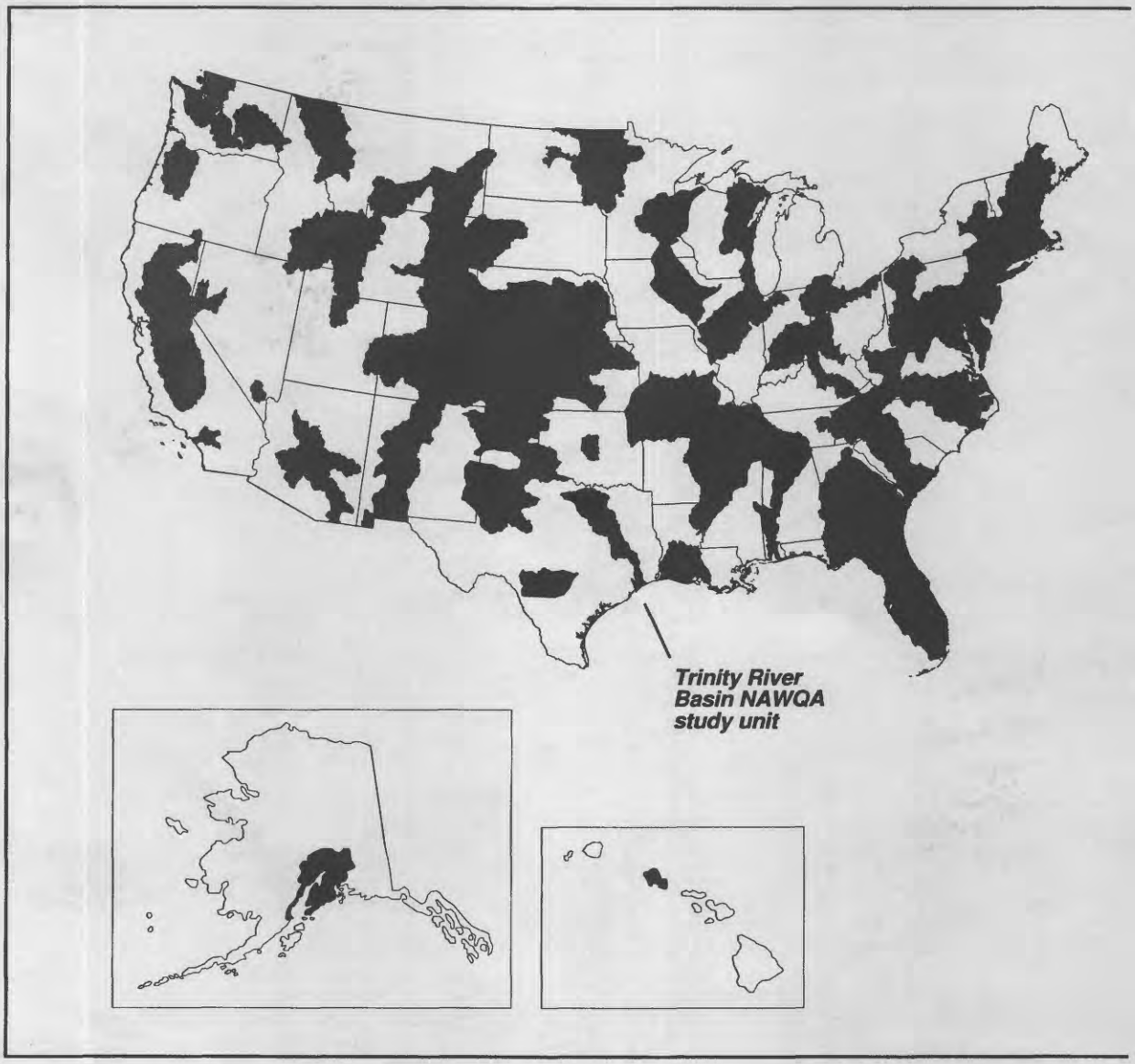
OCCURRENCE AND DISTRIBUTION OF ORGANOCHLORINE COMPOUNDS IN BIOLOGICAL TISSUE AND BED SEDIMENT FROM STREAMS IN THE TRINITY RIVER BASIN, TEXAS, 1992–93



U.S. GEOLOGICAL SURVEY

Water-Resources Investigations Report 97–4057

NATIONAL WATER–QUALITY ASSESSMENT PROGRAM

OCCURRENCE AND DISTRIBUTION OF ORGANOCHLORINE COMPOUNDS IN BIOLOGICAL TISSUE AND BED SEDIMENT FROM STREAMS IN THE TRINITY RIVER BASIN, TEXAS, 1992–93

By J. Bruce Moring

A Contribution of the
National Water-Quality Assessment Program

U.S. GEOLOGICAL SURVEY
WATER-RESOURCES INVESTIGATIONS REPORT 97–4057

Austin, Texas
1997

U.S. DEPARTMENT OF THE INTERIOR

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<URL:http://wwwrvares.er.usgs.gov/nawqa/nawqa_home.html>

FOREWORD

The mission of the U.S. Geological Survey (USGS) is to assess the quantity and quality of the earth resources of the Nation and to provide information that will assist resource managers and policymakers at Federal, State, and local levels in making sound decisions. Assessment of water-quality conditions and trends is an important part of this overall mission.

One of the greatest challenges faced by water-resources scientists is acquiring reliable information that will guide the use and protection of the Nation's water resources. That challenge is being addressed by Federal, State, interstate, and local water-resource agencies and by many academic institutions. These organizations are collecting water-quality data for a host of purposes that include: compliance with permits and water-supply standards; development of remediation plans for specific contamination problems; operational decisions on industrial, wastewater, or water-supply facilities; and research on factors that affect water quality. An additional need for water-quality information is to provide a basis on which regional- and national-level policy decisions can be based. Wise decisions must be based on sound information. As a society we need to know whether certain types of water-quality problems are isolated or ubiquitous, whether there are significant differences in conditions among regions, whether the conditions are changing over time, and why these conditions change from place to place and over time. The information can be used to help determine the efficacy of existing water-quality policies and to help analysts determine the need for and likely consequences of new policies.

To address these needs, the U.S. Congress appropriated funds in 1986 for the USGS to begin a pilot program in seven project areas to develop and refine the National Water-Quality Assessment (NAWQA) Program. In 1991, the USGS began full implementation of the program. The NAWQA Program builds upon an existing base of water-quality studies of the USGS, as well as those of other Federal, State, and local agencies. The objectives of the NAWQA Program are to:

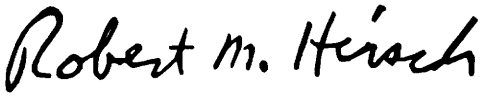
- Describe current water-quality conditions for a large part of the Nation's freshwater streams, rivers, and aquifers.
- Describe how water quality is changing over time.
- Improve understanding of the primary natural and human factors that affect water-quality conditions.

This information will help support the development and evaluation of management, regulatory, and monitoring decisions by other Federal, State, and local agencies to protect, use, and enhance water resources.

The goals of the NAWQA Program are being achieved through ongoing and proposed investigations of 60 of the Nation's most important river basins and aquifer systems, which are referred to as study units. These study units are distributed throughout the Nation and cover a diversity of hydrogeologic settings. More than two-thirds of the Nation's freshwater use occurs within the 60 study units and more than two-thirds of the people served by public water-supply systems live within their boundaries.

National synthesis of data analysis, based on aggregation of comparable information obtained from the study units, is a major component of the program. This effort focuses on selected water-quality topics using nationally consistent information. Comparative studies will explain differences and similarities in observed water-quality conditions among study areas and will identify changes and trends and their causes. The first topics addressed by the national synthesis are pesticides, nutrients, volatile organic compounds, and aquatic biology. Discussions on these and other water-quality topics will be published in periodic summaries of the quality of the Nation's ground and surface water as the information becomes available.

This report is an element of the comprehensive body of information developed as part of the NAWQA Program. The program depends heavily on the advice, cooperation, and information from many Federal, State, interstate, Tribal, and local agencies and the public. The assistance and suggestions of all are greatly appreciated.



Robert M. Hirsch
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VERTICAL DATUM

Sea level: In this report, "sea level" refers to the National Geodetic Vertical Datum of 1929—a geodetic datum derived from a general adjustment of the first-order level nets of both the United States and Canada, formerly called Sea Level Datum of 1929.

Occurrence and Distribution of Organochlorine Compounds in Biological Tissue and Bed Sediment From Streams in the Trinity River Basin, Texas, 1992–93

By J. Bruce Moring

Abstract

This report describes the occurrence and distribution of organochlorine compounds in biological tissue and bed sediment from the Trinity River Basin study area of the National Water-Quality Assessment Program. Concentrations of organochlorine pesticides, polychlorinated biphenyls (PCBs), and other organochlorine compounds were determined in biological tissue and surficial bed sediment from 16 stream sites in the Trinity River Basin of east-central Texas. Asiatic clams (*Corbicula fluminea*) were collected at 10 sites, and fish, including blue catfish (*Ictalurus furcatus*), common carp (*Cyprinus carpio*), bluegill (*Lepomis cyanellus*), and yellow bullhead (*Ameiurus natalis*) were collected at all mainstem and two tributary sites. Thirty of the 36 compounds analyzed in biological tissue or surficial bed sediment were detected in one or both media. Overall, more organochlorine compounds were detected in bed sediment than in biological tissue; however, various chlordane isomers, DDT metabolites, and PCBs were detected more frequently in tissue than in sediment. The chlordane isomers and PCBs that were detected more frequently in biological tissue also were detected more frequently at urban sites than at agricultural sites. Organochlorine compound concentrations generally were highest in fish tissue from Trinity River mainstem sites. Fish tissue from the mainstem sites contained a higher percentage of lipids than did fish- and clam-tissue samples from the tributary sites.

