Organochlorine Compounds and Trace Elements in Fish Tissue and Streambed Sediment in the Mobile River Basin, Alabama, Mississippi, and Georgia, 1998

By Humbert Zappia

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FOREWORD

The U.S. Geological Survey (USGS) is committed to serve the Nation with accurate and timely scientific information that helps enhance and protect the overall quality of life, and facilitates effective management of water, biological, energy, and mineral resources. Information on the quality of the Nation's water resources is of critical interest to the USGS because it is so integrally linked to the long-term availability of water that is clean and safe for drinking and recreation and that is suitable for industry, irrigation, and habitat for fish and wildlife. Escalating population growth and increasing demands for the multiple water uses make water availability, now measured in terms of quantity *and* quality, even more critical to the long-term sustainability of our communities and ecosystems.

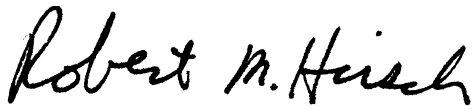
The USGS implemented the National Water-Quality Assessment (NAWQA) Program to support national, regional, and local information needs and decisions related to water-quality management and policy. Shaped by and coordinated with ongoing efforts of other Federal, State, and local agencies, the NAWQA Program is designed to answer: What is the condition of our Nation's streams and ground water? How are the conditions changing over time? How do natural features and human activities affect the quality of streams and ground water, and where are those effects most pronounced? By combining information on water chemistry, physical characteristics, stream habitat, and aquatic life, the NAWQA Program aims to provide science-based insights for current and emerging water issues and priorities. NAWQA results can contribute to informed decisions that result in practical and effective water-resource management and strategies that protect and restore water quality.

Since 1991, the NAWQA Program has implemented interdisciplinary assessments in more than 50 of the Nation's most important river basins and aquifers, referred to as Study Units. Collectively, these Study Units account for more than 60 percent of the overall water use and population served by public water supply, and are representative of the Nation's major hydrologic landscapes, priority ecological resources, and agricultural, urban, and natural sources of contamination.

Each assessment is guided by a nationally consistent study design and methods of sampling and analysis. The assessments thereby build local knowledge about water-quality issues and trends in a particular stream or aquifer while providing an understanding of how and why water quality varies regionally and nationally. The consistent, multiscale approach helps to determine if certain types of water-quality issues are isolated or pervasive, and allows direct comparisons of how human activities and natural processes affect water quality and ecological health in the Nation's diverse geographic and environmental settings. Comprehensive assessments on pesticides, nutrients, volatile organic compounds, trace metals, and aquatic ecology are developed at the national scale through comparative analysis of the Study-Unit findings.

The USGS places high value on the communication and dissemination of credible, timely, and relevant science so that the most recent and available knowledge about water resources can be applied in management and policy decisions. We hope this NAWQA publication will provide you the needed insights and information to meet your needs, and thereby foster increased awareness and involvement in the protection and restoration of our Nation's waters.

The NAWQA Program recognizes that a national assessment by a single program cannot address all water-resource issues of interest. External coordination at all levels is critical for a fully integrated understanding of watersheds and for cost-effective management, regulation, and conservation of our Nation's water resources. The Program, therefore, depends extensively on the advice, cooperation, and information from other Federal, State, interstate, Tribal, and local agencies, non-government organizations, industry, academia, and other stakeholder groups. The assistance and suggestions of all are greatly appreciated.



Robert M. Hirsch
Associate Director for Water

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Multiply	By	To obtain
	Area	
square mile (mi^2)	2.590	square kilometer

Water-quality units: Chemical concentrations were measured and reported in metric units for this study. The metric units can be converted to standard units by using the following conversion table:

Multiply	By	To obtain
	Length	
centimeter (cm)	0.3937	inch
millimeter (mm)	0.03937	inch
meter (m)	3.281	foot
	Weight	
microgram (µg)	0.00000003527	ounce
gram (g)	0.03527	ounce
kilogram (kg)	2.205	pound

***Acronyms and abbreviations used in this report*:**

BHC	hexachlorocyclohexane
BRD	Biological Resources Discipline of the U.S. Geological Survey
CV-AAS	cold vapor atomic absorption spectrophotometry
DCPA	chlorthaldimethyl
DDE	dichlorodiphenyldichloroethylene
DDT	dichlorodiphenyltrichloroethane
GC/ECD	gas chromatography with electron-capture detection
GPC	gel-permeation chromatography
HCB	hexachlorobenzene
ICP-AES	inductively coupled plasma atomic emission spectrometry
ICP-MS	inductively coupled plasma mass spectrometry
LRL	laboratory reporting level
MOBL	Mobile River Basin Study Unit in the National Water-Quality Assessment Program
MRL	minimum reporting level
MRLC	Multi-Resolution Land Characteristics
NAS/NAE	National Academy of Science and National Academy of Engineering
NAWQA	National Water-Quality Assessment Program
NWQL	National Water Quality Laboratory of the U.S. Geological Survey
PCB	polychlorinated biphenyl
PEC	probable-effects concentrations
QA/QC	quality assurance and quality control
RL	reporting level
SQG	sediment-quality guidelines
TEC	threshold-effects concentrations
TRG	tissue residue guidelines, established by the Canadian Council of Ministers of the Environment
USGS	U.S. Geological Survey
WRD	Water Resources Discipline of the U.S. Geological Survey
ng/kg	nanogram per kilogram
µg/kg	microgram per kilogram
µm	micrometer

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ABSTRACT

During the summer of 1998, as part of the National Water-Quality Assessment Program, a survey was conducted to determine which organochlorine compounds and trace elements occur in fish tissues and streambed sediments in the Mobile River Basin, which includes parts of Alabama, Mississippi, Georgia, and Tennessee. The data collected were compared to guidelines related to wildlife, land use, and to 1991 and 1994 National Water-Quality Assessment Program Study-Unit data.

Twenty-one sites were sampled in subbasins of the Mobile River Basin. The subbasins ranged in size from about 9 to 22,000 square miles and were dominated by either a single land use or a combination of land uses. The major land-use categories were urban, agriculture, and forest.

Organochlorine compounds were widespread spatially in the Mobile River Basin. At least one organochlorine compound was reported at the majority of sampling sites (84 percent) and in a majority of whole-fish (80 percent) and streambed-sediment (52 percent) samples. Multiple organochlorine compounds were reported at 75 percent of the sites where fish tissues were collected and were reported at many of the streambed-sediment sampling sites (45 percent). The majority of concentrations reported, however, were less than 5 micrograms per kilogram in fish-tissue samples and less than 1 microgram per kilogram in streambed-sediment samples.

The majority of trace elements analyzed in fish-liver tissue (86 percent) and streambed-sediment (98 percent) samples were reported during this study. Multiple trace elements were reported in all samples and at all sites.

Based on comparisons of concentrations of organochlorine compounds and trace elements in fish-tissue and streambed-sediment samples in relation to National Academy of Science and National Academy of Engineering and Canadian tissue guidelines, probable-effects concentrations, and mean probable-effects concentration quotients for streambed sediment, the potential exists for adverse effects to wildlife at 15 (72 percent) of the sites sampled. The potential for adverse effects at these sites is because of the presence of residues or breakdown products related to polychlorinated biphenyls (PCB's), chlordane, dichlorodiphenyltrichloroethane (DDT), chromium, lead, and zinc.

The majority of compounds reported (65 percent) were chlordane, DDT, and PCB's, or their breakdown products. Concentrations of chlordane and heptachlor epoxide in whole-fish tissue were positively correlated to the amount of urban land use in a basin. Total DDT concentrations in whole-fish tissues were positively correlated to agriculture.

The relation of trace elements to land use is not as clear as the relation of organochlorine compounds to land use. This lack of clarity may be due to the possibility of geologic sources of trace elements in the Mobile River Basin and to the ubiquitous nature of many of these trace elements. However, there may be a correlation between the amount of urban land use and concentrations of antimony, cadmium, lead, and zinc in streambed-sediment samples from the Mobile River Basin.

Fewer organochlorine compounds and trace elements were reported in samples from the Mobile

River Basin than in samples collected during the 1991 and 1994 National Water-Quality Assessment Program studies. Of the organochlorine compounds analyzed nationally, 57 percent were reported in whole-fish tissue samples collected locally and 41 percent were reported in streambed-sediment samples collected locally, whereas 96 percent and 86 percent, respectively, were reported nationally. Of trace elements analyzed nationally, 86 percent were reported in fish-liver tissue locally and 95 percent were reported in streambed-sediment samples locally, whereas 95 percent and 98 percent, respectively, were reported nationally.

In general, concentrations of organochlorine compounds and trace elements and the frequency with which they were reported in the Mobile River Basin are similar to or less than those reported by 1991 and 1994 Study Units; however, exceptions do exist to this generality.

Exceptions are the higher reporting frequency of heptachlor epoxide, *p,p*'-DDT, and PCB's in whole-fish samples, higher quartile concentrations of heptachlor epoxide and *p,p*'-DDT in whole-fish samples, the higher maximum concentration of heptachlor epoxide in whole-fish samples, and the higher maximum concentration and reporting frequency of *trans*-chlordane in streambed-sediment samples in the Mobile River Basin. In addition, aluminum, barium, chromium, cobalt, nickel, and strontium were reported more frequently in fish-liver samples locally than nationally, boron concentrations were consistently higher in fish-liver samples locally than nationally, and mercury, silver, and ytterbium were reported more frequently in streambed-sediment samples from the Mobile River Basin than nationally.

The higher reporting frequencies and concentrations of heptachlor epoxide, *p,p*'-DDT, and *trans*-chlordane in samples from the Mobile River Basin are probably due to the greater use of these compounds locally than nationally. The reason for the higher reporting frequency of PCB's is less clear, but may be due to the production of these compounds within the basin.

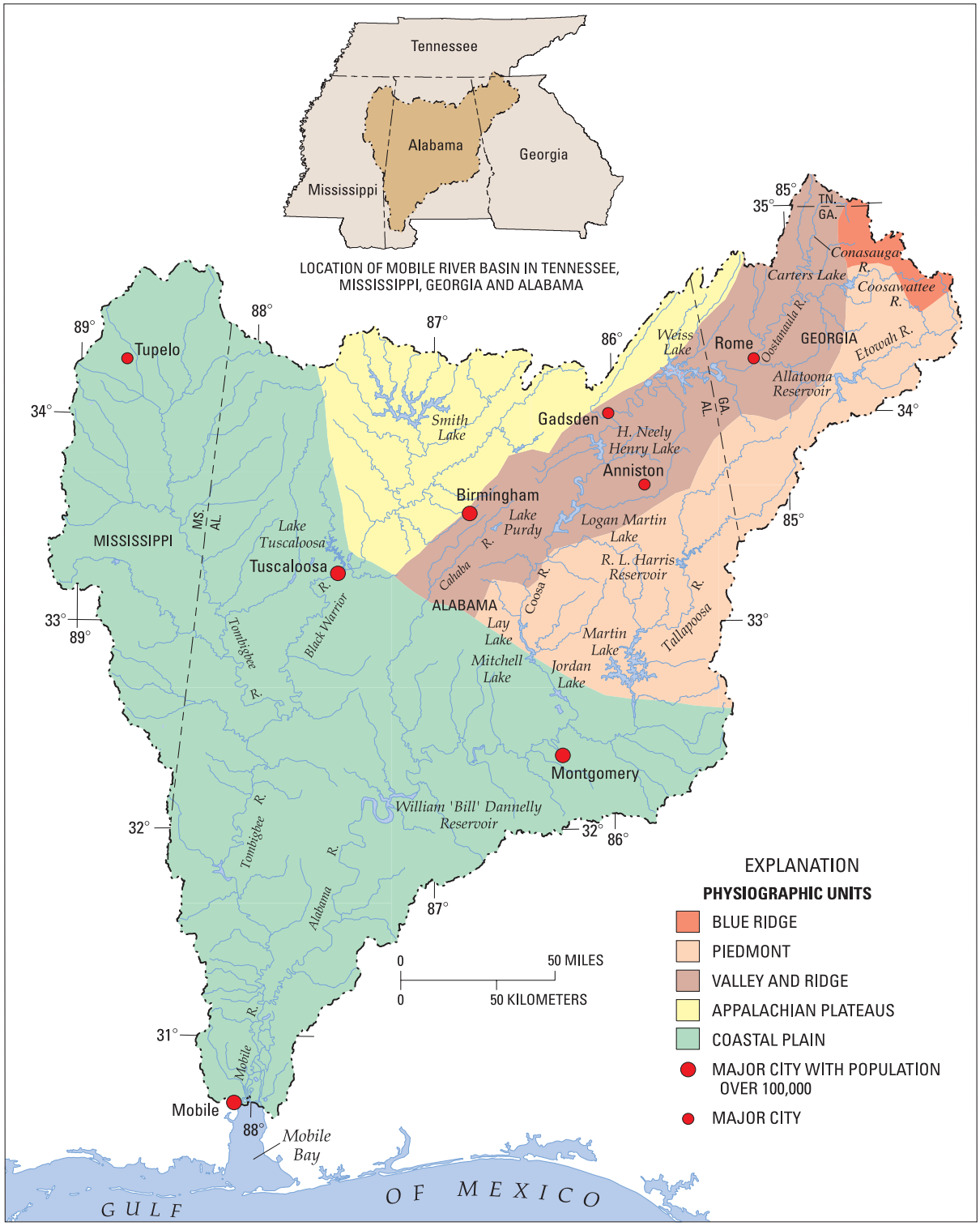
The higher frequency with which some trace elements were reported in fish-liver tissue and streambed-sediment samples in the Mobile River Basin may be due to geology or anthropomorphic activities. Higher boron concentrations locally are probably due to anthropomorphic activities, because there are no major geological sources for boron in the Mobile River Basin. Potential sources locally for most of these trace elements include irrigation drain water (mercury), coal combustion (mercury and nickel), metallurgy (barium, boron, chromium, and nickel), soaps (boron), and the wood and pulp industry (barium and chromium). Other sources that could enrich samples from the Mobile River Basin are the Black Warrior coal fields (aluminum and mercury) in the northwestern quarter of the basin, which are known to have elevated levels of mercury, and barite deposits (barium) in east-central Alabama.

INTRODUCTION

An investigation was conducted in 1998 to determine the occurrence and distribution of organochlorine compounds and trace elements in the Mobile River Basin, which includes most of Alabama, and parts of Mississippi, Georgia, and Tennessee (fig. 1). This investigation was conducted as part of the U.S. Geological Survey's (USGS) National Water-Quality Assessment (NAWQA) Program.

To address the need for consistent and scientifically sound information for managing the Nation's water resources, the USGS fully implemented the NAWQA Program in 1991 (Leahy, and others, 1990; Atkins, 1998). The NAWQA Program integrates the monitoring of the quality of surface and ground waters with the study of aquatic ecosystems. The objectives of the NAWQA Program are to (1) describe current water-quality conditions for a large part of the Nation's freshwater streams and aquifers, (2) describe how water quality is changing over time, and (3) improve the understanding of primary natural and human factors that affect water quality (Gilliom and others, 1995; Atkins, 1998). The investigation of organochlorine compounds and trace elements in the Mobile River Basin Study Unit (MOBL) is one of the many components used to achieve the goal of water-quality assessment locally, regionally, and nationally (Leahy and others, 1990; Gilliom and others, 1995).

Organochlorine pesticides and polychlorinated biphenyls (PCB's) in the environment have been a concern nationally since the 1960's because of their toxicity and persistence in the environment. The majority of organochlorine pesticides and PCB's were banned in the United States in the 1970's and 1980's (Nowell and others, 1999). In particular, the use of chlordane and PCB's has been banned since 1988 and the use of dichlorodiphenyltrichloroethane (DDT)



Base from U.S. Geological Survey digital data, 1:250,000, 1994
Universal Transverse Mercator projection,
Zone 16

Figure 1. Location of the Mobile River Basin in Alabama, Georgia, Mississippi, and Tennessee, and the physiographic units within the basin.

since 1973 (U.S. Environmental Protection Agency, 1992).

Organochlorine pesticides and PCB's have been used throughout the United States in agriculture, households, and industry. In particular, DDT was used heavily as a pesticide in agriculture and for mosquito control; chlordane was used for termite control; and PCB's were used as a dielectric fluid in transformers, lubricant, solvent, and as a plasticizer (U.S. Environmental Protection Agency, 1992; Nowell and others, 1999).

In addition, many trace elements are of concern. Because of potential environmental harm, uses of some trace elements have also been restricted, such as lead as an additive in gasoline.

Trace elements in the environment occur from many natural and manmade sources. For example, arsenic, barium, cadmium, chromium, mercury, nickel, lead, and zinc all can be released into the environment through metallurgy, wood and pulp production, and the production of electrical power (Rice, 1999; U.S. Environmental Protection Agency, 2001a). Trace elements also have nonpoint sources in urban areas and are often associated with runoff from urban centers. Nonpoint sources for trace elements in urban areas include, batteries, ceramics, wear of automobile parts, pigments, and combustion (U. S. Environmental Protection Agency, 1997, 2001b). In addition, arsenic, cadmium, chromium, mercury, lead, zinc, and other trace elements can occur naturally, such as impurities in coals and ores and as constituents of many rock types (U.S. Department of the Interior, 1998; U.S. Environmental Protection Agency, 2001a). Sources that could enrich samples from the Mobile River Basin are the Black Warrior coal fields (aluminum and mercury) in the northwest quarter of the basin, and barite deposits (barium) in east-central Alabama (Travis and Lynch, 1973; Goldhaber and others, 2000).

Many organochlorine compounds and trace elements do not easily dissolve in streamwater. Instead, these materials tend to accumulate in streambed sediments and aquatic organisms. Both acute and chronic exposure to these materials can adversely affect the health of aquatic organisms and, depending on the concentration and duration of exposure, can be lethal or sub-lethal. Once in the food chain, these materials can affect terrestrial organisms, such as fish-eating wildlife (herons, otters, and kingfishers), and potentially humans. Organochlorine compounds, particularly chlordane and DDT, their related compounds, and PCB's are known to have adverse effects on wildlife. Eggshell thinning and reduced fecundity in several piscivorous bird species have been well documented, as well as the potential for liver disease and carcinogenicity (U.S. Environmental Protection Agency, 1992; U.S. Department of the Interior, 1998). Endocrine-system effects have been associated with these compounds as well (Goodbred and others, 1996; Steven L. Goodbred, U.S. Geological Survey, written commun., 1996; Keith, 1997). Some trace elements also cause adverse effects to wildlife, such as carcinogenicity, liver disease, reduced fecundity, and endocrine-system disruption (Steven L. Goodbred, U.S. Geological Survey, written commun., 1996; U.S. Department of the Interior, 1998). For these reasons, organochlorine compounds and trace elements were analyzed in fish-tissue and streambed-sediment samples from the Mobile River Basin.

Purpose and Scope

This report presents the results of the 1998 investigation of the occurrence and distribution of organochlorine compounds and trace elements in fish tissue and streambed sediment in the MOBL Study Unit. Also presented in this report are comparisons of these results to current standards and guidelines, land-use characteristics in the study basin, and 1991 and 1994 NAWQA study results. The significance of these relations and the sampling media are discussed.

Description of the Mobile River Basin

The Mobile River Basin is the sixth largest river basin in the Nation. Encompassing about 44,000 square miles, the Mobile River Basin drains portions of Mississippi, Tennessee, Georgia, and Alabama (fig. 1). The Alabama and Tombigbee Rivers meet to form the Mobile River, which then flows into Mobile Bay and discharges into the Gulf of Mexico. Approximately 71 percent of the basin lies in Alabama, and approximately 4.9 million people live in the basin. Cities with populations of 100,000 people or more include Birmingham, Mobile, Montgomery, and Tuscaloosa (fig. 1; Atkins, 1998). Approximately 69 percent of the basin is forested, 18 percent is agricultural, 2 percent is urban, and 11 percent is other land-use categories (fig. 2; Atkins, 1998; Charles R. Lawson, U.S. Geological Survey, written commun., 1998).

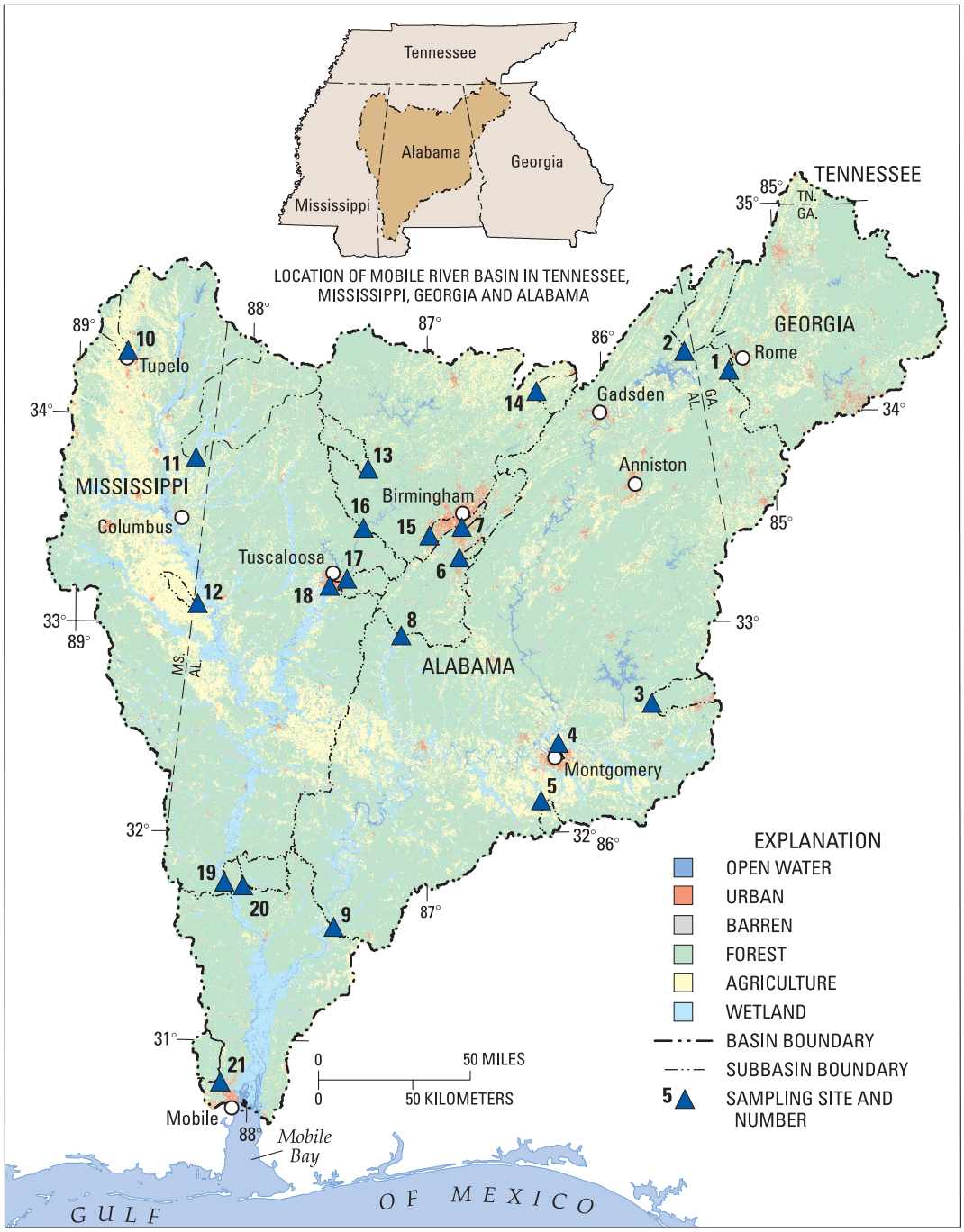


Figure 2. Land use and fish-tissue and streambed-sediment sampling sites and their associated drainage basins in the Mobile River Basin Study Unit.

Many agricultural and industrial activities occur within the Mobile River Basin. Agricultural activities include row crops, such as cotton, corn, and soybeans; aquaculture; and poultry and cattle production. Major industries in the basin include power production; silviculture; and chemical, pulp, paper, iron, steel, coal, and textile production (Atkins, 1998).

The Mobile River Basin lies within five physiographic provinces (fig. 1). These provinces include the Blue Ridge, Piedmont, Valley and Ridge, Appalachian Plateaus, and the Coastal Plain (Atkins, 1998).

Study Design

The Mobile Basin is one of more than 50 of the Nation's river basins, also referred to as Study Units, that are being investigated as part of the NAWQA Program (fig. 3.) Intense water-quality data collection began in the MOBL Study Unit in 1997. In 1998, 21 sites were selected in nontidal areas of the basin to collect fish-tissue and streambed-sediment samples to determine the occurrence and distribution of organochlorine compounds and trace elements in the basin. Sampling sites were selected to represent major subbasins and land uses within the MOBL basin and to provide broad, spatial coverage (fig. 2; table 1).

The MOBL subbasins associated with the fish-tissue and streambed-sediment sampling sites range in size from 8.96 to 21,967 square miles (mi^2) (table 1). The largest subbasins are the Alabama (site 9) and Tombigbee (site 19) River Basins, which drain approximately 90 percent of the Mobile River Basin and represent multiple land uses, but are predominantly forested. The smallest MOBL subbasins are Three Mile Branch (site 4) and Cribbs Mill Creek (site 18), both of which are smaller than 10 mi^2.

In 1998, the majority of the MOBL subbasins were predominantly forested, although they all contained multiple land uses (Charles R. Lawson, U.S. Geological Survey, written commun., 1998). Three Mile Branch (site 4), Cribbs Mill Creek (site 18), Shades Creek (site 7), and Valley Creek (site 15) all drained areas with greater than 20 percent urban land use, while Bogue Chitto (site 12), Town Creek (site 10), and Locust Fork (site 14) drained basins with greater than 40 percent agriculture. The remainder of the sites were dominated by forested land use—the Alabama (site 9) and Tombigbee (site 19) Rivers and Shades Creek (site 7) (table 1; fig. 2).

Acknowledgments

The author would like to acknowledge the land owners and local government authorities who provided access to several sites used in this study, to USGS Biological Resources Discipline (BRD) personnel who determined fish ages, and to the USGS Water Resources Discipline (WRD) personnel who gave an extraordinary effort during field activities that were, at times, outside of their normal duties.

METHODS OF DATA COLLECTION AND ANALYSIS

Sampling fish tissues and streambed sediments for the presence of selected organochlorine compounds and trace elements offers several advantages over water-quality sampling. Organochlorine compounds and trace elements in water samples are often at concentrations too low to be detected; however, concentrations of organochlorine compounds and trace elements tend to accumulate in fish tissues and streambed sediments at levels that are more readily detected. Analysis of fish-tissue and streambed-sediment samples can provide a time-averaged assessment of the compound or trace element in question. In addition, concentrations in tissue samples provide a direct measurement of bioavailability (Crawford and Luoma, 1993).

Because hydrophobic organic compounds do not readily dissolve in water, they typically are at extremely low concentrations in streams. However, these organochlorine compounds are readily associated with organic material in streambed sediments and in lipids of aquatic organisms (Shelton and Capel, 1994). In addition, organisms that have bioaccumulated organochlorine compounds may be consumed by other organisms, adding potential for increasing concentrations of organochlorine compounds in the predator organism's tissues (Crawford and Luoma, 1993).

Trace elements readily sorb to fine-grained sediment particles in streams. The majority of trace elements are highly sorptive and associated with fine sediment particles in almost all natural surface waters. Because a large fraction of the total mass of trace elements in surface water is associated with fine-grained sediment, the water column may contain only small quantities of these constituents (Shelton and Capel, 1994).

Sample Collection and Laboratory Analysis

Sampling reaches were established at 21 sites using methods described in Crawford and Luoma (1993) and Meador and others (1993). Composite fish-tissue and streambed-sediment samples were collected from the sampling reach at each site. The samples were processed on site and then shipped to the USGS National Water Quality Laboratory (NWQL) in Arvada, Colo. The tissue samples were collected,

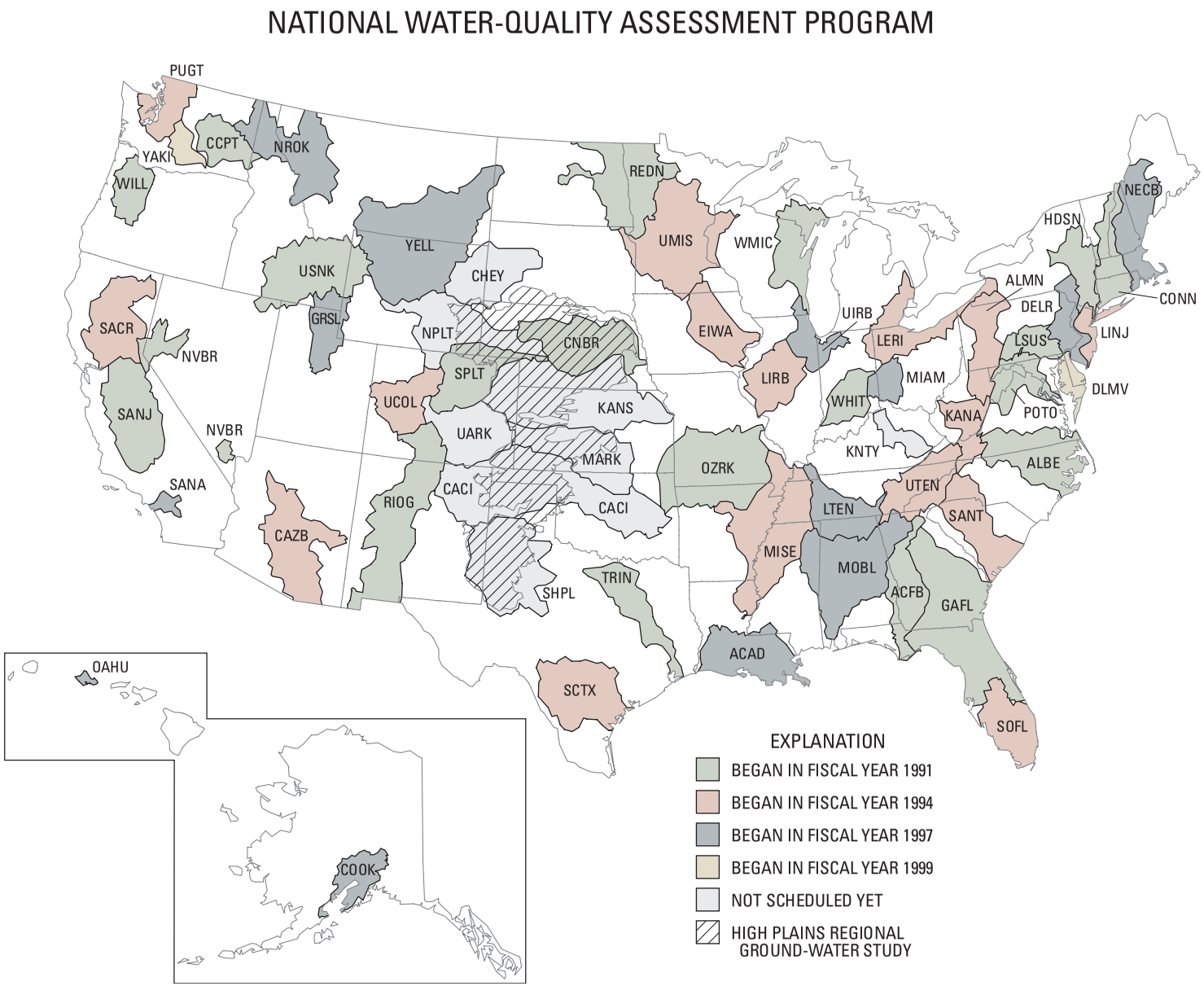


Figure 3. Study Units of the National Water-Quality Assessment Program (U.S. Geological Survey, 2002).

Table 1. Fish-tissue and streambed-sediment sampling sites and land-use percentages in the Mobile River Basin

[USGS, U.S. Geological Survey; mi^2, square mile; Blvd., Boulevard; L&D, Lock and Dam]

Site number (fig. 2)	Site name (USGS identification number[a])	Drainage area (mi^2)	Land-use categories, in percent					
			Open water	Urban	Barren	Forest	Agricul-ture	Wetlands
1	Coosa River near Rome, GA (02397000)	4,040.00	0.94	2.43	2.12	79.94	14.36	0.21
2	Chattooga River above Gaylesville, AL (02398300)	365.53	.27	1.43	1.71	74.58	21.75	.26
3	Sougahatchee Creek above Reeltown, AL (02418264)	170.08	.73	3.62	1.20	83.33	9.78	1.33
4	Three Mile Branch at North Blvd. at Montgomery, AL (02419977)	8.96	.04	58.51	.03	31.53	9.85	.05
5	Pintlalla Creek at Liberty Church Road near Pintlalla, AL (02421115)	59.38	.82	.08	3.01	68.37	23.83	3.90
6	Cahaba Valley Creek at Cross Creek Road at Pelham, AL (0242354750)	25.11	1.26	9.01	.05	78.33	11.09	.25
7	Shades Creek at Homewood, AL (02423581)	21.47	.18	28.77	2.05	60.88	7.83	.29
8	Cahaba River at Centreville, AL (02424000)	1,024.90	.74	4.47	2.35	80.92	10.51	1.02
9	Alabama River at Claiborne, AL (02429500)	18,458.52	1.35	1.36	2.81	64.10	22.38	8.00
10	Town Creek at Tupelo, MS (02434000)	100.84	1.17	.57	.37	46.49	51.13	.26
11	Buttahatchee River near Aberdeen, MS (02439400)	810.19	.23	.51	5.36	75.98	11.06	6.87
12	Bogue Chitto Creek near Memphis, AL (02444490)	52.62	.58	.28	.00	8.50	88.73	1.92
13	Lost Creek above Parrish, AL (02454055)	143.13	.16	.63	4.02	85.13	10.02	.05
14	Locust Fork below Snead, AL (02454500)	122.72	.41	.57	.67	57.33	40.77	.25
15	Valley Creek near Bessemer, AL (02461500)	53.56	.20	56.65	1.77	31.79	9.59	.00
16	Black Warrior River at Bankhead L&D near Bessemer, AL (02462500)	3,982.82	1.41	3.03	1.84	76.24	17.29	.20
17	Hurricane Creek near Holt, AL (02463500)	108.18	.33	1.76	3.66	85.58	8.52	.15
18	Cribbs Mill Creek at Tuscaloosa, AL (02465288)	9.54	.40	49.29	.00	37.69	12.61	.00
19	Tombigbee River below Coffeeville L&D near Coffeeville, AL (02469762)	21,967.44	1.64	1.62	1.99	74.02	16.67	4.06
20	Satilpa Creek near Coffeeville, AL (02469800)	163.09	.03	.05	3.56	91.22	1.55	3.60
21	Chickasaw Creek near Kushla, AL (02471001)	125.11	.15	.28	4.17	81.92	9.99	3.50
	Summary statistics							
	Minimum	8.96	0.03	0.05	0.00	8.50	1.55	0.00
	25th percentile	53.56	.20	.57	.67	57.33	9.85	.20
	Median	125.11	.41	1.62	1.99	74.58	11.09	.26
	75th percentile	810.19	.94	4.47	3.01	80.92	21.75	3.50
	Maximum	21,967.44	1.64	58.51	5.36	91.22	88.73	8.00
	Range	21,958.48	1.61	58.46	5.36	82.72	87.18	8.00

[a] USGS identification number is based on geographic location and the downstream order of streamflow sites.

processed, and handled by using methods specified in Crawford and Luoma (1993).

