase was assigned with uncertainty. Table G-2 presents a list of species used in toxicity tests whose results are included in the NSI. Table G-2 also presents the type of toxicity test for which each species is generally used (i.e., liquid-phase, elutriate-phase, suspended particulate-phase, sediment/solid-phase). The data presented in Table G-2 are the basis for determining whether the toxicity test of concern was conducted using the solid or elutriate phase. A "Y" entered in Table G-2 indicates that the phase was given with the test results; an "E" indicates that the phase was estimated using best professional judgment based on the species used in the toxicity test.

Table G-1. Toxicity Test Database Characteristics

Database	Sample Locations Identified by Lat/Long	Type of Test	Laboratory Control Tests	Reference Sediment Tests	Comments
U.S. Army Corps of Engineers, Dredged Material Tracking System (DMATS)	Yes, all 74	Solid and Elutriate (identified in database)	Replicate control test results provided	Replicate reference sediments tested with each batch of sediment samples	Used means of reference sediment replicates in the evaluation (contact: Alan Ota, EPA Region 9)
EPA's Environmental Monitoring and Assessment Program, Louisianian Province (EMAP-LA)	Yes, all 259	Solid Phase (not identified in database, provided)	Not provided in D3 database, provided on request	No	Sediment sample test results were calculated from the additional data provided (contact: Kevin Summers, EPA/ERLGB)
EPA's Environmental Monitoring and Assessment Program, Virginian Province (EMAP-VA)	Yes, all 179	Solid and Elutriate (not identified in database, provided)	Not provided in D3 database, provided on request	No	Sediment sample test results were calculated from the additional data provided (contact: Daryl Keith, EPA/ ERLN)
Gulf of Mexico Program's Contaminated Sediment Inventory (GOM)	Yes, all 42	Solid Phase (identified in database)	ERL-N: Yes USACE: No GCRL: No, provided on request	ERL-N: Yes USACE: Yes GCRL: No	Used LI control data for tests done by ERL-N (contacts: Phil Crocker, EPA; John Scott, SAIC) and control data obtained for GCRL (contact: Julia Lyle, GCRL); for USACE tests used mean of the reference test results as control
EPA's Great Lakes Sediment Inventory (GLSI)	No	Not identified in database	Not provided in database	No?	Sample location IDs and control test reults were not provided; therefore, these data were not evaluated for the NSI (contact: Bob Hoke, SAIC)
EPA's Ocean Data Evaluation System (ODES)	Only 18 out of 68	Solid Phase (not identified in database)	Yes	No	Used controls (contact: Tad Deschler, Tetra Tech)
EPA's Region 10/U.S. Army Corps of Engineers Seattle District's Sediment Inventory (SEACOE)	Only 18 out of 68	Solid Phase (not identified in database)	Yes, some had to be provided on request	Yes	Used controls (contact: Roberts Feins, Environmental Information Consultants; John Armstrong, EPA Region 10; and Gary Braun, Tetra Tech, for Puget Sound Estuary Program Reports, 1988)

Table G-2. Test Species Used in Sediment Bioassay Test Results Included in the NSI

Species Code	Species Name	*Type of Toxicity Test*							
		Liquid (L)	Elutriate (E)	Particulate (P)	Solid (S)	C (L most Common) (L or E)	D (L,E, or P)	A (L,E,P,or S)	Unknown
80509070600									E
615301010900	*Acanthomysis costata*		Y		Y				
615301010400	*Acanthomysis macropsis*	Y	Y		Y				
615301010700	*Acanthomysis sculpta*	Y				E			
611829010000	*Acartia spp.*	Y	Y						
616902010800	*Ampelisca abdita*				Y,E				
616800000000	*Amphipods*				Y				
610401010100	*Artemia salina*	Y	Y						
616302070900	*Asellus intermedius*				E				
650508331700	*Chironomus riparius*				E				
650508330100	*Chironomus tentans*				E				
885703010200	*Citharichthys stigmaeus*	Y			Y				
616915021500	*Corophium spinicorne*				Y,E				
617922010000	*Crangon spp.*	Y	Y		Y				
551002010100	*Crassostrea gigas*		Y		Y		E		
551002010200	*Crassostrea virginica*				Y				
880404010100	*Cyprinodon variegatus*	Y		Y					
610902010900	*Daphnia magna*					E			
610902010100	*Daphnia pulex*					E			
815501010100	*Dendraster excentricus*					E			

Table G-2. (Continued)

Species Name	Species Name	Type of Toxicity Test							
		Liquid (L)	Elutriate (E)	Particulate (P)	Solid (S)	C (L most Common) (L or E)	D (L,E, or P)	A (L,E,P,or S)	Unknown
880404020700	*Fundulus grandis*	Y		Y					
881801010100	*Gasterosteus aculeatus*					E			
616915090200	*Grandidierella japonica*				Y				
622003030700	*Hexagenia limbata*				E				
615301010700	*Holmesimysis sculpta*	Y	Y		Y	E			
616923040100	*Hyallella azteca*				E				
500501010300	*Lumbriculus variegatus*				E				
814802010200	*Lytechinus pictus*	Y	Y						
551531011600	*Macoma balthica*				E				
551531011400	*Macoma nasuta*		Y		Y,E				
551531010000	*Macoma spp.*				E				
615303140600	*Metamysidopsis elongata*	Y	Y		Y				
651530100000	*Mysid shrimp*	Y		Y	Y				
615301210200	*Mysidopsis bahia*			Y	Y				
550701010100	*Mytilus edulis*	Y	Y					E	
500124030500	*Neanthes arenaceodentata*				Y,E				
500124030000	*Neanthes spp.*				E				
500125011900	*Nephtys caecoides*				Y,E				
500124030200	*Nereis virens*				Y				
551706040100	*Panopea generosa*				E				

Table G-2. (Continued)

Species Code	Species Name	Type of Toxicity Test							
		Liquid (L)	Elutriate (E)	Particulate (P)	Solid (S)	C (L most Common) (L or E)	D (L,E, or P)	A (L,E,P,or S)	Unknown
	Paratanytarsus parthogenetic				E				
617701010200	*Penaeus duorarum*				Y				
MICROTOX	*Photobacterium phosphoreum*					E			
877601160200	*Pimephales promeles*	Y				E			
551547070100	*Protothaca staminea*				Y				
616942150400	*Rhepoxynius abronius*				Y,E				
080309070600	*Selenastrum capricornutum*								E
814903020400	*Strongylocentrotus purpuratus*	Y	Y			E			
611910030100	*Tigriopus californicus*								E

Only DMATS contained elutriate test results in addition to sediment test results; all other tests evaluated were sediment (solid- phase) test results.