INTRODUCTION

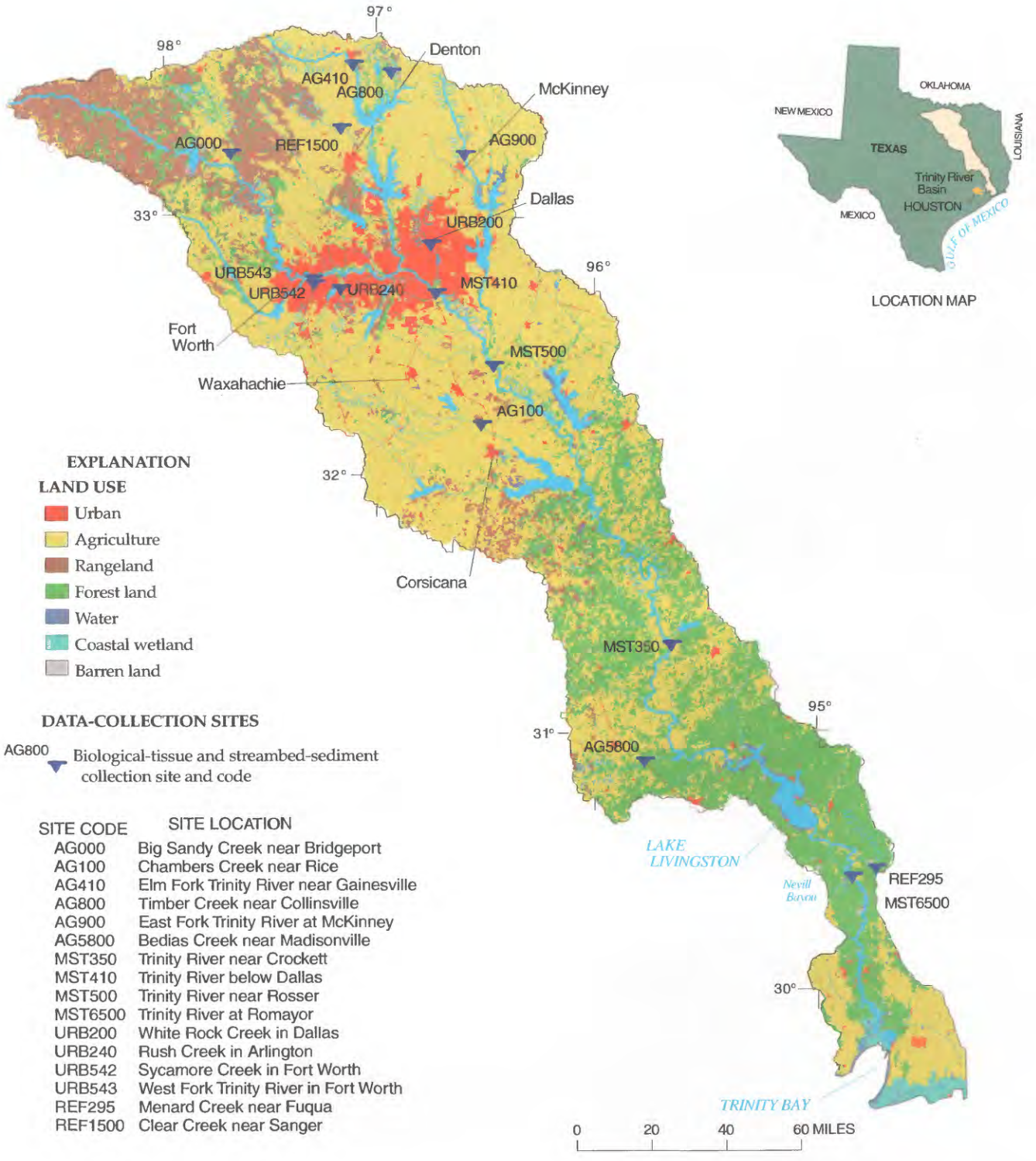
The Trinity River Basin is one of 60 river basins and aquifer systems (study units) in the United States investigated under the U.S. Geological Survey (USGS) National Water-Quality Assessment (NAWQA) Program. The emphasis of the NAWQA Program is to provide assessments of the status of and trends in the Nation's surface- and ground-water quality.

The Trinity River Basin was among the first set of 20 study units to be fully implemented by NAWQA. Study design and long-term planning of data-collection and analysis activities began in 1991. A 3-year period of intensive data collection began in March 1993 and ended in September 1995. The collection of biological-tissue and surficial bed-sediment samples during 1992 and 1993 in the Trinity River Basin was designed to assess the occurrence and distribution of organochlorine pesticides, polychlorinated biphenyls (PCBs), and other organochlorine compounds. Use of the majority of organochlorine compounds was discontinued in the 1970s and 1980s; however, the environmental persistence of these compounds warrants continued monitoring (Schmitt and others, 1985).

Purpose and Scope

The purpose of this report is to describe the occurrence and distribution of organochlorine compounds in biological tissue and bed sediment from streams in the Trinity River Basin. The distribution of organochlorine compounds in relation to general land-use practices in the basin and characteristics of the aquatic biota used for tissues analysis and sediment are emphasized.

The scope of this study includes only data-collection sites within the Trinity River Basin (fig. 1). The study was designed to provide an assessment of the status and occurrence of organochlorine compounds in biological tissue and bed sediment. Compounds not



SITE CODE	SITE LOCATION
AG000	Big Sandy Creek near Bridgeport
AG100	Chambers Creek near Rice
AG410	Elm Fork Trinity River near Gainesville
AG800	Timber Creek near Collinsville
AG900	East Fork Trinity River at McKinney
AG5800	Bedias Creek near Madisonville
MST350	Trinity River near Crockett
MST410	Trinity River below Dallas
MST500	Trinity River near Rosser
MST6500	Trinity River at Romayor
URB200	White Rock Creek in Dallas
URB240	Rush Creek in Arlington
URB542	Sycamore Creek in Fort Worth
URB543	West Fork Trinity River in Fort Worth
REF295	Menard Creek near Fuqua
REF1500	Clear Creek near Sanger

Figure 1. Land use and biological-tissue and streambed-sediment collection sites in the Trinity River Basin study unit, Texas (see table 1 for details on collection sites).

detected during this first intensive sampling phase will be de-emphasized in later sampling efforts.

Organochlorine Compounds in Biological Tissue and Bed Sediment

Use of organochlorine pesticides and PCBs was widespread beginning in the 1940s until bans and use restrictions were placed on these compounds in the 1970s and 1980s. Concerns over the environmental effects of organochlorine compounds is a consequence of their persistence in the environment (Schmitt and others, 1990). Compounds such as chlordane, DDT and its metabolites (DDE and DDD), and the various PCB aroclors are water insoluble, are strongly associated with organic carbon and fine sediment, and have long half-lives. Because of their high lipid solubility, the compounds can be sequestered in biota for long periods of time. Organochlorine compounds were selected by NAWQA for assessment because these compounds are not metabolized rapidly to undetectable metabolites and because they have high bioaccumulation and bioconcentration factors (Crawford and Luoma, 1993).

Other national programs that have addressed organochlorine compounds in fish tissue include the U.S. Fish and Wildlife Service National Contaminant Biomonitoring Program (NCBP) (Schmitt and others, 1990) and the U.S. Environmental Protection Agency National Study of Chemical Residues in Fish (NSCRF) (U.S. Environmental Protection Agency, 1992). These programs have emphasized sampling efforts at or near the mouths of large rivers (NCBP) or at proposed least- and most-contaminated sites (NSCRF). NAWQA's differences in approach include: (1) a watershed approach including a network of sites throughout the river basin selected to represent various land uses; (2) the collocated collection of biological tissue and bed sediment for analysis of organochlorine compounds; and (3) a focus on target taxa, both vertebrate and invertebrate, that will provide the most information on the occurrence and distribution of contaminants and the potential for accumulation in aquatic biota.

The distribution of organochlorine compounds in biological tissue and streambed sediment is, in part, a reflection of the historical applications of pesticides. In the Trinity River Basin, pesticide uses were concentrated in agricultural areas, particularly the Blackland Prairie (Ulery and Brown, 1995), and in urban settings such as the Dallas-Fort Worth (DFW) metropolitan area.

Study-Area Description

The Trinity River Basin NAWQA study area is in east-central Texas and extends from northwest to southeast some 360 miles (mi) from near the Oklahoma-Texas State line, about 60 mi north of the DFW metropolitan area, to Trinity Bay at the mouth of the Trinity River, about 50 mi east of Houston, Texas (fig. 1). The Trinity River Basin drainage area encompasses 18,570 square miles (mi^2) and has 38 Texas counties partially or entirely within the river basin boundary.

The Trinity River Basin is geologically a modified sedimentary landform that reflects a depositional history of successive climatic and sea-level changes altered by subsequent uplifts or subsidence of areas of the basin (Van Metre and Reutter, 1995). The basin is characterized by alternating zones of rolling, treeless prairies, smooth to slightly rolling prairies, rolling timbered hills, and a relatively flat coastal plain. The drainage area slopes gradually from 1,200 feet (ft) above sea level in the northwestern part of the basin to about 600 ft at mid-basin, and finally to sea level in the southeastern coastal part of the basin.

The climate of the study area is best described as modified marine, humid subtropical, with warm summers and a predominate onshore flow of tropical maritime air from the Gulf of Mexico (Carr, 1967). Most of the study area has a winter surplus and a summer deficit of precipitation. The northwestern part of the study area has little or no water surplus during any season, and the extreme southeastern part has no water deficit during any season. Average annual precipitation ranges from less than 32 inches (in.) for the northwestern part of the study area to greater than 52 in. for the southeastern coastal prairie (Larkin and Bomar, 1983). Average annual temperature is relatively uniform, ranging from 69 degrees Fahrenheit (°F) in the coastal areas to 65 °F in the prairies of the northwestern part of the study area.

Texas is the seventh fastest growing State in the United States and third largest in total population behind California and New York, with a 1990 population of about 17 million (A.H. Belo Corp., 1991). The greater DFW metropolitan area accounts for 66 percent of the 1990 population in the study area (about 3 million). During 1980–90, the population of Texas increased by 19 percent; however, the population of the study area increased by about 26 percent. Most of this growth has occurred in the greater DFW metropolitan area. The average population density in Texas is about 68 persons per square mile, and the population density

of the study area is about 263 persons per square mile. The greater DFW metropolitan area has a population density of more than 1,015 persons per square mile (A.H. Belo Corp., 1991).

