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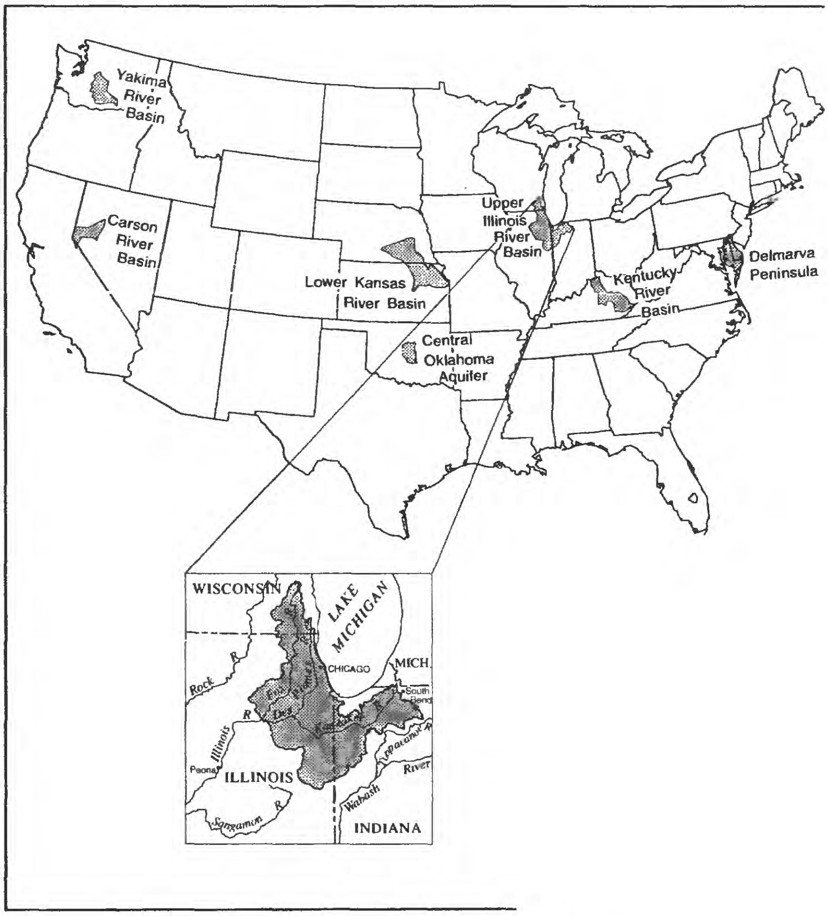
Surface-Water-Quality Assessment of the Upper Illinois River Basin in Illinois, Indiana, and Wisconsin—Pesticides and Other Synthetic Organic Compounds in Water, Sediment, and Biota, 1975–90

by Daniel J. Sullivan, Troy W. Stinson, J. Kent Crawford, and Arthur R. Schmidt
(with a section on historical conditions, 1975-86, by John A. Colman)



Water-Resources Investigations Report 96–4135

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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

Robert M. Hirsch
Chief Hydrologist

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CONVERSION FACTORS AND ABBREVIATED WATER-QUALITY UNITS

Multiply	By	To obtain
foot (ft)	0.3048	meter
mile (mi)	1.609	kilometer
square mile (mi^2)	2.590	square kilometer
cubic foot per second (ft^3/s)	0.02832	cubic meter per second
million gallons per day (Mgal/d)	3,785	cubic meter per day

Temperature is given in degrees Celsius (°C), which can be converted to degrees Fahrenheit (°F) by use of the following equation:

$$°F = 1.8(°C) + 32 \text{ degrees}$$

Abbreviated water-quality units used in this report: Chemical concentrations and water temperature are given in metric units. Chemical concentration is given in milligrams per liter (mg/L), micrograms per liter (µg/L), or milligrams per kilogram (mg/kg). Milligrams per liter is a unit expressing the concentration of chemical constituents in solution as weight (milligrams) of solute per unit volume (liter) of water. One thousand micrograms per liter is equivalent to one milligram per liter. For concentrations less than 7,000 mg/L, the numerical value is the same as for concentrations in parts per million. Milligrams per kilogram is a unit expressing the concentration of chemical constituents as weight (milligrams) of constituent per unit weight of the solid matrix (kilograms) in which the constituent is found. Milligrams per kilogram is used to express constituent concentrations in streambed sediment.

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By Daniel J. Sullivan, Troy W. Stinson, J. Kent Crawford, *and* Arthur R. Schmidt (with a section on historical conditions, 1975–86, by John A. Colman)

Abstract

The distribution of pesticides and other synthetic organic compounds in water, sediment, and biota in the upper Illinois River Basin in Illinois, Indiana, and Wisconsin was examined from 1987 through 1990 as part of the pilot National Water-Quality Assessment program conducted by the U.S. Geological Survey. Historical data for water and sediment collected from 1975 through 1986 were similar to data collected from 1987 through 1990. Some compounds were detected in concentrations that exceed U.S. Environmental Protection Agency water-quality criteria.

Results from pesticide sampling at four stations in 1988 and 1989 identified several agricultural pesticides that were detected more frequently and at higher concentrations in urban areas than in agricultural areas. Results from herbicide sampling at 17 stations in the Kankakee and Iroquois River Basins in 1990 indicated that atrazine concentrations exceeded the U.S. Environmental Protection Agency's maximum contaminant level for drinking water during runoff periods.

Results from sampling for volatile and semivolatile organic compounds in water indicate that, with one exception, all stations at which more than one compound was detected were within 2 miles downstream from the nearest point source. Detections at two stations in the Chicago urban area accounted for 37 percent of the total number of detections. Concentrations of tetrachloroethylene, trichloroethylene, and 1,2-dichloroethane from stations in the Des Plaines River Basin exceeded the U.S. Environmental Protection Agency's maximum contaminant level for drinking water in one and two samples from the two stations in the Chicago area.

Phenols and pentachlorophenols were detected most frequently in the Des Plaines River Basin where point-source discharges were common. Phenol concentrations were significantly different among the Des Plaines, Kankakee, and Fox River Basins. Phenols and pentachlorophenols never exceeded the general use and secondary contact standards.

Results from a 1989 synoptic survey of semivolatile organic compounds in sediment indicate that these compounds were detected most frequently at sites in the Chicago urban area. Of the 17 stations at which 10 or more compounds were detected, 14 were located in the Des Plaines River subbasin, and 1 was on the Illinois River main stem. As was the case with organic compounds in water, each of these sites

was located within 2 miles downstream from point sources.

Biota samples were collected and analyzed for organochlorines and polynuclear aromatic hydrocarbons in 1989 and 1990. The most commonly detected compound in both years was *p,p′*-DDE. National Academy of Science recommendations for chlordane and dieldrin for protection of predators were exceeded in 19 and 10 samples, respectively, when the 1989 and 1990 data were combined. In the nine fish-fillet samples collected in 1989, concentrations exceeded U.S. Environmental Protection Agency fish tissue criteria in nine fillets for *p,p′*-DDE and five fillets for dieldrin.

INTRODUCTION

In 1986, the U.S. Geological Survey (USGS) began a National Water-Quality Assessment (NAWQA) program to (1) provide nationally consistent descriptions of the current status of water quality for a large, diverse, and geographically distributed part of the Nation's water resources; (2) define trends in water quality in recent decades and provide a baseline for evaluating future trends in water quality; and (3) identify and describe the relations of both the status and the trends in water quality to relevant natural factors and the history of land use, and land- and waste-management practices (Hirsch and others, 1988).

The upper Illinois River Basin was one of four river basins in the Nation selected for testing and developing NAWQA concepts for surface water. This pilot phase lasted about 4 years, from late 1986 to 1990. The other surface-water pilot projects were conducted in the lower Kansas River Basin in Kansas and Nebraska, the Kentucky River Basin in Kentucky, and the Yakima River Basin in Washington (Hirsch and others, 1988).

The upper Illinois River Basin was selected as a NAWQA pilot study because of the unique features of the basin, including one of the Nation's largest metropolitan areas—the city of Chicago. In addition, the State of Illinois also has the most agricultural acres in soybeans, and the second-most number of acres in corn of any of the States. Many areas of the upper Illinois River Basin are used for intensive cultivation of corn and soybean row crops.

Purpose and Scope

This report presents spatial and temporal patterns in the observed concentrations of pesticides (herbicides and insecticides) and other synthetic organic compounds (SOC's) in the upper Illinois River Basin. In addition, relations among and factors affecting observed concentrations of pesticides and other SOC's in water, sediment, and biota are discussed. This report also discusses relations of pesticides and other SOC's among two media—sediment and biota.

The scope of this report generally is limited to analysis of data collected during intensive basin surveys from 1987 to 1990 associated with the upper Illinois River Basin NAWQA pilot study, historical data collected from 1975 to 1988, and data collected in the study area from 1987 to 1990 for other purposes and by other agencies. Some of the data analyzed and described in this report were not collected during these dates; therefore, dates are listed for all tabulations of data. Historical data analyzed were collected by the Illinois Environmental Protection Agency (IEPA), the U.S. Army Corps of Engineers (USACE), the U.S. Environmental Protection Agency (USEPA), the USGS, and Northern Illinois Power Company, Inc. (NIPCI). Data collected from 1987 to 1990 for other purposes include samples collected by the USGS as part of the Mid-Continent Herbicide Initiative (MCHI), as well as data collected by the IEPA and the Metropolitan Water Reclamation District of Greater Chicago (MWRDGC).

Overview of Pesticides and Other Synthetic Organic Compounds

Pesticides and other SOC's have been detected in the water, sediment, and biota of surface waters throughout the United States. The production and use of these compounds have greatly increased over the past 50 years, and the result has been a gradual decrease in the quality of the Nation's surface-water resources (Smith and others, 1988). By 1964, more than 10,000 commercial pesticide products had been developed that contained various combinations and formulations of over 250 active ingredients, most of which were SOC's (Eichers and others, 1970). About 60,000 known SOC's also are used in manufacturing, in addition to an unknown number of manufacturing byproducts and degradation products (Shackelford and Cline, 1986).

Pesticides and other SOC's enter surface-water systems from a variety of sources that include direct point-source discharges of municipal and industrial wastewater and accidental spills, indirect nonpoint-source runoff, ground-water discharges, and atmospheric deposition. Specific compounds may show a preference to dissolve in water (hydrophilic) or sorb (less soluble or hydrophobic) onto stream sediments and organic matter. Soluble pesticides and other SOC's may be transported directly to streams in storm runoff and in discharge of wastewaters in municipal and industrial areas. Soluble pesticides and other SOC's may enter streams indirectly through ground-water discharges and atmospheric deposition. Insoluble, hydrophobic, and sediment-sorbed pesticides, and other SOC's also may enter streams in storm runoff in association with sediments, wastewaters, and atmospheric deposition. Both soluble and insoluble organic compounds also may enter streams by careless handling that results in spills or direct dumpage.

Many pesticides and other SOC's, particularly those with low solubility, show a tendency to bioaccumulate in organisms (Smith and others, 1988) and, thus, can be harmful and (or) toxic to aquatic organisms when present in water or sediment even in very low concentrations. Organisms may bioaccumulate pesticides and other SOC's from either water, food, or sediments, and their tissue may accumulate, in time, concentrations several orders of magnitude higher than the aqueous concentrations of the compounds. Many of the effects of bioaccumulation are complex and unknown (Elder, 1990).

Many pesticides and other SOC's have been shown to be potentially toxic, carcinogenic, and mutagenic (Commoner, 1979). However, less information is available on the sources, fates, and effects of pesticides and other SOC's in aquatic environments than for many other water-quality constituents. Much of the difficulty in understanding the behavior and effects of organic compounds is the result of the large number of SOC's potentially available to the environment and the relatively short period of time these compounds have been used and were available for study. Pesticides and other SOC's also may have negative effects on aquatic ecosystems, which may not directly affect human health. For example, high concentrations of herbicides flushed to surface water during spring runoff may adversely affect the growth and survival of aquatic plants, which are essential food sources and breeding grounds for aquatic organisms. The widespread use and relative ease of transport of these compounds to surface waters makes knowledge of their occurrence and distribution essential to the wise management of the Nation's water resources.

Description of the Upper Illinois River Basin

The upper Illinois River Basin drains 10,949 mi^2 in northeastern Illinois, northwestern Indiana, and southeastern Wisconsin (fig. 1). A brief description of relevant basin characteristics is presented here. A more detailed description of the study area is presented in Mades (1987, p. 4–15).

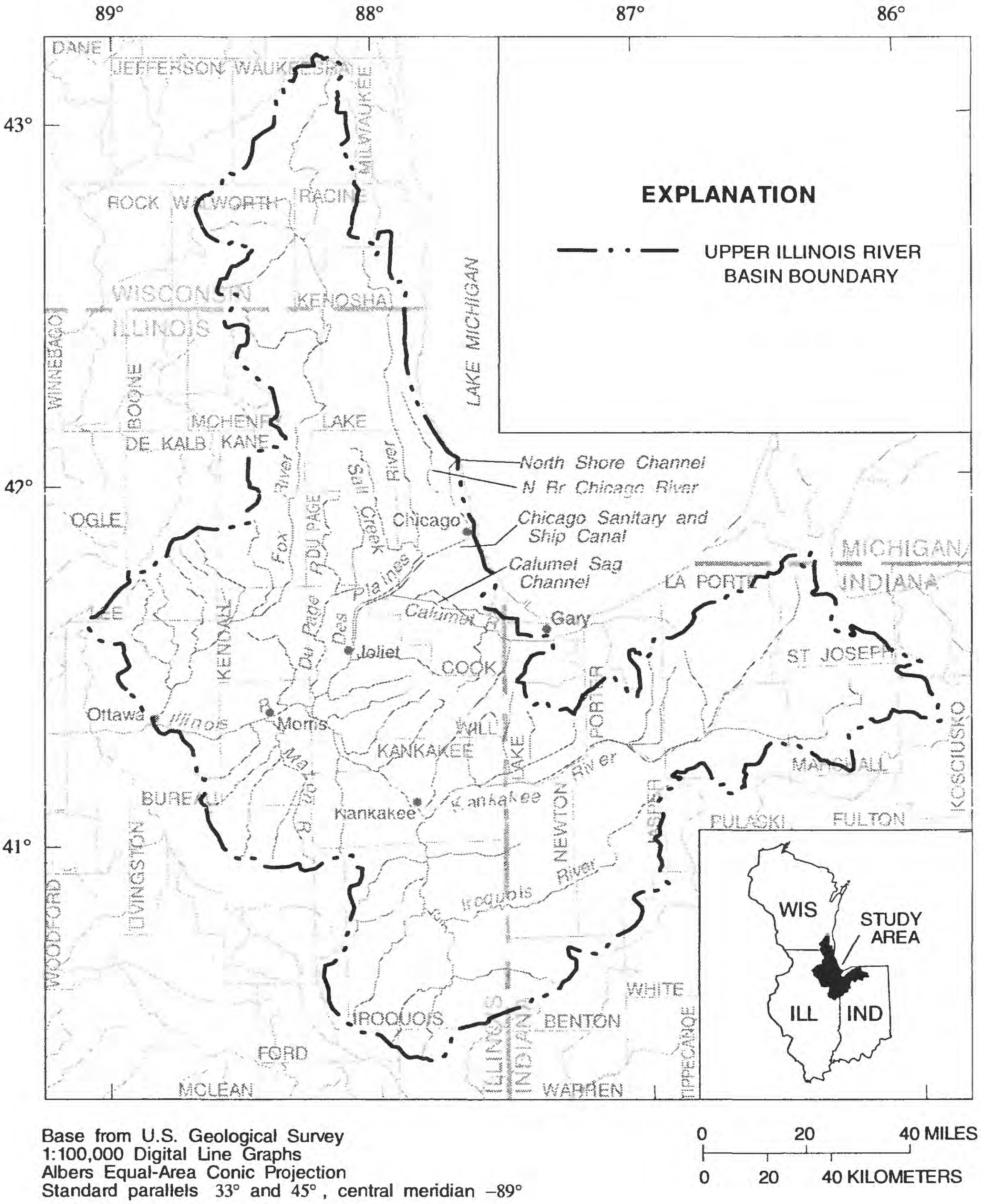
The upper Illinois River Basin is drained by four principal river systems: the Kankakee, Fox, and Des Plaines Rivers, and the Chicago Sanitary and Ship Canal (CSSC). The Kankakee River, along with its major tributary, the Iroquois River, drains 47.2 percent of the study area; the Fox River drains 24.3 percent; the Des Plaines River drains 19.3 percent; the CSSC drains 6.8 percent; and smaller tributaries to the Illinois River drain 2.4 percent. The Kankakee and Des Plaines Rivers join near Morris, Ill. (fig. 1), to form the Illinois River. The Fox River discharges into the Illinois River at the southwestern boundary of the basin near Ottawa, Ill. The Illinois River, downstream from the study area, flows to the west and southwest 240 mi to the Mississippi River.

A navigable link between Lake Michigan and the Mississippi River is provided by the Illinois River, the lower Des Plaines River, and two canal systems. The CSSC links the Chicago River and the Des Plaines River, and the Calumet Sag Channel links the CSSC to the Calumet River.

The upper Illinois River Basin is in what was formerly a prairie plain. Most of the underlying bedrock surface is covered by glacial-drift deposits that vary in thickness from 0 to 500 ft. Local relief ranges as much as 300 ft but typically is less than 100 ft for most of the study area. The general geology of the study area consists of a deep, granitic basement rock that is overlain consecutively by consolidated sedimentary rock and unconsolidated glacial deposits (Willman and others, 1975).

Land Use

Land use in the study area is dominated by rural areas with row-crop agriculture and by the large



Base from U.S. Geological Survey
1:100,000 Digital Line Graphs
Albers Equal-Area Conic Projection
Standard parallels 33° and 45°, central meridian −89°

Figure 1. Location of the upper Illinois River Basin.

metropolitan Chicago urban and industrial area. Agriculture, mainly row crops of corn and soybeans, accounts for about 75 percent of the land use in the basin. Urban and industrial areas account for about 18 percent of the land use with the remaining 7 percent made up of forest and pasture lands. In the Kankakee and Iroquois River Basins, about 90 percent of the land use is agricultural, with the remaining 10 percent about evenly divided between urban and forest. About 60 percent of the Des Plaines River Basin is urban or industrial land, and the remaining 40 percent is agricultural land and forest. The types of land use across the upper Illinois River Basin are shown in figure 2. The population in the study area is approximately 7.5 million, of which 6 million live in the Des Plaines River Basin.

Major Potential Sources of Pesticides and Other Synthetic Organic Compounds

Agricultural areas in Illinois and neighboring States are among the most productive grain-growing

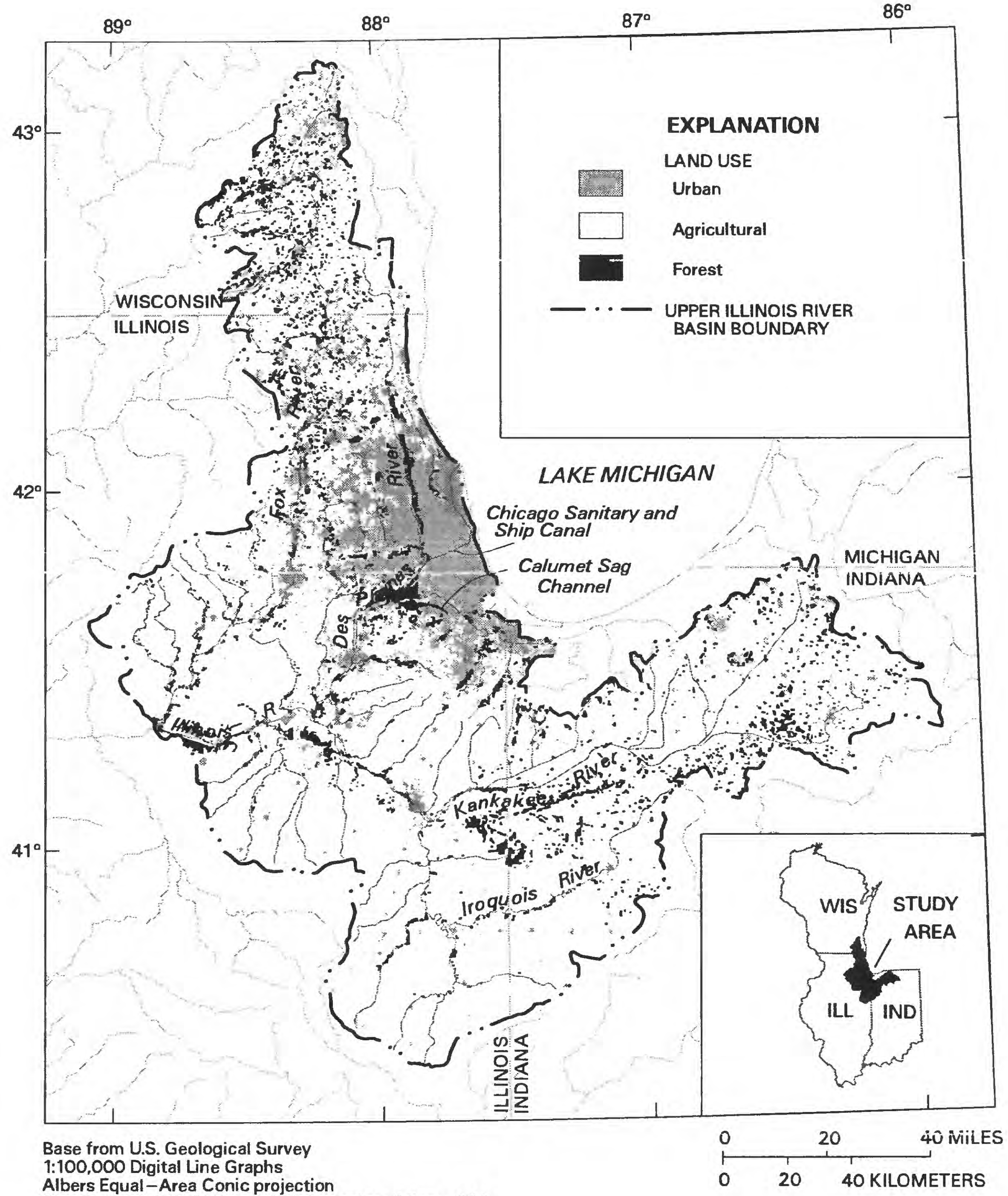


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Figure 2. Land use in the upper Illinois River Basin.

regions in the world. Modern agriculture in the United States heavily depends on applications of pesticides, including herbicides and insecticides, to ensure high productivity. The herbicide atrazine is the most heavily used agricultural pesticide in the United States (Gianessi and Puffer, 1988).

In Illinois, herbicides were applied to 99 and 97 percent of fields with corn crops, and 97 and 96 percent of those with soybean crops in 1985 and 1988, respectively, according to surveys of farmers (University of Illinois College of Agriculture, 1986; University of Illinois College of Agriculture, 1990). It also was determined from these surveys that insecticides were applied to 44 and 37 percent of fields with corn crops, and less than 1 and 36 percent of those with soybean crops in 1985 and 1988, respectively. The 36 percent of soybean acreage treated with insecticides in 1988 was unusually high because of a spider mite outbreak associated with drought conditions. Although the percentages of corn and soybean acres treated with pesticides remain high in Illinois, the total amount of active ingredients applied has decreased about 25 percent since 1982. The usage of selected herbicides in Illinois in 1988 is listed in table 1 (University of Illinois College of Agriculture, 1990).

Herbicide application in the agricultural areas of the upper Illinois River Basin is among the highest in the Nation. For example, the basinwide average usage of atrazine (the most commonly used pre-emergent corn herbicide (Gianessi and Puffer, 1988)) for NAWQA study units across the United States is shown in figure 3. Within the upper Illinois River Basin, Iroquois County has the second highest amount of alachlor, third highest amount of metolachlor, and fifth highest amount of atrazine applied of all the counties in the United States (Gianessi and Puffer, 1988). Atrazine usage on corn in the upper Illinois River Basin is shown in figure 4 (Gianessi and Puffer, 1988).

The large urban area of Chicago and its surrounding suburbs also receive high levels of pesticide loadings from domestic, industrial, and governmental sources. Ginsberg and Osborne (1984) estimated that 75–90 percent of households in the Chicago area use pesticides against weeds and insects. Other pesticide applicators include municipal public works departments, street and highway departments, mosquito-abatement districts, forest preserve and park districts, public transportation authorities, utilities, and others. Taylor and others (1989) list atrazine, 2,4-D, and diuron as the most heavily applied herbicides in urban areas, and malathion and diazinon as the most heavily applied insecticides in northeastern Illinois. In addition, individuals may still be using banned pesticides, such as chlorinated insecticides, from stored supplies (Ginsberg and Osborne, 1984). Annual loadings to residential lawns have been estimated as high as 10 pounds of active ingredient per acre. Based on this estimate, about 3.8 million pounds of pesticides are applied annually at suburban Chicago residences. In contrast, University of Illinois College of Agriculture (1990) estimated average atrazine application rates in 1988 to agricultural land as only 1.2 pounds per acre. In addition to heavy application in urban areas, Taylor and others (1989) also estimated that more than 120,000 pounds of unused pesticides from users in the Chicago area are disposed of in landfills each year.

In addition to the large potential for surface-water contamination by agricultural and urban sources of pesticides, the large population density in the study area results in a large potential for contamination from other SOC's. Diffuse sources of SOC's, such as atmospheric deposition and ground-water discharges, are probably minor sources because most nonagricultural SOC's enter streams through industrial effluent and municipal wastewater discharges (Moore and Ramamoorthy, 1984).

Point-source dischargers in the upper Illinois River Basin include 750 sites permitted through the National Point Source Discharge Elimination System (based on the Illinois State Water-Use Data Base, John LaTour, U.S. Geological Survey, written commun., 1988; and Industrial Facilities Discharge Data Base, Phillip Taylor, U.S. Environmental Protection Agency, oral commun., 1988). Three types of point-source dischargers account for nearly 90 percent of the total number in the basin and include municipal wastewater-treatment plants (35 percent), industrial sources (31 percent), and commercial sources (22 percent) (John LaTour, U.S. Geological Survey, written commun., 1988; and Phillip Taylor, U.S. Environmental Protection Agency, oral commun., 1988). The nonagricultural SOC's produced in the upper Illinois River Basin include volatile organic compounds (VOC's) and semivolatile organic compounds (SVOC's). The VOC's include the halogenated aliphatic hydrocarbons and monocyclic aromatic hydrocarbons. The VOC's are used as solvents, degreasers, lubricants, and fumigants; in dry-cleaning operations; and in the production of plastics, textiles, fluorocarbons, pharmaceuticals, pesticides, and other

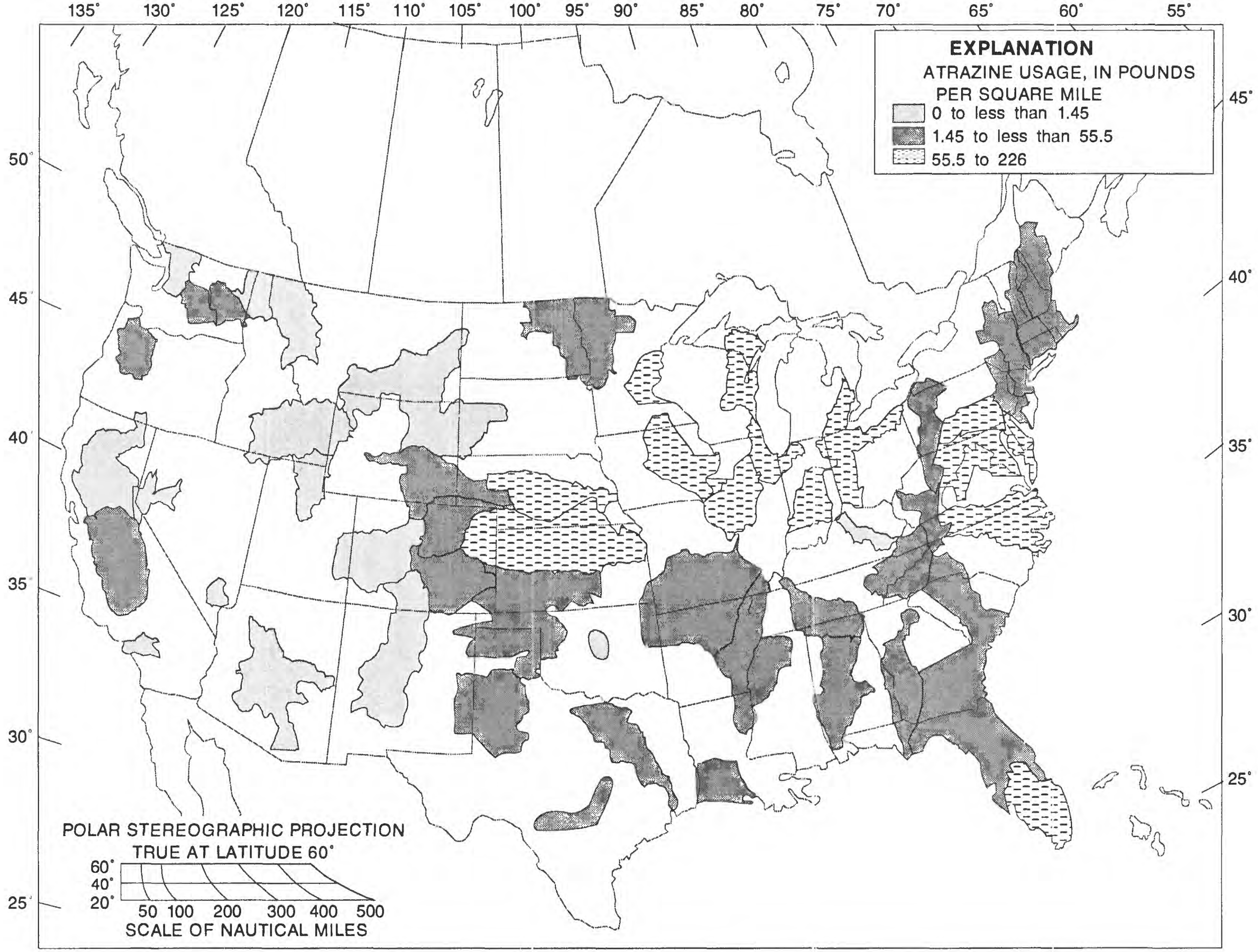
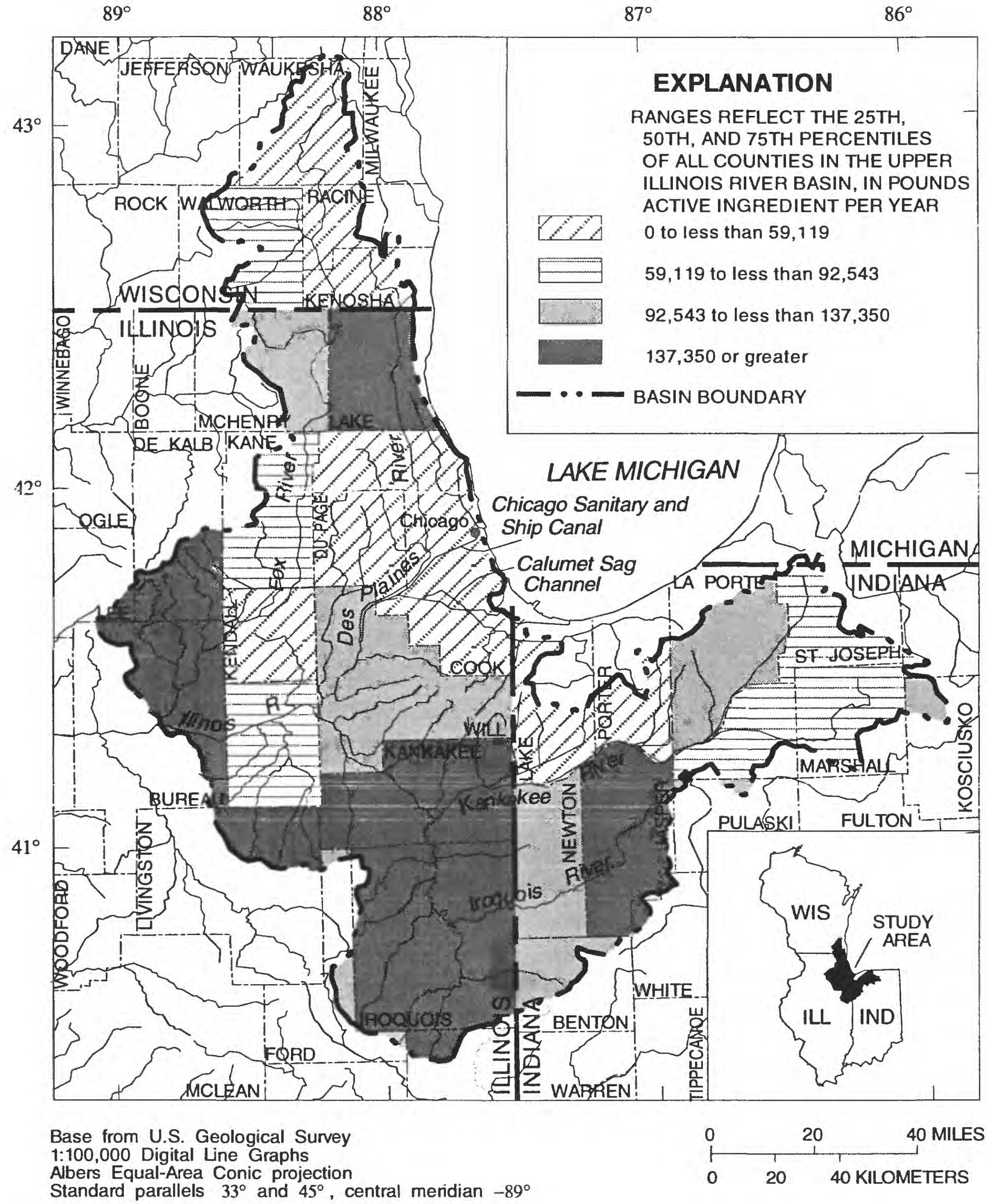


Figure 3. Estimated atrazine usage in selected river basins in the United States (from Gianessi and Puffer, 1988).



Base from U.S. Geological Survey
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Figure 4. Estimated atrazine usage on corn in the upper Illinois River Basin, by county, 1982–85.

chemicals. Included among the SVOC's are polycyclic aromatic hydrocarbons (PAH's), chlorinated insecticides, and phenols. The PAH's are produced mainly by high-temperature pyrolitic reactions, such as municipal incineration and coal combustion; and PAH residues have been found in fossil fuels and wood-preservative sludges (Smith and others, 1988). Chlorinated hydrocarbons also are frequently found in effluent from industries and wastewater-treatment plants (WWTP's) using chlorination in the treatment process. Domestic wastewater and urban runoff may contain higher concentrations of PAH's than industrial effluents (Moore and Ramamoorthy, 1984). Commercial uses of PAH's are limited to the simpler chemical compounds, which are used mainly for dye and plastics manufacturing. Phenols are one of the most widely used industrial organic compounds; they are used in the manufacture of oil additives, pesticides, gasoline additives, drugs, resins, and plasticizers.

Most of the point-source dischargers in the study area are in the lower Des Plaines River Basin within the Chicago metropolitan area. The location of WWTP's as an example of point-source distribution in the basin is shown in figure 5. Approximately 181 WWTP's discharge effluents into the streams of the study area; 72 have capacities of 1 Mgal/d or greater. WWTP's in Illinois contribute 1,768 Mgal/d of the 1,815 Mgal/d (97 percent) of effluent discharged to streams in the study area. The three largest WWTP's have capacities exceeding 300 Mgal/d; the Stickney WWTP has a design capacity of 1,200 Mgal/d, making it among the largest in the world. These three large WWTP's contribute 73 percent of the total effluent discharged to streams of the study area (Zogorski and others, 1990). Effluent from these large WWTP's accounts for 30 percent of the mean annual flow in the upper Illinois River Basin. Maps showing the locations of industrial and commercial point-source dischargers in the basin are in Fitzpatrick and Colman (1993).

DATA SOURCES AND COLLECTION

The primary source of data describing concentrations of pesticides and other SOC's in water, sediment, and biota in the upper Illinois River Basin was samples collected by the USGS as part of the NAWQA pilot study; data collected by the USGS as part of the MCHI, and by the IEPA and the MWRDGC also were included to support and expand the data collected during the NAWQA pilot study. The following sections summarize the upper Illinois River Basin NAWQA data-collection program for pesticides and other SOC's, describe data compiled from other projects and agencies, and discuss the historical data selected for analysis.

Intensive Data-Collection Programs, 1987–90

Water, sediment, and biota samples were collected during surveys done in the study area from 1987 to 1990. These samples were analyzed for selected pesticides or other selected SOC's. Data reports have been prepared that present more detailed information on several of these sampling efforts (Fitzpatrick and Colman, 1993; Sullivan and Terrio, 1994); for other sampling efforts, the data are available from the Illinois District office. The upper Illinois River Basin NAWQA project sampling programs for pesticides and other SOC's in water, sediment, and biota are summarized in table 2.

The sampling program for pesticides was designed to identify the types and amounts of these compounds entering streams in agricultural and urban areas. Sampling for pesticides in the upper Illinois River Basin was done in two phases. Data collected during Phase I sampling were compared to pesticide runoff from urban and agricultural lands to determine the presence and extent of a suite of current-generation pesticides in the study area. Data were collected during Phase II to provide information on concentrations and factors affecting herbicide runoff from agricultural lands in the study area. Complete information on the sampling network design and data for both phases of the pesticide sampling is presented in Sullivan and Terrio (1994); a brief summary is presented here.

Phase I sampling was done during 1988 and 1989 at two stations in urban watersheds and two stations in agricultural watersheds. Generally, urban areas have not been sampled for pesticides, but contamination of streams is potentially high in these areas in the upper Illinois River Basin based on estimates by Taylor and others (1989) of use in residential areas, on right-of-ways, and on commercial and park properties. The stations selected were in small watersheds because pesticide concentrations have been shown to be highest during runoff in small watersheds (Baker, 1985) and result in detectable concentrations if these compounds actually are present in the environment. Selected information for the Phase I sampling stations and station locations are shown in table 3 and figure 6, respectively.

Phase II sampling was designed to determine the distribution and factors affecting concentrations of herbicides at 17 stations in the Kankakee and Iroquois River Basins. Data were collected during the growing season in 1990, starting when corn planting was nearly 75 percent completed (U.S. Department of Agriculture and Illinois Department of Agriculture, 1990a–d) and continued through late July. Samples were analyzed for a suite of triazine and chloro-acetanilide herbicides,

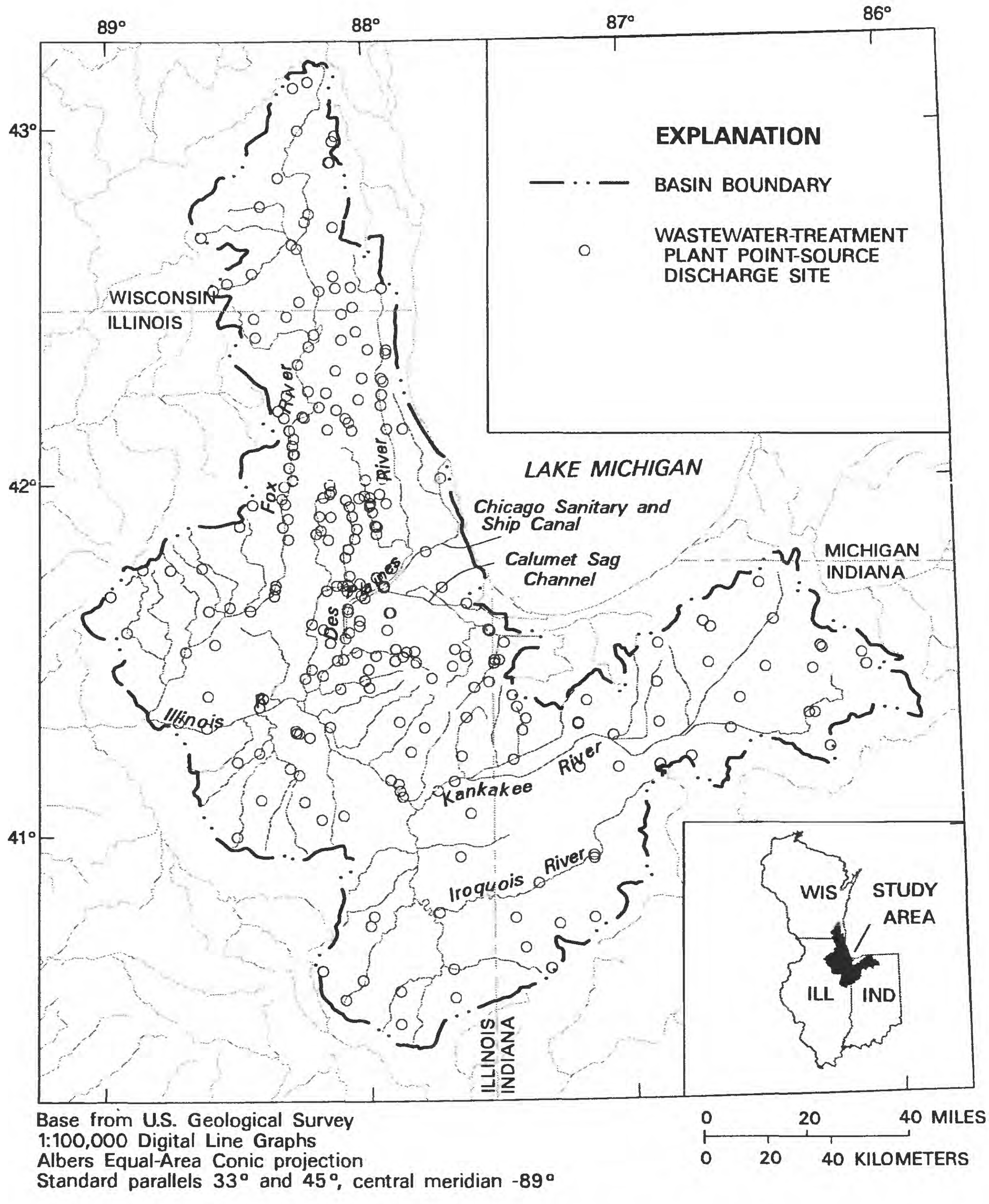

Figure 5. Location of municipal wastewater-treatment plant point-source discharge sites in the upper Illinois River Basin.

support constituents including nitrite- plus nitrate-nitrogen (which from here on will be referred to as nitrate), and suspended-sediment concentrations. Selected information and the locations of Phase II sampling stations are shown in table 4 and figure 7, respectively.

For the purpose of this description of the Phase II sampling, the Kankakee River Basin is divided into the

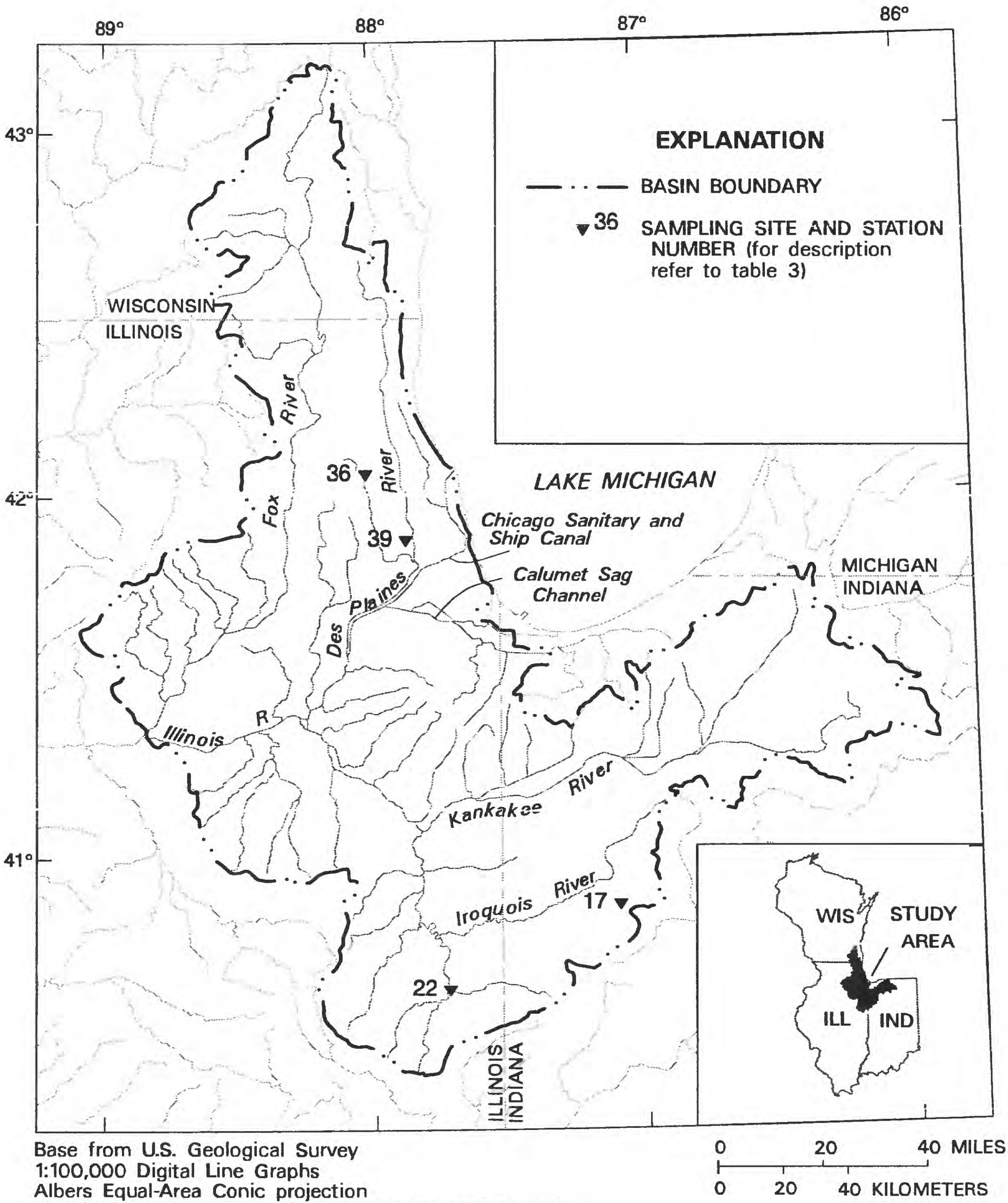

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Figure 6. Location of sampling stations included in Phase I pesticide sampling in the upper Illinois River Basin, 1988–89.

Kankakee and Iroquois River Basins. The stations sampled during Phase II included 11 in the Kankakee River Basin and 6 in the Iroquois River Basin. Different sampling schemes were designed for stations in the Kankakee and Iroquois River Basins.