Test Controls

Toxicity data were screened to determine whether control data were reported. Sediment toxicity test laboratory or performance controls are usually clean sand or sediment run under the same conditions in which the same test organisms are exposed at the same time as those exposed to the sediment samples tested. Controls are used to determine whether observed mortality might be the result of the quality of test organisms used or other factors, and not the result of exposure to possible toxics in the sediment samples.

The databases were screened to locate control test data for each sediment sample tested. The GLSI database did not contain any control test data; because of this, as well as the lack of station-identifying coordinates, the GLSI database was eliminated from evaluation for the NSI. For the other databases, control test results were matched to the sediment test results and were treated as follows:

- Multiple control and reference sample test results were reported for each sediment tested in the DMATS database. These were determined to be replicate test results. Because the sediment samples tested in DMATS were usually fine-grained and the laboratory performance controls were sand, the reference sediment samples were used as "controls" to evaluate toxicity of sediment samples. The percent mortality for the reference replicates were averaged for each reference site to obtain the mean percent mortality for the reference sediment for comparison with the sediment sample test result.

- The D3 version of both the EMAP-LA and EMAP-VA databases contained control-corrected results for the sediment samples tested. The control-corrected results were obtained using the following equation:

$$\frac{\textit{percent survival of organisms in sediment sample test}}{\textit{percent survival of organisms in control test percent survival}} = \textit{control-corrected percent survival}$$

- EMAP-LA provided a revised database on request that contained the percent survival of the controls. The sediment sample test results were calculated according to this equation:

$$\textit{percent survival of organisms in sediment sample test} =$$

$$\frac{\textit{control-corrected percent survival X percent survival of organisms in control test}}{100}$$

- EMAP-VA provided a revised database on request which contained the mean percent mortality of controls and the mean percent mortality of the sediment sample tests for each station, as well as the control-corrected percent survival.

- The GOM database reported control test results for tests conducted by EPA's Environmental Research Laboratory (ERL) in Narragansett. A low-salinity control test performed at the same time was not used in the evaluation. The single ERL reference sediment sample was treated as a sediment toxicity test result. No control tests were available from the USACE data set within this database; the mean of reference sediment toxicity test results was used as the "control" for these test data. No control test results were found in the GOM database for the GCRL data set. Total percent mortality of pooled control test replicate results were provided by Julia Lytle of GCRL and entered into the database for the NSI analysis.

- The ODES database reported single-value control results for the ARSR and OSE data sets. (Whether these were means of replicate tests is unknown.) One sediment test result in ARSR was matched to two different control test results; however, the one control test result that was not matched elsewhere in the data set was eliminated for the analysis.

- The SEACOE database contained single-value control test results for the ALCTRAZ data set and several series of control test results for other data sets (e.g., EVCHEM and EBCHEM). Information on the correct control series was obtained, and the proper control test results were evaluated in the computer program. Means were calculated for replicates in the series and used to evaluate the sediment sample test results.

Results of control tests reported as "percent survival" were converted to "percent mortality" by the following calculations:

$$\textit{percent mortality} = 100 - \textit{percent survival}$$

$$\textit{percent mortality} = \textit{number of surviving organisms/total number of organisms in test}$$

Sometimes entries in databases reversed "mortality" and "survival" (e.g., PSE data set in the ODES database). Any questions concerning the designation were checked and corrected if necessary. If replicate sediment toxicity test results were provided for a sampling site in the database, a mean was calculated and compared to the mean control mortality. (Some databases provided only the means, e.g., EMAP-LA, EMAP-VA.) For the purpose of the NSI evaluation, if the control had greater than 20 percent mortality (less than 80 percent survival), that test was excluded from further consideration.

Reference Sediment Stations

Some data sets included data for reference sediments that were run simultaneously with the control and sediment samples. Reference sediment is sediment collected from a field site that is apparently pristine (does not contain toxic chemical contaminants) and has grain size, total organic carbon, sulfide and ammonia levels, and other characteristics similar to the sediment samples to be tested for toxicity. Because reference sediments should match the characteristics of the sediment samples more closely than the sand or sediment used for the laboratory (performance) control, they should provide information on the appropriateness of using a particular test organism since the suitability and survival of different species can be affected by these other physical and chemical characteristics of the sediment.

- As noted previously, DMATS provided several reference sediment samples for each toxicity test, along with control test results. The number of such reference sediment samples varied for different test dates, and these sediment samples were determined to represent replicates. The average percent mortality was determined from each set of replicates and this was used as a "control" to evaluate the toxicity of sediment samples in this database. If percent mortality of the mean reference test result exceeded 20 percent, the sediment toxicity tests that were run with that reference sediment were not used in the evaluation.

- Reference sediment test results were not identified in the EMAP-LA, EMAP-VA, or ODES databases.

- In the GOM database, a reference sediment test was run in tests conducted by EPA's Environmental Research Laboratory in Narragansett. This single reference sediment sample was treated as a sediment toxicity test result. Reference sediment tests in the USACE data set were averaged and used as the control for analysis since other control test data were not provided in the data set.

- Reference sediment toxicity test results in the SEACOE database were treated as a sample site.