An initial land-use and land-cover classification was applied to the Trinity River Basin study area (Ulery and others, 1993) on the basis of Geographic Information and Retrieval Analysis System (GIRAS) land-use and land-cover data (Anderson and others, 1976). This information is an approximation of land use and land cover for 1973–84. Urban land use was updated to reflect the 1990 census. Urban developed areas account for 5 percent of the study area (fig. 1). About 25 percent of the study area is classified as forested or as wetlands. Rangeland accounts for 10 percent of the study area. Agricultural activities, including cropland, pastures, orchards, or vineyards, account for 57 percent of the study area.

STUDY METHODS

Site Selection

Aquatic-biota and surficial streambed-sediment samples were collected at 16 sites (fig. 1, table 1 at end of report) in the Trinity River Basin during late winter 1992 and early spring 1993. Sites on Trinity River tributaries were chosen to reflect general urban and agricultural land-use areas and those areas least affected by urban and agricultural land uses. Four Trinity River mainstem sites were selected (fig. 1). Twelve of the 16 sites make up the Trinity NAWQA network of fixed, long-term monitoring stations (fixed stations, table 1). The remaining four sites were selected to provide additional sites in urban and agricultural land-use areas.

Biological Tissue

Specific taxa were targeted for the collection of biological tissue for the analysis of organochlorine pesticides, PCBs, and other organochlorine compounds (Crawford and Luoma, 1993) to allow for comparisons of the occurrence, distribution, and concentrations of organochlorine compounds among the same or similar taxa. Determination of percentage of lipids for each tissue sample was required for the normalization of organochlorine concentrations as needed to make comparisons among tissue samples from different taxa. Aquatic organisms were collected at all 16 sites for the analysis of organochlorine pesticides, PCBs, and percentage of lipids (table 1). Adult asiatic clams were collected at 10 of the 12 tributary sites (table 1). The asiatic clam (*Corbicula fluminea*) was the number one priority taxon for the analysis of biological tissue (Crawford and Luoma, 1993). Adult clams, unlike fish, are sessile (permanently attached) suspension feeders that can provide site-specific information about the occurrence and bioavailability of contaminants. Fish were collected at all four Trinity River mainstem sites (table 1) because of difficulties in locating and collecting clams under deep-channel, large riverine conditions and because of local concerns about the quality of fish tissue for human consumption.

Collection Methods

Asiatic clams were collected at 10 of the 12 tributary sites (table 1) with a D-frame, 212-micrometer (μm) mesh net and various sieves. Clams were collected primarily in cobble, gravel, and sand substrates and usually in shallow, flowing parts of the stream. A minimum of 50 grams (g) wet weight and a range of 20 to 100 individual clams were collected for each sample. Clams were held for 24 hours in native water collected at the site to allow for purging of gut contents. Purging was done to help standardize samples by removing all sources of contaminants other than what had been accumulated by the soft tissue of the organism. Clams were individually weighed to the nearest 0.1 g, measured for total length to the nearest millimeter, rinsed with deionized water, and frozen on dry ice pending shipment to the USGS National Water-Quality Laboratory (NWQL) in Arvada, Colo., for sample preparation and analysis.

Fish were collected at the four Trinity River mainstem sites and two tributary sites (table 1) for the analysis of organochlorine compounds. Fish were collected by either boat or backpack electrofishing, which involves the use of a direct current (DC) applied to the water with anode and cathode arrays extending into the water (Meador and others, 1993). Generally, a current of 3 to 8 amps was used. The DC causes involuntary swimming by the fish toward the anode array. The closer the fish is to the anodes, the greater the voltage gradient, and eventually the fish's muscles will reach tetany or "lock-up," and the fish can be netted easily and placed in an aerated holding tank on the boat. Individual fish were identified according to species, measured for total length to the nearest millimeter, rinsed with deionized water, and double-wrapped in heavy-duty aluminum foil (dull side against fish); fish samples were labeled and frozen on dry ice pending shipment to

the NWQL for sample preparation and analysis. A minimum of five fish was collected at each site to form a composite sample.

Sample Preparation and Laboratory Analysis

The clam samples were received by the NWQL as whole clams with the shells intact. The shells were removed, and the remaining soft tissue was composited and homogenized using a blender. A fish sample consisted of 5 to 10 whole-body fish, which were homogenized into a single composite using a Hobart meat grinder (Leiker and others, 1995). A clam or fish 10-g sample aliquot of tissue was homogenized with 100 g of granular anhydrous sodium sulfate. The sample/sodium sulfate mix was quantitatively transferred to a glass soxhlet thimble. Surrogates were added to the sample prior to extraction. The sample then was soxhlet extracted with dichloromethane overnight, and the extract was filtered through granular anhydrous sodium sulfate and concentrated by a Kuderna-Danish Concentrator to a volume of 5 milliliters (mL). A 1-mL aliquot was removed for percent-lipid determination. A 2-mL aliquot of the extract was injected into an automated gel permeation chromatograph (GPC) to isolate the compounds of interest from the lipid material that was co-extracted. After the compounds were extracted from the GPC, the extract was solvent exchanged into hexane and concentrated under a gentle stream of nitrogen at ambient temperature to a volume of 1 mL. The extract was fractionated into two parts on a column packed with 1 centimeter (cm) of sodium sulfate over 5 g of 8.5-percent deactivated alumina over 3 g of 2-percent water-deactivated silica. The column was prerinsed with 50 mL of hexane. While the column still contained a small amount of hexane rinse that had not penetrated the sodium sulfate, the 1 mL of sample extract was placed on top of the sodium sulfate and eluted to 30 mL of hexane. This first fraction contains DDE, PCBs, and other nonpolar organic compounds that were in the sample. The second fraction was eluted with 35 mL of 50-percent (volume/volume) acetone in hexane. The second fraction contains chlordane components, toxaphene, and other polar organic compounds that were in the sample. Each fraction was concentrated to a volume of 1 mL and analyzed by dual capillary column gas chromatography with electron-capture detection.

The tissue-sample preparation and analysis methods used are suitable for the determination of select organochlorine compounds such as pesticides and industrial chemicals in clam and whole-body fish tissue at minimum reporting levels (MRLs) of approximately 5 micrograms per kilogram (µg/kg) wet weight for chlorinated pesticides, 50 µg/kg wet weight for PCBs, and 200 µg/ kg for toxaphene. The method was used to determine concentrations of 28 organochlorine compounds (table 2 at end of report).

Bed Sediment

Collection Methods

Surficial streambed sediment was collected at 16 sites in the Trinity River Basin study unit (fig. 1, table 1) for the analysis of organochlorine pesticides, PCBs, and other organochlorine compounds (table 3 at end of report). Samples were collected in depositional zones of the channel where fine-grained particles and particulate organic material are expected to accumulate.

Collection equipment included: (1) a 2.5-cm diameter, polytetrafluoroethylene (PTFE) coring device (Shelton and Capel, 1994); (2) a 22.8- by 22.8- by 22.8-cm pole-mounted, Ekman Dredge; (3) PTFE spoons or scoops at the tributary sites; and (4) a Petite Ponar Dredge or Wildco® Box Corer at all Trinity River mainstem sites. Emphasis was placed on using the sampler that would ensure the collection of surficial bed sediments with the least amount of disturbance. The top 2 to 3 cm of surficial sediment were collected with the sampling device. Sediment samples were collected from five or more locations in the reach and composited into a pre-cleaned, 1.5-liter (L) glass bowl. The composite was thoroughly mixed with a PTFE spoon, and a small proportion removed and placed in a 2.0-millimeter (mm) mesh, stainless steel sieve fitted over the mouth of a 1-L glass jar, and gently stirred with a PTFE policeman until the jar was about three-fourths full of sample. Each sample jar was placed in a labeled, sealed plastic bag, put in a protective sleeve, and packed on ice pending shipment to the NWQL for sample preparation and analysis. Samples that could not be shipped to the NWQL within 48 hours were frozen on dry ice and held for a later shipment.

Sample Preparation and Laboratory Analysis

Chilled or frozen samples were received by the NWQL. Frozen samples were thawed, and all samples were centrifuged to remove excess water (Foreman and others, 1995). The centrifuged sample was thoroughly

homogenized, and a 2-g aliquot was placed on a drying balance for dry-weight determination. A 25-g equivalent dry-weight sample was measured out and mixed with sodium sulfate to remove residual water. The sediment mixture was soxhlet extracted overnight with 350 mL dichloromethane and 35 mL methanol. The sample extract was concentrated on a steam bath using a Kuderna-Danish Concentrator to about 4 mL and further evaporated to about 2 mL using a gentle stream of nitrogen.

The sample extract was centrifuged, filtered through a 0.2-μm PTFE syringe filter, and increased to 3 mL with dichloromethane to remove unwanted high-molecular weight natural organic matter and inorganic sulfur. An 800-microliter (μL) aliquot was injected into the GPC. Dichloromethane was used as the mobile phase throughout a 30-minute run time with a flow rate of 0.1 mL per minute. A GPC fraction was collected, beginning at 13 minutes and 45 seconds and ending at 21 minutes and 30 seconds, the contents of which contain the selected organochlorine pesticides and PCBs that were in the sample. The extract was cleaned by GPC, further cleaned by alumina/silica adsorption chromatography, and fractions were analyzed independently by gas chromatography with electron capture detection (Foreman and others, 1995).

The method just described is suitable for determination and quantitation of 36 organochlorine compounds (table 3) in soil or sediment samples at MRLs ranging from 0.5 to 5.0 μg/kg with the exceptions of 50 μg/kg for total, gross PCBs and 200 μg/kg for toxaphene.

OCCURRENCE AND DISTRIBUTION OF ORGANOCHLORINE COMPOUNDS IN BIOLOGICAL TISSUE AND BED SEDIMENT

Organochlorine compounds were analyzed in biological tissue and surficial bed sediment from 16 sites in the Trinity River Basin (table 1). Thirty of the 36 organochlorine compounds analyzed in tissue and sediment were detected in one or both media (fig. 2). A detection was considered as any reported concentration above the MRL for that compound (tables 2 and 3). Overall, more organochlorine compounds were detected in bed sediment than in biological tissue; however various chlordane compounds, DDT derivatives, and PCBs were detected more frequently in biological tissue than in sediment (fig. 2). These lipid-soluble, hydrophobic compounds are expected to accumulate in the lipid-containing tissues of aquatic organisms by passive uptake across gill membranes, known as bioconcentration, or by active uptake through ingestion of food items, known as bioaccumulation (Rand and Petrocelli, 1985). Concentrations of hydrophobic organochlorine compounds in the tissue of aquatic organisms are often several thousand times greater than the concentrations of the same compounds in sediment or water. These high uptake or concentration factors of contaminant sources in biota help explain the more frequent detections in biological tissue compared to detections in sediment and water. Aquatic organisms, particularly long-lived fish that might be several years in age, are integrators of exposure, concentrating the more lipophilic compounds (Crawford and Luoma, 1993).