Kankakee River Basin stations were sampled at or near the peak of as many as three runoff periods following herbicide application in the spring with a single sample collected during each period. Low-flow samples were collected between runoff periods to

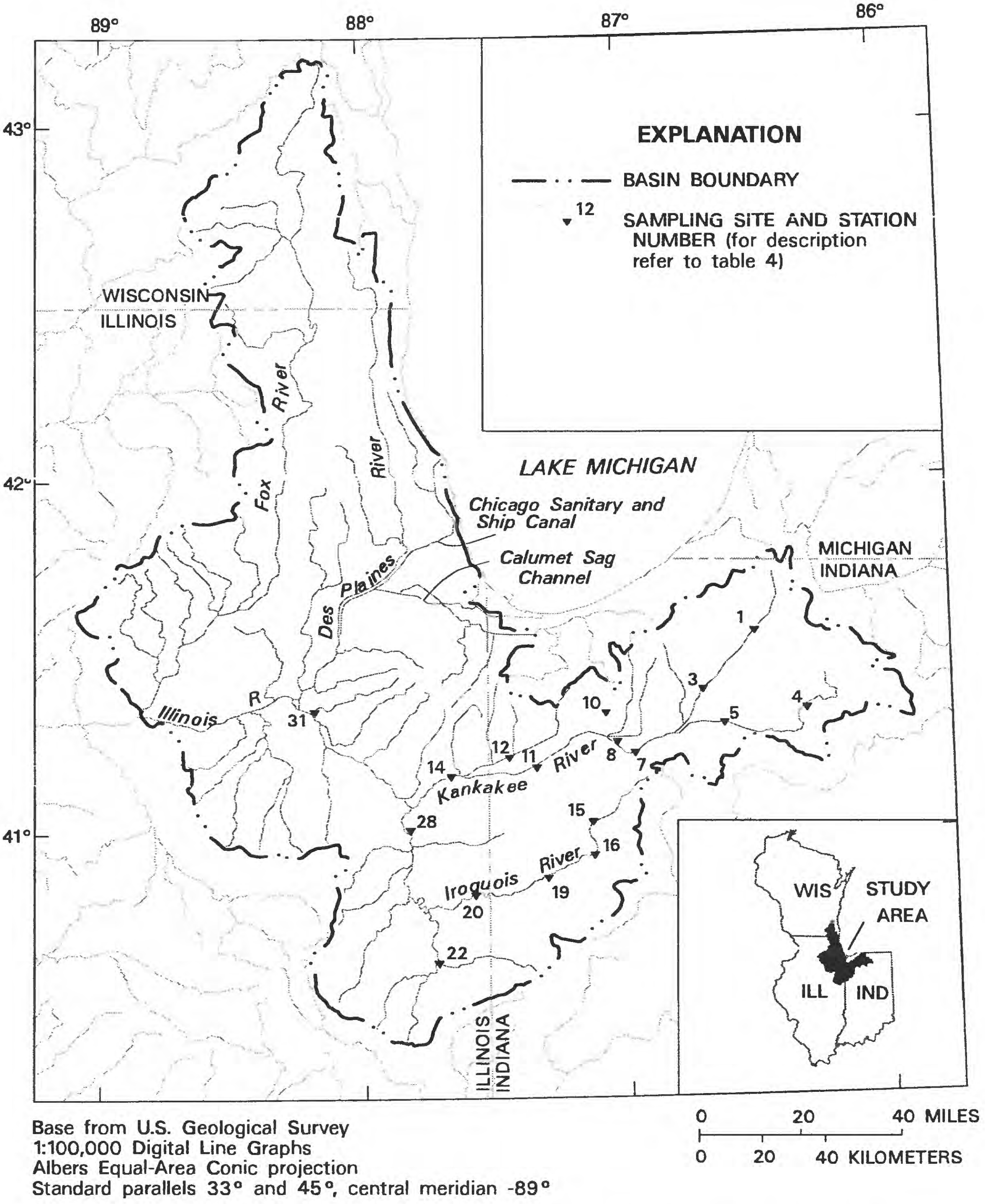


Figure 7. Location of sampling stations included in Phase II pesticide sampling in the Kankakee and Iroquois River Basins, 1990.

provide information on concentrations in the streams during nonrunoff conditions during the sampling period. Nutrient, sediment, and streamflow data, collected in conjunction with the herbicide data, provided information on factors affecting herbicide concentrations in the basin.

Iroquois River Basin stations were sampled intensively during runoff periods with multiple samples collected over the duration of specific storm hydrographs. Low-flow samples also were collected between runoff periods to provide information on herbicide concentrations in the streams during the sampling period. The samples collected during runoff periods provided a record of herbicide concentrations over as many as three runoff periods at each station. The data were used to calculate loads from various parts of the Iroquois River Basin. Nutrient, sediment, and streamflow data, collected in conjunction with the herbicide data, provided information on factors affecting herbicide concentrations in the basin.

Most of the samples collected during Phase II sampling were analyzed based on enzyme-linked immunosorbent assay (ELISA) for triazine and chloro-acetanilide herbicides. A more complete description of the ELISA procedure is in Pomes and others (1991), and a brief description also is provided in Sullivan and Terrio (1994). Res-I-Quant kits that utilize polyclonal antibodies that adsorb either triazine or chloro-acetanilide herbicide molecules, depending on the analysis, were used. Samples were placed in a plate reader, optical absorbances were compared with those of known standards, and concentrations were determined from standard curves.

A subset of splits of the Phase II herbicide samples were analyzed for a suite of triazine herbicides by gas chromatography/mass spectrometry (GC/MS), which provided a fully quantitative, comparison data set to the immunoassay data for concentrations of atrazine and alachlor. The GC/MS splits also identified the concentrations of other triazine and chloro-acetanilide herbicides and two metabolites present in the samples.

The distribution of VOC's and SVOC's in streams in the study area was determined in a two-phase sampling scheme completed between May 1988 and March 1990. A brief description of the sampling efforts is provided here; for more information on the sampling network design, methods, and data on VOC's and SVOC's in water, see Fitzpatrick and Colman (1993).

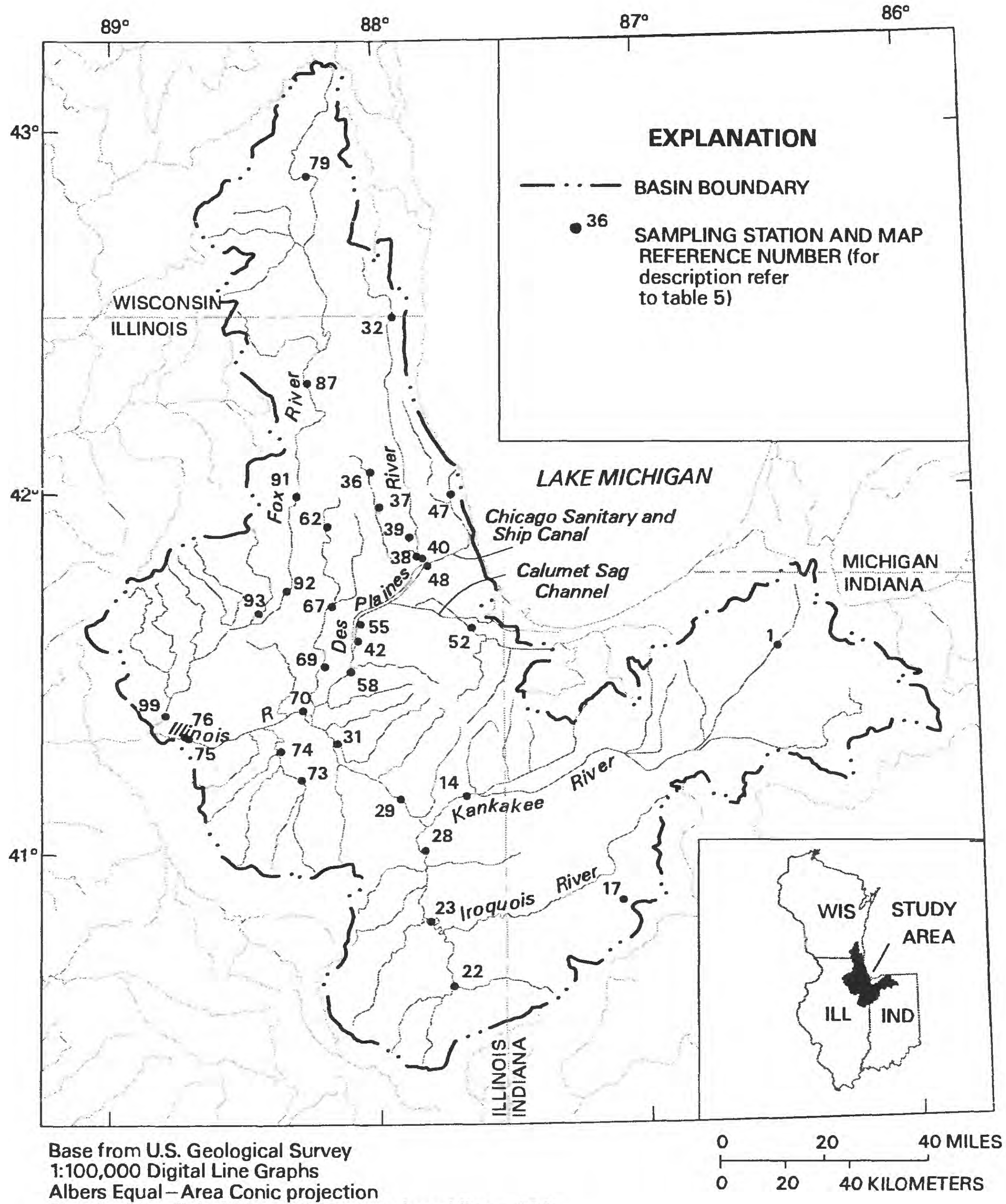
The two sampling phases followed preliminary sampling that was done at four sites to test sampling and laboratory analytical techniques. Data from this preliminary sampling were analyzed to assure that techniques were adequate for the purpose of sampling for low levels of organic contaminants in water before large-scale sampling was started.

The first phase of sampling for VOC's and SVOC's in water was a synoptic survey at stations during low-flow conditions in July 1988. Samples were analyzed for VOC's at 32 stations and SVOC's at 27 stations. Samples were analyzed for SVOC's from a smaller number of stations because review of the historical data base indicated that SVOC's are rarely (with the exception of phenolic compounds) detected in water-column samples. The USGS National Water Quality Laboratory (NWQL) in Arvada, Colo., analyzed the NAWQA samples for SVOC's in water. The NWQL was capable of reporting concentrations of various SVOC's at a lower minimum reporting level (MRL) than the MRL utilized for the historical data. Therefore, it was decided that limited sampling for SVOC's in water was justified. Selected information for VOC's and SOC's is listed in table 5 and the locations of sampling stations are shown in figure 8.

The second phase of sampling for VOC's consisted of monitoring concentrations at two stations included in the synoptic survey—the Des Plaines River at Riverside, Ill. (map reference number 40), and the Chicago Sanitary and Ship Canal at Romeoville, Ill. (map reference number 55)—on an approximately monthly basis from June 1988 through March 1990. The purpose of the second phase of sampling was to document fluctuations in the concentrations of VOC's over time and during differing hydrologic conditions.

Sampling for SVOC's in streambed sediments was done in preliminary sampling in 1987 and in a synoptic survey in 1989. The sampling program for SVOC's in water targeted mainly soluble, hydrophilic compounds. Less soluble, hydrophobic compounds are more likely to partition into sediment organic matter or bioaccumulate in aquatic organisms. Consequently, the sampling program for sediments targeted the less soluble SVOC's.

Streambed-sediment samples were collected at 10 stations in October and November 1987. The sampling was done during low-flow conditions and was designed as a reconnaissance-level survey to determine the suite of SVOC's present in streambed sediments in the study area. The sampling locations included eight stations in urban and industrial areas considered to be affected heavily by point-source pollution. The other two stations were in agricultural areas with few known upstream point sources. Samples were analyzed for 54 priority pollutants.



Base from U.S. Geological Survey
1:100,000 Digital Line Graphs
Albers Equal–Area Conic projection
Standard parallels 33° and 45°, central meridian –89°

Figure 8. Location of sampling stations for volatile and semivolatile organic compounds in water in the upper Illinois River Basin, 1988.

Stations sampled in 1987 for SVOC's in streambed sediment are listed in table 6, and the locations of the sampling stations are shown in figure 9. Data from the sampling are on file at the Illinois District office.

Synoptic sampling was done at 81 stations in July and August 1989 to determine the spatial distribution of 74 SVOC's in streambed sediment in the upper Illinois River Basin. Sampling stations were selected

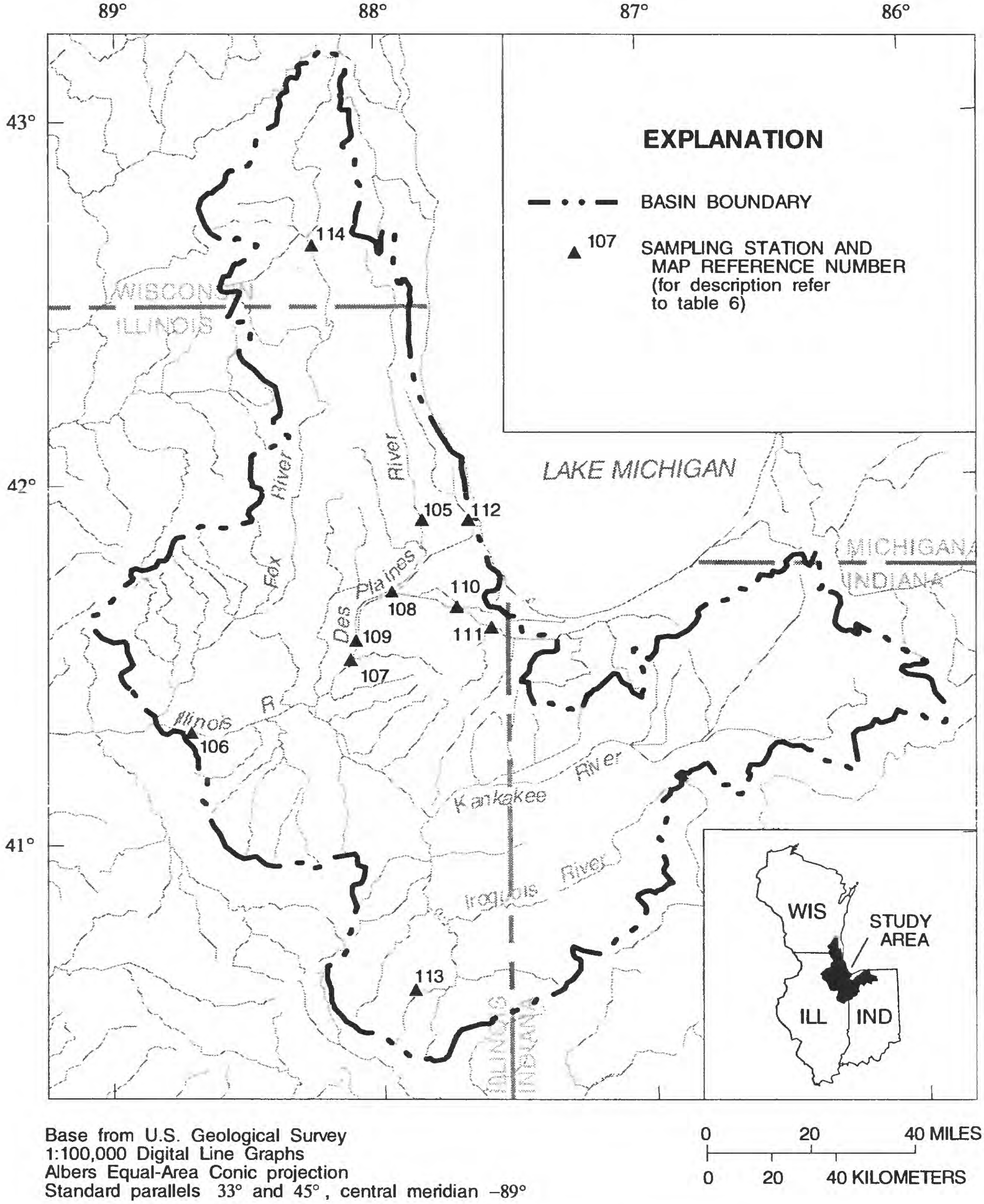


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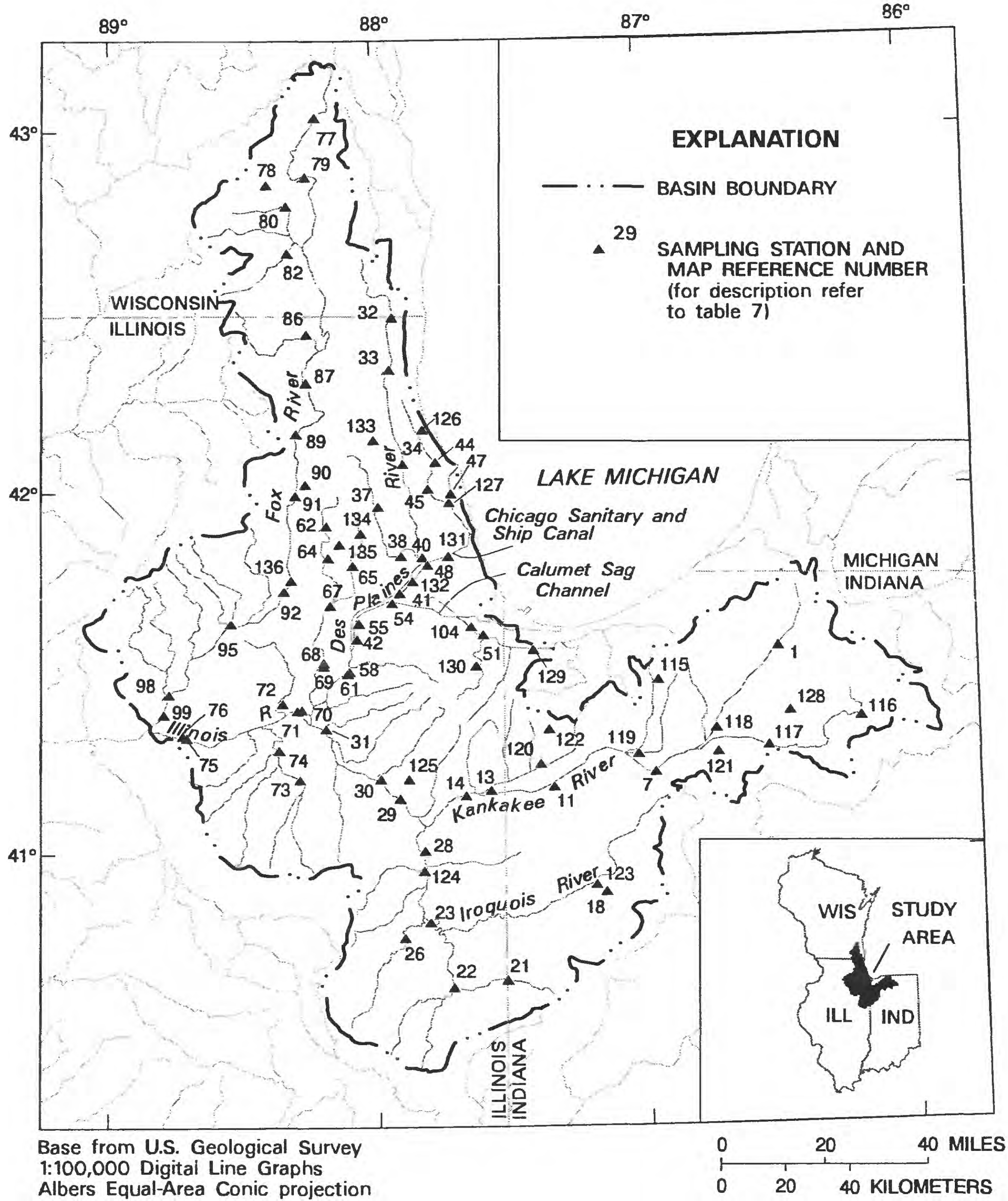
Figure 9. Location of sampling stations for the reconnaissance-level survey of semivolatile organic compounds in streambed sediments in the upper Illinois River Basin, 1987.

in order to have a minimum resolution of 50 mi between stations along major river reaches. Additional stations were on important tributaries and near point-source discharges. The station locations were not a random design but were biased toward urban areas where the streambed sediments were more likely to be contaminated with SVOC's. However, good overall spatial coverage of the upper Illinois River Basin was achieved. Selected information on the stations sampled in 1989 for SVOC's in streambed sediment are listed in table 7, and the locations of the sampling stations are shown in figure 10. Data from the sampling are on file at the Illinois District office.

In addition to the two media previously discussed (water and sediment), aquatic biota were collected and analyzed for a variety of SVOC's. Further understanding of the distribution of SVOC's in the study area is achieved from analyzing biota because they may bioaccumulate compounds that are at low levels in the water and (or) sediment. In addition, biota



Base from U.S. Geological Survey
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Albers Equal-Area Conic projection
Standard parallels 33° and 45°, central meridian -89°

Figure 10. Location of sampling stations for a synoptic survey of semivolatile organic compounds in streambed sediments in the upper Illinois River Basin, 1989.

present additional risk factors because human consumption of contaminated fish may be a threat. Other predators, including birds (such as bald eagles and osprey) that eat fish, thus, are susceptible to contamination from tainted fish tissue.

Sampling of biological tissues was done in the upper Illinois River Basin in 1989 and 1990. Fish, mollusks, crayfish, and aquatic plants were collected and analyzed for organochlorine insecticides and PCB's to determine relative concentrations among different specie types. Samples including mollusks, crayfish, and aquatic plants also were analyzed for selected PAH's. PAH's are metabolized largely by fish; thus, generally, PAH's are not present in high concentrations in fish tissue. Information on the sampling stations and the organisms collected at each station is presented in table 8; the locations of the sampling stations are shown in figure 11.

Biological samples collected in 1989 and 1990 were, in most cases, composites of multiple organisms. Ideally, the composites included one of the following: 10 fish, 20 crayfish, 20 mollusks, or at least 20 g (wet weight) of plant material. Fewer organisms were collected when the desired number could not be obtained in a reasonable timeframe.

Fish were collected by electrofishing techniques, in which fish are temporarily stunned by an electrical current and then netted for collection. Crayfish were collected using kicknets. Mollusks were located with an underwater viewer and were collected individually by hand or with a kicknet. Aquatic plants were collected by hand.

The upper Illinois River Basin NAWQA sampling covered the entire study area. The sampling was based on similar techniques and a short timeframe, in contrast to the historical data discussed later in this report, which were collected by different agencies at different times and using various laboratories to conduct the analyses. Data collected for SOC's in the water, sediment, and biota were analyzed to develop an understanding of the extent and distribution of SOC's in the upper Illinois River Basin and to augment the available data. Typically, sampling programs of other agencies targeted specific areas or were limited to the particular State boundary.

Data Sources, 1975–88

Data collected from 1975 to 1988 by IEPA, USACE, USEPA, USGS, and NIPCI provided valuable information on the distribution of pesticides and other SOC's in the upper Illinois River Basin. These data were useful in designing the NAWQA sampling program for pesticides and other SOC's. Historical data were selected according to the following criteria:

1. Do the data represent ambient stream conditions, as opposed to effluent? This criterion was included to identify those water-quality data collected to describe ambient surface-water conditions. If samples were collected from lakes, cooling ponds, effluent discharges, or treated water, then the data were excluded.
2. Are the data available for public use? Accessibility of the data was a fundamentally important criterion. If the data were readily available, then the data could be used for regional assessment of current water-quality conditions.
3. Are the data in computer files? For practical reasons, availability of data in computer files was a criterion. Given the constraints of manpower and time, the compilation and manipulation of large volumes of data was not feasible unless these data were stored in computer files for ready accessibility.
4. Were the water samples collected as depth-integrated cross-section composite samples? (This criterion applies to all constituents and properties except bacteria and radionuclides.) This criterion applied to water-column samples collected for chemical analysis. A major part of the evaluation of the current water-quality conditions in the upper Illinois River Basin involved quantitative analyses, such as loads computations and mass-balance calculations. To keep the error in the analyses to a minimum, study personnel set the criterion for a depth-integrated, cross-sectionally composited sample. This type of sample ensures that the results of the chemical analysis were representative of the entire width and depth of the cross section. A data base did not meet this criterion if the data were collected from grab samples. Samples collected for the determination of radionuclides in water were exempted from this criterion because the paucity of depth- and width-integrated data limits the assessment to descriptive techniques.
5. Do the data have appropriate detection limits? This criterion required that the detection limit for the chemical analysis be low enough to make the data useful for a regional descriptive assessment and

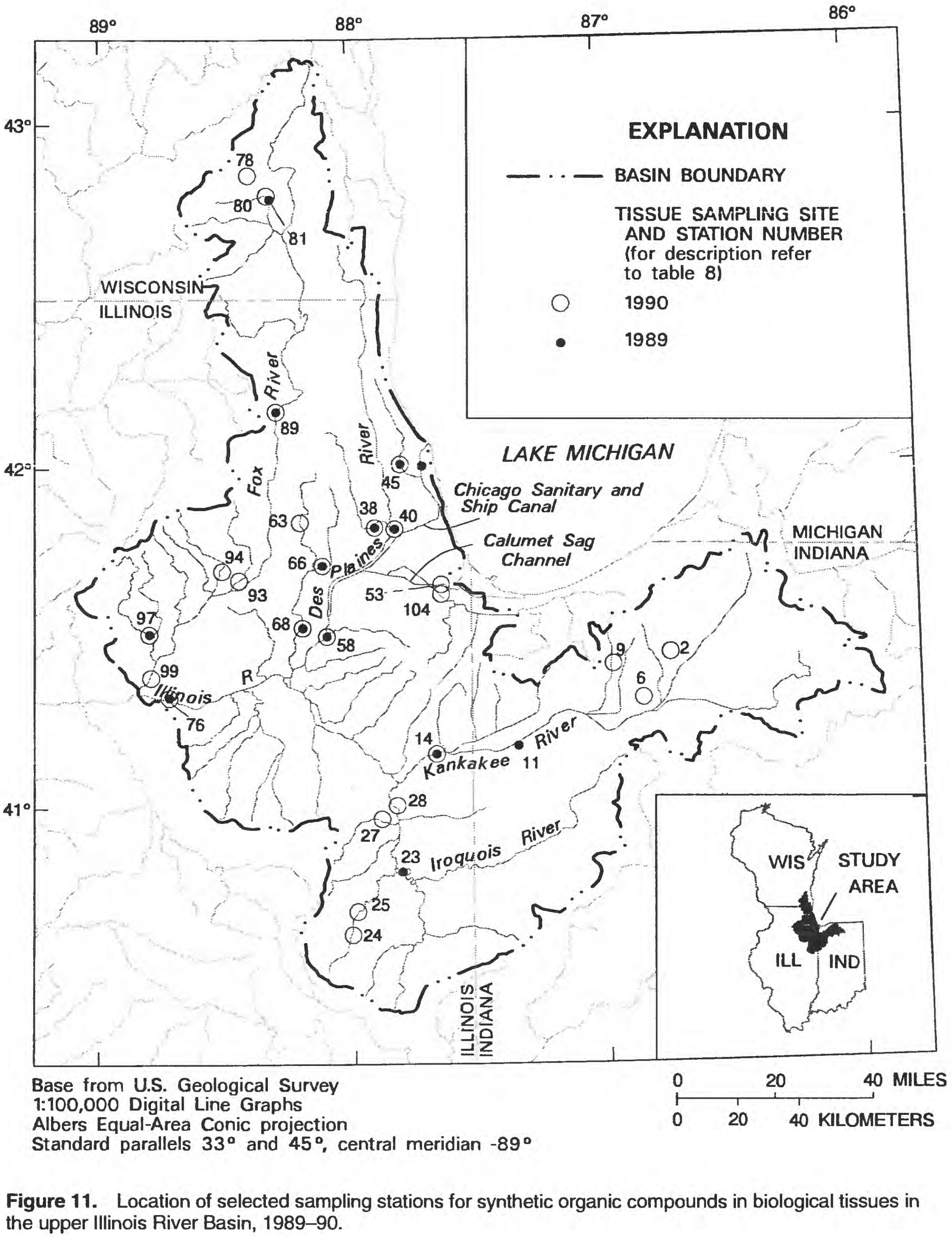

Figure 11. Location of selected sampling stations for synthetic organic compounds in biological tissues in the upper Illinois River Basin, 1989–90.

that the detection limit be comparable to the detection limit for the rest of the data. The detection-limit criterion differed with each water-quality characteristic of interest.

Data Sources, 1987–90

Samples for pesticides and other SOC's were collected in the upper Illinois River Basin from 1987 to 1990 by several agencies, including the USGS, as part of MCHI; the IEPA; and the MWRDGC. The dates, locations, sampling medium, and analysis for types of pesticides and other SOC's in samples collected by these agencies are discussed in this section.

Mid-Continent Herbicide Initiative of the U.S. Geological Survey

The USGS, as part of the Toxic Substances Hydrology Program, conducted a reconnaissance study in 10 Midwestern States in 1989 and 1990 to determine the temporal and geographic distribution of selected herbicides, as well as selected metabolites, in streams of the region (Goolsby and others, 1989). The sampling in 1989 included six stations in the upper Illinois River Basin, each of which was sampled three times: (1) at low flow before herbicide application, (2) during the first runoff period after application, and (3) at low flow at the end of the growing season. Results and further discussion of the sampling are discussed in Scribner and others (1993). In 1990, samples for herbicides and related water-quality constituents were collected from the Iroquois River near Chebanse, Ill., from mid-April through late August (D.A. Goolsby, U.S. Geological Survey, written commun., 1991). The data were collected concurrently with data collected as part of the upper Illinois River Basin NAWQA herbicide sampling in 1990 and are available from the Illinois District office.

Illinois Environmental Protection Agency

The IEPA maintains an Ambient Water-Quality Monitoring Network (AWQMN) that includes three surface-water-quality stations in the study area, which are sampled at approximately 6-week intervals for many water-quality constituents. As part of an agreement between the USGS and IEPA, the USGS sampled 6 of the 38 IEPA AWQMN stations. The USGS also sampled two additional stations—the Chicago Sanitary and Ship Canal at Romeoville, Ill. (05536995), and the Des Plaines River at Riverside, Ill. (05532500)—at monthly intervals as part of the upper Illinois River Basin NAWQA pilot study. The IEPA provided analyses of samples collected by the USGS. In this report, these two additional stations, along with the other 38 IEPA AWQMN stations, will be referred to as the AWQMN stations. Phenols were sampled at a subset of 20 of these stations. In addition, pentachlorophenol (PCP) was sampled at 11 of these 20 stations. At 3 of the 40 AWQMN stations, the IEPA collected water samples 5 times a year to monitor concentrations of 15 pesticides at stations on large rivers in the upper Illinois River Basin as part of their Pesticide Monitoring Subnetwork (PMSN). The PMSN stations were sampled at fixed intervals, and the analytes included seven herbicides, seven insecticides, and one fungicide (Illinois Environmental Protection Agency, 1990a). In addition, samples were collected at a subset of 15 AWQMN stations in urban areas of the upper Illinois River Basin to determine concentrations of a suite of 19 nonagricultural SOC's as part of the IEPA's Industrial Solvent Subnetwork (ISSN) (Illinois Environmental Protection Agency, 1990a, p. 150–151). Information on the IEPA stations in the upper Illinois River Basin is listed in table 9 and indicates if phenols or PCP's were sampled and which stations were included in the PMSN and ISSN. The locations of selected IEPA sampling stations in the upper Illinois River Basin are shown in figure 12.

Metropolitan Water Reclamation District of Greater Chicago

The MWRDGC is required to evaluate the water quality of water bodies that receive discharges from MWRDGC facilities (Illinois Pollution Control Board, 1988). The water bodies sampled include the CSSC, the lower Des Plaines River, and the upper Illinois River. Surface-water samples analyzed for phenols were collected at 24 stations in the study area. Samples were collected 12 times from May 9 to October 13, 1989, at approximately 2-week intervals. The approximate locations of the stations sampled by MWRDGC were between station 42 and downstream from station 76 (fig. 10).

The MWRDGC also monitors effluent water quality of their WWTP's. Effluent samples were collected once a day and included analyses of phenols. Selected information for the MWRDGC WWTP's is listed in table 10, and the locations of MWRDGC WWTP's in the upper Illinois River Basin are shown in figure 13.

The remainder of this report discusses the data collected and current knowledge of the distribution of pesticides and other SOC's in the water, sediment, and biota of the upper Illinois River Basin. However, analysis of data is reliable only if the data are proven to

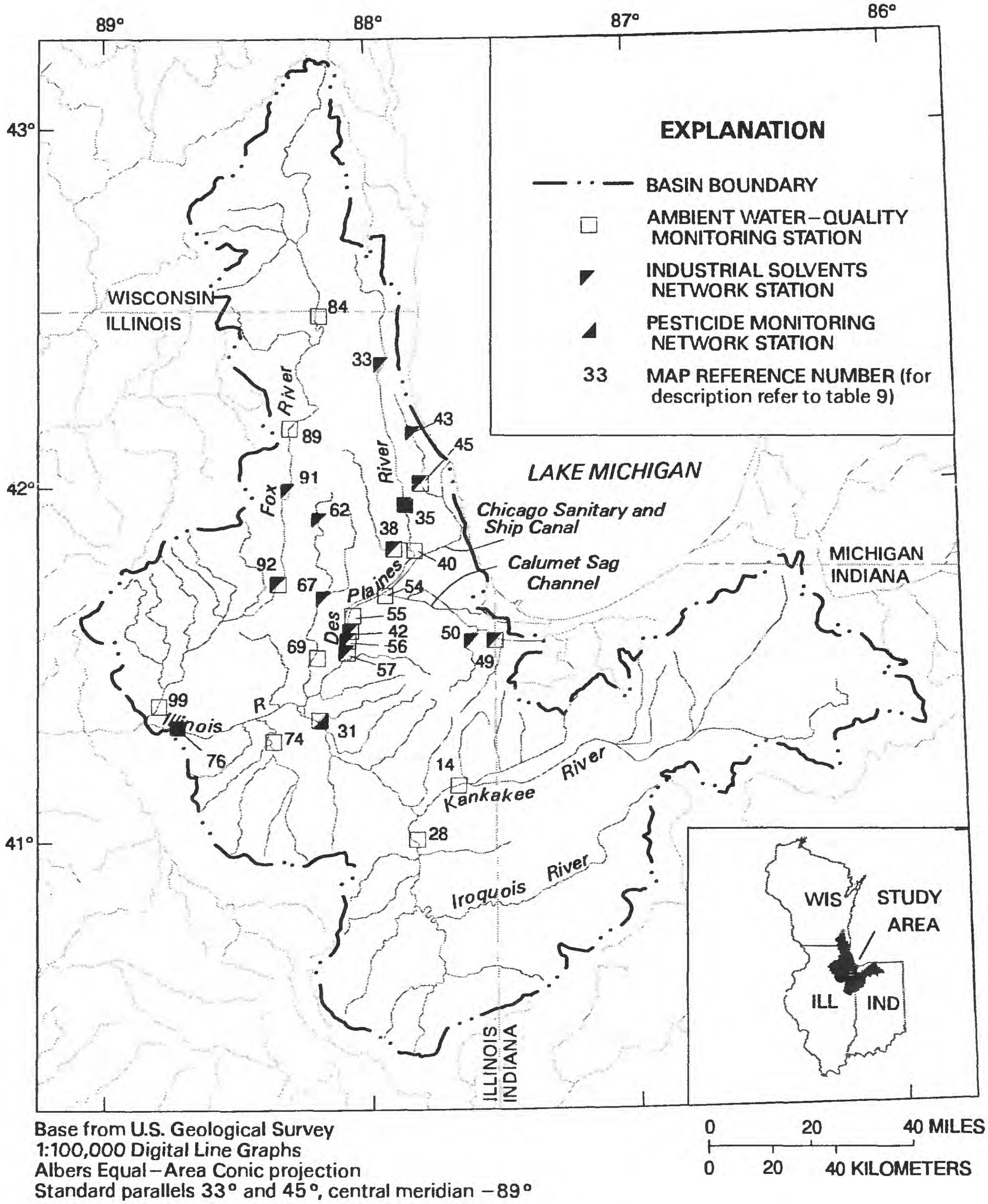

Figure 12. Location of Illinois Environmental Protection Agency sampling stations for synthetic organic compounds in the upper Illinois River Basin.

be accurate and reproducible, and for this reason, extensive quality-assurance and quality-control (QA/QC) measures were included in all phases of the NAWQA sampling.

Quality Assurance and Quality Control

An extensive program of QA/QC was conducted throughout the course of the NAWQA study. The QA/QC plan addressed all aspects of

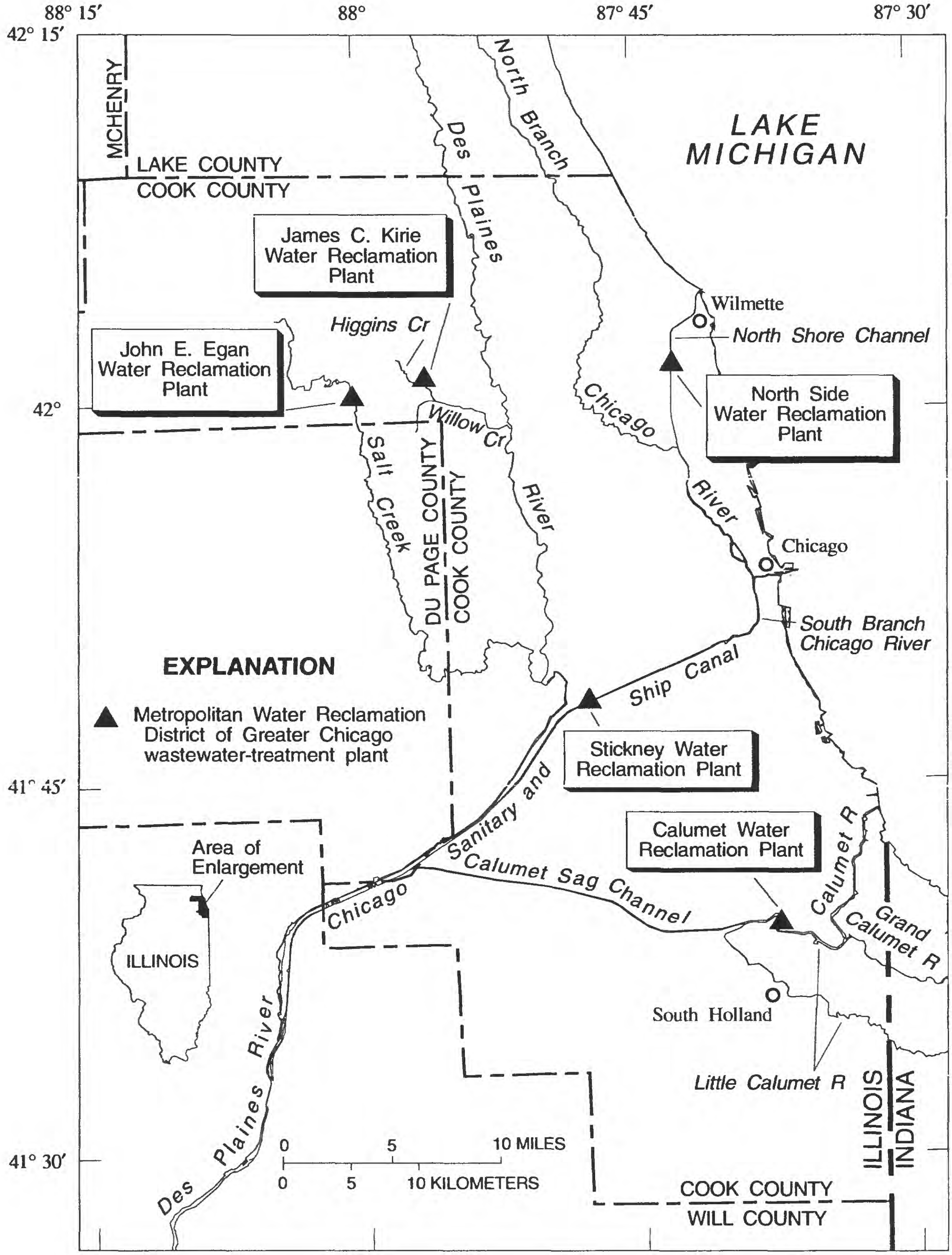

Figure 13. Location of some selected wastewater-treatment plants operated by the Metropolitan Water Reclamation District of Greater Chicago (modified from Terrio, 1994).

sample collection, analysis, and reporting needed to produce reliable and verifiable data in a nationally consistent manner (Mattraw and others, 1989).

The QA/QC measures and results of analyses for QA/QC samples collected in Phase I of sampling for pesticide concentrations in water are presented in Sullivan and Terrio (1994). The QA/QC samples from the Phase II pesticide sampling included eight spikes of reagent water samples, three field blanks, and three collection duplicates (D.A. Goolsby, U.S. Geological Survey, written commun., 1991). In addition, because samples at the Iroquois River near Chebanse, Ill., were collected by an automatic sampler with a fixed intake, six samples were collected that were composites of individual samples collected at three to five points across the entire cross section (concurrently with samples collected by the automatic sampler) to determine if the location of the automatic sampler intake biased analytical results. Results of the analyses of Phase II QA/QC samples are presented in tables 11 and 12. Most samples were submitted to the USGS laboratory in Lawrence, Kans. A subset of 27 whole-water split samples were filtered and submitted to the USGS NWQL to confirm that most of the detected soluble herbicides were in the dissolved phase in water.

Two different laboratories were used for VOC sample analysis: The Ohio Environmental Protection Agency (OEPA) analyzed samples from the preliminary and synoptic survey, and the USGS NWQL analyzed samples from the follow-up monitoring. The QA/QC measures and results of analyses for QA/QC samples collected for VOC's and SVOC's in water are presented in Fitzpatrick and Colman (1993).

The QA/QC measures for the streambed-sediment sampling for SVOC's included the submittal of field-spiked samples and blanks to the laboratory. In addition, a special sampling design was developed for 11 stations, each of which was downstream from numerous point sources, in order to maximize the number of expected detections of SVOC's. Samples were collected at each of the 11 stations, then split, and each sample was submitted to the laboratory as a discrete sample. The 11 stations were then resampled within 1 to 7 days, as near as possible to the original sampling location, and the same splitting procedure was followed so that a total of 4 samples were analyzed for each of the 11 stations. The results could then be analyzed by a nested analysis of variance (ANOVA); the results could be used to determine the relative differences in SVOC concentrations attributable to (1) variation between splits, (2) variation between samples at a site, and (3) variation between samples at different sites. As a final comparison, a fifth sample split from each of the 11 stations was submitted to a different laboratory. The results of all sample splits and spikes are presented in table 13.

Streambed-sediment samples were collected using a stainless-steel Ponar sampler (Ward and Harr, 1990, p. 28). Samples were collected at three points across the stream cross section and composited in the field. The samples were then passed through a 2-mm-size stainless-steel-mesh screen to remove larger pebbles and stones. Between use at sampling stations, the sampler was washed with a phosphate-free detergent and then rinsed three times with organic-free water. Samples were chilled after collection to prevent degradation.

The QA/QC measures for biota included packing samples on dry ice immediately after collecting, measuring, and weighing the samples to avoid degradation. Replicate samples were submitted to determine within-site variation. In addition, internal laboratory QA/QC measures included analyses of blanks, spikes, and splits. The QA/QC results for biota are presented in tables 14 and 15.

METHODS OF ANALYSIS

This section provides a brief overview of the statistical procedures used to describe and analyze the pesticide and other SOC data collected in the upper Illinois River Basin. References are provided for a description of the statistical procedures and their applications.

A general description of the distribution of concentrations for a variety of constituents was illustrated by the use of percentiles and schematic box plots called Tukey plots (Tukey, 1977). Percentiles are provided to locate different portions of the concentration distribution. The percentiles provided in this report are the 10th, 25th, 50th, 75th, and 90th. The 50th percentile is the median, or the middle observation of the data when the concentrations are ordered from smallest to largest. The concentration associated with the 90th percentile is the concentration that has 90 percent of the concentrations less than that value. The 10th and 90th percentile are not presented for stations with less than 30 observations for a given constituent within the period of analysis. Percentiles are further described by Iman and Conover (1983).

Estimation of percentiles for the pesticide and SOC data was complicated by censored data. Censored data are values that are reported as less than a given concentration because of limitations in lab techniques and equipment, or other factors. These limitations result in a minimum concentration that is considered reliable. This concentration is the MRL for that analysis. The MRL for a given constituent may vary over time because of factors including different laboratories performing the analyses, improvement in laboratory equipment or techniques used in the analyses, and varying sample interference, such as suspended sediment, during analyses. Consequently, some constituents may contain data values with multiple MRL's.

Percentiles for stations having constituents with multiple MRL's were estimated based on a procedure described by Helsel (1990). In this procedure, the data were fit to a log-normal distribution prior to the computation of percentiles. Percentiles for values less than the MRL's were estimated from the log-normal distribution. Percentiles for values greater than the MRL's were calculated from the raw data. These estimated values are not considered as estimates for specific samples but are used collectively only to estimate summary statistics. Application of this method, rather than simple substitution for the censored values, should lower estimation errors for summary statistics of data sets containing multiple MRL's, especially when noncensored data fall between multiple MRL's and substitution to the highest MRL results in a loss of raw data. An asterisk is listed in the percentile tables next to the percentile value that was estimated from the log-normal maximum-likelihood method.

Tukey plots are used to graphically display the distribution of all the data. A Tukey plot is a modified boxplot. The Tukey plot has a box drawn from the 25th to the 75th percentiles. The height of this box is the interquartile range. A bar is drawn across the box at the 50th percentile (median). Vertical lines (whiskers) are drawn to the smallest value greater than or equal to the 25th percentile minus 1.5 times the interquartile range (lower adjacent value) and the largest value less than or equal to the 75th percentile plus 1.5 times the interquartile range (upper adjacent value). Values more extreme than the adjacent values but less extreme than the 25th percentile minus 3 times the interquartile range (outside values) were plotted using asterisks. Values more extreme than the outside values (far outside values) were plotted as open circles.

Tukey plots for stations having constituents with multiple detection limits were modified to display quartiles estimated by fitting the data to a log-normal distribution applying the same procedure used to estimate percentiles (Helsel, 1990). A heavy horizontal line was drawn across the boxplot and represents the MRL value. Any part of the box below the MRL was shown with dashed lines to show that it was based on estimated values. If the MRL was greater than the upper adjacent value, no upper whisker was drawn. If the MRL was greater than the 25th percentile, no lower whisker was drawn. If the MRL was less than the lower adjacent value, the lower whisker was not extended below the MRL. Outside or far-outside values that were less than the MRL cannot be estimated and were not plotted.

The Wilcoxon signed-ranks procedure was used to test for differences between process duplicate and collection duplicate samples submitted for analysis. This is a nonparametric test, which is similar to a t-test, except that the nonparametric test is performed on the signed ranks of the differences between paired samples. For a detailed description of this test, see Iman and Conover (1983).

HISTORICAL CONDITIONS, 1975–88

by John A. Colman

Data collected between 1975 and 1988 by the IEPA, USACE, USEPA, USGS, and NIPCI provided valuable information on the distribution of pesticides and other SOC's in the upper Illinois River Basin. Historical data were selected according to guidelines presented in the "Data Sources and Collection" section.

Organics in the Water Column

Water-column samples were analyzed for the SOC's listed in table 16. Compound name, number of observations, number of detections, and number of stations for each parameter are included in table 16. A total of 90 compounds were included in the historical data; only the 39 compounds having 10 or more samples analyzed were included in table 16. A large number of samples between 234 and 520 were analyzed for chlorinated pesticides, PCB's, phenols, and PCP. The number of stations sampled varied from

28 to 59. Of these groups, only the phenols and PCP were observed at concentrations above the MRL. Two additional groups of compounds in table 16 are the organophosphorus pesticides and herbicides. These compounds were sampled at only three or four locations in the basin and only since 1985, at approximately 6-week intervals, resulting in 38 to 51 observations per compound. Of these, none of the organophosphorus compounds were found at concentrations above the MRL, but most of the herbicides were above MRL concentrations.

As expected, water-soluble, hydrophilic compounds were detected more frequently in the water-column samples, whereas the insoluble, hydrophobic compounds were detected infrequently. Some of the insoluble compounds that were never detected in the water column were detected in the streambed sediments. Thus, the sediments may be the preferred medium for indicating the distribution of insoluble compounds.