Since reference toxicity test results were not available for all of the sediment toxicity tests, reference sediment sample test results were not used as "controls" in the evaluation of sediment toxicity test data in the NSI, with the exception of the DMATS data and the USACE data in the GOM database. The remaining reference sediment test results were compared with the control results to determine whether significant toxicity was indicated at that field site; i.e., they were treated like a sediment toxicity test result (see below).

It should be noted, however, that careful examination of such reference test results could improve the interpretation of sediment toxicity tests; i.e., they might indicate that test organisms were adversely affected by sediment characteristics, not by toxic chemicals. Thus, the classification of some sites using the sediment toxicity tests might be

inappropriate because the control test result did not adequately explain the result, based on the test organism's health or sensitivity to test conditions.

Test Results

For the NSI evaluation protocol for sediment toxicity test data, significant toxicity was indicated if there was a difference of 20 percent survival from control survival (e.g., if control survival was 100 percent and 80 percent or less of the test organisms survived, or if control survival was 80 percent and 60 percent or less of the test organisms survived, significant toxicity was indicated). Although a number of different test species and protocols were used in the tests evaluated, this threshold provides a preliminary indication of sediment toxicity for classifying sediment sites for the NSI.

Appendix H

Additional Analyses for PCBs and Mercury

To perform the screening analysis for the National Sediment Quality Survey using NSI data, EPA selected reasonably conservative screening values, including theoretically and empirically derived risk-based screening levels. The limited number of sediment criteria available for use in this type of evaluation, however, contributed to the possibility of over- and underestimation of potential adverse effects associated with sediment contaminated with some chemicals. Two chemicals where this issue is particularly relevant are PCBs and mercury. EPA conducted further analyses on PCBs and mercury to determine the effect of using different assessment parameters on the number of sites where these chemicals were identified with the potential for adverse effects.

Because of the tendency for PCBs to bind to sediment and because of the relative toxicity of these chemicals to humans, EPA selected a very conservative approach for the analysis of PCBs in the current NSI evaluation. The approach was conservative because (1) it did not require matching sediment chemistry data and tissue residue data and (2) it used the cancer risk level of 10^{-5} for all congener, aroclor, or total PCB measurements to evaluate human health effects related to PCB contamination. EPA applied the cancer slope factor for aroclor 1260, the most potent commercial mixture, to all measures. It should be noted that there were only 542 stations where matching sediment chemistry data and tissue residue data were available for analysis. In the following evaluation, the amount of PCB sediment and fish tissue data exceeding screening values other than those used in the NSI analysis is compared to the number of stations classified as Tier 1 or Tier 2.

Figure H-1 is a cumulative density function graph depicting the maximum PCB concentration at each sediment sampling station where PCBs were detected. The various screening values that could be used to indicate

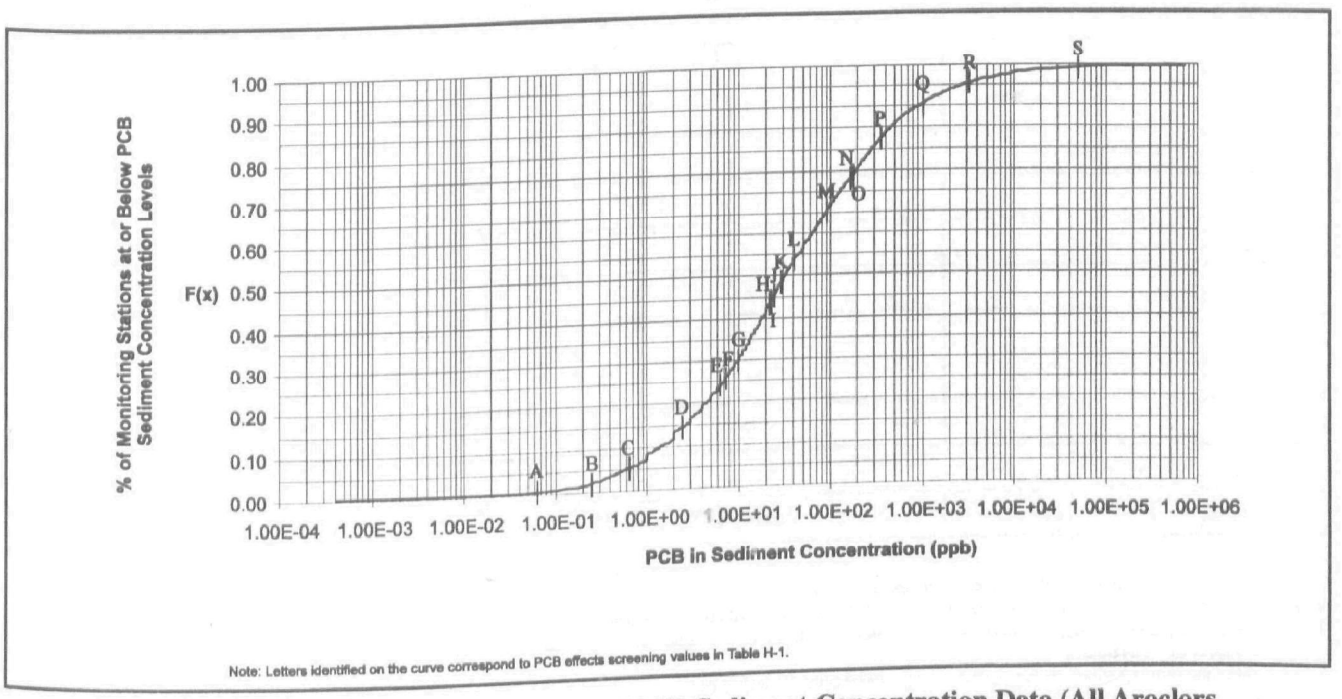

Figure H-1. Cumulative Frequency Distribution of PCB Sediment Concentration Data (All Aroclors and Total PCB).