A minimum of five fish of a single species and of similar size formed a composite sample. The fish species and sex were identified, and the fish were measured, weighed, and examined for internal and external anomalies. In this region of the country, fish age is often difficult to determine from scale samples. However, scale samples were taken for use in determining fish age rather than risk potential contamination of the fish samples during the removal of other portions of the fish that are more reliable for fish aging, but require substantially more dissecting skill to remove than fish scales. Pectoral spines were removed from Ictalurid species and used for age determination. Fish age was determined by counting the number of annuli present on scales or spines that were removed from individual fish.

Scale samples were analyzed by WRD personnel from the USGS in Mississippi who are experienced in determining the age of fish from this region of the country. Fish age and size data from this study were then compared to age and size class data from other sites in the area to determine the accuracy of the age determinations. In addition, a subsample of fish scales collected during this study was simultaneously and independently analyzed by BRD personnel for quality assurance. Fish ages determined by WRD and BRD personnel were similar, with only two exceptions—one largemouth bass *(Micropterus salmoides*) and several longear sunfish (*Lepomis megalotis*). The ages assigned by the BRD and WRD personnel differed by 1 year. The age differences probably occurred because (1) there was not a series of fish to examine from any one locality, (2) fish collected from areas within the MOBL basin had dissimilar growth rates, and (3) the age of fish is difficult to determine from small sunfish scales.

Whole-fish composite samples were analyzed for organochlorine compounds. The whole-fish samples were wrapped in aluminum foil, placed in plastic bags, frozen with dry ice, and then shipped to the NWQL for analysis. If enough fish were not available for both organochlorine-compound and trace-element samples, portions of liver were removed from the fish collected for analysis of organochlorine compounds. The livers were then composited into a single sample and analyzed for trace elements. The remainder of the fish were then processed, composited into a single sample, and analyzed for organochlorine compounds.

The livers of individual fish collected for trace-element analysis were removed and composited into a single sample. The remainder of the fish was then discarded. The liver samples were immediately frozen with dry ice and shipped to the NWQL for analysis.

Whole-fish composite samples were analyzed for organochlorine compounds at the NWQL by using methods described in Leiker and others (1995). Methylene chloride extracts of the homogenized sample were used in the analysis. The extracts were processed by using gel-permeation chromatography (GPC) and fractionated by using alumina/silica adsorption chromatography. These extracts were then analyzed by using two dissimilar fused-silica gas chromatographic capillary columns with electron-capture detection.

Fish-liver samples were analyzed for trace elements at the NWQL by using methods described in Hoffman (1996). The tissues were dried and acid digested. Inductively coupled plasma mass spectrometry (ICP-MS) and inductively coupled plasma atomic emission spectrometry (ICP-AES) were used to analyze the liver samples for trace elements. Mercury concentrations were determined using cold vapor atomic absorption spectrophotometry (CV-AAS) (Hoffman, 1996; Long and others, 1999).

A composite streambed-sediment sample was collected from as many of the depositional areas in each stream reach as possible, usually more than 10. Using methods described in Shelton and Capel (1994), only the most recently deposited sediments were collected by sampling only the top 3–5 centimeters (cm) of the sediment. The composite sample was then split into two samples by sieving, one sample greater than 2 millimeters (mm) in size for synthetic organochlorine compound analysis, and one sample less than 63 micrometers (µm) in size for trace-element analysis. The sediment samples for trace-element analysis were allowed to settle out of solution; excess water was then decanted, and the samples were shipped to the NWQL. Sediment samples processed for analysis of organochlorine compounds were frozen with dry ice immediately after processing and sent to the NWQL.

Streambed-sediment samples were analyzed to determine organochlorine compounds and PCB concentrations by using methods described in Foreman and others (1995) and Tate and Heiny (1996). Excess

water was removed from the samples by centrifuge. Each sample was homogenized, and dry weight was determined on a 2-gram (g) subsample. Then, a 25-g equivalent dry-weight subsample was mixed with sodium sulfate to remove residual water. Three surrogates were added to the 25-g equivalent dry-weight subsample. The subsample was Soxhlet extracted with dichloromethane and then concentrated. The extract was centrifuged and cleaned by GPC. The GPC fraction was further processed and split into two fractions. One fraction contained PCB's, dichloro-diphenyldichloroethylene (*p,p*'-DDE), heptachlor, aldrin, hexachlorobenzene (HCB), isodrin, mirex, and one surrogate. The other fraction contained all other organochlorine compounds. Samples were analyzed by dual capillary column gas chromatography with electron-capture detection (GC/ECD).

Streambed-sediment samples were analyzed for trace elements at the USGS Branch of Geochemistry Laboratory in Denver, Colo., using methods described in Arbogast (1996) and Heiny and Tate (1997). The samples were dried, acid digested, and analyzed by using a variety of atomic spectroscopy methods.

Quality Assurance and Quality Control

The NWQL has established stringent quality-assurance and quality-control (QA/QC) methods for analytical operations. Details of these methods are provided in Pritt and Raese (1992, 1995), Glodt and Pirkey (1998), and Pirkey and Glodt (1998). In addition, specific information concerning method performance is available in Foreman and others (1995), Leiker and others (1995), Arbogast (1996), and Hoffman (1996).

The addition of three surrogate compounds to streambed-sediment samples and two surrogate compounds to tissue samples was also part of the QA/QC procedures for analysis of organochlorine compounds. The relative rates of recovery of these compounds can provide insight into the accuracy and precision associated with the analysis of each sample.

No field replicates or split samples were collected during this investigation because it often was difficult to obtain the amount of material required for a sample. Also, because of the paucity of the appropriated fish species and streambed sediments, no field QA/QC samples were collected.

Data Analysis

Results from the laboratory analysis of fish-tissue and streambed-sediment samples were analyzed by using various approaches to determine the distribution of organochlorine compounds and trace elements within the Mobile River Basin and the relation of observed concentrations to current standards and guidelines, land use, sampling media, and to 1991 and 1994 NAWQA Study-Unit data. No comparison was made to other data from the MOBL basin because of the paucity of other data, and because of differences between local agency data and NAWQA data in regard to sampling media, analytes, and site coverages.

Concentrations of organochlorine compounds and trace elements in fish-tissue samples from the MOBL basin were compared to two standards and guidelines. The standards and guidelines used in this study are (1) the recommended maximum concentration for the protection of fish-eating wildlife established by the National Academy of Science and National Academy of Engineering (NAS/NAE) (Nowell and Resek, 1994) and (2) tissue residue guidelines (TRG's) for the protection of wildlife consumers of aquatic biota established by the Canadian Council of Ministers of the Environment (1999).

The NAS/NAE recommended maximum concentrations for the protection of fish-eating wildlife were considered preliminary values when published in 1973 (Nowell and Resek, 1994); however, no subsequent Federal guidelines have been established. The guidelines are based on experimental studies of DDT and its metabolites in relation to eggshell thinning in several families of birds. By analogy to DDT, values for other pesticides were established conservatively. The guidelines indicate that when pesticide concentrations exceed the guidelines in whole-fish tissue samples, adverse effects may occur to fish-eating wildlife that are dependent on freshwater food sources (Nowell and Resek, 1994).

Canadian TRG's are recommended guidelines to protect wildlife that consume aquatic biota in freshwater. In order to protect a particular species, the guidelines must be applied at the trophic level at which the species feed (Canadian Council of Ministers of the Environment, 1999). To protect all wildlife, the TRG's must be applied at the highest known aquatic trophic level. This was not possible at all MOBL sites sampled during this investigation. Multiple species were sampled in the study area, some of which were not the top predators within the system. Thus, the data cannot

be used to infer potential adverse effects to all wildlife, although all of the fish species collected during this investigation probably are preyed upon by fish-eating wildlife.

Many of the fish species sampled were omnivores or insectivores, which may be less likely than piscivorous fish species to encounter food sources that have accumulated significant concentrations of organic contaminants. Consumption of organisms that have bioaccumulated contaminants is one of the main mechanisms for biomagnification (Canadian Council of Ministers of the Environment, 1999). For this reason, concentrations of organochlorine compounds reported in fish species other than top predators may underestimate the potential for adverse effects to wildlife that feed on organisms that typically are considered to be at the top of the aquatic food chain.

Concentrations of organochlorine compounds and trace elements in streambed-sediment samples from the MOBL basin were compared to consensus-based sediment-quality guidelines (SQG's), and mean probable-effects concentration quotients were calculated for each sample. Two groups of SQG's have been developed by MacDonald and others (2000)—threshold-effects concentrations (TEC's) and probable-effects concentrations (PEC's). The TEC's represent concentrations in streambed sediment below which adverse effects to aquatic organisms in association with streambed sediments would not be expected to be frequent. The PEC's represent concentrations above which adverse effects to aquatic organisms would be expected to occur frequently (MacDonald and others, 2000). Mean PEC quotients are the average ratio of organochlorine compounds and trace elements in a sample to their respective PEC's. Samples with mean quotients greater than 0.5 are predicted to be toxic to sediment-dwelling organisms. Because the comparison of data to PEC's and mean PEC quotients is a relatively new technique, a brief description of the development of SQG's and mean PEC quotients is presented in this report.

Consensus-based SQG's were developed by using previously published sediment-quality guidelines. Only sediment-quality guidelines that (1) have readily discernible derivation methods, (2) are based on empirical data relating contaminant concentrations to harmful effects in sediment-dwelling organisms, (3) are intended to be predictive of effects, (4) are newly derived, and (5) have three sediment-quality guidelines available were used to derive SQG's (MacDonald and others, 2000). The existing sediment-quality guidelines were then grouped into two categories based on their original narrative intent. A geometric mean was then calculated for each sediment-quality guideline. The two categories were TEC's and PEC's.

The potential for harmful effects to sediment-dwelling organisms as a result of contaminant concentrations in streambed sediment was evaluated by using TEC's, PEC's, and concentration data and toxicity-test results from previously published studies. If the measured concentration of a contaminant in a sample was less than the TEC's, the sample was considered to be nontoxic. If the measured concentration of a contaminant was greater than any one of the PEC's, the sample was considered to be toxic. Concentrations in streambed-sediment samples between TEC's and PEC's were considered to be neither toxic nor nontoxic (MacDonald and others, 2000).

Samples that were predicted to be toxic or nontoxic based on TEC's and PEC's were then compared to data from toxicity tests conducted on the original sediment samples associated with the previously published SQG's. Based on toxicity tests, the PEC's and TEC's that accurately predicted either frequent (greater than 75 percent of the samples were correctly predicted to be toxic) or infrequent (greater than 75 percent of the samples were correctly predicted to be nontoxic) harmful effects to organisms in association with streambed sediment were adopted as SQG's.

With the exception of using SQG's, MacDonald and others (2000), derived the PEC quotient methodology from a previously published study. Only mean PEC quotients that accurately predicted harmful effects to sediment-dwelling organisms were adopted by MacDonald and others, (2000) based on toxicity tests and mean PEC quotients.

Sediment samples analyzed in NAWQA investigations for organochlorine compounds typically include only sediment particles less than 2 mm in size. Concentrations of organochlorine compounds reported from the analysis of a sediment sample containing particles less than 2 mm may be greater than the concentrations that would have been reported from a whole-sediment sample. Higher concentrations may be expected in a sediment sample containing particles less than 2 mm because (1) the majority of the organochlorine compounds in streambed sediment are

associated with organic matter less than 2 mm in size, and (2) the removal of particulate material greater than 2 mm from a sample would reduce the total mass of the sample without significantly decreasing the total amount of the organochlorine compounds present (Shelton and Capel, 1994).

In addition, trace element concentrations in NAWQA streambed-sediment samples may be greater than those that would be reported in a whole sediment sample. Trace element concentrations may be higher because many trace elements are known to associate with clay particles, and NAWQA sediment samples typically are less than 63 µm in size and contain the majority of clay particles from a whole sediment sample.

Furthermore, the laboratory uses a strong acid digestion for processing trace element samples, which extracts all trace elements associated with clay particles, including those that might not be bioavailable (Dennis R. Helsel, U.S. Geological Survey, written commun., 2001).

Because trace element concentrations may be higher in NAWQA streambed-sediment samples than those reported in whole streambed-sediment samples, comparison of NAWQA data to SQG's may overestimate the potential for harmful effects to organisms associated with streambed sediments. This may not be a real disadvantage, however, since this approach is considered "conservative" and provides early warning of potential problems, thus serving to protect more sensitive species.

Comparisons of concentrations of organochlorine compounds and trace elements in fish-tissue and streambed-sediment samples to land-use percentages in the study basins were done using nonparametric statistical tests. Spearman-rho and Kendall-tau rank correlations at the 95-percent confidence level were calculated, where appropriate, based on the number of sites with concentrations reported. Correlation statistics were calculated by using median concentrations from sites where multiple fish-tissue samples were collected. Information pertaining to the number and type of samples collected at a site are presented in the next section of this report. All data with a remark code of less than (<) were considered nondetects. Comparisons of data were made by using non-normalized data. Data comparisons also were made by using lipid-normalized organochlorine data from fish-tissue samples and percentages of organic carbon normalized trace element data from streambed-sediment samples. The total concentration and total number of organochlorine compounds reported also were related to land use by using rank correlations and medians. Because the results of both correlations were similar, only Spearman-rho rank correlations are presented in this report.

The land-use data used in this report were extracted from the Federal Region 4 portion of the 30-meter resolution land cover data set produced as a cooperative project between the U.S. Environmental Protection Agency and the USGS. The data were developed from Landsat Thematic Mapper Scenes. The cooperative project was one of the Multi-Resolution Land Characteristics (MRLC) Consortium activities (Charles R. Larson, U.S. Geological Survey, written commun., 1998).

Only comparisons to major land-use categories are presented. Land-use categories are considered major if they represent a substantial percentage of a basin's area and have values that range over 10 percent. Major land-use categories in the MOBL Study Unit are urban, agriculture, and forest. Relations to other land uses were considered to be insignificant and are not presented.

Fish-tissue and streambed-sediment sampling results from this investigation were compared to sampling results from 1991 and 1994 NAWQA Study-Unit investigations. Only the first sample from each site sampled nationally was used for comparison with MOBL data. Both the MOBL and national data were censored to a common minimum reporting level (MRL) or laboratory reporting level (LRL) for comparative purposes. Values below the common MRL or LRL were considered as nondetections, whereas values censored above the MRL or LRL were eliminated from comparison. All estimated values were included in the comparisons. For simplicity, MRL's and LRL's will both be referred to as reporting level (RL) throughout the report.

In almost all cases, organochlorine compound and trace element data were censored to the RL currently used (2002) in NWQL investigations. In some instances, it was necessary to censor data at a concentration other than the current RL, because some RL's have changed during the course of the NAWQA Program. In these instances, censoring the data to the current RL would have eliminated all or most of the data from current or previous studies from comparison with national data. A comparison of summary statistics and the frequency with which compounds were

reported both locally and nationally are presented in this report. Summary statistics presented are for data above the RL. In the vast majority of the samples analyzed, concentrations of organochlorine compounds and trace elements were below the RL.

Sampling sites in the NAWQA Program were selected to address specific objectives. For example, sites may have been selected to quantify the extent of known contamination or the effects of a particular land use, to provide for spatial coverage within a basin, or to sample in areas not previously investigated. This sampling approach does not represent a random approach for quantifying conditions nationally. However, these data do provide a frame of reference for comparing data collected in the Mobile River Basin.

Comparing concentration data between fish tissue and streambed sediments can aid in determining bioavailability and the partitioning of organochlorine compounds and trace elements in the environment, provide insight into the value of sampling both media, and give a more complete picture of the occurrence and spatial distribution of organochlorine compounds and trace elements. Comparisons were made between fish-tissue and streambed-sediment samples based on individual and total organochlorine compound concentrations and detection frequencies by using Spearman-rho rank correlations at the 95-percent confidence level. In addition, a comparison between sampling media for trace-element concentrations also was completed. Median concentrations were used to represent sites were multiple fish samples were collected.

ORGANOCHLORINE COMPOUNDS AND TRACE ELEMENTS

Results of the 1998 sampling of fish tissue and streambed sediment at 21 sampling sites in the MOBL Study Unit are presented in this section of the report. The surrogate recoveries for whole-fish tissue and streambed-sediment samples in the MOBL basin are presented in tables 2 and 3, respectively. Recoveries of surrogate compounds in fish-tissue and streambed-sediment samples were less than 80 percent in many of the samples.

Table 2. Percentages of surrogate recoveries for whole-fish tissue samples from the Mobile River Basin

[USGS, U.S. Geological Survey; Blvd., Boulevard; L&D, Lock and Dam]

Site number (fig. 2)	Site name (USGS identification number[a])	Surrogate recovery, in percent	
		α-d_6-Hexachloro-cyclohexane	3,5-Dichloro-biphenyl
1	Coosa River near Rome, GA (02397000)	75, 94	76, 71
2	Chattooga River above Gaylesville, AL (02398300)	69	58
3	Sougahatchee Creek above Reeltown, AL (02418264)	90, 102	80, 66
4	Three Mile Branch at North Blvd. at Montgomery, AL (02419977)	108	100
5	Pintlalla Creek at Liberty Church Road near Pintlalla, AL (02421115)	116	95
6	Cahaba Valley Creek at Cross Creek Road at Pelham, AL (0242354750)	93	81
7	Shades Creek at Homewood, AL (02423581)	109	112
8	Cahaba River at Centreville, AL (02424000)	90	70
9	Alabama River at Claiborne, AL (02429500)	104	66
10	Town Creek at Tupelo, MS (02434000)	100, 109	84, 108
13	Lost Creek above Parrish, AL (02454055)	62, 75, 91	56, 61, 65
14	Locust Fork below Snead, AL (02454500)	96	90
15	Valley Creek near Bessemer, AL (02461500)	93	86
16	Black Warrior River at Bankhead L&D near Bessemer, AL (02462500)	94	84
17	Hurricane Creek near Holt, AL (02463500)	89, 108	88, 86
18	Cribbs Mill Creek at Tuscaloosa, AL (02465288)	75, 78, 84, 98	47, 61, 67, 70
19	Tombigbee River below Coffeeville L&D near Coffeeville, AL (02469762)	68, 97	59, 74
20	Satilpa Creek near Coffeeville, AL (02469800)	91, 94	99, 95
21	Chickasaw Creek near Kushla, AL (02471001)	88	93

[a] USGS identification number is based on geographic location and the downstream order of streamflow sites.

Table 3. Percentages of surrogate recoveries for streambed-sediment samples from the Mobile River Basin

[USGS, U.S. Geological Survey; Blvd., Boulevard; NA, not available; L&D, Lock and Dam]

Site number (fig. 2)	Site name (USGS identification number[a])	Surrogate recovery, in percent		
		α-d_6-Hexachloro-cyclohexane	Octachloro-biphenyl	3,5-Dichloro-biphenyl
1	Coosa River near Rome, GA (02397000)	86	88	94
2	Chattooga River above Gaylesville, AL (02398300)	94	86	117
3	Sougahatchee Creek above Reeltown, AL (02418264)	70	84	70
4	Three Mile Branch at North Blvd. at Montgomery, AL (02419977)	84	93	78
5	Pintlalla Creek at Liberty Church Road near Pintlalla, AL (02421115)	60	78	64
6	Cahaba Valley Creek at Cross Creek Road at Pelham, AL (0242354750)	86	82	94
7	Shades Creek at Homewood, AL (02423581)	92	80	81
8	Cahaba River at Centreville, AL (02424000)	95	88	96
9	Alabama River at Claiborne, AL (02429500)	60	51	52
10	Town Creek at Tupelo, MS (02434000)	71	78	75
11	Buttahatchee River near Aberdeen, MS (02439400)	84	136	NA
12	Bogue Chitto Creek near Memphis, AL (02444490)	62	NA	NA
13	Lost Creek above Parrish, AL (02454055)	68	55	91
14	Locust Fork below Snead, AL (02454500)	94	86	101
15	Valley Creek near Bessemer, AL (02461500)	96	83	NA
16	Black Warrior River at Bankhead L&D near Bessemer, AL (02462500)	94	82	79
17	Hurricane Creek near Holt, AL (02463500)	86	84	94
18	Cribbs Mill Creek at Tuscaloosa, AL (02465288)	99	83	78
19	Tombigbee River below Coffeeville L&D near Coffeeville, AL (02469762)	91	85	83
20	Satilpa Creek near Coffeeville, AL (02469800)	106	83	86
21	Chickasaw Creek near Kushla, AL (02471001)	86	80	102

[a] USGS identification number is based on geographic location and the downstream order of streamflow sites.

The low recoveries of surrogate compounds in some samples may indicate the potential for underestimating concentrations and underdetection of organochlorine compounds in a sample. No correlations could be made, however, between the total concentration of organochlorine compounds or the number of organochlorine compounds reported in samples and the surrogate recovery rates, based on Spearman-rho rank correlations at the 95-percent confidence level. Based on this correlation analysis, the sample results are reported without correction for bias associated with rates of recovery of surrogate compounds.

Fish-Tissue Samples

A total of 30 whole-fish tissue samples were collected from 19 sites and analyzed for organochlorine compounds during this study. Twenty-five fish-liver samples were collected and analyzed for trace elements from 18 sites. Either equipment failure or flow conditions prevented collection of fish-tissue samples at two sites, Buttahatchee (site 11) and Bogue Chitto (site 12) Creeks (fig. 4). Additionally, Three Mile Branch (site 4) did not have enough fish available for both a whole-fish and fish-liver samples, so only a whole-fish sample was collected at this site and analyzed for organochlorine compounds.

An attempt was made to sample the same fish species at all sites. This was not possible, however, because of the diverse environmental settings and the limited number of fish at many of the sites. Therefore, a total of 13 species were collected for analysis of organochlorine compounds from the sites sampled, and multiple species and samples were collected at seven sites for analysis of organochlorine compounds. These sites were Cribbs Mill (site 18), Hurricane (site 17), Lost (site 13), and Sougahatchee (site 3) Creeks and Tombigbee River (site 19) in Alabama; Town Creek

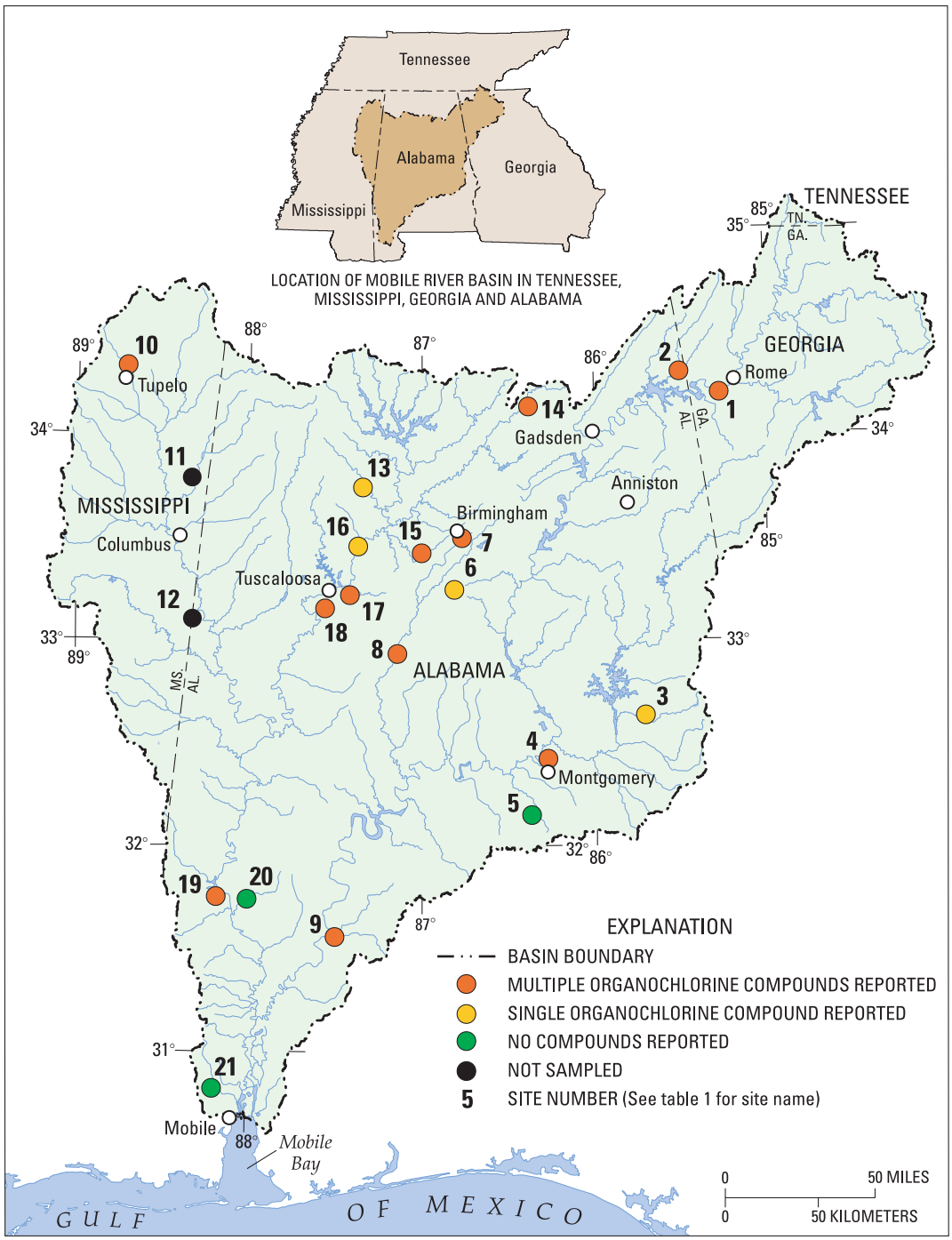


Figure 4. Sites where organochlorine compounds were reported in whole-fish tissue samples in the Mobile River Basin.

(site 10) in Mississippi; and the Coosa River (site 1) in Georgia (Appendix 1). Eleven species were collected for analysis of trace elements. At some of the sites, multiple species and samples were collected for analysis of trace elements in fish-liver tissue samples—Cribbs Mill (site 18), Lost (site 13), and Town (site 10) Creeks, and the Tombigbee River (site 19; Appendix 1).

Although an effort was made to collect fish of the same size and age at each site, variations in age did exist in the fish comprising a sample. The species, weight, age, and number of fish in the composite

samples are listed by site in Appendix 1. Because the samples were composites of fish of varying ages, no analysis of data relative to fish age was conducted. Concentrations of organochlorine compounds and trace elements reported were similar among the samples at a particular site, regardless of the species. For this reason, only median concentrations of organochlorine compounds and trace elements are used for correlations to land use, 1991 and 1994 NAWQA data, and between sampling media. In addition, no analysis of anomaly data is presented because of the limited number of anomalies reported.

The whole-fish tissue samples were analyzed for the presence of 28 organochlorine compounds and 16 (57 percent) were reported (table 4). The organochlorine compounds reported were pentachloroanisole, mirex, *p,p*'-methoxychlor, hexachlorobenzene, endrin, *trans*-chlordane, oxychlordane, *cis*-nonachlor, *p,p*'-DDT, heptachlor epoxide, *cis*-chlordane, *p,p*'-DDD, dieldrin, *trans*-nonachlor, PCB's, and *p,p*'-DDE. All of the organochlorine compounds reported in whole-fish tissues except PCB's are an organochlorine pesticide or related compound. PCB's, used in industry as a plasticizer, lubricant, and dielectric fluid in capacitors and transistors, were reported in the highest concentrations (900 micrograms per kilogram [µg/kg]) in whole-fish tissues of any compound analyzed (U.S. Environmental Protection Agency, 1992). The most frequently reported compound was *p,p*'-DDE, which also was reported at the highest concentration in whole-fish tissue and at more sites (15) than any other pesticide or related compound.

Organochlorine compounds were reported in 24 of the 30 samples (80 percent) analyzed from the 19 sampling sites (Appendix 2). Of these 24 samples, 19 samples (79 percent) contained multiple organochlorine compounds. Five samples contained a single organochlorine compound, and six samples contained no organochlorine compounds (Appendix 2).

Organochlorine compounds were reported at 16 of the 19 sites (84 percent) sampled (fig. 4; table 5). Of these 16 sites, 12 (75 percent) had multiple organochlorine compounds, and 4 sites each had a single organochlorine compound reported. Only three sites had no organochlorine compounds reported (fig. 4). The site with the most organochlorine compounds reported was Cribbs Mill Creek (site 18), where multiple samples were collected. Only one sample was collected at Three Mile Branch (site 4), which had the second highest number of organochlorine compounds reported (table 5). At only two sites, Cribbs Mill Creek (site 18) and Town Creek (site 10), did multiple samples greatly increase the total number of organochlorine compounds reported at the site (fig. 4; table 5; Appendix 2).

All of the 25 fish-liver samples analyzed from the 18 sites sampled had multiple trace elements reported. The samples were analyzed for 22 trace elements, and all except antimony, beryllium, and uranium, or 86 percent, were reported (table 6). The most frequently reported trace elements were aluminum, boron, copper, iron, manganese, selenium, strontium, and zinc (table 6).

Comparison of Concentrations of Organochlorine Compounds and Trace Elements in Whole-Fish Tissue Samples to Standards and Guidelines

Of the 16 organochlorine compounds reported in whole-fish tissue samples, only 13 are included in NAS/NAE or Canadian guidelines (table 7). Comparison to NAS/NAE standards requires the summation of DDT congeners, and the summation of aldrin, BHC (hexachlorocyclohexane), chlordane, dieldrin, endrin, heptachlor, heptachlor epoxide, lindane, and toxaphene residue concentrations (Nowell and Resek, 1994). The sum of all DDT congeners is referred to as total DDT in this report. The sum of aldrin, BHC, chlordane, dieldrin, endrin, heptachlor, heptachlor epoxide, lindane, and toxaphene residues is referred to as chlordane and related compounds in this report when compared to NAS/NAE guidelines.

Chlordane and related compounds exceeded the NAS/NAE-recommended maximum concentration to protect fish-eating wildlife at three sites—Three Mile Branch (site 4), Shades Creek (site 7), and Cribbs Mill Creek (site 18). PCB's exceeded NAS/NAE-recommended maximum concentrations at the Coosa River (site 1) (table 7; fig. 5).

Several of the DDT congeners, singly and in combination, exceeded the Canadian TRG of 14 µg/kg at 13 sites—the Coosa (site 1), Chattooga (site 2), Cahaba (site 8), Alabama (site 9), Black Warrior (site 16), and Tombigbee (site 19) Rivers; Shades (site 7), Town (site 10), Lost (site 13), Hurricane (site 17), and Cribbs Mill (site 18) Creeks; Three Mile Branch (site 4), and Locust Fork (site 14).