Organochlorine Pesticides

Chlordane

The various chlordane isomers, including cis- and trans-chlordane and cis- and trans-nonachlor, were detected more frequently in biological tissue than in bed sediment; detections in both media were more frequent at urban sites than at agricultural sites (figs. 3 and 4). Oxychlordane was detected only in sediment at one agricultural site (table 3). The chlordane and nonachlor cis- and trans-isomers are all constituents of technical chlordane which is the application grade chlordane used for pest control. Technical chlordane consists of 60 to 75 percent chlordane isomers and 20 to 25 percent related compounds and impurities. Oxychlordane is a chlordane metabolite (Verschueren, 1983).

The highest total chlordane concentrations (defined as the sum of all chlordane isomers and oxychlordane) in biological-tissue samples were from fish collected at mainstem sites (fig. 5). The drainage area above site MST410 includes most of the DFW metropolitan area. The chlordane isomer, trans-nonachlor, made up the largest proportion of total chlordane in biological tissue from all sites (fig. 5). The replacement of cis-chlordane by trans-chlordane between 1980 and 1984 as the most abundant chlordane isomer in fish-tissue samples from the U.S. Fish and Wildlife Service NCBP network suggests a smaller influx of chlordane to the environment (Schmitt and others, 1990). No major differences in total chlordane tissue concentrations were apparent between urban and agricultural sites (fig. 5). Only 2 of 6 agricultural sites, Elm Fork Trinity

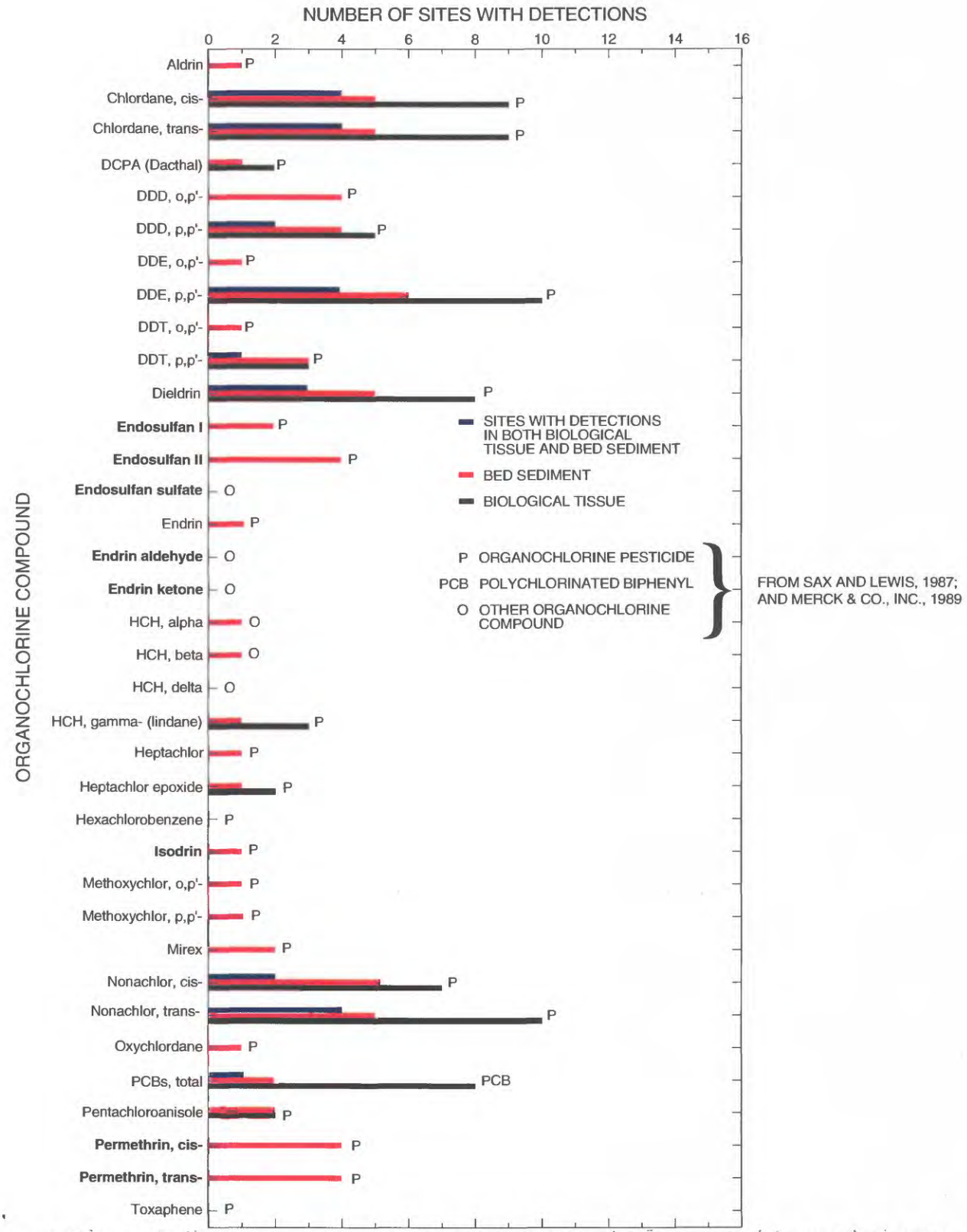


Figure 2. Detections of organochlorine compounds in biological-tissue and bed-sediment samples from sites in the Trinity River Basin, 1992–93. Highlighted compounds (aldrin, endosulfan I, endosulfan II, endosulfan sulfate, endrin aldehyde, endrin ketone, isodrin, cis-permethrin, and trans-permethrin) were analyzed in sediment only.

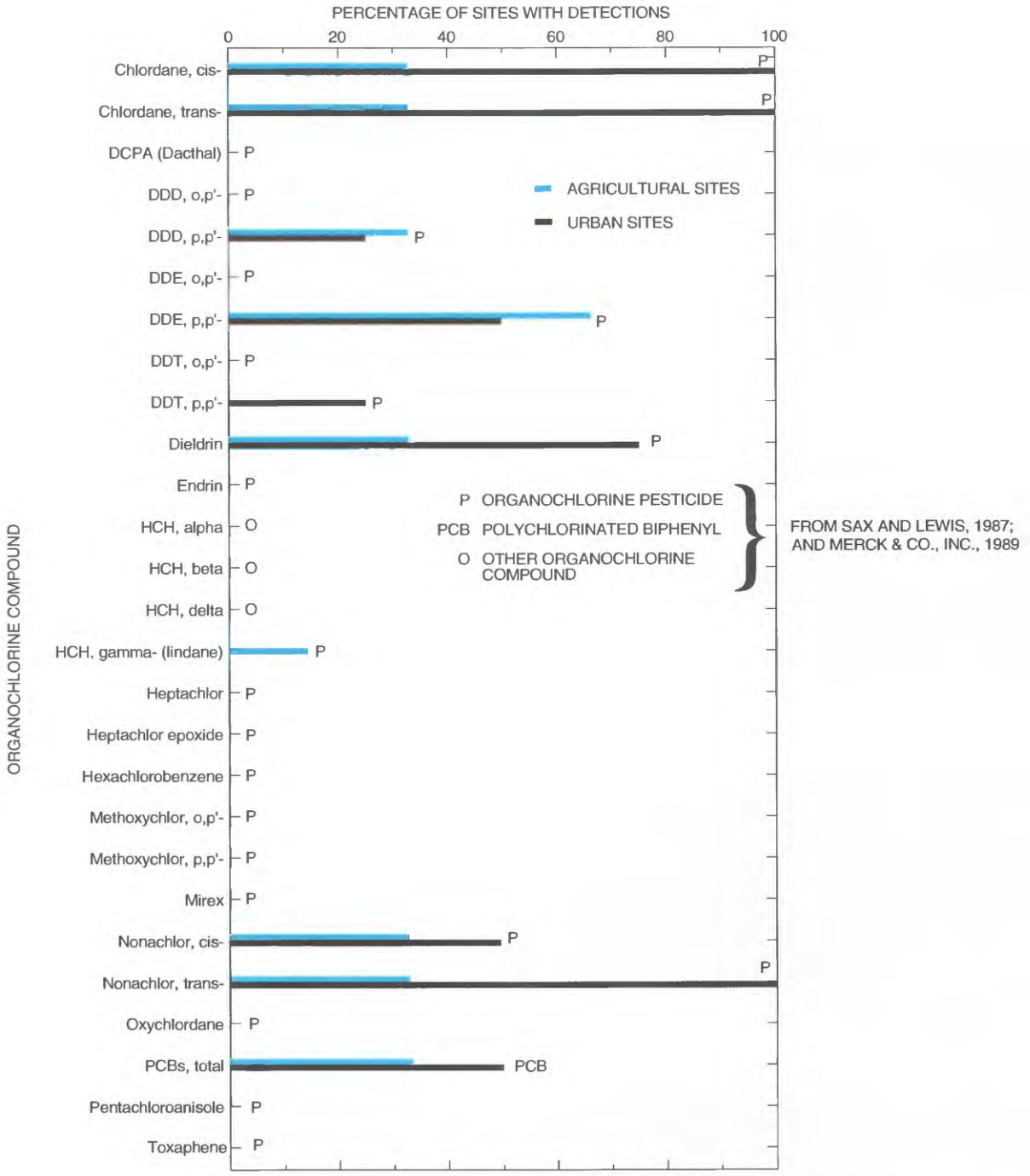


Figure 3. Percentage of urban and agricultural sites in the Trinity River Basin study unit with detections of organochlorine compounds in biological-tissue samples, 1992–93.