adverse effects levels of PCBs in sediment are plotted as A through S in the figure and described in Table H-1. The top two sections of Table H-1 present the screening values of PCBs in sediment that are protective of human or wildlife consumers. The levels shown were derived using the theoretical bioaccumulative potential (TBP) analysis with the default lipid content (3 percent), default organic carbon content (1 percent), and BSAFs with and without the safety factor of 4. (See Appendices B and C for further explanation.) Depending on the screening value, the number of sediment chemistry sampling stations with detectable PCBs exhibiting potential human health or aquatic life effects varies from under 1 percent to over 99 percent. The screening values selected for the NSI evaluation classify approximately 85 percent of sediment chemistry sampling stations in

Table H-1. Sediment Sampling Stations with Detectable Levels of PCBs That Exceed Various Screening Values[a,b]

Type of Screening Value	Associated Level (ppb)	Level Plotted in Figure H-1 Corresponds to Letter	Number of Stations with Detected PCBs Exceeding Level	Percentage of Stations with Detected PCBs Exceeding Level
Protection of Consumers				
Cancer Risk Level				
10^{-6}	0.25	B	3,772	98.2
10^{-5}[d]	2.5	D	3,290	85.6
10^{-4}	25	J	2,076	54.0
Noncancer Hazard Quotient of 1	40	L	1,761	45.8
FDA Tolerance Level	360	P	652	17.0
Wildlife Criteria	29	K	1,977	51.5
Protection of Consumers Using BSAF with Safety Factor[c]				
Cancer Risk Level				
10^{-6}	0.063	A	3,828	99.6
10^{-5}	0.63	C	3,648	95.0
10^{-4}	6.3	E	2,921	76.0
Noncancer Hazard Quotient of 1	9.9	G	2,699	70.2
FDA Tolerance Level	90	M	1,330	34.6
Wildlife Criteria	7.2	F	2,849	74.2
Protection of Aquatic Life				
ER-L	22.7	I	2,150	56.0
ER-M	180	N	976	25.4
AET-L	1,000	Q	353	9.2
AET-H	3,100	R	165	4.3
TEL[e]	21.6	H	2,182	56.8
PEL[f]	189	O	962	25.0
Other Protection Levels				
TSCA[g] Level	50,000	S	21	0.55

[a]Maximum total or aroclor-specific value at a given station was used.
[b]PCBs were detected at 3,842 (41%) of the 9,401 stations where collected samples were analyzed for them.
[c]For this presentation, measured levels were compared to risk levels using a default organic carbon content (1%) and default organism lipid content (3%). Use of site-specific organic carbon would yield slightly different results.
[d]Levels used in the current National Sediment Quality Survey evaluation for human health.
[e]Levels used in the current National Sediment Quality Survey evaluation for aquatic life (Tier 2).
[f]Levels used in the current National Sediment Quality Survey evaluation for aquatic life (Tier 1).
[g]Toxic Substances Control Act. 40 CFR Part 761, Subpart B, § 761.20.

Tier 1 for human health effects (Point D). For aquatic life effects, the selected screening values classify 25 percent of sampling stations as Tier 1 (Point O) and 57 percent of sampling stations as Tier 2 (Point H).

Figure H-2 and Table H-2 present the comparison of different screening values and the corresponding number of fish tissue stations with detected levels of PCBs exceeding the screening values.

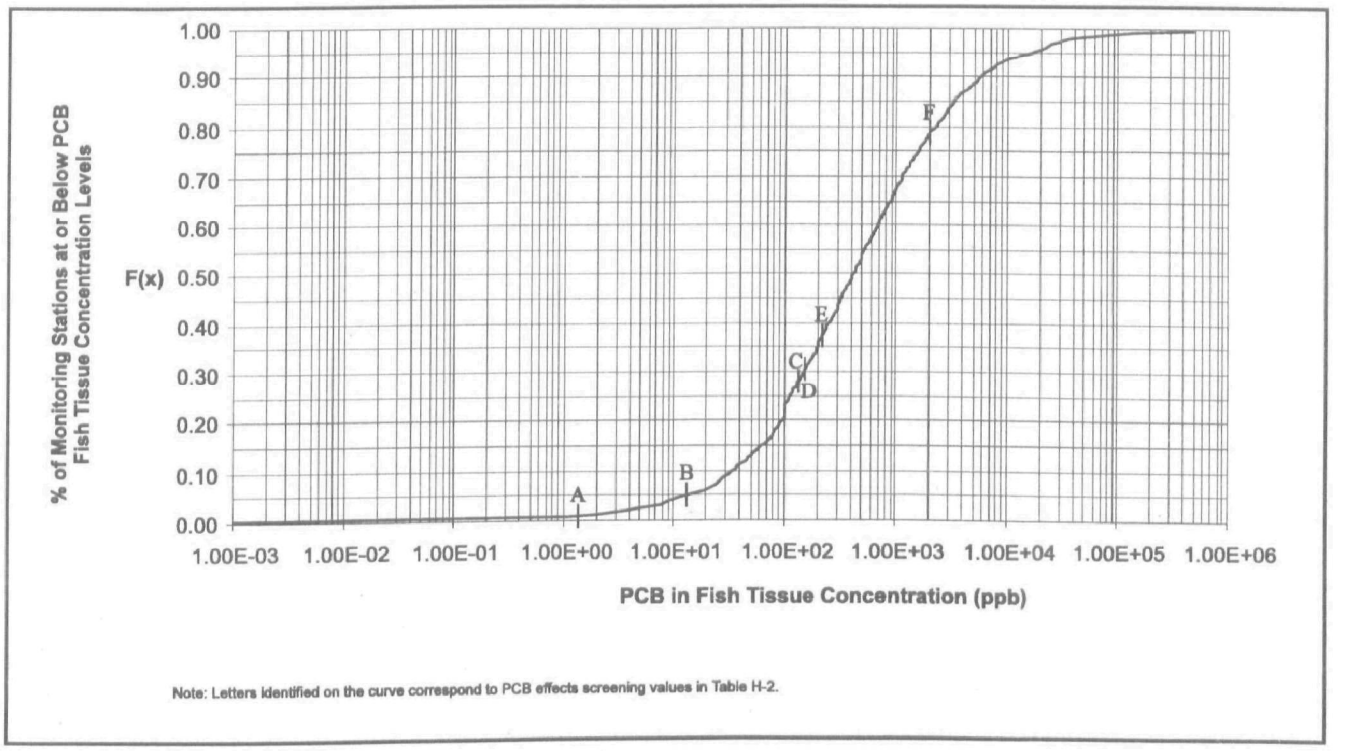

Figure H-2. Cumulative Frequency Distribution of PCB Fish Tissue Concentration Data (All Aroclors and Total PCB).