Concentration percentiles were determined by station for all constituents with concentrations above the MRL (phenol, PCP, and agricultural herbicides) and with 10 or more observations at a station (table 17). Values for PCP appear at the 25th percentile at most stations for those concentrations above the MRL listed in the percentiles tables. In contrast, concentrations of phenols above the MRL appear only at the 90th percentiles and only at three stations. The difference between the number of detections for PCP's and phenols may result from their detection limits, 0.01 and 5.0 µg/L, respectively. Three herbicides (alachlor, atrazine, and metolachlor) had concentrations greater than the MRL at multiple stations for the 50th, 25th, and 50th percentiles (respectively).

PCP was the only water-column SOC measured at enough stations and detected in sufficient concentration to describe spatially. However, because collection programs in the upper Illinois River Basin continued through 1990 and trends over time may be indicated, data on both PCP's and total phenols collected during 1978–90 are discussed in the section "Concentrations and Distribution of Phenolic Compounds in the Upper Illinois River Basin, 1978–90" of this report.

Established criteria for chronic toxicity of organochlorine and organophosphorus compounds generally were below the MRL, whereas the criteria for acute toxicity were above the MRL. The large number of concentrations less than the MRL common to the organochlorine compounds indicates that the acute criteria were not exceeded but allows for no comparison to the chronic level. Acute and chronic toxicity criteria for PCP with concentrations greater than the MRL are much higher than those of other organochlorines (20 and 13 µg/L, respectively, at pH = 7.8) so that no exceedances were recorded. Primary drinking-water standards for maximum contaminant levels (MCL)[1] have been set by USEPA (1989) for alachlor (2 µg/L) and atrazine (3 µg/L). Atrazine and alachlor concentrations in the study area have been observed above their respective MCL's; however, the health risk associated with the standards is based on lifetime exposure. Because concentrations exceeding the MCL have a seasonal rather than constant pattern, the health effect on a drinking-water supply is not clear. The seasonal pattern of herbicide concentration is discussed below.

A seasonal periodicity would be expected for the herbicide concentrations because herbicides are applied for agricultural use primarily in the spring. The Tukey schematic plots showing the seasonal pattern of concentrations by month for selected herbicides are shown in figure 14. Data combined for the entire study area from 1986 to 1988 are shown. All compounds except metribuzin had the highest concentrations during May. Concentrations of metribuzin peaked in June, rather than May, probably because metribuzin is applied exclusively on soybeans, which are planted later in the season than corn (the other herbicides are applied to corn and soybeans).

The pronounced seasonality of concentrations affects comparisons among stations. Of the three stations sampled for herbicides, the Illinois River at Marseilles, Ill. (map reference number 76) (fig. 12), generally has the highest percentile concentrations; however, this station was sampled five times in May, five times in June, and once in July. In contrast, the Kankakee River near Wilmington, Ill. (map reference number 31), for example, was sampled once in May and three times in July.

Another feature relating to seasonality is the consequent co-occurrence of the compounds in water. The correlations among compounds by sample are

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[1] Maximum contaminant level is an enforceable, health-based maximum concentration for contaminants in public drinking-water supplies as defined in the national primary and secondary drinking-water standards established by the U.S. Environmental Protection Agency (U.S. Environmental Protection Agency, 1989).

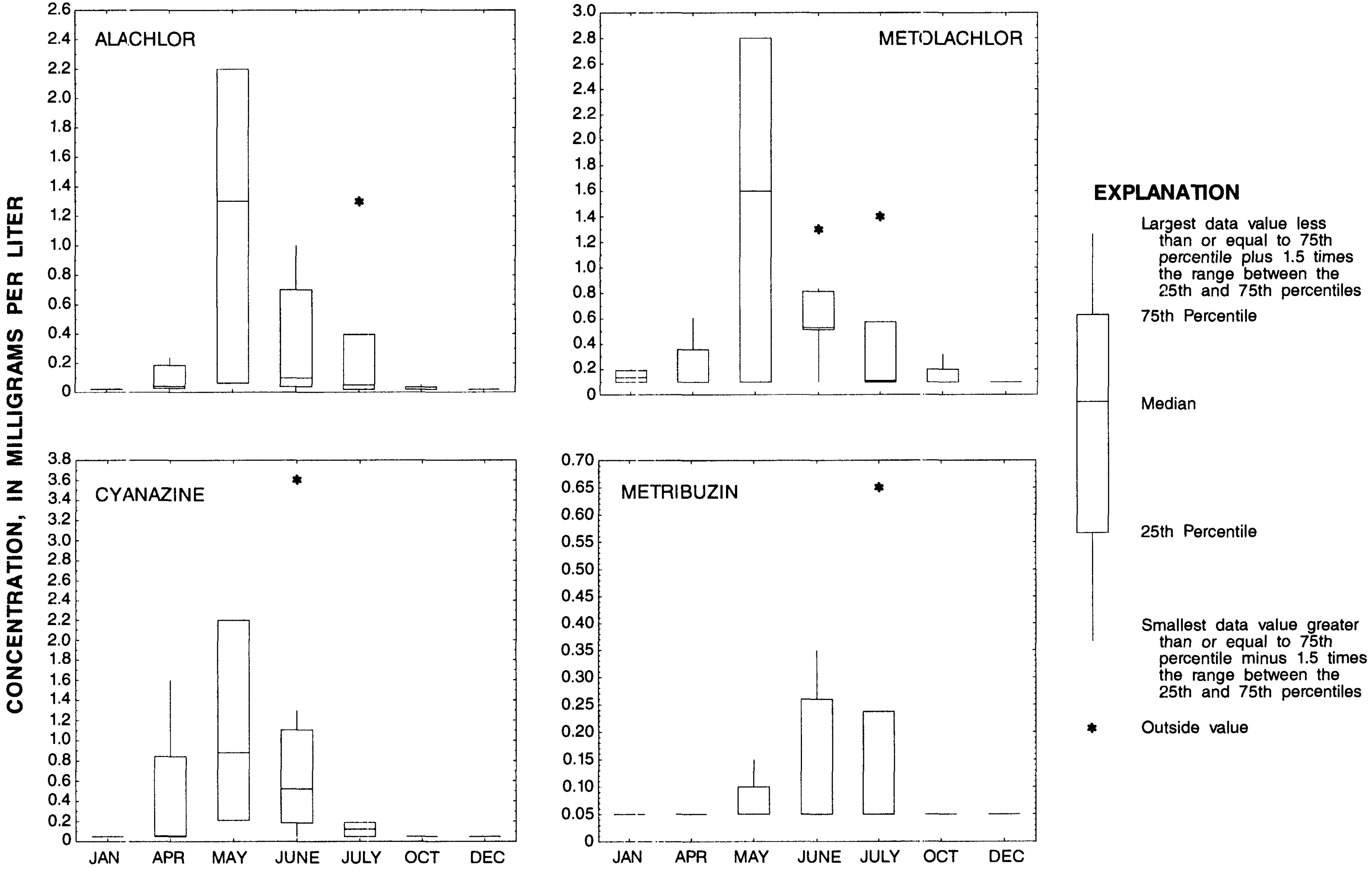


Figure 14. Seasonal patterns of herbicide concentrations in water in the upper Illinois River Basin, 1986–88.

shown in table 18. The correlation coefficients, which range from 0.49 to 0.76, indicate the compounds that are detected in combination. Co-occurrence of toxic compounds is important because of possible enhanced toxic effects through synergism. For the herbicides, which are designed to stop or slow plant growth, coincident occurrence in the spring may affect the early growth stages of some aquatic plants.

The data from the upper Illinois River Basin (table 17) can be compared with a data base of concentrations of current-generation agricultural pesticides in surface water that has been generated for eight streams that drain northwestern Ohio and southeastern Michigan and enter Lake Erie (Baker, 1987). Concentrations of herbicides reported in Baker (1987) are approximately 4 times higher for larger rivers and 10 times higher for smaller streams than the median values from the upper Illinois River Basin. When the data from the large Ohio rivers (the Maumee and Cuyahoga) are corrected for percent recovery and the season measured, these data are roughly comparable to the data from the upper Illinois River Basin. Adjusted values for the smaller Ohio rivers, however, remain higher in concentration than values observed in Illinois. Comparison of maximum concentrations of herbicides indicates values were similar for the Cuyahoga River, somewhat higher for the Maumee River, and much higher for all the Ohio and Michigan small streams relative to the concentrations in rivers in the upper Illinois River Basin. Baker (1987) included sampling over the hydrograph for storms. In contrast, the upper Illinois River Basin data were collected at set intervals and contained storm samples only by chance.

Only one insecticide, terbufos, was common to the two data sets. Concentrations of terbufos were less than the MRL in all 41 observations in the upper Illinois River Basin; the time-averaged concentrations in Baker (1987) were generally low, but many high concentrations of terbufos were detected in discrete samples from small streams in Ohio and Michigan.

Organics in Streambed Sediment

Historical data that passed the screening criteria included 47 SOC's and 3 bulk organic indicators. An additional data set of 87 constituents available from the MWRDGC are included because of the limited amount of available data and because the MWRDGC sampling sites were in the heavily urbanized/industrialized areas of the lower Des Plaines and upper Illinois Rivers. The MWRDGC data were used primarily in defining the types of compounds found rather than for statistical analysis because of uncertain quantitative correspondence with the screened data.

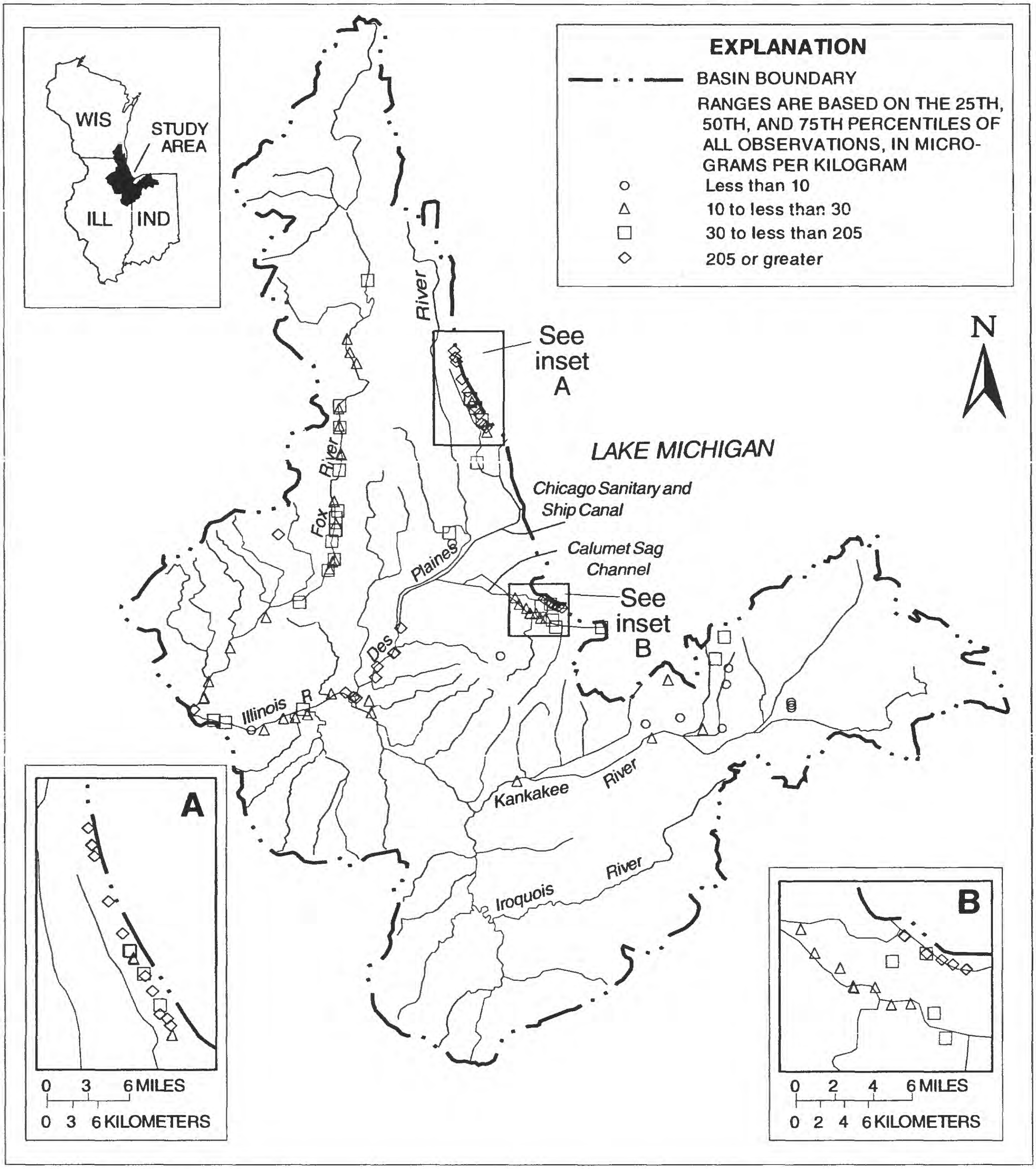
The compound name, number of observations greater than or equal to the MRL, and number of samples analyzed with concentrations less than the MRL for the screened data are presented in table 19. A similar tabulation for MWRDGC data is given in table 20.

The data base for organochlorine pesticides and total PCB's in streambed sediments was large (130–300 samples per constituent). Approximately 80 of these samples per constituent were made on the clay/silt fraction of samples. A small number of observations (4–17) were found for current-generation agricultural compounds, such as organophosphorus insecticides, and triazine and chlorophenoxy-acid herbicides. The MWRDGC data base contained observations of various SOC's at six sites.

Approximately one-half of the analyses for organochlorine compounds indicated concentrations above MRL's. No concentrations of the current-generation agricultural compounds were above MRL's. Detections of 9 VOC's, 18 base-neutral extractables (primarily PAH's), and 1 phenol were observed in the MWRDGC data base.

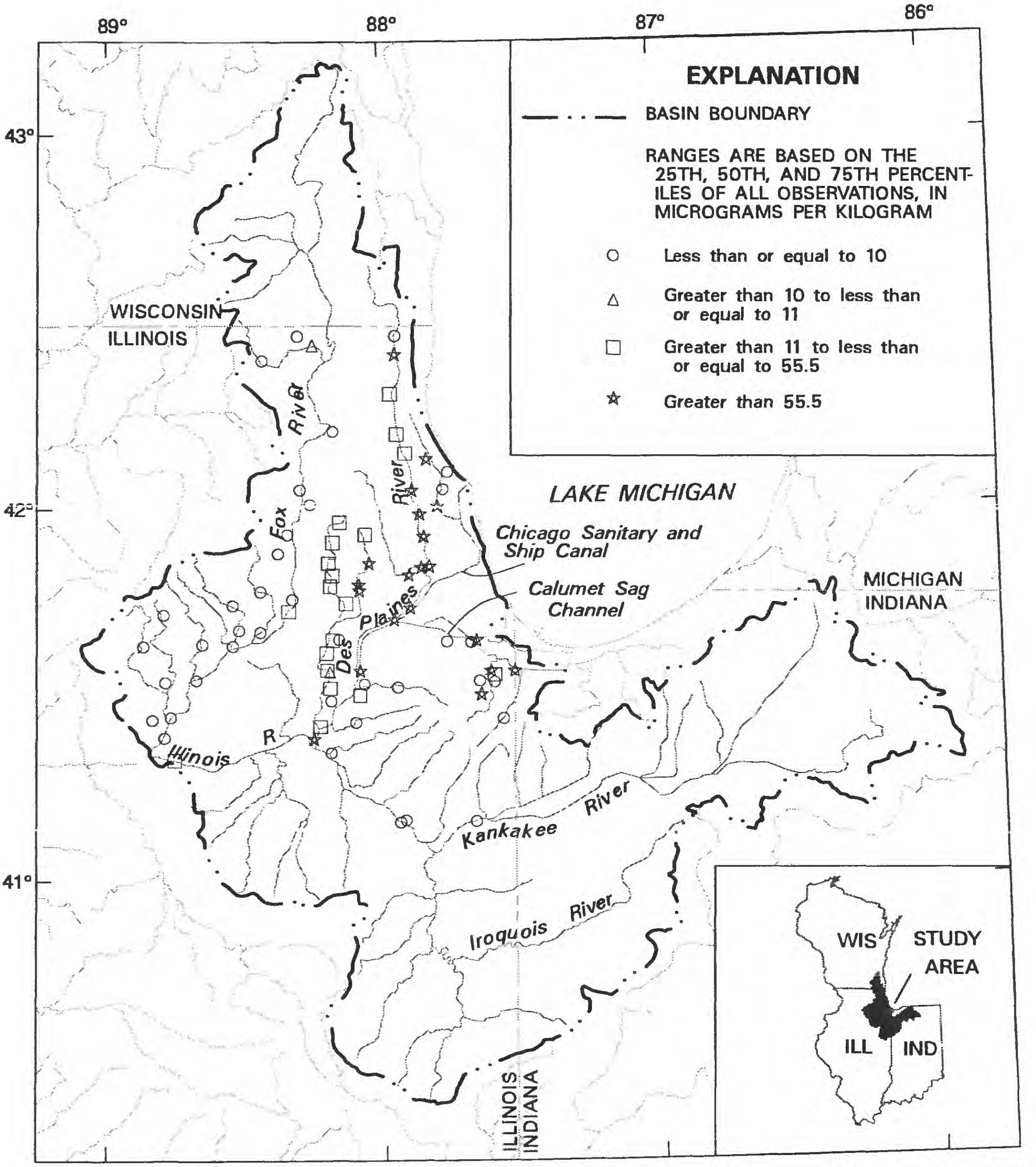
In general, spatial coverage for each constituent is affected by the data-collection programs and surveys of various agencies. Compounds included in the IEPA surveys have the most uniform coverage in the Illinois part of the study area. The IEPA surveys included samples from the main stems of the Fox, Du Page, Des Plaines, Skokie, and Illinois Rivers. In other investigations, compounds were analyzed at only one or two sites. In general, the spatial distribution of sieved and unsieved samples for a given compound is not the same. The spatial distribution of the concentrations of compounds is shown in figures 15–18.

Concentration percentiles were determined for compounds that were surveyed at 10 or more sites (table 21). Whole-sediment (unsieved) analyses were treated as separate data sets from clay/silt fraction (sieved) sediment analyses. Although different distributions were observed for the clay/silt fraction sediment analyses as compared with whole-sediment analyses, differences in sample locations between the two analyses preclude conclusions about the effect of sieving. Most compounds surveyed at 10 or more sites had concentrations at the 50th percentile that were



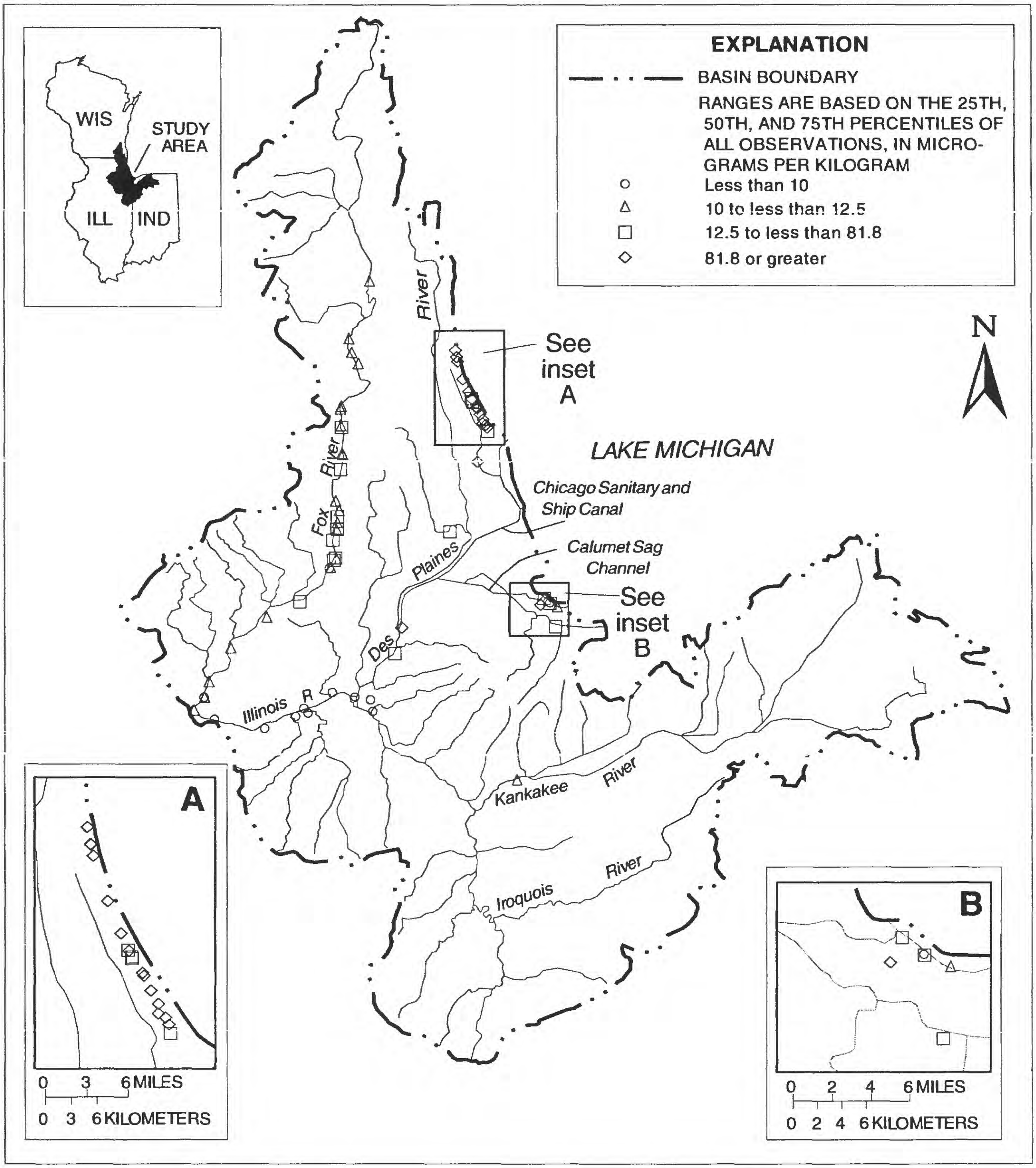
Base from U.S. Geological Survey
1:100,000 Digital Line Graphs
Albers Equal-Area Conic projection
Standard parallels 33° and 45°, *central meridian -89°*

Figure 15. Spatial distribution of polychlorinated biphenyl (PCB) concentrations in unsieved streambed sediments in the upper Illinois River Basin, 1978–88.



Base from U.S. Geological Survey
1:100,000 Digital Line Graphs
Albers Equal-Area Conic projection
Standard parallels 33° and 45°, central meridian -89°

Figure 16. Spatial distribution of polychlorinated biphenyl (PCB) concentrations in clay/slit fraction streambed sediments in the upper Illinois River Basin, 1978–88.



Base from U.S. Geological Survey
1:100,000 Digital Line Graphs
Albers Equal-Area Conic projection
Standard parallels 33° and 45°, central meridian -89°

0 20 40 MILES
0 20 40 KILOMETERS

Figure 17. Spatial distribution of dichloro-diphenyl-trichloroethane (DDT) concentration analogs in unsieved streambed sediments in the upper Illinois River Basin, 1978–88.

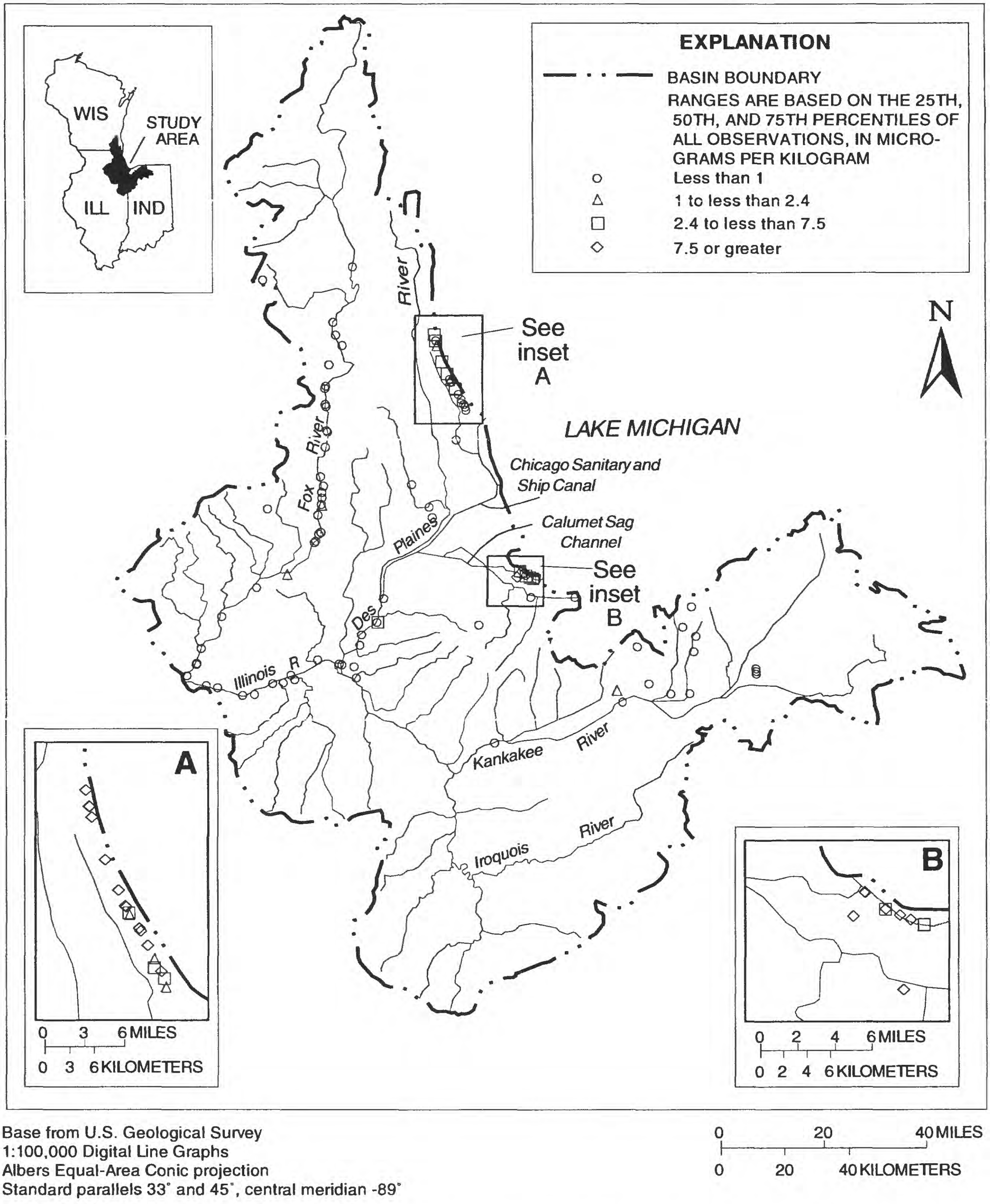


Figure 18. Spatial distribution of dieldrin concentrations in unsieved streambed sediments in the upper Illinois River Basin, 1978–88.

above the MRL. Only PCB's (aroclors 1242 and 1254), which were sampled primarily by the USACE in the Illinois River and the navigation channels connecting the Illinois River to Lake Michigan, exceeded MRL's at or below the 25th percentile. The distributions of the concentrations were, in general, skewed, extending much higher above the median than below.

A recent summary of concentrations of chlorinated hydrocarbons in bed sediments of surface waters in the United States assembled by Smith and others (1988) is given in table 22. These concentrations can be compared with concentrations listed for whole-sediment samples in the upper Illinois River Basin (table 21). The upper Illinois River Basin had the highest concentrations of PCB's listed (the concentration of PCB aroclor 1242 at 8,850 µg/kg) except for the Hudson River, where concentrations were three orders of magnitude higher. The concentrations of total DDT and chlordane in the upper Illinois River Basin are relatively high by comparison with the concentrations in the rivers listed in table 22 except for concentrations detected in the highly contaminated Los Angeles Harbor.

The spatial distribution for total PCB, total DDT, and dieldrin concentrations for clay/silt fraction sediment analyses and whole-sediment analyses is shown in figures 15–18. These compounds are representative chlorinated pesticides with a sufficient number of concentrations above the MRL to observe patterns of concentration distribution. These figures clearly show the biased distribution of sampling sites toward particular river reaches rather than a random selection of sites. As a result, summary statistics, including the percentiles, are biased toward conditions in the sampled reaches. Whole-sediment and clay/silt fraction sediment data indicate higher concentrations in urban areas. Concentrations in whole sediment generally were higher than in clay/silt fraction sediment, but the comparison is not statistically valid because sampling sites for the two sediments generally were on different streams.

Concentrations of total DDT in whole sediment appear to follow the population distribution of the upper Illinois River Basin. Concentrations were highest in the urban areas, such as near the Skokie River, somewhat lower in the moderate population areas of Elgin and Aurora on the Fox River, and lowest in the mostly rural areas of the lower Fox and Illinois Rivers. The historical use of DDT to control Dutch Elm disease in urban areas, where elm trees were popular for landscaping, is the most probable reason for this distribution. Distribution patterns for PCB's and dieldrin are similar, except that concentrations did not appear to decrease to such low relative values as total DDT concentrations decreased in the lower Fox and Illinois Rivers. Similar concentration distributions in the clay/silt fraction sediment were detected for PCB's, DDT, and dieldrin.

The highest quartile concentrations of total DDT, PCB's, and dieldrin in the clay-silt fraction sediment are, as in whole sediment, are fairly tightly grouped in the urban sections of the Des Plaines, Du Page, and North Branch Chicago River,s and in the Calumet Sag Channel and Little Calumet River Basins. Concentrations are lower in the upper Fox River Basin in Illinois and in tributaries to the Fox, which were included in these surveys.

The similar concentration distributions across subbasins, such as described above, may be quantified by computation of correlation coefficients among SOC's. Correlation coefficients were determined among all the streambed constituents available in a sample for clay/silt fraction sediment (table 23) and whole sediment (table 24). The constituents included organic compounds, metals, and nutrients. Because of the large number of less-than values and non-normal distributions for some of the constituents, the correlation analysis was performed on ranked values of the data set. The analysis included a significance-of-correlation test. Only those correlation coefficients having significance at the p less-than or equal to 0.10 level are presented in the tables.

Organics were more highly correlated in whole sediment than in clay/silt fraction sediment. Some of the organic constituents in both data sets were strongly correlated with certain streambed trace metals.

For the clay/silt fraction sediment samples (table 23), correlations between the constituents indicating the bulk of organic carbon (Kjeldahl nitrogen, total volatile solids, and chemical oxygen demand (COD)) were not highly correlated (coefficients were less than 0.49) with any of the organic constituents. However, high correlations resulted between *cis*- and *trans*-chlordane, and *p,p'*-DDD and *p,p'*-DDE. Also, reasonably high correlations (0.66–0.68) resulted between these constituents and PCB's. High correlations (0.65–0.84) resulted between trace organics and the metals copper, chromium, zinc, and mercury.

For the whole-sediment samples (table 24), one constituent, Kjeldahl nitrogen, was highly correlated with a trace organic compound, DDE. Besides correlations within a family of compounds, high correlations were determined among heptachlor epoxide, *cis*- and *trans*-chlordane, and DDT and its metabolites. Also, high correlations resulted among PCB aroclors 1254 and 1242, DDT compounds, and phenols.

Correlations among compounds by sample may be the most significant feature of the data analyzed. Whereas correlations among toxic compounds have been observed in other studies, the comparison between organic and inorganic toxins possible in this data set is unusual. Because most toxicity testing for aquatic plants and animals is done for one compound at a time, the possibility of synergistic effects resulting from multiple constituents occurring in one sample is not considered. Synergistic effects would likely be important in streambed sediment in the upper Illinois River Basin given the coincident detections of toxic compounds.

Organics in Fish Tissue

The post-1978 data base of SOC's in fish tissue consists of observations for 16 organochlorine pesticides and metabolites, and PCB's collected by the IEPA and the Indiana and Wisconsin Departments of Natural Resources (table 25). The data base is important particularly for studies in the upper Illinois River Basin because of concentrations of organic compounds in fish tissue and their effect on the health of consumers. Sampling of fish tissue for constituent concentrations is useful for basin surveys because fish tissue (1) represents the bioavailability of the compounds, (2) has relatively low MRL values, and (3) is not compromised by field-processing procedures, such as sieving.

Good spatial coverage of SOC's in fish tissue in Illinois, Indiana, and Wisconsin, except for the Iroquois River Basin, is provided in the data base (fig. 19). The number of samples analyzed for each pesticide ranges from 10 for beta-Hexachlorocyclohexane to 300 for total PCB. The samples are from 35 species of fish and 3 tissue types (whole fish, fillets, and fat). Data from Indiana and Wisconsin were sent to specific laboratories; the IEPA data were sent to multiple laboratories. Because the concentration of a given pesticide depends on factors, such as species, the organ or tissue analyzed, spawning condition, and lipid content, it is necessary to summarize the data by species and tissue for each pesticide as given in table 26.

A significant part of concentration variation in the data set can be attributed to trophic position in the food web, or percent of body-lipid content. To minimize these sources of variation so that variations among basins are more obvious, temporal and spatial comparisons are made on SOC concentrations normalized to lipid content separated according to species and tissue analyzed. The effect of the laboratory performing the analyses on the variation of concentrations also may be important. The IEPA Laboratory has done the majority of analyses in Illinois, especially for whole-carp samples, which are the most common combination of species and tissue. To improve comparability of the data, only results from the IEPA Laboratory will be considered for the Illinois data.

Spatial distributions of chlordane, DDT, PCB's, and dieldrin with a significant number of detections are shown in figures 20–23, respectively. Heptachlor epoxide concentrations are not shown because the concentrations are low and vary slightly across the basin. Ranges shown are quartile ranges of median values at a station.

Two general patterns are seen in the spatial distribution of SOC concentrations in fish tissue. Total chlordane, total DDT, and total PCB's were detected usually at higher concentrations in the urban and more highly populated areas, and dieldrin was usually detected at higher concentrations away from the urban areas. Distributions also vary among the three SOC's detected at higher concentrations in urban areas. The highest concentrations of chlordane are at sites on the Fox and Kankakee Rivers, Salt Creek, and the Des Plaines River.

The pattern of specific SOC concentrations in tissue within river reaches indicates the spatial resolution possible in basin surveys of fish-tissue concentrations. Localized patterns of high and low concentrations are observed. For example, total DDT ranges from the lowest quartile concentrations in the upstream reaches of the Du Page River to the highest quartile in the middle of the reach and returns to the lowest quartile near the mouth at the confluence with the Illinois River. Although fish swim in the river, their movement is limited apparently to obscure variable exposure levels to SOC's over a 40-mi stream reach.

Concentrations of SOC's in fish fillets in the upper Illinois River Basin were compared to levels established by the U.S. Food and Drug Administration (USFDA) for fish-tissue-consumption advisories. The sites, the species, and the number of samples at these

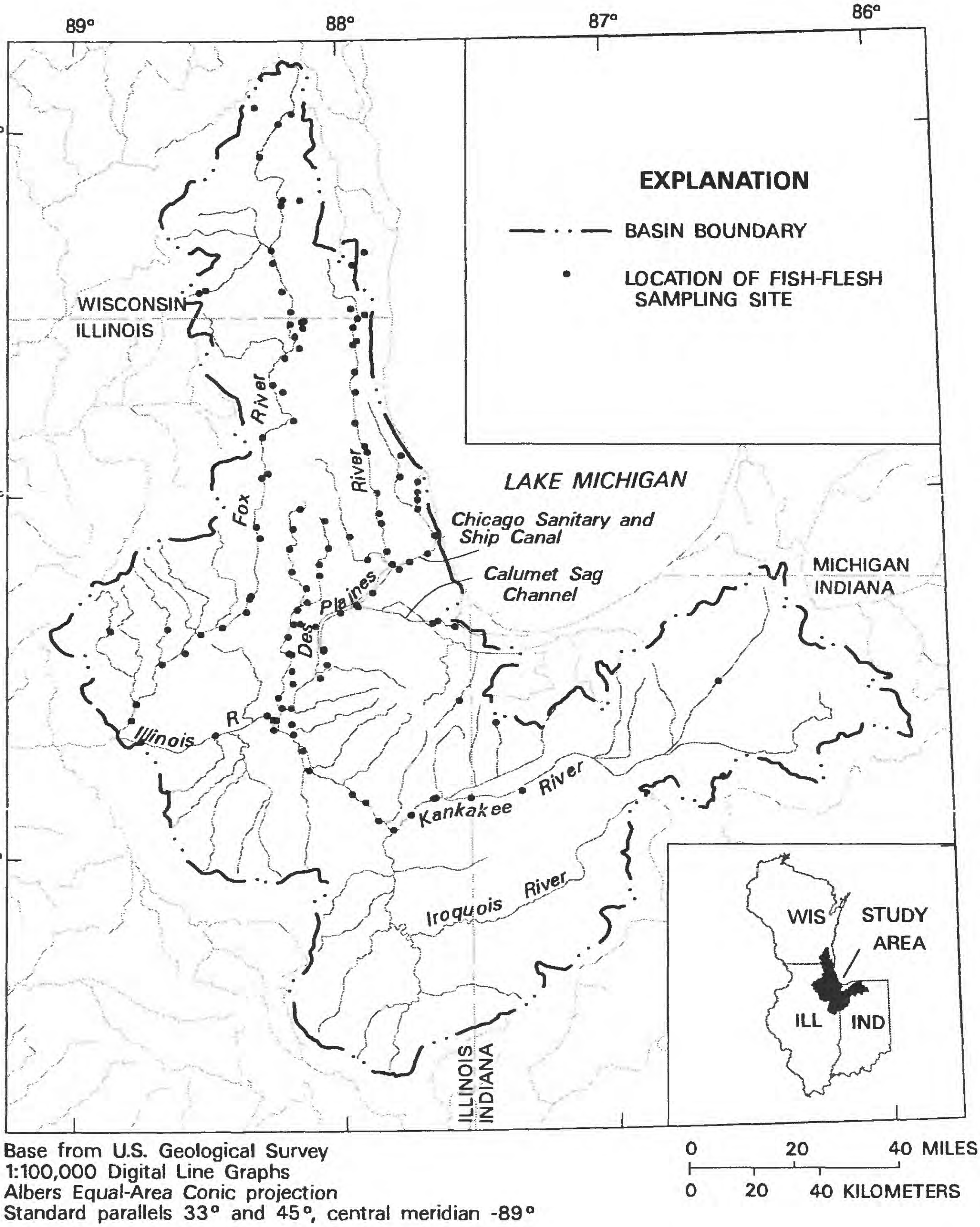
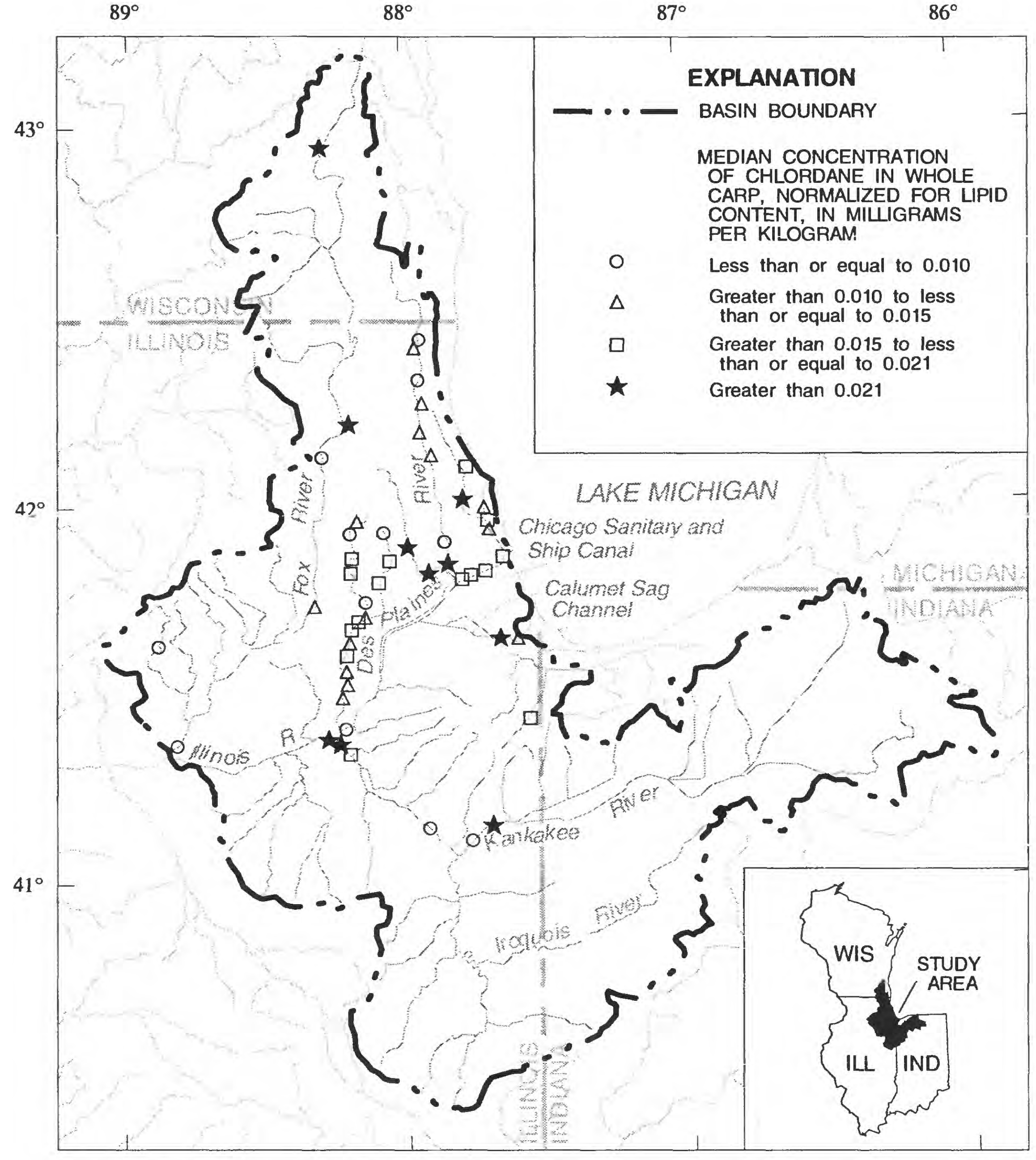
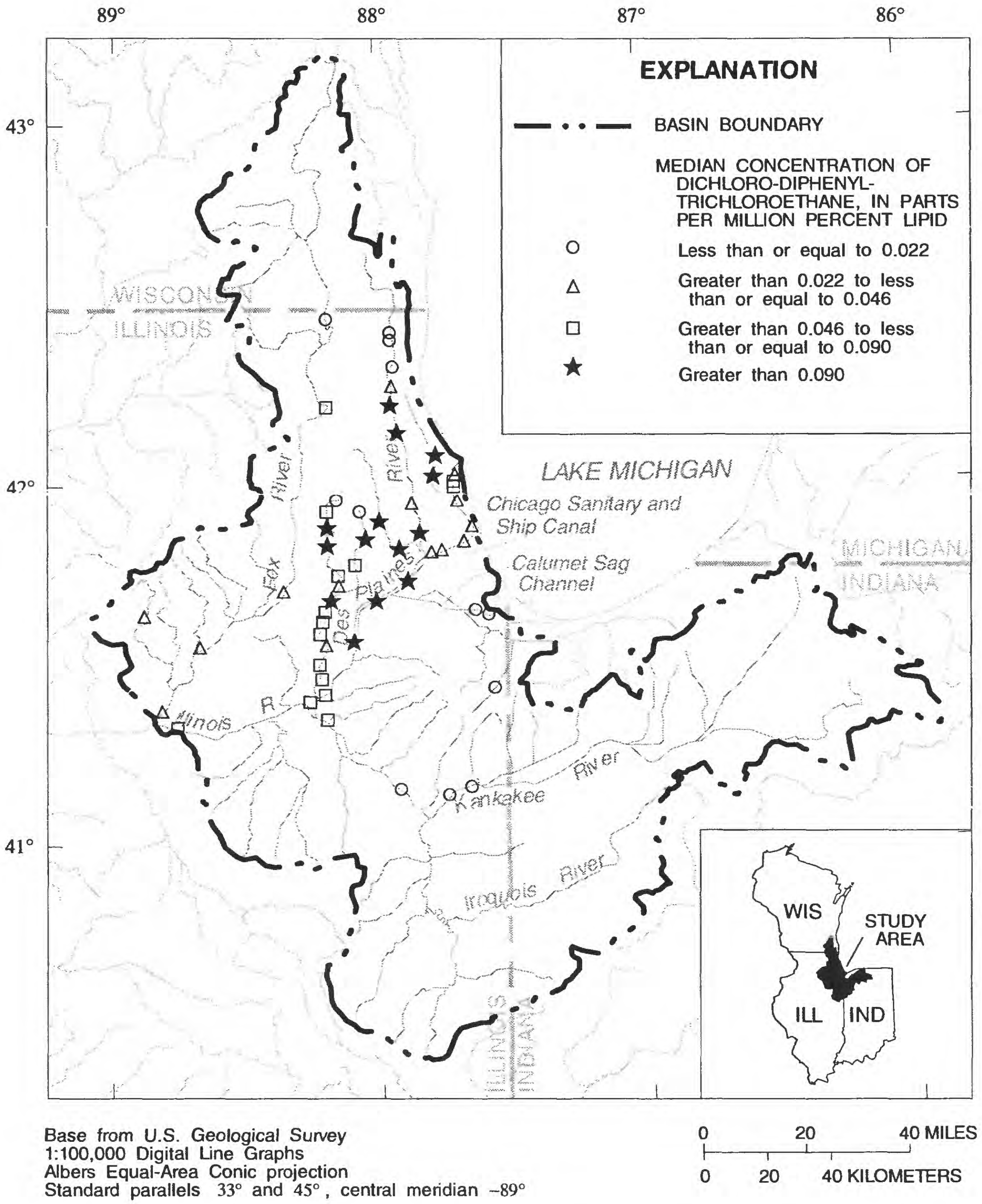


Figure 19. Location of stations in the upper Illinois River Basin sampled for synthetic organic compounds in fish tissue by the Illinois Environmental Protection Agency and the Indiana and Wisconsin Departments of Natural Resources, 1978–88.



Base from U.S. Geological Survey
1:100,000 Digital Line Graphs
Albers Equal-Area Conic projection
Standard parallels 33° and 45°, central meridian –89°

Figure 20. Spatial distribution of chlordane concentrations in whole carp in the upper Illinois River Basin, 1978–88.