Table 4. Reporting frequency and range in concentrations of organochlorine compounds in 30 whole-fish tissue samples from the Mobile River Basin

[µg/kg, microgram per kilogram; <, less than; —, not reported; BHC, hexachlorocyclohexane; DCPA, chlorthaldimethyl; PCB's, polychlorinated biphenyls; NA, not applicable]

Compound	Reporting level, in µg/kg wet weight	Number of detections	Minimum concentration, in µg/kg wet weight	Concentrations, in µg/kg wet weight, within the 25th percentile	Median concentration, in µg/kg wet weight	Concentrations, in µg/kg wet weight, within the 75th percentile	Maximum concentration, in µg/kg wet weight	Number of sites where concentrations were reported
Aldrin	< 5	0	—	—	—	—	—	0
alpha-BHC	< 5	0	—	—	—	—	—	0
beta-BHC	< 5	0	—	—	—	—	—	0
delta-BHC	< 5	0	—	—	—	—	—	0
cis-Chlordane	< 5	9	5.7	6.8	12	36	72	6
trans-Chlordane	< 5	4	8.8	10.4	20	35.5	43	3
DCPA	< 5	0	—	—	—	—	—	0
o,p'-DDD	< 5	0	—	—	—	—	—	0
p,p'-DDD	< 5	10	6.5	9.2	11.5	15	37	6
o,p'-DDE	< 5	0	—	—	—	—	—	0
p,p'-DDE	< 5	23	6.4	18	31	96	550	15
o,p'-DDT	< 5	0	—	—	—	—	—	0
p,p'-DDT	< 5	6	5.3	5.6	11.4	35	39	6
Dieldrin	< 5	11	8.1	15	84	180	720	7
Endrin	< 5	1	10	10	10	10	10	1
Heptachlor	< 5	0	—	—	—	—	—	0
Heptachlor epoxide	< 5	8	5.6	12.4	34	66	220	5
Hexachlorobenzene	< 5	1	5.4	5.4	5.4	5.4	5.4	1
Lindane	< 5	0	—	—	—	—	—	0
o,p'-Methoxychlor	< 5	0	—	—	—	—	—	0
p,p'-Methoxychlor	< 5	1	15	15	15	15	15	1
Mirex	< 5	1	8.6	8.6	8.6	8.6	8.6	1
cis-Nonachlor	< 5	6	4.8	6.6	15	24	29	3
trans-Nonachlor	< 5	13	5.7	11	18	39	130	9
Oxychlordane	< 5	6	7.8	8.2	17.8	31	51	3
Pentachloroanisole	< 5	1	4.8	4.8	4.8	4.8	4.8	1
PCB's	< 50	16	50	74.5	135	240	900	12
Toxaphene	< 200	0	—	—	—	—	—	0
Lipids and sample weight								
Lipids, in percent	NA	30	1.45	2.4	3.35	4.4	10.25	0
Sample weight, in grams	NA	30	10	10	10	10.01	10.04	0

Table 5. Sites in the Mobile River Basin where organochlorine compounds were reported in whole-fish tissue samples

[Site locations are shown in figure 2; number in parentheses is the U.S. Geological Survey downstream order number; PCB's, polychlorinated biphenyls; Blvd., Boulevard; L&D, Lock and Dam]

Site identification and organochlorine compounds reported		
Site 1. Coosa River near Rome, GA (02397000)—4 compounds reported		
p,p'-DDD	*p,p*'-DDT	
p,p'-DDE	PCB's	
Site 2. Chattooga River above Gaylesville, AL (02398300)—2 compounds reported		
p,p'-DDE	PCB's	
Site 3. Sougahatchee Creek above Reeltown, AL (02418264)—1 compound reported		
p,p'-DDE		
Site 4. Three Mile Branch at North Blvd. at Montgomery, AL (02419977)—11 compounds reported		
cis-Chlordane	*p,p*'-DDT	*trans*-Nonachlor
trans-Chlordane	*cis*-Nonachlor	Oxychlordane
p,p'-DDD	Heptachlor epoxide	PCB's
p,p'-DDE	Dieldrin	
Site 6. Cahaba Valley Creek at Cross Creek Road at Pelham, AL (0242354750)—1 compound reported		
trans-Nonachlor		
Site 7. Shades Creek at Homewood, AL (02423581)—8 compounds reported		
cis-Chlordane	Heptachlor epoxide	PCB's
p,p'-DDE	*trans*-Nonachlor	*cis*-Nonachlor
Dieldrin	Oxychlordane	
Site 8. Cahaba River at Centreville, AL (02424000)—6 compounds reported		
cis-Chlordane	Dieldrin	Pentachloroanisole
p,p'-DDE	*trans*-Nonachlor	PCB's
Site 9. Alabama River at Claiborne, AL (02429500)—6 compounds reported		
p,p'-DDD	*p,p*'-DDT	Hexachlorobenzene
p,p'-DDE	Endrin	PCB's
Site 10. Town Creek at Tupelo, MS (02434000)—9 compounds reported		
cis-Chlordane	*p,p*'-DDT	Mirex
p,p'-DDD	Dieldrin	*trans*-Nonachlor
p,p'-DDE	Heptachlor epoxide	PCB's
Site 13. Lost Creek above Parrish, AL (02454055)—1 compound reported		
p,p'-DDE		
Site 14. Locust Fork below Snead, AL (02454500)—4 compounds reported		
p,p'-DDE	*trans*-Nonachlor	
p,p'-DDT	PCB's	
Site 15. Valley Creek near Bessemer, AL (02461500)—6 compounds reported		
cis-Chlordane	*p,p*'-DDE	*trans*-Nonachlor
trans-Chlordane	Dieldrin	PCB's
Site 16. Black Warrior River at Bankhead L&D near Bessemer, AL (02462500)—1 compound reported		
p,p'-DDE		
Site 17. Hurricane Creek near Holt, AL (02463500)—5 compounds reported		
p,p'-DDE	Heptachlor epoxide	PCB's
Dieldrin	*trans*-Nonachlor	
Site 18. Cribbs Mill Creek at Tuscaloosa, AL (02465288)—12 compounds reported		
cis-Chlordane	*p,p*'-DDT	Oxychlordane
trans-Chlordane	Heptachlor epoxide	PCB's
p,p'-DDD	*cis*-Nonachlor	Dieldrin
p,p'-DDE	*trans*-Nonachlor	*p,p'*-Methoxychlor
Site 19. Tombigbee River below Coffeeville L&D near Coffeeville, AL (02469762)—3 compounds reported		
p,p'-DDD	*p,p*'-DDE	
PCB's		

Table 6. Reporting frequency and range in concentrations of trace elements in 25 fish-liver samples from the Mobile River Basin

[µg/g, microgram per gram; <, less than; —, not reported]

Trace element	Reporting level, in µg/g dry weight	Number of detections	Minimum concentration, in µg/g dry weight	Concentrations, in µg/g dry weight, within the 25th percentile	Median concentration, in µg/g dry weight	Concentrations, in µg/g dry weight, within the 75th percentile	Maximum concentration, in µg/g dry weight	Number of sites where concentrations were reported
Aluminum	< 1	25	1.10	5.09	8.22	12.58	180.17	18
Antimony	< .1	0	—	—	—	—	—	0
Arsenic	< .1	12	.34	.42	.69	1.17	2.70	9
Barium	< .1	19	.10	.14	.26	.39	5.65	14
Beryllium	< .1	0	—	—	—	—	—	0
Boron	< .2	25	.84	1.19	2.90	5.63	20.52	18
Cadmium	< .1	16	.29	.54	.78	2.25	10.90	13
Chromium	< .5	12	.52	.63	.72	.86	1.34	11
Cobalt	< .1	17	.37	.65	1.01	1.99	2.81	13
Copper	< .5	25	4.39	8.59	12.82	34.91	151.63	18
Iron	< 1	25	146.23	608.94	758.29	1,010.20	2,066.10	18
Lead	< .1	2	.21	.21	.33	.44	.44	2
Manganese	< .1	25	3.30	4.77	6.49	8.47	30.01	18
Mercury	< .1	13	.04	.07	.24	.58	1.80	9
Molybdenum	< .1	18	.46	.77	.98	1.09	1.77	13
Nickel	< .1	4	.29	.39	.53	.78	.98	4
Selenium	< .1	25	3.31	5.62	7.14	9.18	19.56	18
Silver	< .1	3	.29	.29	.43	1.10	1.10	3
Strontium	< .1	25	.14	.59	.78	1.33	3.21	18
Uranium	< .1	0	—	—	—	—	—	0
Vanadium	< .1	20	.34	.76	1.19	1.51	3.21	15
Zinc	< .5	25	60.00	82.56	89.99	108.57	800.64	18

Table 7. Comparison of concentrations of organochlorine compounds in whole-fish tissue samples from the Mobile River Basin with standards and guidelines

[µg/kg, microgram per kilogram; NAS/NAE, National Academy of Science and National Academy of Engineering; ng/kg, nanogram per kilogram; site locations are shown in figure 2]

Compound	Standard concentration, in µg/kg wet weight	Sites where standards or guidelines were exceeded	Concentration in whole-fish tissue sample, in µg/kg wet weight
NAS/NAE-recommended maximum concentration			
Chlordane and related compounds	100	Three Mile Branch (site 4)	508
		Shades Creek (site 7)	316
		Cribbs Mill Creek (site 18)[a]	1,205; 257.1; 250.4; 344.8
Polychlorinated biphenyls (PCB's)	500	Coosa River (site 1)[a]	530, 900

[a] Multiple samples were collected and analyzed at this site.

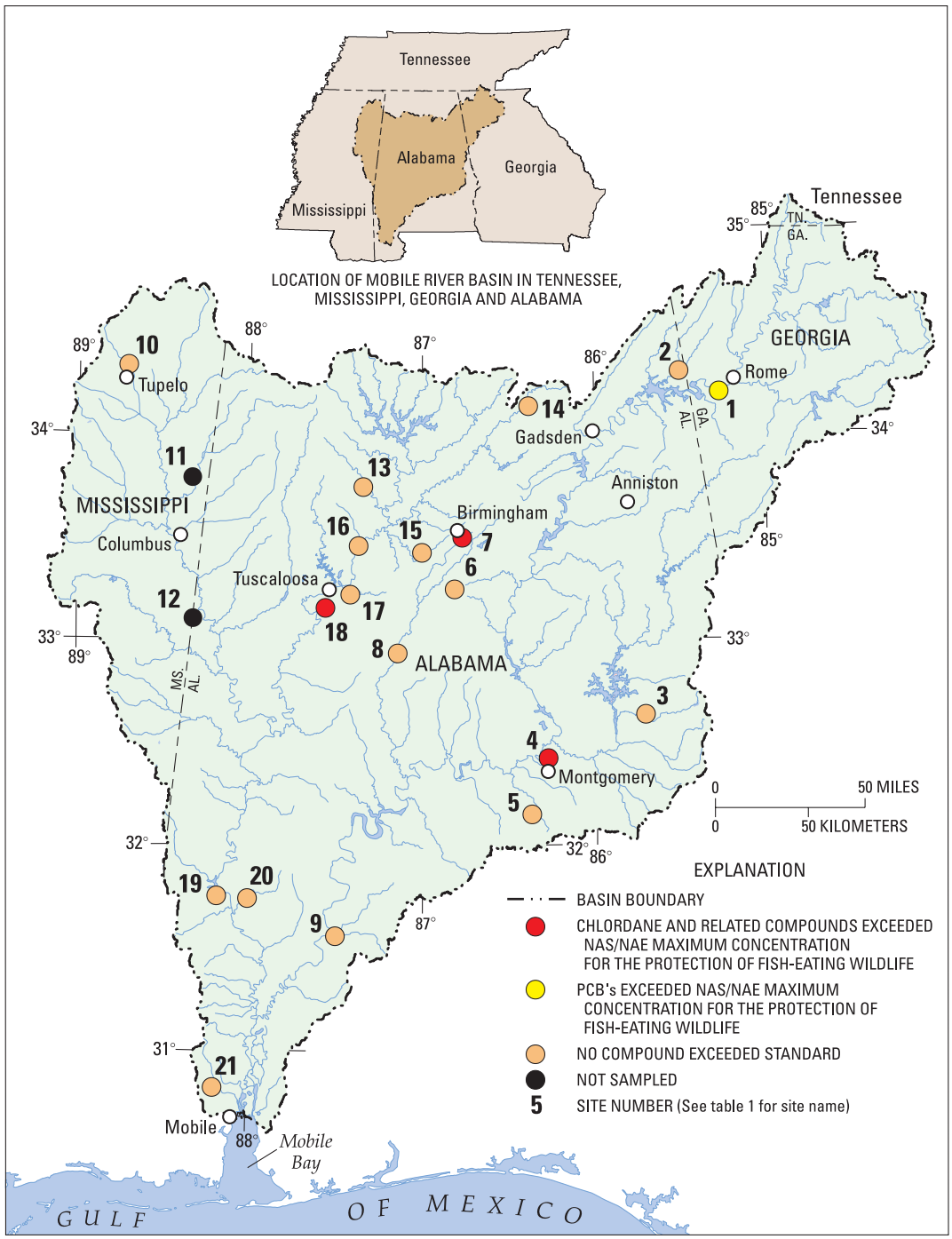


Figure 5. Sites in the Mobile River Basin where concentrations of organochlorine compounds in whole-fish tissue exceeded National Academy of Science and National Academy of Engineering guidelines for piscivorous wildlife.

No NAS/NAE or Canadian standards currently exist for trace-element concentrations in fish-liver tissue. However, standards do exist for selected trace elements in fish tissues other than liver. For example, the U.S. Food and Drug Administration has established

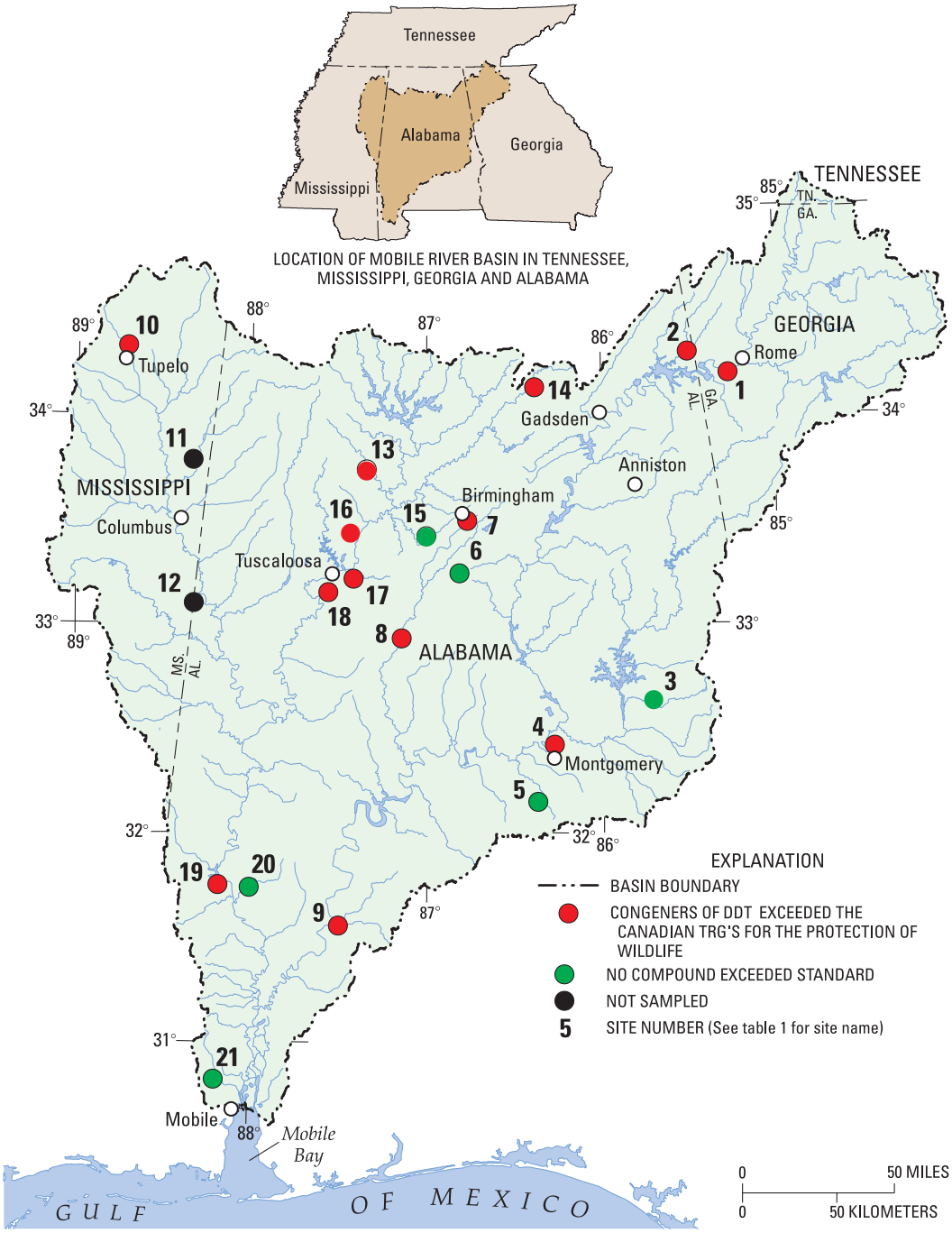


Figure 6. Sites in the Mobile River Basin where concentrations of organochlorine compounds in whole-fish tissue exceeded Canadian tissue residue guidelines (TRG's) for the protection of wildlife.

standards for mercury concentrations in edible fish for the protection of human health, and the U.S. Department of the Interior (1998) has presented concentrations for several trace elements, above which adverse effects could occur to wildlife.

Relation of Organochlorine Compounds and Trace Elements in Whole-Fish Tissue Samples to Land Use

Individual concentrations of organochlorine compounds, total DDT, the sum of *cis*- and *trans*-chlordane, *cis*- and *trans*-nonachlor, and oxychlordane (referred to as chlordane), total concentrations of organochlorine compounds, and the total number of organochlorine compounds reported in whole-fish tissue samples were related to land use by using a Spearman-rho rank correlation at the 95-percent confidence level. Normalizing the data to the percentage of lipid content in a sample did not alter the correlations substantially. Only non-normalized concentration data are presented in further discussions in this report. For sites where multiple samples were collected, median concentrations were used for correlation analysis.

Total DDT, chlordane, and heptachlor epoxide concentrations in whole-fish tissue samples were correlated with land use. Total DDT was positively correlated to agricultural land use (table 8). Chlordane and heptachlor epoxide were positively correlated to urban land use and negatively correlated to forested land use. In addition, total concentrations of organochlorine compounds and numbers of organochlorine compounds reported were negatively correlated to forested land use (table 8).

Based on Spearman-rho rank correlation analysis and a 95-percent confidence level, there was an apparent relation between concentrations of three trace elements analyzed in fish-liver tissue and land use. The three trace elements were aluminum, zinc, and selenium (table 9). Selenium and zinc showed a negative relation to agricultural land use, and aluminum had a negative relation to urban land use in a basin (table 9).

Table 8. Spearman-rho rank correlations of land use and concentrations of organochlorine compounds in whole-fish tissue samples from the Mobile River Basin

[—, no correlation; NA, not applicable]

	Correlation with percentage of land use				
	Total DDT	Heptachlor epoxide	Chlordane	Total concentration	Total number of compounds reported
Urban land use					
Spearman-rho statistic	—	0.900	0.667	—	—
p-value	—	.037	.050	—	—
Number of sites where reported	NA	5	9	NA	NA
Agricultural land use					
Spearman-rho statistic	0.714	—	—	—	—
p-value	.003	—	—	—	—
Number of sites where reported	15	NA	NA	NA	NA
Forested land use					
Spearman-rho statistic	—	– 0.900	– 0.667	– 0.656	– 0.691
p-value	—	.037	.050	.006	.003
Number of sites where reported	NA	5	9	16	16

Table 9. Spearman-rho rank correlations of land use and concentrations of trace elements in fish-liver tissue samples from the Mobile River Basin

[—, no correlation; NA, not applicable]

	Correlation with percentage of land use		
	Aluminum	Selenium	Zinc
Urban land use			
Spearman-rho statistic	– 0.507	—	—
p-value	.032	—	—
Number of sites where reported	18	NA	NA
Agricultural land use			
Spearman-rho statistic	—	– 0.476	– 0.474
p-value	—	.046	.045
Number of sites where reported	NA	18	18

Comparison of Concentrations of Organochlorine Compounds and Trace Elements in Fish-Tissue Samples to 1991 and 1994 National Water-Quality Assessment Program Study-Unit Data

Whole-fish tissue samples from 504 sites in the 1991 and 1994 NAWQA Study-Unit investigations throughout the United States were analyzed at the selected RL's for concentrations of 28 organochlorine compounds. Of these 28 compounds, 27 (96 percent) were reported nationally, whereas 54 percent were reported locally. Aldrin was the only compound not reportednationally. Aldrin also was not reported in the MOBL basin. The most frequently reported compound nationally (81 percent of sites) as well as in the MOBL Study Unit (79 percent of sites) was *p-p*'-DDE (tables 4, 10).

Fifteen of the 27 organochlorine compounds were reported in whole-fish tissue samples from less than 10 percent of the national NAWQA sites—DCPA, *o,p*'-DDE, *o,p*'-DDT, endrin, *alpha*-BHC, *beta*-BHC, *delta*-BHC, heptachlor, hexachlorobenzene, lindane, *p,p*'-methoxychlor, *o,p*'-methoxychlor, mirex, pentachloroanisole, and toxaphene. Four of these 15 organochlorine compounds also were reported at less than 10 percent of the sites sampled in the MOBL Study Unit—endrin, hexachlorobenzene, *p,p*'-methoxychlor, and mirex. The remaining organochlorine compounds reported nationally at less than 10 percent of the sites sampled were not reported in samples from the MOBL basin. Because of the low reporting frequency of these compounds nationally, the probability of detecting these compounds in the Mobile River Basin is low.

Twelve organochlorine compounds were reported at more than 10 percent of the national NAWQA sites. These compounds were *cis*-chlordane, *trans*-chlordane, *o,p*'-DDD, *p,p*'-DDD, *p-p*'-DDE, *p,p*'-DDT, dieldrin, heptachlor epoxide, *cis*-nonachlor, *trans*-nonachlor, oxychlordane, and PCB's. All of these organochlorine compounds except *o,p*'-DDD, which was not reported in the MOBL, also were reported at 10 percent or more of the MOBL sites.

Minimum, 25th percentile, median, and 75th percentile concentrations of several organochlorine compounds reported in whole-fish tissue nationally were lower than those in the MOBL basin (table 10; fig. 7). These differences in concentrations may be the result of greater use of DDT and chlordane in the MOBL basin than in other parts of the country. The majority of the compounds with higher concentrations were DDT and chlordane or their related compounds. These differences in concentration, however, could be a result of the greater range in concentrations assessed nationally, or due to the limited number of samples collected in the MOBL, compared to the number of samples collected nationally. Otherwise, concentrations reported in whole-fish tissue in the MOBL River Basin are less than or similar to (within 1 µg/kg) those reported nationally.

Maximum concentrations of organochlorine compounds in fish-tissue samples typically were higher nationally than in the MOBL Study Unit, excluding heptachlor epoxide. Concentrations of organochlorine compounds nationally might be expected to be higher than those in the MOBL Study Unit because of site-selection criteria used in some NAWQA Study Units. In order to quantify conditions in the study basins, some national NAWQA sites were selected based on the known or suspected presence of organochlorine compound contamination in streams. Concentrations

Table 10. Summary data for organochlorine compounds in whole-fish tissue samples from the Mobile River Basin and from 1991 and 1994 National Water-Quality Assessment Program Study Units nationwide

[µg/kg, microgram per kilogram; MOBL, Mobile River Basin Study Unit; —, not reported; BHC, hexachlorocyclohexane; DCPA, chlorthaldimethyl; PCB's, polychlorinated biphenyls]

Compound and reporting level	Data source and number of sites	Number of sites where concentrations were reported	Minimum concentration, in µg/kg wet weight	Concentrations, in µg/kg wet weight, within the 25th percentile	Median concentration, in µg/kg wet weight	Concentrations, in µg/kg wet weight, within the 75th percentile	Maximum concentration, in µg/kg wet weight	Frequency of detection, in percent
Aldrin	MOBL (19 sites)	0	—	—	—	—	—	0
5 µg/kg	National (502 sites)	0	—	—	—	—	—	0
alpha-BHC	MOBL (19 sites)	0	—	—	—	—	—	0
5 µg/kg	National (486 sites)	1	5.4	5.4	5.4	5.4	5.4	0.2
beta-BHC	MOBL (19 sites)	0	—	—	—	—	—	0
5 µg/kg	National (472 sites)	3	5.4	5.5	5.7	5.8	5.9	.6
delta-BHC	MOBL (19 sites)	0	—	—	—	—	—	0
5 µg/kg	National (464 sites)	3	5.5	5.7	6.4	16.5	19.9	.6
cis-Chlordane	MOBL (19 sites)	6	5.7	6.8	18	25.5	36	31.6
5 µg/kg	National (491 sites)	169	5	8.7	13	23.2	230	34.4
trans-Chlordane	MOBL (19 sites)	3	8.8	8.8	12	35.5	35.5	15.8
5 µg/kg	National (495 sites)	115	5	6.9	10	20	140	23.2
DCPA	MOBL (19 sites)	0	—	—	—	—	—	0
5 µg/kg	National (493 sites)	23	5	5.9	12	32.8	78	4.7
o,p'-DDD	MOBL (19 sites)	0	—	—	—	—	—	0
5 µg/kg	National (474 sites)	54	5	6.7	9.2	20	360	11.4
p,p'-DDD	MOBL (19 sites)	6	7.8	9.3	12.2	16.5	37	31.6
5 µg/kg	National (477 sites)	226	5.1	10	20	41	2,000	47.4
o,p'-DDE	MOBL (19 sites)	0	—	—	—	—	—	0
5 µg/kg	National (464 sites)	22	5.1	7.5	15.5	22	130	4.7
p,p'-DDE	MOBL (19 sites)	15	6.4	23	25.5	100	550	78.9
5 µg/kg	National (504 sites)	408	5	18	48	130	7,300	81.0
o,p'-DDT	MOBL (19 sites)	0	—	—	—	—	—	0
5 µg/kg	National (461 sites)	20	5.1	5.9	16.5	25.5	140	4.3
p,p'-DDT	MOBL (19 sites)	6	5.3	5.6	11.4	35	39	31.6
5 µg/kg	National (472 sites)	126	5.2	7.4	14.5	30	430	26.7
Dieldrin	MOBL (19 sites)	7	8.1	15	25	180	240	36.8
5 µg/kg	National (488 sites)	184	5	8.6	17.5	33	390	37.7

Table 10. Summary data for organochlorine compounds in whole-fish tissue samples from the Mobile River Basin and from 1991 and 1994 National Water-Quality Assessment Program Study Units nationwide—Continued

[µg/kg, microgram per kilogram; MOBL, Mobile River Basin Study Unit; —, not reported; BHC, hexachlorocyclohexane; DCPA, chlorthaldimethyl; PCB's, polychlorinated biphenyls]

Compound and reporting level	Data source and number of sites	Number of sites where concentrations were reported	Minimum concentration, in µg/kg wet weight	Concentrations, in µg/kg wet weight, within the 25th percentile	Median concentration, in µg/kg wet weight	Concentrations, in µg/kg wet weight, within the 75th percentile	Maximum concentration, in µg/kg wet weight	Frequency of detection, in percent
Endrin 5 µg/kg	MOBL (18 of 19 sites)	1	10	10	10	10	10	5.6
	National (463 sites)	4	9.2	9.6	13	18.5	21	.9
Heptachlor 5 µg/kg	MOBL (19 sites)	0	—	—	—	—	—	0
	National (502 sites)	2	11	11	11.5	12	12	.4
Heptachlor epoxide 5 µg/kg	MOBL (19 sites)	5	5.6	6.8	18	41	85	26.3
	National (495 sites)	55	5	7.7	11	18.5	44	11.1
Hexachlorobenzene 5 µg/kg	MOBL (19 sites)	1	5.4	5.4	5.4	5.4	5.4	5.3
	National (497 sites)	25	5	6.4	9.1	13.2	33	5.0
Lindane 5 µg/kg	MOBL (19 sites)	0	—	—	—	—	—	0
	National (485 sites)	14	5.6	7.7	8.5	12	17	2.9
o,p'-Methoxychlor 5 µg/kg	MOBL (19 sites)	0	—	—	—	—	—	0
	National (457 sites)	1	9.6	9.6	9.6	9.6	9.6	.2
p,p'-Methoxychlor 5 µg/kg	MOBL (19 sites)	1	15	15	15	15	15	5.3
	National (464 sites)	1	8.2	8.2	8.2	8.2	8.2	.2
Mirex 5 µg/kg	MOBL (19 sites)	1	8.6	8.6	8.6	8.6	8.6	5.3
	National (495 sites)	8	5.1	6.0	27	55	96	1.6
cis-Nonachlor 5 µg/kg	MOBL (19 sites)	3	11	11	19	29	29	15.8
	National (485 sites)	108	5.1	6.6	9.0	13	53	22.3
trans-Nonachlor 5 µg/kg	MOBL (19 sites)	9	8.2	11	13	28	130	47.4
	National (482 sites)	212	5	8.8	14.5	27	220	44.0
Oxychlordane 5 µg/kg	MOBL (19 sites)	3	8.8	8.8	31	51	51	15.8
	National (495 sites)	81	5.2	7.2	9.7	14	67	16.4
Pentachloroanisole 5 µg/kg	MOBL (19 sites)	0	—	—	—	—	—	0
	National (490 sites)	38	5	5.6	7.2	14	87	7.8
Total PCB's 5 µg/kg	MOBL (19 sites)	12	50	85.8	145	240	715	63.2
	National (504 sites)	251	50	90.2	160	380	72,000	49.8
Toxaphene 5 µg/kg	MOBL (19 sites)	0	—	—	—	—	—	0
	National (482 sites)	21	210	537.5	950	2,025	12,000	4.4

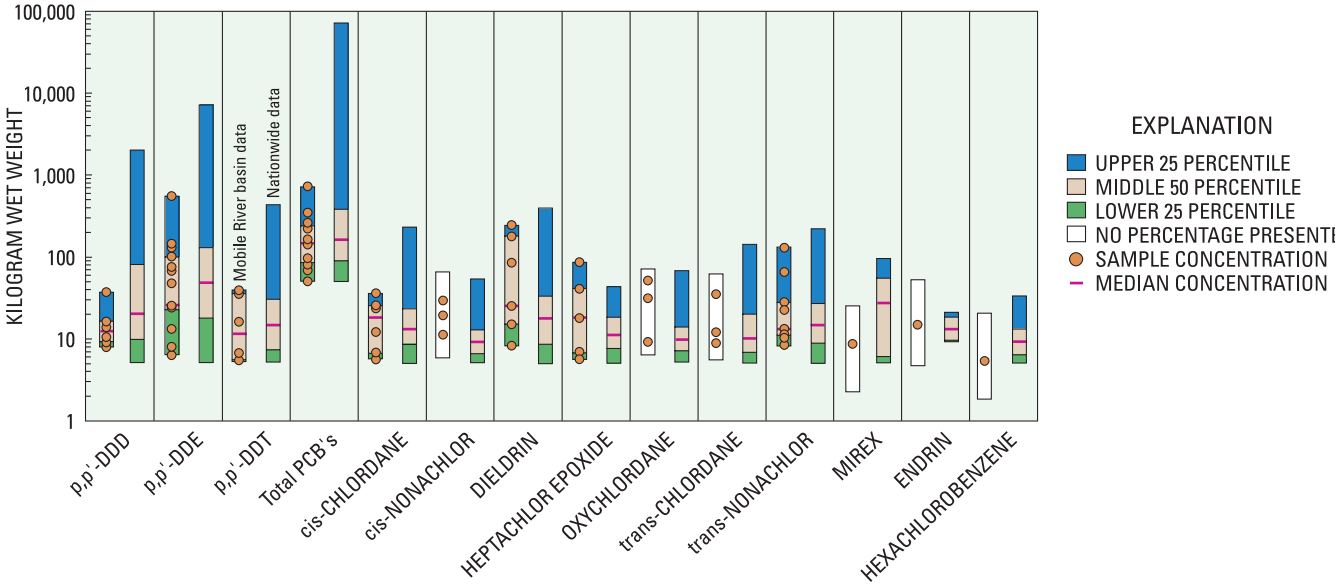


Figure 7. Floating bar charts of statistical distributions of concentrations of organochlorine compounds in whole-fish tissue samples from the Mobile River Basin and in 1991 and 1994 National Water-Quality Assessment Program Study-Unit data.

of heptachlor epoxide are probably higher in samples from the MOBL because of the intensive use of chlordane for termite control locally.

In addition, the frequency at which organochlorine compounds were reported in the MOBL basin was either similar to (less than 5 percent difference in reporting frequency between local and national data) or less than for national data, excluding total PCB's, *p,p*'-DDT, and heptachlor epoxide (table 10). Total PCB's, *p,p*'-DDT, and heptachlor epoxide were reported more frequently in the MOBL than nationally (greater than 5 percent difference in reporting frequency between local and national data). Reasons for these difference in reporting frequency, at least when considering *p,p*'-DDT and heptachlor epoxide, are also probably a result of the historical use of DDT and chlordane in the Mobile River Basin.

Fish-liver samples from approximately 285 sites from the 1991 and 1994 NAWQA Study Units were analyzed for 22 trace elements, and all except beryllium (95 percent) were reported (table 11). Fish-liver samples from the MOBL were analyzed for the same trace elements, and all except antimony, beryllium, and uranium (86 percent) were reported. Antimony and uranium were reported in fish-liver samples from only 6 percent of the sites nationally (table 11). Because of the low reporting frequency of these trace elements in fish-liver tissues nationally, detections of these trace elements likely would not be expected in the MOBL Study Unit.

Maximum trace-element concentrations in fish-liver tissue reported in the 1991 and 1994 NAWQA Study Unit samples typically were higher than those in the MOBL Study Unit, and sometimes substantially higher (table 10; fig. 8). This difference may be a result of site-selection criteria used in some NAWQA Study Units to quantify sites with suspected or known contamination and different rock types in other parts of the Nation. Nationally, minimum, 25th percentile, median, and 75th percentile concentrations of several trace elements in fish-liver samples were lower than those from the MOBL Study Unit probably because of the greater range in concentrations quantified nationally. Boron was the only trace element from the MOBL basin with concentrations consistently higher than those reported nationally. Geological sources of boron are typically associated with the western half of the United States and probably do not account for these higher concentrations (Hulbert and Klein, 1977). Other sources for boron in the MOBL basin include borax in soaps, antiseptics, and preservatives and many metallurgical processes (Hulbert and Klein, 1977).

The frequency with which trace elements were reported in fish-liver tissue was generally similar between MOBL and national samples (less than 5 percent difference in reporting frequency between local and national data). The only exceptions were aluminum, barium, chromium, cobalt, lead, nickel, and strontium, which were reported more frequently in the MOBL than nationally.