River near Gainesville (site AG410) and East Fork Trinity River at McKinney (site AG900), had 1 or more detections of any of the chlordane compounds in biological tissue. Chlordane compounds were not detected in tissue from the two reference sites, Menard Creek near Fuqua (site REF295) and Clear Creek near Sanger (site REF1500). One chlordane isomer, trans-nonachlor, was detected in fish tissue from the Trinity River at Romayor (site MST6500) downstream from a large impoundment, Lake Livingston, which might be

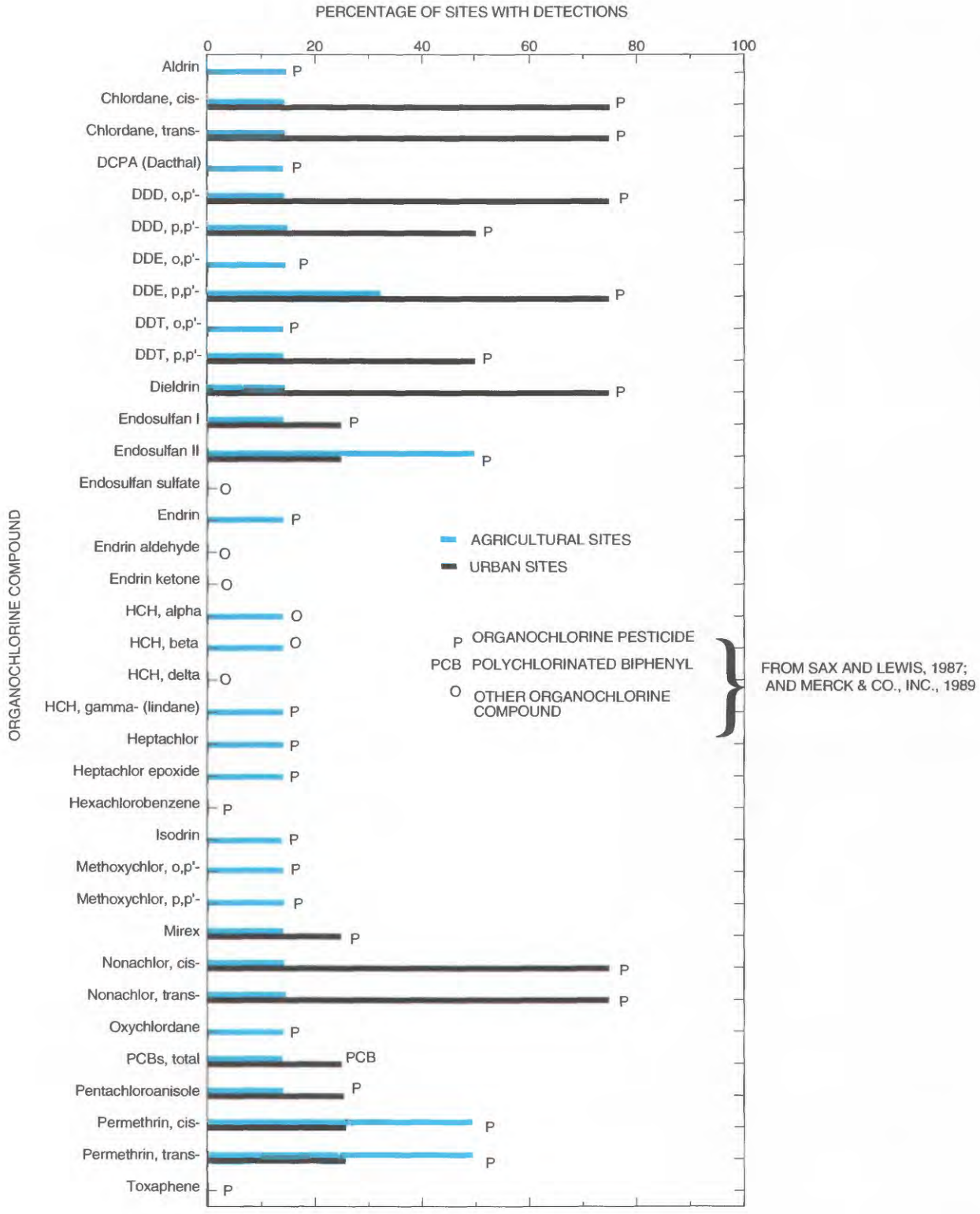


Figure 4. Percentage of urban and agricultural sites in the Trinity River Basin study unit with detections of organochlorine compounds in bed-sediment samples, 1992–93.

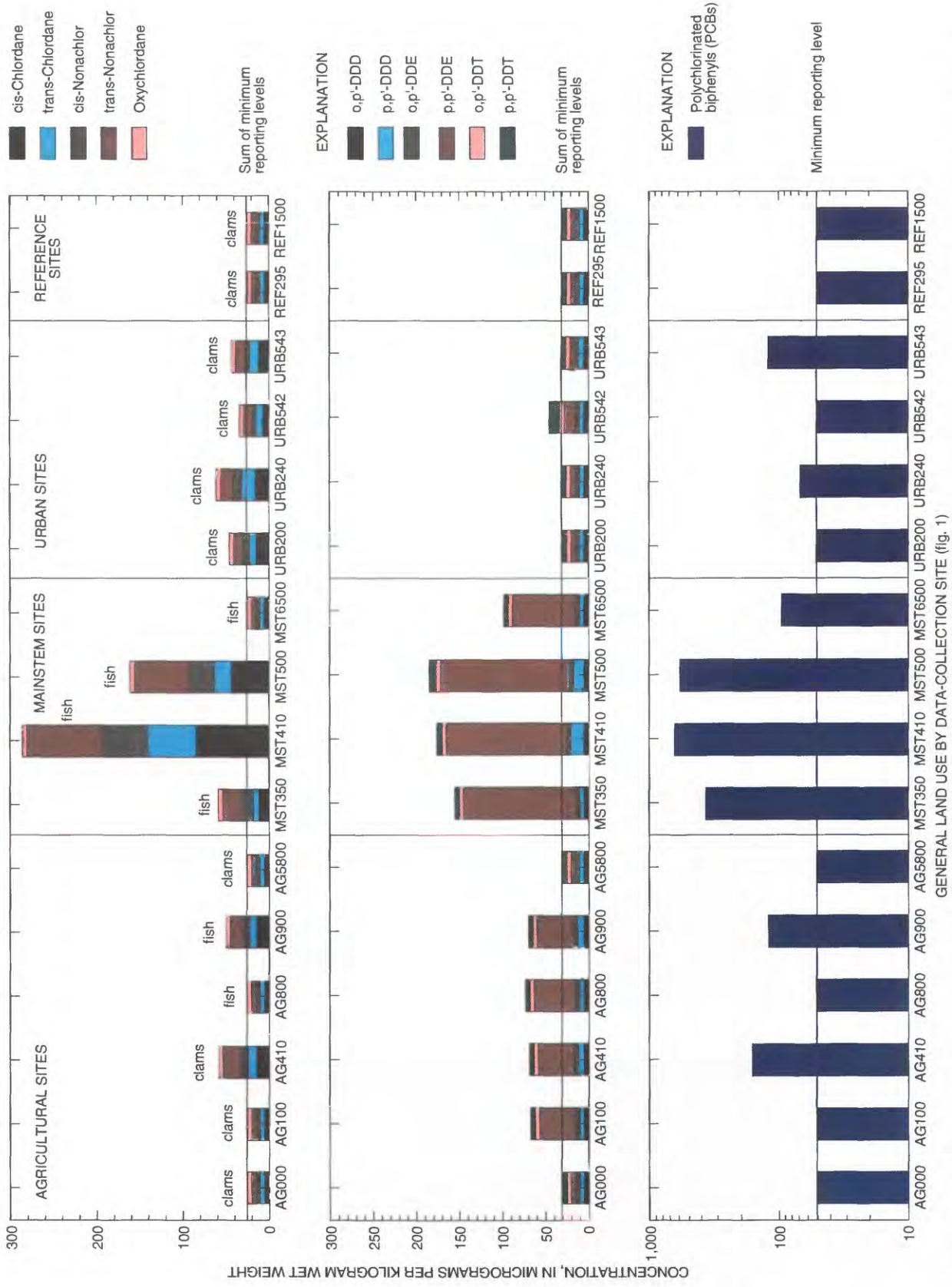


Figure 5. Selected organochlorine compounds detected in biological-tissue samples from sites in the Trinity River Basin study unit, 1992–93. Concentrations less than the minimum reporting level are shown equal to the minimum reporting level.

an important catchment for contaminants, particularly hydrophobic contaminants that are associated with fine sediment and organic material in bed sediment.

Detections of all four chlordane isomers, cis- and trans-chlordane and cis- and trans-nonachlor, in bed sediment were more frequent at urban sites than at agricultural sites (fig. 6). Chlordane concentrations in bed sediment were highest at the urban sites White Rock Creek in Dallas (site URB200) and West Fork Trinity River in Fort Worth (site URB543) (fig. 6). Chlordane compounds were not detected in bed sediment at most of the agricultural sites; however, total chlordane concentrations of 10.0 µg/kg at the agricultural site Chambers Creek near Rice (site AG100) is indicative of broader uses of chlordane as an insecticide prior to the late 1970s (Irwin, 1988); uses after the late 1970s were largely restricted to termite control.

DDT

The DDT metabolites detected in biological tissue (p,p'-DDD and p,p'-DDE) were detected more frequently at agricultural sites than at urban sites (fig. 3); 3 of the 4 DDT metabolites detected in bed sediment (o,p'-DDD, p,p'-DDD, and p,p'-DDE) were detected more frequently at urban sites than at agricultural sites (fig. 4). The most frequently detected DDT metabolite in both media, p,p'-DDE, was detected more often in biological tissue than in bed sediment (fig. 2) and was detected in tissue at all mainstem sites (fig. 4). Continued detection of metabolites such as DDE with a corresponding lack of DDT detections indicates a low rate of influx and continued weathering of DDT in the environment (Schmitt and others, 1990). DDT and particularly its metabolites (DDE and DDD) are still commonly found in biological tissue and bed sediment (Schmitt and others, 1985; U.S. Environmental Protection Agency, 1992) even though DDT was banned in the United States in 1972. DDE, like most other organochlorine compounds, has a low water solubility (0.040 milligrams per liter (mg/L) at 20 degrees Celsius (°C)), a relatively high octanol-to-water partition coefficient ($\log P_{oct} = 4.28$), and a water-to-fish-tissue bioconcentration factor (BCF) as high as 11,000 (Verschueren, 1983).