Base from U.S. Geological Survey
1:100,000 Digital Line Graphs
Albers Equal-Area Conic projection
Standard parallels 33° and 45°, central meridian –89°

Figure 21. Spatial distribution of dichloro-diphenyl-trichloroethane (DDT) concentration analogs in whole carp in the upper Illinois River Basin, 1978–88.

sites with concentrations of SOC's in fish tissue higher than the USFDA advisory level are listed in table 27. PCB's were the only compounds with concentrations higher than the USFDA advisory levels. The location of the sites where tissue samples for PCB's were collected and the location of the sites where the fish-tissue-consumption advisory level was exceeded are shown in figure 24. All sites that had concentrations

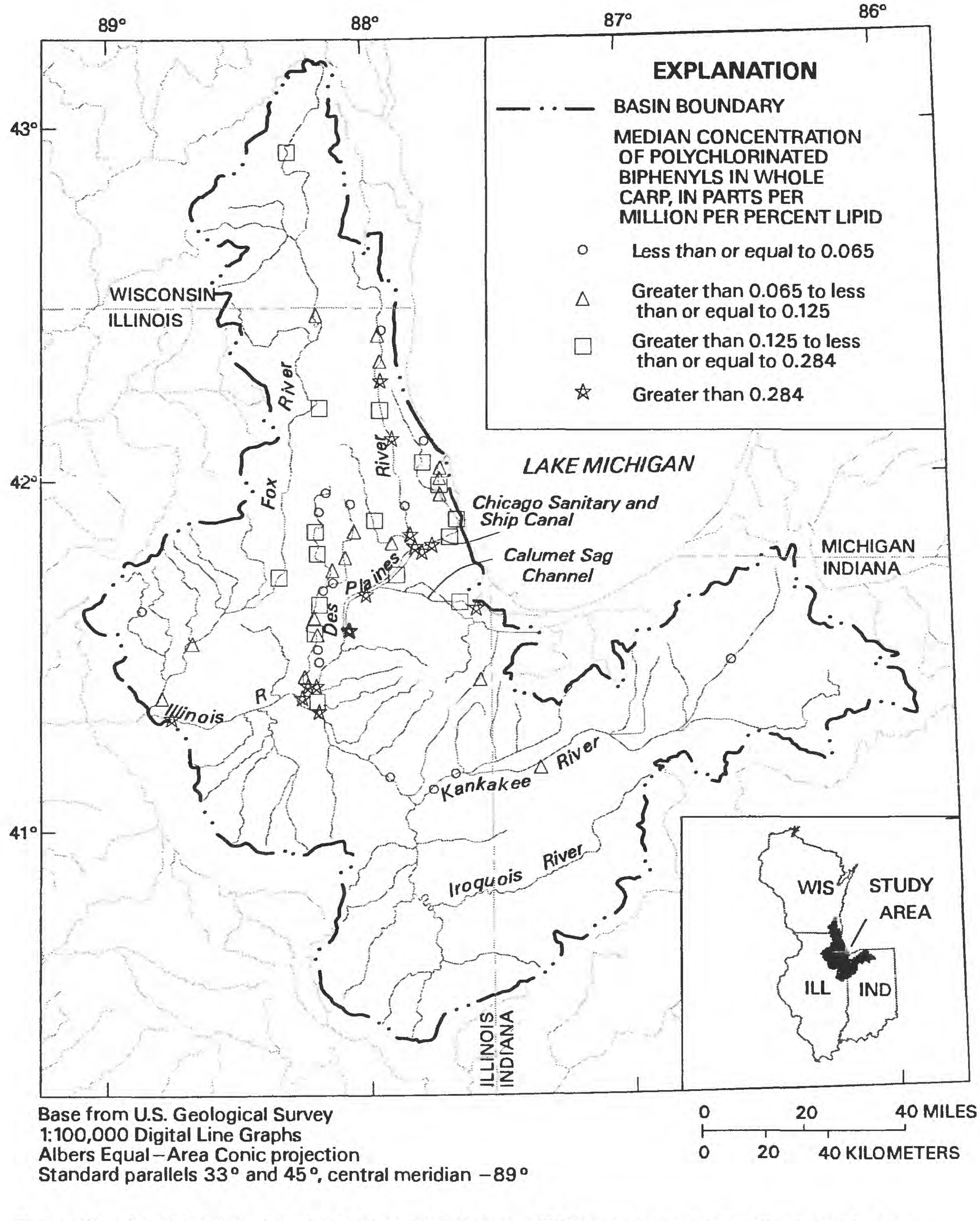
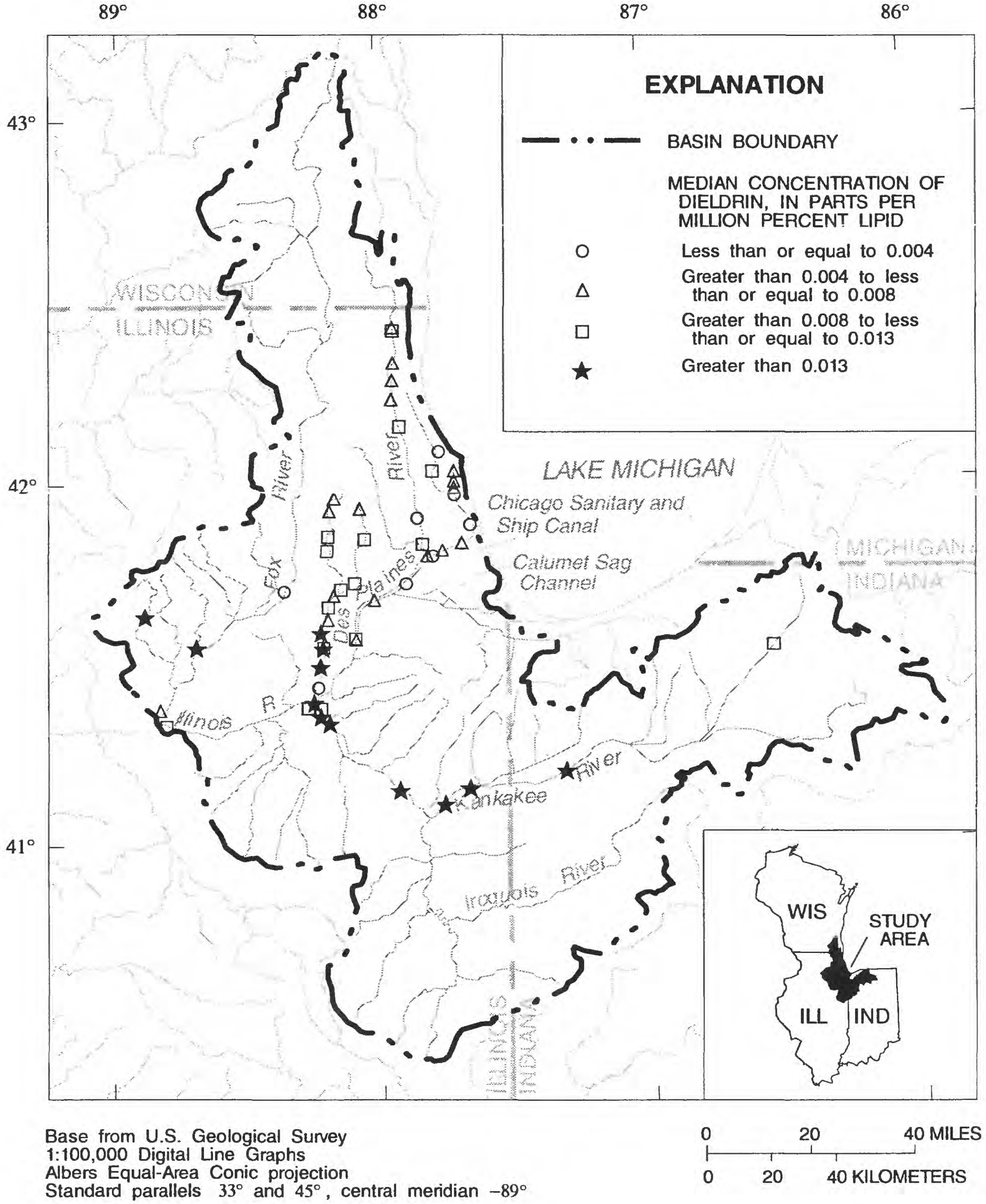


Figure 22. Spatial distribution of polychlorinated biphenyl (PCB) concentrations in whole carp in the upper Illinois River Basin, 1978–88.

exceeding the USFDA advisory level were on the Illinois and Des Plaines Rivers in and downstream from Chicago.

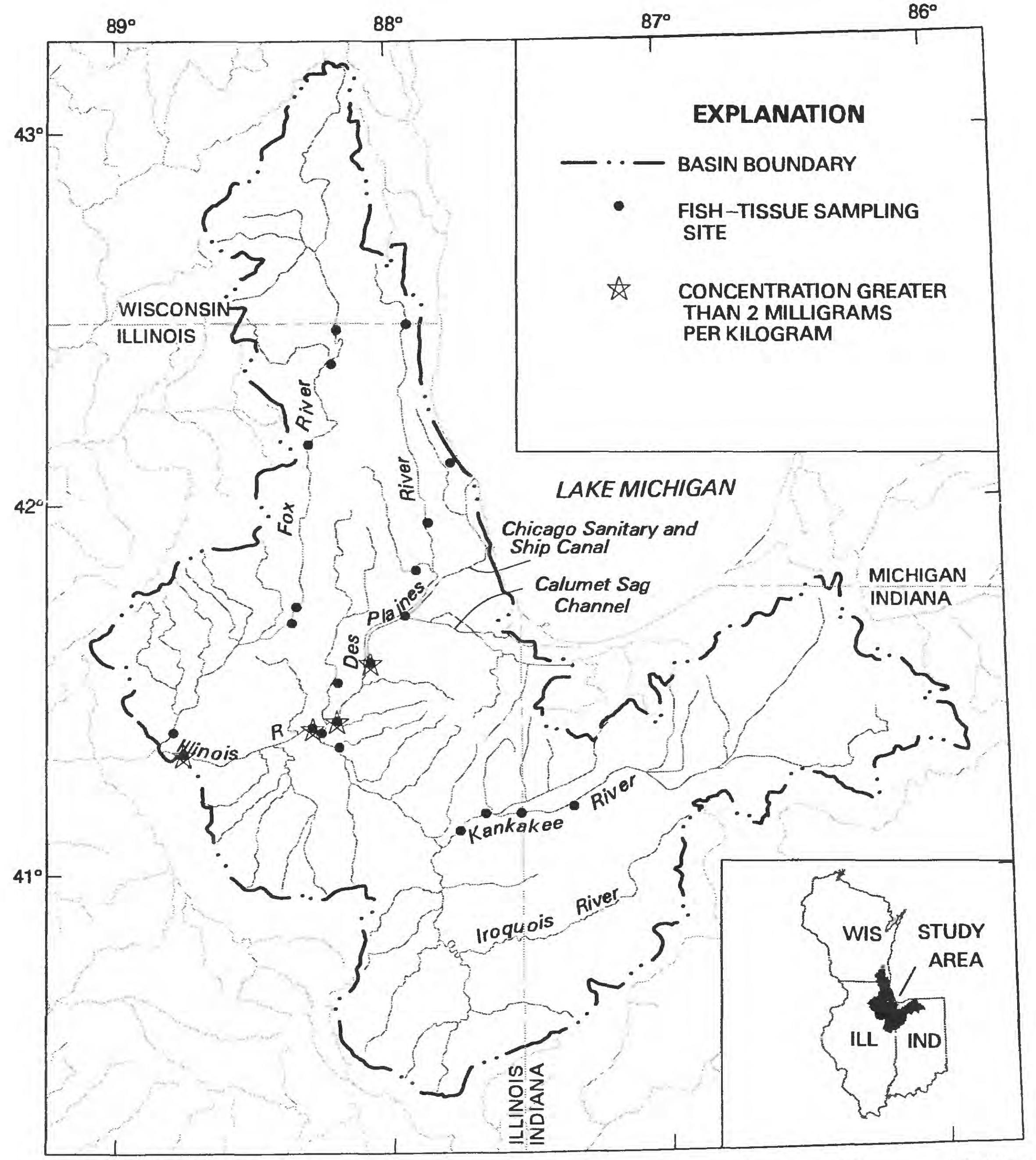
Fish-tissue consumption advisories are based on concentrations of specific SOC's. If concentrations of several SOC's are high, additive or synergistic toxicities also may be important. Correlations among ranked SOC concentrations in whole carp for raw and lipid-normalized data are shown in table 28. Correlations were higher than 0.50 in the raw data among total



Base from U.S. Geological Survey
1:100,000 Digital Line Graphs
Albers Equal-Area Conic projection
Standard parallels 33° and 45°, central meridian −89°

Figure 23. Spatial distribution of dieldrin concentrations in whole carp in the upper Illinois River Basin, 1978–88.

chlordane, total PCB, total DDT, and heptachlor epoxide. Correlations among these compounds and dieldrin were lower than 0.50. Correlations were not strong (less than 0.50) in the lipid-normalized data.



Base from U.S. Geological Survey
1:100,000 Digital Line Graphs
Albers Equal-Area Conic projection
Standard parallels 33° and 45°, central meridian −89°

Figure 24. Spatial distribution of polychlorinated biphenyl (PCB) concentrations in fish tissue in the upper Illinois River Basin, 1978–88.

Comparisons of Synthetic Organic Compounds in Water, Sediment, and Biota

The data summarized in this section provide information on the extent and distribution of SOC's in the upper Illinois River Basin. Interpretations include the general ranges of SOC concentrations in the three media of the aquatic environment (water, sediment, and biota), observations of the distribution of the sampled SOC's, and observations of correlations among SOC's by sample. However, difficulties in data interpretation also are apparent, especially in more complex statistical analyses based on data pooled from previous investigations. Determination of time trends of the sediment data or of loads of SOC's was not possible with the available data. Averages of SOC concentrations in the basin also are questionable because of the known bias in locating sampling sites near the main stems of rivers and possible bias of locating sites near point sources.

Many of the analyses performed resulted in concentrations less than the MRL. Distribution of concentrations less than the MRL was not uniform for compounds measured over the three media. Insoluble compounds were detected in the streambed sediment and fish tissue but not in the water column. Soluble compounds were detected in the water column and generally were not sampled in the streambed or fish-tissue samples. Compounds can remain undetected in water samples although they are present in the aquatic environment in sufficient quantities to be concentrated in fish. Therefore, water-column sampling for insoluble SOC's is of little benefit where MRL's are applied.

Although streambed surveys of insoluble organic compounds are effective for showing the distribution of these compounds, loads cannot be computed without representative sampling of the water column. Loads are necessary to determine whether and to what extent SOC's in sediments in the lower part of the upper Illinois River Basin are transported from upstream locations.

Soluble compounds were determined more readily than insoluble compounds in water-column sampling. It was possible to observe spatial distribution patterns where sampling included enough stations and samples were collected in different seasons. Because concentrations of soluble compounds in water columns are more variable by season and river stage, more samples are required to adequately describe conditions in water than in streambed sediment. In particular, compounds associated with nonpoint sources, such as pesticides, should be investigated in relation to storm hydrographs.

PESTICIDES AND OTHER SYNTHETIC ORGANIC COMPOUNDS IN WATER, SEDIMENT, AND BIOTA

The following sections provide information collected during 1987–90 on the distribution of pesticides and other SOC's in the upper Illinois River Basin. Data from the NAWQA project and other data-collection activities are summarized to describe the pesticides and other SOC's detected and their concentrations, spatial and temporal variability, relations among compounds in each of the three media sampled, and relations of compounds among sediment and biota. In this report, biota refers to the aquatic organisms collected in streams of the study area.

Water

Water samples were collected and analyzed for soluble pesticides, including insecticides and herbicides, at urban and agricultural stations in 1988 and 1989, and for selected triazine and chloro-acetanilide herbicides in an agricultural subbasin in 1990. Water samples were collected and analyzed for VOC's and SVOC's in a synoptic survey in 1988, and for VOC's in samples collected monthly from June 1988 through March 1990. Each of these sampling efforts included extensive QA/QC measures.

Quality-Assurance Results for Pesticides

Recovery of triazine herbicides in ambient-water field spikes and a laboratory spike during Phase I sampling ranged from 90 to 120 percent (Sullivan and Terrio, 1994). Recovery of chlorophenoxy-acid herbicides and organophosphate insecticides from the spiked samples was near zero percent except for trifluralin and prometryne (which ranged from 90 to 100 percent). This low recovery may be because of the complex steps required for analysis of these pesticides or perhaps from an interference in the sample matrix (M.W. Sandstrom, U.S. Geological Survey, oral commun., 1991). Reagent-water blanks were not available to determine if the problem was matrix interference. Therefore, the reported results of recovery for dicamba, picloram, silvex, 2,4,5-T, diazinon, malathion, and parathion for samples collected in Phase I may be low. The laboratory analyses of two field-split samples—one collected at an urban station and one collected at an agricultural station—are presented in Sullivan and Terrio (1994) and indicated good agreement for the analyte recoveries.

Spikes analyzed during Phase II, similar to those analyzed in Phase I, also indicated recovery of triazine herbicides from 90 to 120 percent. The analytical results of cross-section samples collected concurrently with samples from the automatic sampler at the Iroquois River near Chebanse, Ill. (map reference number 28), are presented in table 12. Little difference is indicated, which is attributable to the various sampling techniques.

The ELISA technique was developed as a screening tool for determining the presence/absence of atrazine and alachlor. However, analysis of herbicide sample splits during Phase II sampling by ELISA and GC/MS techniques indicates a linear relation between ELISA results for triazines and GC/MS results for atrazine (fig. 25). The relation between ELISA results for chloro-acetanilides and GC/MS results for alachlor was not linear (fig. 25).

The relation of triazine and chloro-acetanilides, determined by ELISA, to atrazine and alachlor concentrations, as determined by GC/MS, varies between river basins and possibly between stations within river basins (D.A. Goolsby, U.S. Geological Survey, oral commun., 1991). The results of Kruskil-Wallis tests showed that the means of the ratios of triazine and alachlor concentrations determined with ELISA to the atrazine and alachlor concentrations determined with GC/MS were not significantly different among stations (alpha = 0.10). Because the Kruskil-Wallis test showed no significant differences in concentrations among stations and a linear relation was indicated between values determined with ELISA and GC/MS, these results from all Kankakee and Iroquois River stations were combined to develop a regression model to determine "actual" (defined here as the concentration determined by GC/MS) atrazine and alachlor concentrations using results from ELISA sample analyses. A one-way ANOVA of the residuals from the two regression equations confirmed that differences among stations were not statistically different (alpha = 0.10). The regression equation was then applied to all triazine and chloro-acetanilide values determined with ELISA to indicate temporal patterns of atrazine and alachlor concentrations during runoff. The regression for atrazine indicated an adjusted R-squared value of 0.86, from the equation

$$\text{Atrazine} = 0.43\,(\text{triazine}) + 0.90, \qquad (1)$$

where atrazine is the determined atrazine concentration, and triazine is the triazine concentration determined with ELISA.

The regression analysis for alachlor was done on log-transformed data to eliminate negative calculated values. The adjusted R-squared value for the regression was 0.41, as calculated from the equation

$$\ln\,(\text{Alachlor}) = 1.34 \times [\ln\,(\text{chloro-acetanilide})] - 2.39, \qquad (2)$$

where alachlor is the predicted alachlor concentration, chloro-acetanilide is the chloro-acetanilide concentration determined with ELISA, and ln is the natural (base e) logarithm.

Results of NAWQA Phase II herbicide sampling in the Kankakee and Iroquois River Basins indicated that triazine herbicides in streams were mostly in the dissolved phase. This was expected because of the relatively high solubility of these herbicides. The results of a Wilcoxon Matched-Pairs Signed-Ranks test on 27 sample splits that were analyzed for total and dissolved herbicide concentrations by GC/MS (table 29) indicated that the concentrations of triazine herbicide were statistically equal (p=0.05) in the total and dissolved phases, except for cyanazine and simazine. The reason for the variability in concentration of these two compounds is not clear, because both are soluble and expected to be found predominantly in the dissolved phase. Summary statistics for the dissolved and total phases of the 27 sample splits analyzed with GC/MS are listed in table 30.

Detections and Concentrations of Pesticides in Urban and Agricultural Areas of the Upper Illinois River Basin, 1988–89

The results of sampling indicate that the total number of pesticides detected in each land-use category was the same. In both urban and agricultural areas, 17 different pesticides (though not the same 17 in both areas) were detected at least once. Summary statistics for pesticide samples collected in 1988 and 1989 are listed in tables 31 and 32, respectively. The number of pesticides detected within pesticide classes

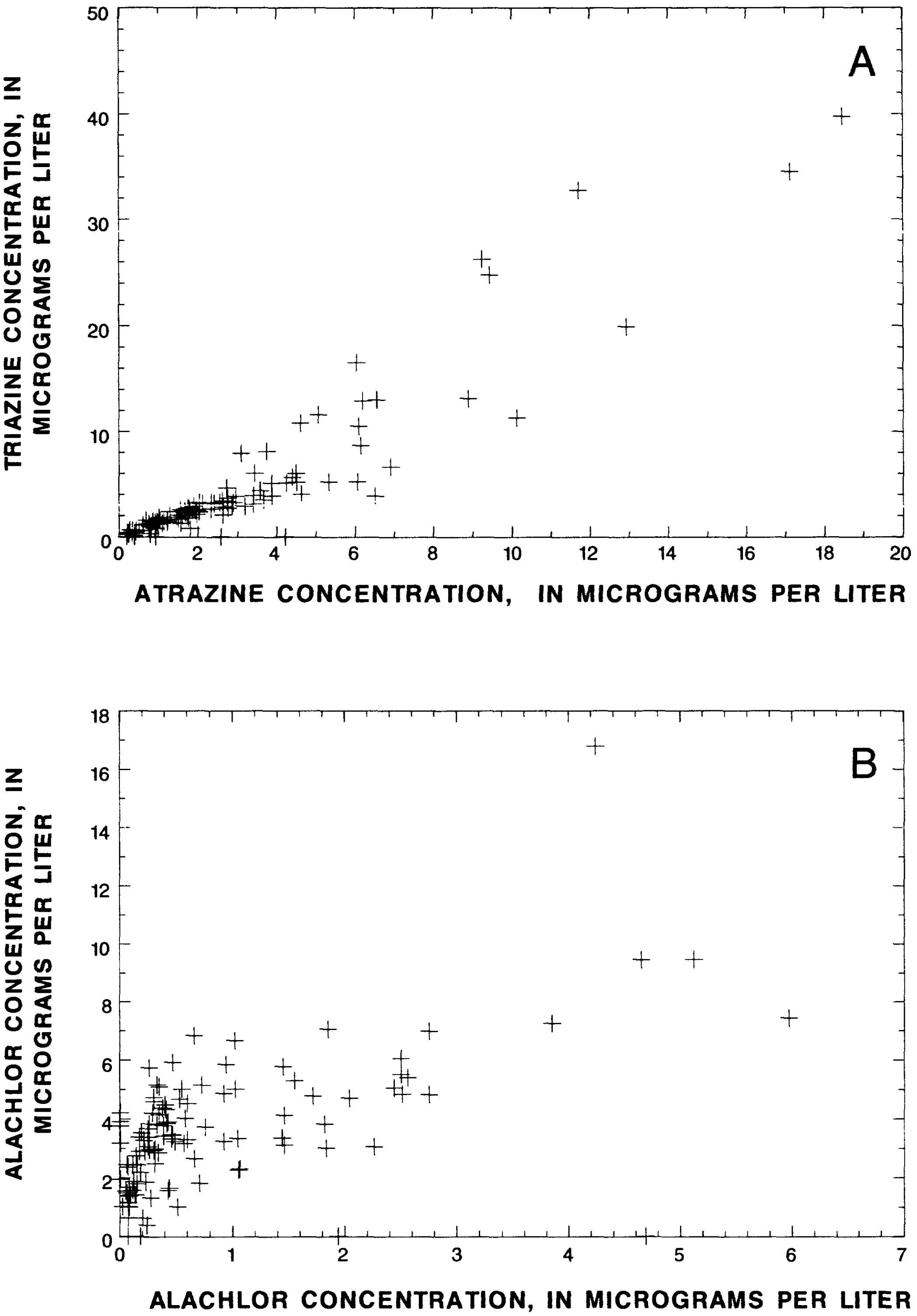


Figure 25. Scatterplots of (A) triazine concentrations determined by enzyme-linked immunosorbent assay techniques in relation to atrazine concentrations determined by gas-chromatography/mass spectrometry, and (B) alachlor concentrations determined by enzyme-linked immunosorbent assay techniques in relation to alachlor concentrations determined by gas-chromatography/mass spectrometry.

also was similar between samples from urban and agricultural areas. However, the insecticides diazinon and malathion were detected almost exclusively in urban areas.

Percentage of detections are shown in figure 26, and maximum concentrations of pesticides by land use, that were detected in at least 50 percent of Phase I samples from either urban or agricultural stations are shown in figure 27. Based on percent detections, cyanazine, metolachlor, and metribuzin are predominantly agricultural herbicides. Alachlor was detected in similar percentages of samples from each land-use category, but maximum and median concentrations were much higher in agricultural areas. Urban pesticides included bromacil (which was detected in 60 percent of urban samples but was not detected in any agricultural samples), prometon, simazine, diazinon, and malathion. Dicamba was detected in similar concentrations and percentages of samples in each of the two land-use categories. Higher concentrations of 2,4-D were detected in urban samples, although it also was detected in a high percentage of agricultural samples. Atrazine was detected in 100 percent of urban and agricultural samples, indicating the widespread use of this herbicide.

The pesticide with the second-highest and highest median concentration at urban stations in 1988 and 1989, respectively, was the chlorophenoxy-acid herbicide 2,4-D. The presence of 2,4-D in surface waters is of concern because the compound is highly toxic to fish (Moores, 1981) and persistent for up to 3 months in the stream environment. The insecticides diazinon and malathion were detected in nearly all samples from urban stations, but the reported concentrations were low. However, as discussed in the "Quality-Assurance Results for Pesticides" section, the concentrations of these pesticides may be underreported. In 1988, bromacil, a uracil herbicide, was reported at the highest concentration (30 µg/L) of any of the pesticides in the Phase I sampling in a sample collected at an urban station, Addison Creek at Bellwood, Ill. (map reference number 39) (fig. 6).

The pesticides detected at the highest median concentrations in samples collected at urban stations are the same that Taylor and others (1989) list as the highest-use pesticides in the urban areas of the upper Illinois River Basin. The herbicides most used by homeowners and lawn-care professionals include 2,4-D, dicamba, and combinations of these and other chemicals (Taylor and others, 1989). The insecticides diazinon and malathion are used by park, public-works, and highway departments, and by tree-care companies. Organophosphorus insecticides, such as these, have low persistence in the environment, so detection in a high percentage of samples indicates fairly continuous usage. Atrazine and simazine, detected in all samples at urban stations, are used extensively in parks—atrazine for weed control and simazine as an algicide. Both herbicides are persistent in soil for an average from 6 to 24 months. Because many parks are near surface waters, the potential for movement of these compounds to surface waters is high. Bromacil is an herbicide used in the upper Illinois River Basin primarily for weed control along highways.

The herbicides identified as "agricultural" from Phase I sampling included metolachlor, cyanazine, and alachlor. These three herbicides along with atrazine, the single most heavily applied herbicide, were applied to more acres of corn than any other chemical in Illinois in 1988 (University of Illinois College of Agriculture, 1990) (table 1). Metribuzin, an herbicide used for soybeans, is applied on more acres than cyanazine but at lower rates per acre.

Thus, the occurrence and distribution of pesticides detected in the stream environment during the study reflect the pattern and usage of these compounds. Currently (1992), the USEPA has established drinking-water standards for four herbicides (Federal Register, 1991): alachlor, atrazine, 2,4-D, and simazine (table 33). Atrazine concentration exceeded the MCL in 4 of 17 samples (24 percent) from urban stations, and in 4 of 8 samples (50 percent) from agricultural stations. Alachlor exceeded the MCL in three agricultural samples, and 2,4-D and simazine concentrations did not exceed the MCL in any samples. All of the exceedances were in samples collected during runoff.

High concentrations of herbicides in runoff detected during the study were similar to those noted by Baker (1985). These findings were used in the sampling scheme for Phase II, which targeted runoff periods and stations in agricultural areas.

Concentrations and Seasonal Distribution of Triazine Herbicides in the Kankakee and Iroquois River Basins, 1990

Summary statistics for 68 samples collected during Phase II sampling in the Kankakee and Iroquois River Basins that were analyzed with GC/MS for selected triazine and chloro-acetanilide herbicides and 2 herbicide metabolites are listed in table 34. The

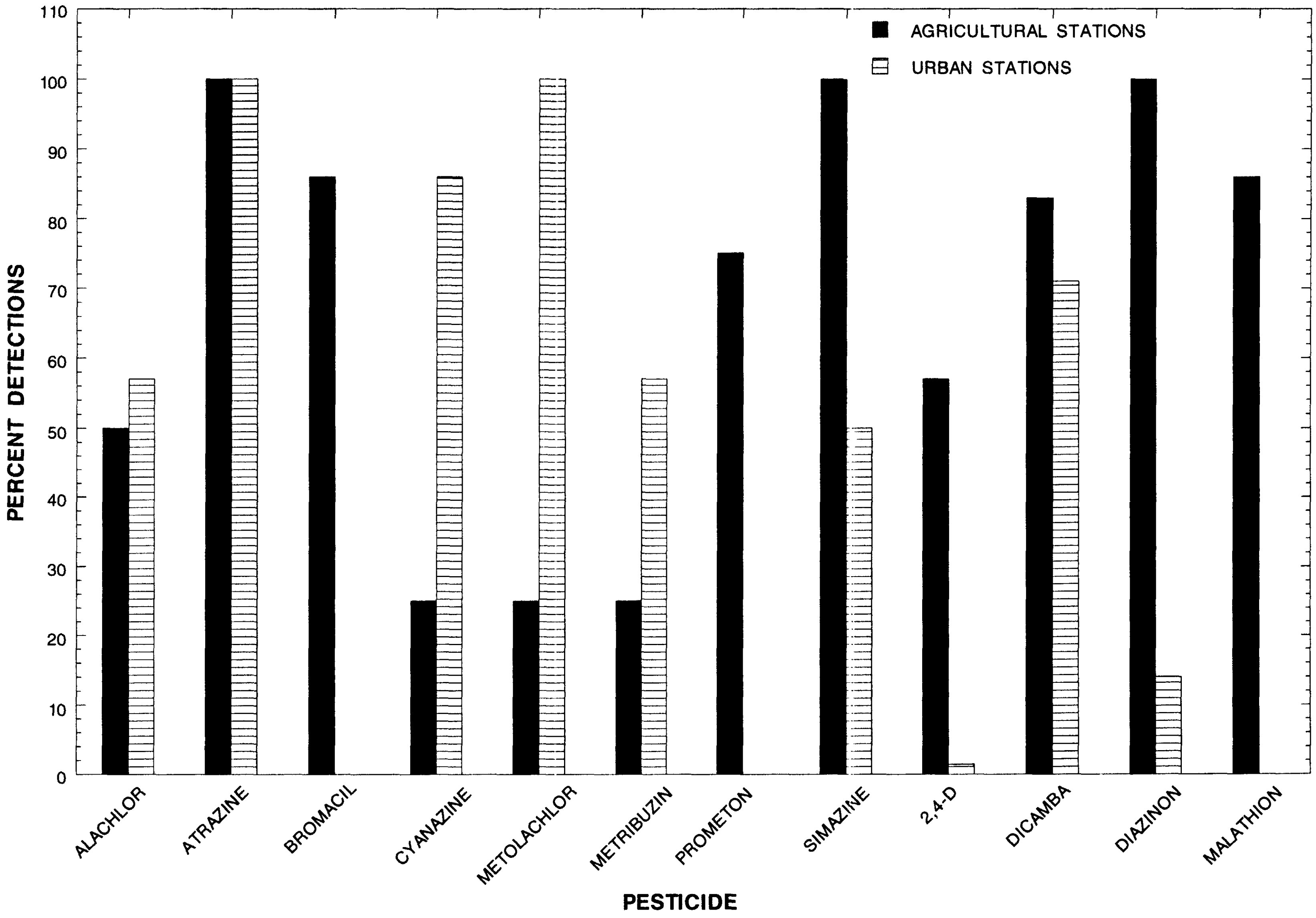


Figure 26. Percentage of detections of selected pesticides in water from urban and agricultural stations in the upper Illinois River Basin, 1988–89.

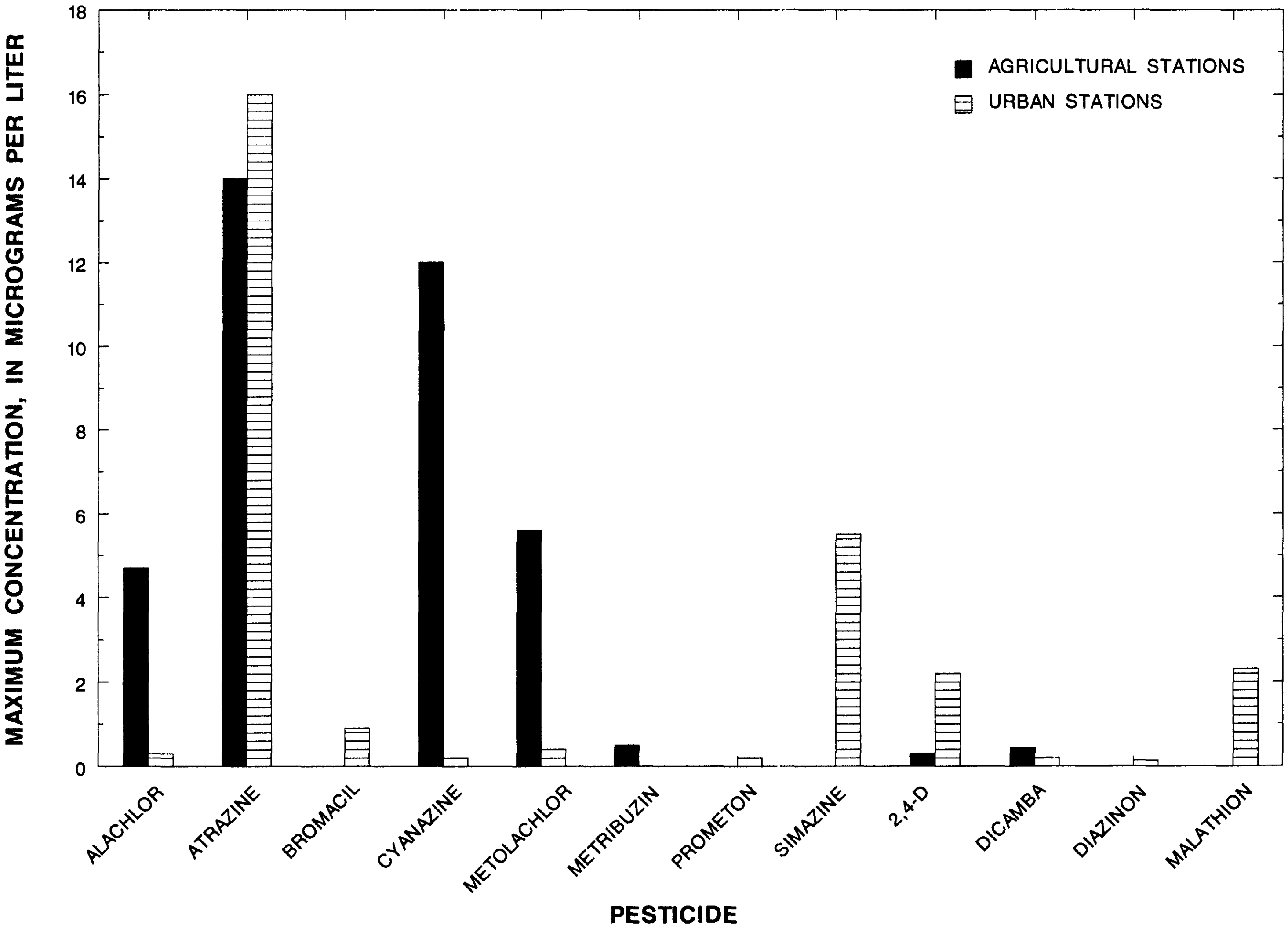


Figure 27. Maximum concentrations of selected pesticides in water from urban and agricultural stations in the upper Illinois River Basin, 1988–89.

percentiles shown are not necessarily representative of average conditions over the period of sampling and are certainly not representative of year-round conditions in these streams—the data are biased toward runoff periods and are not time or discharge weighted. The data are valuable, however, for discerning relative concentrations of the various herbicides analyzed.

Atrazine and metolachlor were detected in all of the samples collected during Phase II. Desethylatrazine and desisopropylatrazine, products of atrazine decomposition, were detected in 100 and 94 percent of samples, respectively. A higher median concentration was determined for desethylatrazine than alachlor in the study area. As indicated by the low concentrations at the 75th and 90th percentiles, however, concentrations of this atrazine metabolite varied less than the herbicides. The 90th percentile concentrations of atrazine, cyanazine, metolachlor, and alachlor were from about two to almost six times higher than the 90th percentile concentration of desethylatrazine.

The four herbicides having the highest median concentrations, listed in descending order, were atrazine, cyanazine, metolachlor, and alachlor. These same four herbicides were identified in the Phase I sampling as having the highest median concentrations in agricultural areas and were applied on more acres of corn than any other pesticides.

The maximum concentrations of herbicides in the Phase II sampling are listed in table 34. The largest maximum concentrations of dissolved pesticides were for cyanazine and atrazine at 36.5 and 20.2 μg/L, respectively. These herbicides were detected in samples collected at Sugar Creek at Milford, Ill. (map reference number 22), in the Iroquois River Basin (fig. 7) during a runoff period, which began on May 16 (Sullivan and Terrio, 1994).

Maximum concentrations of herbicides at Kankakee River stations may have occurred before sampling at those stations began. Because of logistical problems, a runoff period in mid-May at the Kankakee River stations was not sampled. This was the largest runoff at the Kankakee River stations during the period of sampling. This period was concurrent with the completion of corn planting in the area and at about the same time when maximum herbicide concentrations were detected at Iroquois River stations. The maximum observed concentration of dissolved atrazine, in a sample collected in late July, at Yellow River at Knox, Ind. (map reference number 5), on the Kankakee River (fig. 7) was 4.63 μg/L (Sullivan and Terrio, 1994).

For comparison, maximum concentrations of herbicides detected in areas outside the upper Illinois River Basin are listed in table 35. In small basins in Ohio, Baker (1988) found concentrations of atrazine as high as 240 μg/L from a small watershed (4.4 mi^2) and maximum cyanazine concentrations as high as 86 μg/L from another small watershed (17 mi^2). In larger basins studied by Goolsby and others (1991), maximum concentrations of 10 μg/L for atrazine and 7.3 μg/L for cyanazine were detected in a 86,000 mi^2 watershed. Similar to the upper Illinois River Basin NAWQA data, these maximum concentrations were detected during runoff periods in the growing season.

Herbicides such as atrazine, which are water soluble and only moderately persistent in the environment, have the greatest potential to be transported off fields in runoff within about 2 weeks of application (Wauchope, 1978). The seasonal pattern of atrazine concentration (fig. 28) at the Iroquois River near Chebanse, Ill. (map reference number 28) (fig. 7), indicates this potential. The large maximum observed concentration of atrazine (about 16 μg/L) in the runoff period in mid-May (about 7,000 ft^3/s peak flow) was about four times higher than concentrations (about 4 μg/L) in a larger runoff period (about 8,500 ft^3/s peak flow) in late July. According to the U.S. Department of Agriculture and Illinois Department of Agriculture (1990a–d), herbicide application during the May runoff period was about 70 percent complete; whereas, by late July, most applications of herbicides had been completed up to 2 months earlier. However, throughout the growing season, herbicide concentrations increased during runoff periods compared to low-flow periods, indicating that these compounds generally are transported in runoff. This pattern of herbicide transport in runoff has been found throughout the "corn belt" of the United States (Thurman and others, 1991). Although high concentrations of atrazine sometimes enter streams, estimates of the amount of atrazine transported in streamflow indicate that only about 1 percent of the amount applied to cropland enters streams.

Numerous exceedances of MCL's resulted for alachlor and atrazine in Phase II samples. Simazine was not detected above the proposed MCL (3 μg/L) in any Phase II samples. The pattern of atrazine concentration over time shown in figure 29 indicates that atrazine may exceed the MCL during runoff periods. As previously discussed, MCL's are based on lifetime exposure, and the effect on human health of several

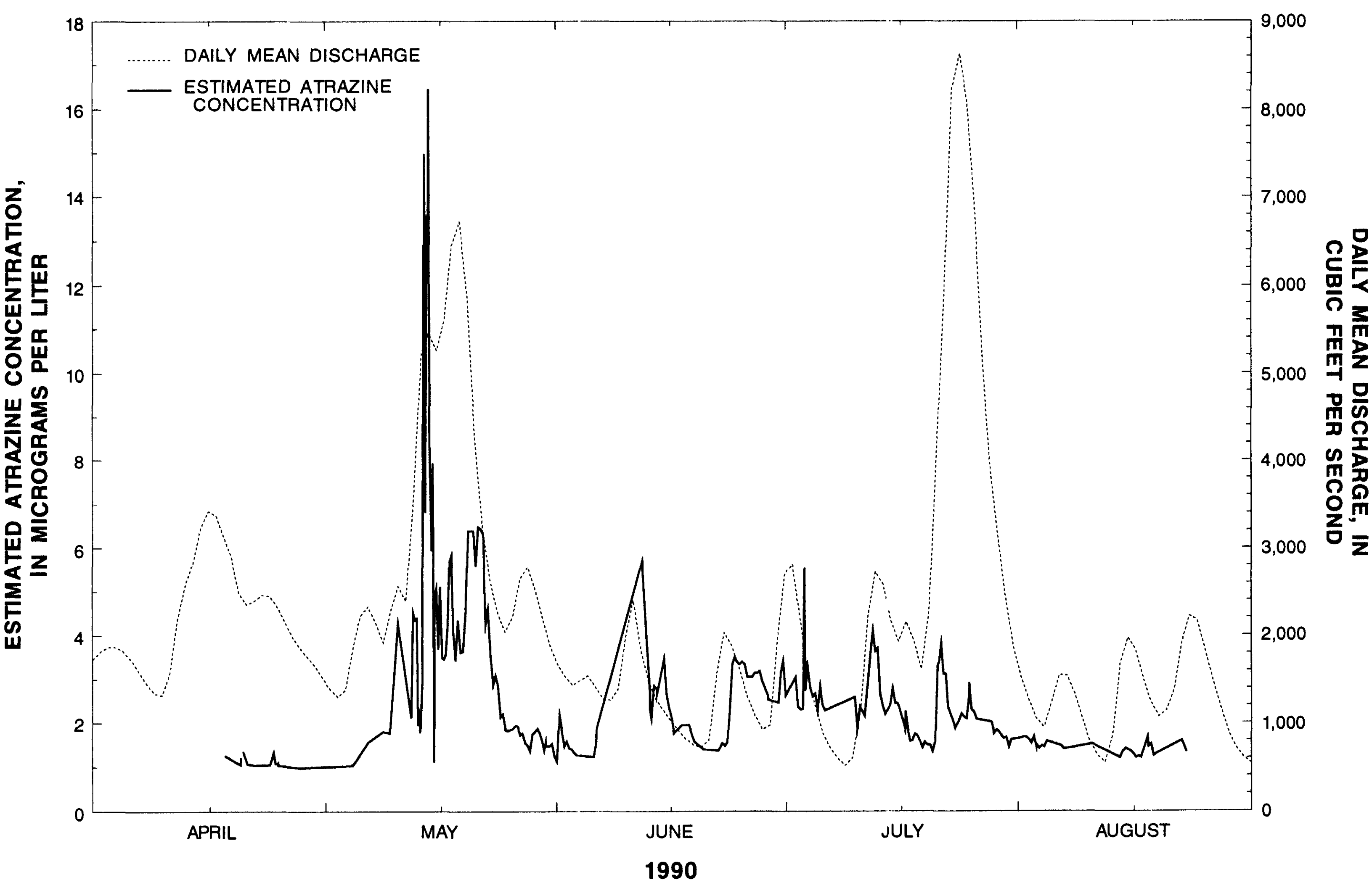


Figure 28. Daily mean discharges and estimated atrazine concentrations at Iroquois River near Chebanse, Ill., April–August 1990.

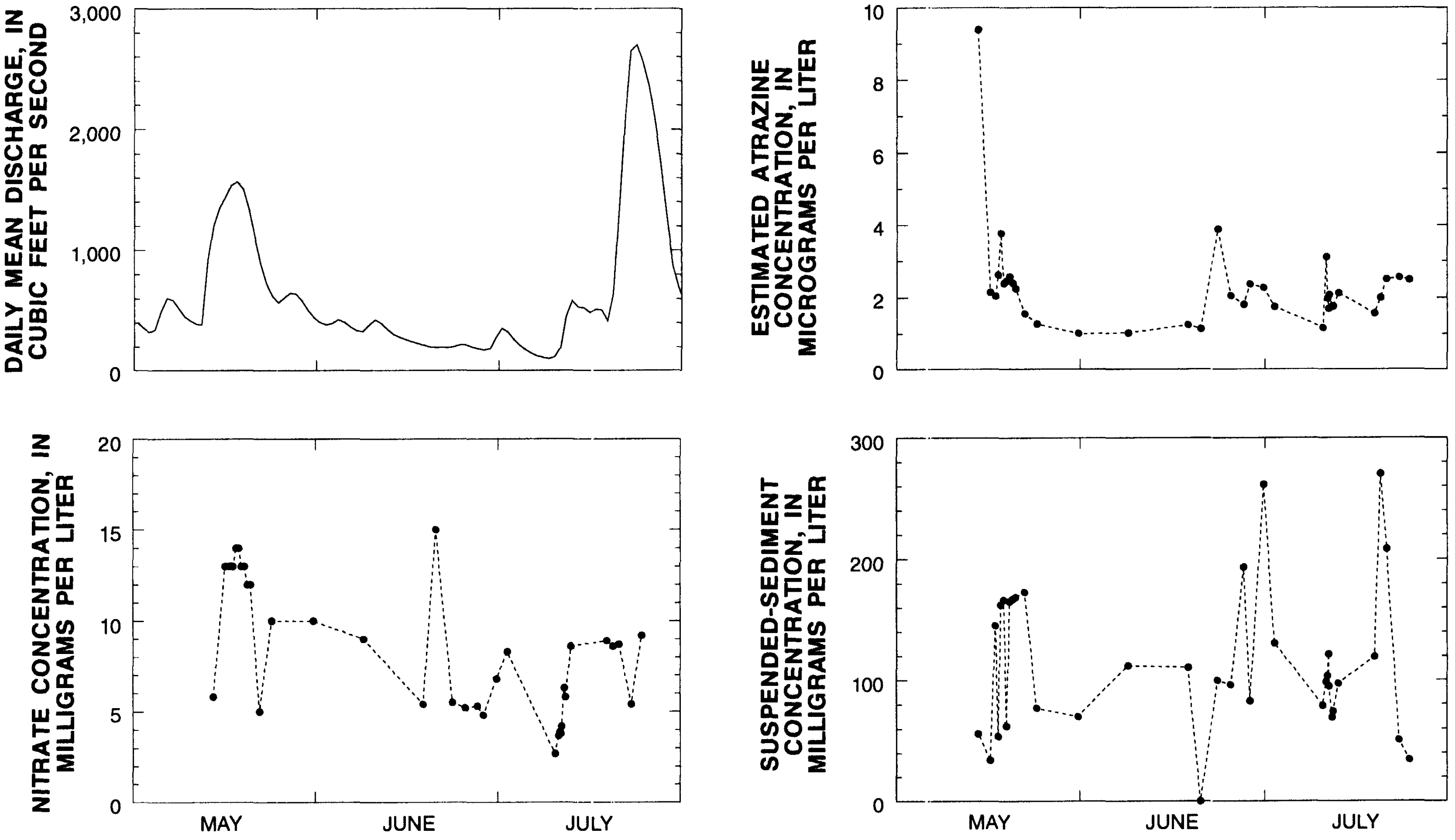


Figure 29. Discharge and concentrations of atrazine, suspended sediment, and nitrate at Iroquois River at Iroquois, Ill., May–July 1990.

days of atrazine concentrations exceeding the MCL is not known.

The atrazine concentrations observed in 1990 in the Iroquois River Basin were too low to cause acute effects on stream biota. The maximum acceptable toxicant concentration for bluegill, for example, is 90 to 500 μg/L (Macek and others, 1976), which is much higher than any observed concentrations.