Table 11. Summary data for trace elements in fish-liver tissue samples from the Mobile River Basin and from 1991 and 1994 National Water-Quality Assessment Program Study Units nationwide

[µg/g, microgram per gram; MOBL, Mobile River Basin Study Unit; —, not reported]

Trace element and reporting level	Data source and number of sites	Number of sites where concentrations were reported	Minimum concentration, in µg/g dry weight	Concentrations, in µg/g dry weight, within the 25th percentile	Median concentration, in µg/g dry weight	Concentrations, in µg/g dry weight, within the 75th percentile	Maximum concentration, in µg/g dry weight	Frequency of detection, in percent
Aluminum 1 µg/g	MOBL (18 sites)	18	1.10	6.72	10.50	14.99	91.86	100
	National (281 sites)	180	1.1	2.90	6.58	18.05	1,280	64.06
Antimony 0.2 µg/g	MOBL (2 sites)	0	—	—	—	—	—	0
	National (31 sites)	2	.20	.20	.20	.20	.20	6.45
Arsenic 0.1 µg/g	MOBL (9 sites)	9	.38	.60	.72	.98	2.70	100
	National (189 sites)	180	.14	.30	.40	.53	3.80	95.24
Barium 0.1 µg/g	MOBL (18 sites)	14	.11	.14	.27	.39	3.06	77.78
	National (281 sites)	153	.10	.14	.20	.50	82.10	54.45
Beryllium 0.1 µg/g	MOBL (18 sites)	0	—	—	—	—	—	0
	National (280 sites)	0	—	—	—	—	—	0
Boron 0.2 µg/g	MOBL (18 sites)	18	.84	1.19	2.64	5.72	20.52	100
	National (280 sites)	258	.23	.50	.70	1.10	4.60	92.14
Cadmium 0.1 µg/g	MOBL (13 sites)	13	.29	.57	.71	1.77	10.90	100
	National (238 sites)	236	.20	.60	1.50	4.10	58.10	99.16
Chromium 0.5 µg/g	MOBL (18 sites)	11	.52	.64	.75	.87	1.34	61.11
	National (280 sites)	150	.54	.60	.70	.80	2.60	53.57
Cobalt 0.1 µg/g	MOBL (13 sites)	13	.52	.90	1.24	1.93	2.81	100
	National (171 sites)	160	.13	.20	.31	.67	3.80	93.57
Copper 0.5 µg/g	MOBL (18 sites)	18	4.58	9.80	12.59	48.23	151.63	100
	National (281 sites)	281	1.40	22.50	55.90	92.10	552	100
Iron 0.1 µg/g	MOBL (18 sites)	18	146.23	657.35	765.61	987.98	2,066.10	100
	National (281 sites)	281	104	349	544	891	18,200	100
Lead 0.1 µg/g	MOBL (2 sites)	2	.21	.21	.32	.44	.44	100
	National (97 sites)	77	.14	.22	.32	.50	5.40	79.38

Table 11. Summary data for trace elements in fish-liver tissue samples from the Mobile River Basin and from 1991 and 1994 National Water-Quality Assessment Program Study Units nationwide—Continued

[µg/g, microgram per gram; MOBL, Mobile River Basin Study Unit; —, not reported]

Trace element and reporting level	Data source and number of sites	Number of sites where concentrations were reported	Minimum concentration, in µg/g dry weight	Concentrations, in µg/g dry weight, within the 25th percentile	Median concentration, in µg/g dry weight	Concentrations, in µg/g dry weight, within the 75th percentile	Maximum concentration, in µg/g dry weight	Frequency of detection, in percent
Manganese 0.1 µg/g	MOBL (18 sites)	18	3.30	4.77	6.66	11.21	30.01	100
	National (281 sites)	281	.70	4.40	5.90	8	542	100
Mercury 0.1 µg/g	MOBL (10 sites)	6	.24	.39	.53	1.64	1.80	60
	National (285 sites)	180	.11	.19	.24	.40	112	63.16
Molybdenum 0.1 µg/g	MOBL (13 sites)	13	.46	.80	1.03	1.18	1.77	100
	National (277 sites)	277	.30	.90	1.10	1.40	6.70	100
Nickel 0.1 µg/g	MOBL (4 sites)	4	.29	.38	.53	.78	.98	100
	National (140 sites)	128	.20	.30	.40	.80	7.37	91.43
Selenium 0.1 µg/g	MOBL (18 sites)	18	3.31	5.71	7.40	9.18	19.56	100
	National (273 sites)	273	1.30	3.90	5.30	7.30	76	100
Silver 0.1 µg/g	MOBL (3 sites)	3	.29	.29	.43	1.10	1.10	100
	National (172 sites)	169	.15	.30	.60	.90	19.70	98.26
Strontium 0.1 µg/g	MOBL (18 sites)	18	.14	.58	.82	1.38	2.42	100
	National (281 sites)	254	.13	.30	.50	.80	40.30	90.39
Uranium 0.1 µg/g	MOBL (2 sites)	0	—	—	—	—	—	0
	National (31 sites)	2	.20	.20	.35	.50	.50	6.45
Vanadium 0.1 µg/g	MOBL (15 sites)	15	.34	.75	1.30	1.62	3.21	100
	National (214 sites)	212	.18	.50	.80	1.22	9.90	99.07
Zinc 0.5 µg/g	MOBL (18 sites)	18	60.00	83.60	100.40	108.57	443.74	100
	National (281 sites)	281	34.69	85.12	123	524	1,950	100

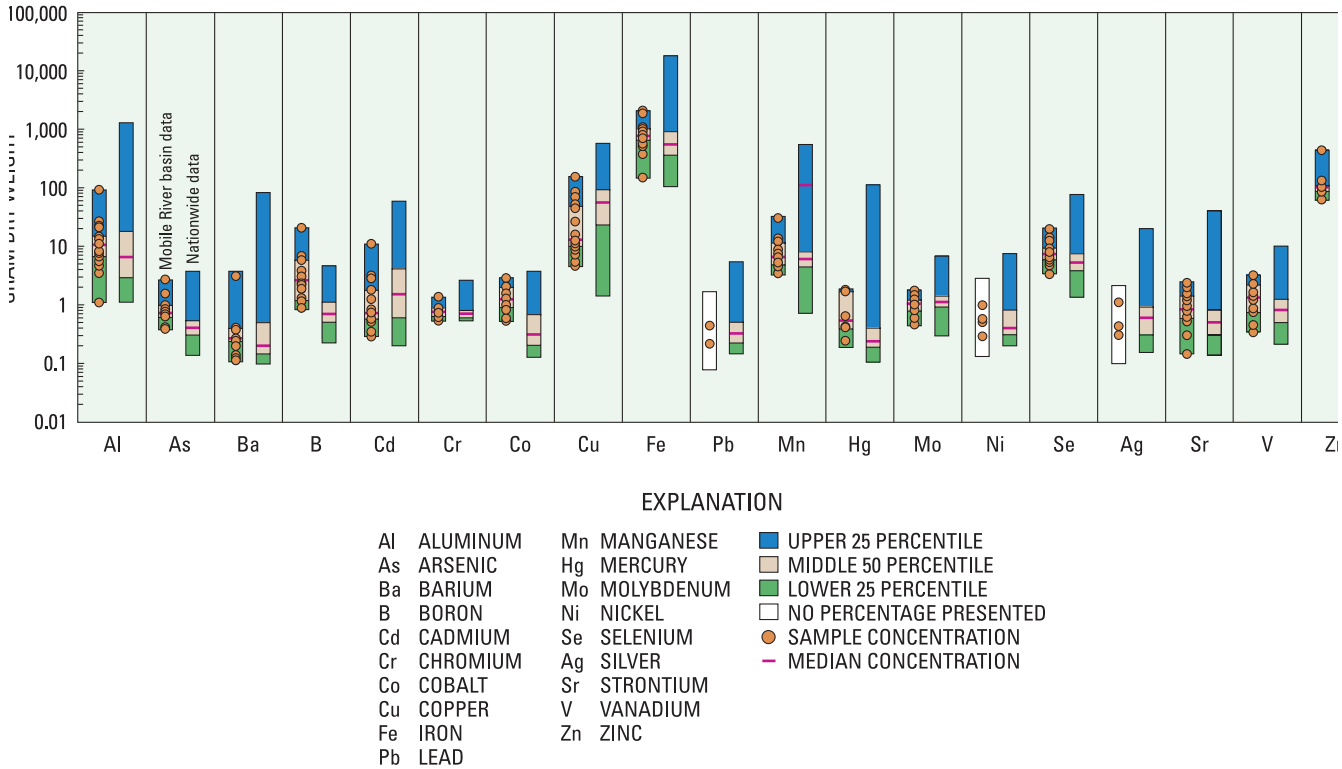


Figure 8. Floating bar charts of statistical distributions of concentrations of trace elements in fish-liver tissue samples from the Mobile River Basin and in 1991 and 1994 National Water-Quality Assessment Program Study-Unit data.

Streambed-Sediment Samples

During this study, 21 streambed-sediment samples from 21 sites were collected and analyzed for organochlorine compounds and trace elements. Sediment samples were collected at one site, Bogue Chitto Creek (site 12), in 1999. Sampling at this site was postponed during 1998 because of low-flow conditions.

Of the 21 streambed-sediment samples analyzed, 11 (52 percent) contained concentrations of organochlorine compounds (tables 12, 13). Five of these 11 streambed-sediment samples (45 percent) contained multiple organochlorine compounds, and 6 samples (55 percent) contained a single compound (fig. 9). No organochlorine compounds were reported in 10 of the streambed-sediment samples (48 percent). The greatest number of organochlorine compounds were reported in the Valley Creek sample (site 15, table 13).

Of the 32 organochlorine compounds analyzed in 21 streambed-sediment samples, 13 (41 percent) were reported (table 12). The organochlorine compounds reported were *p*, *p*' -DDE, *p*, *p*' -DDD, *trans*-chlordane, *cis*-chlordane, *trans*-nonachlor, *p,p*'-DDT, dieldrin, PCB's, *cis*-nonachlor, oxychlordane, *o,p*'-DDD, *o,p*'-DDT, and *o,p*'-DDE. The most frequently reported compound was *p,p*'-DDE. PCB's had the highest concentration reported.

All of the organochlorine compounds reported in streambed-sediment samples except one, PCB's, are organochlorine pesticides or related compounds. PCB's were used in industry as a plasticizer, lubricant, and dielectric fluid in capacitors and transistors (U.S. Environmental Protection Agency, 1992).

Multiple trace elements were reported in all 21 samples analyzed from the 21 sites. MOBL streambed-sediment samples were analyzed for 44 trace elements, and all but 8 (82 percent) were reported in all samples (table 14). A total of 98 percent of the trace elements analyzed were reported. Gold was the only trace element not reported, and bismuth was reported at one site only.

Table 12. Reporting frequency and range in concentrations of organochlorine compounds in 21 streambed-sediment samples from the Mobile River Basin

[µg/kg, microgram per kilogram; <, less than; —, not reported; BHC, hexachlorocyclohexane; DCPA, chlorthaldimethyl; PCB's, polychlorinated biphenyls]

Compound	Reporting level, in µg/kg dry weight	Number of detections	Minimum concentration, in µg/kg dry weight	Concentrations, in µg/kg dry weight, within the 25th percentile	Median concentration, in µg/kg dry weight	Concentrations, in µg/kg dry weight, within the 75th percentile	Maximum concentration, in µg/kg dry weight	Number of sites where concentrations were reported
Aldrin	< 1	0	—	—	—	—	—	0
alpha-BHC	< 1	0	—	—	—	—	—	0
beta-BHC	< 1	0	—	—	—	—	—	0
delta-BHC	< 1	0	—	—	—	—	—	0
cis-Chlordane	< 2	4	1	2	2	8	14	4
trans-Chlordane	< 1	5	2	2	2	3	25	5
Chloroneb	< 5	0	—	—	—	—	—	0
DCPA	< 5	0	—	—	—	—	—	0
o,p'-DDD	< 1	1	7	7	7	7	7	1
p,p'-DDD	< 1	5	1	2	3	4	19	5
o,p'-DDE	< 1	1	7	7	7	7	7	1
p,p'-DDE	< 1	7	1	2	2	4	8	7
o,p'-DDT	< 2	1	7	7	7	7	7	1
p,p'-DDT	< 2	3	4	4	14	23	23	3
Dieldrin	< 1	2	2	2	7	12	12	2
Endosulfan I	< 1	0	—	—	—	—	—	0
Endrin	< 2	0	—	—	—	—	—	0
Heptachlor	< 1	0	—	—	—	—	—	0
Heptachlor epoxide	< 1	0	—	—	—	—	—	0
Isodrin	< 1	0	—	—	—	—	—	0
Lindane	< 1	0	—	—	—	—	—	0
o,p'-Methoxychlor	< 5	0	—	—	—	—	—	0
p,p'-Methoxychlor	< 5	0	—	—	—	—	—	0
Mirex	< 1	0	—	—	—	—	—	0
cis-Nonachlor	< 1	1	4	4	4	4	4	1
trans-Nonachlor	< 1	4	2	2	3	8	13	4
Oxychlordane	< 1	1	3	3	3	3	3	1
Pentachloroanisole	< 1	0	—	—	—	—	—	0
cis-Permethrin	< 5	0	—	—	—	—	—	0
trans-Permethrin	< 5	0	—	—	—	—	—	0
PCB's	< 50	1	160	160	160	160	160	1
Toxaphene	< 200	0	—	—	—	—	—	0

Table 13. Sites in the Mobile River Basin where organochlorine compounds were reported in streambed-sediment samples

[Site locations are shown in figure 2; number in parentheses is the U.S. Geological Survey downstream order number; Blvd., Boulevard; PCB's, polychlorinated biphenyls]

Site identification and organic compounds reported		
Site 1. Coosa River near Rome, GA (02397000)—1 compound reported		
p,p'-DDE		
Site 2. Chattooga River above Gaylesville, AL (02398300)—1 compound reported		
p,p'-DDE		
Site 4. Three Mile Branch at North Blvd. at Montgomery, AL (02419977)—7 compounds reported		
cis-Chlordane	*p,p*'-DDE	*trans*-Nonachlor
trans-Chlordane	*p,p*'-DDT	
p,p'-DDD	Dieldrin	
Site 7. Shades Creek at Homewood, AL (02423581)—3 compounds reported		
cis-Chlordane	*trans*-Chlordane	*trans*-Nonachlor
Site 8. Cahaba River at Centreville, AL (02424000)—1 compound reported		
p,p'-DDD		
Site 10. Town Creek at Tupelo, MS (02434000)—1 compound reported		
p,p'-DDE		
Site 11. Buttahatchee River near Aberdeen, MS (02439400)—1 compound reported		
p,p'-DDE		
Site 13. Lost Creek above Parrish, AL (02454055)—4 compounds reported		
cis-Chlordane	*p,p*'-DDD	
trans-Chlordane	*trans*-Nonachlor	
Site 14. Locust Fork below Snead, AL (02454500)—3 compounds reported		
p,p'-DDD	*p,p*'-DDT	*p,p*'-DDE
Site 15. Valley Creek near Bessemer, AL (02461500)—13 compounds reported		
cis-Chlordane	*p,p*'-DDE	*trans*-Nonachlor
trans-Chlordane	*o,p*'-DDT	Oxychlordane
o,p'-DDD	*p,p*'-DDT	PCB's
p,p'-DDD	Dieldrin	
o,p'-DDE	*cis*-Nonachlor	
Site 18. Cribbs Mill Creek at Tuscaloosa, AL (02465288)—1 compound reported		
trans-Chlordane		

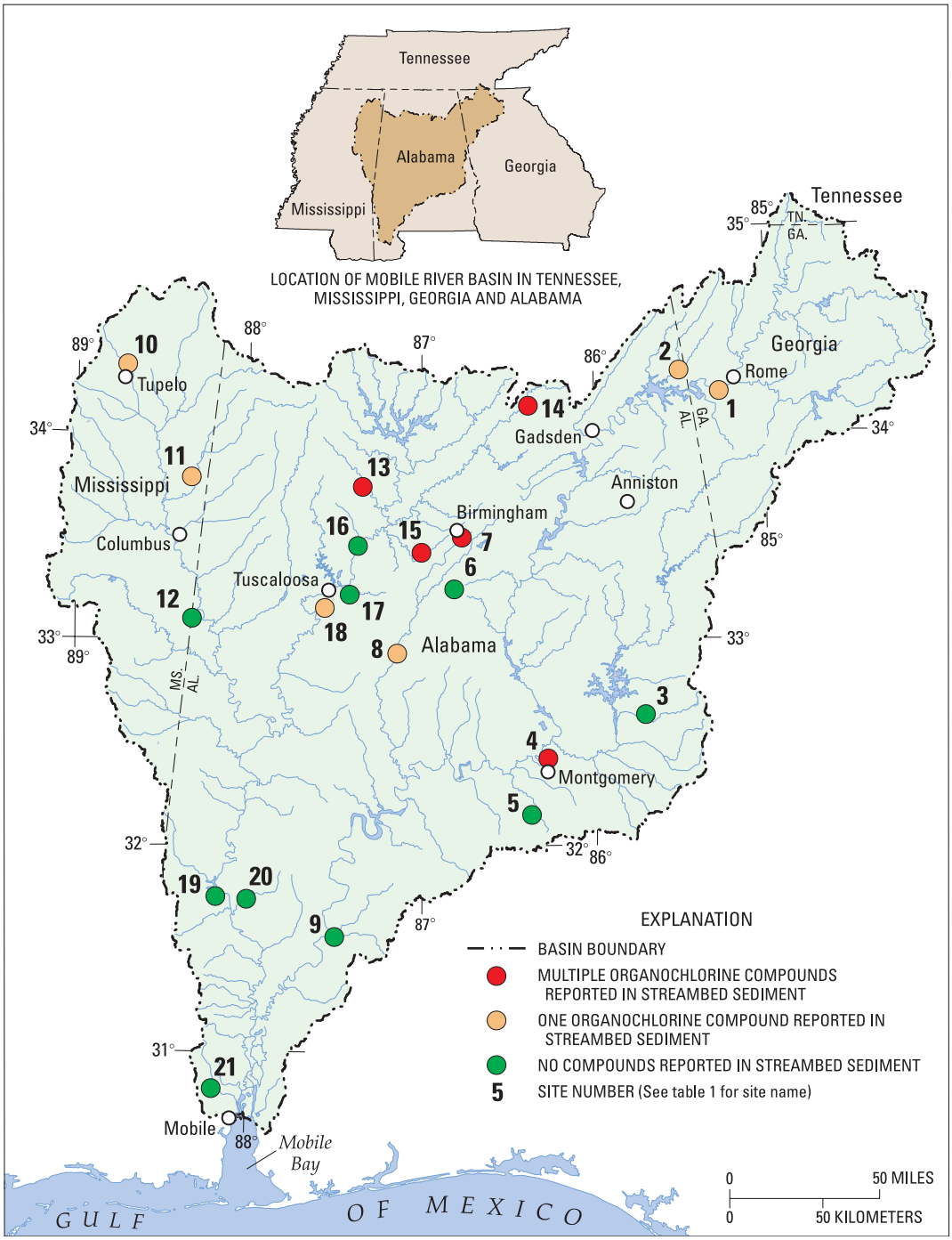


Figure 9. Sites in the Mobile River Basin where organochlorine compounds were reported in streambed- sediment samples.

Table 14. Reporting frequency and range in concentrations of trace elements in 21 streambed-sediment samples from the Mobile River Basin

[μg/g, microgram per gram; —, not reported; NA, not applicable]

Trace element	Reporting level in μg/g dry weight	Number of detections	Minimum concentration, in μg/g dry weight	Concentrations, in μg/g dry weight, within the 25th percentile	Median concentration, in μg/g dry weight	Concentrations, in μg/g dry weight, within the 75th percentile	Maximum concentration, in μg/g dry weight	Number of sites where concentrations were reported
Aluminum	< 0.005[a]	21	3.30	5.40	6.80	8	10	21
Antimony	< .1	21	.40	.53	.60	.90	3.30	21
Arsenic	< .1	21	3.80	8.50	11	16	34	21
Barium	< 1	21	230	320	430	520	4,300	21
Beryllium	< .1	21	1	1.40	2.10	2.40	2.60	21
Bismuth	< 1	1	1	1	1	1	1	1
Cadmium[b]	< .1	18	.10	.10	.20	.26	1.30	18
Calcium	< .005[a]	21	.10	.27	.39	.74	6.70	21
Cerium	< 1	21	56	80	96	120	160	21
Chromium	< 1	21	32	54	78	96	170	21
Cobalt	< 1	21	8	13	14	22	32	21
Copper	< 1	21	11	20	22	28	73	21
Europium	< 1	19	1	1.60	2	2	3	19
Gallium	< 1	21	7	13	16	18	27	21
Gold	< 1	0	—	—	—	—	—	0
Holmium	< 1	18	1	1	1	2	3	18
Iron	< .005[a]	21	1.80	3.20	3.70	4.70	6.50	21
Lanthanum	< 1	21	31	39	53	61	78	21
Lead	< 1	21	17	22	26	30	160	21
Lithium	< 1	21	16	33	38	49	97	21
Magnesium	< .005[a]	21	.15	.28	.45	.53	.85	21
Manganese	< 4	21	380	1,000	1,400	2,600	5,900	21
Mercury	< .02	21	.04	.05	.05	.07	.23	21
Molybdenum	< .5	21	.60	1	1.20	1.80	4.70	21

Table 14. Reporting frequency and range in concentrations of trace elements in 21 streambed-sediment samples from the Mobile River Basin—Continued

[µg/g, microgram per gram; —, not reported; NA, not applicable]

Trace element	Reporting level in µg/g dry weight	Number of detections	Minimum concentration, in µg/g dry weight	Concentrations, in µg/g dry weight, within the 25th percentile	Median concentration, in µg/g dry weight	Concentrations, in µg/g dry weight, within the 75th percentile	Maximum concentration, in µg/g dry weight	Number of sites where concentrations were reported
Neodymium	< 1	21	23	34	45	54	68	21
Nickel	< 2	21	9	25	29	34	49	21
Niobium	< 4	21	9	14	16	18	28	21
Phosphorus	< .005[a]	21	.02	.05	.08	.10	.16	21
Potassium	< .005[a]	21	.53	.81	1.10	1.40	2.40	21
Scandium	< 2	21	5	8	11	14	20	21
Selenium	< .1	21	.30	.50	.60	.80	1.60	21
Silver	< .1	18	.50	.70	.80	.90	1.70	18
Sodium	< .005[a]	21	.06	.09	12	.18	.43	21
Strontium	< 2	21	38	46	64	86	330	21
Sulfur	< .05[a]	10	.05	.06	.07	.12	.21	10
Tantalum	< 1	18	1	1	2	2	2.60	18
Thorium	< 1	21	9	12	13	18	21	21
Tin	< 1	21	2	2	3	3	20	21
Titanium	< .005[a]	21	.31	.44	.49	.58	.81	21
Uranium	< .1	21	2.40	3.10	3.80	4.10	5.80	21
Vanadium	< 2	21	44	74	99	110	140	21
Ytterbium	< 1	21	2	2.60	3	3	4	21
Yttrium	< 1	21	15	23	26	29	40	21
Zinc	< 2	21	41	96	110	130	510	21
Carbon, in percent								
Organic carbon	NA	21	0.89	1.30	1.60	2.90	3.70	20
Organic and inorganic carbon	NA	21	.95	1.50	2.10	3.10	4.30	20
Inorganic carbon	NA	21	.01	.03	.05	.10	1.70	20

[a] Value represents the percentage of sample composed of the trace element.

[b] Only 20 of 21 streambed-sediment samples were analyzed for concentrations of cadmium.

Comparison of Concentrations of Organochlorine Compounds and Trace Elements in Streambed-Sediment Samples to Standards and Guidelines

Concentrations of organochlorine compounds and trace elements in streambed-sediment samples from the MOBL basin were compared to consensus-based sediment-quality guidelines (SQG's), and mean probable-effects concentrations (PEC's) quotients were calculated for each sample. Only mean PEC quotients and PEC's are presented in this report. The PEC's represent concentrations above which effects to aquatic organisms would be expected to be frequent (MacDonald and others, 2000). Mean PEC quotients greater than 0.5 are predicted to be toxic to sediment-dwelling organisms.

Organochlorine compound and trace element concentrations reported in streambed-sediment samples exceeded PEC's at five sites. These sites were Valley (site 15), Lost (site 13), Pintlalla (site 5), and Bogue Chitto (site 12) Creeks and the Black Warrior River (site 16) (table 15; fig. 10).

Although concentrations of five trace elements exceeded PEC's, chlordane was the only organochlorine compound to exceed a PEC in streambed sediment (Valley Creek, site 15). Concentrations of arsenic, chromium, lead, nickel, and zinc exceeded their respective PEC's. The arsenic concentration in the sample from the Black Warrior River (site 16) exceeded the PEC for streambed sediment. Zinc and lead concentrations were higher than PEC's in the sample from Valley Creek (site 15). Nickel concentrations exceeded the PEC in the sample from Lost Creek (site 13), and chromium concentrations were higher than the PEC in samples from Pintlalla (site 5) and Bogue Chitto (site 12) Creeks (table 15).

Mean PEC quotients were greater than 0.5 at two sites—Pintlalla (site 5) and Valley (site 15) Creeks. The mean PEC quotient was higher than 0.5 at Pintlalla Creek because of the concentration of chromium (table 15; fig. 10). The mean PEC quotient was higher than 0.5 at Valley Creek as a result of concentrations of total chlordane, lead, and zinc (table 15; fig. 10).

Table 15. Comparison of concentrations of organochlorine compounds and trace elements in streambed-sediment samples from the Mobile River Basin with consensus-based probable-effects guidelines

[µg/g, microgram per gram; PEC, consensus-based probable-effects concentration; NA, not applicable; µg/kg, microgram per kilogram; site locations are shown in figure 2]

Analyte	Consensus-based probable-effects concentration, in µg/g dry weight	Sites where probable-effects concentration was exceeded	Concentration in streambed-sediment sample, in µg/g dry weight
Mean PEC quotient[a] (0.5)	NA	Pintlalla Creek (site 5) Valley Creek (site 15)	NA
Total chlordane	17.6	Valley Creek (site 15)	25 (µg/kg)
Arsenic	33	Black Warrior River (site 16)	34
Chromium	111	Pintlalla Creek (site 5) Bogue Chitto Creek (site 12)	167 120
Lead	128	Valley Creek (site 15)	156
Nickel	48.6	Lost Creek (site 13)	49
Zinc	459	Valley Creek (site 15)	514

[a] The mean PEC quotient is a unitless value.

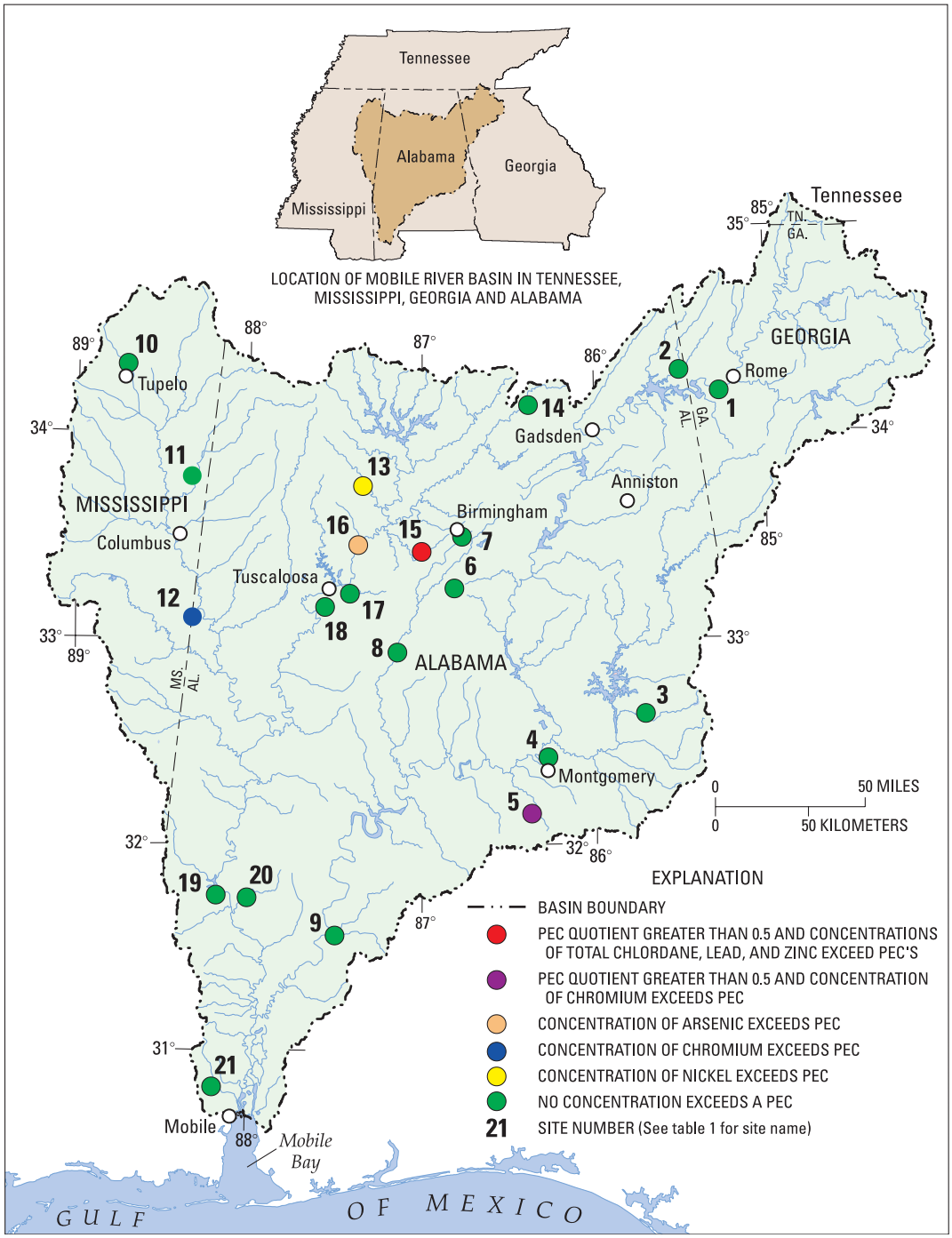


Figure 10. Sites in the Mobile River Basin where concentrations of organochlorine compounds and trace elements exceeded probable-effects concentrations and mean quotients in streambed-sediment samples.

Relation of Organochlorine Compounds and Trace Elements in Streambed-Sediment Samples to Land Use

Total DDT and the total concentration and number of all organochlorine compounds reported in a sample were related to land use, based on the test statistic at the 95-percent confidence level. Total DDT and the total concentrations and numbers of all organochlorine compounds reported in streambed sediment at a site were negatively related to the amount of agriculture within a basin (table 16).

Concentrations of antimony, cadmium, cobalt, lead, lithium, manganese, niobium, tantalum, and zinc

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Table 16. Spearman-rho rank correlations of land use and concentrations of organochlorine compounds in streambed-sediment samples from the Mobile River Basin

	Correlation with percentage of land use		
	Total DDT	Total organochlorine concentration	Total number of organochlorine compounds reported
Agricultural land use			
Spearman-rho statistic	– 0.714	– 0.651	– 0.641
p-value	.031	.030	.034
Number of sites where reported	9	11	11

in streambed sediment were significantly correlated to land use based on non-normalized data and the test statistic. When the data were normalized, however, most of the correlations were no longer apparent (table 17).

Although normalized data may indicate otherwise, some of the concentrations of trace elements probably are related to land use. This is supported by several facts. Concentrations of only one trace element related to land use, niobium, was correlated to the percentage of organic carbon in the samples. The trace element that was correlated to land use after normalizing was phosphorus, which also was correlated with the percentage of organic carbon based on the Spearman-rho statistic at the 95-percent confidence level. In addition, there was no relation to percentages of organic carbon and land use. This is why many correlations were no longer apparent after normalization, except for the trace element with a positive relation to percentages of organic carbon. Therefore, sediment samples from sites with the highest concentrations of most trace elements reported did not necessarily have the highest percentages of organic carbon. For these reasons, the trace elements that appeared to be related to land-use percentages before normalizing probably are related, and likely are

Table 17. Spearman-rho rank correlations of land use and concentrations of trace elements in streambed-sediment samples from the Mobile River Basin

[—, no correlation; NA, not applicable]

	Correlation with percentage of land use								
	Antimony	Cadmium	Cobalt	Lead	Lithium	Manganese	Niobium	Tantalum	Zinc
Urban land use									
Spearman-rho statistic	0.550	0.508	—	0.663	—	—	– 0.481	– 0.470	0.478
p-value	.010	.026	—	.001	—	—	.027	.049	.028
Number of sites where reported	21	19	NA	21	NA	NA	21	18	21
Agricultural land use									
Spearman-rho statistic	– 0.509	—	– 0.5	– 0.500	0.449	0.447	0.492	—	—
p-value	.019	—	.010	.021	.041	.042	.023	—	—
Number of sites where reported	21	NA	21	21	21	21	21	NA	NA
Forested land use									
Spearman-rho statistic	—	– 0.570	0.597	—	—	—	—	—	—
p-value	—	.011	.004	—	—	—	—	—	—
Number of sites where reported	NA	19	21	NA	NA	NA	NA	NA	NA

from sources with low amounts of organic carbon associated with them. This also seems reasonable in that the majority of the trace elements in question were positively related to the amount of urban land use in a basin. Urban land use may not have large allochthenous carbon inputs when compared to other land uses. In addition, there are a large number of potential sources of trace elements in urban settings. Examples of potential sources of these trace elements in streambed-sediment include industrial effluents, pipes, and runoff from roadways and steel-production facilities, although in the MOBL basin, geology also may have contributed to the observed concentrations. Adequate data from the different geological settings in the study area are not available to test for this hypothesis.

In addition, the streambed-sediment samples analyzed were less than a 63-micron fraction and contained very little carbon. The maximum percentage of organic carbon was 2.7 percent, with a range of only 1.83 percent. So, there was only a slight difference between samples when considering organic carbon, and potentially not enough of a difference to account for the observed concentration ranges. Also, some trace elements are known to be associated with fine clay particles, and the laboratory used a total-extraction method that would liberate these trace elements from the particles regardless of the percentage of carbon.

Comparison of Concentrations of Organochlorine Compounds and Trace Elements in Streambed-Sediment Samples to 1991 and 1994 National Water-Quality Assessment Study-Unit Data

At the selected RL's, streambed-sediment samples from 820 NAWQA sites across the Nation were analyzed for 32 organochlorine compounds, and 26 organochlorine compounds (81 percent) were reported (table 18). The most frequently reported compound locally and nationally was *p,p*'-DDE. Organochlorine compounds that were not reported in streambed-sediment samples nationally were chloroneb, endrin, heptachlor, isodrin, *o,p*'-methoxychlor, and pentachloroanisole. These compounds also were not reported in streambed-sediment samples from the MOBL Study Unit.

Eighteen of the 26 organochlorine compounds (69 percent) reported nationally were reported at less than 10 percent of the NAWQA sites (table 18). These organochlorine compounds are aldrin, DCPA, *o,p*'-DDD, *o,p*'-DDE, *o,p*'-DDT, endosulfan I, *alpha*-BHC, *beta*-BHC, heptachlor epoxide, hexachlorobenzene, lindane, *p,p*'-methoxychlor, mirex, *cis*-nonachlor, oxychlordane, *cis*-permethrin, *trans*-permethrin, and toxaphene. Five of these organochlorine compounds were reported in less than 10 percent of the streambed-sediment samples from the MOBL Study Unit—*o,p*'-DDD, *o,p*'-DDE, *o,p*'-DDT, *cis*-nonachlor, and oxychlordane. The remainder of these compounds—aldrin, DCPA, endosulfan I, *alpha*-BHC, *beta*-BHC, heptachlor epoxide, hexachlorobenzene, lindane, *p,p*'-methoxychlor, mirex, *cis*-permethrin, *trans*-permethrin and toxaphene—were not reported in the MOBL basin.

Eight organochlorine compounds (31 percent) were reported in streambed-sediment samples nationally at 10 percent or more of the NAWQA sites. These organochlorine compounds are *cis*-chlordane, *trans*-chlordane, *p,p*'-DDD, *p-p*'-DDE, *p,p*'-DDT, dieldrin, *trans*-nonachlor, and PCB's. These same organochlorine compounds, except PCB's, which were reported at 4.7 percent of the sites, also were reported at 10 percent or more of the MOBL Study-Unit sites (table 18).

The percentage of sites where organochlorine compounds were reported and minimum, 25th percentile, median, and 75th percentile concentrations of organochlorine compounds in streambed-sediment samples from the MOBL Study Unit generally were similar to (within 5-percent detection frequency and concentrations within 1 µg/kg) or less than those reported nationally, although there were some exceptions (table 18; fig. 11). Differences in these concentrations may be a result of the greater range in concentrations quantified nationally. Indications that a greater range in concentrations was quantified nationally are the lower frequency at which and the limited number of analyses in which these compounds were reported in the MOBL Study Unit. One compound, *trans*-chlordane, was reported more frequently in the MOBL Study Unit than nationally (table 18).