Table H-2. Fish Tissue Sampling Stations with Detectable Levels of PCBs in Demersal, Resident, Edible Fish That Exceed Various Screening Values[a,b]

Type of Screening Value	Associated Level (ppb)	Level Plotted in Figure H-2 Corresponds to Letter	Number of Stations with Detected PCBs Exceeding Level	Percentage of Stations with Detected PCBs Exceeding Level
Protection of Consumers				
Cancer Risk Level				
10-6	1.4	A	2,354	99.3
10-5[c]	14	B	2,256	95.2
10-4	140	C	1,686	71.1
Noncancer Hazard Quotient of 1	220	E	1,473	62.2
FDA Tolerance Level	2,000	F	489	20.6
Wildlife Criteria	160	D	1,620	68.4

[a]Maximum total or aroclor-specific value at a given station was used.
[b]PCBs were detected at 2,370 (73%) of the 3,234 stations where collected samples were analyzed for them.
[c]Levels used in the current National Sediment Quality Survey evaluation for human health.

The 10^{-5} cancer risk level (Point B) was one of the most conservative thresholds: concentrations exceeded this level at approximately 95 percent of tissue residue sampling stations where PCBs were detected.

In contrast to the PCB evaluation, the evaluation of mercury detected in fish tissue residue in the NSI analysis was substantially less conservative than that which would result from use of different screening values. To determine the possible outcomes of different data evaluations, EPA performed additional analyses of mercury fish tissue data included in the NSI. Figure H-3 and Table H-3 present six screening values that could be applied for the protection of consumers

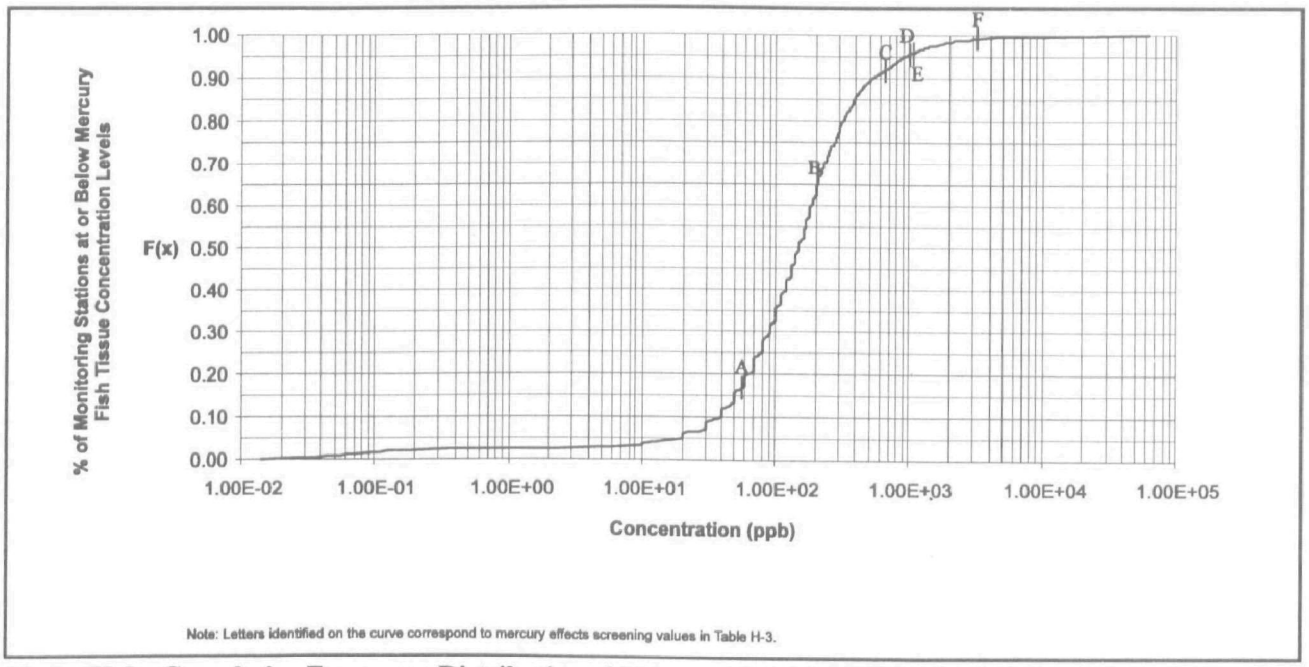

Figure H-3. Cumulative Frequency Distribution of Mercury Fish Tissue Data for Demersal, Resident, and Edible Species.