The highest concentrations of p,p'-DDE in biological tissue were in fish tissue from the mainstem sites (fig. 5). p,p'-DDE was the larger proportion of total DDT (defined as the sum of all homologs) in biological tissue from most sites. Fish tissue from mainstem sites contained a higher percentage of lipids than fish- and clam-tissue samples from tributary sites. The percentage of lipids in biological tissue is important in determining the quantity of lipid-soluble compound(s) that is accumulated (Chiou and others, 1977). However, the significant correlation ($r^2 = 0.79$, $p < 0.01$) between lipid-normalized and non-normalized p,p'-DDE suggests that lipid normalization made no comparative difference for p,p'-DDE. A high correlation between lipid-normalized and non-normalized data was found for most of the other organochlorine compounds.

The highest total DDT concentrations in biological tissue were in fish samples at mainstem sites. The distribution of total DDT in bed sediment does not show any patterns among sites; however at 3 of the 4 urban sites, concentrations generally were higher than at any of the agricultural sites except Chambers Creek near Rice (site AG100) (fig. 6). The Chambers Creek drainage is an intensely row-cropped area where, historically, DDT was applied extensively as an insecticide (Ulery and Brown, 1995).

Other Organochlorine Pesticides

Additional organochlorine pesticides detected in biological tissue and bed sediment included DCPA (Dacthal), dieldrin, HCH-gamma (lindane), heptachlor epoxide, and pentachloroanisole. DCPA is a chlorinated pre-emergent herbicide that was detected in biological tissue at two mainstem sites, Trinity River below Dallas (site MST410) and Trinity River near Rosser (site MST500) (table 2), and in bed sediment at the indicator agricultural site, Chambers Creek near Rice (site AG100) (table 3).

Dieldrin was detected frequently in biological tissue and bed sediment, with more detections in biological tissue (fig. 2). Dieldrin in tissue and sediment was detected more frequently at urban sites than at agricultural sites (figs. 3 and 4). Dieldrin concentrations in tissue ranged from less than the MRL of 5.0 µg/kg in 6 of 10 clam-tissue composites and 2 of 4 fish-tissue composites to 66 µg/kg in a blue catfish composite from the Trinity River below Dallas (site MST410) (table 2). Dieldrin concentrations in bed sediment ranged from less than the MRL of 1.0 µg/kg in 11 of 16 samples to 4.7 µg/kg in a sample from White Rock Creek in Dallas (site URB200) (table 3). Dieldrin was an extensively used insecticide prior to 1974; however, use since then has been restricted to termite control and non-food plant treatments (Rompala and others, 1984).

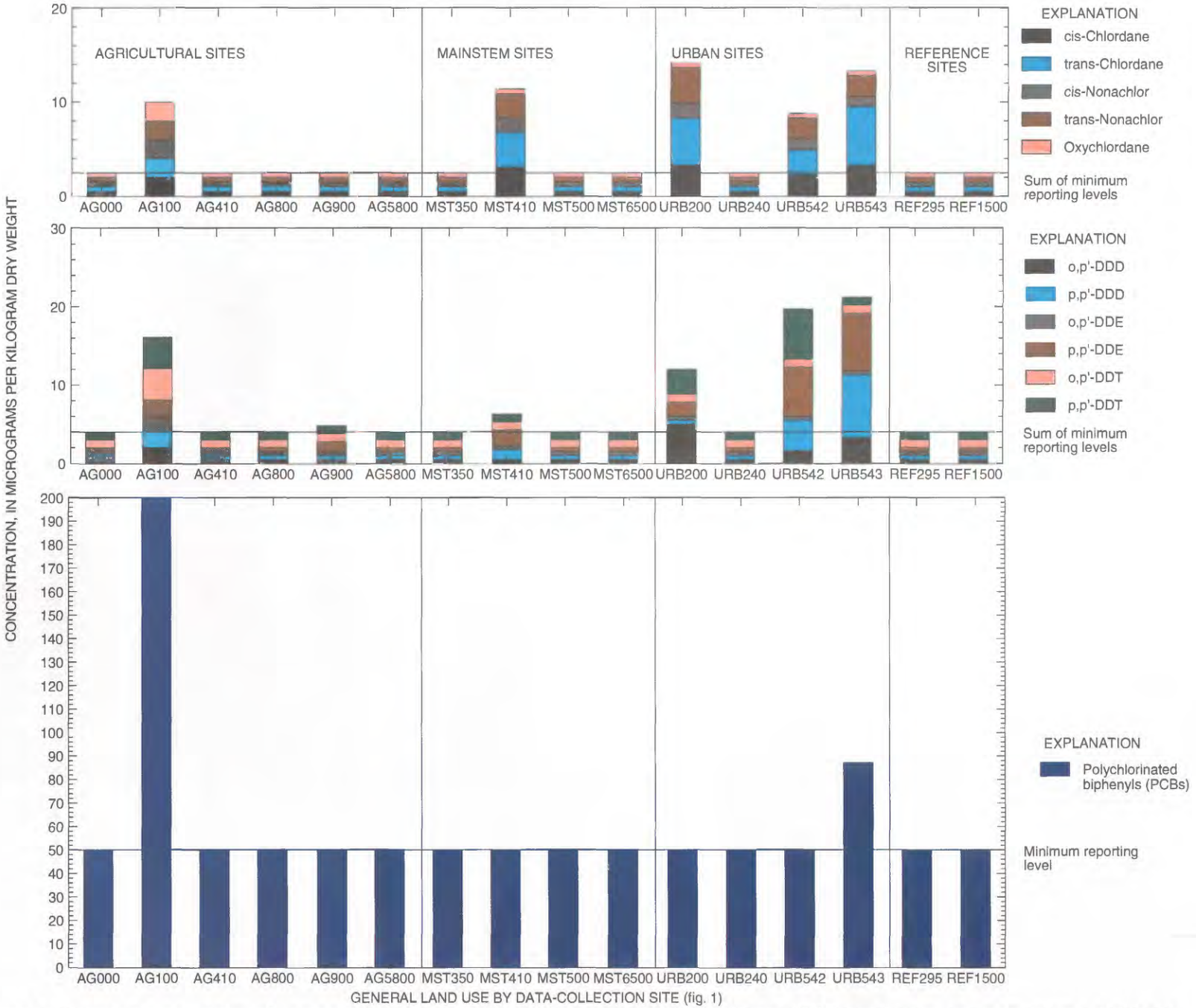


Figure 6. Selected organochlorine compounds detected in bed-sediment samples from sites in the Trinity River Basin study unit, 1992–93. Concentrations less than the minimum reporting level are shown equal to the minimum reporting level.

HCH-gamma, or lindane, was detected more frequently in biological tissue than in bed sediment (fig. 2). HCH-gamma was detected in tissue and sediment at agricultural sites but not at urban sites (figs. 3 and 4). HCH-gamma was detected in tissue from 3 of the 16 sites, and concentrations ranged from less than the MRL of 5.0 µg/kg in 13 of 16 samples to 12 µg/kg in a sample from Trinity River near Rosser (site MST500) (table 2). HCH-gamma was detected in bed sediment (2.0 µg/kg) at one site, Chambers Creek near Rice (site AG100) (table 3). HCH-gamma is continually degraded and eliminated from the body (Rompala and others, 1984), and unlike other organochlorine compounds, biological-tissue concentrations generally indicate recent exposure. This would explain the small number of sites with HCH-gamma detections in biological-tissue samples from the Trinity River Basin.

Heptachlor epoxide, a degradation product of the insecticide heptachlor, was detected in biological tissue at two sites (table 2), Trinity River below Dallas (site MST410) (22 µg/kg) and Trinity River near Rosser (site MST500) (15 µg/kg). The parent compound, heptachlor, is rapidly metabolized by organisms and was detected in sediment at only one site (table 3), Chambers Creek near Rice (site AG100) (2.0 µg/kg).

Pentachloroanisole (PCA) was detected in biological tissue at two mainstem sites (table 2), Trinity River below Dallas (site MST410) (87 µg/kg) and Trinity River near Rosser (site MST500) (22 µg/kg). PCA was detected in bed sediment (table 3) at one agricultural site, Timber Creek near Collinsville (site AG800) (50 µg/kg), and at one urban site, Rush Creek in Arlington (site URB240) (50 µg/kg). PCA is a metabolic breakdown product (metabolite) of pentachlorophenol. Primary uses of PCA include treating telephone poles, fence posts, and railroad ties and as a antimicrobial agent in pulp and paper manufacturing (U.S. Environmental Protection Agency, 1992).

PCBs

PCBs were quantified as total, gross PCBs that can include more than 209 individual PCB compounds or congeners. Historically, PCBs have been used extensively as lubricants, insulators, and coolants (Reulle, 1986). Other known sources include electrical transformers, capacitors, heat-transfer fluids, and electrical utilities. PCBs are very stable, environmentally persistent compounds that belong to a group of chemicals known as arene halides, which are considered by some scientists to be the most hazardous group of chemicals found in biological tissue, particularly fish (Passino and Smith, 1987). A number of fish-possession bans issued on the basis of PCBs in edible fish tissues have been instituted for water bodies in the Trinity River Basin, particularly in the DFW metropolitan area (Texas Department of Health, 1996).

PCBs were detected in tissue samples at one-half of the data-collection sites (fig. 2) and were detected in a larger percentage of tissue samples at urban sites than at agricultural sites (fig. 3). PCB concentrations in fish tissue ranged from less than the MRL of 50.0 µg/kg for a bluegill composite sample from Timber Creek near Collinsville (site AG800) to 640 µg/kg for a blue catfish composite sample from Trinity River below Dallas (site MST410) (table 2). As insectivores or piscivores, fish can biomagnify organochlorine and other hydrophobic compounds at concentrations greater than would be expected in the tissue of suspension or filter-feeding clams (Rand and Petrocelli, 1985). PCBs in clams were less than the MRL of 50 µg/kg at 7 of 10 sites. PCB concentrations in clams were 68 µg/kg for a sample from Rush Creek in Arlington (site URB240), 120 µg/kg in a sample from White Rock Creek in Dallas (site URB200), and 160 µg/kg in a sample from Elm Fork Trinity River near Gainesville (site AG410). The fact that several of the clam PCB concentrations fall within the same order of magnitude as some of the fish PCB concentrations is not unexpected because clams and mussels are suspension feeders, are in close association with contaminant sources in surficial bed sediment, are good accumulators because of a tolerance to many contaminants, and lack the metabolic pathways for the biodegradation of many contaminants (Eisler, 1987). Overall, the highest PCB concentrations were in fish samples collected at mainstem sites (fig. 5). Two of the four urban sites, Rush Creek in Arlington (site URB240) and West Fork Trinity River in Fort Worth (site URB543), had higher PCB concentrations in clam tissue than any of the other urban sites. Two of the agricultural sites, Elm Fork Trinity River near Gainesville (site AG410) and East Fork Trinity River at McKinney (site AG900), had PCB concentrations in biological tissue of 160 and 120 µg/kg, respectively, which are equal to or greater than PCB concentrations in clam tissue from any urban sites.