Nationally, maximum concentrations of some organochlorine compounds were at least 10 times greater than those reported in the MOBL (table 10; fig. 11). The only compound reported at a higher maximum concentration locally, than nationally, was *trans*-chlordane. However, the concentration of *trans*-chlordane (25 µg/kg) reported in a sample from the MOBL basin was only slightly higher than the maximum nationally (23 µg/kg). Higher maximum concentrations reported in the 1991 and 1994 Study

Table 18. Summary data for organochlorine compounds in streambed-sediment samples from the Mobile River Basin and from 1991 and 1994 National Water-Quality Assessment Study Units nationwide

[µg/kg, microgram per kilogram; MOBL, Mobile River Basin Study Unit; —, no detections; BHC, hexachlorocyclohexane; DCPA, chlorthaldimethyl; PCB's, polychlorinated biphenyls]

Compound and reporting level	Data source and number of sites	Number of sites where concentrations were reported	Minimum concentration, in µg/kg dry weight	Concentrations, in µg/kg dry weight, within the 25th percentile	Median concentration, in µg/kg dry weight	Concentrations, in µg/kg dry weight, within the 75th percentile	Maximum concentration, in µg/kg dry weight	Frequency of detection, in percent
Aldrin	MOBL (21 sites)	0	—	—	—	—	—	0
1 µg/kg	National (811 sites)	5	1.3	1.75	2.2	2.93	3	.62
alpha-BHC	MOBL (21 sites)	0	—	—	—	—	—	0
1 µg/kg	National (788 sites)	1	1	1	1	1	1	.13
beta-BHC	MOBL (21 sites)	0	—	—	—	—	—	0
1 µg/kg	National (780 sites)	3	1	1.03	1.1	1.18	1.2	.38
cis-Chlordane	MOBL (20 sites)	3	2	2	3	14	14	15
1 µg/kg	National (805 sites)	110	1	1.5	2.5	4.1	23	13.66
trans-Chlordane	MOBL (21 sites)	5	2	2	2	3	25	23.81
1 µg/kg	National (808 sites)	115	1	1.6	2.6	4.5	23	14.23
Chloroneb	MOBL (20 sites)	0	—	—	—	—	—	0
5 µg/kg	National (774 sites)	0	—	—	—	—	—	0
DCPA	MOBL (21 sites)	0	—	—	—	—	—	0
5 µg/kg	National (808 sites)	7	5	5.63	7.1	9.25	32	.87
o,p'-DDD	MOBL (21 sites)	1	7	7	7	7	7	4.76
1 µg/kg	National (675 sites)	56	1	1.35	2.3	5.05	150	8.30
p,p'-DDD	MOBL (21 sites)	5	1	2	3	4	19	23.81
1 µg/kg	National (692 sites)	192	1	1.8	3.1	6.35	130	27.75
o,p'-DDE	MOBL (21 sites)	1	7	7	7	7	7	4.76
1 µg/kg	National (771 sites)	11	1	1.18	1.8	3.85	22	1.43
p,p'-DDE	MOBL (21 sites)	7	1	2	2	4	8	33.33
1 µg/kg	National (820 sites)	340	1	1.6	3.2	7.85	440	41.46
o,p'-DDT	MOBL (21 sites)	1	7	7	7	7	7	4.76
2 µg/kg	National (715 sites)	23	2	2.6	3.3	4.88	42	3.22
p,p'-DDT	MOBL (21 sites)	3	4	4	14	23	23	14.29
2 µg/kg	National (722 sites)	133	2	2.78	4.8	10	180	18.42
Dieldrin	MOBL (21 sites)	2	2	2	7	12	12	9.52
1 µg/kg	National (802 sites)	103	1	1.4	1.9	3.5	21	12.84
Endosulfan I	MOBL (21 sites)	0	—	—	—	—	—	0
1 µg/kg	National (776 sites)	16	1.2	1.6	2.2	4.65	8.8	2.06
Endrin	MOBL (20 sites)	0	—	—	—	—	—	0
2 µg/kg	National (805 sites)	0	—	—	—	—	—	0

Table 18. Summary data for organochlorine compounds in streambed-sediment samples from the Mobile River Basin and from 1991 and 1994 National Water-Quality Assessment Study Units nationwide—Continued

[µg/kg, microgram per kilogram; MOBL, Mobile River Basin Study Unit; —, no detections; BHC, hexachlorocyclohexane; DCPA, chlorthaldimethyl; PCB's, polychlorinated biphenyls]

Compound and reporting level	Data source and number of sites	Number of sites where concentrations were reported	Minimum concentration, in µg/kg dry weight	Concentrations, in µg/kg dry weight, within the 25th percentile	Median concentration, in µg/kg dry weight	Concentrations, in µg/kg dry weight, within the 75th percentile	Maximum concentration, in µg/kg dry weight	Frequency of detection, in percent
Heptachlor 1 µg/kg	MOBL (21 sites)	0	—	—	—	—	—	0
	National (813 sites)	0	—	—	—	—	—	0
Heptachlor epoxide 1 µg/kg	MOBL (21 sites)	0	—	—	—	—	—	0
	National (784 sites)	7	1.1	1.12	1.4	2.18	4.6	.89
Hexachlorobenzene 1 µg/kg	MOBL (21 sites)	0	—	—	—	—	—	0
	National (728 sites)	20	1	1.6	2.4	6	11	2.75
Isodrin 1 µg/kg	MOBL (21 sites)	0	—	—	—	—	—	0
	National (803 sites)	0	—	—	—	—	—	0
Lindane 1 µg/kg	MOBL (21 sites)	0	—	—	—	—	—	0
	National (787 sites)	6	1	1	1.9	3.6	5.2	.76
o,p'-Methoxychlor 5 µg/kg	MOBL (20 sites)	0	—	—	—	—	—	0
	National (719 sites)	0	—	—	—	—	—	0
p,p'-Methoxychlor 5 µg/kg	MOBL (20 sites)	0	—	—	—	—	—	0
	National (708 sites)	5	5.2	6.4	22	43.25	71	.71
Mirex 1 µg/kg	MOBL (21 sites)	0	—	—	—	—	—	0
	National (809 sites)	18	1	1.2	1.6	2.5	5.7	2.22
cis-Nonachlor 1 µg/kg	MOBL (21 sites)	1	4	4	4	4	4	4.76
	National (800 sites)	53	1	1.3	1.6	2.68	10	6.63
trans-Nonachlor 1 µg/kg	MOBL (21 sites)	4	2	2	3	8.5	13	19.05
	National (804 sites)	119	1	1.6	2.2	3.4	18	14.80
Oxychlordane 1 µg/kg	MOBL (21 sites)	1	3	3	3	3	3	4.76
	National (795 sites)	3	1.2	1.2	1.2	1.35	1.4	.38
Pentachloroanisole 1 µg/kg	MOBL (21 sites)	0	—	—	—	—	—	0
	National (718 sites)	0	—	—	—	—	—	0
cis-Permethrin 5 µg/kg	MOBL (21 sites)	0	—	—	—	—	—	0
	National (669 sites)	6	6.7	8.6	16	18	26	.90
trans-Permethrin 5 µg/kg	MOBL (21 sites)	0	—	—	—	—	—	0
	National (651 sites)	6	7	7.6	10.45	14	15	.92
PCB's 50 µg/kg	MOBL (21 sites)	1	160	160	160	160	160	4.76
	National (558 sites)	69	51	75.75	120	300	13,000	12.37
Toxaphene 200 µg/kg	MOBL (21 sites)	0	—	—	—	—	—	0
	National (815 sites)	2	351	351	490.5	630	630	.25

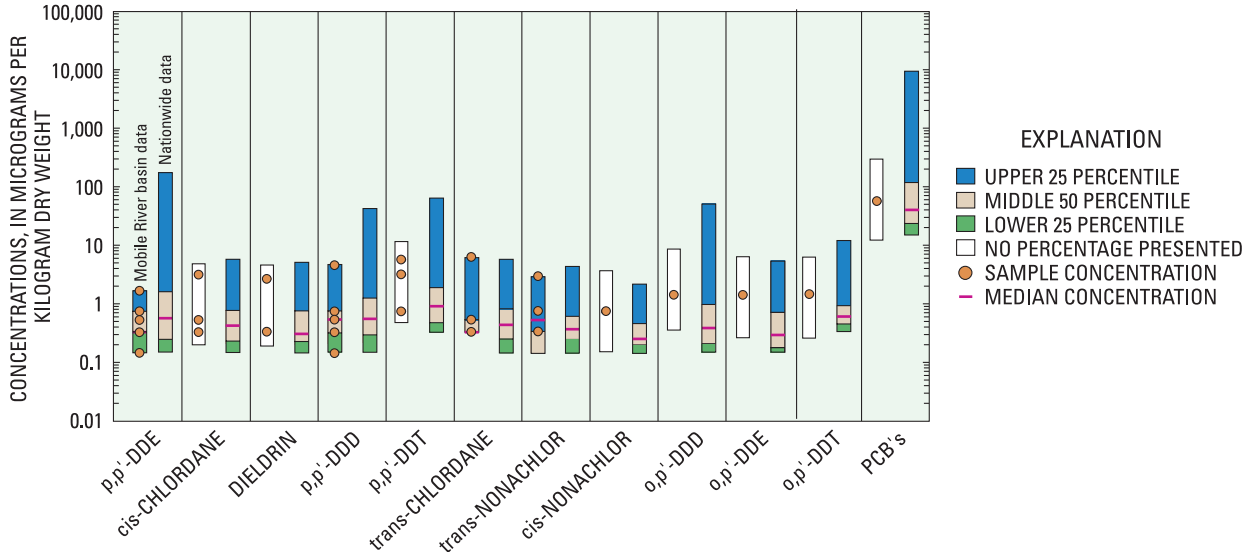

Figure 11. Floating bar charts of statistical distributions of concentrations of organochlorine compounds in streambed-sediment samples from the Mobile River Basin and in 1991 and 1994 National Water-Quality Assessment Program Study-Unit data.

Units may be a result of site-selection criteria used in some of the NAWQA Study Units as previously described in the fish-tissue section of this report.

Of the 44 trace elements analyzed in MOBL streambed-sediment samples, only 40 were readily comparable at the common censoring level (table 19). Nationally, bismuth, gold, holmium, and tantalum had too few samples censored at the current RL used by the NWQL to enable comparison with data from the MOBL Study Unit.

The percentage of sites where a trace elements was reported and the minimum and quartile concentrations reported in streambed-sediment samples from the MOBL basin were similar to (within 1 µg/g in concentration or within 5 percent difference in reporting frequency) or less than those reported nationally, although there were several exceptions. Minimum, 25th percentile, median, and 75th percentile concentrations of several trace elements analyzed in streambed-sediment samples in the MOBL were slightly greater than those nationally, probably as a result of a wider range in concentrations characterized nationally. Mercury, silver, and ytterbium were reported more frequently in the MOBL than nationally, although at similar concentrations (table 19). Maximum concentrations typically were higher in the national NAWQA streambed-sediment samples (table 19; fig. 12). This may be a result of site-selection criteria used in some of the NAWQA Study Units. Sites of suspected or known trace-element contamination were selected for sampling in some NAWQA Study Units to quantify the worse-case scenario.

Table 19. Summary data for trace elements in streambed-sediment samples from the Mobile River Basin and from 1991 and 1994 National Water-Quality Assessment Study Units nationwide

[µg/g, microgram per gram; MOBL, Mobile River Basin Study Unit; —, not reported]

Trace element and reporting level	Data source and number of sites	Number of sites where concentrations were reported	Minimum concentration, in µg/g dry weight	Concentrations, in µg/g dry weight, within the 25th percentile	Median concentration, in µg/g dry weight	Concentrations, in µg/g dry weight, within the 75th percentile	Maximum concentration, in µg/g dry weight	Frequency of detection, in percent
Aluminum[a]	MOBL (21 sites)	21	3.3	5.4	6.8	8	10	100
0.005% of sample	National (781 sites)	781	1.4	5.3	6.3	7.5	14	100
Antimony	MOBL (21 sites)	21	.4	.53	.6	.9	3.3	100
0.1 µg/g	National (756 sites)	753	.2	.6	.9	1	24	99.60
Arsenic	MOBL (21 sites)	21	3.8	8.5	11	16	34	100
0.1 µg/g	National (765 sites)	764	1	5	6.9	10	110	99.87
Barium	MOBL (21 sites)	21	230	320	430	520	4,300	100
1 µg/g	National (775 sites)	775	6	380	490	580	1,600	100
Beryllium	MOBL (21 sites)	21	1	1.4	2.1	2.4	2.6	100
0.1 µg/g	National (702 sites)	702	1	1	2	2	20	100
Bismuth	MOBL (21 sites)	0	—	—	—	—	—	0
1 µg/g	National (2 sites)	1	20	20	20	20	20	50
Cadmium	MOBL (21 sites)	13	.2	.2	.2	.3	1.3	61.90
0.1 µg/g	National (775 sites)	724	.16	.3	.5	.9	57	93.42
Calcium[a]	MOBL (21 sites)	21	.1	.27	.39	.74	6.7	100
0.005% of sample	National (770 sites)	770	.1	.64	1.5	3.4	28	100
Cerium	MOBL (21 sites)	21	56	80	96	120	160	100
1 µg/g	National (771 sites)	771	13	56	73	96	360	100
Chromium	MOBL (21 sites)	21	32	54	78	96	170	100
1 µg/g	National (781 sites)	781	8	51	65	83	630	100
Cobalt	MOBL (21 sites)	21	8	13	14	22	32	100
1 µg/g	National (781 sites)	781	2	11	16	22	210	100
Copper	MOBL (21 sites)	21	11	20	22	28	73	100
1 µg/g	National (781 sites)	781	1	18	28	43	620	100
Europium	MOBL (21 sites)	15	1.6	2	2	2	3	71.43
1 µg/g	National (80 sites)	80	1.3	2	2	3	37	100
Gallium	MOBL (21 sites)	21	7	13	16	18	27	100
1 µg/g	National (762 sites)	762	4	12	16	19	50	100
Gold	MOBL (21 sites)	0	—	—	—	—	—	0
1 µg/g	National (2 sites)	1	8	8	8	8	8	50
Holmium	MOBL (21 sites)	8	2	2	2	2	3	38.10
1 µg/g	National (3 sites)	3	1.2	1.2	4	4	4	100

Table 19. Summary data for trace elements in streambed-sediment samples from the Mobile River Basin and from 1991 and 1994 National Water-Quality Assessment Study Units nationwide—Continued

Trace element and reporting level	Data source and number of sites	Number of sites where concentrations were reported	Minimum concentration, in µg/g dry weight	Concentrations, in µg/g dry weight, within the 25th percentile	Median concentration, in µg/g dry weight	Concentrations, in µg/g dry weight, within the 75th percentile	Maximum concentration, in µg/g dry weight	Frequency of detection, in percent
Iron[a]	MOBL (21 sites)	21	1.8	3.2	3.7	4.7	6.5	100
1% of sample	National (781 sites)	781	.7	2.6	3.5	4.5	21	100
Lanthanum	MOBL (21 sites)	21	31	39	53	61	78	100
1 µg/g	National (773 sites)	773	9	31	40	52	200	100
Lead	MOBL (21 sites)	21	17	22	26	30	160	100
1 µg/g	National (781 sites)	776	6	19	29	45.5	2,300	99.36
Lithium	MOBL (21 sites)	21	16	33	38	49	97	100
1 µg/g	National (781 sites)	781	6	23	30	50	91	100
Magnesium[a]	MOBL (21 sites)	21	.15	.28	.45	.53	.85	100
0.005% of sample	National (771 sites)	771	.07	.49	.79	1.1	4.7	100
Manganese	MOBL (21 sites)	21	380	1,000	1,400	2,600	5,900	100
4 µg/g	National (781 sites)	781	53	680	1,000	1,700	34,000	100
Mercury	MOBL (21 sites)	21	.04	.05	.05	.07	.23	100
0.02 µg/g	National (780 sites)	669	.03	.05	.08	.15	14.5	85.77
Molybdenum	MOBL (21 sites)	21	.6	1	1.2	1.8	4.7	100
0.5 µg/g	National (51 sites)	51	.52	2	3	6	260	100
Neodymium	MOBL (21 sites)	21	23	34	45	54	68	100
1 µg/g	National (764 sites)	764	5	27	34	46	180	100
Nickel	MOBL (21 sites)	21	9	25	29	34	49	100
2 µg/g	National (781 sites)	781	6	21	28	38	400	100
Niobium	MOBL (21 sites)	21	9	14	16	18	28	100
4 µg/g	National (769 sites)	718	5	9	12	16	68	93.37
Phosphorus[a]	MOBL (21 sites)	21	.02	.05	.08	.10	.16	100
0.005% of sample	National (771 sites)	771	.03	.09	.12	.16	1.8	100
Potassium[a]	MOBL (21 sites)	21	.53	.81	1.1	1.4	2.4	100
0.005% of sample	National (771 sites)	771	.06	1.1	1.4	1.8	3.1	100
Scandium	MOBL (21 sites)	21	5	8	11	14	20	100
2 µg/g	National (769 sites)	768	3	8	11	14	53	99.87
Selenium	MOBL (21 sites)	21	.3	.5	.6	.8	1.6	100
0.1 µg/g	National (778 sites)	775	.17	.5	.7	1.1	13	99.61
Silver	MOBL (20 sites)	18	.5	.7	.8	.9	1.7	90
0.1 µg/g	National (770 sites)	549	.12	.2	.3	.5	12.8	71.30

Table 19. Summary data for trace elements in streambed-sediment samples from the Mobile River Basin and from 1991 and 1994 National Water-Quality Assessment Study Units nationwide—Continued

Trace element and reporting level	Data source and number of sites	Number of sites where concentrations were reported	Minimum concentration, in µg/g dry weight	Concentrations, in µg/g dry weight, within the 25th percentile	Median concentration, in µg/g dry weight	Concentrations, in µg/g dry weight, within the 75th percentile	Maximum concentration, in µg/g dry weight	Frequency of detection, in percent
Sodium[a]	MOBL (21 sites)	21	0.06	0.09	0.12	0.18	0.43	100
0.005% of sample	National (771 sites)	771	.02	.24	.61	.96	2.4	100
Strontium	MOBL (21 sites)	21	38	46	64	86	330	100
2 µg/g	National (781 sites)	781	17	90	140	210	1,600	100
Sulfur[a]	MOBL (19 sites)	7	.06	.07	.1	.19	.21	36.84
0.05% of sample	National (760 sites)	586	.06	.08	.12	.21	1.69	77.11
Tantalum	MOBL (21 sites)	10	2	2	2	2	2.6	47.62
1 µg/g	National (1 site)	0	—	—	—	—	—	0
Thorium	MOBL (21 sites)	21	9	12	13	18	21	100
1 µg/g	National (728 sites)	728	2.9	9.58	12	15.7	91	100
Tin	MOBL (21 sites)	21	2	2	3	3	20	100
1 µg/g	National (33 sites)	33	2.7	6	9	16	54	100
Titanium[a]	MOBL (21 sites)	21	.31	.44	.49	.58	.81	100
0.05% of sample	National (758 sites)	758	.05	.28	.36	.48	1.9	100
Uranium	MOBL (21 sites)	21	2.4	3.1	3.8	4.1	5.8	100
0.1 µg/g	National (756 sites)	756	.67	3.02	3.96	5.49	45.2	100
Vanadium	MOBL (21 sites)	21	44	74	99	110	140	100
2 µg/g	National (781 sites)	781	14	70	88	110	380	100
Ytterbium	MOBL (21 sites)	21	2	2.6	3	3	4	100
1 µg/g	National (769 sites)	682	2	2	2	3	12	88.69
Yttrium	MOBL (21 sites)	21	15	23	26	29	40	100
1 µg/g	National (771 sites)	771	4	19	23	29	130	100
Zinc	MOBL (21 sites)	21	41	96	110	130	510	100
2 µg/g	National (781 sites)	781	21	86	120	180	9,000	100

[a] Trace element was reported as a percentage of the sample and not as a unit of measure in micrograms per gram.

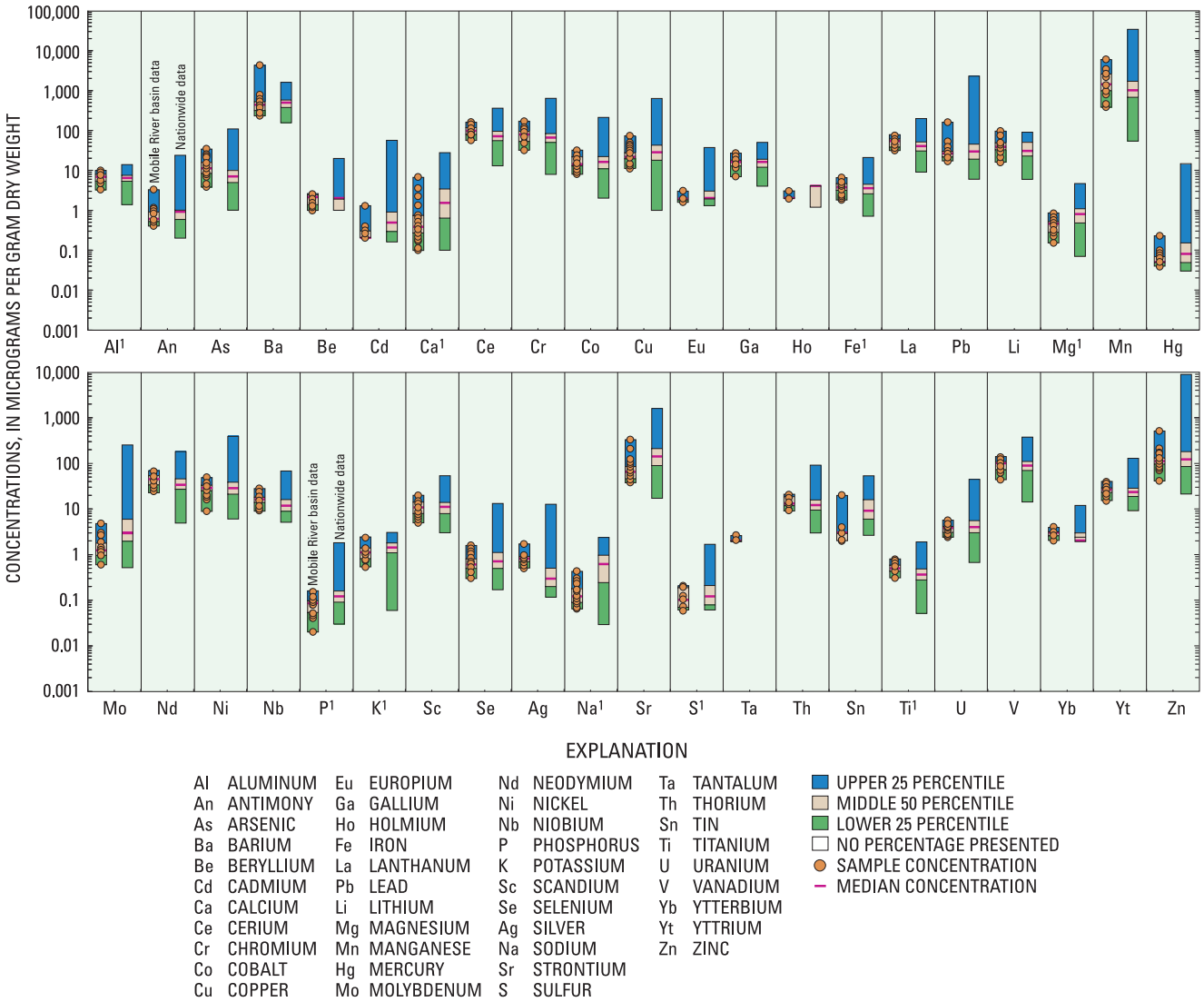

Figure 12. Floating bar charts of statistical distributions of concentrations of trace elements in streambed-sediment samples from the Mobile River Basin and in 1991 and 1994 National Water-Quality Assessment Program Study-Unit data. ([1]Trace element was reported as a percentage of the sample and not as a unit of measure in micrograms per gram.)

Comparison Between Sampling Media

Whole-fish tissue and streambed-sediment samples from the MOBL Study Unit were analyzed for 33 organochlorine compounds. About half, or 55 percent, of the 33 compounds were reported in the MOBL. These two sampling media had 27 analytes (81 percent) in common (table 20). A total of 18 (67 percent) of the organochlorine compounds were reported in either media, and 10 (37 percent) were reported in both media. Sixteen (59 percent) of the 27 compounds in common between these media were reported in whole-fish tissues, whereas 12 (44 percent) of the compounds were reported in streambed-sediment samples from the MOBL (table 20).

Although streambed-sediment samples were analyzed for a greater number of compounds from a greater number of sites than were fish-tissue samples, tissue samples had a greater number of compounds reported and greater reporting frequency when considering both samples and sites than did streambed sediments. Of the 28 organochlorine compounds analyzed in whole-fish tissue samples, 16 (57 percent) were reported from 16 of the 19 sites (84 percent) sampled (fig. 13). Twelve (41 percent) of the 32 organochlorine compounds analyzed in streambed-

Table 20. Organochlorine compounds analyzed in streambed-sediment and fish-tissue samples from the Mobile River Basin

[Shaded blocks indicate the analyte was analyzed and reported; blank blocks indicate the analyte was analyzed but not reported; BHC, hexachlorocyclohexane; —, the analyte was not analyzed; DCPA, chlorthaldimethyl; PCB's, polychlorinated biphenyls]

Compound	Streambed-sediment samples	Fish-tissue samples
Aldrin		
alpha-BHC		
beta-BHC		
delta-BHC	—	
cis-Chlordane		
trans-Chlordane		
Chloroneb		—
DCPA		
o,p'-DDD		
p,p'-DDD		
o,p'-DDE		
p,p'-DDE		
o,p'-DDT		
p,p'-DDT		
Dieldrin		
Endosulfan I		—
Endrin		
Heptachlor		
Heptachlor epoxide		
Hexachlorobenzene		
Isodrin		—
Lindane		
o,p'-Methoxychlor		
p,p'-Methoxychlor		
Mirex		
cis-Nonachlor		
trans-Nonachlor		
Oxychlordane		
Pentachloroanisole		
cis-Permethrin		—
trans-Permethrin		—
PCB's		
Toxaphene		

sediment samples were reported from 11 of the 21 sites (52 percent) sampled.

One possible explanation for a greater number of organochlorine compounds reported with a higher frequency in fish-tissue samples is that multiple tissue samples were collected at several sites, whereas only a single sediment sample was collected at each site. Having multiple samples at some sites and a greater number of samples overall could increase the potential for detection of individual organochlorine compounds and the number of organochlorine compounds at individual sites. On average, approximately two additional organochlorine compounds were reported for sites with multiple samples than for sites with only a single sample. Other studies, however, have noted higher detection frequencies in fish tissue than in streambed sediment. These higher detection frequencies possibly occur because of bioaccumulation

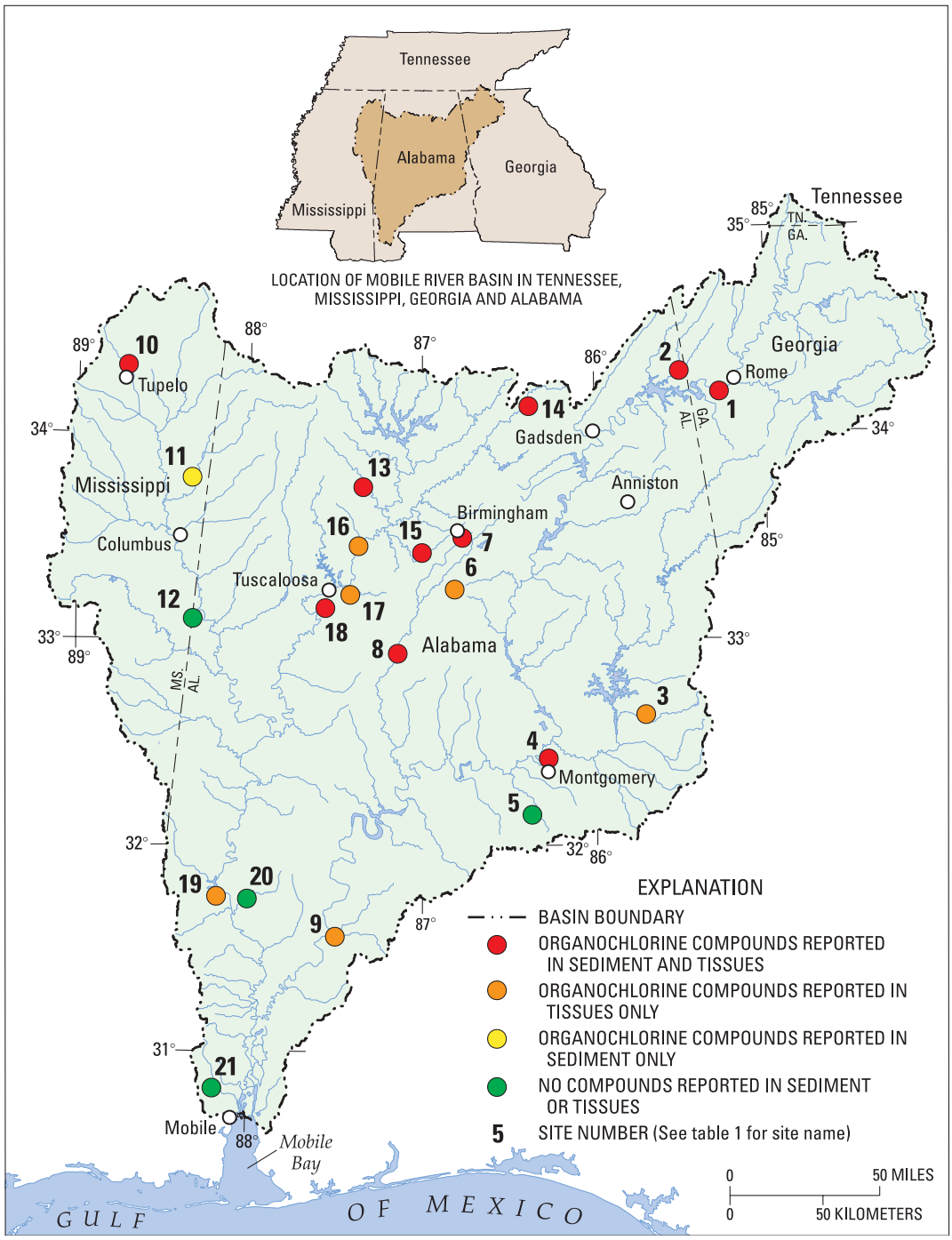

Figure 13. Sites in the Mobile River Basin where organochlorine compounds were reported.

and biomagnification, or because of the greater solubility of organochlorine compounds in fish lipids than in organic carbon in streambed sediment (Nowell and others, 1999; Steven L. Goodbred, U.S. Geological Survey, written commun., 2002; tables 4, 11, 20; fig. 13). In the MOBL basin, 86 percent of the 22 trace elements analyzed in fish-tissue samples were reported (table 21). All sites and samples had reportable concentrations of trace elements. Ninety-eight percent of the 44 trace elements analyzed in streambed-sediment samples were reported. All sediment-sampling sites had reportable trace-element

Table 21. Trace elements analyzed in streambed-sediment and fish-tissue samples from the Mobile River Basin

[Shaded blocks indicate the analyte was analyzed and reported; blank blocks indicate the analyte was analyzed but not reported; —, the analyte was not analyzed]

Compound	Streambed-sediment samples	Fish-tissue samples
Aluminum		
Antimony		
Arsenic		
Barium		
Beryllium		
Bismuth		—
Boron	—	
Cadmium		
Calcium		—
Cerium		—
Chromium		
Cobalt		
Copper		
Europium		—
Gallium		—
Gold		—
Holmium		—
Iron		
Lanthanum		—
Lead		
Lithium		—
Magnesium		—
Manganese		
Mercury		
Molybdenum		
Neodymium		—
Nickel		
Niobium		—
Phosphorus		—
Potassium		—
Scandium		—
Selenium		
Silver		
Sodium		—
Strontium		
Sulfur		—
Tantalum		—
Thorium		—
Tin		—
Titanium		—
Uranium		
Vanadium		
Ytterbium		—
Yttrium		—
Zinc		

concentrations. Collectively, a total of 44 trace elements were reported from both media. These two sampling media had 21 analytes in common, 18 of which (86 percent) were reported in both media (table 21). Antimony, beryllium, and uranium were the only trace elements analyzed in both media but only reported in streambed-sediment samples. Trace elements typically were reported more frequently in streambed-sediment samples than in fish-liver samples, possibly because of the total extraction method used by the NWQL, which is a good indication of what is present in streambed sediments as a whole. Fish-tissue samples, however, may give a better idea as to which trace elements are bioavailable (tables 6, 14, 21).

Spearman-rho rank correlations were calculated between the two sampling media using median concentrations of organochlorine compounds reported in fish-tissue and streambed-sediment samples at each site. In addition, the test statistic was calculated for the median total concentration and median total number of organochlorine compounds reported at each site in each medium. Based on the test statistic at the 95-percent confidence level, no relation was found between the sampling media when considering organochlorine compounds.

A Spearman-rho rank correlation also was calculated for individual trace-element median concentrations at each site in fish tissue and streambed sediments. Based on the test statistic at the 95-percent confidence level, no relation was evident between the two media.

SUMMARY AND CONCLUSIONS

During the summer of 1998, as part of the National Water-Quality Assessment Program, a survey was conducted to determine which organochlorine compounds and trace elements occur in fish tissues and streambed sediments in the Mobile River Basin, which includes parts of Alabama, Mississippi, Georgia, and Tennessee. The data collected were compared to guidelines related to wildlife, land use, and to 1991 and 1994 National Water-Quality Assessment Program Study-Unit data.

Twenty-one sites were sampled in subbasins of the Mobile River Basin. The subbasins ranged in size from about 9 to 22,000 square miles and were dominated by either a single land use or a combination of land uses. The major land-use categories were urban, agriculture, and forest.

Organochlorine compounds are widespread in the Mobile River Basin (MOBL). At least one organochlorine compound was present at a reportable level at a majority of the sampling sites (84 percent) in the MOBL and in the whole-fish (80 percent) and streambed-sediment (52 percent) samples. A majority of sites (75 percent) where fish-tissue samples were collected had multiple organochlorine compounds reported, as did many of the streambed-sediment sampling sites (45 percent). The majority of concentrations reported were less than their reporting levels (RL's), typically 5 µg/kg in fish-tissue samples and 1 µg/kg in streambed-sediment samples. Organochlorine compounds were reported more frequently in fish tissue than in streambed-sediment samples, possibly because of bioaccumulation and biomagnification.

Based on concentrations of organochlorine compounds reported in fish-tissue samples from the MOBL basin, National Academy of Science and National Academy of Engineering (NAS/NAE) recommended maximum concentrations, and Canadian tissue-residue guidelines (TRG's), a potential exists for adverse effects to piscivorous wildlife at a majority (13 of 19 sites or 68 percent) of sites sampled due to residues or breakdown products related to PCB's, chlordane, and DDT. Examples of piscivorous wildlife inhabiting the MOBL basin include otter, herons, and kingfishers. The sites with samples exceeding these concentrations are Three Mile Branch (site 4), Cribbs (site 18), Hurricane (site 17), Locust (site 14), Lost (site 13), Shades (site 7), and Town (site 10) Creeks, and the Alabama (site 9), Black Warrior (site 16), Chattooga (site 2), Cahaba (site 8), Coosa (site1), and Tombigbee (site 19) Rivers.