Table H-3. Fish Tissue Sampling Stations with Detectable Levels of Mercury in Demersal, Resident, Edible Fish Species That Exceed Various Screening Values[a,b]

Type of Screening Value	Associated Level (ppb)	Level Plotted in Figure H-3 Corresponds to Letter	Number of Stations with Detected Mercury Exceeding Level	Percentage of Stations with Detected Mercury Exceeding Level
Protection of Consumers				
Canadian Guideline[b]	200	B	908	35.1
Noncancer Hazard Quotient of 1 (1995)[c]	1,100	E	91	3.5
Noncancer Hazard Quotient of 1 (pre-1995)[d]	3,231	F	15	0.6
Noncancer Hazard Quotient of 1 (pre-1995 for infants)[e]	646	C	204	7.9
FDA Action Level[f]	1,000	D	103	4.0
Wildlife Criteria[g]	57.3	A	2,150	83.0

[a]Mercury was detected at 2,589 (90%) of the 2,861 stations where collected samples were analyzed for mercury.
[b]Canadian guideline limit for mercury in fish that are part of a subsistence diet (Health and Welfare Canada, 1979).
[c]Methylmercury reference dose that was available in IRIS in 1995 ($1x10^{-4}$ mg/kg-day).
[d]Corresponds to mercury reference dose available in IRIS prior to 1995 ($3x10^{-4}$ mg/kg-day).
[e]Corresponds to mercury reference dose available in IRIS prior to 1995 divided by a factor of 5 to protect against developmental effects among infants ($6x10^{-5}$ mg/kg-day). This value was formerly used by the EPA Office of Water.
[f]Level used in the current National Sediment Quality Survey evaluation for human health.
[g]The results of the wildlife analysis shown in Table 3-5 are slightly different because the data set used for that analysis included demersal, resident species (could be considered edible or not).

ingesting mercury-contaminated fish. As shown in these displays, both EPA's current noncancer reference dose recommended for general use (Point E) and the FDA action level (Point D), the screening value used in the current NSI analysis, result in only about 4 percent of stations with detectable levels classified as posing potential risk to human health.

The NSI evaluation restricted the data analyzed to demersal, resident, and edible species. Figure H-4 and Table H-4 present the same six mercury screening values with the data for all fish species considered edible by humans with detectable levels of mercury in the NSI. If all edible fish species were analyzed using selected screening values, 9 percent of stations would be classified as Tier 2 because of mercury contamination (Point D). However, the proportion of stations with detectable levels of mercury that exceed some other human health levels ranges from 20 percent to over 55 percent of stations.

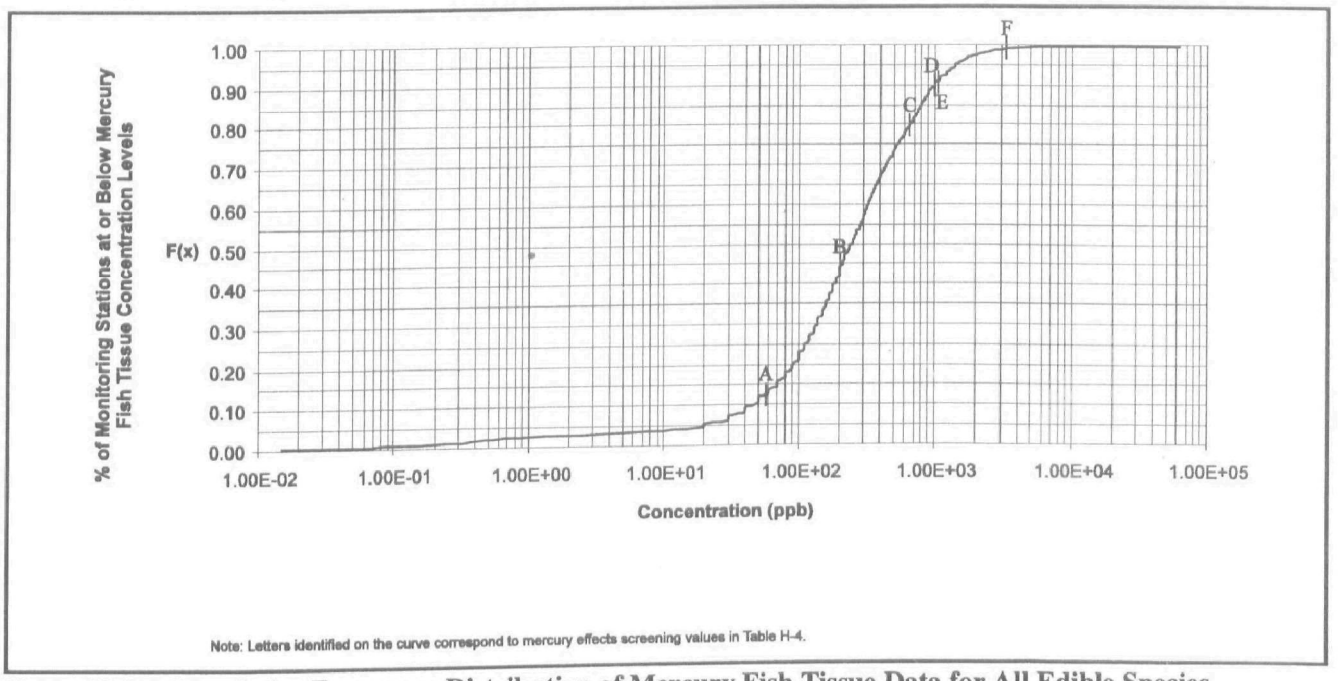

Figure H-4. Cumulative Frequency Distribution of Mercury Fish Tissue Data for All Edible Species.