Results of Spearman's rank correlation coefficient test on herbicide data collected in 1990 are listed in table 36. Only herbicides detected in at least 50 percent of samples are shown. A value greater than 0.70 generally indicates a strong correlation. The results indicate that atrazine concentrations are correlated strongly with alachlor, metolachlor, desethylatrazine, and propazine. In general, some correlation appears among many of the herbicides, indicating co-occurrence in the stream environment. This is most likely attributable to herbicides applied on corn and soybeans at similar times. As previously discussed by Colman (this report), this co-occurrence may have synergistic effects on biota and possibly on humans if the water were used for drinking and was not treated. However, the effect of this co-occurrence on human and animal health is largely unknown.

The high median concentrations of atrazine are of particular concern. The large number of samples analyzed with ELISA make temporal distributions easy to determine. Atrazine, suspended-sediment, and nitrate concentrations, and discharge over the period of sampling at three Iroquois River Basin stations are shown in figures 29–31. Certain consistent patterns of seasonal variation are evident at all three stations. For a given runoff period, as discharge increased, atrazine and suspended-sediment concentrations also increased. Later in the growing season, the proportional increase in atrazine and suspended-sediment concentrations was less for an equivalent magnitude increase in discharge.

The relation between nitrate concentration and discharge was complex and was not consistent among stations or among runoff periods at a given station. These results indicate that the factors that affect nitrate concentrations may be independent of factors that affect herbicide concentrations. This is important because the larger data bases available in most of the United States are for nitrates in surface waters.

An empirical equation to estimate atrazine concentrations was developed, based on multi-variable linear-regression analysis, with the following independent variables:

- instantaneous discharge at the time of sample collection
- magnitude of the storm (instantaneous discharge divided by long-term average discharge) at the time of sample collection
- drainage area of the sampling station
- time since pesticide application (number of days since May 13, 1990, an arbitrarily chosen date representing the approximate start of the growing season)
- suspended-sediment concentration
- limb of the hydrograph (rising, peak, or falling; or low flow)
- nitrite- plus nitrate-nitrogen concentration

The best-fit regression model was chosen based on Mallows Cp statistic (Mallows, 1964). Results of the analysis (table 37) indicate that the magnitude of the runoff during which the sample was collected explains the greatest percentage of variation in atrazine concentration.

The estimated load for the period of sampling was calculated for the Iroquois River near the Chebanse sampling site. Atrazine concentrations (estimated from eq. 1) were interpolated among sample dates. The flow-weighted concentrations were summed and compared to estimates of atrazine usage in the basin (Gianessi and Puffer, 1988). Based on the load estimate at the sampling site, less than 1 percent of the atrazine applied to fields was transported from the basin in surface waters. This result is similar for other river basins in the Midwest (Squillace and Thurman, 1992; Schottler and others, 1991).

Distribution of Volatile Organic Compounds in the Upper Illinois River Basin, 1987–90

The QA results for data collected on VOC's in water are presented in Fitzpatrick and Colman (1993) and show the data to be reliable. A Wilcoxon Matched-pairs Signed-Ranks test of 61 data pairs from collection duplicates submitted to OEPA with reported concentrations of VOC's above the MRL indicated no statistical differences in concentrations among duplicate samples. Results of analyses of standard-reference samples submitted to OEPA indicated 65 to 95 percent recovery of VOC's. Results of blind sample analyses submitted to OEPA indicated 69 to 97 percent recovery for eight VOC's, but only 36 percent for toluene. Trip blanks submitted to OEPA and NWQL indicated no

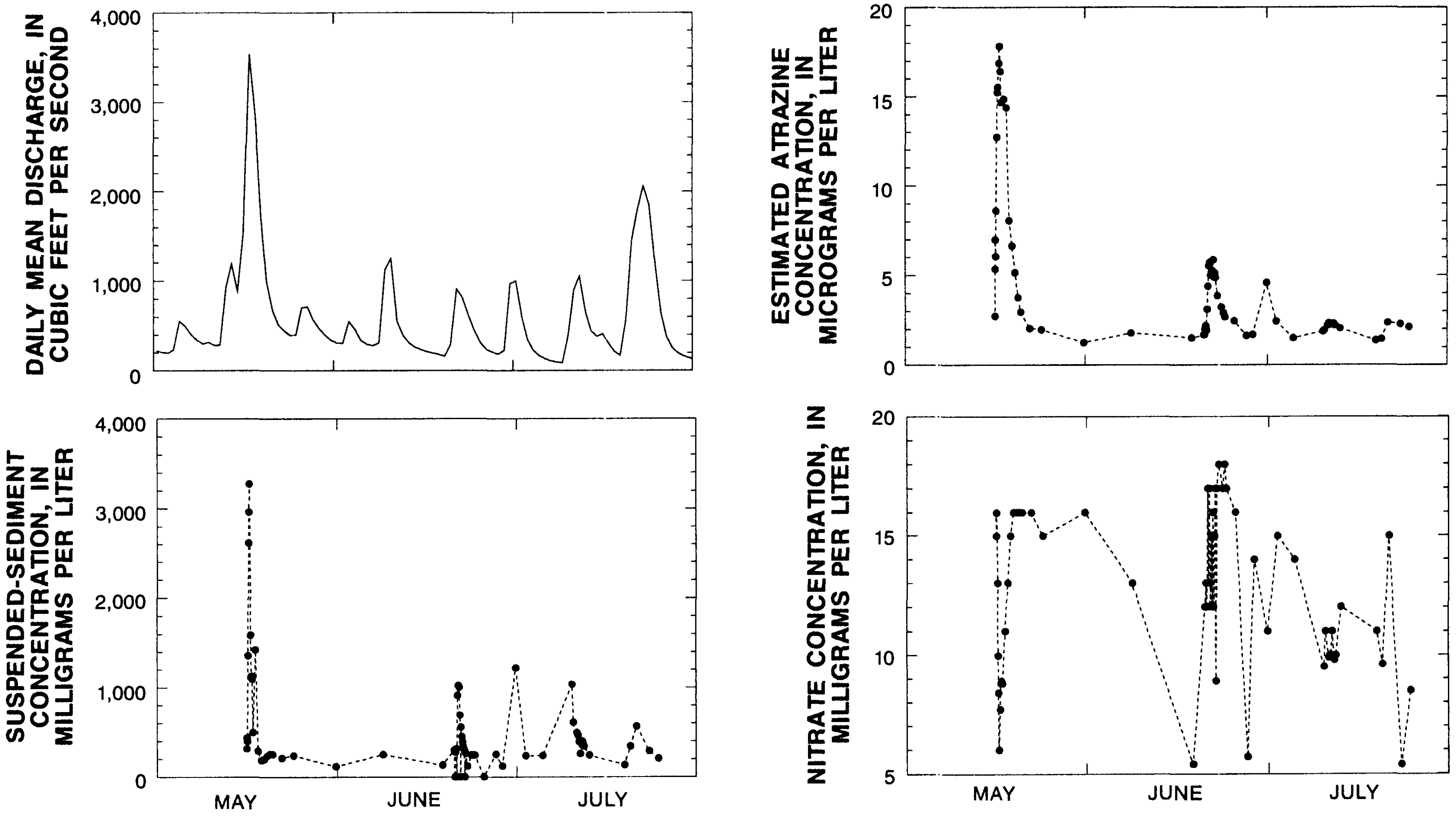


Figure 30. Discharge and concentrations of atrazine, suspended sediment, and nitrate at Sugar Creek at Milford, Ill., May–July, 1990.

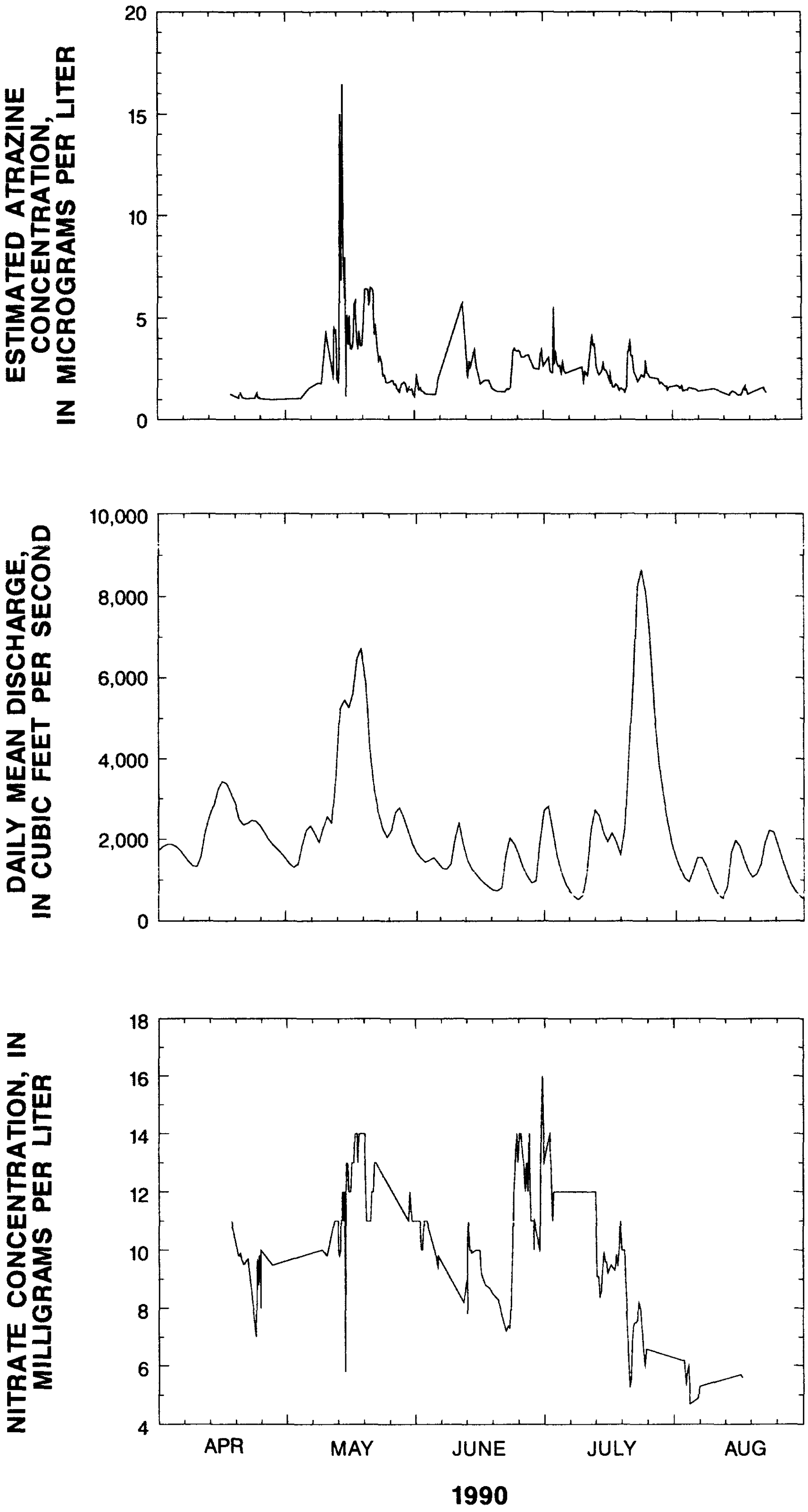


Figure 31. Discharge and concentrations of atrazine and nitrate at Iroquois River near Chebanse, Ill., April–August 1990.

contamination of most VOC's for which analyzed, with the exceptions of methylene chloride, bromoform, and chlorodibromomethane, each of which were detected multiple times but always at concentrations below 1.0 µg/L.

The data from the 1988 low-flow synoptic survey of VOC's in water indicate that 21 out of 52 (40 percent) VOC's for which analyzed were detected in at least 1sample from at least 1 station (Fitzpatrick and Colman, 1993). Chloroform was the most commonly detected VOC, and was present in samples from 13 of the 31 (42 percent) stations. Tetrachloroethylene and 1,1,1-trichloroethane each were detected at nine stations. Other compounds detected at three or more stations were chlorodibromomethane, dichlorobromomethane, 1,4-dichlorobenzene, 1,1-dichloroethane, 1,2-dichloroethane, *cis*-1,2-dichloroethene, methylene chloride, naphthalene, toluene, and trichloroethylene. Summary statistics for the compounds for which analyzed in the low-flow synoptic survey for VOC's are listed in table 38.

Samples from 2 of the 31 stations, the Chicago Sanitary and Ship Canal at Forest View, Ill. (map reference number 48), and the North Shore Channel at Devon Avenue at Chicago, Ill. (map reference number 47) (fig. 32), accounted for 28 of 76 (37 percent) of the total number of VOC detections from the synoptic survey. Each of these two stations are within 0.6 mi or less downstream from two of the largest WWTP's in the study area and also are downstream from numerous other point sources of VOC's. This pattern of VOC detections, predominantly at stations near point sources, was evident throughout the upper Illinois River Basin.

The spatial distribution of sampling stations at which two or more VOC's were detected in water samples collected during the 1988 low-flow synoptic survey is shown in figure 32. All stations, except one, are 2 mi or less downstream from a known point source. Two VOC's were detected at Iroquois River near Watseka, Ill. (map reference number 23), about 8 mi downstream from the nearest known point source, a WWTP. Elevated concentrations of 1,1,1-trichloroethane at stations in and near the city of Chicago indicate the effects on water quality of a large urban and industrial center (fig. 33). Concentrations of 1,1,1-trichloroethane decreased steadily downstream from the city and was only detected in samples collected at stations in the Des Plaines River Basin and downstream on the Illinois River.

Percentiles from the follow-up monitoring at two stations (fig. 8) are listed in table 39. Concentrations of most compounds were higher at the Chicago Sanitary and Ship Canal at Romeoville, Ill. (map reference number 55), than at the Des Plaines River at Riverside, Ill. (map reference number 40). The highest median concentrations at Romeoville were for methylene chloride and 1,2-dichloroethane. The CSSC is not a natural waterway, and most of the flow is from wastewater return flow, which is supplemented by diversions of Lake Michigan water. The concentrations of VOC's in water, when detected, generally were at or near the MRL. Long-term monitoring by the IEPA indicated that concentrations of VOC's remain near the MRL most of the time.

All 15 IEPA ISSN stations are located near point sources (Illinois Environmental Protection Agency, 1990a). At these stations, 10 of the 15 (67 percent) compounds for which analyzed have been detected at least once. Percentiles for these 10 compounds, by station, are listed in table 40. Only four stations had median concentrations of any VOC above the MRL. Four VOC's with median concentrations above the MRL were detected at the Des Plaines River near Gurnee, Ill. (map reference number 33). This was the only station where the median concentration of more than one VOC exceeded the MRL. This station is downstream from two WWTP's that discharge to the Des Plaines River. The IEPA Laboratory uses a higher MRL for most VOC's (1.0 µg/L compared with 0.01 µg/L for the laboratories used for the NAWQA samples), and this may be reflected in the lower percentages of detections in samples from the IEPA stations.

The VOC's for which MCL's have been developed are listed in table 33. Only four exceedances of MCL's were observed at two of the fixed stations during the synoptic survey and the follow-up monitoring. The observed concentration of tetrachloroethylene at the Des Plaines River at Lockport, Ill. (map reference number 42), during the 1988 low-flow synoptic survey was 5.5 µg/L, exceeding the MCL of 5 µg/L. Three exceedances were detected during the monthly fixed-station monitoring for VOC's. The concentration of trichloroethylene from a sample at the Des Plaines River at Riverside, Ill. (map reference number 40), was 11.7 µg/L on September 12, 1988, which was more than twice the MCL of 5 µg/L.

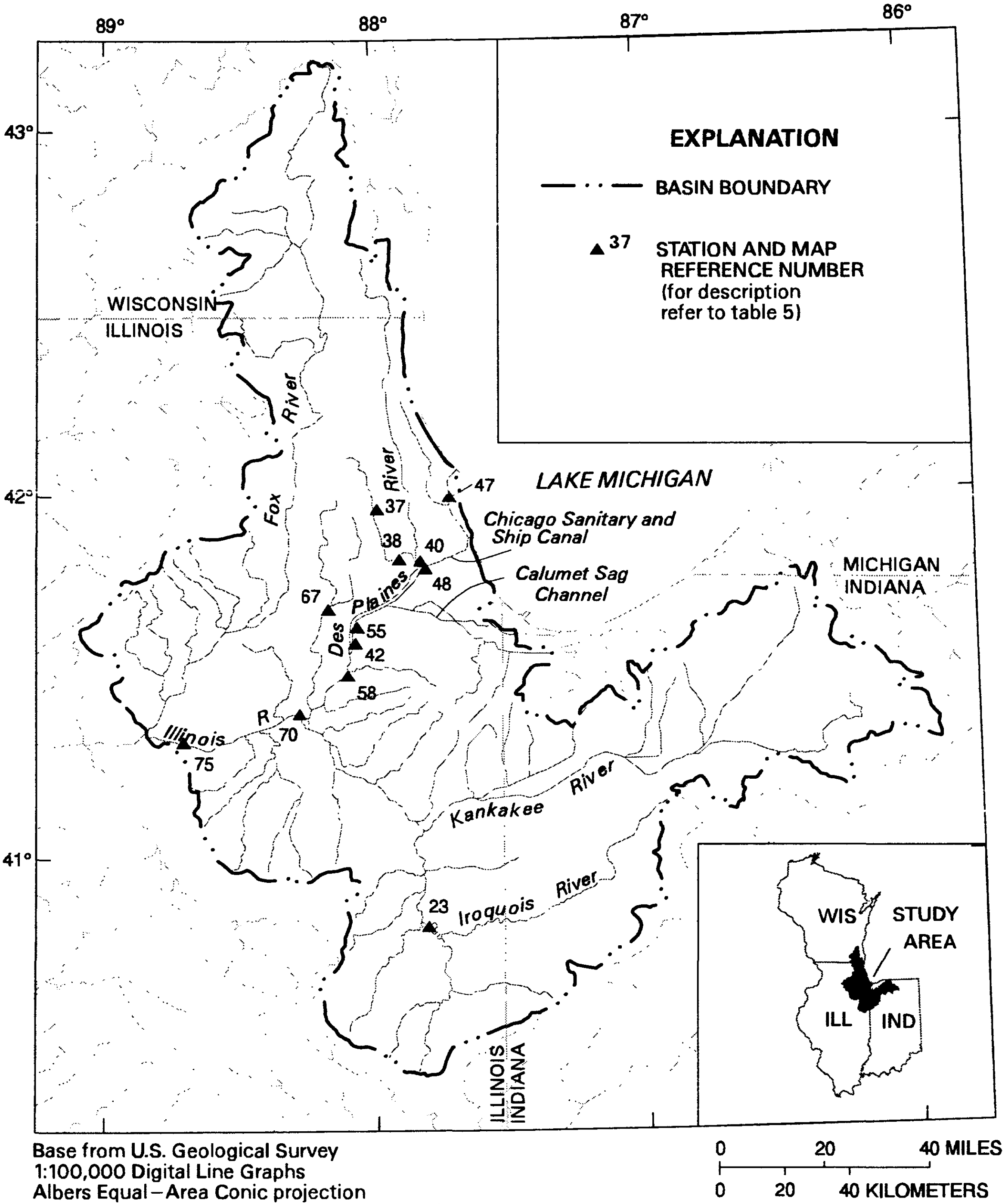
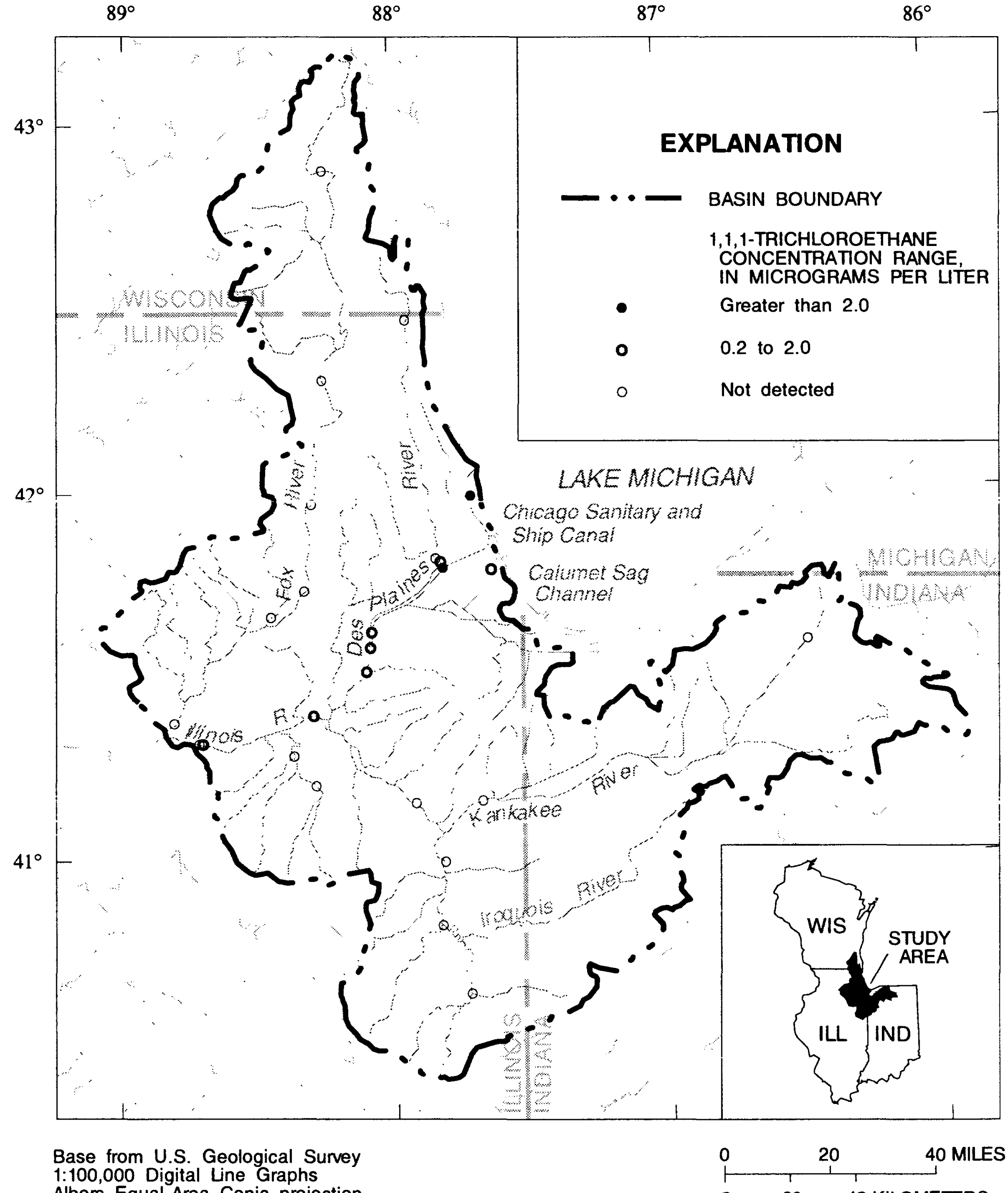


Figure 32. Location of stations at which two or more volatile organic compounds were detected in water collected in the upper Illinois River Basin, 1988.



Base from U.S. Geological Survey
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Albers Equal-Area Conic projection
Standard parallels 33° and 45°, central meridian -89°

Figure 33. Spatial distribution of 1,1,1-trichloroethane concentrations in water collected in the upper Illinois River Basin, 1988.

Concentrations of 1,2-dichloroethane exceeded the MCL of 5 µg/L in two samples collected during March and April 1989 at the Chicago Sanitary and Ship Canal at Romeoville, Ill. (map reference number 55).

The long-term monitoring by the IEPA indicated 1,2-dichloroethane exceeded the MCL in a sample at the Des Plaines River at Gurnee, Ill. (map reference number 33), in June 1989, with a concentration of 7.0 µg/L. The concentration of tetrachloroethylene was 10.0 µg/L in a May 1990 sample from the Chicago Sanitary and Ship Canal at Lockport, Ill. (map reference number 56), exceeding the proposed MCL of 5.0 µg/L.

The fixed-station monitoring of VOC's at the Des Plaines River at Riverside, Ill. (map reference number 40), and Chicago Sanitary and Ship Canal at Romeoville, Ill. (map reference number 55), indicated no patterns relating VOC concentrations to discharge or seasonal variation. Monthly sampling for VOC's was, therefore, discontinued after a little over a year.

During the 1988 synoptic survey for VOC's and SVOC's in water, *bis* (2-ethylhexyl) phthalate, a plasticizer, was the only SVOC detected at the 21 stations sampled for SVOC's. *bis* (2-Ethylhexyl) phthalate is one of the most widely used of the phthalates and is ubiquitous in the environment (Smith and others, 1988). Although SVOC's may be present in surface waters, the low solubilities and tendency of SVOC's to quickly partition into sediment and organic matter and bioaccumulate in biota apparently reduces the concentrations of SVOC's below detectable levels with current analytical methods.

Quality-Assurance Results for Phenolic Compounds

The QA results for data collected at 8 of the 20 stations sampled for phenols indicated a reliable data set. The consistency and quality of field techniques were monitored through collection and process duplicates. Process duplicates were samples that were split; processed concurrently, with as nearly identical techniques as possible; and submitted to the laboratory as discrete samples. Collection duplicates, as previously described, involved concurrent collection of samples. A Wilcoxon Matched-Pairs Signed-Ranks test was performed on 31 collection and process duplicate samples submitted to the IEPA laboratory for phenols. The results indicated no significant difference ($p=0.05$) between duplicate-sample results. The QA results indicated that 21 of 31 duplicate samples (68 percent) had the same value, and the mean difference between the duplicate samples was only 1 µg/L. Blanks submitted to the IEPA laboratory indicated that of the five samples analyzed for phenols, all were below the MRL. These results indicate no contamination from the equipment or sampling procedures, and, thus, sample integrity was maintained.

Concentrations and Distribution of Phenolic Compounds in the Upper Illinois River Basin, 1987–90

The widespread use of phenol as an intermediate compound in chemical manufacturing, the generation of phenolic wastes by industry and agriculture, and the toxic and organoleptic properties of phenol make it a potential source of point and nonpoint water contamination (U.S. Environmental Protection Agency, 1980b). Phenols are present primarily in aqueous solutions because sorption to natural sediments and bioaccumulation generally are minor, except for highly chlorinated phenols (Smith and others, 1988).

Total phenol concentrations were reported by the IEPA laboratory with multiple MRL's of 5 and 2 µg/L because of changes in laboratory analytical techniques. In addition, the reported phenol concentration is probably a minimum value because the analytical technique used by IEPA may under-report some phenolic compounds (Illinois Environmental Protection Agency, 1985).

Analyses of 780 samples indicated phenol concentrations above the MRL in 406 samples (52 percent) (fig. 34). Of the 406 samples with concentrations above the MRL, 251 samples were collected in the Des Plaines River Basin, most notably at the Calumet Sag Channel at Sag Bridge, Ill. (map reference number 54), Salt Creek at Western Springs, Ill. (map reference number 38), the Des Plaines River at Lockport, Ill. (map reference number 42), and the Little Calumet River at Munster, Ind. (map reference number 49) (fig. 35). Concentration distributions (fig. 35) are similar to those for other SVOC's and are associated mainly with urban land-use activities. A statistical summary of concentrations of phenols for IEPA stations in the upper Illinois River Basin is listed in table 41.

Results from a 1989 survey by the Metropolitan Water Reclamation District of Greater Chicago (1990c) indicate that phenol concentrations from stations along the upper Illinois River decrease with distance

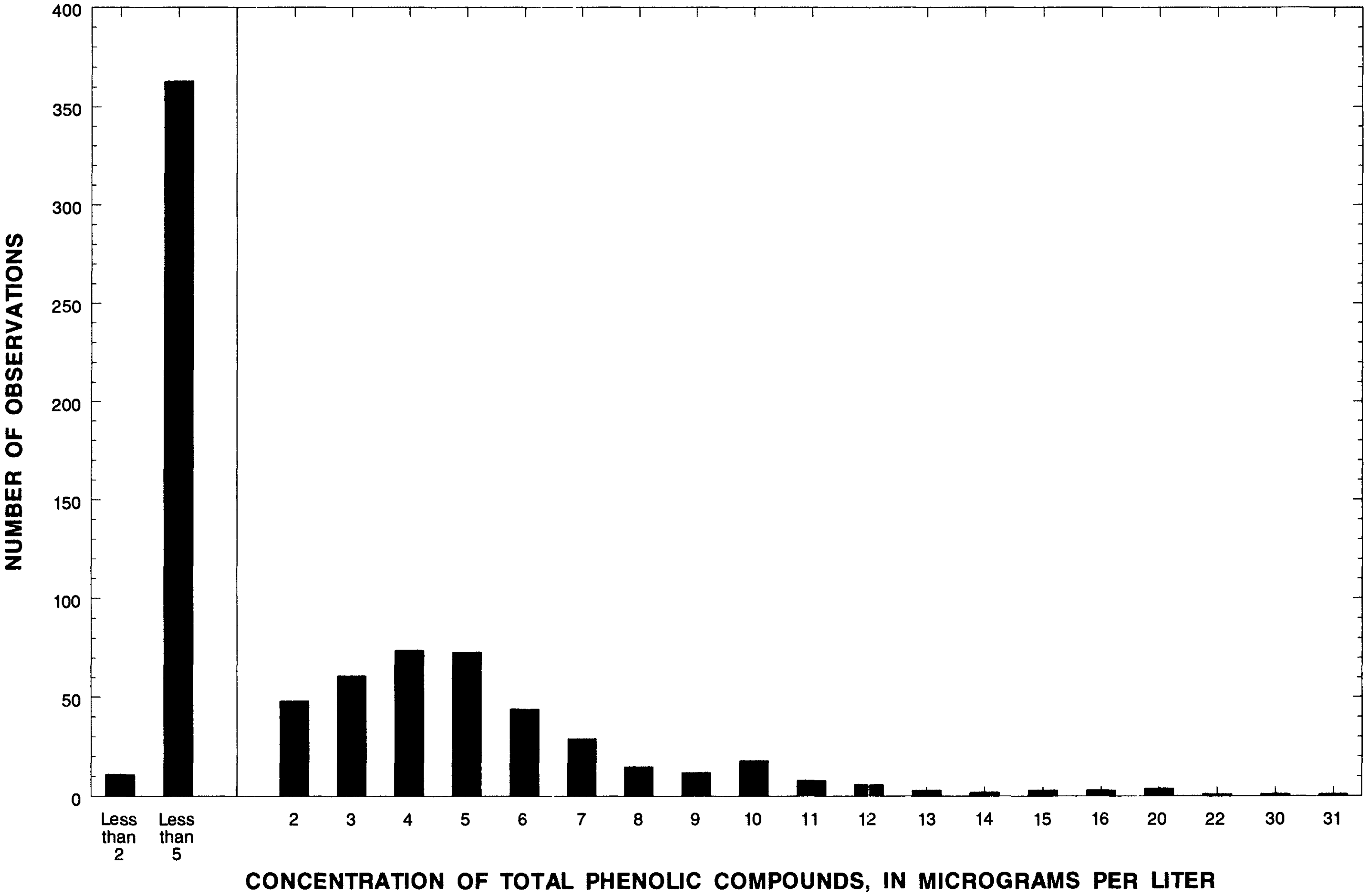
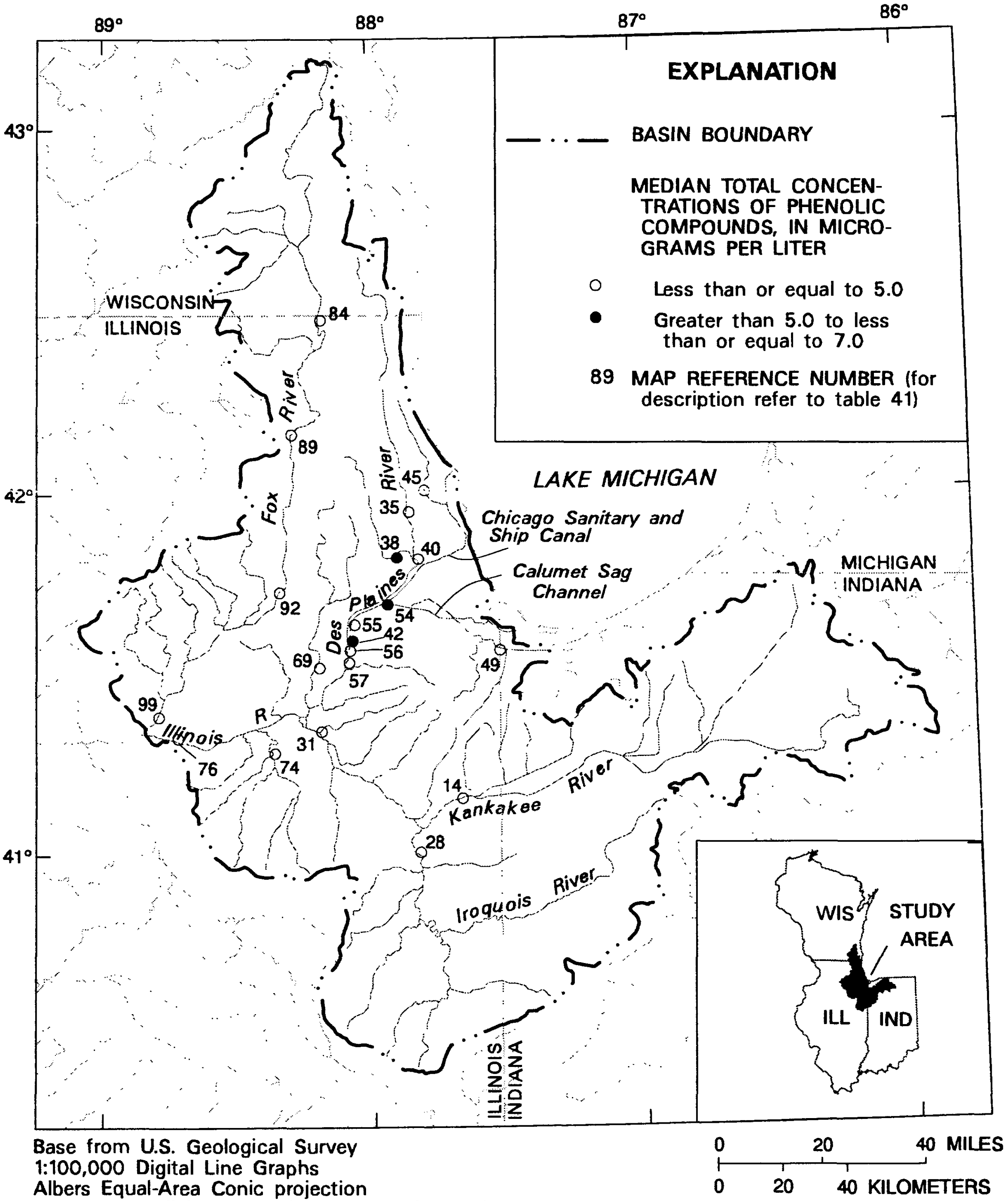


Figure 34. Concentrations of total phenolic compounds collected at the Illinois Environmental Protection Agency Ambient Water-Quality Monitoring Network stations in the upper Illinois River Basin, 1987–90.



Base from U.S. Geological Survey
1:100,000 Digital Line Graphs
Albers Equal-Area Conic projection
Standard parallels 33° and 45°, central meridian -89°

Figure 35. Spatial distribution of concentrations of phenolic compounds in water in the upper Illinois River Basin, 1987–90.

downstream from dense urban areas and point sources. Summary statistics of the MWRDGC 1989 survey are presented in table 42, and Tukey plots of the data are shown in figure 36.

The highest phenol concentrations were observed at stations on the CSSC and the Des Plaines River (above river mile 273, fig. 36), with decreasing concentrations downstream from the confluence of the Des Plaines River and the Kankakee River, which is affected by agricultural practices. This pattern is consistent with SOC's in water, sediment, and biota from urban sources.

The mean concentrations of phenols vary among samples from stations on the Des Plaines River and CSSC. Increases in concentrations are related to point sources; however, the effect attributable to point sources is limited locally, because phenols have been shown to biologically and photolytically attenuate very quickly in the environment (Smith and others, 1988). For example, a point source is present at about river mile 272 (fig. 36). Whereas a sharp increase in concentration was detected in a sample from a station at river mile 273, mean concentrations are similar to concentrations upstream from the point source at river mile 276.

The MWRDGC measures the concentration of phenols in the effluent from their WWTP's (Metropolitan Water Reclamation District of Greater Chicago, 1990a, b; 1991). Data from the WWTP's indicate that phenol concentrations in the effluent are as high as 140 μg/L. Mean and maximum concentrations of phenols for each of the seven MWRDGC WWTP's are shown in figure 37. Mean phenol concentrations in the effluents from the WWTP's were similar to concentrations in the receiving streams; maximum concentrations from the WWTP's were higher than concentrations in the receiving streams.

The USEPA (1980b) criteria for phenols indicate that acute and chronic toxicity to freshwater aquatic life may occur at concentrations of 10.2 and 2.56 mg/L, respectively. A limit of 3.5 mg/L is imposed as the allowable level to ensure protection of public health. Illinois water-quality regulations impose a general-use regulation of phenols at 100 μg/L and a secondary contact and indigenous aquatic life regulation of 300 μg/L (Illinois Environmental Protection Agency, 1992). Concentrations of phenols observed in the study area were well below regulatory standards for general-use and secondary-contact streams.

The IEPA also analyzed samples for concentrations of pentachlorophenol (PCP), which is the most extensively used chlorophenol. PCP is manufactured primarily by the organic chemical and pesticide industries (Smith and others, 1988). Chlorinated phenols are less soluble and have higher octanol-water partition coefficients than other phenols and, thus, may partition into streambed sediment organic matter and lipid reservoirs of fish. Pierce (1978) reported that a PCP spill in a freshwater lake caused an extensive fish kill. Above-background PCP concentrations persisted in the lake for an additional 6 months because of sorption of PCP onto sediment organic matter and leaf litter, and a slow rate of desorption back into the environment. Because certain temporal trends became evident that were not evident in data from 1987 to 1990, PCP data from 1981 to 1992 were analyzed. These are the only data collected in 1991 and 1992 that are considered and analyzed in this study.

Summary statistics of PCP data from water samples collected by the IEPA are listed in table 43. The data indicate that patterns of higher concentrations of PCP in the heavily populated areas of the upper Illinois River Basin are similar to those of other SOC's discussed in this report.

Temporal variability in PCP concentrations was observed from samples at the Illinois River at Marseilles, Ill. (map reference number 76) (fig. 38). The observed decrease in concentration may be because of a ban on nonwood uses of PCP in 1987 U.S. Environmental Protection Agency, 1991a), which likely resulted in decreased PCP concentrations in industrial and municipal effluents. Also, use of herbicides containing PCP's was limited to the application of available supplies, which would lead to reduced runoff contaminated with PCP from agricultural areas. Results from the Wilcoxon Mann-Whitney rank-sum test on PCP concentrations before and after the 1987 ban by the USEPA on nonwood uses of PCP indicate that observed PCP concentrations after the ban were significantly lower ($p=0.0007$) than before the ban.

Proposed ambient water-quality criteria for PCP's for the protection of freshwater and marine life range from 48 to 55 μg/L for acute effects and from 3.2 to 34 μg/L for chronic effects (U.S. Environmental Protection Agency, 1980a). Available data, however, indicate significant adverse effects occur at much lower PCP concentrations, between 0.035 and 19 μg/L (Eisler 1989). At a pH of 6.8, a PCP concentration of 1.74 μg/L caused a 50-percent reduction in the growth

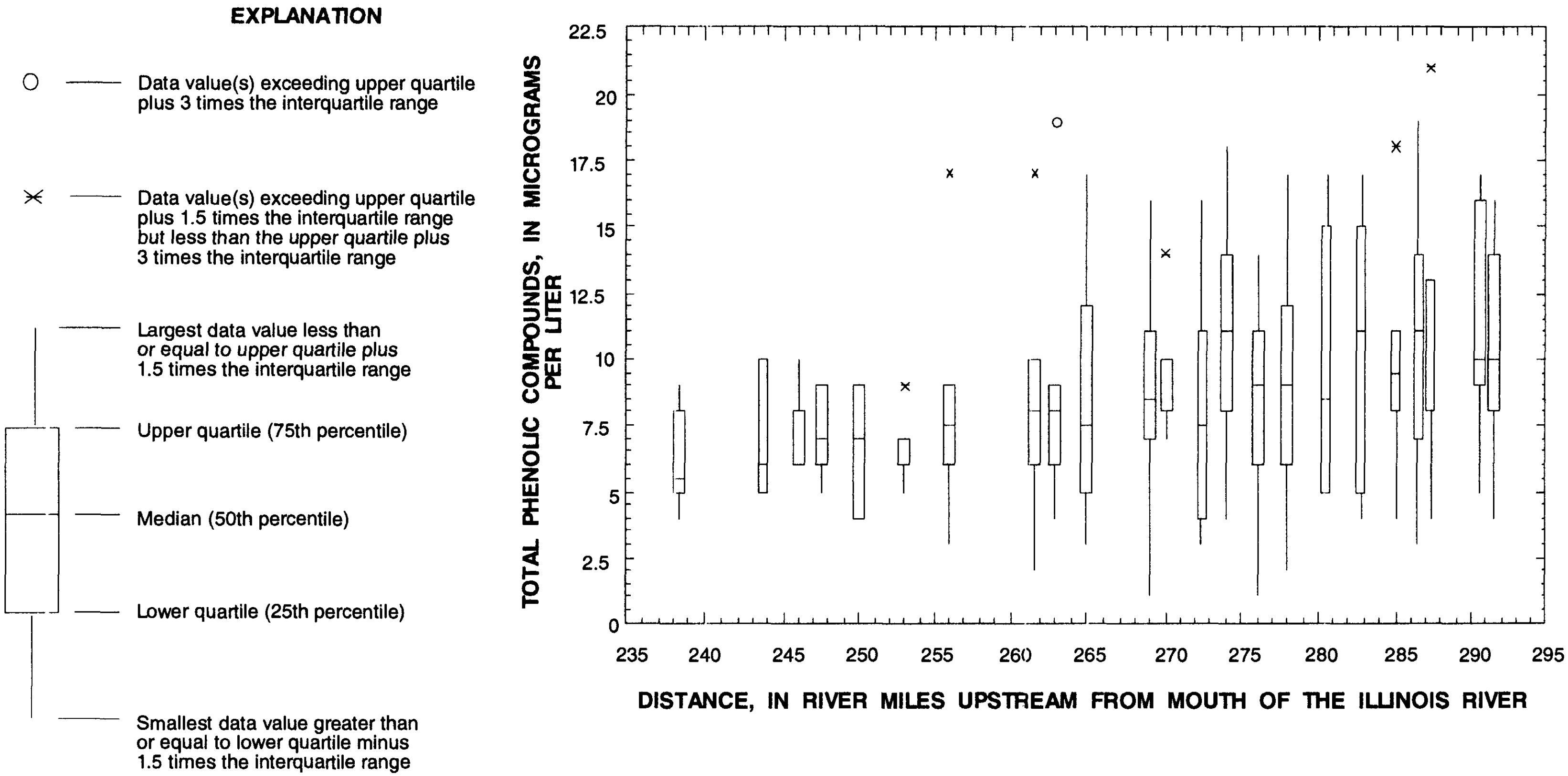


Figure 36. Concentrations of total phenolic compounds sampled by the Metropolitan Water Reclamation District of Greater Chicago in the upper Illinois River Basin, 1989.

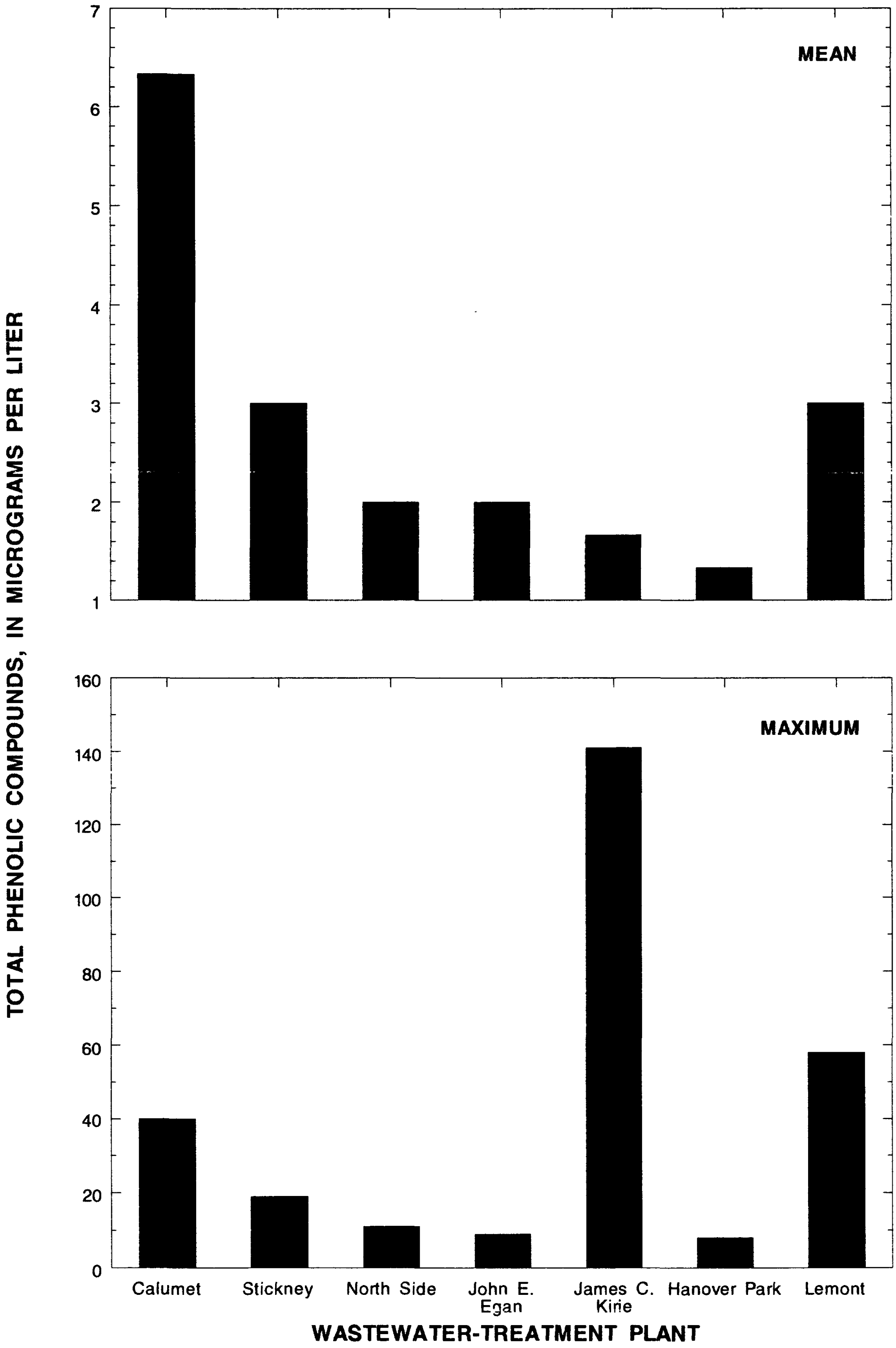


Figure 37. Mean and maximum concentrations of total phenolic compounds sampled in the effluent from seven Metropolitan Water Reclamation District of Greater Chicago wastewater-treatment plants in the upper Illinois River Basin, 1988–90.