Although concentration data for streambed-sediment samples produced using NAWQA sample processing and analysis methods may overestimate the actual concentration in whole sediment and, therefore, overestimate the potential for adverse effects to organisms in association with streambed sediment when compared to probable-effects concentrations (PEC's), there probably is a potential for adverse effects at two sites. Pintlalla (site 5) and Valley (site 15) Creeks were the only sites out of five sites, from which samples contained concentrations of either organochlorine compounds or trace elements that exceed PEC's, to have mean PEC quotients greater

than 0.5. Samples whose mean PEC quotients are greater than 0.5 are considered to indicate a high probability of adverse effects to organisms in association with the streambed sediment at that site. In addition, the mean PEC quotient at Valley Creek (site 15) was calculated based on multiple analytes exceeding their respective PEC's. Therefore, based on the mean PEC quotient and the occurrence of multiple analytes above their respective PEC's, adverse effects may occur to organisms in association with streambed sediments at the Pintlalla (site 5) and Valley (site 15) Creek sites.

The potential harm to wildlife caused by exposure to organochlorine compounds and trace elements can be due to chronic or acute exposure and, depending on the concentration and duration of exposure, can be lethal or sub-lethal. Chlordane and its related compounds, total DDT, and PCB's are known to have several adverse effects on wildlife. Reduced fecundity due to eggshell thinning in several piscivorous bird species has been well documented, as well as the potential for liver disease and carcinogenicity. In addition, endocrine system effects have been associated with these compounds. The types of adverse effects to wildlife due to concentrations of various trace elements also include carcinogenicity, liver disease, reduced fecundity, and endocrine disruption.

The majority of the 18 organochlorine compounds reported in samples from the MOBL basin and those compounds most frequently reported were chlordane, DDT, PCB's, or their breakdown products. These compounds were prevalent, although the use of chlordane and PCB's has been banned since 1988 and for DDT since 1973.

Concentrations of chlordane, total DDT, heptachlor epoxide, and the total number and concentrations of pesticides reported in a basin were related to land use. Concentrations of chlordane and heptachlor epoxide in whole-fish tissue were positively correlated to the amount of urban land use in a basin. Total DDT concentrations in whole-fish tissues were positively related to agricultural land use, whereas total DDT concentrations in streambed sediments were negatively related to agricultural land use.

It is not surprising that concentrations of chlordane, heptachlor epoxide, and the total concentration and number of organochlorine compounds reported were either positively related to urban land use or negatively related to the amount of agriculture or forest within a basin. Chlordane, although used on crops, was extensively used for termite control in urban areas of the termite-prone subtropical Southeast. These uses often outstripped those of agriculture. In addition, PCB's often are associated with urban areas because they were used in electrical transformers and in manufacturing processes. The negative relation of these organochlorine compounds with agricultural and forested lands can be explained by the inverse relation of agricultural and forested land uses to the amount of urban land use within a basin.

DDT was used extensively for agricultural purposes in the United States, and other studies have shown the positive relation of concentrations of DDT in stream sediments and fish tissue to agricultural land use. Thus the observed positive relation of DDT concentrations in whole-fish tissue samples from the Mobile River Basin to agriculture is probably to be expected, although DDT was commonly used for mosquito control in urban areas of the South. The negative correlation of DDT concentrations in streambed sediment to the amount of agriculture in a basin is harder to explain. This correlation may be because concentrations of DDT in sediment are low enough that the relation is not perceptible by using current analysis methods but is perceptible in whole-fish tissues because of bioaccumulation or because the correlation may be spurious.

Fewer of the total number of organochlorine compounds analyzed both locally and nationally were reported in whole-fish tissue (57 percent) and streambed-sediment (41 percent) samples in the MOBL basin than nationally (96 percent in whole-fish tissue samples and 86 percent in streambed-sediment samples). The fewer number of compounds reported in the MOBL basin is because of the greater number of pesticides used nationally than in the MOBL.

Organochlorine compounds that were not reported in samples from the MOBL but were reported nationally were reported at extremely low frequencies. This low frequency of detection nationally may indicate a very low probability of detection in any one study unit. In addition, sites in some NAWQA Study Units were sampled because of known contamination to quantify the extent of contamination. This site-selection criterion probably accounts for the higher maximum concentrations reported in the 1991 and 1994 NAWQA Study Units for many of the organochlorine compounds.

In general, concentrations of organochlorine compounds and the frequency with which they were reported in whole-fish and streambed-sediment samples from the MOBL Study Unit are similar to or less than those reported in 1991 and 1994 NAWQA Study Units. Exceptions to this generality that cannot be explained by the wider range in concentrations characterized, the lower reporting frequency, and site-selection criteria for sites nationally, are the higher reporting frequency of heptachlor epoxide, *p,p*'-DDT, and PCB's in whole-fish samples, higher quartile concentrations of heptachlor epoxide and *p,p*'-DDT in whole-fish samples, the higher maximum concentration of heptachlor epoxide in whole-fish samples, and the higher maximum concentration and reporting frequency of *trans*-chlordane in streambed-sediment samples in the MOBL Study Unit. The higher reporting frequencies and concentrations of heptachlor epoxide, *p,p*'-DDT, and *trans*-chlordane in samples from the MOBL are probably due to the greater use of these compounds locally than nationally. The reason for the higher reporting frequency of PCB's is less clear but may be due to the production of these compounds within the basin.

The majority of trace elements analyzed in fish-liver tissues (86 percent) and streambed-sediment (98 percent) samples were reported during this study. All of the fish-liver tissue and streambed-sediment samples analyzed contained reportable concentrations of multiple trace elements. In addition, multiple trace elements were reported in samples from all sites.

When considering the relation of trace-element concentrations in samples from the MOBL to land use, the picture is not as clear as that for organochlorine compounds. This lack of clarity is due to the possibility of geologic sources for the trace elements analyzed within the MOBL and the ubiquitous nature of many of these trace elements. However, there may be a correlation between several trace elements and land use based on the current analysis.

Concentrations of antimony, cadmium, lead, and zinc in streambed-sediment samples were positively correlated to the amount of urban land use within a basin. This positive correlation of concentrations of antimony, cadmium, lead, and zinc to urban land use within a basin is reasonable. Several of the sites sampled during the 1998 study were within the Birmingham area. This portion of the basin is known for its long history of involvement with the steel industry. Cadmium, lead, and zinc are all known to be associated with this type of industry, and antimony is a common impurity in ores. In addition, these trace elements have nonpoint sources in urban areas and are often associated with runoff from urban centers. Nonpoint sources for these trace elements in urban areas include batteries, ceramics, wear of automobile parts, pigments, and combustion.

At the common reporting level selected for this analysis, fewer trace elements were reported in fish-liver tissue (86 percent) and streambed-sediment (95 percent) samples in the MOBL basin than nationally (95 percent in fish-liver samples and 98 percent in streambed-sediment samples). The fewer number of trace elements reported in the MOBL is due to the greater range in geologies sampled nationally.

In general, concentrations of trace elements and the frequency with which they were reported in fish-liver and streambed-sediment samples from the MOBL Study Unit are similar to or less than those reported in 1991 and 1994 NAWQA Study Units. Exceptions do exist, typically explained by the wider range of geological settings, low detection frequency, and site-selection criterion nationally.

Concentration quartiles of a few trace elements reported in the MOBL were slightly higher that those nationally. These concentrations were probably lower in 1991 and 1994 NAWQA Study Unit data because of the more diverse geological settings sampled nationally. Samples from other NAWQA Study Units were probably collected from areas where the composition of weatherable material contained less of some trace elements than the geologic settings of the MOBL, accounting for the lower concentrations.

Trace elements not reported in samples from the MOBL Study Unit that were reported nationally were reported infrequently. This low reporting frequency nationally probably indicates a very low probability of detection in any one study unit. In addition, some NAWQA Study Units sampled sites of known contamination to quantify the extent of that contamination. This site-selection criterion probably accounts for the higher maximum concentrations reported in the 1991 and 1994 Study Units for many of the trace elements.

Exceptions not explained by low detection frequency and site-selection criteria nationally are the higher frequencies with which aluminum, barium, chromium, cobalt, nickel, and strontium were reported

in fish-liver samples, the consistently higher concentrations of boron in fish-liver samples, and the higher reporting frequency in streambed-sediment samples of mercury, silver, and ytterbium in the MOBL Study Unit.

The frequency with which these trace elements were reported in fish-liver tissue and streambed-sediment samples may be higher in the MOBL due to geology or anthropomorphic activities. Boron concentrations are probably due to anthropomorphic activities, because there are no major geological sources for boron in the MOBL basin. Potential sources locally for most of these trace elements include irrigation drain water (mercury), coal combustion (mercury and nickel), metallurgy (barium, boron, chromium, and nickel), soaps (boron), and the wood and pulp industry (barium and chromium). Other sources that could enrich samples from the MOBL basin are the Black Warrior coal fields (aluminum and mercury) in the northwestern quarter of the basin, which are known to have elevated levels of mercury, and barite deposits (barium) in east-central Alabama. Although, the potential reasons for the higher frequencies with which cobalt, strontium, silver, and ytterbium were reported in the MOBL basin are less clear.

In summary, the widespread occurrence of many organochlorine compounds and certain trace elements in samples from the Mobile River Basin can probably be attributed to land use. The higher concentration of certain organochlorine compounds and trace elements in samples from the MOBL than in those samples collected nationally and the potential for adverse effects to wildlife at many sites can also be attributed to land-use practices within the MOBL basin. The majority of compounds reported were related to those used in termite control in urban areas and to control of crop pests in agricultural areas. In addition, the majority of trace elements reported were related to metallurgy or nonpoint runoff from urban areas—the majority of the metallurgical practices within the MOBL River Basin are associated with the Birmingham metropolitan area.

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APPENDIXES

1. Data for individual fish collected at sites in the Mobile River Basin Study Unit for organochlorine compound and trace element analyses.

2. Concentration data for organochlorine compounds in whole-fish tissue samples from the Mobile River Basin, 1998.

3. Concentration data for trace elements in fish-liver tissue samples from the Mobile River Basin, 1998.

4. Concentration data for organochlorine compounds in streambed-sediment samples from the Mobile River Basin, 1998.

5. Concentration data for trace elements in streambed-sediment samples from the Mobile River Basin, 1998.

Appendix 1. Data for individual fish collected at sites in the Mobile River Basin Study Unit for organochlorine compound and trace element analyses

[mm, millimeter; g, gram; USGS, U.S. Geological Survey; ?, unable to determine; NA, not applicable; min., minimum; <, less than; max., maximum; —, not determined; L&D, lock and dam]

Sample type	Common name	Species	Standard length (mm)	Total length (mm)	Weight (g)	Gender	External anomalies	Age, in years
Coosa River near Rome, Georgia—USGS station number 02397000								
Organochlorine compounds	Bluegill	*Lepomis macrochirus*	126	161	71	Male	None	3
			122	154	73	Female	None	3
			124	157	76	Male	None	3
			132	168	90	Male	Lesion	4
			138	177	104	Male	None	4
			118	155	63	Male	None	5
Trace elements	Bluegill	*Lepomis macrochirus*	121	153	62	Male	None	3
			118	152	63	Male	None	3
			111	143	53	Male	None	3
			128	168	91	Male	None	4
			126	163	79	Male	None	4
			132	171	97	Male	Lesion	5
			128	170	98	Male	None	5
Organochlorine compounds	Common carp	*Cyprinus carpio*	355	442	1,250	Female	None	5
			378	457	1,250	Female	Undefined anomalie	5
			382	466	1,600	Female	None	6
			468	582	3,050	Female	None	8
			480	583	3,150	Female	None	8
Trace elements	Common carp	*Cyprinus carpio*	415	515	1,700	Male	Lesion	6
			412	515	2,100	Female	None	7
			475	582	2,650	Female	None	8
			448	553	2,400	Male	None	8
			462	570	3,600	Female	None	8
Chattooga River above Gaylesville, Alabama—USGS station number 02398300								
Organochlorine compounds	Redspotted sunfish	*Lepomis miniatus*	77	98	22	Female	None	2
			107	133	52	Male	None	3
			85	105	28	Female	None	3
			82	104	23	Female	None	3
			122	152	81	Male	None	4
Trace elements	Redspotted sunfish	*Lepomis miniatus*	68	86	15	?	None	2
			61	78	11	Female	None	2
			68	86	17	Male	None	2
			73	94	18	Male	None	2
			74	92	16	Female	None	2
			67	86	16	Female	None	3
			68	86	14	Female	None	3
			83	114	22	Female	None	3

Appendix 1. Data for individual fish collected at sites in the Mobile River Basin Study Unit for organochlorine compound and trace element analyses—Continued

[mm, millimeter; g, gram; USGS, U.S. Geological Survey; ?, unable to determine; NA, not applicable; min., minimum; <, less than; max., maximum; —, not determined; L&D, lock and dam]

Sample type	Common name	Species	Standard length (mm)	Total length (mm)	Weight (g)	Gender	External anomalies	Age, in years
Sougahatchee Creek above Reeltown, Alabama—USGS station number 02418264								
Organochlorine compounds	Alabama hogsucker	*Hypentelium etowanum*	122	149	35	Male	None	NA
			132	155	35.5	Female	None	NA
			132	157	36	Female	None	NA
			133	163	42	Male	None	NA
			133	159	42.5	Female	None	NA
			135	158	39.5	Female	None	NA
			136	164	48	Male	None	NA
Organochlorine compounds	Channel catfish	*Ictalurus punctatus*	111	131	23.5	?	None	1
			109	135	21.5	?	None	2
			132	169	38.5	Female	None	2
			150	190	55.5	?	None	3
			142	171	44	?	None	3
			137	173	40.5	Female	None	3
Trace elements	Channel catfish	*Ictalurus punctatus*	145	186	45	Female	None	2
			122	151	33.5	Female	None	2
			109	134	21.5	Female	None	2
			232	286	192.5	Male	None	3
			335	409	529.5	Female	None	6
Three Mile Branch at North Boulevard at Montgomery, Alabama—USGS station number 02419977								
Organochlorine compounds	Mosquito fish (48 specimens)	*Gambusia affinis*	18 min.	21 min.	< 1 min.	?	None	NA
			46 max.	56 max.	2 max.	?	None	NA
Pintlalla Creek at Liberty Church Road near Pintlalla, Alabama—USGS station number 02421115								
Organochlorine compounds	Longear sunfish	*Lepomis megalotis*	68	82	11	Female	None	2
			65	81	9	Female	None	2
			62	78	9	Male	None	2
			72	89	12.5	Female	None	3
			72	91	12.5	Male	None	3
Trace elements	Longear sunfish	*Lepomis megalotis*	72	89	11.5	?	None	2
			77	98	22	Male	None	3
			88	109	27.5	Male	None	4
			84	107	24.5	Male	Lesion	4

Appendix 1. Data for individual fish collected at sites in the Mobile River Basin Study Unit for organochlorine compound and trace element analyses—Continued

[mm, millimeter; g, gram; USGS, U.S. Geological Survey; ?, unable to determine; NA, not applicable; min., minimum; <, less than; max., maximum; —, not determined; L&D, lock and dam]

Sample type	Common name	Species	Standard length (mm)	Total length (mm)	Weight (g)	Gender	External anomalies	Age, in years
Cahaba Valley Creek at Cross Creek Road at Pelham, Alabama—USGS station number 0242354750								
Organochlorine compounds	Longear sunfish	*Lepomis megalotis*	63	81	9.5	Female	None	2
			75	94	13.5	Female	None	3
			75	97	17.5	Male	None	3
			76	98	17	Male	None	3
			85	106	23	Male	None	4
			91	113	24	Female	None	4
Trace elements	Longear sunfish	*Lepomis megalotis*	61	80	10	Male	None	2
			65	83	10	Female	None	2
			67	87	?	Female	None	3
			72	89	13	Male	None	3
			68	87	12	Male	None	3
			80	100	18.5	Male	Lesion	3
			71	89	14.5	Male	None	3
			68	87	12.5	Female	None	3
Shades Creek at Homewood, Alabama—USGS station number 02423581								
Organochlorine compounds	Longear sunfish	*Lepomis megalotis*	98	122	38	Male	Lesion	2
			89	109	26.5	?	Deformaties	2
			82	105	21.5	?	Lesion	2
			98	122	35.5	Male	Lesion	3
			95	122	35	Male	Lesion	3
			103	128	42.5	Male	Lesion	4
			96	118	36	Male	Lesion	4
			104	132	48	Male	Lesion	5
Trace elements	Longear sunfish	*Lepomis megalotis*	88	115	29	Male	None	2
			82	105	21	Male	Deformaties	2
			88	110	22.5	?	None	2
			98	122	36	Male	None	4
			98	124	36	Male	Lesion	4
			92	116	28	Male	None	—
			93	118	31	Male	None	—
			100	125	36.5	Male	Deformaties	—
			85	105	22	?	Lesion	—
			95	117	32	Male	Lesion	—

Appendix 1. Data for individual fish collected at sites in the Mobile River Basin Study Unit for organochlorine compound and trace element analyses—Continued

[mm, millimeter; g, gram; USGS, U.S. Geological Survey; ?, unable to determine; NA, not applicable; min., minimum; <, less than; max., maximum; —, not determined; L&D, lock and dam]

Sample type	Common name	Species	Standard length (mm)	Total length (mm)	Weight (g)	Gender	External anomalies	Age, in years
Cahaba River at Centreville, Alabama—USGS station number 02424000								
Organochlorine compounds	Smallmouth buffalo	*Ictiobus bubalus*	281	374	600	Female	None	3
			335	438	1,300	Female	None	4
			315	417	760	Female	None	4
			355	455	1,400	Male	None	4
			390	493	1,550	Male	None	5
Trace elements	Smallmouth buffalo	*Ictiobus bubalus*	275	354	620	Female	None	4
			335	438	1,300	Female	None	4
			315	417	760	Female	None	4
			355	455	1,400	Male	None	4
Alabama River at Claiborne, Alabama—USGS station number 02429500								
Organochlorine compounds	Largemouth bass	*Micropterus salmoides*	218	267	220	Male	Lesion	2
			270	330	421	Male	None	3
			228	276	232	Female	None	3
			270	328	425	Male	None	4
			332	400	811	Male	None	5
Trace elements	Spotted bass	*Micropterus punctulatus*	188	230	155	Female	Lesion	2
			206	250	161	Male	None	3
			235	284	288	Female	None	3
			226	274	241	Female	Lesion	3
			312	383	762	Female	None	4
			312	380	737	Male	None	4
Town Creek at Tupelo, Mississippi—USGS station number 02434000								
Organochlorine compounds	Bluegill	*Lepomis macrochirus*	93	116	33	Female	None	2
			88	111	26	?	Anchor worm, bacterial infection, eroded fins	2
			78	100	23	Female	Bacterial infection, eroded fins	2
			68	90	14	Female	None	2
			131	163	99	Male	None	4
Trace elements	Bluegill	*Lepomis macrochirus*	82	101	21	Female	None	2
			108	135	48	Male	Undefined anomalie	2
			85	105	29	Male	None	2
			128	161	99	Male	Anchor worm	4
			128	160	105	Male	Lesion	4

Appendix 1. Data for individual fish collected at sites in the Mobile River Basin Study Unit for organochlorine compound and trace element analyses—Continued

[mm, millimeter; g, gram; USGS, U.S. Geological Survey; ?, unable to determine; NA, not applicable; min., minimum; <, less than; max., maximum; —, not determined; L&D, lock and dam]

Sample type	Common name	Species	Standard length (mm)	Total length (mm)	Weight (g)	Gender	External anomalies	Age, in years
Town Creek at Tupelo, Mississippi—USGS station number 02434000 (Continued)								
Organochlorine compounds	Channel catfish	*Ictalurus punctatus*	202	265	126	Male	None	2
			168	206	72	Female	None	3
			174	224	88	Male	None	3
			168	219	73	Male	None	3
			201	261	120	Female	None	4
Trace elements	Channel catfish	*Ictalurus punctatus*	168	220	79	Male	Leeches	2
			160	206	62	Female	None	3
			170	216	76	Male	None	3
			180	234	86	Male	None	3
			188	242	102	Female	None	3
Lost Creek above Parrish, Alabama—USGS station number 02454055								
Organochlorine compounds	Longear sunfish	*Lepomis megalotis*	88	112	27	?	None	2
			108	137	60	Male	None	4
			112	138	58	Male	None	5
			124	154	77	Male	None	5
			110	135	55	Male	None	5
Trace elements	Longear sunfish	*Lepomis megalotis*	91	110	26	Female	None	2
			77	97	17	Female	None	2
			89	110	24	Female	None	3
Organochlorine compounds	Bluegill	*Lepomis macrochirus*	108	140	52	Female	None	2
			103	145	56	Male	Deformaties, black spot	3
			135	170	93	Male	None	4
			135	174	110	Male	None	4
			132	170	101	Male	None	4
Trace elements	Bluegill	*Lepomis macrochirus*	86	110	21	?	None	2
			95	118	29	?	None	2
			115	145	57	Male	None	2
			105	135	46	Male	None	2
			110	130	38	Male	None	2
			91	118	27	?	Undefined anomalie	2
			98	127	33	Male	None	3
			82	105	21	?	None	3
Organochlorine compounds	Spotted bass	*Micropterus punctulatus*	194	235	155	Female	None	2
			240	292	288	Male	None	3

Appendix 1. Data for individual fish collected at sites in the Mobile River Basin Study Unit for organochlorine compound and trace element analyses—Continued

[mm, millimeter; g, gram; USGS, U.S. Geological Survey; ?, unable to determine; NA, not applicable; min., minimum; <, less than; max., maximum; —, not determined; L&D, lock and dam]

Sample type	Common name	Species	Standard length (mm)	Total length (mm)	Weight (g)	Gender	External anomalies	Age, in years
Locust Fork below Snead, Alabama—USGS station number 02454500								
Organochlorine compounds	Largemouth bass	*Micropterus salmoides*	268	322	450	Male	None	3
			270	328	509	Male	None	3
			340	411	953	Male	None	4
			315	386	703	Male	None	4
			323	391	900	Male	None	4
Trace elements	Spotted bass	*Micropterus punctulatus*	145	177	57	Male	None	2
			206	249	191.5	Female	None	3
			212	252	202	Female	None	3
			296	359	575	Male	Lesion	4
Valley Creek near Bessemer, Alabama—USGS station number 02461500								
Organochlorine compounds	Yellow bullhead	*Ameiurus natalis*	141	166	77.5	Male	None	2
			185	216	143	Male	Lesion	3
			184	206	135.5	Male	Deformaties	3
			163	190	105.5	Male	Lesion	3
			151	181	78.5	Female	None	3
			195	235	167.5	Male	Lesion	3
Trace elements	Yellow bullhead	*Ameiurus natalis*	198	232	170.5	Male	Lesion	3
			155	182	83	Male	Deformaties	3
			176	213	150	Female	None	3
			165	196	104	Female	Deformaties	3
			198	232	166.5	Male	Lesion	3
			186	225	144.5	Female	Lesion	3
Black Warrior River at Bankhead L&D near Bessemer, Alabama—USGS station number 02462500								
Organochlorine compounds	Bluegill	*Lepomis macrochirus*	92	116	30	Male	None	2
			97	120	28	Male	None	2
			98	125	29	Male	Protruding anus	2
			88	110	20	Female	None	2
			124	158	66	Male	None	2
			96	121	28	Male	None	2
Trace elements	Bluegill	*Lepomis macrochirus*	118	139	47	Female	None	2
			90	116	29	?	None	2
			94	119	30	Female	None	2
			93	120	32	Female	None	2
			93	119	29	Male	None	2
			93	118	31	Female	Black spot	2

Appendix 1. Data for individual fish collected at sites in the Mobile River Basin Study Unit for organochlorine compound and trace element analyses—Continued

[mm, millimeter; g, gram; USGS, U.S. Geological Survey; ?, unable to determine; NA, not applicable; min., minimum; <, less than; max., maximum; —, not determined; L&D, lock and dam]

Sample type	Common name	Species	Standard length (mm)	Total length (mm)	Weight (g)	Gender	External anomalies	Age, in years
Hurricane Creek near Holt, Alabama—USGS station number 02463500								
Organochlorine compounds	Largemouth bass	*Micropterus salmoides*	170	206	97	Male	None	1
			230	277	257	Male	None	3
			225	275	250	Male	Deformaties	3
			228	277	228.5	Female	None	3
			303	364	594.5	Female	None	4
Organochlorine compounds	Channel catfish	*Ictalurus punctatus*	300	378	418.5	Female	None	5
			295	338	394	Male	None	5
			268	341	267.5	Female	None	5
			305	381	440.5	Male	None	6
			328	402	521	Male	None	6
			328	407	539	Male	None	6
Trace elements	Channel catfish	*Ictalurus punctatus*	208	265	136.5	Male	None	3
			184	250	101	Female	None	3
			210	272	152	Female	None	4
			230	306	195	?	None	4
			291	362	351	Female	None	5
			281	365	362.5	Male	None	6
Cribbs Mill Creek at Tuscaloosa, AL—USGS station number 02465288								
Organochlorine compounds	Largemouth bass	*Micropterus salmoides*	166	202	135	?	None	1
			205	252	228	Female	None	2
			192	232	175	Male	None	2
			280	335	600	Female	Eroded fins	3
			234	284	348	Female	Lesion	3
Trace elements	Largemouth bass	*Micropterus salmoides*	166	202	135	?	None	1
			205	252	228	Female	None	2
			192	232	175	Male	None	2
			280	335	600	Female	Eroded fins	3
			234	284	348	Female	Lesion	3

Appendix 1. Data for individual fish collected at sites in the Mobile River Basin Study Unit for organochlorine compound and trace element analyses—Continued

[mm, millimeter; g, gram; USGS, U.S. Geological Survey; ?, unable to determine; NA, not applicable; min., minimum; <, less than; max., maximum; —, not determined; L&D, lock and dam]

Sample type	Common name	Species	Standard length (mm)	Total length (mm)	Weight (g)	Gender	External anomalies	Age, in years
Cribbs Mill Creek at Tuscaloosa, AL—USGS station number 02465288 (Continued)								
Organochlorine compounds	Longear sunfish	*Lepomis megalotis*	86	108	30	Female	None	3
			98	121	40	Female	None	4
			102	128	56	Male	Lesion	5
			101	128	55	Male	None	5
			105	132	55	Male	None	5
			100	130	50	Male	None	2
			108	141	65	?	None	2
			102	134	50	?	None	2
			108	141	55	?	None	2
			107	151	50	?	Fungus	3
Trace elements	Longear sunfish	*Lepomis megalotis*	76	96	20	?	None	2
			85	105	20	Female	None	2
			82	104	25	Female	None	3
			104	134	35	Male	None	3
			98	126	30	Male	Lesion	4
			100	132	48	?	None	2
			112	140	60	?	Deformaties	3
			118	150	75	Male	None	3
			99	132	45	?	None	4
			116	157	62	Male	None	4
Organochlorine compounds	Yellow bullhead	*Ameiurus natalis*	160	184	95	Female	None	2
			154	182	45	Male	None	2
			180	215	235	Male	Undefined anomalie	3
			192	227	135	Male	None	3
			215	255	250	Male	None	4
Trace elements	Yellow bullhead	*Ameiurus natalis*	128	154	45	Male	None	2
			167	192	90	Female	None	2
			167	195	100	Male	None	3
			198	230	155	Male	None	3
			169	197	95	Male	None	3

Appendix 1. Data for individual fish collected at sites in the Mobile River Basin Study Unit for organochlorine compound and trace element analyses—Continued

[mm, millimeter; g, gram; USGS, U.S. Geological Survey; ?, unable to determine; NA, not applicable; min., minimum; <, less than; max., maximum; —, not determined; L&D, lock and dam]

Sample type	Common name	Species	Standard length (mm)	Total length (mm)	Weight (g)	Gender	External anomalies	Age, in years
Tombigbee River below Coffeeville L&D near Coffeeville, Alabama—USGS station number 02469762								
Organochlorine compounds	Gizzard shad	*Dorosoma cepedianum*	212	267	202.5	Male	None	3
			192	250	170	Male	None	3
			208	265	236	Female	None	3
			183	235	124.5	?	None	3
			168	216	112.5	?	None	3
Trace elements	Gizzard shad	*Dorosoma cepedianum*	212	267	202.5	Male	None	3
			192	250	170	Male	None	3
			208	265	236	Female	None	3
			183	235	124.5	?	None	3
			168	216	112.5	?	None	3
Organochlorine compounds	Largemouth bass	*Micropterus salmoides*	220	270	237	Male	None	2
			220	268	237	Female	Black spot, lesion	2
			258	311	421	Male	Lesion	3
			231	280	292	Female	None	3
			310	373	662	Male	Black spot, lesion	4
			302	358	630	Female	Lesion, black spot	4
Trace elements	Largemouth bass	*Micropterus salmoides*	200	247	174	Female	None	2
			222	270	233	Male	None	3
			290	350	577	Male	Lesion, black spot	3
			247	300	353	Female	Black spot	3
			228	275	263	Male	None	3
			307	370	611	Male	None	4
Satilpa Creek near Coffeeville, Alabama—USGS station number 02469800								
Organochlorine compounds	Blacktail redhorse	*Moxostoma poecilurum*	220	270	216.5	Male	None	3
			207	252	161.5	Male	Lesion	3
			204	248	147.5	Male	None	3
			268	314	293.5	Male	None	4
			248	304	274.5	Female	None	4
Trace elements	Blacktail redhorse	*Moxostoma poecilurum*	220	270	216.5	Male	None	3
			207	252	161.5	Male	Lesion	3
			204	248	147.5	Male	None	3
			268	314	293.5	Male	None	4
			248	304	274.5	Female	None	4

Appendix 1. Data for individual fish collected at sites in the Mobile River Basin Study Unit for organochlorine compound and trace element analyses—Continued

[mm, millimeter; g, gram; USGS, U.S. Geological Survey; ?, unable to determine; NA, not applicable; min., minimum; <, less than; max., maximum; —, not determined; L&D, lock and dam]

Sample type	Common name	Species	Standard length (mm)	Total length (mm)	Weight (g)	Gender	External anomalies	Age, in years
Satilpa Creek near Coffeeville, Alabama—USGS station number 02469800 (Continued)								
Organochlorine compounds	Longear sunfish	*Lepomis megalotis*	70	90	16	Male	None	2
			77	97	16.5	?	None	2
			72	88	14	?	None	2
			111	132	42.5	Female	None	4
Chickasaw Creek near Kushla, Alabama—USGS station number 02471001								
Organochlorine compounds	Longear sunfish	*Lepomis megalotis*	67	86	11.5	Female	None	2
			88	110	22	Female	None	3
			102	126	31	Female	None	4
			122	150	66	Female	None	5
			98	127	40.5	Female	None	5
Trace elements	Longear sunfish	*Lepomis megalotis*	67	86	11.5	Female	None	2
			88	110	22	Female	None	3
			102	126	31	Female	None	4
			122	150	66	Female	None	5
			98	127	40.5	Female	None	5

Appendix 2. Concentration data for organochlorine compounds in whole-fish tissue samples from the Mobile River Basin, 1998

[USGS, U.S. Geological Survey; PCB's, polychlorinated biphenyls; <, less than; Blvd., Boulevard; L&D, Lock and Dam; E, estimated; BHC, hexachlorocyclohexane]

Site name (USGS identification number[a])	Species	Concentration, in microgram per kilogram, wet weight					
		a-d6-Hexachloro-cyclohexane[b]	3,5-Dichloro-biphenyl[b]	Percent lipid content	Aldrin	PCB's	Toxaphene
Coosa River near Rome, GA (02397000)	*Cyprinus carpio*	75	76	4.9	< 5	900	< 200
	Lepomis macrochirus	94	71	2.4	< 5	530	< 200
Chattooga River above Gaylesville, AL (02398300)	*Lepomis miniatus*	69	58	2.4	< 5	78	< 200
Sougahatchee Creek above Reeltown, AL (02418264)	*Hypentelium etowanum*	90	80	4	< 5	< 50	< 200
	Ictalurus punctatus	102	66	3.2	< 5	< 50	< 200
Three Mile Branch at North Blvd. at Montgomery, AL (02419977)	*Gambusia affinis*	108	100	4.6	< 5	340	< 200
Pintlalla Creek at Liberty Church Road near Pintlalla, AL (02421115)	*Lepomis megalotis*	116	95	3.1	< 5	< 50	< 200
Shades Creek at Homewood, AL (02423581)	*Lepomis megalotis*	109	112	4.3	< 5	220	< 200
Cahaba River at Centreville, AL (02424000)	*Ictiobus bubalus*	90	70	5.05	< 5	140	< 200
Alabama River at Claiborne, AL (02429500)	*Micropterus salmoides*	104	66	3.5	< 5	160	< 200
Town Creek at Tupelo, MS (02434000)	*Ictalurus punctatus*	100	84	2.4	< 5	50	< 200
	Lepomis macrochirus	109	108	3.3	< 5	< 50	< 200
Lost Creek above Parrish, AL (02454055)	*Lepomis megalotis*	75	61	3.9	< 5	< 50	< 200
	Lepomis macrochirus	91	65	4.4	< 5	< 50	< 200
	Micropterus punctulatus	62	56	3.4	< 5	< 50	< 200
Locust Fork below Snead, AL (02454500)	*Micropterus salmoides*	96	90	5.3	< 5	150	< 200
Valley Creek near Bessemer, AL (02461500)	*Ameiurus natalis*	93	86	4	< 5	260	< 200
Black Warrior River at Bankhead L&D near Bessemer, AL (02462500)	*Lepomis macrochirus*	94	84	1.9	< 5	< 50	< 200
Hurricane Creek near Holt, AL (02463500)	*Ictalurus punctatus*	108	86	6	< 5	93	< 200
	Micropterus salmoides	89	88	5.2	< 5	97	< 200
Cribbs Mill Creek at Tuscaloosa, AL (02465288)	*Micropterus salmoides*	98	70	2.2	< 5	130	< 200
	Lepomis megalotis	78	61	2.1	< 5	< 50	< 200
	Lepomis macrochirus	75	47	1.45	< 5	< 50	< 200
	Ameiurus natalis	84	67	2.7	< 5	57	< 200
Tombigbee River below Coffeeville L&D near Coffeeville, AL (02469762)	*Dorosoma cepedianum*	68	59	10.25	< 5	65	< 200
	Micropterus salmoides	97	74	2.4	< 5	71	< 200
Satilpa Creek near Coffeeville, AL (02469800)	*Moxostoma poecilurum*	94	95	1.9	< 5	< 50	< 200
	Lepomis megalotis	91	99	3.6	< 5	< 50	< 200
Chickasaw Creek near Kushla, AL (02471001)	*Lepomis megalotis*	88	93	2.2	< 5	< 50	< 200
Cahaba Valley Creek at Cross Creek Road at Pelham, AL (0242354750)	*Lepomis megalotis*	93	81	1.8	< 5	< 50	< 200

[a] USGS identification number is based on geographic location and the downstream order of streamflow sites.