PCBs were detected in bed sediment above the MRL of 50 µg/kg at two sites, Chambers Creek near Rice (site AG100) and West Fork Trinity River in Fort Worth (site URB543) (fig. 6).

SUMMARY

This report describes the occurrence and distribution of organochlorine compounds in the Trinity River Basin NAWQA study area. Biological tissue and surficial bed sediment from 16 sites in the Trinity River Basin were sampled for organochlorine pesticides, PCBs, and other organochlorine compounds. Asiatic clams (*Corbicula fluminea*) were collected at 10 sites, and fish, including blue catfish (*Ictalurus furcatus*), common carp (*Cyprinus carpio*), bluegill (*Lepomis cyanellus*), and yellow bullhead (*Ameiurus natalis*), were collected at all of the mainstem and two tributary sites. Thirty of the 36 compounds analyzed in biological tissue or surficial bed sediment were detected in one or both media. Overall, more organochlorine compounds were detected in bed sediment than in biological tissue; however, various chlordane isomers, DDT metabolites, and PCBs were detected more frequently in biological tissue than in bed sediment.

The chlordane and nonachlor isomers were detected more frequently in biological tissue than in bed sediment, and detections in both media were more frequent at urban sites than at agricultural sites.

DDT metabolites in biological tissue were detected more frequently at agricultural sites than at urban sites; DDT metabolites in bed sediment were detected more frequently at urban sites than at agricultural sites. The most frequently detected DDT metabolite, p,p'-DDE, was detected more often in biological tissue than in bed sediment. Concentrations of p,p'-DDE and percentages of lipids were highest in fish tissue at mainstem sites. Lipid-normalized and non-normalized p,p'-DDE concentrations were significantly correlated ($r^2 = 0.79$, $p < 0.01$). This was the case for most of the organochlorine compounds. The highest total DDT concentrations in biological tissue were in fish tissue at mainstem sites; and the highest total DDT concentrations in sediment were at three urban sites and one agricultural site.

PCBs were detected in biological tissue at 8 sites and in bed sediment at 2 sites. PCB concentrations in tissue ranged from less than 50 µg/kg for asiatic clams at many sites and for a bluegill composite sample from Timber Creek near Collinsville to 640 µg/kg for a blue catfish composite sample from mainstem site Trinity River below Dallas. PCB concentrations were generally lower in clams than in fish. The highest PCB concentrations in fish tissue were at mainstem sites; and the highest PCB concentration in bed sediment was at one agricultural site.

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Table 1. Site descriptions and species collected for analysis of organochlorine compounds in biological-tissue and streambed-sediment samples from the Trinity River Basin, Texas, 1992–93

[Bed-sediment samples were collected at all sites. Land use from Ulery and Brown, 1995. Site code: AG, agricultural; MST, mainstem; URB, urban; REF, reference. NAWQA, National Water-Quality Assessment; mi, miles; lat, latitude; long, longitude]

Site code (fig. 1)	Site name and identification number	Location	NAWQA site type[1]	Principal land use	Species used for tissues samples
AG000	Big Sandy Creek near Bridgeport—08044000	4.0 mi east of Bridgeport at U.S. Highway 380 bridge lat: 33°13'54" long: 97°41'40" Wise County	indicator, fixed station	agriculture (rangeland)	asiatic clam (*Corbicula fluminea*)
AG100	Chambers Creek near Rice—08064100	3.4 mi southwest of Rice at Farm Road 1126 bridge lat: 32°11'54" long: 96°31'12" Navarro County	indicator, fixed station	agriculture (cropland)	asiatic clam (*Corbicula fluminea*)
AG410	Elm Fork Trinity River near Gainesville—08050410	3.0 mi south of Gainesville at Farm Road 2071 bridge lat: 33°34' 56" long: 97°07'49" Cooke County	indicator	agriculture (cropland)	asiatic clam (*Corbicula fluminea*)
AG800	Timber Creek near Collinsville—08050800	2.1 mi west of Collinsville at Farm Road 902 bridge lat: 33°33'16" long: 96°56'49" Cooke County	indicator	agriculture (cropland)	bluegill (*Lepomis cyanellus*)
AG900	East Fork Trinity River at McKinney—08058900	3.3 mi north of McKinney at State Highway 5 bridge lat: 33°14'38" long: 96°36'32" Collin County	indicator, fixed station	agriculture (cropland)	yellow bullhead (*Ameiurus natalis*)
AG5800	Bedias Creek near Madisonville—08065800	9.5 mi southeast of Madisonville at U.S. Highway 75 bridge lat: 30°53'03" long: 95°46'39" Madison-Walker County line	indicator, fixed station	agriculture (cropland)	asiatic clam (*Corbicula fluminea*)
MST350	Trinity River near Crockett—08065350	11.9 mi east of Crockett at State Highway 7 bridge lat: 31°20'18" long: 95°39'22" Houston-Leon County line	integrator, fixed station	main stem	blue catfish (*Ictalurus furcatus*)
MST410	Trinity River below Dallas—08057410	South Loop Highway 12 bridge in Dallas lat: 32°42'26" long: 96°44'08" Dallas County	integrator, fixed station	main stem (urban affected)	blue catfish (*Ictalurus furcatus*)
MST500	Trinity River near Rosser—08062500	2.5 mi south of Rosser at State Highway 34 bridge lat: 32°25'35" long: 96°27'46" Ellis County	integrator, fixed station	main stem	blue catfish (*Ictalurus furcatus*)
MST6500	Trinity River at Romayor—08066500	1.9 mi south of Romayor at State Highway 787 bridge lat: 30°25'30" long: 94°51'02" Liberty County	integrator, fixed station	main stem (downstream from large reservoir)	common carp (*Cyprinus carpio*)
URB200	White Rock Creek in Dallas—08057200	Greenville Ave. bridge in Dallas lat: 32°53'21" long: 96°45'23" Dallas County	indicator	urban	asiatic clam (*Corbicula fluminea*)
URB240	Rush Creek in Arlington—08049240	Woodland Park Blvd. bridge in Arlington lat: 32°42'50" long: 97°10'19" Tarrant County	indicator, fixed station	urban	asiatic clam (*Corbicula fluminea*)
URB542	Sycamore Creek in Fort Worth—08048542	Sycamore Park in Fort Worth lat: 32°40'33" long: 97°18'00" Tarrant County	indicator	urban	asiatic clam (*Corbicula fluminea*)

Table 1. Site descriptions and species collected for analysis of organochlorine compounds in biological-tissue and streambed-sediment samples from the Trinity River Basin, Texas, 1992–93—Continued

Site code (fig. 1)	Site name and identification number	Location	NAWQA site type[1]	Principal land use	Species used for tissues samples
URB543	West Fork Trinity River in Fort Worth—08048543	Beach St. bridge in Fort Worth lat: 32°45'06" long: 97°17'21" Tarrant County	integrator, fixed station	urban	asiatic clam (*Corbicula fluminea*)
REF295	Menard Creek near Fuqua—08066295	1.5 mi upstream from State Highway 41 bridge at Rye and in Menard Creek Unit of Big Thicket National Preserve lat: 30°27'42" long: 94°43'22" Liberty County	indicator, reference, fixed station	silviculture (reference site in Big Thicket Preserve)	asiatic clam (*Corbicula fluminea*)
REF1500	Clear Creek near Sanger—08051500	1.1 mi upstream from Gulf, Colorado and Sante Fe Railway Co. bridge; and 1.8 mi south of Sanger lat: 33° 20'10" long: 97°10'45" Denton County	indicator, reference, fixed station	agriculture (reference site in rangeland)	asiatic clam (*Corbicula fluminea*)

[1] NAWQA site type as defined in Gilliom and others (1995):

Indicator sites—Stream sampling sites at outlets of drainage basins with homogenous land use and physiographic conditions.

Fixed-station sites—Sites or streams at which streamflow is measured and samples are collected to assess the broad-scale spatial and temporal character and transport of inorganic constituents of stream-water in relation to hydrologic conditions and environmental setting.

Integrator sites—Stream sampling sites downstream of drainage basins that are large and complex and often contain multiple environmental settings.

Reference sites—Stream sampling sites least affected by urban and agricultural land uses.