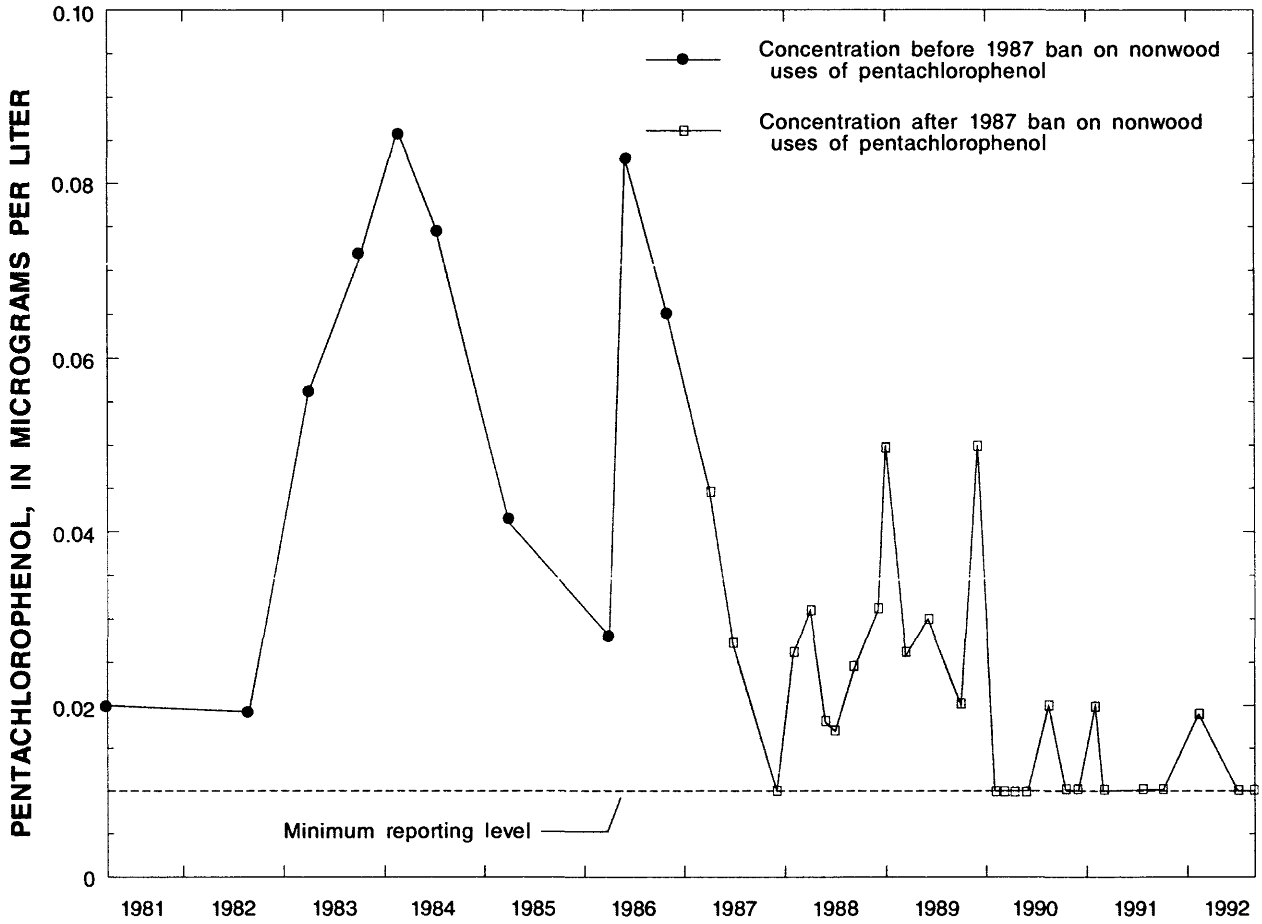


Figure 38. Pentachlorophenol concentrations in the Illinois River at Marseilles, Ill., 1981–92.

of yearling sockeye salmon in a 56-day test (U.S. Environmental Protection Agency, 1986). In rainbow trout (*Oncorynchus mykiss*), concentrations of 0.035 and 1 µg/L produced elevated residues in tissue analyses (Choudhury and others, 1986). The data for the upper Illinois River Basin indicate a maximum PCP concentration of 0.35 µg/L; although accumulation and growth interference in salmonids or accumulation in oysters could occur at this concentration (Eisler, 1989), this concentration would not affect most aquatic species indigenous to the upper Illinois River Basin negatively.

The USEPA has set the drinking-water standard for PCP at 1 µg/L to protect against the risk of adverse health effects (U.S. Environmental Protection Agency, 1991b). PCP concentrations in surface-water samples from the upper Illinois River Basin always were lower than the USEPA drinking-water standard of 1 µg/L. In addition, concentrations were below standards for the protection of aquatic biota (U.S. Environmental Protection Agency, 1980a).

Sediment

In this report, sediment refers to samples of bed sediment collected in streams in the upper Illinois River of the upper Illinois River Basin. Sediment samples were collected during a reconnaissance sampling effort at 10 stations in 1987 and during a basinwide survey at 82 stations in 1989. As part of the basinwide survey, extensive QA/QC measures were included to validate the data. Samples were analyzed for relatively insoluble, hydrophobic SOC's that have been shown to partition into sediments.

Quality-Assurance Results for Synthetic Organic Compounds

The QA results for the 1989 synoptic survey of SVOC's in streambed sediments indicate limitations on data interpretations. Results from sample duplicates and splits, reference standards, and spikes are shown in table 44. The first step in evaluating the QA results is to estimate method precision, based on published methods, and then to establish a baseline for the expected accuracy of the results (M.W. Sandstrom, U.S. Geological Survey, written commun., 1991). The USEPA 8000 Series method was used in laboratory analysis. A standard deviation of 21 to 33 percent was determined. An interlaboratory comparison of PAH analysis in a reference marine sediment resulted in relative standard deviations of 15 to 36 percent for 18 PAH's (MacLeod and others, 1988). Another procedure for determination of PAH's in sludge resulted in standard deviations of 11 to 15 percent (Bedding and others, 1988). The variation in the NAWQA data was greater than would be expected based on these standard deviations. For example, the results for fluoranthene and phenanthrene in the reference sediments indicate large variability because concentrations of these compounds are below the MRL (420 g/kg) in the first subsample and 1,200 and 2,400 g/kg, respectively, in the second subsample. The standard deviations of these reference samples were greater than 68 and 99 percent, respectively. The reference standard was a dry, well-homogenized sediment, so the subsampling error should have been small. Recovery of most SVOC's in spike samples was less than 50 percent, except for a few organochlorine pesticides. Large variations in laboratory-reported concentrations of SVOC's in subsamples and splits indicated that the data were not sufficient to quantify SVOC concentrations in sediments in the upper Illinois River Basin accurately.

The results of a nested ANOVA on 11 sediment stations used for QA were limited because of the small number of compounds detected in over 50 percent of the samples. The results indicate that variability among sample splits exceeded the variability among stations for the compounds listed in table 45. For the majority of the stations, determining a mean or median value was impossible because often two or more of the four reported values were below the MRL. Therefore, considering the poor recovery in spiked samples and the large variability among splits, the only analyses that can be considered reliable for the data on SVOC's in sediments are the identification of types, number, and extent of compounds detected at the stations.

Detections and Concentrations of Synthetic Organic Compounds, 1987

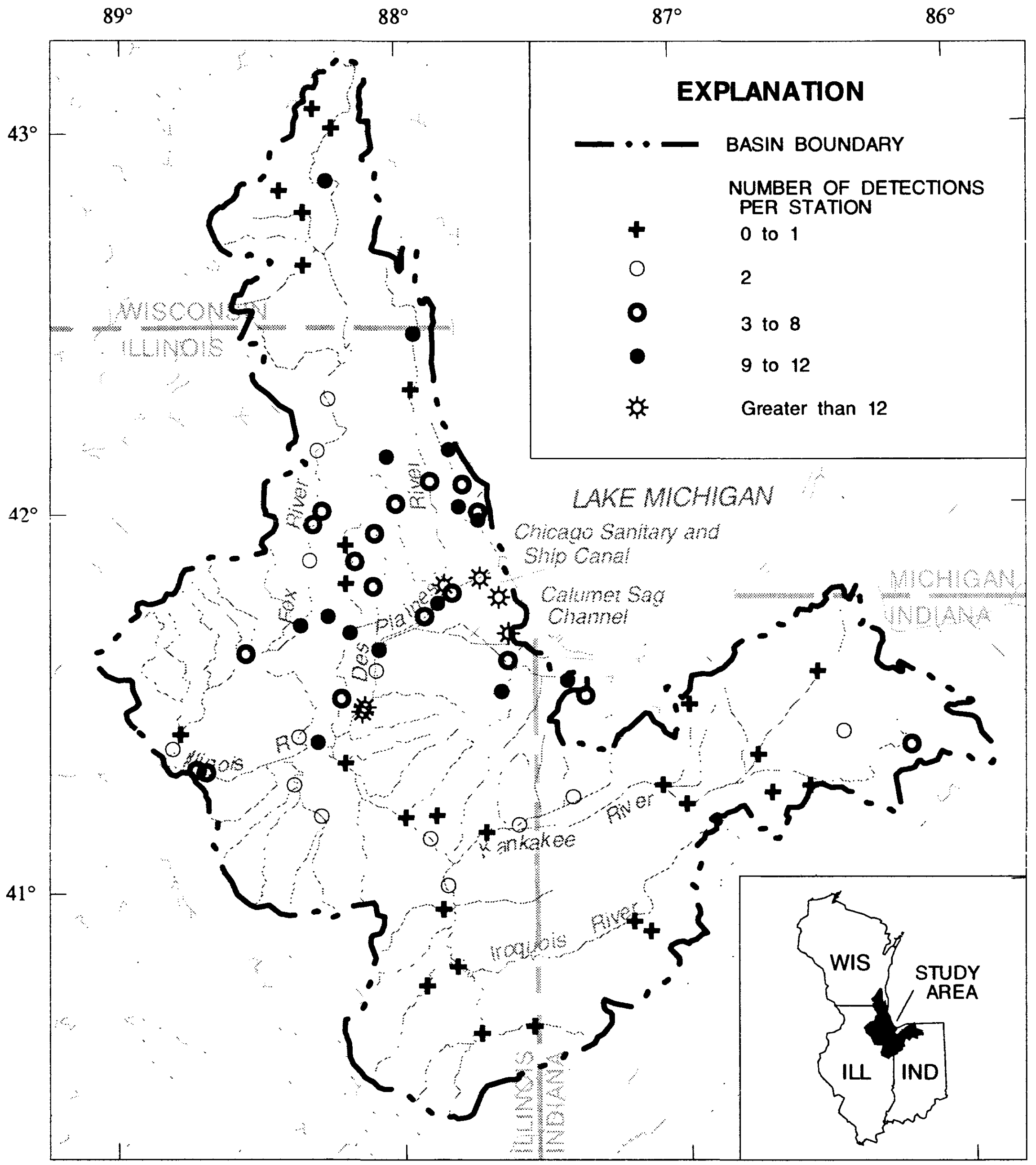
The data from the initial survey of 10 stations in 1987 indicate that 22 of 54 SVOC's (41 percent) for which analyzed were detected in sediment from one or more stations. All detections were at the eight stations in urban areas. The data indicate that PAH's were the most commonly detected compounds. The compounds and the number of sites where the compounds were detected are listed in table 46.

Distribution of Synthetic Organic Compounds in the Upper Illinois River Basin, 1989

The SVOC's detected in sediment samples collected in the study area during the 1989 basinwide survey are listed in table 47. Again, as in the 1987 reconnaissance sampling, the type of SVOC most commonly detected in sediment were PAH's and included phenanthrene (55 percent of stations), fluoranthene, pyrene, fluorene, benzo(*a*)anthracene, and benzo(*g,h,i*)perylene. Many of the compounds detected at greater than 20 percent of stations were the same as were detected in the 1987 survey. *bis*(2-Ethylhexyl)phthalate, a phthalate ester, used mainly as a plasticizer, was detected at 37 of 82 stations (45 percent). The analyte list in 1989 was expanded to include organochlorine compounds. Of these compounds, *p,p′*-DDE, a biodegradation-resistant metabolic-breakdown product of the pesticide DDT, was detected at 25 (30 percent) of the stations.

The spatial distribution of SVOC's in sediment in the study area is shown in figure 39. Of the 82 stations sampled for SVOC's in sediment, the data indicate that 10 or more compounds were detected at 17 stations. Of these 17 stations, 14 are in the Des Plaines River Basin and another is downstream on the Illinois River. The other two stations include one each in urbanized areas of the Fox and Du Page Rivers. This pattern is similar to the distribution of VOC's and phenols in water.

The spatial distribution of VOC's and phenolic compounds in water and SVOC's in sediment indicates the effect from the many point sources in the Chicago metropolitan area. Samples of water and sediment collected at stations in the Des Plaines River Basin, specifically in and around the Chicago metropolitan area, had the most detections and highest concentrations of VOC's and phenolic compounds in water and the most detections of SVOC's in sediment. All of these stations are within 2 mi of the nearest point source.



Base from U.S. Geological Survey
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Albers Equal-Area Conic projection
Standard parallels 33° and 45°, central meridian −89°

Figure 39. Spatial distribution of synthetic organic compounds in streambed sediments in the upper Illinois River Basin, 1989.

Biota

As previously stated in this report, biota refers to the aquatic organisms collected in streams of the study area. Although fish were the primary organism sampled, various species including crayfish, mollusks, snails, and aquatic plants were analyzed for organochlorine pesticides, and PCB's were sampled in 1989 and 1990. Biota other than fish, collected at fewer stations than fish, were analyzed additionally for selected PAH's, which fish metabolize.

In 1989, crayfish, snails, and plants were collected, as well as numerous fish species. In addition, whole fish and fish fillets from the same species were collected at five stations. At stations where more than one species were collected, detections and concentrations of SOC's can be compared to determine the species that are most suitable for detecting contamination. Collections and analyses of whole fish and fish fillets provide important data on concentrations to which human consumers are exposed.

Another important aspect of the 1989 data collection was to determine target species for the full-scale NAWQA program. National consistency in the NAWQA program requires that in addition to similar collection techniques and analyses, similar biota need to be used for contamination studies in order to compare results across a large area. Additional information on the NAWQA protocol for contaminants in biotic tissue are in Crawford and Luoma (1993).

In contrast to data collected in 1989, data collected in 1990 represent an attempt to discern the spatial distribution of SOC concentrations in biota in the upper Illinois River Basin. Therefore, only whole-fish samples were collected in 1990. Ideally, the same species would have been collected at all stations; however, because this was not possible, as few species as possible were collected. The data from the 1989 and 1990 biotic-tissue sampling are available from the Illinois District of the U.S. Geological Survey.

Another difference in sampling strategies between 1989 and 1990 is that only whole fish were analyzed in 1990. More compounds generally are detected in whole fish compared to fillets, which allows for a more complete picture of the spatial distribution of SOC's. Analyses of 1989 data indicate that wet-weight concentrations of SOC's generally were higher in whole fish than fillets; however, when the data are normalized to lipid content, concentrations are similar (fig. 40).

Quality-Assurance Results for Synthetic Organic Compounds

Results of analyses of QA samples for biota are presented in table 14. Laboratory-spiked samples of fish and vegetation indicated recoveries of organochlorines from 50 to 100 percent. In fish spikes, recoveries of PCB's and organochlorine pesticides, except hexachlorobenzene, were greater than 85 percent. Reagent blanks indicated no contamination of the samples. One matrix blank for fish indicated background concentrations of dieldrin, *p,p'*-DDD, *p,p'*-DDE, and *cis*-chlordane in the 0.01 to 0.02 µg/kg range. All other matrix blanks indicated no detections of SOC's. Reported results have not been corrected for recovery.

Detections and Concentrations of Synthetic Organic Compounds in the Upper Illinois River Basin, 1989–90

The data indicate that 16 of 27 organochlorine compounds were detected in at least one sample collected in 1989 or 1990. Of the 14 PAH's for which analyzed, 13 were detected in 1989 and 11 in 1990.

Overall, *p,p'*-DDE was the most ubiquitous compound detected in the basin. In 1989, *p,p'*-DDE was detected in all whole-fish samples, eight of nine fish-fillet samples, six of eight crayfish samples, and plant and snail samples that were collected only at one site. The second most commonly detected compound was *p,p'*-DDE, which is another breakdown product of the pesticide DDT. The continued presence of these compounds in biota, in spite of the 1969 ban on the use of DDT in the United States, is indicative of their persistence in the environment.

As expected, the highest concentrations of SOC's were observed in whole-fish samples. In 1989, a sample of whole carp from the Illinois River at Marseilles, Ill. (map reference number 76), had a PCB concentration of 3.3 mg/kg. In 1990, carp from the Des Plaines River above Brandon Road Dam near Joliet (map reference number 58), had a PCB concentration of 1.8 mg/kg. The highest concentration of *p,p'*-DDE in 1989 was 0.84 mg/kg in whole carp from Honey Creek at Hill Valley Road near East Troy, Wis. (map reference number 81), an agricultural site. In 1990, a concentration of 0.61 mg/kg of *p,p'*-DDE was observed in carp collected from the Des Plaines River at Riverside (map reference number 40).

The concentrations of PAH's in biota were relatively low; the highest was 0.06 mg/kg. In general,

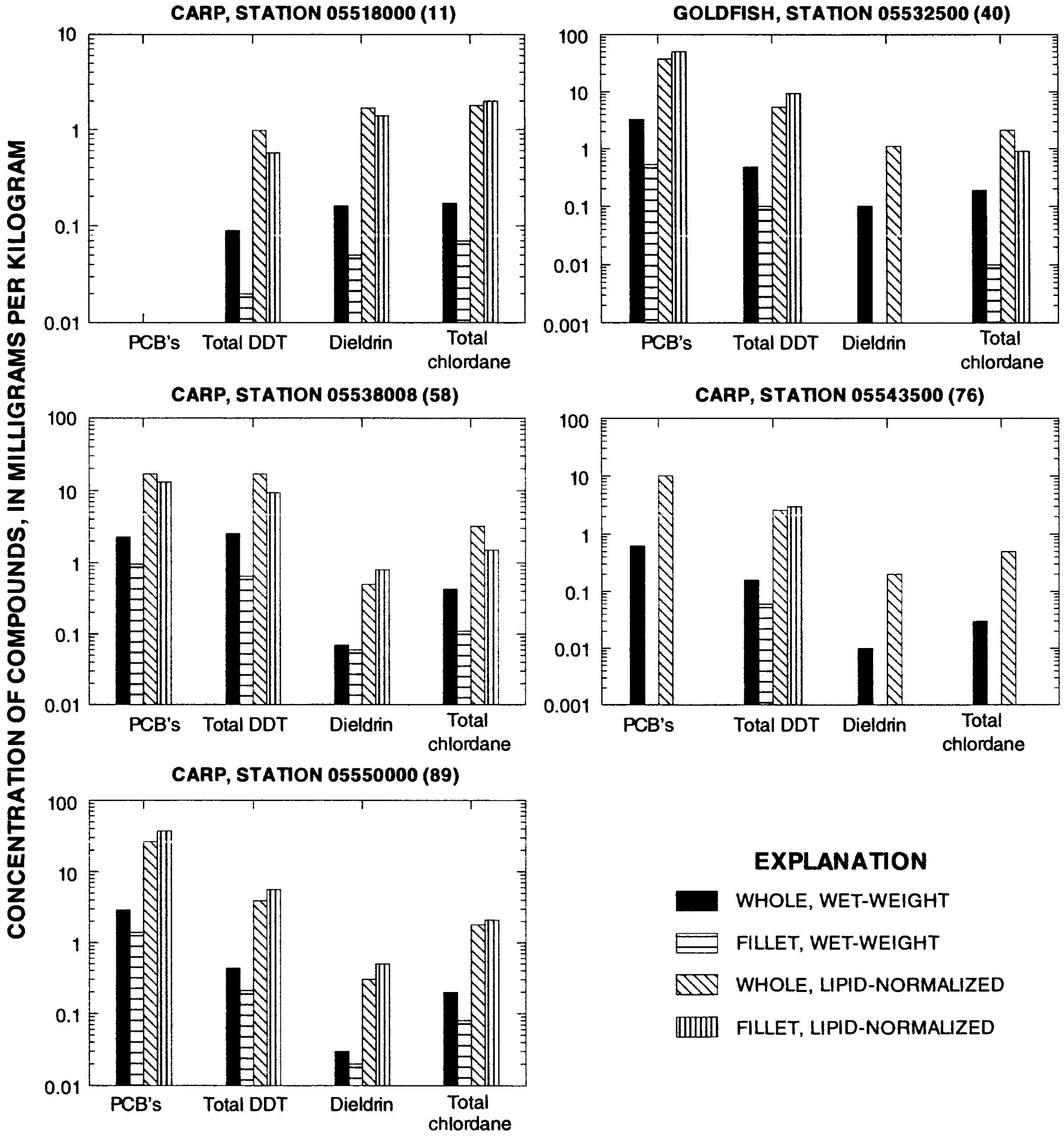


Figure 40. Wet-weight and lipid-normalized concentrations of selected compounds in whole fish and fish fillets in the upper Illinois River Basin, 1989.

analysis of biota was not useful for determining the amount of PAH's in the aquatic environment; analysis of sediment may be more useful.

Correlations among compounds detected in greater than 50 percent of whole-fish samples are shown in table 48. Few strong correlations (greater than 50 percent) appear in the 1989 data, but weak correlations (less than 50 percent) are indicated among most compounds. The 1990 data indicate correlations among chlordane components, among DDT breakdown products, and between these two groups of compounds. Dieldrin was correlated to chlordane but not DDT. As expected, some correlation to lipid content was indicated in most of the compounds. These correlations indicate that in a given fish, numerous compounds have bioaccumulated. As previously stated for other SOC's in other media, the health effects of this co-occurrence are not well understood but may be significant.

Spatial distributions of organic compounds in biota are best described by comparing concentrations in fish. Concentrations of chlordane and polychlorinated biphenyl in whole-fish samples are shown in figure 41. The distribution and relative concentrations of organic compounds in biota indicate a pattern of higher concentrations in the Chicago metropolitan area.

Dieldrin was the most uniformly distributed organic compound across the basin, with higher concentrations in agricultural areas. Dieldrin may be present as a breakdown product of aldrin, a corn pesticide no longer used. PCB's were highest in urban areas, probably the result of historical industrial usages of this compound. Chlordane concentrations also were higher in urban areas, although not as high as concentrations of PCB's. The highest observed concentrations of DDT analogs at urban sites indicate the use of DDT in the 1960's for control of Dutch Elm disease. These patterns are similar to those found in the historical data and indicate long-term contamination. Future sampling may indicate lower concentrations as these compounds slowly degrade in the environment.

Several levels of water-quality criteria that apply to organochlorines in biota are shown in table 49. These include standards for the protection of fish-eating birds and mammals, which are based on consumption of the entire fish, and standards for human consumption, which are based on the fillet portion of fish.

Concentrations of chlordane in whole fish met or exceeded National Academy of Sciences (NAS) recommendations for protection of fish-eating birds and mammals at 16 sites sampled in 1989 and (or) 1990; in 8 of these samples, dieldrin concentrations also exceeded NAS recommendations. The NAS recommendations for PCB's were exceeded in one sample collected in 1989. Although the highest concentrations of PCB's were in fish from sites in the immediate Chicago metropolitan area, exceedances were observed basinwide (especially for chlordane and dieldrin). This is a concern because the presence of fish-eating birds and mammals generally is greater in areas outside the metropolitan area of Chicago. Risk from eating fish with high concentrations of PCB's is still present in agricultural areas, although possibly lower than in urban areas.

Criteria for human-health risks from eating fish apply to levels of contaminants in the fish fillet (table 49). The USFDA Action Levels (U.S. Food and Drug Administration, 1990), if exceeded, can cause the USFDA to remove tainted fish from public availability. The Fish Tissue Concentrations (FTC's) standards from the USEPA are based on lifetime daily intake and represent levels below which the specified noncarcinogenic compounds cause no known adverse health effects, and, for carcinogens, excess cancer risk should not exceed 1 in 1,000,000. Based on the limited data collected on fish fillets, no exceedances of USFDA Action Levels were observed. The FTC's for *p,p'*-DDE were exceeded in all nine fish fillets collected in 1989 in agricultural and urban areas. Exceedances also were observed for dieldrin in six of nine fillets. These results may indicate a risk to human health because a sizable number of people consume fish caught from waters in the basin.

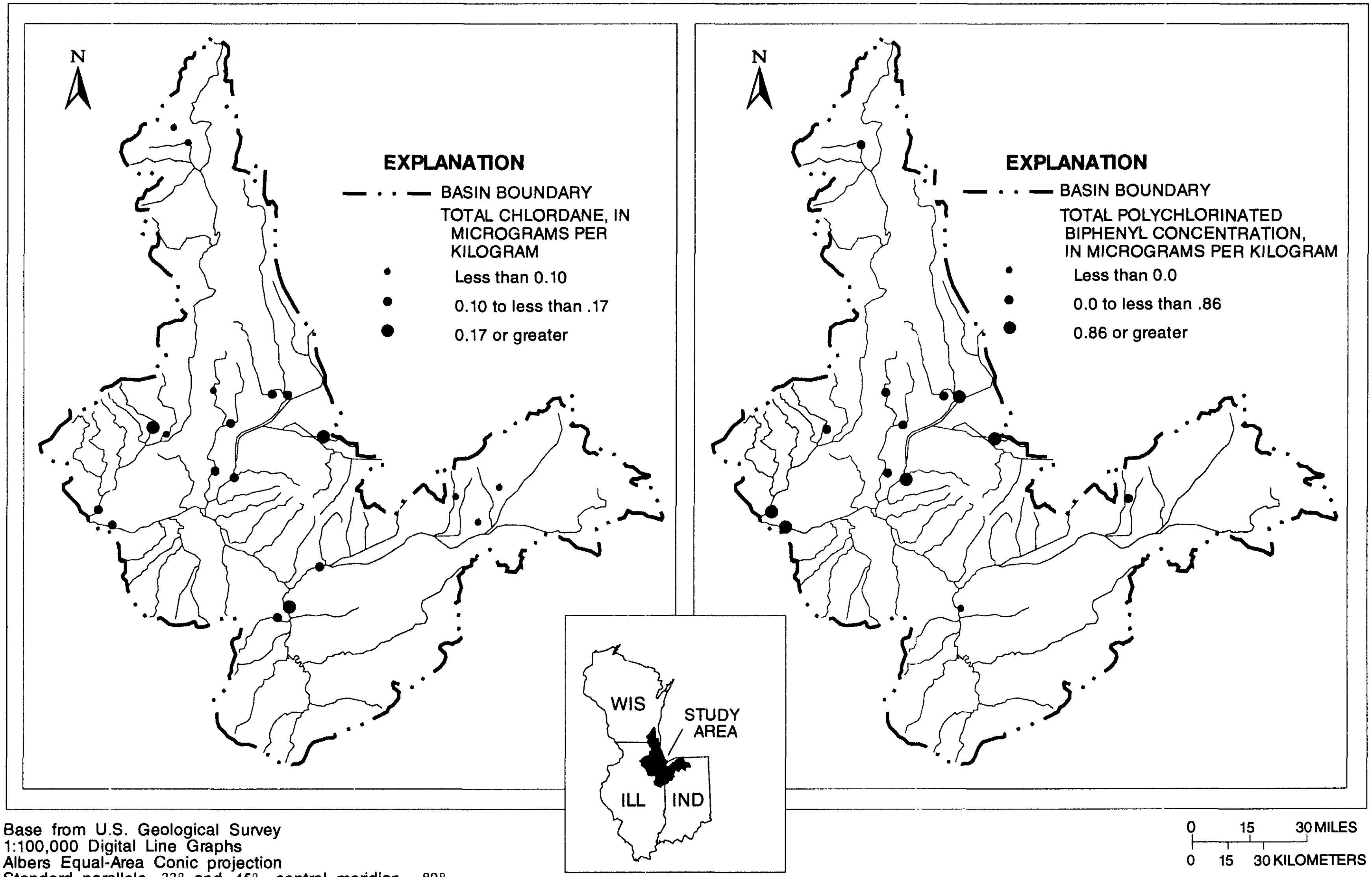
A summary of the mean concentrations of organochlorine compounds from the National Contaminant Biomonitoring Program (Schmitt and others, 1990) and the National Study of Chemical Residues in Fish (U.S. Environmental Protection Agency, 1992a) is presented in table 50. Five compounds (*p,p'*-DDE, PCB's, *cis*- and *trans*-chlordane, and dieldrin) were observed at higher mean concentrations in the upper Illinois River Basin than the mean determined for these compounds for the entire Nation.

Elevated concentrations of five compounds described above in the upper Illinois River Basin indicate the unique nature of the basin. The intensive of urban and agricultural land-use activities in the upper Illinois River Basin contribute to serious water-quality problems.

The data on contaminants in biota helped define the major water-quality problems in the upper Illinois River Basin related to SOC's. The relations among organic compounds in sediment and biota are presented in the next section.

RELATIONS AMONG ORGANIC COMPOUNDS IN SEDIMENT AND BIOTA

The co-occurrence of sampling sites for water, sediment, and biota in the NAWQA program is unique among water-quality studies. For organic compounds, the discussion of the occurrence of contaminants is limited to comparisons of SOC concentrations in sediment and biota because concentrations of hydrophobic



Base from U.S. Geological Survey
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Albers Equal-Area Conic projection
Standard parallels 33° and 45°, central meridian −89°

Figure 41. Concentrations of chlordane and polychlorinated biphenyl in whole-fish samples collected in the upper Illinois River Basin, 1989–90.

SOC's in water were below the MRL in all data presented in this report.

Because of limitations in the sediment data in determining levels of SOC's (see "Quality-Assurance Results for Synthetic Organic Compounds" under the "Sediment" section), relations among organic compounds in sediment and biota are limited to analysis of patterns of occurrence in various land-use categories and co-occurrence at specific sampling stations.

The pattern of greater number of detections and higher concentrations of compounds, such as PCB's, DDT, and PAH's in samples from urban stations, has been discussed at length in this report. The urban effect on contamination of waterways and associated sediments and biota is well documented. A few compounds, such as dieldrin, were more prevalent in samples from nonurban areas.

The co-occurrence of selected organochlorines in sediment and biota at selected sampling stations is shown in table 51. Of 46 detections in either sediment, biota, or in both, only in 13 cases is the same compound detected in samples of both media from the same site. The data for PAH's (table 52) indicate a similar level of co-occurrence; of 56 detections, only 24 occur in sediment and biota collected at the same site. Without samples collected from each media during similar periods, much information on the occurrence and distribution of these compounds in the environment would be lost.

These results indicate the value of the aquatic media for comprehensive water-quality studies. Whereas some compounds may be below detection levels in one media, sampling a different media will detect their presence. These results can affect water use and the protection of fish and wildlife.

SUMMARY AND CONCLUSIONS

Pesticides and other synthetic organic compounds have been detected in the water, sediment, and biota of surface waters throughout the United States. The production and use of these compounds has increased greatly over the past 50 years, and the result has been a gradual decrease in the quality of the Nation's surface-water resources. Pesticides and other SOC's enter surface-water systems from a variety of sources, which include direct point-source discharges of municipal and industrial wastewater and indirect nonpoint-source runoff. Specific compounds may show a preference to dissolve in water (hydrophilic) or sorb onto stream sediments and organic matter (hydrophobic). Many hydrophobic compounds tend to bioaccumulate in organisms. Many pesticides and other SOC's have been shown to be potentially toxic, carcinogenic, and mutagenic.

The National Water-Quality Assessment program was designed to provide nationally consistent descriptions of water quality in large, diverse, and geographically distributed areas; define trends in water quality; and identify and describe the relations of the status and the trends in water quality to relevant natural factors and the history of land use and land- and waste-management practices. The objectives of the upper Illinois River Basin NAWQA pilot study were addressed through (1) a series of intensive surveys and fixed-station sampling for pesticides and other SOC's, and (2) a review of data collected by the U.S. Geological Survey and other agencies. Historical data from 1975–88 and data from 1987–90 collected by the Illinois Environmental Protection Agency, Metropolitan Water Reclamation District of Greater Chicago, Northern Illinois Power Company, U.S. Army Corps of Engineers, U.S. Environmental Protection Agency, and U.S. Geological Survey were analyzed.

Agricultural areas in Illinois and neighboring States are among the most productive grain-growing regions in the world. Modern agriculture depends heavily on pesticides to ensure high productivity, and, in Illinois, herbicides are applied to 97 percent of the corn fields and 96 percent of the soybean fields. Insecticides are applied to lower percentages of croplands. Herbicide applications in the upper Illinois River Basin are among the highest in the Nation.

Urban pesticide loadings also are high in the upper Illinois River Basin. Between 75 and 90 percent of households use pesticides. Homeowners, land-management agencies, and other governmental agencies apply herbicides and insecticides at rates as high as 10 pounds per acre. Therefore, urban areas in the basin may have a large potential for surface-water contamination by pesticides.

The large urban and industrial areas in and around Chicago also create a large potential for surface-water contamination by nonagricultural SOC's. The major sources of these SOC's to streams are industrial effluent and municipal wastewater discharges.

Analyses of historical data were used to describe the presence and distribution of SOC's in the upper

Illinois River Basin. Statistical analyses of historical data were limited because the data were pooled from several sources, and the procedures used for collection and analysis were not well documented. The data indicated that water-column sampling should be limited to relatively soluble compounds and sediment sampling to relatively insoluble compounds. This knowledge guided the design of the organic sampling NAWQA pilot study.

Intensive data-collection activities conducted as part of the NAWQA pilot study included pesticide sampling at four stations in 1988 and 1989. Results indicate that 2,4-D had the highest median concentrations at urban stations, whereas atrazine had the highest median concentrations at agricultural stations. Pesticides identified from urban sources included bromacil, diazinon, malathion, prometon, and simazine. Pesticides identified from agricultural sources included alachlor, cyanazine, metolachlor, and metribuzin. Atrazine was present in all of the urban and agricultural samples. Concentrations of atrazine exceeded the maximum contaminant level for drinking water in runoff samples from agricultural and urban areas.

Herbicide sampling was conducted in 1990 at 17 stations in the Kankakee and Iroquois River Basins. Atrazine and metolachlor were detected in all samples. The atrazine breakdown products desethylatrazine and desisopropylatrazine were detected in 100 and 94 percent of samples, respectively. The data indicate that atrazine concentrations exceeded the MCL during runoff periods. The estimated total atrazine load from the Iroquois River Basin was less than 1 percent of the estimated amount of atrazine applied to the land. The magnitude of the runoff period was the most important factor affecting atrazine concentrations in streams. High correlation coefficients (greater than 0.50) among most of the triazine herbicides indicate co-occurrence in the environment. The effects of this co-occurrence are not well understood.

A low-flow synoptic survey for volatile organic compounds and semivolatile organic compounds in water was conducted in 1988. Results indicate that chloroform was the most commonly detected compound present in 42 percent of the samples. The next most commonly detected compounds, tetrachloroethylene and 1,1,1-trichloroethane, were detected in 29 percent of the samples. A total of 21 different VOC's and 1 SVOC were detected at least once. Except at one station, all stations (at which more than one compound were detected) were within 2 mi downstream from the nearest point source, indicating that these compounds originate from wastewater inputs and volatilize quickly from the water. Detections at two stations in the Chicago urban area accounted for 37 percent of the total number of VOC detections. One exceedance of a drinking water MCL was observed—tetrachloroethylene concentration was 5.5 µg/L (above the MCL of 5 µg/L) at the Des Plaines River at Lockport, Ill. (map reference number 42).

Fixed-station monitoring of VOC concentrations at two NAWQA fixed stations was conducted from June 1988 to March 1990. Results indicate three exceedances of MCL's during this period. Trichloroethylene concentration of 11.7 µg/L (above the MCL of 5 µg/L) was observed in a September 1988 sample from the Des Plaines River at Riverside, Ill. (map reference number 40). Concentrations of 1,2-dichloroethane exceeded the MCL of 5 µg/L at the Chicago Sanitary and Ship Canal at Romeoville, Ill. (map reference number 55), in samples collected in March and April 1989.

Phenols were detected most frequently in the Des Plaines River Basin where point-source discharges, such as wastewater-treatment plants and industrial effluents, are more predominant. Median phenol concentrations from a 1989 survey were observed to decrease with distance downstream from point sources. Phenol concentrations never exceeded the general use and secondary contact standards of 100 and 300 µg/L, respectively.

Pentachlorophenols were detected most frequently in the Des Plaines River Basin with concentrations as high as 0.180 µg/L observed at the North Branch Chicago River at Niles, Ill. (map reference number 45). A decrease in PCP concentrations was observed between 1978 and 1990 at the Illinois River at Marseilles, Ill. (map reference number 76), and was most likely associated with a 1987 ban on nonwood uses of PCP. Observed PCP concentrations in the study area never exceeded the 1 µg/L drinking-water standard.

A survey of the presence and distribution of SVOC's in sediment was conducted in 1987, and a basinwide survey was conducted in 1989. Results indicate that stations in the Chicago urban/industrial area had the most detections of SVOC's. Of the 17 stations at which 10 or more compounds were detected, 14 stations were in the Des Plaines River Basin and 1 station was downstream on the Illinois River main stem. The other two stations were in urbanized areas of the Fox and Du Page Rivers. The same was the case with VOC's in water, each of these stations was within 2 mi downstream from point sources. The most commonly detected compounds included the polycyclic aromatic hydrocarbons phenanthrene, fluoranthene, pyrene, fluorene, benzo(*a*)anthracene, and benzo(*g*,*h*,*i*)perylene, and the plasticizer *bis*(2-ethylhexyl)phthalate.

Biota samples were collected and analyzed for organochlorines and PAH's in 1989 and 1990. The most commonly detected compound in 1989 and 1990 was *p,p′*-DDE. Concentrations of PCB's, *p,p′*-DDE, *p,p′*-DDD, and dieldrin had the most variability and the highest median. Although concentrations were lower in fish fillets than in whole fish, lipid normalization reduced the differences, indicating the strong tendency of these compounds to accumulate in the lipid portion of the organism. Correlations were observed among the chlordane components, among the DDT breakdown products, and between these two groups of compounds. Correlation was indicated between dieldrin and chlordane components but was not correlated to DDT breakdown products. Some correlation was observed between most of the compounds and the lipid content of the sample.

Numerous exceedances of National Academy of Sciences standards for protection of predators on fish were observed in the upper Illinois River Basin, including a total of 19 for chlordane and 10 for dieldrin when 1989 and 1990 data are combined. Exceedances of U.S. Environmental Protection Agency Fish Tissue Concentration Standards for human consumption were indicated for *p,p′*-DDE in all nine fillets and six of nine fillets for dieldrin.

Comparisons between SOC's in sediment and biota were limited to the analyses of co-occurrence of compounds. There were 37 total detections of organochlorines in biota and 23 detections in sediment, of which 14 were cases that the compound was detected in both media at a station. Total chlordane, PCB's, *p,p′*-DDE, and dieldrin each had 2–4.5 as many detections in biota as in sediment. Thirty-nine and 41 PAH's were detected in biota and sediment, respectively. PAH's were detected in both media in 24 cases.

The data on current-generation herbicides indicate a relatively narrow timeframe when these compounds exceed health standards. This information is useful to water managers responsible for the treatment of drinking water. More research is needed on the synergistic effects of co-occurring herbicides on aquatic plants because indirect effects on higher aquatic organisms may be present.

Sampling for VOC's and SVOC's in the water column was of limited value in this study. Concentrations of these compounds generally are low, often below the detection limit, and few statistical analyses can be made. More emphasis could be placed on locating sources of these compounds and monitoring outputs, if possible, and then simulating the fate and transport to determine the possible outcomes of the actual loadings to the streams.

Sampling of sediment and biota could be most useful in determining the concentrations and distributions of relatively insoluble SOC's. Sediment samples usually are analyzed for a wider variety of compounds, whereas higher concentrations of insoluble SOC's usually are detected in biota because of bioaccumulation.

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TABLES

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Table 1. Selected herbicides used for agriculture in Illinois, 1988
[From Pike and others, 1990; --, indicates herbicide not applied]

Herbicide	Quantity applied (millions of pounds)			Percentage of crop acres	
	Corn	Soybeans	Total	Corn	Soybeans
Alachlor	6.2	1.7	7.9	27.9	10.7
Atrazine	9.5	--	9.5	76.1	--
Butylate	4.9	--	4.9	12.9	--
Cyanazine	2.5	--	2.5	13.2	--
2, 4-D	.4	.2	.6	11.7	3.7
Dicamba	.4	--	.4	11.6	--
Metolachlor	8.1	1.9	10.0	36.2	9.9
Metribuzin	--	.7	.7	--	21.8
Propachlor	.2	--	.2	1.0	--
Simazine	.3	--	.3	3.2	--

Table 2. Description of the U.S. Geological Survey National Water-Quality Assessment sampling programs for pesticides and other synthetic organic compounds in the upper Illinois River Basin, 1987–90

Sampling date	Compounds for which analyzed	Number and location of stations	Sampling design
		Water	
May–July 1988 and May–August 1989	Triazine herbicides, organophosphorus insecticides, chlorophenoxy-acid herbicides	4 stations in small watersheds; 2 in urban areas and 2 in agricultural areas	Runoff periods
July 1988	Volatile organics	31 stations	Low-flow synoptic survey
	Semivolatile organics	Subset of 21 of the 31 stations	
June 1988 –March 1990	Volatile organics	2 stations in urban areas	Monthly
May–July 1990	Triazine herbicides	17 stations, Kankakee and Iroquois River Basins	Runoff periods
		Sediment	
October–November 1987	Semivolatile organics	9 stations in urban areas, 1 background (agricultural)	Occurrence survey
August 1989	Semivolatile organics	83 stations, mostly random but some bias toward urban	Synoptic survey
		Biota	
July–August 1989	Organochlorines and polynuclear aromatic hydrocarbons	16 stations	Synoptic survey
July–August 1990	Organochlorines and polynuclear aromatic hydrocarbons	25 stations	Synoptic survey

Table 3. Selected information for stations included in Phase I pesticide sampling in the upper Illinois River Basin, 1988–89
[mi^2, square miles; ft^3/s, cubic feet per second]

Map reference number (fig. 6)	Station number	Station name	Drainage area (mi^2)	Land use	Mean annual discharge (ft^3/s) through 1989 water year[1]	Mean discharge (ft^3/s)		Number of samples			
								1988		1989	
						1988	1989	Low flow	Runoff period	Low flow	Runoff period
17	05523000	Bice Ditch near South Marion, Ind.	21.8	Agricultural	17.4	13.1	12.1	1	0	2	1
22	05525500	Sugar Creek at Milford, Ill.	446.9	Agricultural	362	215	251	0	0	1	3
36	05530990	Salt Creek at Rolling Meadows, Ill.	30.5	Urban	29.6	28.9	24.1	0	2	2	4
39	05532000	Addison Creek at Bellwood, Ill.	17.9	Urban	15.5	16.9	18.6	1	6	2	0

[1] Water year defined as October 1st through September 30th.

Table 4. Selected information for stations included in Phase II pesticide sampling in the Kankakee and Iroquois River Basins, 1990

[mi^2, square miles; ft^3/s, cubic feet per second]

Map reference number (fig. 7)	Station number	Station name	Drainage area (mi^2)	Mean annual discharge (ft^3/s) (through 1990 water year)[1]	Mean discharge (ft^3/s) (1990 water year)[1]	Number of samples collected[2]			
						Low flow	Rising limb	Peak	Falling limb
			Kankakee River Basin						
1	05515000	Kankakee River near North Liberty, Ind.	174	154	194	3	0	0	1
3	05515500	Kankakee River at Davis, Ind.	537	508	624	1	1	1	1
4	05516500	Yellow River at Plymouth, Ind.	294	259	286	1	2	3	0
5	05517000	Yellow River at Knox, Ind.	435	398	443	0	4	0	1
7	05517500	Kankakee River at Dunns Bridge, Ind.	1,352	1,341	1,679.0	0	1	2	2
8	05517530	Kankakee River near Kouts, Ind.	1,376	1,480	1,723	0	0	1	3
10	05517890	Cobb Ditch near Kouts, Ind.	30.3	33.1	37.8	2	0	1	0
11	05518000	Kankakee River at Shelby, Ind.	1,779	1,636	2,189	2	0	1	1
12	05519000	Singleton Ditch at Schneider, Ind.	123	110	149	2	2	0	0
14	05520500	Kankakee River at Momence, Ill.	2,294	1,998	2,750	2	0	1	1
31	05527500	Kankakee River near Wilmington, Ill.	5,150	4,381	6,506	2	0	1	1
			Iroquois River Basin						
15	05521000	Iroquois River at Rosebud, Ind.	35.6	27.3	36.5	5	3	1	4
16	05522500	Iroquois River at Rensselaer, Ind.	203	170	238	3	3	3	7
19	05524500	Iroquois River near Foresman, Ind.	449	387	504	2	13	6	3
20	05525000	Iroquois River at Iroquois, Ill.	686	559	712	4	12	2	12
22	05525500	Sugar Creek at Milford, Ill.	446	364	432	8	24	13	20
28	05526000	Iroquois River near Chebanse, Ill.	2,091	1,664	2,259	13	69	21	50

[1] Water year defined as October 1st through September 30th.

[2] The terms low flow, rising limb, peak, and falling limb refer to the stage of the hydrograph when the sample was collected.

Table 5. Description of sampling stations for volatile and semivolatile organic compounds in surface water in the upper Illinois River Basin

[mi, miles; --, no point sources known; <, less than]

Type of site: AG, agricultural; MR, minimum resolution; UR, urban.

Stage of survey: PRE, preliminary sampling; SYN, low-flow synoptic investigation; FOL, follow-up monitoring; STO, survey of agricultural organic chemicals during runoff.

Chemical group analyzed: V, water sample analyzed for volatile organic compounds; S, water sample analyzed for semivolatile organic compounds.

Number of observations: First number describes the number of samples collected for analysis of volatile organic compounds; second number describes the number of samples collected for analysis of semivolatile organic compounds. For example, 18,5 means that 18 samples for analysis of volatile organic compounds and 5 samples for analysis of semivolatile organic compounds were collected.