[b] Reported as percent of sample.

Appendix 2. Concentration data for organochlorine compounds in whole-fish tissue samples from the Mobile River Basin, 1998—Continued

[USGS, U.S. Geological Survey; PCB's, polychlorinated biphenyls; <, less than; Blvd., Boulevard; L&D, Lock and Dam; E, estimated; BHC, hexachlorocyclohexane]

Site name (USGS identification number[a])	Species	Concentration, in microgram per kilogram, wet weight					
		Pentachloro-anisole	Oxy-chlordane	trans-Nonachlor	cis-Nonachlor	Mirex	p,p'-Methoxychlor
Coosa River near Rome, GA (02397000)	*Cyprinus carpio*	< 5	< 5	< 5	< 5	< 5	< 5
	Lepomis macrochirus	< 5	< 5	< 5	< 5	< 5	< 5
Chattooga River above Gaylesville, AL (02398300)	*Lepomis miniatus*	< 5	< 5	< 5	< 5	< 5	< 5
Sougahatchee Creek above Reeltown, AL (02418264)	*Hypentelium etowanum*	< 5	< 5	< 5	< 5	< 5	< 8
	Ictalurus punctatus	< 5	< 5	< 5	< 5	< 5	< 5
Three Mile Branch at North Blvd. at Montgomery, AL (02419977)	*Gambusia affinis*	< 5	51	65	19	< 5	< 5
Pintlalla Creek at Liberty Church Road near Pintlalla, AL (02421115)	*Lepomis megalotis*	< 5	< 5	< 5	< 5	< 5	< 5
Shades Creek at Homewood, AL (02423581)	*Lepomis megalotis*	< 5	31	E 130	29	< 5	< 5
Cahaba River at Centreville, AL (02424000)	*Ictiobus bubalus*	E 4.8	< 5	13	< 5	< 5	< 5
Alabama River at Claiborne, AL (02429500)	*Micropterus salmoides*	< 5	< 5	< 5	< 5	< 5	< 5
Town Creek at Tupelo, MS (02434000)	*Ictalurus punctatus*	< 5	< 5	5.7	< 5	8.6	< 5
	Lepomis macrochirus	< 5	< 5	39	< 5	< 5	< 5
Lost Creek above Parrish, AL (02454055)	*Lepomis megalotis*	< 5	< 5	< 5	< 5	< 5	< 5
	Lepomis macrochirus	< 5	< 5	< 5	< 5	< 5	< 5
	Micropterus punctulatus	< 5	< 5	< 5	< 5	< 5	< 5
Locust Fork below Snead, AL (02454500)	*Micropterus salmoides*	< 5	< 5	E 11	< 5	< 5	< 5
Valley Creek near Bessemer, AL (02461500)	*Ameiurus natalis*	< 5	< 5	13	< 5	< 5	< 5
Black Warrior River at Bankhead L&D near Bessemer, AL (02462500)	*Lepomis macrochirus*	< 5	< 5	< 5	< 5	< 5	< 5
Hurricane Creek near Holt, AL (02463500)	*Ictalurus punctatus*	< 5	< 5	< 5	< 5	< 5	< 5
	Micropterus salmoides	< 5	< 5	10	< 5	< 5	< 5
Cribbs Mill Creek at Tuscaloosa, AL (02465288)	*Micropterus salmoides*	< 5	26	100	24	< 5	< 6
	Lepomis megalotis	< 5	9.5	24	6.6	< 5	< 5
	Lepomis macrochirus	< 5	8.2	18	E 4.8	< 5	15
	Ameiurus natalis	< 5	7.8	32	11	< 5	< 5
Tombigbee River below Coffeeville L&D near Coffeeville, AL (02469762)	*Dorosoma cepedianum*	< 5	< 5	< 5	< 5	< 5	< 5
	Micropterus salmoides	< 5	< 5	< 5	< 5	< 5	< 5
Satilpa Creek near Coffeeville, AL (02469800)	*Moxostoma poecilurum*	< 5	< 5	< 5	< 5	< 5	< 5
	Lepomis megalotis	< 5	< 5	< 5	< 5	< 5	< 5
Chickasaw Creek near Kushla, AL (02471001)	*Lepomis megalotis*	< 5	< 5	< 5	< 5	< 5	< 5
Cahaba Valley Creek at Cross Creek Road at Pelham, AL (0242354750)	*Lepomis megalotis*	< 5	< 5	8.2	< 5	< 5	< 5

[a] USGS identification number is based on geographic location and the downstream order of streamflow sites.

Appendix 2. Concentration data for organochlorine compounds in whole-fish tissue samples from the Mobile River Basin, 1998—Continued

[USGS, U.S. Geological Survey; PCB's, polychlorinated biphenyls; <, less than; Blvd., Boulevard; L&D, Lock and Dam; E, estimated; BHC, hexachlorocyclohexane]

Site name (USGS identification number[a])	Species	Concentration, in microgram per kilogram, wet weight					
		o,p'-Methoxychlor	Lindane	delta-BHC	beta-BHC	alpha-BHC	Hexachloro-benzene
Coosa River near Rome, GA (02397000)	*Cyprinus carpio*	< 5	< 5	< 5	< 5	< 5	< 5
	Lepomis macrochirus	< 5	< 5	< 5	< 5	< 5	< 5
Chattooga River above Gaylesville, AL (02398300)	*Lepomis miniatus*	< 5	< 5	< 5	< 5	< 5	< 5
Sougahatchee Creek above Reeltown, AL (02418264)	*Hypentelium etowanum*	< 5	< 5	< 5	< 5	< 5	< 5
	Ictalurus punctatus	< 5	< 5	< 5	< 5	< 5	< 5
Three Mile Branch at North Blvd. at Montgomery, AL (02419977)	*Gambusia affinis*	< 5	< 5	< 5	< 5	< 5	< 5
Pintlalla Creek at Liberty Church Road near Pintlalla, AL (02421115)	*Lepomis megalotis*	< 5	< 5	< 5	< 5	< 5	< 5
Shades Creek at Homewood, AL (02423581)	*Lepomis megalotis*	< 5	< 5	< 5	< 5	< 5	< 5
Cahaba River at Centreville, AL (02424000)	*Ictiobus bubalus*	< 5	< 5	< 5	< 5	< 5	< 5
Alabama River at Claiborne, AL (02429500)	*Micropterus salmoides*	< 5.4	< 5	< 5	< 5	< 5	< 5
Town Creek at Tupelo, MS (02434000)	*Ictalurus punctatus*	< 5	< 5	< 5	< 5	< 5	< 5
	Lepomis macrochirus	< 5	< 5	< 5	< 5	< 5	< 5
Lost Creek above Parrish, AL (02454055)	*Lepomis megalotis*	< 5	< 5	< 5	< 5	< 5	< 5
	Lepomis macrochirus	< 5	< 5	< 5	< 5	< 5	< 5
	Micropterus punctulatus	< 5	< 5	< 5	< 5	< 5	< 5
Locust Fork below Snead, AL (02454500)	*Micropterus salmoides*	< 5	< 5	< 5	< 5	< 5	< 5
Valley Creek near Bessemer, AL (02461500)	*Ameiurus natalis*	< 5	< 5	< 5	< 5	< 5	< 5
Black Warrior River at Bankhead L&D near Bessemer, AL (02462500)	*Lepomis macrochirus*	< 5	< 5	< 5	< 5	< 5	< 5
Hurricane Creek near Holt, AL (02463500)	*Ictalurus punctatus*	< 5	< 5	< 5	< 5	< 5	< 5
	Micropterus salmoides	< 5	< 5	< 5	< 5	< 5	< 5
Cribbs Mill Creek at Tuscaloosa, AL (02465288)	*Micropterus salmoides*	< 5	< 5	< 5	< 5	< 5	< 5
	Lepomis megalotis	< 5	< 5	< 5	< 5	< 5	< 5
	Lepomis macrochirus	< 5	< 5	< 5	< 5	< 5	< 5
	Ameiurus natalis	< 5	< 5	< 5	< 5	< 5	< 5
Tombigbee River below Coffeeville L&D near Coffeeville, AL (02469762)	*Dorosoma cepedianum*	< 5	< 5	< 5	< 5	< 5	5.4
	Micropterus salmoides	< 5	< 5	< 5	< 5	< 5	< 5
Satilpa Creek near Coffeeville, AL (02469800)	*Moxostoma poecilurum*	< 5	< 5	< 5	< 5	< 5	< 5
	Lepomis megalotis	< 5	< 5	< 5	< 5	< 5	< 5
Chickasaw Creek near Kushla, AL (02471001)	*Lepomis megalotis*	< 5	< 5	< 5	< 5	< 5	< 5
Cahaba Valley Creek at Cross Creek Road at Pelham, AL (0242354750)	*Lepomis megalotis*	< 5	< 5	< 5	< 5	< 5	< 5

[a] USGS identification number is based on geographic location and the downstream order of streamflow sites.

Appendix 2. Concentration data for organochlorine compounds in whole-fish tissue samples from the Mobile River Basin, 1998—Continued

[USGS, U.S. Geological Survey; PCB's, polychlorinated biphenyls; <, less than; Blvd., Boulevard; L&D, Lock and Dam; E, estimated; BHC, hexachlorocyclohexane]

Site name (USGS identification number[a])	Species	Concentration, in microgram per kilogram, wet weight					
		Heptachlor-epoxide	Hepta-chlor	Endrin	Dieldrin	p,p'-DDE	o,p'-DDE
Coosa River near Rome, GA (02397000)	*Cyprinus carpio*	< 5	< 5	< 5	< 5	97	< 5
	Lepomis macrochirus	< 5	< 5	< 5	< 5	160	< 5
Chattooga River above Gaylesville, AL (02398300)	*Lepomis miniatus*	< 5	< 5	< 7	< 5	47	< 5
Sougahatchee Creek above Reeltown, AL (02418264)	*Hypentelium etowanum*	< 5	< 5	< 5	< 5	8	< 5
	Ictalurus punctatus	< 5	< 5	< 5	< 5	< 5	< 5
Three Mile Branch at North Blvd. at Montgomery, AL (02419977)	*Gambusia affinis*	85	< 5	< 5	240	100	< 5
Pintlalla Creek at Liberty Church Road near Pintlalla, AL (02421115)	*Lepomis megalotis*	< 5	< 5	< 5	< 5	< 5	< 5
Shades Creek at Homewood, AL (02423581)	*Lepomis megalotis*	18	< 5	< 5	84	23	< 5
Cahaba River at Centreville, AL (02424000)	*Ictiobus bubalus*	< 5	< 5	< 5	8.1	24	< 5
Alabama River at Claiborne, AL (02429500)	*Micropterus salmoides*	< 5	< 5	< 5	< 5	75	< 5
Town Creek at Tupelo, MS (02434000)	*Ictalurus punctatus*	< 5	< 5	< 5	< 5	210	< 5
	Lepomis macrochirus	6.8	< 5	< 5	25	81	< 5
Lost Creek above Parrish, AL (02454055)	*Lepomis megalotis*	< 5	< 5	< 5.3	< 5	< 5	< 5
	Lepomis macrochirus	< 5	< 5	< 5	< 5	11	< 5
	Micropterus punctulatus	< 5	< 5	< 6	< 5	15	< 5
Locust Fork below Snead, AL (02454500)	*Micropterus salmoides*	< 5	< 5	< 5	< 5	550	< 5
Valley Creek near Bessemer, AL (02461500)	*Ameiurus natalis*	< 5	< 5	< 5	15	6.4	< 5
Black Warrior River at Bankhead L&D near Bessemer, AL (02462500)	*Lepomis macrochirus*	< 5	< 5	< 5	< 5	25	< 5
Hurricane Creek near Holt, AL (02463500)	*Ictalurus punctatus*	< 5	< 5	< 5	12	18	< 5
	Micropterus salmoides	5.6	< 5	< 5	18	29	< 5
Cribbs Mill Creek at Tuscaloosa, AL (02465288)	*Micropterus salmoides*	220	< 5	< 5	720	68	< 5
	Lepomis megalotis	35	< 5	< 5	170	20	< 5
	Lepomis macrochirus	33	< 5	< 5	180	11	< 5
	Ameiurus natalis	47	< 5	< 5	180	31	< 5
Tombigbee River below Coffeeville L&D near Coffeeville, AL (02469762)	*Dorosoma cepedianum*	< 5	< 5	10	< 5	38	< 5
	Micropterus salmoides	< 5	< 5	< 5	< 5	96	< 5
Satilpa Creek near Coffeeville, AL (02469800)	*Moxostoma poecilurum*	< 5	< 5	< 5	< 5	< 5	< 5
	Lepomis megalotis	< 5	< 5	< 5	< 5	< 5	< 5
Chickasaw Creek near Kushla, AL (02471001)	*Lepomis megalotis*	< 5	< 5	< 5	< 5	< 5	< 5
Cahaba Valley Creek at Cross Creek Road at Pelham, AL (0242354750)	*Lepomis megalotis*	< 5	< 5	< 5	< 5	< 5	< 5

[a] USGS identification number is based on geographic location and the downstream order of streamflow sites.

Appendix 2. Concentration data for organochlorine compounds in whole-fish tissue samples from the Mobile River Basin, 1998—Continued

[USGS, U.S. Geological Survey; PCB's, polychlorinated biphenyls; <, less than; Blvd., Boulevard; L&D, Lock and Dam; E, estimated; BHC, hexachlorocyclohexane]

Site name (USGS identification number[a])	Species	Concentration, in microgram per kilogram, wet weight					
		o,p'-DDD	p,p'-DDD	p,p'-DDT	o,p'-DDT	DCPA	trans-Chlordane
Coosa River near Rome, GA (02397000)	*Cyprinus carpio*	< 5	9.2	< 5	< 5	< 5	< 5
	Lepomis macrochirus	< 5	6.5	5.3	< 5	< 5	< 5
Chattooga River above Gaylesville, AL (02398300)	*Lepomis miniatus*	< 5	< 5	< 5	< 5	< 5	< 5
Sougahatchee Creek above Reeltown, AL (02418264)	*Hypentelium etowanum*	< 5	< 5	< 5	< 5	< 5	< 5
	Ictalurus punctatus	< 5	< 5	< 5	< 5	< 5	< 5
Three Mile Branch at North Blvd. at Montgomery, AL (02419977)	*Gambusia affinis*	< 5	37	35	< 5	< 5	12
Pintlalla Creek at Liberty Church Road near Pintlalla, AL (02421115)	*Lepomis megalotis*	< 5	< 5	< 5	< 5	< 5	< 5
Shades Creek at Homewood, AL (02423581)	*Lepomis megalotis*	< 5	< 5	< 5	< 5	< 5	< 5
Cahaba River at Centreville, AL (02424000)	*Ictiobus bubalus*	< 5	< 5	< 5	< 5	< 5	< 5
Alabama River at Claiborne, AL (02429500)	*Micropterus salmoides*	< 5	9.3	< 5	< 5	< 5	< 5
Town Creek at Tupelo, MS (02434000)	*Ictalurus punctatus*	< 5	22	16	< 5	< 5	< 5
	Lepomis macrochirus	< 5	11	< 5	< 5	< 5	< 5
Lost Creek above Parrish, AL (02454055)	*Lepomis megalotis*	< 5	< 5	< 5	< 5	< 5	< 5
	Lepomis macrochirus	< 5	< 5	< 5	< 5	< 5	< 5
	Micropterus punctulatus	< 5	< 5	< 5	< 5	< 5	< 5
Locust Fork below Snead, AL (02454500)	*Micropterus salmoides*	< 5	< 5	39	< 5	< 5	< 5
Valley Creek near Bessemer, AL (02461500)	*Ameiurus natalis*	< 5	< 5	< 5	< 5	< 5	8.8
Black Warrior River at Bankhead L&D near Bessemer, AL (02462500)	*Lepomis macrochirus*	< 5	< 5	< 5	< 5	< 5	< 5
Hurricane Creek near Holt, AL (02463500)	*Ictalurus punctatus*	< 5	< 5	< 5	< 5	< 5	< 5
	Micropterus salmoides	< 5	< 5	< 5	< 5	< 5	< 5
Cribbs Mill Creek at Tuscaloosa, AL (02465288)	*Micropterus salmoides*	< 5	12	5.6	< 5	< 5	43
	Lepomis megalotis	< 5	< 5	< 5	< 5	< 5	< 5
	Lepomis macrochirus	< 5	< 5	< 5	< 5	< 5	< 5
	Ameiurus natalis	< 5	8.8	< 5	< 5	< 5	28
Tombigbee River below Coffeeville L&D near Coffeeville, AL (02469762)	*Dorosoma cepedianum*	< 5	13	6.7	< 5	< 5	< 5
	Micropterus salmoides	< 5	15	< 5	< 5	< 5	< 5
Satilpa Creek near Coffeeville, AL (02469800)	*Moxostoma poecilurum*	< 5	< 5	< 5	< 5	< 5	< 5
	Lepomis megalotis	< 5	< 5	< 5	< 5	< 5	< 5
Chickasaw Creek near Kushla, AL (02471001)	*Lepomis megalotis*	< 5	< 5	< 5	< 5	< 5	< 5
Cahaba Valley Creek at Cross Creek Road at Pelham, AL (0242354750)	*Lepomis megalotis*	< 5	< 5	< 5	< 5	< 5	< 5

[a] USGS identification number is based on geographic location and the downstream order of streamflow sites.

Appendix 2. Concentration data for organochlorine compounds in whole-fish tissue samples from the Mobile River Basin, 1998—Continued

[USGS, U.S. Geological Survey; PCB's, polychlorinated biphenyls; <, less than; Blvd., Boulevard; L&D, Lock and Dam; E, estimated; BHC, hexachlorocyclohexane]

Site name (USGS identification number[a])	Species	Concentration, in microgram per kilogram, wet weight	
		cis-Chlordane	Sample weight
Coosa River near Rome, GA (02397000)	*Cyprinus carpio*	< 5	10
	Lepomis macrochirus	< 5	10
Chattooga River above Gaylesville, AL (02398300)	*Lepomis miniatus*	< 5	10
Sougahatchee Creek above Reeltown, AL (02418264)	*Hypentelium etowanum*	< 5	10
	Ictalurus punctatus	< 5	10
Three Mile Branch at North Blvd. at Montgomery, AL (02419977)	*Gambusia affinis*	36	10
Pintlalla Creek at Liberty Church Road near Pintlalla, AL (02421115)	*Lepomis megalotis*	< 5	10.04
Shades Creek at Homewood, AL (02423581)	*Lepomis megalotis*	24	10.01
Cahaba River at Centreville, AL (02424000)	*Ictiobus bubalus*	6.8	10
Alabama River at Claiborne, AL (02429500)	*Micropterus salmoides*	< 5	10
Town Creek at Tupelo, MS (02434000)	*Ictalurus punctatus*	< 5	10
	Lepomis macrochirus	5.7	10
Lost Creek above Parrish, AL (02454055)	*Lepomis megalotis*	< 5	10
	Lepomis macrochirus	< 5	10
	Micropterus punctulatus	< 5	10
Locust Fork below Snead, AL (02454500)	*Micropterus salmoides*	< 5	10.01
Valley Creek near Bessemer, AL (02461500)	*Ameiurus natalis*	12	10
Black Warrior River at Bankhead L&D near Bessemer, AL (02462500)	*Lepomis macrochirus*	< 5	10.01
Hurricane Creek near Holt, AL (02463500)	*Ictalurus punctatus*	< 5	10
	Micropterus salmoides	< 5	10
Cribbs Mill Creek at Tuscaloosa, AL (02465288)	*Micropterus salmoides*	72	10
	Lepomis megalotis	12	10
	Lepomis macrochirus	6.4	10.01
	Ameiurus natalis	39	10
Tombigbee River below Coffeeville L&D near Coffeeville, AL (02469762)	*Dorosoma cepedianum*	< 5	10
	Micropterus salmoides	< 5	10
Satilpa Creek near Coffeeville, AL (02469800)	*Moxostoma poecilurum*	< 5	10
	Lepomis megalotis	< 5	10.01
Chickasaw Creek near Kushla, AL (02471001)	*Lepomis megalotis*	< 5	10.01
Cahaba Valley Creek at Cross Creek Road at Pelham, AL (0242354750)	*Lepomis megalotis*	< 5	10.01

[a] USGS identification number is based on geographic location and the downstream order of streamflow sites.

Appendix 3. Concentration data for trace elements in fish-liver tissue samples from the Mobile River Basin, 1998

[USGS, U.S. Geological Survey; <, less than; Blvd., Boulevard; L&D, Lock and Dam; —, missing data]

Site name (USGS identification number[a])	Species	Concentration, in microgram per gram, dry weight							
		Aluminum	Barium	Boron	Chromium	Copper	Iron	Manganese	Strontium
Coosa River near Rome, GA (02397000)	*Lepomis macrochirus*	10.283	0.479	0.865	< 0.5	9.29	876.56	8.407	0.588
	Cyprinus carpio	10.481	5.646	3.829	< 0.5	95.663	1,099.4	9.471	0.668
Chattooga River above Gaylesville, AL (02398300)	*Lepomis miniatus*	7.7699	0.36335	5.8402	0.80763	11.905	758.29	12.698	1.1904
Sougahatchee Creek above Reeltown, AL (02418264)	*Ictalurus punctatus*	8.2611	0.12	1.34	0.75	9.8	659.08	13.9	0.77
Pintlalla Creek at Liberty Church Road near Pintlalla, AL (02421115)	*Lepomis megalotis*	13.049	< 0.1	20.524	< 0.5	7.0289	752.23	4.679	0.97371
Shades Creek at Homewood, AL (02423581)	*Lepomis megalotis*	7.7611	< 0.1	3.91	0.69	15.46	901.17	5.19	0.58
Cahaba River at Centreville, AL (02424000)	*Ictiobus bubalus*	14.987	0.23393	0.84058	1.3448	68.146	1,807.5	6.1471	0.14386
Alabama River at Claiborne, AL (02429500)	*Micropterus punctulatus*	1.099	< 0.1	0.899	< 0.5	5.433	146.23	3.301	0.298
Town Creek at Tupelo, MS (02434000)	*Lepomis macrochirus*	6.3559	0.13381	1.2609	< 0.5	6.6571	586.2	5.5869	1.3272
	Ictalurus punctatus	7.0941	0.15464	4.8432	< 0.5	18.083	1,646.5	5.877	2.7893
Lost Creek above Parrish, AL (02454055)	*Lepomis macrochirus*	5.0914	0.10235	3.4022	< 0.5	4.3908	288.64	3.3552	1.304
	Lepomis megalotis	5.9807	0.11015	10.375	< 0.5	4.7599	463.65	3.6955	1.8737
Locust Fork below Snead, AL (02454500)	*Micropterus punctulatus*	21.556	0.27	1.08	0.65	11.33	813.43	4.77	2.42
Valley Creek near Bessemer, AL (02461500)	*Ameiurus natalis*	3.451	< 0.1	1.19	0.6	48.23	561.68	4.27	0.56
Black Warrior River at Bankhead L&D near Bessemer, AL (02462500)	*Lepomis macrochirus*	10.623	0.358	5.715	< 0.5	8.591	657.35	13.952	0.779
Hurricane Creek near Holt, AL (02463500)	*Ictalurus punctatus*	12.581	0.14	0.87	0.52	151.63	684.18	8.47	0.86
Cribbs Mill Creek at Tuscaloosa, AL (02465288)	*Lepomis macrochirus*	1.7174	< 0.1	1.195	< 0.5	7.9107	608.94	4.6065	0.14197
	Micropterus salmoides	4.5938	0.14102	1.5275	< 0.5	22.6	890.53	5.1134	0.39623
	Lepomis macrochirus	4.7086	0.19349	5.6271	0.61616	29.298	1,010.2	6.4901	0.59687
	Ameiurus natalis	8.222	0.31179	8.1126	1.1316	34.911	1,380.6	7.8103	1.1989
Tombigbee River below Coffeeville L&D near Coffeeville, AL (02469762)	*Dorosoma cepedianum*	3.546	< 0.1	1.188	< 0.5	11.306	614.9	7.189	0.635
	Micropterus salmoides	180.17	3.0252	2.9008	0.82965	13.103	930.97	15.227	3.213
Satilpa Creek near Coffeeville, AL (02469800)	*Moxostoma poecilurum*	26.759	0.41035	1.7514	0.63706	44.701	2,066.1	30.008	0.62962
Chickasaw Creek near Kushla, AL (02471001)	*Lepomis megalotis*	20.249	0.39146	2.936	0.89304	12.819	1,047.5	7.1788	1.3766
Cahaba Valley Creek at Cross Creek Road at Pelham, AL (0242354750)	*Lepomis megalotis*	11.319	0.26463	20.094	< 0.5	85.083	502.66	7.249	1.3356

[a] USGS identification number is based on geographic location and the downstream order of streamflow sites.

Appendix 3. Concentration data for trace elements in fish-liver tissue samples from the Mobile River Basin, 1998—Continued

[USGS, U.S. Geological Survey; <, less than; Blvd., Boulevard; L&D, Lock and Dam; —, missing data]

Site name (USGS identification number[a])	Species	Concentration, in microgram per gram, dry weight							
		Zinc	Antimony	Arsenic	Beryllium	Cadmium	Cobalt	Lead	Molybdenum
Coosa River near Rome, GA (02397000)	*Lepomis macrochirus*	86.849	< 0.15	0.6	< 0.15	3.01	0.37	0.21	1.05
	Cyprinus carpio	800.64	< 0.97	< 0.97	< 0.97	3.38	2.11	< 0.97	1.08
Chattooga River above Gaylesville, AL (02398300)	*Lepomis miniatus*	100.12	< 1.44	< 1.44	< 1.44	< 1.44	1.99	< 1.44	< 1.44
Sougahatchee Creek above Reeltown, AL (02418264)	*Ictalurus punctatus*	133.45	< 0.51	< 0.51	< 0.51	0.68	< 0.51	< 0.51	1.09
Pintlalla Creek at Liberty Church Road near Pintlalla, AL (02421115)	*Lepomis megalotis*	63.12	< 1.73	< 1.73	< 1.73	< 1.73	< 1.73	< 1.73	< 1.73
Shades Creek at Homewood, AL (02423581)	*Lepomis megalotis*	89.99	< 0.9	< 0.9	< 0.9	2.73	1.93	< 0.9	1.77
Cahaba River at Centreville, AL (02424000)	*Ictiobus bubalus*	134.88	< 0.28	0.66	< 0.28	1.77	0.52	0.44	1.22
Alabama River at Claiborne, AL (02429500)	*Micropterus punctulatus*	59.996	< 0.2	0.98	< 0.2	0.29	0.6	< 0.2	0.59
Town Creek at Tupelo, MS (02434000)	*Lepomis macrochirus*	82.555	< 0.31	0.42	< 0.31	0.34	0.41	< 0.31	0.91
	Ictalurus punctatus	118.82	< 0.37	E 0.42	< 0.37	< 0.37	E 1.39	< 0.37	E 1.44
Lost Creek above Parrish, AL (02454055)	*Lepomis macrochirus*	61.465	< 0.43	0.72	< 0.43	0.69	1.01	< 0.43	0.46
	Lepomis megalotis	64.95	< 1.3	< 1.3	< 1.3	< 1.3	< 1.3	< 1.3	< 1.3
Locust Fork below Snead, AL (02454500)	*Micropterus punctulatus*	81.5	< 0.36	< 0.36	< 0.36	1.25	2.14	< 0.36	1.03
Valley Creek near Bessemer, AL (02461500)	*Ameiurus natalis*	108.04	< 0.41	< 0.41	< 0.41	< 0.41	< 0.41	< 0.41	0.77
Black Warrior River at Bankhead L&D near Bessemer, AL (02462500)	*Lepomis macrochirus*	83.602	< 1.22	2.7	< 1.22	< 1.22	2.81	< 1.22	< 1.22
Hurricane Creek near Holt, AL (02463500)	*Ictalurus punctatus*	131.79	< 0.42	< 0.42	< 0.42	0.84	1.27	< 0.42	0.97
Cribbs Mill Creek at Tuscaloosa, AL (02465288)	*Lepomis macrochirus*	67.786	< 0.3	0.34	< 0.3	0.45	< 0.31	< 0.3	0.7
	Micropterus salmoides	85.124	< 0.31	0.41	< 0.31	0.5	0.65	< 0.31	0.8
	Lepomis macrochirus	98.372	< 0.84	< 0.84	< 0.84	1.32	2.46	< 0.84	0.99
	Ameiurus natalis	119.38	< 2.85	< 2.85	< 2.85	< 2.85	< 2.85	< 2.85	< 2.85
Tombigbee River below Coffeeville L&D near Coffeeville, AL (02469762)	*Dorosoma cepedianum*	89.214	< 0.33	1.35	< 0.33	< 0.37	0.96	< 0.33	0.77
	Micropterus salmoides	89.673	< 0.37	1.72	< 0.37	0.57	0.97	< 0.37	0.97
Satilpa Creek near Coffeeville, AL (02469800)	*Moxostoma poecilurum*	107.26	< 0.33	0.85	< 0.33	0.71	0.79	< 0.33	1.44
Chickasaw Creek near Kushla, AL (02471001)	*Lepomis megalotis*	108.57	< 1.79	< 1.79	< 1.79	10.9	< 1.79	< 1.79	< 1.79
Cahaba Valley Creek at Cross Creek Road at Pelham, AL (0242354750)	*Lepomis megalotis*	104.52	< 2.1	< 2.1	< 2.1	< 2.1	< 2.1	< 2.1	< 2.1

[a] USGS identification number is based on geographic location and the downstream order of streamflow sites.

Appendix 3. Concentration data for trace elements in fish-liver tissue samples from the Mobile River Basin, 1998—Continued

[USGS, U.S. Geological Survey; <, less than; Blvd., Boulevard; L&D, Lock and Dam; —, missing data]

Site name (USGS identification number[a])	Species	Concentration, in microgram per gram, dry weight						
		Nickel	Selenium	Silver	Uranium	Mercury	Percent water in sample	Vanadium
Coosa River near Rome, GA (02397000)	*Lepomis macrochirus*	< 0.15	8.17	< 0.97	< 0.15	< 1	73.61	1.01
	Cyprinus carpio	< 0.97	10.13	1.1	< 0.97	1.8009	76.57	2.22
Chattooga River above Gaylesville, AL (02398300)	*Lepomis miniatus*	< 1.44	13.98	< 1.44	< 1.44	< 0.2	—	2.18
Sougahatchee Creek above Reeltown, AL (02418264)	*Ictalurus punctatus*	< 0.51	7.91	< 0.51	< 0.51	0.066	79.53	1.3
Pintlalla Creek at Liberty Church Road near Pintlalla, AL (02421115)	*Lepomis megalotis*	< 1.73	4.51	< 1.73	< 1.73	—	—	< 1.73
Shades Creek at Homewood, AL (02423581)	*Lepomis megalotis*	0.98	19.56	< 0.9	< 0.9	< 0.9	77.44	1.4
Cahaba River at Centreville, AL (02424000)	*Ictiobus bubalus*	0.29	6.88	0.29	< 0.28	0.04	72.19	2.3
Alabama River at Claiborne, AL (02429500)	*Micropterus punctulatus*	< 0.2	3.31	< 0.2	< 0.2	< 0.2	72.24	0.34
Town Creek at Tupelo, MS (02434000)	*Lepomis macrochirus*	< 0.31	E 4.59	< 0.31	< 0.31	0.06	76.89	1.5
	Ictalurus punctatus	< 0.37	7.24	< 0.37	< 0.37	0.63	81.72	E 1.51
Lost Creek above Parrish, AL (02454055)	*Lepomis macrochirus*	< 0.43	3.79	< 0.43	< 0.43	< 0.06	68.42	0.46
	Lepomis megalotis	< 1.3	5.7	< 1.3	< 1.3	< 0.1	73.28	< 1.3
Locust Fork below Snead, AL (02454500)	*Micropterus punctulatus*	0.58	5.71	< 0.36	< 0.36	1.64	77.53	1.41
Valley Creek near Bessemer, AL (02461500)	*Ameiurus natalis*	< 0.41	14.21	0.43	< 0.41	< 0.4	80.99	1.18
Black Warrior River at Bankhead L&D near Bessemer, AL (02462500)	*Lepomis macrochirus*	< 1.22	9.18	< 1.22	< 1.22	< 1.2	61.54	< 1.22
Hurricane Creek near Holt, AL (02463500)	*Ictalurus punctatus*	< 0.42	6.15	< 0.42	< 0.42	0.39	81.39	0.75
Cribbs Mill Creek at Tuscaloosa, AL (02465288)	*Lepomis macrochirus*	< 0.3	4.24	< 0.3	< 0.3	0.08	65.79	0.46
	Micropterus salmoides	< 0.31	5.62	< 0.31	< 0.31	0.17	70	0.89
	Lepomis macrochirus	< 0.84	7.14	< 0.84	< 0.84	0.24	74.42	1.19
	Ameiurus natalis	< 2.85	9.96	< 2.85	< 2.85	0.58	83.75	< 2.85
Tombigbee River below Coffeeville L&D near Coffeeville, AL (02469762)	*Dorosoma cepedianum*	< 0.33	4.05	< 0.33	< 0.33	0.06	65.38	0.73
	Micropterus salmoides	0.48	6.33	< 0.37	< 0.37	< 0.3	71.4	0.77
Satilpa Creek near Coffeeville, AL (02469800)	*Moxostoma poecilurum*	< 0.33	8.17	< 0.33	< 0.33	0.43	75.91	0.84
Chickasaw Creek near Kushla, AL (02471001)	*Lepomis megalotis*	< 1.79	11.86	< 1.79	< 1.79	< 1.8	60.71	3.21
Cahaba Valley Creek at Cross Creek Road at Pelham, AL (0242354750)	*Lepomis megalotis*	< 2.1	E 7.93	< 2.1	< 2.1	—	—	< 2.1

[a] USGS identification number is based on geographic location and the downstream order of streamflow sites.