Table H-4. Fish Tissue Sampling Stations with Detectable Levels of Mercury in Edible Fish Species That Exceed Various Screening Values[a,b]

Type of Screening Value	Associated Level (ppb)	Level Plotted in Figure H-4 Corresponds to Letter	Number of Stations with Detected Mercury Exceeding Level	Percentage of Stations with Detected Mercury Exceeding Level
Protection of Consumers				
Canadian Guideline[b]	200	B	2,308	55.8
Noncancer Hazard Quotient of 1 (1995)[c]	1,100	E	353	7.8
Noncancer Hazard Quotient of 1 (pre-1995)[d]	3,231	F	37	0.9
Noncancer Hazard Quotient of 1 (pre-1995 for infants)[e]	646	C	821	19.9
FDA Action Level[f]	1,000	D	374	9.0
Wildlife Criteria[g]	57.3	A	3,623	87.6

[a]Mercury was detected at 4,135 (93%) of the 4,426 stations where collected samples were analyzed for mercury.
[b]Canadian guideline limit for mercury in fish that are part of a subsistence diet (Health and Welfare Canada, 1979).
[c]Methylmercury reference dose that was available in IRIS in 1995 ($1x10^{-4}$ mg/kg-day).
[d]Corresponds to mercury reference dose available in IRIS prior to 1995 ($3x10^{-4}$ mg/kg-day).
[e]Corresponds to mercury reference dose available in IRIS prior to 1995 divided by a factor of 5 to protect against developmental effects among infants ($6x10^{-5}$ mg/kg-day). This value was formerly used by the EPA Office of Water.
[f]Level used in the current National Sediment Quality Survey evaluation for human health.
[g]The results of the wildlife analysis shown in Table 3-5 are slightly different because the data set used for that analysis included demersal, resident species (could be considered edible or not).

Appendix I

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

The original proposed approach for the integration and evaluation of NSI sediment chemistry and biological data was developed at the Second National Sediment Inventory Workshop held on April 26 and 27, 1994, in Washington, D.C. The proposed workshop approach was modified, however, to address inconsistencies found in trying to implement the approach and to address the concerns of the many experts in the field of sediment quality assessment who commented on the workshop approach. This appendix presents the NSI data evaluation approach developed by the April 1994 workshop participants. The actual approach that EPA used in the NSI data evaluation is presented in Chapter 2. A list of workshop participants is provided at the end of this appendix.

Using the approach recommended by workshop participants, sediment sites could be placed into one of the following five categories based on an evaluation of data compiled for the NSI:

- High probability of adverse effects to aquatic life or human health
- Medium-high probability of adverse effects to aquatic life or human health
- Medium-low probability of adverse effects to aquatic life
- Low probability of adverse effects to aquatic life or human health
- Unknown probability of adverse effects to aquatic life or human health.

Using the workshop approach, contaminated sediment sites could be placed into one of the five categories based on an evaluation of the following types and combinations of data:

- Sediment chemistry data alone
- Toxicity data alone
- Tissue residue data alone
- Sediment chemistry and tissue residue data
- Sediment chemistry and histopath-ological data
- Sediment chemistry, sediment toxicity, and tissue residue data.

The overall approach developed by workshop participants is summarized in Table I-1 and is described below.

High Probability of Adverse Effects to Aquatic Life or Human Health

Based on the evaluation approach proposed by the April 1994 workshop participants, a site could be classified as having a high probability of adverse effects to aquatic organisms or human health based on sediment chemistry data alone, toxicity data alone, tissue residue data alone, or a combination of sediment chemistry and tissue residue or histopathological data.

Table I-1. Original Approach Recommended by NSI Workshop (April 1994)

Category of Site Classifications	Data Used to Determine Classifications				
	Sediment Chemistry (site is identified by any one of the following characteristics)		**Tissue Residue/ Histopathology**		**Toxicity**
High Probability of Adverse Effects to Aquatic Life or Human Health	Sediment chemistry values exceed draft sediment quality criteria for any one of the five chemicals for which criteria have been developed by EPA (must have measured TOC)	OR	Human health thresholds for dioxins or PCBs are exceeded in resident species (not a consensus agreement–participants evenly divided on this issue)	OR	Toxicity demonstrated by two or more acute toxicity tests (one of which must be a solid-phase nonmicrobial test)
	OR Sediment chemistry values exceed *all* relevant AETs (high), ERMs, PELs, and SQALs for any one chemical(can use default TOC)				
	OR Sediment chemistry values >50 ppm for PCBs				
	OR Sediment chemistry TBP exceeds FDA action levels, EPA risk levels, or wildlife criteria	AND	Tissue levels in resident species exceed FDA action levels or EPA risk levels or wildlife criteria	—	—
	OR Elevated sediment chemistry concentrations of PAHs	AND	Presence of fish tumors	—	—
Medium-High Probability of Adverse Effects to Aquatic Life or Human Health	Sediment chemistry values exceed at least two of the sediment upper screening values (i.e., ERM,, SQAL, PEL, high AET)(can use default TOC)	OR	Tissue levels in resident species exceed FDA action levels or wildlife criteria	OR	Toxicity demonstrated by a single-species toxicity test (solid-phase, nonmicrobial)
	OR Sediment chemistry TBP exceeds FDA action levels or wildlife criteria				
Medium-Low Probability of Adverse Effects to Aquatic Life	Sediment chemistry values exceed one of the lower screening values (ERL, SQAL, TEL, lower AET)(can use default TOC and AVS)	OR	—	—	Toxicity demonstrated by a single-species toxicity test (elutriate-phase, nonmicrobial)
Low Probability of Adverse Effects to Aquatic Life or Human Health	No exceedance of lower screening values **AND** No sediment chemistry TBP exceedances of FDA action levels or wildlife criteria	AND	Tissue levels in resident species are lower than FDA action levels or wildlife criteria	AND	No toxicity demonstrated in tests using at least two species and at least one solid-phase test using amphipods
Unknown	Not enough data to place a site in any of the other categories				

For a site to be classified as one with a high probability of adverse effects based on sediment chemistry data alone, at least one of three criteria must be met: (1) sediment chemistry values exceed the draft sediment quality criteria (SQCs) developed by EPA for acenaphthene, dieldrin, endrin, fluoranthene, or phenanthrene; (2) sediment chemistry values exceed all appropriate screening values for a given chemical (i.e., high apparent effects thresholds (AETs), effects range-medians (ERMs), probable effects levels (PELs), and sediment quality advisory levels (SQALs)); and/or (3) sediment chemistry values exceed 50 ppm for polychlorinated biphenols (PCBs). When comparing sediment chemistry values to the draft SQCs, measured total organic carbon (TOC) must be used. Workshop participants suggested using default TOC values in the comparison of sediment chemistry values to SQALs if actual measured TOC values are not available. However, if default TOC values are used in a comparison of sediment chemistry measurements to draft SQCs, the highest that a site could be classified would be medium-high potential for adverse effects.