Map reference number (fig. 8)	Station number	Station name	Latitude	Longitude	Distance to nearest point source (mi)	Type of site	Stage of survey	Chemical group analyzed	Sampling period	Number of observations
1	05515000	Kankakee River near North Liberty, Ind.	41°33'50"	86°29'50"	6	AG,MR	SYN	V,S	07/22/88	1,1
14	05520500	Kankakee River at Momence, Ill.	41°09'36"	87°40'07"	1	AG,MR	SYN	V	07/18/88	1,0
17	05523000	Bice Ditch near South Marion, Ind.	40°52'00"	87°05'32"	--	AG	SYN	V,S	07/18/88	1,1
22	05525500	Sugar Creek at Milford, Ill.	40°37'50"	87°43'25"	3	AG,MR	PRE	S	05/02/88	0,1
							SYN	V	07/18/88	1,0
23	05525540	Iroquois River near Watseka, Ill.	40°48'44"	87°48'25"	13	AG	SYN	V,S	07/18/88	1,1
28	05526000	Iroquois River near Chebanse, Ill.	41°00'32"	87°49'27"	12	AG,MR	SYN	V,S	07/18/88	1,1
29	05526130	Kankakee River near Bourbonnais, Ill.	41°09'08"	87°54'49"	1	UR	SYN	V,S	07/18/88	1,1
31	05527500	Kankakee River near Wilmington, Ill.	41°20'48"	88°11'11"	1	UR,MR	SYN	V,S	07/18/88	1,1
32	05527800	Des Plaines River at Russell, Ill.	42°29'22"	87°55'32"	7	AG,MR	SYN	V,S	07/21/88	1,1
36	05530990	Salt Creek at Rolling Meadows, Ill.	42°03'37"	88°00'59"	--	UR	STO	S	08/17/88 06/22/89	0,8
37	05531175	Salt Creek at Wood Dale, Ill.	41°57'51"	87°59'03"	<1	UR	SYN	V	07/20/88	1,0
38	05531500	Salt Creek at Western Springs, Ill.	41°49'35"	87°54'00"	3	UR,MR	SYN	V,S	07/19/88	2,2
39	05532000	Addison Creek at Bellwood, Ill.	41°52'48"	87°52'07"	1	UR	STO	S	06/20/88 07/13/88	0,9
40	05532500	Des Plaines River at Riverside, Ill.	41°49'20"	87°49'15"	3	UR,MR	PRE	V,S	07/06/88	2,3
42	05534050	Des Plaines River at Lockport, Ill.	41°35'47"	88°04'07"	<1	UR	SYN	V	07/19/88	1,0
47	05536108	North Shore Channel at Devon Avenue at Chicago, Ill.	41°59'51"	87°42'38"	1	UR	SYN	V,S	07/21/88	2,2
48	05536142	Chicago Sanitary and Ship Canal at Forest View, Ill.	41°48'04"	87°48'06"	<1	UR	SYN	V,S	07/19/88	2,1
52	055363252	Little Calumet River at Halsted Avenue at Harvey, Ill.	41°37'45"	87°38'30"	7	UR	SYN	V,S	07/20/88	2,2
55	05536995	Chicago Sanitary and Ship Canal at Romeoville, Ill.	41°38'26"	88°03'38"	<1	UR,MR	PRE	V,S	05/03/88 07/06/88	2,3
							SYN	V	07/19/88	1,0
							FOL	V,S	08/10/88 09/13/88	19,3
58	05538008	Des Plaines River above Brandon River Dam at Joliet, Ill.	41°30'24"	88°05'49"	3	UR,MR	SYN	V,S	07/27/88	1,1
62	05539900	West Branch Du Page River near West Chicago, Ill.	41°54'39"	88°10'44"	<1	UR	SYN	V	07/20/88	1,0
67	05540290	Du Page River near Naperville, Ill.	41°41'24"	88°09'58"	2	UR	SYN	V,S	07/22/88	2,2
69	05540500	Du Page River at Shorewood, Ill.	41°31'20"	88°11'35"	8	UR,MR	SYN	V	07/18/88	1,0

Table 5. Description of sampling stations for volatile and semivolatile organic compounds in surface water in the upper Illinois River Basin—Continued

Map reference number (fig. 8)	Station number	Station name	Latitude	Longitude	Distance to nearest point source (mi)	Type of site	Stage of survey	Chemical group analyzed	Sampling period	Number of observations
70	05541498	Illinois River above Dresden Island Dam near Minooka, Ill.	41°23'58"	88°16'35"	<1	UR,MR	SYN	V,S	07/28/88	1,1
73	05541745	Mazon River near Gardner, Ill.	41°12'22"	88°17'01"	4	AG,MR	SYN	V	07/18/88	1,0
74	05542000	Mazon River near Coal City, Ill.	41°17'10"	88°21'35"	9	AG.MR	SYN	V,S	07/22/88	1,1
75	05543484	Illinois River above Marseilles Dam at Marseilles, Ill.	41°19'19"	88°42'19"	2	UR,MR	SYN	V,S	07/29/88	1,1
76	05543500	Illinois River at Marseilles, Ill.	41°19'37"	88°43'03"	<1	UR,MR	SYN	V,S	07/19/88	1,1
79	05544315	Fox River near Big Bend, Wis.	42°52'38"	88°14'53"	25	AG,MR	SYN	V,S	07/21/88	1,1
87	05549500	Fox River near McHenry, Ill.	41°18'35"	88°15'05"	4	UR,MR	SYN	V,S	07/22/88	1,1
91	05551000	Fox River at South Elgin, Ill.	41°59'40"	88°17'38"	<1	UR	SYN	V	07/21/88	1,0
92	05551540	Fox River at Montgomery, Ill.	41°43'46"	88°20'19"	6	UR,MR	SYN	V,S	07/20/88	1,1
93	05551700	Blackberry Creek near Yorkville, Ill.	41°40'18"	88°26'29"	20	AG	PRE	V,S	05/04/88 06/08/88	2,3
99	05552500	Fox River at Dayton, Ill.	41°23'12"	88°47'26"	5	AG,MR	SYN	V,S	07/19/88	1,1

Table 6. Description of sampling stations for reconnaissance-level survey of semivolatile organic compounds in streambed sediments in the upper Illinois River Basin, 1987

Map reference number (fig. 9)	Stream Name and location	Latitude	Longitude	Primary land use upstream of station
105	Des Plaines River at North Avenue, Ill.	41°54'35"	87°49'29"	Urban
106	Illinois River at Marseilles Pool, Ill.	41°19'17"	88°41'55"	Urban
107	Des Plaines River above Brandon Road Dam, Ill.	41°30'32"	88°05'38"	Urban
108	Calumet Sag Channel at Route 83 Bridge, Ill.	41°41'46"	87°56'06"	Urban
109	Chicago Sanitary and Ship Canal at Lockport Locks, Ill.	41°34'16"	88°04'40"	Urban
110	Calumet Sag Channel at Crawford Avenue Bay, Ill.	41°39'05"	87°43'03"	Urban
111	Little Calumet River at confluence with Grand Calumet River, Ill.	41°38'38"	87°33'39"	Urban
112	Chicago River at Goose Island, Ill.	41°53'47"	87°38'39"	Urban
113	Mud Creek, Ill.	40°36'12"	87°52'58"	Agricultural
114	Hoosier Creek upstream from Route 43 Bridge, Wis.	42°39'30"	88°14'01"	Agricultural

Table 7. Description of sampling stations included in the synoptic survey of semivolatile organic compounds in streambed sediments in the upper Illinois River Basin, 1989

[--, not applicable]

Map reference number (fig. 10)	Date sampled	Station name	Latitude	Longitude	Station number
1	08/02/89	Kankakee River near North Liberty, Ind.	41°33'50"	86°29'50"	05515000
7	08/03/89	Kankakee River at Dunns Bridge, Ind.	41°13'17"	86°57'52"	05517500
11	08/03/89	Kankakee River at Shelby, Ind.	41°10'58"	87°20'33"	05518000
13	08/01/89	Singleton Ditch at County Road 52 near Illiana Heights, Ill.	41°10'25"	87°34'32"	05520150
14	08/01/89	Kankakee River at Momence, Ill.	41°09'36"	87°40'07	05520500
18	08/30/89	Slough Creek near Collegeville, Ind.	40°53'30"	87°09'17"	05523500
21	08/29/89	Sugar Creek near Stockland, Ill.	40°39'01"	87°31'34"	05525290
22	08/29/89	Sugar Creek at Milford, Ill.	40°37'50"	87°43'25"	05525500
23	08/29/89	Iroquois River near Watseka, Ill.	40°48'44"	87°48'25"	05525540
26	08/29/89	Spring Creek near Gilman, Ill.	40°46'08"	87°54'02"	05525600
28	08/30/89	Iroquois River near Chebanse, Ill.	41°00'32"	87°49'27"	05526000
29	08/30/89	Kankakee River near Bourbonnais, Ill.	41°09'08"	87°54'49"	05526130
30	08/30/89	Rock Creek at Highway 102 near Deselm, Ill.	41°12'23"	87°59'05"	05526410
31	07/31/89	Kankakee River near Wilmington, Ill.	41°20'48"	88°11'11"	05527500
32	08/22/89	Des Plaines River at Russell, Ill.	42°29'22"	87°55'32"	05527800
33	08/22/89	Des Plaines River near Gurnee, Ill.	42°20'39"	87°56'18"	05528000
34	08/18/89	Des Plaines River near Des Plaines, Ill.	42°04'55"	87°53'25"	05529000
37	08/12/89	Salt Creek at Wood Dale, Ill.	41°57'51"	87°59'03"	05531175
38	08/12/89	Salt Creek at Western Springs, Ill.	41°49'35"	87°54'00"	05531500
40	08/14/89	Des Plaines River at Riverside, Ill.	41°49'20"	87°49'15"	05532500
41	08/14/89	Flag Creek at 91st Street near Willow Springs, Ill.	41°43'26"	87°54'28"	05533020
42	08/17/89	Des Plaines River at Lockport, Ill.	41°35'47"	88°04'07"	05534050
44	08/18/89	Skokie River at Happ Road at Northfield, Ill.	42°05'11"	87°46'00"	05535172
45	08/18/89	North Branch Chicago River at Niles, Ill.	42°00'44"	87°47'45"	05536000
47	08/25/89	North Shore Channel at Devon Avenue at Chicago, Ill.	41°59'51"	87°42'38"	05536108
48	08/15/89	Chicago Sanitary and Ship Canal at Forest View, Ill.	41°48'04"	87°48'06"	05536142
51	08/15/89	Little Calumet River at South Holland, Ill.	41°36'25"	87°35'52"	05536290
54	08/25/89	Calumet Sag Channel at Sag Bridge, Ill.	41°41'45"	87°56'11"	05536700
55	08/10/89	Chicago Sanitary and Ship Canal at Romeoville, Ill.	41°38'26"	88°03'38"	05536995
58	08/10/89	Des Plaines River above Brandon Road Dam at Joliet, Ill.	41°30'24"	88°05'49"	05538008
61	08/10/89	Des Plaines River below Lock and Dam at Rockdale, Ill.	41°30'00"	88°06'12"	05539360
62	08/07/89	West Branch Du Page River near West Chicago, Ill.	41°54'39"	88°10'44"	05539900
64	08/07/89	West Branch Du Page River near Warrenville, Ill.	41°49'22"	88°10'23"	05540095
65	08/07/89	East Branch Du Page River at Route 34 Bridge at Lisle, Ill.	41°48'02"	88°04'53"	05540210
67	08/07/89	Du Page River near Naperville, Ill.	41°41'24"	88°09'58"	05540290
68	07/31/89	Du Page River at Hamel Woods at Shorewood, Ill.	41°31'54"	88°11'34"	05540490
69	08/08/89	Du Page River at Shorewood, Ill.	41°31'20"	88°11'35"	05540500
70	08/09/89	Illinois River above Dresden Island Dam near Minooka, Ill.	41°23'58"	88°16'35"	05541498
71	08/09/89	Illinois River below Dresden Island Dam near Minooka, Ill.	41°23'51"	88°17'29"	05541508
72	08/08/89	Aux Sable Creek near Morris, Ill.	41°25'02"	88°20'51"	05541710
73	08/08/89	Mazon River near Gardner, Ill.	41°12'22"	88°17'01"	05541745
74	08/08/89	Mazon River near Coal City, Ill.	41°17'10"	88°21'35"	05542000

Table 7. Description of sampling stations included in the synoptic survey of semivolatile organic compounds in streambed sediments in the upper Illinois River Basin, 1989—Continued

Map reference number (fig. 10)	Date sampled	Station name	Latitude	Longitude	Station number
75	08/16/89	Illinois River above Marseilles Dam at Marseilles, Ill.	41°19'19"	88°42'19"	05543484
76	08/16/89	Illinois River at Marseilles, Ill.	41°19'37"	88°43'03"	05543500
77	08/23/89	Pewaukee River at State Route 164 at Waukesha, Wis.	43°02'29"	88°12'39"	05543814
78	08/23/89	Mukwonago River at Marsh Road near Mukwonago, Wis.	42°51'17"	88°23'44"	05544090
79	08/23/89	Fox River near Big Bend, Wis.	42°52'38"	88°14'53"	05544315
80	08/23/89	Honey Creek at Bell School Road near East Troy, Wis.	42°47'43"	88°19'15"	05544908
82	08/23/89	White River near Burlington, Wis.	42°39'57"	88°19'03"	05545300
86	08/22/89	Nippersink Creek near Spring Grove, Ill.	42°26'37"	88°14'51"	05548280
87	08/22/89	Fox River near McHenry, Ill.	42°18'35"	88°15'05"	05549500
89	08/21/89	Fox River at Algonquin, Ill.	42°09'59"	88°17'25"	05550000
90	08/11/89	Poplar Creek at Elgin, Ill.	42°01'35"	88°15'20"	05550500
91	08/11/89	Fox River at South Elgin, Ill.	41°59'40"	88°17'38"	05551000
92	08/17/89	Fox River at Montgomery, Ill.	41°43'46"	88°20'19"	05551540
95	08/09/89	Big Rock Creek at Route 276 near Plano, Ill.	41°38'28"	88°32'14"	05551937
98	08/16/89	Indian Creek at Route 258 at Wedron, Ill.	41°26'33"	88°46'15"	05552400
99	08/16/89	Fox River at Dayton, Ill.	41°23'12"	88°47'26"	05552500
104	08/15/89	Little Calumet River at Halsted Avenue at Harvey, Ill.	41°37'45"	87°38'30"	055363252
115	08/02/89	Crooked Creek at 600 East Road, Ind.	41°28'32"	86°56'59"	--
116	08/02/89	Yellow River at North Hickory Road near Inwood, Ind.	41°21'47"	86°11'37"	--
117	08/02/89	Yellow River above State Route 8 near Knox, Ind.	41°17'14"	86°32'26"	--
118	08/03/89	Kankakee River at Route 39, Ind.	41°20'19"	86°44'06"	--
119	08/03/89	Reeves Ditch at State Route 49 near Kouts, Ind.	41°16'16"	87°01'31"	--
120	08/04/89	Griesel Ditch, Ind.	41°14'47"	87°23'27"	--
121	08/03/89	Ditch at 41°16'24" 86°43'43"	41°16'24"	86°43'43"	--
122	08/04/89	Spring Run, Ind.	41°20'27"	87°21'32"	--
123	08/30/89	Iroquois River near Rensselaer, Ind.	40°54'43"	87°11'28"	--
124	08/30/89	Langan Creek at First bridge upstream from Iroquois River	40°57'15"	87°49'41"	--
125	08/30/89	Ditch near Bourbonnais, Ill.	41°12'23"	87°52'48"	--
126	08/18/89	Skokie River at Highland Park, Ill.	42°10'34"	87°48'58"	--
127	08/18/89	North Branch Chicago River at Central Park Avenue at Chicago, Ill.	41°58'23	87°43'07"	05536100
128	08/02/89	Carlson Ditch, Ind.	41°23'01"	86°27'31"	--
129	08/04/89	Little Calumet River, Ind.	41°33'49"	87°24'46"	--
130	08/15/89	Thorn Creek at Joe Orr Road, Ill.	41°31'14"	87°37'31"	--
131	08/26/89	Chicago Sanitary and Ship Canal at Pulaski Road, Ill.	41°49'30"	87°43'26"	--
132	08/14/89	Des Plaines River near Hodgkins, Ill.	41°45'25"	87°51'31"	--
133	08/21/89	Buffalo Creek at Shaefer Road, Ill.	42°08'58"	88°00'01"	--
134	08/05/89	East Branch Du Page River at St. Charles, Ill.	41°56'05"	88°03'34"	05540150
135	08/07/89	Tributary to West Branch Du Page River near Wheaton, Ill.	41°51'38"	88°07'51"	--
136	08/11/89	Fox River at Aurora, Ill.	41°45'33"	88°18'42"	--

Table 8. Selected information for sampling for synthetic organic compounds in biological tissues in the upper Illinois River Basin, 1989–90

[mm, millimeters; g, grams; yr, years; --, no data]

Portion of organism analyzed: W, whole; F, fillet; A, algae; T, tissue

Map reference number (fig. 11)	Date sampled	Station number	Station name	Common name of organism collected	Portion of organism analyzed	Number of organisms in sample	Average length (mm)	Average weight (g)	Average age (yr)
			1989						
11	07/24/89	05518000	Kankakee River at Shelby, Ind.	Common carp	W	10	408	917	--
11	07/24/89	05518000	Kankakee River at Shelby, Ind.	Common carp	F	9	476	1,560	--
14	07/31/89	05520500	Kankakee River at Momence, Ill.	Smallmouth bass	W	10	162	50	--
14	07/31/89	05520500	Kankakee River at Momence, Ill.	Common carp	F	4	440	1,340	8
23	07/31/89	05525540	Iroquois River near Watseka, Ill.	Largemouth bass	W	9	184	94	--
38	07/25/89	05531500	Salt Creek at Western Springs, Ill.	Crayfish	W	10	--	--	--
40	07/25/89	05532500	Des Plaines River at Riverside, Ill.	Crayfish	W	10	--	--	--
40	07/25/89	05532500	Des Plaines River at Riverside, Ill.	Crayfish	W	10	--	--	--
40	07/25/89	05532500	Des Plaines River at Riverside, Ill.	Crayfish	W	10	--	--	--
40	07/25/89	05532500	Des Plaines River at Riverside, Ill	Goldfish	W	8	244	365	--
40	07/25/89	05532500	Des Plaines River at Riverside, Ill.	Goldfish	F	9	288	873	--
45	08/02/89	05536000	North Branch Chicago River at Niles, Ill.	Crayfish	W	10	--	--	--
45	08/02/89	05536000	North Branch Chicago River at Niles, Ill.	Sago pondweed	A	--	--	[1]114	--
46	08/02/89	05536107	North Shore Channel at Touhy Avenue at Chicago, Ill.	Snail	W	10	--	--	--
46	08/03/89	05536107	North Shore Channel at Touhy Avenue at Chicago, Ill.	Common carp	W	1	440	1,217	--
58	07/28/89	05538008	Des Plaines River above Brandon Dam Road at Joliet, Ill.	Common carp	W	10	336	676	--
58	07/28/89	05538008	Des Plaines River above Brandon Dam Road at Joliet, Ill.	Common carp	F	10	436	1,460	--
66	08/01/89	05540258	East Branch Du Page River at Naperville, Ill.	Unidentified crayfish	W	10	--	--	--
66	08/01/89	05540258	East Branch Du Page River at Naperville, Ill.	Unidentified crayfish	W	10	--	--	--
66	08/03/89	05540258	East Branch Du Page River at Naperville, Ill.	Green sunfish	W	10	85	17	--
68	08/01/89	05540490	Du Page River at Hamel Woods at Shorewood, Ill.	Smallmouth bass	W	4	148	41	--
68	08/01/89	05540490	Du Page River at Hamel Woods at Shorewood, Ill.	Common carp	F	5	506	1,890	12
68	07/29/89	05540490	Du Page River at Hamel Woods at Shorewood, Ill.	Unidentified crayfish	W	10	--	--	--
76	07/27/89	05543500	Illinois River at Marseilles, Ill.	Common carp	W	10	367	704	--
76	07/27/89	05543500	Illinois River at Marseilles, Ill.	Common carp	F	10	428	1,250	--

Table 8. Selected information for sampling for synthetic organic compounds in biological tissues in the upper Illinois River Basin, 1989–90—Continued

Map reference number (fig. 11)	Date sampled	Station number	Station name	Common name of organism collected	Portion of organism analyzed	Number of organisms in sample	Average length (mm)	Average weight (g)	Average age (yr)
			1989—Continued						
81	08/03/89	05544950	Honey Creek at Hill Valley Road near East Troy, Wis.	Crayfish	W	10	--	--	--
81	08/03/89	05544950	Honey Creek at Hill Valley Road near East Troy, Wis.	Common carp	F	9	544	2,960	--
81	08/03/89	05544950	Honey Creek at Hill Valley Road near East Troy, Wis.	Green sunfish	W	5	98	26	--
89	07/26/89	05550000	Fox River at Algonquin, Ill.	Common carp	F	10	556	2,260	--
89	07/26/89	05550000	Fox River at Algonquin, Ill.	Common carp	W	5	512	1,750	--
89	07/26/89	05550000	Fox River at Algonquin, Ill.	Crayfish	W	10	--	--	--
97	07/27/89	05552200	Indian Creek near Harding, Ill.	Yellow bullhead	W	6	145	45	--
97	07/27/89	05552200	Indian Creek near Harding, Ill.	Green sunfish	W	8	108	32	--
			1990						
2	08/02/90	05515480	Mill Creek at Highway 39 near Kingsford Heights, Ind.	White sucker	W	10	262	198	2.1
6	08/03/90	05517120	Pitner Ditch at State Highway 8 near La Crosse, Ind.	White sucker	W	5	363	562	3.6
9	08/02/90	05517725	Crooked Creek at 100 South Road near Wanatah, Ind.	White sucker	W	10	323	487	3.5
9	08/02/90	05517725	Crooked Creek at 100 South Road near Wanatah, Ind.	White sucker	W	10	324	373	3.4
14	08/13/90	05520500	Kankakee River at Momence, Ill.	Common carp	W	9	443	1,210	5.4
24	07/30/90	05525555	Spring Creek near Delrey, Ill.	Green sunfish	W	10	125	48	2.2
24	07/30/90	05525555	Spring Creek near Delrey, Ill.	Mussel	T	6	86	28	--
25	07/31/90	05525570	Spring Creek at Road 730 East near Onarga, Ill.	Green sunfish	W	10	102	27	1.7
27	07/03/90	05525680	Langan Creek at Road 1300 East near Clifton, Ill.	White sucker	W	5	272	199	2.8
28	08/01/90	05526000	Iroquois River near Chebanse, Ill.	Common carp	W	3	465	1,330	7
38	08/08/90	05531500	Salt Creek at Western Springs, Ill.	White sucker	W	6	274	260	2.3
40	08/09/90	05532500	Des Plaines River at Riverside, Ill.	Common carp	W	10	434	1,150	6.3
45	08/09/90	05536000	North Branch Chicago River at Niles, Ill.	Sago pondweed	--	--	--	[1]77	--
45	08/09/90	05536000	North Branch Chicago River at Niles, Ill.	Unidentified crayfish	W	40	--	[1]188	--
53	08/03/90	05536366	Little Calumet River at Calumet Park, Ill.	Common carp	W	10	384	894	5.3

Table 8. Selected information for sampling for synthetic organic compounds in biological tissues in the upper Illinois River Basin, 1989–90—Continued

Map reference number (fig. 11)	Date sampled	Station number	Station name	Common name of organism collected	Portion of organism analyzed	Number of organisms in sample	Average length (mm)	Average weight (g)	Average age (yr)
			1990—Continued						
58	08/13/90	05538008	Des Plaines River above Brandon Road Dam at Joliet, Ill.	Common carp	W	6	376	929	6.2
63	08/07/90	05540066	West Branch Du Page River at Mack Road near West Chicago, Ill.	Common carp	W	10	364	673	5.5
66	08/07/90	05540258	East Branch Du Page River at Naperville, Ill.	White sucker	W	10	257	176	2.6
66	08/07/90	05540258	East Branch Du Page River at Naperville, Ill.	Unidentified crayfish	W	10	--	[1]166	--
66	08/07/90	05540258	East Branch Du Page River at Naperville, Ill.	Unidentified crayfish	W	10	--	[1]168	--
68	08/08/90	05540490	Du Page River at Hamel Woods at Shorewood, Ill.	Common carp	W	10	404	973	7.2
68	08/08/90	05540490	Du Page River at Hamel Woods at Shorewood, Ill.	Asiatic clam	T	21	24	--	--
76	08/05/90	05543500	Illinois River at Marseilles, Ill.	Common carp	W	6	364	668	4.8
78	08/11/90	05544090	Mukwonago River at Marsh Road near Mukwonago, Wis.	White sucker	W	10	192	87	1.2
80	08/11/90	05544908	Honey Creek at Hill Valley Road near East Troy, Wis.	Common carp	W	10	466	1,300	7.8
80	08/11/90	05544908	Honey Creek at Hill Valley Road near East Troy, Wis.	Mussel	T	8	[1]133	--	--
89	08/10/90	05550000	Fox River at Algonquin, Ill.	Common carp	W	10	503	1,620	8.3
93	08/04/90	05551700	Blackberry Creek near Yorkville, Ill.	White sucker	W	10	255	197	8.1
93	08/04/90	05551700	Blackberry Creek near Yorkville, Ill.	Mussel (Elktoe)	T	11	75	--	--
94	08/06/90	05551933	Big Rock Creek above Henning Road near Plano, Ill.	Common carp	W	10	392	796	5.5
97	08/05/90	05552200	Indian Creek near Harding, Ill.	Golden redhorse	W	10	281	219	3.6
99	08/06/90	05552500	Fox River at Dayton, Ill.	Common carp	W	9	358	640	4.3
104	08/03/90	055363252	Little Calumet River at Halsted Road at Harvey, Ill.	Goldfish	W	10	173	116	2.7

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[1] Total weight of organisms.

Table 9. Selected information for the Illinois Environmental Protection Agency Ambient Water-Quality Monitoring Network sampling stations for synthetic organic compounds in the upper Illinois River Basin, 1987–90

[IEPA, Illinois Environmental Protection Agency; USGS, U.S. Geological Survey; mi^2, square miles]

Compounds analyzed: PHE, phenol (samples collected periodically; analyzed for total phenolic compounds); PCP, pentachlorophenol (samples collected periodically); ISSN, Industrial Solvents Subnetwork (samples collected periodically; analyzed for volatile organic compounds); PMSN, Pesticide Monitoring Subnetwork (samples collected 5 times a year; analyzed for pesticides)

Map reference number (fig. 12)	IEPA station code	USGS station number	Sampling agency	Station name	Latitude longitude	Miles above mouth	Drainage area (mi^2)	Compounds analyzed
14	F02	05520500	USGS	Kankakee River at Momence, Ill.	41°09'36" 87°40'07"	47.9	2,294	PHE, PCP
28	FL02	05526000	USGS	Iroquois River near Chebanse, Ill.	41°00'32" 87°49'27"	6.5	2,091	PHE
31	F01	05527500	IEPA	Kankakee River near Wilmington, Ill.	41°20'48" 88°11'11"	5.7	5,150	PHE, PCP, PMSN
33	G07	05528000	IEPA	Des Plaines River near Gurnee, Ill.	42°20'39" 87°56'18"	94.2	232	ISSN
35	G15	05530590	IEPA	Des Plaines River near Schiller Park, Ill.	41°57'11" 87°51'15"	56.9	444	PHE, ISSN, PMSN
38	GL09	05531500	IEPA	Salt Creek at Western Springs, Ill.	41°49'35" 87°54'00"	8.8	115	PHE, PCP, ISSN
40	G39	[1]05532500	USGS	Des Plaines River at Riverside, Ill.	41°49'20" 87°49'15"	44.3	630	PHE
42	G11	05534050	IEPA	Des Plaines River at Lockport, Ill.	41°35'47" 88°04'07"	20.1	700	PHE,ISSN
43	HCCC02	05534500	IEPA	North Branch Chicago River at Deerfield, Ill.	42°09'10" 87°49'07"	64.7	19.7	ISSN
45	HCC07	05536000	IEPA	North Branch Chicago River at Niles, Ill.	42°00'44" 87°47'45"	51.4	100	PHE, PEP, ISSN
49	HB42	05536195	IEPA	Little Calumet River at Munster, Ind.	41°34'07" 87°31'18"	29.6	90.0	PHE, PCP, ISSN
50	HBD04	05536275	IEPA	Thorn Creek at Thornton, Ill.	41°34'05" 87°36'30"	4.2	104	ISSN
54	H01	05536700	IEPA	Calumet Sag Channel at Sag Bridge, Ill.	41°41'45" 87°56'11"	0.9	389	PHE, PCP
55	GI01	05536995	USGS	Chicago Sanitary and Ship Canal at Romeoville, Ill.	41°38'26" 88°03'38"	6.2	739	PHE
56	GI02	05537000	IEPA	Chicago Sanitary and Ship Canal at Lockport, Ill.	41°34'11" 88°04'42"	1.1	740	PHE, PCP, ISSN
57	G23	05537980	IEPA	Des Plaines River at Route 53 at Joliet, Ill.	41°32'12" 88°04'57"	15.7	1,502	PHE, PCP, ISSN
62	GBK09	05539900	IEPA	West Branch Du Page River near West Chicago, Ill.	41°54'39" 88°10'44"	49.2	28.5	ISSN
67	GB10	05540290	IEPA	Du Page River near Naperville, Ill.	41°41'24" 88°09'58"	26.1	220	ISSN
69	GB11	05540500	USGS	Du Page River at Shorewood, Ill.	41°31'20" 88°11'35"	10.6	324	PHE
74	DV04	05542000	IEPA	Mazon River near Coal City, Ill.	41°17'10" 88°21'35"	15.0	455	PHE
76	D23	05543500	USGS	Illinois River at Marseilles, Ill.	41°19'37" 88°43'03"	246.5	8,259	PHE, PCP, ISSN, PMSN
84	DT35	05546700	IEPA	Fox River near Channel Lake, Ill.	42°28'45" 88°10'42"	113.6	871	PHE, PCP
89	DT06	05550000	USGS	Fox River at Algonquin, Ill.	42°09'59" 88°17'25"	81.6	1,403	PHE
91	DT09	05551000	IEPA	Fox River at South Elgin, Ill.	41°59'40" 88°17'38"	67.2	1,556	ISSN
92	DT38	05551540	IEPA	Fox River at Montgomery, Ill.	41°43'46" 88°20'19"	45.9	1,732	PHE, PCP, ISSN
99	DT46	05552500	USGS	Fox River at Dayton, Ill.	41°23'12" 88°47'26"	5.3	2,642	PHE

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[1] U.S. Geological Survey station only.

Table 10. Selected information for the Metropolitan Water Reclamation District of Greater Chicago wastewater-treatment plants
[MWRDGC; Metropolitan Water Reclamation District of Greater Chicago; Mgal/d, million gallons per day]

MWRDGC wastewater-treatment plant	Latitude longitude	Design-average discharge (Mgal/d)	Design-maximum discharge (Mgal/d)	Mean discharge 1987–90 (Mgal/d)	Receiving water (and classification[1])	Level of treatment[2]
Stickney[3]	41°48'36" 87°46'18"	1,200	1,440	784	Chicago Sanitary and Ship Canal (secondary contact[4])	Secondary
Calumet	41°39'42" 87°37'06"	354	430	260	Little Calumet River (secondary contact[4])	Secondary
North Side	42°01'06" 87°42'36"	333	450	278	North Shore Channel (secondary contact[4])	Secondary
James C. Kirie[5]	42°01'06" 88°56'06"	72	110	36	Higgins Creek (general use[6])	Tertiary
John E. Egan	[7]42°00'54" 88°00'00"	30	50	22	Salt Creek (general use[6])	Tertiary
Hanover Park	41°59'54" 88°08'12"	[8]12	[8]22	89	West Branch of Du Page River (general use[6])	Tertiary
Lemont	41°40'42" 88°00'30"	1.6	4.0	1.5	Chicago Sanitary and Ship Canal (secondary contact[4])	Secondary

[1] Classification as defined in Illinois Environmental Protection Agency (1990b).

[2] Level of treatment is categorized as either primary, secondary, or tertiary (advanced). The determination of these categories depends on the removal of suspended solids, biochemical oxygen demand, and other constituents (Zogorski and others, 1990).

[3] Combination of West and Southwest wastewater-treatment plants.

[4] Incidental or accidental contact with the water with minimal risk of ingestion of appreciable quantities.

[5] Formerly O'Hare wastewater-treatment plant.

[6] Suitable for aquatic life, agriculture and industrial uses, and prolonged and intimate body-contact recreation.

[7] South outfall, north outfall at latitude 41°59'06" and longitude 88°08'12".

[8] Combination of north and south outfalls.

Table 11. Results of analysis of reagent-water spikes for Phase II herbicide sampling in the upper Illinois River Basin, 1990

[All concentrations are in micrograms per liter (from D.A. Goolsby, U.S. Geological Survey, written commun., 1991); --, no data; GC/MS, gas chromatography/mass spectrometry; IA, immunoassay; <, less than; >, greater than]

Date submitted to laboratory		Atrazine	Alachlor	Cyanazine	Metribuzin	Metolachlor	Desethyl-atrazine
05/31/90	Expected concentrations	1.2	0.8	0.4	0.2	0.5	--
	Laboratory result;						
	(GC/MS)	1.24	.76	.37	.22	.49	<0.05
	(IA)	1.7	1.8	--	--	--	--
06/05/90	Expected concentrations	20.1	10	14.1	3.0	6.1	--
	Laboratory result;						
	(GC/MS)	18.2	9.34	10.9	3.15	5.75	<.05
	(IA)	10	52	--	--	--	--
06/12/90	Expected concentrations	20.1	10	14.1	3.0	6.1	--
	Laboratory result;						
	(GC/MS)	23.9	11.6	16.7	4.73	6.69	<.05
	(IA)	11	8.0	--	--	--	--
06/20/90	Expected concentrations	2.4	2.0	2.0	.5	1.0	--
	Laboratory result;						
	(GC/MS)	--	--	--	--	--	--
	(IA)	3.3	2.8	--	--	--	--
07/30/90	Expected concentrations	10	5.0	7.0	1.5	3.0	--
	Laboratory result;						
	(IA)	19	5.6	--	--	--	--
08/20/90	Expected concentrations	4.1	2.0	3.1	1.0	3.0	.8
	Laboratory result;						
	(GC/MS)	5.01	2.19	2.49	1.28	3.44	.73
	(IA)	11	2.7	--	--	--	--
05/29/90	Expected concentrations	4.9	4.0	4.0	1.0	2.0	--
	Laboratory result;						
	(GC/MS)	4.58	3.46	2.33	.92	1.58	<.05
	(IA)	4.7	3.8	--	--	--	--

Table 12. Results of analysis of composite[1] samples and automatic-sampler samples collected concurrently at the Iroquois River near Chebanse, Ill., June and July, 1990

[All concentrations are in micrograms per liter (from D.A. Goolsby, U.S. Geological Survey, written commun., 1991); #, number]

Sample type	Triazines (Immunoassay as atrazine)	Chloro-acetanilides (Immunoassay as alachlor)
	June 28, 1990	
Automatic sampler	4.0	4.9
Composite sample #1	4.0	4.9
Composite sample #2	4.3	5.0
Composite sample #3	3.9	4.9
	July 27, 1990	
Automatic sampler	2.6	3.4
Composite sample #1	2.6	3.8
Composite sample #2	2.2	3.5
Composite sample #3	2.4	3.5

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[1] Each sample composited from three verticals.

Table 13. Results of analyses of reference and spiked samples for synthetic organic compounds and other constituents in streambed sediment from the upper Illinois River Basin, August 1989

[Parameter codes are from U.S. Geological Survey WATSTORE data base; g/kg, grams per kilogram; µg/kg, micrograms per kilogram; mg/kg, milligrams per kilogram; <, less than; ±, plus or minus; --, no data]

		Marine reference samples			Polychlorinated biphenyl spikes				Supelco spikes			
Parameter code	Constituent	Reference concentration	^{1}Sample 1	^{1}Sample 2	Reference concentration	^{2}Sample 1	^{3}Sample 2	^{4}Sample 3	Reference concentration	^{5}Sample 1	^{5}Sample 2	^{5}Sample 3
00533	Oil and grease, total (mg/kg)	--	3,300	2,200	--	870	<400	<400	--	<400	<400	<400
00687	Carbon, organic, total, dry weight (mg/kg)	--	140	110	--	62	--	--	--	--	--	--
34203	Acenaphthylene (µg/kg)	±190 50	<420	<420	--	<330	<200	<200	4,000	<250	<200	<200
34208	Acenaphthene (µg/kg)	±230 50	<420	<420	--	480	<200	<200	4,000	<250	<200	<200
34223	Anthracene (µg/kg)	1,100 ±400	<420	<420	--	<300	<200	<200	4,000	410	<200	<200
34233	Benzo(*b*)fluoranthene (µg/kg)	2,800 ±600	<830	<830	--	<660	<400	<400	4,000	<500	<400	<400
34245	Benzo(*k*)fluoranthene (µg/kg)	1,430 ±150	<830	<830	--	<660	<400	<400	4,000	<500	<400	<400
34250	Benzo(*a*)pyrene (µg/kg)	2,200 ±400	<830	<830	--	660	<400	<400	4,000	<500	<400	<400
34276	*bis*(2-Chloroethyl) ether (µg/kg)	--	<420	<420	--	<330	<200	<200	--	<250	<200	<200
34281	*bis*(2-Chloroethoxy) methane (µg/kg)	--	<420	<420	--	<330	<200	<200	--	<250	<200	<200
34286	*bis*(2-Chloroisopropyl) ether (µg/kg)	--	<420	<420	--	<330	<200	<200	--	<250	<200	<200
34295	*n*-Butyl benzyl phthalate (µg/kg)	--	<420	<420	--	<330	<200	<200	--	<250	<200	<200
34323	Chrysene (µg/kg)	2,000 ±300	<830	<830	--	<660	<400	<400	4,000	<500	<400	<400
34339	Diethyl phthalate (µg/kg)	--	<420	<420	--	<330	<200	<200	--	<250	<200	<200
34344	Dimethyl phthalate (µg/kg)	--	<420	<420	--	<330	<200	<200	--	<250	<200	<200
34364	α-Endosulfan (µg/kg)	--	<10	<10	--	<2.5	--	--	--	--	<10	<10
34379	Fluoranthene (µg/kg)	3,540 ±650	<420	1,200	--	3,000.5	<200	<200	4,000	400	<200	<200
34384	Fluorene (µg/kg)	±470 120	<420	<420	--	650	<200	<200	4,000	<250	<200	<200
34389	Hexachlorocyclopentadiene (µg/kg)	--	<420	<420	--	<330	<200	<200	--	<250	<200	<200
34399	Hexachloroethane (µg/kg)	--	<420	<420	--	<330	<200	<200	--	<250	<200	<200
34406	Indeno(1,2,3-*cd*)pyrene (µg/kg)	1,950 ±580	<830	<830	--	<660	<400	<400	4,000	<500	<400	<400
34411	Isophorone (µg/kg)	--	<420	<420	--	<330	<200	<200	--	<250	<200	<200
34431	*N*-nitrosodi-*n*-propylamine (µg/kg)	--	<420	<420	--	<330	<200	<200	--	<250	<200	<200

Table 13. Results of analyses of reference and spiked samples for synthetic organic compounds and other constituents in streambed sediment from the upper Illinois River Basin, August 1989—Continued

		Marine reference samples			Polychlorinated biphenyl spikes				Supelco spikes			
Parameter code	Constituent	Reference concentration	[1]Sample 1	[1]Sample 2	Reference concentration	[2]Sample 1	[3]Sample 2	[4]Sample 3	Reference concentration	[5]Sample 1	[5]Sample 2	[5]Sample 3
34436	*N*-Nitrosodiphenylamine (μg/kg)	--	<420	<420	--	<330	<200	<200	--	<250	<200	<200
34445	Naphthalene (μg/kg)	4,100 ±1,100	<420	2,900	--	<330	<200	<200	4,000	<250	<200	<200
34450	Nitrobenzene (μg/kg)	--	<420	<420	--	<330	<200	<200	--	<250	<200	<200
34455	Parachlorometa cresol (μg/kg)	--	<2,500	<2,500	--	<2,000	<600	<600	--	<1,500	<600	<600
34464	Phenanthrene (μg/kg)	3,000 ±600	<420	2,100	--	<330	<200	<200	4,000	2,100	<200	<200
34472	Pyrene (μg/kg)	3,000 ±600	<420	<420	--	<330	<200	<200	4,000	<250	<200	<200
34524	Benzo(*g,h,i*)-1,12-Benzoperylene (μg/kg)	1,780 ±720	<830	<830	--	<660	<400	<400	4,000	<500	<400	<400
34529	Benzo(*a*)anthracene-1,2-Benzanthracene (μg/kg)	1,800 ±300	<420	<420	--	<330	<400	<400	4,000	<250	<400	<400
34539	1,2-Dichlorobenzene (μg/kg)	--	<420	<420	--	<330	<200	<200	--	<250	<200	<200
34554	1,2,4-Trichlorobenzene (μg/kg)	--	<420	<420	--	<330	<200	<200	--	<250	<200	<200
34559	1,1,5,6-Dibenzanthracene (μg/kg)	--	<830	<830	--	<660	<400	<400	--	<500	<400	<400
34569	1,3-Dichlorobenzene (μg/kg)	--	<420	<420	--	<330	<200	<200	--	<250	<200	<200
34574	1,4-Dichlorobenzene (μg/kg)	--	<420	<420	--	<300	<200	<200	--	<250	<200	<200
34584	2-Chloronaphthalene (μg/kg)	--	<420	<420	--	<330	<200	<200	--	<250	<200	<200
34589	2-Chlorophenol (μg/kg)	--	<420	<420	--	<330	<200	<200	--	<250	<200	<200
34594	2-Nitrophenol (μg/kg)	--	<420	<420	--	<330	<200	<200	--	<250	<200	<200
34599	Dioctyl phthalate (μg/kg)	--	<830	<830	--	<660	<400	<400	--	<500	<400	<400
34604	2,4-Dichlorophenol (μg/kg)	--	<420	<420	--	<330	<200	<200	--	<250	<200	<200
34609	2,4-DP (μg/kg)	--	<420	<420	--	<300	<200	<200	--	<250	<200	<200
34614	2,4-Dinitrotoluene (μg/kg)	--	<420	<420	--	<330	<200	<200	--	<250	<200	<200
34617	2,4-Dinitrophenol (μg/kg)	--	<1,700	<1,700	--	<1,300	<600	<600	--	<1,000	<600	<600
34624	2,4,6-Trichlorophenol (μg/kg)	--	<1,700	<1,700	--	<1,300	<600	<600	--	<1,000	<600	<600
34629	2,6-Dinitrotoluene (μg/kg)	--	<420	<420	--	<330	<200	<200	--	<250	<200	<200
34634	3,3-Dichlorobenzidine (μg/kg)	--	<2,100	<2,100	--	<1,600	--	--	--	<1,300	--	--
34639	4-Bromophenylphenylether (μg/kg)	--	<420	<420	--	<330	<200	<200	--	<250	<200	<200
34644	4-Chlorophenylphenylether (μg/kg)	--	<420	<420	--	<330	--	--	--	<250	--	--
34649	4-Nitrophenol (μg/kg)	--	<2,500	<2,500	--	<2,000	<600	<600	--	<1,500	<600	<600
34660	4,6-Dinitroorthocresol (μg/kg)	--	<2,500	<2,500	--	<2,000	<600	<600	--	<1,500	<600	<600
34695	Phenol (c6h-50h) (μg/kg)	--	<420	<420	--	<330	<200	<200	--	<250	<200	<200

Table 13. Results of analyses of reference and spiked samples for synthetic organic compounds and other constituents in streambed sediment from the upper Illinois River Basin, August 1989—Continued

		Marine reference samples			Polychlorinated biphenyl spikes				Supelco spikes			
Parameter code	Constituent	Reference concentration	[1]Sample 1	[1]Sample 2	Reference concentration	[2]Sample 1	[3]Sample 2	[4]Sample 3	Reference concentration	[5]Sample 1	[5]Sample 2	[5]Sample 3
39061	Pentachlorophenol (µg/kg)	--	<2,500	<2,500	--	<200	<600	<600	--	<1,500	<600	<600
39076	Alpha PHC, total (µg/kg)	--	16	<10	--	<2.5	--	--	20	--	<10	<10
39102	*bis*(2-Ethylhexyl)phthalate (µg/kg)	--	<420	<420	--	<330	<200	<200	--	<250	<200	<200
39112	Dinbutylphthalate (µg/kg)	--	<420	<420	--	<330	<200	<200	--	<250	<200	<200
39121	Benzidine (µg/kg)	--	<4,200	<4,200	--	<,3300	--	--	--	<2,500	--	--
39301	*p,p'*-DDT (µg/kg dry solids)	--	<10	<10	--	<2.5	--	--	120	--	150	150
39321	*p,p'*-DDE (µg/kg dry solids)	--	<10	<10	--	<2.5	--	--	40	--	99	140
39333	Aldrin (µg/kg dry solids)	--	<10	<10	--	<2.5	<.1	<.1	20	<.1	47	60
39343	Lindane (µg/kg dry solids)	--	<10	<10	--	<2.5	<.1	<.1	--	<.1	32	56
38351	Chlordane (µg/kg dry solids)	--	<100	<100	--	<10	<1	<1	--	<1	<100	<100
39383	Dieldrin (µg/kg dry solids)	--	<10	<10	--	<2.5	<.1	<.1	40	<.1	<10	<10
39393	Endrin (µg/kg dry solids)	--	<10	<10	--	<2.5	<.1	<.1	40	.1	<10	<10
39403	Toxaphene (µg/kg dry solids)	--	<500	<500	--	<100	<10	<10	--	<10	<500	<500
39413	Heptachlor (µg/kg dry solids)	--	34	<10	--	<2.5	>.1	<.1	20	<.1	<10	36
39423	Heptachlor epoxide (µg/kg dry solids)	--	<10	<10	--	<2.5	<.1	<.1	20	<.1	49	54
39491	Aroclor 1221 (µg/kg)	--	<100	<100	--	<10	<100	<100	400	<1	<100	<100
39495	Aroclor 1232 (µg/kg)	--	<100	<100	--	<10	<100	<100	--	<1	<100	<100
39499	Aroclor 1242 PCB (µg/kg)	--	<100	<100	14,500	140	6,300	5,800	400	<1	<100	<100
39503	Aroclor a248 PCB (µg/kg)	--	<100	<100	--	<10	<100	<100	--	<1	<100	<100
39507	Aroclor 1254 PCB (µg/kg)	--	<100	<100	37,500	3,400	2,000	2,200	400	<1	<100	<100
39511	Aroclor 1260 PCB (µg/kg)	--	<100	<100	19,000	280	6,000	9,200	--	<1	200	240
39514	Aroclor 1016 PCB (µg/kg)	--	<100	<100	--	<10	<100	<100	--	<1	<100	<100
39701	Hexachlorobenzene (µg/kg dry solids)	--	<420	<420	--	<330	<200	<200	--	<250	<200	<200
39705	Hexachlorobutadine (µg/kg)	--	<420	<420	--	<330	<200	<200	--	<250	<200	<200

[1] Marine reference sample HS-6 from National Research Council, Canada.

[2] PCB's in soil reference sample for Aroclor 1254.

[3] PCB's in soil reference sample for Aroclor 1260.

[4] PCB's in soil reference sample for Aroclor 1242.

[5] 0.1 milliliter each of Supelco reference mixtures 8858, 8905, and 8862 in 50 grams of soil.