Appendix 4. Concentration data for organochlorine compounds in streambed-sediment samples from the Mobile River Basin, 1998

[USGS, U.S. Geological Survey; <, less than; Blvd., Boulevard; —, missing data; L&D, Lock and Dam; DCPA, chlorthaldimethyl; BHC, hexachlorocyclohexane]

Site name (USGS identification number[a])	Concentration, in microgram per kilogram, dry weight							
	Percent organic carbon	Percent organic + inorganic carbon	Percent inorganic carbon	a-d6-hexachloro-cyclohexane[b]	Octochlorbi-phenyl[b]	3,5-dichlorobi-phenyl[b]	cis-Nonachlor	trans-Nonachlor
Coosa River near Rome, GA (02397000)	1.5	1.6	0.04	86	88	94	< 1	< 1
Chattooga River above Gaylesville, AL (02398300)	1	1	0.02	94	86	117	< 1	< 1
Sougahatchee Creek above Reeltown, AL (02418264)	3.2	3.3	0.05	70	84	70	< 1	< 1
Three Mile Branch at North Blvd. at Montgomery, AL (02419977)	3.2	3.2	0.05	84	93	78	< 1	2
Pintlalla Creek at Liberty Church Road near Pintlalla, AL (02421115)	3	3.1	0.03	60	78	64	< 1	< 1
Shades Creek at Homewood, AL (02423581)	1.5	1.7	0.19	92	80	81	< 1	2
Cahaba River at Centreville, AL (02424000)	2.4	2.5	0.06	95	88	96	< 1	< 1
Alabama River at Claiborne, AL (02429500)	1.2	1.2	0.01	60	51	52	< 1	< 1
Town Creek at Tupelo, MS (02434000)	1.4	1.7	0.23	71	78	75	< 1	< 1
Buttahatchee River near Aberdeen, MS (02439400)	1.6	1.6	0.02	84	136	—	< 1	< 1
Bogue Chitto Creek near Memphis, AL (02444490)	1.11	2.81	1.7	62	—	—	< 1	< 1
Lost Creek above Parrish, AL (02454055)	2.1	3.1	0.92	68	55	91	< 1	4
Locust Fork below Snead, AL (02454500)	2.2	2.2	0.02	94	86	101	< 1	< 1
Valley Creek near Bessemer, AL (02461500)	3.6	4.3	0.65	96	83	—	4	13
Black Warrior River at Bankhead L&D near Bessemer, AL (02462500)	3.7	3.8	0.09	94	82	79	< 1	< 1
Hurricane Creek near Holt, AL (02463500)	1.1	1.1	0.04	86	84	94	< 1	< 1
Cribbs Mill Creek at Tuscaloosa, AL (02465288)	1.3	1.4	0.08	99	83	78	< 1	< 1
Tombigbee River below Coffeeville L&D near Coffeeville, AL (02469762)	0.89	0.95	0.06	91	85	83	< 1	< 1
Satilpa Creek near Coffeeville, AL (02469800)	—	—	—	106	83	86	< 1	< 1
Chickasaw Creek near Kushla, AL (02471001)	2.1	2.1	0.01	86	80	102	< 1	< 1
Cahaba Valley Creek at Cross Creek Road at Pelham, AL (0242354750)	1.4	1.5	0.1	86	82	94	< 1	< 1

[a] USGS identification number is based on geographic location and the downstream order of streamflow sites.

[b] Reported as percent of sample.

Appendix 4. Concentration data for organochlorine compounds in streambed-sediment samples from the Mobile River Basin, 1998—Continued

[USGS, U.S. Geological Survey; <, less than; Blvd., Boulevard; —, missing data; L&D, Lock and Dam; DCPA, chlorthaldimethyl; BHC, hexachlorocyclohexane]

Site name (USGS identification number[a])	Concentration, in microgram per kilogram, dry weight							
	Oxychlordane	Aldrin	cis-Chlordane	trans-Chlordane	Chloroneb	DCPA	o,p'-DDD	p,p'-DDD
Coosa River near Rome, GA (02397000)	< 1	< 1	< 1	< 1	< 5	< 5	< 1	< 1
Chattooga River above Gaylesville, AL (02398300)	< 1	< 1	< 1	< 1	< 5	< 5	< 1	< 1
Sougahatchee Creek above Reeltown, AL (02418264)	< 1	< 1	< 1	< 1	< 5	< 5	< 1	< 1
Three Mile Branch at North Blvd. at Montgomery, AL (02419977)	< 1	< 1	3	3	< 5	< 5	< 1	2
Pintlalla Creek at Liberty Church Road near Pintlalla, AL (02421115)	< 1	< 1	< 1	< 1	< 5	< 5	< 1	< 1
Shades Creek at Homewood, AL (02423581)	< 1	< 1	2	2	< 5	< 5	< 1	< 1
Cahaba River at Centreville, AL (02424000)	< 1	< 1	< 2	< 1	< 5	< 5	< 1	3
Alabama River at Claiborne, AL (02429500)	< 1	< 1	< 1	< 1	< 5	< 5	< 1	< 1
Town Creek at Tupelo, MS (02434000)	< 1	< 1	< 1	< 1	< 5	< 5	< 1	< 1
Buttahatchee River near Aberdeen, MS (02439400)	< 1	< 1	< 1	< 1	< 5	< 5	< 1	< 1
Bogue Chitto Creek near Memphis, AL (02444490)	< 1	< 1	< 1	< 1	< 5	< 5	< 1	< 1
Lost Creek above Parrish, AL (02454055)	< 1	< 1	1	2	< 5	< 5	< 1	4
Locust Fork below Snead, AL (02454500)	< 1	< 1	< 1	< 1	< 5	< 5	< 1	1
Valley Creek near Bessemer, AL (02461500)	< 1	< 1	14	25	< 5	< 5	7	19
Black Warrior River at Bankhead L&D near Bessemer, AL (02462500)	3	< 1	< 1	< 1	< 5	< 5	< 1	< 1
Hurricane Creek near Holt, AL (02463500)	< 1	< 1	< 1	< 1	< 5	< 5	< 1	< 1
Cribbs Mill Creek at Tuscaloosa, AL (02465288)	< 1	< 1	< 1	2	< 5	< 5	< 1	< 1
Tombigbee River below Coffeeville L&D near Coffeeville, AL (02469762)	< 1	< 1	< 1	< 1	< 5	< 5	< 1	< 1
Satilpa Creek near Coffeeville, AL (02469800)	< 1	< 1	< 1	< 1	< 5	< 5	< 1	< 1
Chickasaw Creek near Kushla, AL (02471001)	< 1	< 1	< 1	< 1	< 5	< 5	< 1	< 1
Cahaba Valley Creek at Cross Creek Road at Pelham, AL (0242354750)	< 1	< 1	< 1	< 1	< 5	< 5	< 1	< 1

[a] USGS identification number is based on geographic location and the downstream order of streamflow sites.

Appendix 4. Concentration data for organochlorine compounds in streambed-sediment samples from the Mobile River Basin, 1998—Continued

[USGS, U.S. Geological Survey; <, less than; Blvd., Boulevard; —, missing data; L&D, Lock and Dam; DCPA, chlorthaldimethyl; BHC, hexachlorocyclohexane]

Site name (USGS identification number[a])	Concentration, in microgram per kilogram, dry weight							
	o,p'-DDE	p,p'-DDE	o,p'-DDT	p,p'-DDT	Dieldrin	Endosulfan I	Endrin	alpha-BHC
Coosa River near Rome, GA (02397000)	< 1	2	< 2	<2	< 1	< 1	< 2	< 1
Chattooga River above Gaylesville, AL (02398300)	< 1	2	< 2	< 2	< 1	< 1	< 2	< 1
Sougahatchee Creek above Reeltown, AL (02418264)	< 1	< 1	< 2	< 2	< 1	< 1	< 2	< 1
Three Mile Branch at North Blvd. at Montgomery, AL (02419977)	< 1	2	< 2	23	2	< 1	< 2	< 1
Pintlalla Creek at Liberty Church Road near Pintlalla, AL (02421115)	< 1	< 1	< 2	< 2	< 1	< 1	< 2	< 1
Shades Creek at Homewood, AL (02423581)	< 1	< 1	< 2	< 2	< 1	< 1	< 2	< 1
Cahaba River at Centreville, AL (02424000)	< 1	< 1	< 2	< 2	< 1	< 1	< 2	< 1
Alabama River at Claiborne, AL (02429500)	< 1	< 1	< 2	< 2	< 1	< 1	< 2	< 1
Town Creek at Tupelo, MS (02434000)	< 1	1	< 2	< 2	< 1	< 1	< 2	< 1
Buttahatchee River near Aberdeen, MS (02439400)	< 1	4	< 2	< 2	< 1	< 1	< 2	< 1
Bogue Chitto Creek near Memphis, AL (02444490)	< 1	< 1	< 2	< 2	< 1	< 1	< 2	< 1
Lost Creek above Parrish, AL (02454055)	< 1	< 1	< 2	< 2	< 1	< 1	< 2	< 1
Locust Fork below Snead, AL (02454500)	< 1	8	< 2	4	< 1	< 1	< 2	< 1
Valley Creek near Bessemer, AL (02461500)	7	3	7	14	12	< 1	< 3	< 1
Black Warrior River at Bankhead L&D near Bessemer, AL (02462500)	< 1	< 1	< 2	< 2	< 1	< 1	< 2	< 1
Hurricane Creek near Holt, AL (02463500)	< 1	< 1	< 2	< 2	< 1	< 1	< 2	< 1
Cribbs Mill Creek at Tuscaloosa, AL (02465288)	< 1	< 1	< 2	< 2	< 1	< 1	< 2	< 1
Tombigbee River below Coffeeville L&D near Coffeeville, AL (02469762)	< 1	< 1	< 2	< 2	< 1	< 1	< 2	< 1
Satilpa Creek near Coffeeville, AL (02469800)	< 1	< 1	< 2	< 2	< 1	< 1	< 2	< 1
Chickasaw Creek near Kushla, AL (02471001)	< 1	< 1	< 2	< 2	< 1	< 1	< 2	< 1
Cahaba Valley Creek at Cross Creek Road at Pelham, AL (0242354750)	< 1	< 1	< 2	< 2	< 1	< 1	< 2	< 1

[a] USGS identification number is based on geographic location and the downstream order of streamflow sites.

Appendix 4. Concentration data for organochlorine compounds in streambed-sediment samples from the Mobile River Basin, 1998—Continued

[USGS, U.S. Geological Survey; <, less than; Blvd., Boulevard; —, missing data; L&D, Lock and Dam; DCPA, chlorthaldimethyl; BHC, hexachlorocyclohexane]

Site name (USGS identification number[a])	Concentration, in microgram per kilogram, dry weight							
	beta-BHC	Heptachlor	Heptachlor epoxide	BHC	Isodrin	Lindane	p,p'-Methoxychlor	o,p'-Methoxychlor
Coosa River near Rome, GA (02397000)	< 1	< 1	< 1	< 1	< 1	< 1	< 5	< 5
Chattooga River above Gaylesville, AL (02398300)	< 1	< 1	< 1	< 1	< 1	< 1	< 5	< 5
Sougahatchee Creek above Reeltown, AL (02418264)	< 1	< 1	< 1	< 1	< 1	< 1	< 5	< 5
Three Mile Branch at North Blvd. at Montgomery, AL (02419977)	< 1	< 1	< 1	< 1	< 1	< 1	< 5	< 5
Pintlalla Creek at Liberty Church Road near Pintlalla, AL (02421115)	< 1	< 1	< 1	< 1	< 1	< 1	< 5	< 5
Shades Creek at Homewood, AL (02423581)	< 1	< 1	< 1	< 1	< 1	< 1	< 5	< 5
Cahaba River at Centreville, AL (02424000)	< 1	< 1	< 1	< 1	< 1	< 1	< 5	< 5
Alabama River at Claiborne, AL (02429500)	< 1	< 1	< 1	< 1	< 1	< 1	< 5	< 5
Town Creek at Tupelo, MS (02434000)	< 1	< 1	< 1	< 1	< 1	< 1	< 5	< 5
Buttahatchee River near Aberdeen, MS (02439400)	< 1	< 1	< 1	< 1	< 1	< 1	< 5	< 5
Bogue Chitto Creek near Memphis, AL (02444490)	< 1	< 1	< 1	< 1	< 1	< 1	< 5	< 5
Lost Creek above Parrish, AL (02454055)	< 1	< 1	< 1	< 1	< 1	< 1	< 5	< 5
Locust Fork below Snead, AL (02454500)	< 1	< 1	< 1	< 1	< 1	< 1	< 5	< 5
Valley Creek near Bessemer, AL (02461500)	< 1	< 1	< 1	< 1	< 1	< 1	< 16	< 10
Black Warrior River at Bankhead L&D near Bessemer, AL (02462500)	< 1	< 1	< 1	< 1	< 1	< 1	< 5	< 5
Hurricane Creek near Holt, AL (02463500)	< 1	< 1	< 1	< 1	< 1	< 1	< 5	< 5
Cribbs Mill Creek at Tuscaloosa, AL (02465288)	< 1	< 1	< 1	< 1	< 1	< 1	< 5	< 5
Tombigbee River below Coffeeville L&D near Coffeeville, AL (02469762)	< 1	< 1	< 1	< 1	< 1	< 1	< 5	< 5
Satilpa Creek near Coffeeville, AL (02469800)	< 1	< 1	< 1	< 1	< 1	< 1	< 5	< 5
Chickasaw Creek near Kushla, AL (02471001)	< 1	< 1	< 1	< 1	< 1	< 1	< 5	< 5
Cahaba Valley Creek at Cross Creek Road at Pelham, AL (0242354750)	< 1	< 1	< 1	< 1	< 1	< 1	< 5	< 5

[a] USGS identification number is based on geographic location and the downstream order of streamflow sites.

Appendix 4. Concentration data for organochlorine compounds in streambed-sediment samples from the Mobile River Basin, 1998—Continued

[USGS, U.S. Geological Survey; <, less than; Blvd., Boulevard; —, missing data; L&D, Lock and Dam; DCPA, chlorthaldimethyl; BHC, hexachlorocyclohexane]

Site name (USGS identification number[a])	Concentration, in microgram per kilogram, dry weight					
	Mirex	cis-Permethrin	trans-Permethrin	Toxaphene	PCB's	Pentachloro-anisole
Coosa River near Rome, GA (02397000)	< 1	< 5	< 5	< 200	< 50	< 1
Chattooga River above Gaylesville, AL (02398300)	< 1	< 5	< 5	< 200	< 50	< 1
Sougahatchee Creek above Reeltown, AL (02418264)	< 1	< 5	< 5	< 200	< 50	< 1
Three Mile Branch at North Blvd. at Montgomery, AL (02419977)	< 1	< 5	< 5	< 200	< 50	< 1
Pintlalla Creek at Liberty Church Road near Pintlalla, AL (02421115)	< 1	< 5	< 5	< 200	< 50	< 1
Shades Creek at Homewood, AL (02423581)	< 1	< 5	< 5	< 200	< 50	< 1
Cahaba River at Centreville, AL (02424000)	< 1	< 5	< 5	< 200	< 50	< 1
Alabama River at Claiborne, AL (02429500)	< 1	< 5	< 5	< 200	< 50	< 1
Town Creek at Tupelo, MS (02434000)	< 1	< 5	< 5	< 200	< 50	< 1
Buttahatchee River near Aberdeen, MS (02439400)	< 1	< 5	< 5	< 200	< 50	< 1
Bogue Chitto Creek near Memphis, AL (02444490)	< 1	< 5	< 5	< 200	< 50	< 1
Lost Creek above Parrish, AL (02454055)	< 1	< 5	< 5	< 200	< 50	< 1
Locust Fork below Snead, AL (02454500)	< 1	< 5	< 5	< 200	< 50	< 1
Valley Creek near Bessemer, AL (02461500)	< 1	< 5	< 5	< 200	160	< 1
Black Warrior River at Bankhead L&D near Bessemer, AL (02462500)	< 1	< 5	< 5	< 200	< 50	< 1
Hurricane Creek near Holt, AL (02463500)	< 1	< 5	< 5	< 200	< 50	< 1
Cribbs Mill Creek at Tuscaloosa, AL (02465288)	< 1	< 5	< 5	< 200	< 50	< 1
Tombigbee River below Coffeeville L&D near Coffeeville, AL (02469762)	< 1	< 5	< 5	< 200	< 50	< 1
Satilpa Creek near Coffeeville, AL (02469800)	< 1	< 5	< 5	< 200	< 50	< 1
Chickasaw Creek near Kushla, AL (02471001)	< 1	< 5	< 5	< 200	< 50	< 1
Cahaba Valley Creek at Cross Creek Road at Pelham, AL (0242354750)	< 1	< 5	< 5	< 200	< 50	< 1

[a] USGS identification number is based on geographic location and the downstream order of streamflow sites.

Appendix 5. Concentration data for trace elements in streambed-sediment samples from the Mobile River Basin, 1998

[USGS, U.S. Geological Survey; <, less than; Blvd., Boulevard; L&D, Lock and Dam; —, no data]

Site name (USGS identification number[a])	Concentration, in microgram per gram, dry weight							
	Aluminum[b]	Antimony	Arsenic	Barium	Beryllium	Bismuth	Cadmium	Calcium[b]
Coosa River near Rome, GA (02397000)	8.1	1	12	4,300	2.5	< 1	0.18	0.36
Chattooga River above Gaylesville, AL (02398300)	4.5	0.64	6.8	290	1.4	< 1	< 0.1	0.17
Sougahatchee Creek above Reeltown, AL (02418264)	8.38	1.09	4.71	594	2.52	< 1	0.147	0.294
Three Mile Branch at North Blvd. at Montgomery, AL (02419977)	5.92	0.636	26.5	433	1.42	< 1	0.439	0.387
Pintlalla Creek at Liberty Church Road near Pintlalla, AL (02421115)	8.62	0.395	23.5	390	2.31	< 1	0.135	0.744
Cahaba Valley Creek at Cross Creek Road at Pelham, AL (0242354750)	4.67	0.776	11.3	234	1.54	< 1	0.27	0.502
Shades Creek at Homewood, AL (02423581)	5.37	0.917	13.7	357	1.74	< 1	0.361	0.6
Cahaba River at Centreville, AL (02424000)	7.3	0.75	16	510	1.9	< 1	0.15	0.37
Alabama River at Claiborne, AL (02429500)	8.4	0.44	8.5	520	2.4	< 1	0.11	0.49
Town Creek at Tupelo, MS (02434000)	7.3	0.55	16	490	2.1	< 1	0.24	1.3
Buttahatchee River near Aberdeen, MS (02439400)	5.9	0.54	7.8	520	2.4	< 1	0.11	0.12
Bogue Chitto Creek near Memphis, AL (02444490)	6.8	0.53	9.1	240	2.6	< 1	0.26	6.7
Lost Creek above Parrish, AL (02454055)	10	0.77	12	770	2.3	< 1	0.13	3.6
Locust Fork below Snead, AL (02454500)	5	0.6	7.7	350	1.2	< 1	0.2	0.22
Valley Creek near Bessemer, AL (02461500)	5.8	3.3	23.1	319	1.32	1	1.34	2.16
Black Warrior River at Bankhead L&D near Bessemer, AL (02462500)	5.7	1.2	34	520	1.7	< 1	0.19	0.27
Hurricane Creek near Holt, AL (02463500)	7.02	0.911	10.7	428	2.41	< 1	0.133	0.179
Cribbs Mill Creek at Tuscaloosa, AL (02465288)	5.2	0.6	8.5	280	1.1	< 1	0.2	0.33
Tombigbee River below Coffeeville L&D near Coffeeville, AL (02469762)	7.6	0.53	8.7	520	2.3	< 1	0.18	0.74
Satilpa Creek near Coffeeville, AL (02469800)	8	0.8	20	400	2.3	< 1	0.2	0.63
Chickasaw Creek near Kushla, AL (02471001)	3.3	0.5	3.8	250	1	< 1	< 0.1	0.1

[a] USGS identification number is based on geographic location and the downstream order of streamflow sites.

[b] Reported as percent of sample.

Appendix 5. Concentration data for trace elements in streambed-sediment samples from the Mobile River Basin, 1998—Continued

[USGS, U.S. Geological Survey; <, less than; Blvd., Boulevard; L&D, Lock and Dam; —, no data]

Site name (USGS identification number[a])	Concentration, in microgram per gram, dry weight							
	Cerium	Chromium	Cobalt	Copper	Europium	Gallium	Gold	Holmium
Coosa River near Rome, GA (02397000)	110	69	23	42	2.8	21	< 1	1.9
Chattooga River above Gaylesville, AL (02398300)	76	52	11	20	1.2	11	< 1	1.3
Sougahatchee Creek above Reeltown, AL (02418264)	107	103	32.2	37.9	2.42	26.2	< 1	2.51
Three Mile Branch at North Blvd. at Montgomery, AL (02419977)	128	77.6	15.1	22.1	1.61	18	< 1	1.53
Pintlalla Creek at Liberty Church Road near Pintlalla, AL (02421115)	112	167	11.8	24	1.64	26.8	< 1	1.3
Cahaba Valley Creek at Cross Creek Road at Pelham, AL (0242354750)	75.9	61.5	12.8	21	1.25	11	< 1	1.38
Shades Creek at Homewood, AL (02423581)	93.6	83.2	12.6	28.5	1.6	12.8	< 1	1.58
Cahaba River at Centreville, AL (02424000)	93	66	18	26	1.6	16	< 1	1.1
Alabama River at Claiborne, AL (02429500)	140	89	13	22	2.1	18	< 1	1.3
Town Creek at Tupelo, MS (02434000)	120	96	13	49	1.8	18	< 1	1.5
Buttahatchee River near Aberdeen, MS (02439400)	95	54	22	20	1.5	14	< 1	1.4
Bogue Chitto Creek near Memphis, AL (02444490)	94	120	9.5	20	1.6	17	< 1	1
Lost Creek above Parrish, AL (02454055)	110	86	23	33	2	22	< 1	1.1
Locust Fork below Snead, AL (02454500)	68	48	14	14	< 1	11	< 1	< 1
Valley Creek near Bessemer, AL (02461500)	95.5	96.8	13.6	72.7	1.58	13.4	< 1	1.88
Black Warrior River at Bankhead L&D near Bessemer, AL (02462500)	62	52	14	25	1.1	14	< 1	< 1
Hurricane Creek near Holt, AL (02463500)	116	62.7	27.5	24.5	1.7	16.5	< 1	1.72
Cribbs Mill Creek at Tuscaloosa, AL (02465288)	80	46	8	15	1.1	11	< 1	1
Tombigbee River below Coffeeville L&D near Coffeeville, AL (02469762)	130	88	13	20	2.1	16	< 1	1.3
Satilpa Creek near Coffeeville, AL (02469800)	160	96	24	20	2	16	< 1	2
Chickasaw Creek near Kushla, AL (02471001)	56	32	11	11	< 1	7.3	< 1	< 1

[a] USGS identification number is based on geographic location and the downstream order of streamflow sites.

Appendix 5. Concentration data for trace elements in streambed-sediment samples from the Mobile River Basin, 1998—Continued

[USGS, U.S. Geological Survey; <, less than; Blvd., Boulevard; L&D, Lock and Dam; —, no data]

Site name (USGS identification number[a])	Concentration, in microgram per gram, dry weight							
	Iron[b]	Lanthanum	Lead	Lithium	Magnesium[b]	Manganese	Mercury	Molybdenum
Coosa River near Rome, GA (02397000)	4.8	59	39	39	0.47	2,100	0.1	1.1
Chattooga River above Gaylesville, AL (02398300)	2.3	39	24	36	0.28	790	0.06	0.6
Sougahatchee Creek above Reeltown, AL (02418264)	6.46	54.3	29.8	32.3	0.322	5,930	0.07	1.76
Three Mile Branch at North Blvd. at Montgomery, AL (02419977)	6.42	68.8	50.8	28.1	0.281	3,400	0.07	1.89
Pintlalla Creek at Liberty Church Road near Pintlalla, AL (02421115)	6.34	59	25.7	96.9	0.63	1,380	0.04	2.95
Cahaba Valley Creek at Cross Creek Road at Pelham, AL (0242354750)	2.45	37.7	22.8	33.4	0.322	1,270	0.05	1.18
Shades Creek at Homewood, AL (02423581)	3.19	48.8	53.2	38.2	0.482	1,050	0.08	0.904
Cahaba River at Centreville, AL (02424000)	3.7	52	30	45	0.45	2,200	0.06	1.2
Alabama River at Claiborne, AL (02429500)	4.1	76	22	49	0.65	1,300	0.04	1.2
Town Creek at Tupelo, MS (02434000)	4.2	66	28	71	0.53	1,400	0.05	1.4
Buttahatchee River near Aberdeen, MS (02439400)	3.3	53	21	35	0.22	2,700	0.05	0.88
Bogue Chitto Creek near Memphis, AL (02444490)	3.2	50	18	89	0.47	440	0.05	1.2
Lost Creek above Parrish, AL (02454055)	4.1	61	26	76	0.85	2,600	0.07	0.88
Locust Fork below Snead, AL (02454500)	2.2	36	20	30	0.21	2,000	0.05	1.1
Valley Creek near Bessemer, AL (02461500)	4.65	45.1	156	41.3	0.756	915	0.23	4.66
Black Warrior River at Bankhead L&D near Bessemer, AL (02462500)	3.3	35	24	44	0.4	5,600	0.1	3
Hurricane Creek near Holt, AL (02463500)	3.37	59	25.8	34.7	0.302	2,730	0.04	1.16
Cribbs Mill Creek at Tuscaloosa, AL (02465288)	2.6	38	31	21	0.23	470	0.04	1
Tombigbee River below Coffeeville L&D near Coffeeville, AL (02469762)	4.1	75	21	51	0.67	1,000	0.05	1
Satilpa Creek near Coffeeville, AL (02469800)	5.4	78	27	35	0.53	2,400	0.07	2.5
Chickasaw Creek near Kushla, AL (02471001)	1.8	31	17	16	0.15	380	0.04	0.63

[a] USGS identification number is based on geographic location and the downstream order of streamflow sites.

[b] Reported as percent of sample.

Appendix 5. Concentration data for trace elements in streambed-sediment samples from the Mobile River Basin, 1998—Continued

[USGS, U.S. Geological Survey; <, less than; Blvd., Boulevard; L&D, Lock and Dam; —, no data]

Site name (USGS identification number[a])	Concentration, in microgram per gram, dry weight							
	Neodymium	Nickel	Niobium	Phosphorus[b]	Potassium[b]	Scandium	Selenium	Silver
Coosa River near Rome, GA (02397000)	52	36	23	0.092	1.4	14	0.49	0.91
Chattooga River above Gaylesville, AL (02398300)	32	19	19	0.05	0.95	6.6	0.34	0.75
Sougahatchee Creek above Reeltown, AL (02418264)	53.8	36.8	14.3	0.117	1.02	18.7	0.83	0.726
Three Mile Branch at North Blvd. at Montgomery, AL (02419977)	59	20.7	15.1	0.138	0.8	8.96	0.75	0.787
Pintlalla Creek at Liberty Church Road near Pintlalla, AL (02421115)	52.5	32.6	15.6	0.158	1.07	14.5	1.1	0.726
Cahaba Valley Creek at Cross Creek Road at Pelham, AL (0242354750)	31.8	31.6	12.3	0.054	0.786	7.17	0.61	0.633
Shades Creek at Homewood, AL (02423581)	44.8	26.2	9.6	0.0537	1.13	9.31	0.67	0.964
Cahaba River at Centreville, AL (02424000)	43	32	14	0.091	1.4	13	0.73	0.69
Alabama River at Claiborne, AL (02429500)	68	28	17	0.089	1.4	15	0.53	0.81
Town Creek at Tupelo, MS (02434000)	58	28	23	0.11	1.4	11	0.66	0.79
Buttahatchee River near Aberdeen, MS (02439400)	41	25	28	0.049	1.1	8	0.43	0.9
Bogue Chitto Creek near Memphis, AL (02444490)	45	35	22	0.081	0.81	12	0.85	< 1
Lost Creek above Parrish, AL (02454055)	50	49	14	0.074	2.4	20	0.59	0.67
Locust Fork below Snead, AL (02454500)	29	21	16	0.085	0.75	5	0.48	< 0.1
Valley Creek near Bessemer, AL (02461500)	40.9	33.9	11.4	0.104	1.15	9.32	1.6	1.73
Black Warrior River at Bankhead L&D near Bessemer, AL (02462500)	29	30	9.4	0.092	1.3	11	1.3	0.5
Hurricane Creek near Holt, AL (02463500)	51.5	36	14.8	0.0383	1.21	10.1	0.56	0.884
Cribbs Mill Creek at Tuscaloosa, AL (02465288)	34	16	16	0.041	0.7	6	0.29	< 0.1
Tombigbee River below Coffeeville L&D near Coffeeville, AL (02469762)	63	29	18	0.098	1.4	14	0.42	0.89
Satilpa Creek near Coffeeville, AL (02469800)	68	27	18	0.082	0.98	15	1	0.9
Chickasaw Creek near Kushla, AL (02471001)	23	9	11	0.02	0.53	5.6	0.45	0.55

[a] USGS identification number is based on geographic location and the downstream order of streamflow sites.

[b] Reported as percent of sample.

Appendix 5. Concentration data for trace elements in streambed-sediment samples from the Mobile River Basin, 1998—Continued

[USGS, U.S. Geological Survey; <, less than; Blvd., Boulevard; L&D, Lock and Dam; —, no data]

Site name (USGS identification number[a])	Concentration, in microgram per gram, dry weight							
	Sodium[b]	Strontium	Sulfur[b]	Tantalum	Thorium	Tin	Uranium	Vanadium
Coosa River near Rome, GA (02397000)	0.21	78	0.1	1.6	14	2.7	3.3	100
Chattooga River above Gaylesville, AL (02398300)	0.11	38	< 0.05	1.3	10	1.6	2.7	59
Sougahatchee Creek above Reeltown, AL (02418264)	0.175	45.8	0.05	1.4	13.2	4.12	4.78	145
Three Mile Branch at North Blvd. at Montgomery, AL (02419977)	0.0643	59.7	0.07	1.55	21.3	2.48	5.63	99.2
Pintlalla Creek at Liberty Church Road near Pintlalla, AL (02421115)	0.102	104	0.07	1.69	19	2.86	5.76	142
Cahaba Valley Creek at Cross Creek Road at Pelham, AL (0242354750)	0.0901	39.2	< 0.05	< 1	10.4	1.83	3.47	63.1
Shades Creek at Homewood, AL (02423581)	0.159	63.9	< 0.05	1.11	13.2	3.21	3.96	75.9
Cahaba River at Centreville, AL (02424000)	0.12	58	< 0.05	1.3	12	3	3.1	100
Alabama River at Claiborne, AL (02429500)	0.24	83	< 0.05	1.5	20	2.4	4.5	110
Town Creek at Tupelo, MS (02434000)	0.29	130	0.06	1.5	19	2.2	3.8	110
Buttahatchee River near Aberdeen, MS (02439400)	0.13	68	< 0.05	1.7	12	1.9	2.7	74
Bogue Chitto Creek near Memphis, AL (02444490)	0.16	330	0.07	2.6	13	2.2	4.1	110
Lost Creek above Parrish, AL (02454055)	0.43	210	0.12	1.2	14	3.2	3.4	140
Locust Fork below Snead, AL (02454500)	0.09	44	< 0.05	1	10	3	2.8	60
Valley Creek near Bessemer, AL (02461500)	0.0902	64.3	0.19	1.1	13.2	19.8	3.83	76.8
Black Warrior River at Bankhead L&D near Bessemer, AL (02462500)	0.18	55	0.21	< 1	10	2.6	3.7	91
Hurricane Creek near Holt, AL (02463500)	0.112	53.4	< 0.05	1.58	17	2.69	4.1	82.5
Cribbs Mill Creek at Tuscaloosa, AL (02465288)	0.072	39	< 0.05	1.1	12	3	2.9	60
Tombigbee River below Coffeeville L&D near Coffeeville, AL (02469762)	0.24	110	< 0.05	1.5	18	2.1	4	120
Satilpa Creek near Coffeeville, AL (02469800)	0.1	86	0.05	2	19	3	4	120
Chickasaw Creek near Kushla, AL (02471001)	0.084	38	< 0.05	< 1	9.1	1.5	2.4	44

[a] USGS identification number is based on geographic location and the downstream order of streamflow sites.

[b] Reported as percent of sample.

Appendix 5. Concentration data for trace elements in streambed-sediment samples from the Mobile River Basin, 1998—Continued

[USGS, U.S. Geological Survey; <, less than; Blvd., Boulevard; L&D, Lock and Dam; —, no data]

Site name (USGS identification number[a])	Concentration, in microgram per gram, dry weight							
	Yttrium	Ytterbium	Zinc	Organic carbon[b]	Organic + inorganic carbon[b]	Inorganic carbon[b]	Titanium[b]	Thallium
Coosa River near Rome, GA (02397000)	37	4.3	170	1.52	1.56	0.04	0.62	< 1
Chattooga River above Gaylesville, AL (02398300)	25	3.3	69	1	1.02	0.02	0.41	< 1
Sougahatchee Creek above Reeltown, AL (02418264)	40.3	4.5	149	3.21	3.26	0.05	0.815	< 1
Three Mile Branch at North Blvd. at Montgomery, AL (02419977)	26	2.47	208	3.19	3.24	0.05	0.711	< 1
Pintlalla Creek at Liberty Church Road near Pintlalla, AL (02421115)	22.1	1.96	127	3.04	3.07	0.03	0.676	< 1
Cahaba Valley Creek at Cross Creek Road at Pelham, AL (0242354750)	25.4	2.67	116	1.36	1.46	0.1	0.435	< 1
Shades Creek at Homewood, AL (02423581)	26.2	3.14	165	1.51	1.7	0.19	0.476	< 1
Cahaba River at Centreville, AL (02424000)	26	2.8	110	2.43	2.49	0.06	0.41	< 1
Alabama River at Claiborne, AL (02429500)	31	3	110	1.23	1.24	0.01	0.58	< 1
Town Creek at Tupelo, MS (02434000)	28	3.1	120	1.43	1.66	0.23	0.53	< 1
Buttahatchee River near Aberdeen, MS (02439400)	27	3.2	82	1.62	1.64	0.02	0.45	< 1
Bogue Chitto Creek near Memphis, AL (02444490)	23	2.6	100	1.11	2.81	1.7	0.49	—
Lost Creek above Parrish, AL (02454055)	26	2.8	120	2.14	3.06	0.92	0.47	1
Locust Fork below Snead, AL (02454500)	21	2.4	72	2.15	2.17	0.02	0.44	< 1
Valley Creek near Bessemer, AL (02461500)	29.1	3.52	514	3.63	4.28	0.65	0.492	< 1
Black Warrior River at Bankhead L&D near Bessemer, AL (02462500)	19	2.2	110	3.69	3.78	0.09	0.31	< 1
Hurricane Creek near Holt, AL (02463500)	26.3	3	96.2	1.06	1.1	0.04	0.598	< 1
Cribbs Mill Creek at Tuscaloosa, AL (02465288)	23	2.8	88	1.28	1.36	0.08	0.48	< 1
Tombigbee River below Coffeeville L&D near Coffeeville, AL (02469762)	29	2.7	120	0.89	0.95	0.06	0.5	< 1
Satilpa Creek near Coffeeville, AL (02469800)	34	3	110	2.9	2.9	0.03	0.57	< 1
Chickasaw Creek near Kushla, AL (02471001)	15	1.6	41	2.08	2.09	0.01	0.32	< 1

[a] USGS identification number is based on geographic location and the downstream order of streamflow sites.

[b] Reported as percent of sample.