For a site to be classified as having a high probability of adverse effects based on a combination of sediment chemistry and tissue residue data, sediment chemistry theoretical bioaccumulation potential (TBP) and tissue levels in resident, nonmigratory species must exceed FDA tolerance/action/guidance levels, EPA risk levels, or EPA wildlife criteria. Workshop participants also recommended that a site be classified as having a high probability of adverse effects if fish tumors are present in resident species and elevated sediment chemistry concentrations for polynuclear aromatic hydrocarbons (PAHs) are present.

The workshop participants were evenly divided on whether a site could be classified as having a high probability of adverse effects based solely on the exceedance of human health screening values for dioxins or PCBs in resident fish species. Participants did agree that benthic community data in combination with sediment chemistry data could be used in the future, but not for the current evaluation, to classify sediment sites. Methods are currently not adequate to establish a direct causal relationship between benthic community changes and sediment contamination at specific sites without additional data.

For a site to be classified as having a high probability of adverse effects based on toxicity data alone, toxicity must be demonstrated by two or more acute toxicity tests, at least one of which must be a solid-phase, nonmicrobial test.

Medium-High Probability of Adverse Effects to Aquatic Life or Human Health

Workshop participants suggested that a site could be classified as having a medium-high probability of adverse effects on aquatic life or human health based on sediment chemistry data alone, toxicity data alone, or tissue residue data alone.

For a site to be classified as having a medium-high probability of adverse effects based on sediment chemistry data alone, the site must meet at least one of two criteria: (1) sediment chemistry values exceed at least two of the sediment chemistry upper screening values (i.e., appropriate ERMs, SQALs, PELs, or AET-highs) or (2) sediment chemistry TBP values exceed FDA tolerance/action/guidance levels or EPA wildlife criteria. In the comparison of sediment chemistry values to SQALs, default TOC values can be used.

A site could also be classified as having a medium-high probability of adverse effects if toxicity is demonstrated by a single-species, nonmicrobial toxicity test using the solid phase as the testing medium or if actual fish tissue residue levels exceed FDA tolerance/action/guidance levels or EPA wildlife criteria.

Medium-Low Probability of Adverse Effects to Aquatic Life

Workshop participants suggested that a site could be classified as having a medium-low probability of adverse effects to aquatic life based on either sediment chemistry data alone or toxicity data alone. A site could be classified as having a medium-low probability of adverse effects if sediment chemistry values exceed at least one of the lower sediment chemistry screening values (i.e., ERL, TEL, SQAL, or AET-low). Workshop participants suggested that default TOC and AVS values could be used. To classify a site as having a medium-low probability of adverse effects, toxicity would be demonstrated by a single-species, nonmicrobial toxicity test using the elutriate phase as the test

medium. Workshop participants did not propose any human-health-related criteria for placing a site in the medium-low probability of adverse effects category.

Low Probability of Adverse Effects to Aquatic Life and Human Health

Using the workshop approach, for a site to be classified as having a low probability of adverse effects on aquatic life and human health, all of the following criteria must be met: (1) there are no exceedances of the lower sediment chemistry screening values (i.e., ERL, TEL, SQAL, or AET-low); (2) there is no toxicity demonstrated in tests using at least two species and at least one solid-phase test using amphipods; (3) there are no TBP exceedances of FDA tolerance/action/guidance levels and EPA wildlife criteria; and (4) tissue levels of resident species are below FDA levels and EPA wildlife criteria.

Unknown Probability of Adverse Effects

Sites of unknown probability for causing adverse effects are those sites for which there are not enough data to place them in any of the other categories. Sediments at the sites might or might not cause adverse impacts to aquatic life or human health.

Modifications to Workshop Approach

The approach for evaluating NSI data recommended by the April 1994 workshop participants provides the framework for the final evaluation approach actually used to evaluate the NSI data. Workshop participants had less than 4 hours to reach consensus on their recommendations for the approach following a day and a half of debate covering many challenging issues. As a result, some of the specific issues concerning how data were to be evaluated to place sites into the five categories remained unresolved. For example, "elevated sediment chemistry concentrations of PAHs" together with the presence of fish tumors is one criterion for placing a site in the high probability of adverse effects category. However, how "elevated" do sediment chemistry concentrations of PAHs have to be to meet this criterion? As another example, sediment chemistry values that exceed all relevant AETs, ERMs, PELs, and SQAL values for any one chemical are sufficient to place a site in the high probability category, and exceedance of any two of these values is sufficient to place a site in the medium-high probability category. But what if there are only two relevant screening values for comparison for a given contaminant? Does a site at which both values are exceeded for a given chemical belong in the high or medium-high probability category?

A significant modification in the final approach used to evaluate the NSI data was the reduction in the number of categories from five to three, eventually combining the medium-high and medium-low categories and the low and unknown categories proposed in the workshop approach. In addition, the following evaluation parameters were dropped from the final approach:

- Sediment chemistry values > 50 ppm for PCBs
  - Expert reviewers of the methodology believed that this parameter was not necessary; i.e., a site that was targeted as a higher probability for adverse effects by this parameter would already have been targeted at a much lower concentration using other parameters.
- Elevated sediment chemistry concentrations of PAHs and presence of fish tumors
  - Available fish liver histopathology data in the NSI are very limited; therefore, this evaluation parameter was not considered further.

In the final approach adopted for the evaluation of the NSI data, the EPA wildlife criteria were not included in the TBP and fish tissue residue parameters. Reviewers of the methodology felt that the wildlife criteria values were overly conservative for this screening assessment and thus could not be used to distinguish potentially highly contaminated sites from only slightly contaminated sites. A separate analysis of wildlife criteria was, however, conducted.

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