Table 2. Concentrations of organochlorine compounds and percentage of lipids in biological-tissue samples from sites in the Trinity River Basin, Texas, 1992–93

[All concentrations in micrograms per kilogram wet weight. <, less than, concentration shown is the minimum reporting level]

Site code (fig. 1)	Identification number	Aldrin	Chlordane, cis-	Chlordane, trans-	DCPA (Dacthal)	DDD, o,p'-	DDD, p,p'-	DDE, o,p'-	DDE, p,p'-	DDT, o,p'-	DDT, p,p'-	Dieldrin	Endrin	HCH, alpha-	HCH, beta-	HCH, delta-
AG000	08044000	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
AG100	08064100	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	42	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
AG410	08050410	<5.0	14	10	<5.0	<5.0	6.4	<5.0	42	<5.0	<5.0	5.7	<5.0	<5.0	<5.0	<5.0
AG800	08050800	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	48	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
AG900	08058900	<5.0	14	7.8	<5.0	<5.0	7.5	<5.0	42	<5.0	<5.0	9.6	<5.0	<5.0	<5.0	<5.0
AG5800	08065800	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
MST350	08065350	<5.0	11	6.6	<5.0	<5.0	<5.0	<5.0	130	<5.0	<5.0	7.1	<5.0	<5.0	<5.0	<5.0
MST410	08057410	<5.0	84	56	6.0	<5.0	15	<5.0	140	<5.0	6.0	66	<5.0	<5.0	<5.0	<5.0
MST500	08062500	<5.0	43	20	7.0	<5.0	12	<5.0	150	<5.0	7.2	41	<5.0	<5.0	<5.0	<5.0
MST6500	08066500	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	73	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
URB200	08057200	<5.0	14	8.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
URB240	08049240	<5.0	15	16	<5.0	<5.0	<5.0	<5.0	5.8	<5.0	<5.0	20	<5.0	<5.0	<5.0	<5.0
URB542	08048542	<5.0	6.4	7.8	<5.0	<5.0	<5.0	<5.0	13	<5.0	12	7.7	<5.0	<5.0	<5.0	<5.0
URB543	08048543	<5.0	11	11	<5.0	<5.0	6.1	<5.0	<5.0	<5.0	<5.0	7.1	<5.0	<5.0	<5.0	<5.0
REF295	08066295	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
REF1500	08051500	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0

Table 2. Concentrations of organochlorine compounds and percentage of lipids in biological-tissue samples from sites in the Trinity River Basin, Texas, 1992–93—Continued

Site code (fig. 1)	Identification number	HCH, gamma- (lindane)	Heptachlor	Heptachlor epoxide	Hexachlorobenzene	Methoxychlor, o,p'-	Methoxychlor, p,p'-	Mirex	Nonachlor, cis-	Nonachlor, trans-	Oxychlordane	PCBs, total	Pentachloroanisole	Toxaphene	Lipids (percent)
AG000	08044000	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<50.0	<5.0	<200	2.7
AG100	08064100	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<50.0	<5.0	<200	2.7
AG410	08050410	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	8.4	21	<5.0	160	<5.0	<200	3.2
AG800	08050800	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<50.0	<5.0	<200	3.8
AG900	08058900	6.3	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	7.1	16	<5.0	120	<5.0	<200	5.0
AG5800	08065800	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<50.0	<5.0	<200	1.5
MST350	08065350	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	13	23	<5.0	370	<5.0	<200	2.5
MST410	08057410	9.6	<5.0	22	<5.0	<5.0	<5.0	<5.0	53	88	<5.0	640	87	<200	7.6
MST500	08062500	12	<5.0	15	<5.0	<5.0	<5.0	<5.0	29	64	<5.0	580	22	<200	6.5
MST6500	08066500	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	5.1	<5.0	95	<5.0	<200	3.3
URB200	08057200	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	7.7	11	<5.0	<50.0	<5.0	<200	2.0
URB240	08049240	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	9.9	15	<5.0	68	<5.0	<200	2.2
URB542	08048542	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	9.5	<5.0	<50.0	<5.0	<200	1.4
URB543	08048543	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	11	<5.0	120	<5.0	<200	1.6
REF295	08066295	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<50.0	<5.0	<200	2.5
REF1500	08051500	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<50.0	<5.0	<200	1.4

Table 3. Concentrations of organochlorine compounds in bed-sediment samples from sites in the Trinity River Basin, Texas, 1992–93

[All concentrations in micrograms per kilogram dry weight. <, less than, concentration shown is the minimum reporting level]

Site code (fig. 1)	Identification number	Aldrin	Chlordane, -cis	Chlordane, trans-	DCPA (Dacthal)	DDD, o,p'-	DDD, p,p'-	DDE, o,p'-	DDE, p,p'-	DDT, o,p'-	DDT, p,p'-	Dieldrin	Endosulfan I	Endosulfan II
AG000	08044000	<1.0	<0.5	<0.5	<5.0	<0.5	<0.5	<0.5	<0.5	<1.0	<1.0	<1.0	<1.0	1.5
AG100	08064100	2.0	2.0	2.0	10	2.0	2.0	2.0	2.1	4.0	4.0	2.0	4.0	2.0
AG410	08050410	<1.0	<.5	<.5	<5.0	<.5	<.5	<.5	<.5	<1.0	<1.0	<1.0	<1.0	2.4
AG800	08050800	<1.0	<.5	<.5	<5.0	<.5	<.5	<.5	<.5	<1.0	<1.0	<1.0	<1.0	<1.0
AG900	08058900	<1.0	<.5	<.5	<5.0	<.5	<.5	<.5	1.3	<1.0	<1.0	<1.0	<1.0	<1.0
AG5800	08065800	<1.0	<.5	<.5	<5.0	<.5	<.5	<.5	<.5	<1.0	<1.0	<1.0	<1.0	<1.0
MST350	08065350	<1.0	<.5	<.5	<5.0	<.5	<.5	<.5	<.5	<1.0	<1.0	<1.0	<1.0	<1.0
MST410	08057410	<1.0	3.1	3.7	<5.0	<.5	1.3	<.5	2.0	<1.0	<1.0	2.4	<1.0	<1.0
MST500	08062500	<1.0	<.5	<.5	<5.0	<.5	<.5	<.5	<.5	<1.0	<1.0	<1.0	<1.0	<1.0
MST6500	08066500	<1.0	<.5	<.5	<5.0	<.5	<.5	<.5	<.5	<1.0	<1.0	<1.0	<1.0	<1.0
URB200	08057200	<1.0	3.3	5	<5.0	5.0	<.5	<.5	1.8	<1.0	3.2	4.7	3.2	4.7
URB240	08049240	<1.0	<.5	<.5	<5.0	<.5	<.5	<.5	<.5	<1.0	<1.0	<1.0	<1.0	<1.0
URB542	08048542	<1.0	2.3	2.6	<5.0	1.6	3.9	<.5	6.3	<1.0	6.4	3.1	<1.0	<1.0
URB543	08048543	<1.0	3.3	6.2	<5.0	3.3	8.0	<.5	7.4	<1.0	<1.0	1.5	<1.0	<1.0
REF295	08066295	<1.0	<.5	<.5	<5.0	<.5	<.5	<.5	<.5	<1.0	<1.0	<1.0	<1.0	<1.0
REF1500	08051500	<1.0	<.5	<.5	<5.0	<.5	<.5	<.5	<.5	<1.0	<1.0	<1.0	<1.0	<1.0

Table 3. Concentrations of organochlorine compounds in bed-sediment samples from sites in the Trinity River Basin, Texas, 1992–93—Continued

Site code (fig. 1)	Identification number	Endosulfan sulfate	Endrin	Endrin aldehyde	Endrin ketone	HCH, alpha-	HCH, beta-	HCH, delta-	HCH, gamma- (lindane)	Heptachlor	Heptachlor epoxide	Hexachlorobenzene	Isodrin	Methoxychlor, o,p'-	Methoxychlor, p,p'-
AG000	08044000	<1.0	<2.0	<2.0	<2.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<5.0	<5.0
AG100	08064100	<1.0	4.0	<2.0	<2.0	2.0	2.0	<1.0	2.0	2.0	2.0	<1.0	2.0	10	10
AG410	08050410	<1.0	<2.0	<2.0	<2.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<5.0	<5.0
AG800	08050800	<1.0	<2.0	<2.0	<2.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<5.0	<5.0
AG900	08058900	<1.0	<2.0	<2.0	<2.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<5.0	<5.0
AG5800	08065800	<1.0	<2.0	<2.0	<2.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<5.0	<5.0
MST350	08065350	<1.0	<2.0	<2.0	<2.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<5.0	<5.0
MST410	08057410	<1.0	<2.0	<2.0	<2.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<5.0	<5.0
MST500	08062500	<1.0	<2.0	<2.0	<2.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<5.0	<5.0
MST6500	08066500	<1.0	<2.0	<2.0	<2.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<5.0	<5.0
URB200	08057200	<1.0	<2.0	<2.0	<2.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<5.0	<5.0
URB240	08049240	<1.0	<2.0	<2.0	<2.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<5.0	<5.0
URB542	08048542	<1.0	<2.0	<2.0	<2.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<5.0	<5.0
URB543	08048543	<1.0	<2.0	<2.0	<2.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<5.0	<5.0
REF295	08066295	<1.0	<2.0	<2.0	<2.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<5.0	<5.0
REF1500	08051500	<1.0	<2.0	<2.0	<2.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<5.0	<5.0

Site code (fig. 1)	Identification number	Mirex	Nonachlor, cis-	Nonachlor, trans-	Oxychlordane	PCBs, total	Pentachloroanisole	Permethrin, cis-	Permethrin, trans-	Toxaphene
AG000	08044000	<1.0	<0.5	<0.5	<0.5	<50.0	<5.0	<5.0	<5.0	<200.0
AG100	08064100	2.0	2.0	2.0	2.0	200	<5.0	10	10	<200.0
AG410	08050410	<1.0	<.5	<.5	<.5	<50.0	<5.0	10	10	<200.0
AG800	08050800	<1.0	<.5	<.5	<.5	<50.0	50	<5.0	<5.0	<200.0
AG900	08058900	<1.0	<.5	<.5	<.5	<50.0	<5.0	10	<5.0	<200.0
AG5800	08065800	<1.0	<.5	<.5	<.5	<50.0	<5.0	<5.0	5	<200.0
MST350	08065350	<1.0	<.5	<.5	<.5	<50.0	<5.0	<5.0	<5.0	<200.0
MST410	08057410	<1.0	1.5	2.6	<.5	<50.0	<5.0	<5.0	<5.0	<200.0
MST500	08062500	<1.0	<.5	<.5	<.5	<50.0	<5.0	<5.0	<5.0	<200.0
MST6500	08066500	<1.0	<.5	<.5	<.5	<50.0	<5.0	<5.0	<5.0	<200.0
URB200	08057200	1.1	1.6	3.8	<.5	<50.0	<5.0	10	10	<200.0
URB240	08049240	<1.0	<.5	<.5	<.5	<50.0	50	<5.0	<5.0	<200.0
URB542	08048542	<1.0	1.2	2.2	<.5	<50.0	<5.0	<5.0	<5.0	<200.0
URB543	08048543	<1.0	1.1	2.2	<.5	87	<5.0	<5.0	<5.0	<200.0
REF295	08066295	<1.0	<.5	<.5	<.5	<50.0	<5.0	<5.0	<5.0	<200.0
REF1500	08051500	<1.0	<.5	<.5	<.5	<50.0	<5.0	<5.0	<5.0	<200.0

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