Table 14. Results of analyses of quality-assurance samples for synthetic organic compounds and other constituents in biota in the upper Illinois River Basin, 1989

[<, less than; ppm, parts per million; NS, not spiked; --, no data]

Constituent	Common carp (ppm)	Common carp (ppm)	Crayfish (ppm)	Crayfish (ppm)	Crayfish (ppm)	Crayfish (ppm)	Crayfish (ppm)	Spike, vegetation[1] (percent recovery)	Spike, vegetation[1] (percent recovery)
Anthracene	--	--	<0.01	<0.01	0.01	<0.01	<0.01	--	94
1,2-Benzanthracene	--	--	.02	.02	.01	<.01	.01	--	73
Benzo(*b*)fluoranthene	--	--	.01	.01	.01	<.01	<.01	--	100
Benzo(*k*)fluoranthene	--	--	<.01	<.01	<.01	<.01	<.01	--	83
Benzo(*g,h,i*)perylene	--	--	<.01	<.01	.01	<.01	<.01	--	63
Benzo(*e*)pyrene	--	--	<.01	<.01	.01	<.01	<.01	--	98
Benzo(*a*)pyrene	--	--	.01	.01	.01	<.01	<.01	--	79
cis-Chlordane	0.07	0.07	.01	.01	.01	<.01	<.01	90	--
trans-Chlordane	.05	.05	.01	.01	.01	<.01	<.01	NS	--
Chrysene	--	--	.02	.02	.01	.01	.01	--	83
o,p'-DDD	<.01	<.01	.02	.02	.01	<.01	<.01	NS	--
p,p'-DDD	.03	.02	.06	.06	.05	.01	.01	100	--
o,p'-DDE	<.01	<.01	<.01	<.01	<.01	<.01	<.01	95	--
p,p'-DDE	.06	.06	.08	.08	.07	.02	.01	91	--
o,p'-DDT	<.01	<.01	<.01	<.01	<.01	<.01	<.01	95	--
p,p'-DDT	<.01	<.01	<.01	<.01	<.01	<.01	<.01	76	--
1,2,5,6-Dibenzanthracene	--	--	<.01	<.01	<.01	<.01	<.01	--	64
Dieldrin	.16	.15	<.01	<.01	<.01	<.01	<.01	80	--
Endrin	<.01	<.01	<.01	<.01	<.01	<.01	<.01	92	--
Fluoranthene	--	--	.06	.06	.06	.02	.02	--	83
Fluorene	--	--	.01	.01	.01	<.01	<.01	--	100
Heptachlor epoxide	.05	.05	<.01	<.01	<.01	<.01	<.01	98	--
Hexachlorobenzene (HCB)	<.01	<.01	<.01	<.01	<.01	<.01	<.01	65	--
α-Hexachlorocyclohexane	<.01	<.01	<.01	<.01	<.01	<.01	<.01	NS	--
γ-Hexachlorocyclohexane (Lindane)	<.01	<.01	<.01	<.01	<.01	<.01	<.01	97	--
β-Hexachlorocyclohexane	<.01	<.01	<.01	<.01	<.01	<.01	<.01	100	--
δ-Hexachlorocyclohexane	<.01	<.01	<.01	<.01	<.01	<.01	<.01	NS	--
Mirex	<.01	<.01	<.01	<.01	<.01	<.01	<.01	92	--
Napthalene	--	--	<.01	<.01	<.01	<.01	<.01	--	54
cis-Nonachlor	<.01	<.01	<.01	<.01	<.01	<.01	<.01	83	--
trans-Nonachlor	<.01	<.01	<.01	<.01	<.01	<.01	<.01	88	--
Octochlorostyrene	<.01	<.01	<.01	<.01	<.01	<.01	<.01	--	--
Oxychlordane	<.01	<.01	<.01	<.01	<.01	<.01	<.01	87	--
PCB's (total)	<.05	<.05	.24	.24	.25	<.05	<.05	NS	--
Phenanthrene	--	--	.05	.06	.04	<.01	<.02	--	94
Pyrene	--	--	.06	.05	.06	.02	.01	--	83
Toxaphene	<.05	<.05	<.05	<.05	<.05	<.05	<.05	NS	--
Sample weight (grams)	9,170	9,170	351	351	246	108	109	--	--
Moisture content (percent)	72	70.5	79	78	78.5	74.5	74.5	80	80
Lipid content (percent)	9.18	9.46	2.42	2.36	2.32	2.00	1.40	.46	--

Table 14. Results of analysis of quality-assurance samples for synthetic organic compounds and other constituents in biota in the upper Illinois River Basin, 1989—Continued

Constituent	Spike, fish, (percent recovery)	Spike, fish, (percent recovery)	Spike, fish, (percent recovery)	Spike, fish, (percent recovery)	Spike, fish, (percent recovery)	Matrix blank vegetation (ppm)	Matrix blank vegetation (ppm)	Matrix blank fish (ppm)	Matrix blank fish (ppm)
Anthracene	--	--	--	--	79	--	<0.01	--	<0.01
1,2-Benzanthracene	--	--	--	--	73	--	<.01	--	<.01
Benzo(*b*)fluoranthene	--	--	--	--	61	--	<.01	--	<.01
Benzo(*k*)fluoranthene	--	--	--	--	58	--	<.01	--	<.01
Benzo(*g,h,i*)perylene	--	--	--	--	55	--	<.01	--	<.01
Benzo(*e*)pyrene	--	--	--	--	69	--	<.01	--	<.01
Benzo(*a*)pyrene	--	--	--	--	58	--	<.01	--	<.01
cis-Chlordane	100	98	--	--	--	<0.01	--	0.01	--
trans-Chlordane	NS	NS	--	--	--	<.01	--	<.01	--
Chrysene	--	--	--	--	73	--	<.01	--	<.01
o,p'-DDD	NS	NS	--	--	--	<.01	--	<.01	--
p,p'-DDD	120	110	--	--	--	<.01	--	<.01	--
o,p'-DDE	99	97	--	--	--	<.01	--	<.01	--
p,p'-DDE	100	100	--	--	--	<.01	--	.02	--
o,p'-DDT	100	100	--	--	--	<.01	--	<.01	--
p,p'-DDT	100	98	--	--	--	<.01	--	<.01	--
1,2,5,6-Dibenzanthracene	--	--	--	--	62	--	<.01	--	<.01
Dicofol	87	88	--	--	--	--	--	<.01	--
Dieldrin	90	100	--	--	--	<.01	--	.01	--
Endrin	94	100	--	--	--	<.01	--	<.01	--
Fluoranthene	--	--	--	--	72	--	<.01	--	<.01
Fluorene	--	--	--	--	82	--	<.01	--	<.01
Heptachlor epoxide	100	100	--	--	--	<.01	--	<.01	--
Hexachlorobenzene (HCB)	69	67	--	--	--	<.01	--	<.01	--
α-Hexachlorocyclohexane	NS	NS	--	--	--	<.01	--	<.01	--
γ-Hexachlorocyclohexane (Lindane)	96	97	--	--	--	<.01	--	<.01	--
β-Hexachlorocyclohexane	96	94	--	--	--	<.01	--	<.01	--
δ-Hexachlorocyclohexane	NS	NS	--	--	--	<.01	--	<.01	--
Kepone	NS	NS	78	62	--	--	--	<.01	--
Mirex	<10	96	--	--	--	<.01	--	<.01	--
Napthalene	--	--	--	--	74	--	<.01	--	<.01
cis-Nonachlor	100	96	--	--	--	<.01	--	<.01	--
trans-Nonachlor	96	94	--	--	--	<.01	--	<.01	--
Octochlorostyrene	86	86	--	--	--	--	--	<.01	--
Oxychlordane	92	90	00	00	00	<.01	--	<.01	--
PCB's (total)	NS	NS	--	--	--	<.05	--	<.05	--
Phenanthrene	--	--	--	--	90	--	<.01	--	<.01
Pyrene	--	--	--	--	62	--	<.01	--	<.01
Toxaphene	NS	NS	--	--	--	<.05	--	<.05	--
Sample weight (grams)	--	--	--	--	--	--	--	--	--
Moisture content (percent)	71.5	70	71.5	--	81.8	80.0	80.0	71.00	81.8
Lipid content (percent)	8.04	7.98	7.98	--	--	.46	--	8.53	--

Table 14. Results of analysis of quality-assurance samples for synthetic organic compounds and other constituents in biota in the upper Illinois River Basin, 1989—Continued

Compound	Reagent blank (ppm)	Reagent blank (ppm)	Reagent blank (ppm)	Reagent blank (ppm)	Reagent blank (ppm)	Reagent blank (ppm)	Reagent blank (ppm)	Reagent blank (ppm)	Reagent blank (ppm)
Anthracene	--	--	--	--	--	--	<0.01	<0.01	<0.01
1,2-Benzanthracene	--	--	--	--	--	--	<.01	<.01	<.01
Benzo(*b*)fluoranthene	--	--	--	--	--	--	<.01	<.01	<.01
Benzo(*k*)fluoranthene	--	--	--	--	--	--	<.01	<.01	<.01
Benzo(*g,h,i*)perylene	--	--	--	--	--	--	<.01	<.01	<.01
Benzo(*e*)pyrene	--	--	--	--	--	--	<.01	<.01	<.01
Benzo(*a*)pyrene	--	--	--	--	--	--	<.01	<.01	<.01
cis-Chlordane	<0.01	<0.01	<0.01	<0.01	<0.01	--	--	--	--
trans-Chlordane	<.01	<.01	<.01	<.01	<.01	--	--	--	--
Chrysene	--	--	--	--	--	--	<.01	<.01	<.01
o,p'-DDD	<.01	<.01	<.01	<.01	<.01	--	--	--	--
p,p'-DDD	<.01	<.01	<.01	<.01	<.01	--	--	--	--
o,p'-DDE	<.01	<.01	<.01	<.01	<.01	--	--	--	--
p,p'-DDE	<.01	<.01	<.01	<.01	<.01	--	--	--	--
o,p'-DDT	<.01	<.01	<.01	<.01	<.01	--	--	--	--
p,p'-DDT	<.01	<.01	<.01	<.01	<.01	--	--	--	--
1,2,5,6-Dibenzanthracene	--	--	--	--	--	--	<.01	<.01	<.01
Dicofol	<.01	.01	<.01	<.01	--	<.01	--	--	--
Dieldrin	<.01	<.01	<.01	<.01	<.01	--	--	--	--
Endrin	<.01	.01	<.01	<.01	<.01	--	--	--	--
Fluoranthene	--	--	--	--	--	--	<.01	<.01	<.01
Fluorene	--	--	--	--	--	--	<.01	<.01	<.01
Heptachlor epoxide	<.01	<.01	<.01	<.01	<.01	--	--	--	--
Hexachlorobenzene (HCB)	<.01	<.01	<.01	<.01	<.01	--	--	--	--
α-Hexachlorocyclohexane	<.01	<.01	<.01	<.01	<.01	--	--	--	--
γ-Hexachlorocyclohexane (Lindane)	<.01	<.01	<.01	<.01	<.01	--	--	--	--
β-Hexachlorocyclohexane	<.01	<.01	<.01	<.01	<.01	--	--	--	--
δ-Hexachlorocyclohexane	<.01	<.01	<.01	<.01	<.01	--	--	--	--
Kepone	<.01	<.01	<.01	<.01	--	<.01	--	--	--
Mirex	<.01	<.01	<.01	<.01	<.01	--	--	--	--
Napthalene	--	--	--	--	--	--	<.01	<.01	<.01
cis-Nonachlor	<.01	<.01	<.01	<.01	<.01	--	--	--	--
trans-Nonachlor	<.01	<.01	<.01	<.01	<.01	--	--	--	--
Octochlorostyrene	<.01	<.01	<.01	<.01	--	<0.01	--	--	--
Oxychlordane	<.01	<.01	<.01	<.01	<.01	--	--	--	--
PCB's (total)	<.05	<.05	<.05	<.05	<.05	--	--	--	--
Phenanthrene	--	--	--	--	--	--	<.01	<.01	<.01
Pyrene	--	--	--	--	--	--	<.01	<.01	<.01
Toxaphene	<.05	<.05	<.05	<.05	<.05	--	--	--	--
Sample weight (grams)	--	--	--	--	--	--	--	--	--
Moisture content (percent)	--	--	--	--	--	--	--	--	--
Lipid content (percent)	--	--	--	--	--	--	--	--	--

[1] All spikes were to 0.10 parts per million, except kepone, which was spiked to 0.50 parts per million.

Table 15. Results of analyses of quality-assurance samples for synthetic organic compounds and other constituents in biota in the upper Illinois River Basin, 1990

[<,less than; ppm, parts per million; NS, not spiked; --, no data]

Constituent	Lab split		Lab split		Spike, fish[1] (percent recovery)	Spike, fish[1] (percent recovery)	Spike, fish[1] (percent recovery)
	White sucker (ppm)	White sucker (ppm)	Common carp (ppm)	Common carp (ppm)			
Anthracene	--	--	--	--	89	--	--
1,2-Benzanthracene	--	--	--	--	73	--	--
Benzo(*b*)fluoranthene	--	--	--	--	68	--	--
Benzo(*k*)fluoranthene	--	--	--	--	67	--	--
Benzo(*g,h,i*)perylene	--	--	--	--	70	--	--
Benzo(*e*)pyrene	--	--	--	--	71	--	--
Benzo(*a*)pyrene	--	--	--	--	77	--	--
cis-Chlordane	0.03	0.03	0.03	0.02	--	88	92
trans-Chlordane	.01	.01	.02	.02	--	NS	NS
Chrysene	--	--	--	--	73	--	--
o,p'-DDD	<.01	<.01	.02	.01	--	NS	NS
p,p'-DDD	.03	.03	.02	.02	--	100	100
o,p'-DDE	<.01	<.01	<.01	<.01	--	97	100
p,p'-DDE	.03	.03	.04	.03	--	88	92
o,p'-DDT	<.01	<.01	<.01	<.01	--	92	93
p,p'-DDT	<.01	<.01	<.01	<.01	--	94	92
1,2,5,6-Dibenzanthracene	--	--	--	--	70	--	--
Dieldrin	.05	.06	.08	.08	--	97	98
Endrin	<.01	<.01	<.01	<.01	--	100	99
Fluoranthene	--	--	--	--	67	--	--
Fluorene	--	--	--	--	81	--	--
Heptachlor epoxide	.01	.01	.02	.02	--	97	100
Hexachlorobenzene (HCB)	<.01	<.01	<.01	<.01	--	54	63
α-Hexachlorocyclohexane	<.01	<.01	<.01	<.01	--	NS	NS
γ-Hexachlorocyclohexane (Lindane)	<.01	<.01	<.01	<.01	--	85	91
β-Hexachlorocyclohexane	<.01	<.01	<.01	<.01	--	89	94
δ-Hexachlorocyclohexane	<.01	<.01	<.01	<.01	--	NS	NS
Kepone	<.01	<.01	<.01	<.01	--	NS	NS
Mirex	<.01	<.01	<.01	<.01	--	85	87
Napthalene	--	--	--	--	61	--	--
cis-Nonachlor	<.01	<.01	<.01	<.01	--	88	88
trans-Nonachlor	.02	.02	.03.	.02	--	91	88
Oxychlordane	<.01	<.01	.01	.01	--	85	89
PCB's (total)	.25	.23	<.05	<.05	--	NS	NS
Phenanthrene	--	--	--	--	100	--	--
Pyrene	--	--	--	--	77	--	--
Toxaphene	<.05	<.05	<.05	<.05	--	NS	NS
Sample weight (grams)	2,600	2,600	10,900	10,900	--	--	--
Moisture content (percent)	76.8	77.2	70.8	70.8	80	83.4	81.8
Lipid content (content)	3.26	3.34	7.68	7.18	--	.889	1.04

Table 15. Results of analyses of quality-assurance samples for synthetic organic compounds and other constituents in biota in the upper Illinois River Basin, 1990—Continued

Constituent	Spike, fish [1] (percent recovery)	Spike, fish [1] (percent recovery)	Spike, fish [1] (percent recovery)	Matrix blank vegetation (ppm)	Matrix blank fish (ppm)	Matrix blank fish (ppm)	Reagent blank (ppm)
Anthracene	--	--	95	<0.01	--	<0.01	--
1,2-Benzanthracene	--	--	81	<.01	--	<.01	--
Benzo(*b*)fluoranthene	--	--	81	<.01	--	<.01	--
Benzo(*k*)fluoranthene	--	--	66	<.01	--	<.01	--
Benzo(*g,h,i*)perylene	--	--	74	<.01	--	<.01	--
Benzo(*e*)pyrene	--	--	68	<.01	--	<.01	--
Benzo(*a*)pyrene	--	--	73	<.01	--	<.01	--
cis-Chlordane	NS	NS	--	--	<0.01	--	<0.01
trans-Chlordane	NS	NS	--	--	<.01	--	<.01
Chrysene	--	--	73	<.01	--	<.01	--
o,p'-DDD	NS	NS	--	--	<.01	--	<.01
p,p'-DDD	NS	NS	--	--	<.01	--	<.01
o,p'-DDE	NS	NS	--	--	<.01	--	<.01
p,p'-DDE	NS	NS	--	--	<.01	--	<.01
o,p'-DDT	NS	NS	--	--	<.01	--	<.01
p,p'-DDT	NS	NS	--	--	<.01	--	<.01
1,2,5,6-Dibenzanthracene	--	--	71	<.01	--	<.01	--
Dieldrin	NS	NS	--	--	<.01	--	<.01
Endrin	NS	NS	--	--	<.01	--	<.01
Fluorene	--	--	85	<.01	--	<.01	--
Fluoranthene	--	--	79	<.01	--	<.01	--
Heptachlor epoxide	NS	NS	--	--	<.01	--	<.01
Hexachlorobenzene (HCB)	NS	NS	--	--	<.01	--	<.01
α-Hexachlorocyclohexane	NS	NS	--	--	<.01	--	<.01
γ-Hexachlorocyclohexane (Lindane)	NS	NS	--	--	<.01	--	<.01
β-Hexachlorocyclohexane	NS	NS	--	--	<.01	--	<.01
δ-Hexachlorocyclohexane	NS	NS	--	--	<.01	--	<.01
Kepone	68	66	--	--	<.01	--	<.01
Mirex	NS	NS	--	--	<.01	--	<.01
Napthalene	--	--	50	<.01	--	<.01	--
cis-Nonachlor	NS	NS	--	--	<.01	--	<.01
trans-Nonachlor	NS	NS	--	--	<.01	--	<.01
Oxychlordane	NS	NS	--	--	<.01	--	<.01
PCB's (total)	NS	NS	--	--	<.05	--	<.05
Phenanthrene	--	--	89	<.01	--	<.01	--
Pyrene	--	--	81	<.01	--	<.01	--
Toxaphene	NS	NS	--	--	<.05	--	<.05
Sample weight (grams)	--	--	--	--	--	--	--
Moisture content (percent)	--	--	82.8	80	81.4	81.4	--
Lipid content (percent	--	--	--	--	1.14	--	--

Table 15. Results of analyses of quality-assurance samples for synthetic organic compounds and other constituents in biota in the upper Illinois River Basin, 1990—Continued

Constituent	Reagent blank (ppm)	Reagent blank (ppm)	Reagent blank (ppm)	Reagent blank (ppm)	Reagent blank (ppm)	Reagent blank (ppm)	Reagent blank (ppm)
Anthracene	--	--	--	--	--	<0.01	<0.01
1,2-Benzanthracene	--	--	--	--	--	<.01	<.01
Benzo(*b*)fluoranthene	--	--	--	--	--	<.01	<.01
Benzo(*k*)fluoranthene	--	--	--	--	--	<.01	<.01
Benzo(*g,h,i*)perylene	--	--	--	--	--	<.01	<.01
Benzo(*e*)pyrene	--	--	--	--	--	<.01	<.01
Benzo(*a*)pyrene	--	--	--	--	--	<.01	<.01
cis-Chlordane	<0.01	<0.01	<0.01	<0.01	<0.01	--	--
trans-Chlordane	<.01	<.01	<.01	<.01	<.01	--	--
Chrysene	--	--	--	--	--	<.01	<.01
o,p'-DDD	<.01	<.01	<.01	<.01	<.01	--	--
p,p'-DDD	<.01	<.01	<.01	<.01	<.01	--	--
o,p'-DDE	<.01	<.01	<.01	<.01	<.01	--	--
p,p'-DDE	<.01	<.01	<.01	<.01	<.01	--	--
o,p'-DDT	<.01	<.01	<.01	<.01	<.01	--	--
p,p'-DDT	<.01	<.01	<.01	<.01	<.01	--	--
1,2,5,6-Dibenzanthracene	--	--	--	--	--	<.01	<.01
Dieldrin	<.01	<.01	<.01	<.01	<.01	--	--
Endrin	<.01	<.01	<.01	<.01	<.01	--	--
Fluoranthene	--	--	--	--	--	<.01	<.01
Fluorene	--	--	--	--	--	<.01	<.01
Heptachlor epoxide	<.01	<.01	<.01	<.01	<.01	--	--
Hexachlorobenzene (HCB)	<.01	<.01	<.01	<.01	<.01	--	--
α-Hexachlorocyclohexane	<.01	<.01	<.01	<.01	<.01	--	--
γ-Hexachlorocyclohexane (Lindane)	<.01	<.01	<.01	<.01	<.01	--	--
β-Hexachlorocyclohexane	<.01	<.01	<.01	<.01	<.01	--	--
δ-Hexachlorocyclohexane	<.01	<.01	<.01	<.01	<.01	--	--
Kepone	<.01	<.01	<.01	<.01	<.01	--	--
Mirex	<.01	<.01	<.01	<.01	<.01	--	--
Napthalene	--	--	--	--	--	<.01	<.01
cis-Nonachlor	<.01	<.01	<.01	<.01	<.01	--	--
trans-Nonachlor	<.01	<.01	<.01	<.01	<.01	--	--
Oxychlordane	<.01	<.01	<.01	<.01	<.01	--	--
PCB's (total)	<.05	<.05	<.05	<.05	<.05	--	--
Phenanthrene	--	--	--	--	--	<.01	<.01
Pyrene	--	--	--	--	--	<.01	<.01
Toxaphene	<.05	<.05	<.05	<.05	<.05	--	--
Sample weight (grams)	--	--	--	--	--	--	--
Moisture content (percent)	--	--	--	--	--	--	--
Lipid content (percent)	--	--	--	--	--	--	--

[1] All spikes were to 0.10 parts per million.

Table 16. Selected information on synthetic organic compounds in water in the upper Illinois River Basin, 1978–88

Compound	Number of samples analyzed	Number of detections	Number of stations
	Phenolic compounds		
Pentachlorophenol (PCP)	234	187	28
Phenols[1]	520	45	33
	Chlorinated hydrocarbons		
Aldrin	328	1	59
cis-Chlordane	268	0	28
trans-Chlordane	268	0	28
o,p'-DDD	273	0	30
p,p'-DDE	280	1	37
o,p'-DDE	278	0	35
o,p'-DDT	280	1	37
p,p'-DDT	279	1	36
DDT (total)	256	1	48
Dieldrin	328	[2]197	58
Endrin	312	0	59
Heptachlor	44	0	34
Heptachlor epoxide	45	[2]4	35
Hexachlorobenzene	292	0	31
α-Hexachlorocyclohexane	278	0	35
γ-Hexachlorocyclohexane (Lindane)	294	0	36
Methoxychlor	305	0	52
Mirex	14	0	5
cis-Nonachlor	230	0	28
trans-Nonachlor	230	0	28
PCB's (total)	310	0	59
Technical chlordane and metabolites	310	[2]197	58
	Organophosphorus compounds		
Chlorpyrifos	51	[2]2	5
Diazinon	42	0	5
Fonofos	42	0	5
Malathion	48	0	11
Methyl parathion	42	0	5
Phorate	38	0	5
Terbufos	41	0	4
	Herbicides and fungicide		
Alachlor	41	26	4
Atrazine	41	29	4
Butylate	47	0	3
Cyanzine	41	20	4
Captan	38	01	3
Metolachlor	41	25	4
Metribuzin	50	11	4
Trifluralin	38	2	3

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[1] Detection limit of 5 micrograms per liter.

[2] Presence of compound verified but not quantified.

Table 17. Statistical summary of synthetic organic compound concentrations in water from selected stations in the upper Illinois River Basin, 1979–88

[All concentrations are in micrograms per liter; this table includes only those stations having 10 or more samples analyzed; percentiles are the values one-tenth, one-forth, one-half (median), three-fourths, and nine-tenths of the way through the ordered data values; the 10th and 90th percentiles are shown for stations having 30 or more samples; <, less than; --, insufficient sample size to calculate]

Map reference number (fig. 12)	Station name	Period of record	Number of samples analyzed	Concentration at indicated percentile				
				10	25	50	75	90
	Total recoverable phenols							
14	Kankakee River at Momence, Ill.	1979–87	17	--	<5	<5	<5	--
31	Kankakee River near Wilmington, Ill.	1980–87	55	<1	<5	<5	<5	<5
	Total recoverable pentachlorophenol (PCP)							
14	Kankakee River at Momence, Ill.	1979–88	17	--	<.010	<.010	.013	--
31	Kankakee River near Wilmington, Ill.	1979, 1981–88	21	--	<.010	<.010	.016	--
35	Des Plaines River near Schiller Park, Ill.	1979, 1981–88	19	--	.030	.050	.080	--
38	Salt Creek at Western Springs, Ill.	1979, 1981–88	18	--	.056	.082	.168	--
45	North Branch Chicago River at Niles, Ill.	1979, 1981–88	17	--	.021	.039	.054	--
49	Little Calumet River at Munster, Ind.	1981–88	13	--	.023	.044	.064	--
54	Calumet Sag Channel at Sag Bridge, Ill.	1979, 1981–88	18	--	.060	.084	.168	--
55	Chicago Sanitary and Ship Canal at Romeoville, Ill.	1979, 1981–88	17	--	.048	.140	.255	--
76	Illinois River at Marseilles, Ill.	1979, 1981–88	16	--	.024	.061	.085	--
84	Fox River near Channel Lake, Ill.	1979, 1981–88	18	--	<.010	<.010	.015	--
92	Fox River at Montgomery, Ill.	1979, 1981–88	21	--	.012	.019	.040	--
99	Fox River at Dayton, Ill.	1979, 1981–87	17	--	.011	.023	.034	--
	Total recoverable alaclor							
31	Kankakee River near Wilmington, Ill.	1986–88	13	--	<.02	.03	.08	--
35	Des Plaines River near Schiller Park, Ill.	1986–88	12	--	<.02	<.02	<.02	--
76	Illinois River at Marseilles, Ill.	1986–88	13	--	<.02	.05	.19	--
	Total recoverable butylate							
31	Kankakee River near Wilmington, Ill.	1986–88	16	--	<.05	<.05	<.05	--
35	Des Plaines River near Schiller Park, Ill.	1986–88	15	--	<.05	<.05	<.05	--
76	Illinois River at Marseilles, Ill.	1986–88	16	--	<.05	<.05	<.05	--
	Total recoverable atrazine							
31	Kankakee River near Wilmington, Ill.	1986–88	13	--	.07	.25	.58	--
35	Des Plaines River near Schiller Park, Ill.	1986–88	12	--	<.05	.57	1.21	--
76	Illinois River at Marseilles, Ill.	1986–88	13	--	<.05	.62	1.40	--
	Total recoverable cyanazine							
31	Kankakee River near Wilmington, Ill.	1986–88	13	--	<.05	<.05	.08	--
35	Des Plaines River near Schiller Park, Ill.	1986–88	12	--	<.05	<.05	.19	--
76	Illinois River at Marseilles, Ill.	1986–88	13	--	<.05	<.05	.70	--
	Total recoverable captan							
31	Kankakee River near Wilmington, Ill.	1986–88	13	--	<.05	<.05	<.05	--
35	Des Plaines River near Schiller Park, Ill.	1986–88	12	--	<.05	<.05	<.05	--
76	Illinois River at Marseilles, Ill.	1986–88	13	--	<.05	<.05	<.05	--
	Total recoverable metolachlor							
31	Kankakee River near Wilmington, Ill.	1986–88	13	--	<.100	<.100	.275	--
35	Des Plaines River near Schiller Park, Ill.	1986–88	12	--	<.100	<.100	.115	--
76	Illinois River at Marseilles, Ill.	1986–88	13	--	<.100	.200	.570	--
	Total recoverable metribuzin							
31	Kankakee River near Wilmington, Ill.	1986–88	16	--	<.05	<.05	<.05	--
35	Des Plaines River near Schiller Park, Ill.	1986–88	15	--	<.05	<.05	<.05	--
76	Illinois River at Marseilles, Ill.	1986–88	16	--	<.05	<.05	<.05	--
	Total recoverable trifluralin							
31	Kankakee River near Wilmington, Ill.	1986–88	13	--	<.01	<.01	<.01	--
35	Des Plaines River near Schiller Park, Ill.	1986–88	12	--	<.01	<.01	<.01	--
76	Illinois River at Marseilles, Ill.	1986–88	13	--	<.01	<.01	<.01	--

Table 18. *Correlations among ranked concentrations of herbicides in water in the upper Illinois River Basin, 1986–88*

[--, correlation was not significant at the α=0.10 level]

Herbicide	Alachlor	Atrazine	Cyanazine	Metolachlor	Metribuzin
Alachlor	1.00	0.76	0.63	0.71	--
Atrazine		1.00	.73	.74	0.52
Cyanazine			1.00	.61	--
Metolachlor				1.00	.49
Metribuzin					1.00

Table 19. Summary of synthetic organic compounds in streambed sediments collected by the Illinois Environmental Protection Agency in the upper Illinois River Basin, 1978–88

[MRL, minimum reporting level]

Compound	Number of observations having concentrations greater than or equal to the MRL	Number of observations having concentrations less than the MRL
Aldrin	32	271
Atrizine	0	6
α-Benzene hexachloride	0	211
Chemical oxygen demand	455	0
cis-Chlordane	88	66
trans-Chlordane	88	66
Chlordane (technical mixture and metachlorites)	114	203
DDD	22	12
o,p'-DDD	0	151
p,p'-DDD	89	84
DDE	16	17
o,p'-DDE	0	157
p,p'-DDE	89	90
o,p'-DDT	23	134
p,p'-DDT	40	138
DDT	43	84
DDT (sum of analogs and metachorlites)	75	92
Diazinon	0	11
2,4-Dichlorophenoxy-acetic acid	0	15
Dieldrin	198	124
Endrin	0	204
α-HCH	0	214
Heptachlor	0	203
Heptachlor epoxide	73	249
Hexachlorobenzene	0	151
γ-Hexachlorocyclohexane (Lindane)	0	225
Kjeldahl nitrogen	406	0
Malathion	0	17
Methoxychlor	0	248
Methyl parathion	0	11
cis-Nonachlor	0	139
trans-Nonachlor	0	139
Parathion	0	17
PCB-1221	0	22
PCB-1232	0	22
PCB-1242	11	21
PCB-1248	0	22
PCB-1254	2	31
PCB-1260	0	29
PCB-1016	0	22
Phenolic compounds	14	28
Silvex	0	9
Simazine	0	6
1,4,5-Trichlorophenoxy-acetic acid	0	15
Trithion	0	11
Toxaphene	0	54
Solids, volatile, percent of total solids	319	0
Sum of the congeners	1,548	182

Table 20. Summary of data describing synthetic organic compounds in streambed sediments collected by the Metropolitan Water Reclamation District of Greater Chicago in the upper Illinois River Basin, 1978–88
[MRL, minimum reporting level]

Compound	Number of observations having concentrations greater than or equal to the MRL	Number of observations having concentrations less than the MRL
Acenaphthene	3	3
Acenaphthylene	4	2
Acrolein	0	6
Acrylonitrile	0	6
Aldrin	0	6
Anthracene	5	1
Benzene	2	4
Benzidine	0	6
Benzo(*a*)anthracene	4	2
Benzo(*b*)fluoranthene	2	4
Benzo(*k*)fluoranthene	2	4
Benzo(*a*)pyrene	3	3
Benzo(*g,h,i*)perylene	2	4
Bromodichloromethane	0	6
Bromomethane	0	6
4-Bromophenyl phenyl ether	0	6
Butyl benzyl phthalate	0	6
Carbon tetrachloride	0	6
Chlordane	2	4
Chlorobenzene	2	4
p-Chloro-*m*-cresol	0	6
Chloromethane	0	6
Chloroethane	0	6
bis(2-Chloroethoxy) methane	0	6
bis(2-Chloroethyl)ether	0	6
2-Chloroethylvinyl ether	0	6
Chloroform	1	5
bis(2-Chloroisopropyl)ether	0	6
2-Chloronaphthalene	0	6
2-Chlorophenol	0	6
4-Chlorophenyl phenyl ether	0	6
Chrysene	4	2
p,p'-DDD	0	6
p,p'-DDE	0	6
p,p'-DDT	0	6
Dibenzo(*a,h*)anthracene	0	6
Dibromochloromethane	0	6
Di-*n*-butylphthalate	0	6
1,1-Dichlorobenzene	0	6
1,2-Dichlorobenzene	0	6
1,3-Dichlorobenzene	0	6
3,3'-Dichlorobenzidine	0	6
1,1-Dichloroethene	0	6
1,1-Dichloroethane	2	4
1,2-Dichloroethane	0	6
trans-1,2-Dichloroethene	1	5
Dichloromethane	2	4
2,4-Dichlorophenol	0	6
1,2-Dichloropropane	0	6
cis-1,3-Dichloropropene	0	6
trans-1,3-Dichloropropene	0	6
Dieldrin	0	6
Diethylphthalate	0	6
2,4-Dimethylphenol	0	6
Dimethylphthalate	0	6
4,6-Dinitro-*o*-cresol	0	6
2,4-Dinitrophenol	0	6
2,6-Dinitrotoluene	0	6
2,4-Dinitrotoluene	0	6
Di-*n*-octylphthalate	2	4
Diphenylhydrazine	0	6
Endosulfan I	0	6
Endosulfan II	0	6
Endosulfan sulfate	0	6
Endrin	0	6
Ethylbenzene	1	5
bis(2-Ethylhexyl)phthalate	2	4
Fluoranthene	6	0
Fluorene	4	2
Heptachlor	0	6
Heptachlor epoxide	0	6
Hexachlorobenzene	0	6
Hexachlorobutadiene	0	6
α-Hexachlorocyclohexane	0	6
β-Hexachlorocyclohexane	0	6
γ-Hexachlorocyclohexane (Lindane)	0	6
δ-Hexachlorocyclohexane	0	6
Hexachlorocyclopentadiene	0	6
Hexachloroethane	0	6
Indeno(1,2,3-*cd*)pyrene	2	4
Isophorone	1	5
Naphthalene	2	4
Nitrobenzene	0	6
2-Nitrophenol	0	6
4-Nitrophenol	0	6
N-Nitrosodimethylamine	0	6
N-Nitrosodiphenylamine	0	6
N-Nitrosodi-*n*-propylamine	0	6
PCB-1221	0	6
PCB-1232	0	6
PCB-1016	0	6
PCB-1248	6	0
PCB-1254	0	6
PCB-1260	5	1
PCB's (total)	6	0
Phenanthrene	6	0
Phenol	3	3
Pentachlorophenol (PCP)	0	6
Pyrene	6	0
1,1,2,2-Tetrachloroethane	0	6
Tetrachloroethene	2	4
Toluene	1	5
1,2,4-Trichlorobenzene	0	6
Trichloroethene	1	5
1,1,1-Trichloroethane	0	6
1,1,2-Trichloroethane	0	6
Trichlorofluoromethane	0	6
2,4,6-Trichlorophenol	0	6
Toxaphene	0	6
Vinyl chloride	0	6

Table 21. Statistical summary of concentrations of selected synthetic organic compounds and other constituents in streambed sediments in the upper Illinois River Basin, 1975–88

[Percentiles are the values one-tenth, one-fourth, one-half (median), three-fourths, and nine-tenths of the way through the ordered data values; <, less than]

Constituent	Period of record	Number of samples	Concentration at indicated percentile 10	25	50	75	90
Clay/silt, as percent (SIEVED)							
Chemical oxygen demand	1983–87	79	4.8	6.3	7.9	9.8	12.2
Kjeldahl nitrogen	1982–87	80	.15	.21	.28	.35	.44
Clay/silt, in micrograms (SIEVED)							
cis-Chlordane	1983–87	80	<2.0	<2.0	2.2	4.7	12.9
trans-Chlordane	1983–87	80	<2.0	<2.0	2.4	4.2	11.8
p,p′-DDD	1983–87	81	<1	<1	1.9	14	79.6
p,p′-DDE	1983–87	80	<1	<1	2.4	8.9	28.7
o,p′-DDT	1983–87	80	<1.0	<1.0	<1.0	<1.0	<1.0
p,p′-DDT	1983–87	80	<1.0	<1.0	<1.0	<1.0	13.8
DDT (total)	1983–87	80	<10	<10	<10	26.8	120
Dieldrin	1983–87	80	<1	1.7	3.1	6.3	9.99
Heptachlor epoxide	1983–87	80	<1	<1	<1	<1	1.59
PCB's (total)	1983–87	80	<10	<10	11	55.5	394
Technical chlordane	1983–87	80	<5	<5	<5	8.5	23.9
Whole sediment, as percent (UNSIEVED)							
Chemical oxygen demand	1975–88	145	65	.26	7.0	15	26
Kjeldahl nitrogen	1975–88	104	.061	.14	.24	.36	.44
Total volatile solids	1975–88	76	2.2	3.7	6.4	9.9	13.1
Whole sediment, in micrograms per kilogram (UNSIEVED)							
cis-Chlordane	1980–83	39	<2	<2	2.6	5.5	10
trans-Chlordane	1980–83	39	<2	<2	2.2	5.0	9.4
DDD	1976–80	29	<.1	<.1	1.3	40	108
p,p′-DDD	1980–83	39	<1	<1	2.0	6.5	17.0
DDE	1976–80	29	<.1	<.01	<.05	<15.5	76
p,p′-DDE	1978–83	43	<.5	<1	<1	3.3	7.5
Technical chlordane	1976–84	68	<1	<3.5	<5	10.1	29.1
DDT	1975–84	30	<.1	<.1	1.8	10.0	44.1
o,p′-DDT	1978–83	42	<1.0	<1.0	<1.0	<1.0	4.8
p,p′-DDT	1978–83	42	<1.0	<1.0	<1.0	1.6	17.1
DDT (total)	1978–83	68	<5	<10	12.5	81.8	210
Heptachlor epoxide	1975–84	100	<.1	<.5	<1	2.5	7.9
PCB 1242	1978–82	30	<1.0	18.8	1,200	5,500	8,850
PCB 1254	1975–82	32	<1.0	11.5	850	1,400	2,370
PCB, total	1976–83	121	<1.3	<10	30	205	1,280
Phenols, total	1980–82	23	<.1	<.1	<.2	.27	7.3

Table 22. Means and ranges of detectable sediment residues of synthetic organic compounds in bed sediments in the United States

[From Smith and others, 1988; µg/kg, micrograms per kilogram; --, no available data]

Compound	Location	Mean (µg/kg)	Range (µg/kg)
Chlordane	Belmont Lake, N.Y.	171	20–580
Chlordane	Trinity River, Tex.	13.7	.15–64.0
DDE	Rock Reservoir, Iowa	2.4	1.1–7.4
DDD	Rock Reservoir, Iowa	2.4	.6–7.3
DDT	Trinity River, Tex.	16.3	.25–53.6
t-DDT[1]	Los Angeles Harbor, Calif.	768	115–3,212
t-DDT	Salinas River, Calif.	--	1–190
Dieldrin	Los Angeles Harbor, Calif.	1,800	900–4,500
Dieldrin	Rock Reservoir, Iowa	2.9	.3–6.4
Endrin	Trinity River, Tex.	9.4	.15–20
β-HCH	Niagara River, Lake Ontario, Canada	14.3	6.9–33
Heptachlor	Trinity River, Tex.	5.28	.7–9.3
Heptachlor Epoxide	Rockaway River, N.Y.	4.5	.7–10
Lindane	Trinity River, Tex.	.32	.1–.7
Mirex	Lake Ontario shoreline marsh, Canada	.01	--
Mirex	Niagara River, Lake Ontario, Canada	7.1	3.9–18
PCB, Aroclor 1016	Hudson River, N.Y.	[2]2,047	[2]6.6–6,700
PCB's (total)	Delaware River, Del.	123	2–830
PCB's (total)	Los Angeles Harbor, Calif.	140	900–4,500
PCB's (total)	Lake Ontario shoreline marsh, Canada	.02	.002–.038
PCB's (total)	Rocky Mountain National Park, Colo.	277	98–540
PCB's (total)	Southern Puget Sound, Wash.	25.8	.7–330
PCB's (total)	Niagara River, Lake Ontario, Canada	65.7	47.7–121.5
PCB's (total)	Rock Reservoir, Iowa	13	5.7–28.5
PCB's (total)	Bay of Quinte, Lake Ontario, Canada	385	200–620
PCB's (total)	Raritan Bay, N.Y.	212	3–2,035

[1] Total DDT (includes all DDT, DDE, and DDD isomers).

[2] Concentration is in milligrams per kilogram.

Table 23. Correlation coefficients among concentrations of synthetic organic compounds and other constituents in clay/silt

[Ranked data were used; coefficient values have been multiplied by 100; 0, correlation coefficient was not significant at the α = 0.1 level]

Constituent	Chemical oxygen demand	Kjehldahl nitrogen	*o,p'*-DDT	*p,p'*-DDT	Total volatile solids	Hepta-chlor epoxide	Dieldrin	DDT, total	Chlor-dane	*p,p'*-DDE
Chemical oxygen demand	100	84	0	0	82	0	20	34	48	36
Kjehldahl nitrogen		100	0	0	70	21	0	19	37	25
o,p'-DDT			100	56	0	41	0	37	26	32
p,p'-DDT				100	0	41	0	42	0	37
Total volatile solids					100	0	0	28	46	39
Heptachlor epoxide						100	19	35	44	34
Dieldrin							100	31	46	38
DDT (total)								100	65	85
Chlordane									100	68
p,p'-DDE										100
p,p'-DDD										
cis-Chlordane										
PCB's (total)										
Chromium										
Zinc										
Lead										
Phosphorus										
Manganese										
Mercury										
Iron										
Copper										
Arsenic										
Cadmium										

Table 24. Correlation coefficients among concentrations of synthetic organic compounds and other constituents in whole

[Ranked data were used; coefficient values have been multiplied by 100; --, no available data; 0, correlation coefficient was not significant at the

Constituent	Ar-senic	Cad-mium	Chro-mium	Copper	Iron	Mer-cury	Manga-nese	Phos-phorus	Lead	Zinc	PCB, total	Chemical oxygen demand	*cis*-Chlor-dane
Arsenic	100	0	0	0	55	22	49	43	13	20	55	0	0
Cadmium		100	71	62	0	58	−36	39	55	66	30	50	41
Chromium			100	82	52	66	0	67	68	83	25	53	44
Copper				100	35	78	−31	62	78	86	51	47	54
Iron					100	28	33	42	31	38	22	32	41
Mercury						100	−23	63	72	82	62	42	50
Manganese							100	0	−32	−24	0	0	0
Phosphorus								100	56	71	56	0	36
Lead									100	85	44	41	58
Zinc										100	74	33	54
PCB's (total)											100	−29	32
Chemical oxygen demand												100	40
cis-Chlordane													100
trans-Chlordane													
p,p'-DDD													
p,p'-DDE													
Chlordane													
DDT (total)													
Dieldrin													
Heptachlor epoxide													
Total volatile solids													
Kjehldahl nitrogen													
p,p'-DDT													
Phenols, total													
PCB-1242													
PCB-1254													
o,p'-DDT													

fraction of streambed-sediment samples in the upper Illinois River Basin, 1975–88

p,p'-DDD	*cis*-Chlordane	PCB, total	Chromium	Zinc	Lead	Phosphorus	Manganese	Mercury	Iron	Copper	Arsenic	Cadmium
46	47	49	38	51	49	62	0	63	36	54	43	34
34	39	39	23	35	29	58	0	50	30	41	33	0
27	28	0	0	0	0	0	0	0	0	0	0	0
35	25	0	0	0	23	0	28	0	0	0	0	0
42	44	47	45	53	51	59	0	60	45	57	36	35
34	43	0	25	0	0	29	0	28	22	0	0	0
40	47	39	52	49	37	43	–20	46	0	52	21	25
91	64	59	64	64	58	55	0	65	32	62	0	49
71	95	67	71	71	63	67	–29	72	36	77	21	42
89	71	68	65	69	60	54	0	68	33	68	21	44
100	74	66	71	78	67	67	0	79	41	77	23	57
	100	66	72	72	65	61	–29	71	40	76	25	42
		100	79	79	65	58	–33	74	31	84	0	55
			100	87	79	66	–24	80	57	88	26	59
				100	91	66	–26	90	52	94	31	61
					100	55	0	78	55	83	34	47
						100	–31	75	32	75	32	49
							100	0	0	–35	27	–29
								100	47	89	37	60
									100	46	56	24
										100	30	60
											100	0
												100

sediment samples in the upper Illinois River Basin, 1975–88

α = 0.1 level]

trans-Chlordane	*p,p'*-DDD	*p,p'*-DDE	Chlordane	DDT, total	Dieldrin	Heptachlor epoxide	Total volatile solids	Kjehldahl nitrogen	*p,p'*-DDT	Phenols, total	PCB-1242	PCB-1254	*o,p'*-DDT
0	0	0	0	41	0	0	59	52	0	0	0	0	0
40	47	37	37	0	0	0	26	0	0	78	69	51	28
45	54	48	49	40	27	46	51	41	0	70	93	66	40
54	53	30	57	44	23	49	42	25	33	0	94	81	34
44	49	50	27	46	0	20	38	38	0	89	65	58	32
52	37	44	54	45	27	37	43	23	0	69	87	78	33
0	0	0	0	0	0	0	60	50	0	0	0	0	0
37	45	42	45	58	31	37	19	22	0	82	46	44	29
60	58	45	55	63	22	48	35	18	0	92	93	94	43
56	55	39	63	70	44	67	43	32	0	0	78	68	37
37	47	43	52	67	51	47	–18	–22	0	--	96	86	30
44	0	41	29	0	–51	–17	67	56	0	90	78	73	0
98	57	48	95	66	45	71	0	0	55	--	--	--	27
100	60	48	96	68	44	72	0	0	51	--	--	--	27
	100	55	56	68	41	0	0	0	47	--	--	--	47
		100	58	56	33	0	27	27	43	--	--	--	53
			100	58	27	54	0	0	64	--	--	--	51
				100	46	68	20	22	65	--	0	86	36
					100	39	–27	–34	27	--	0	0	35
						100	0	0	33	--	0	0	0
							100	93	–28	--	--	--	0
								100	–28	0	0	0	0
									100	--	--	--	32
										100	92	79	--
											100	89	--
												100	--
													100

Table 25. Summary of synthetic organic compounds surveyed in fish tissue collected by the Illinois Environmental Protection Agency and the Indiana and Wisconsin Departments of Natural Resources in the upper Illinois River Basin, 1978–86

Compound	Number of observations	Percentage of observations greater than detection limit
Aldrin	238	2
Chlordane	262	85
DDT (total)	265	98
Dieldrin	280	83
Dursban	14	100
Endrin	240	1
HCB	204	5
Heptachlor	232	1
Heptachlor epoxide	200	46
α-Hexachlorocyclohexane	217	14
β-Hexachlorocyclohexane	10	90
Lindane	194	4
Methoxychlor	242	0
Mirex	203	0
PCB's (total)	300	91
Toxaphene	230	0

Table 26. Summary of data describing concentrations of selected synthetic organic compounds in fish tissue in the upper Illinois River Basin, 1978–87

Subbasin	Number of observations	Period of record	Number of the three most common species
Polychlorinated biphenyls (PCB's), sum of isomers			
Kankakee River	193	1979–84, 1986	16 whole carp; 13 whole catfish; 10 carp fillets
North Branch Chicago River and Calumet Sag Channel	40	1984–86	36 whole carp; 4 undefined
Des Plaines River	150	1978–87	41 whole carp; 29 carp fillets; 6 whole white sucker
Fox River	119	1978–82, 1984–86	21 whole carp; 8 carp fillets; 5 smallmouth bass fillets
Du Page River	31	1981, 1983, 1986	16 whole carp; 4 carp fillets; 2 whole white sucker and 2 white sucker fillets
DDT, sum of analogs			
Kankakee River	102	1978–83, 1986	13 whole channel catfish; 7 whole carp; 5 whole smallmouth bass and 5 whole shorthead redhorse
North Branch Chicago River and Calumet Sag Channel	40	1984–86	36 whole carp; 4 undefined
Des Plaines River	115	1980–83, 1985–87	41 whole carp; 29 carp fillets; 6 white sucker
Fox River	74	1978, 1980–82, 1984–86	12 whole carp; 8 carp fillets; 5 smallmouth bass fillets
Du Page River	31	1981, 1983, 1986	16 whole carp; 4 carp fillets; 2 whole white sucker and 2 white sucker fillets
Heptachlor			
Kankakee River	67	1978–80, 1984, 1986	11 channel catfish fillets; 10 carp fillets; smallmouth bass fillets
North Branch Chicago River and Calumet Sag Channel	36	1984–86	36 whole carp
Des Plaines River	89	1983, 1985–87	38 whole carp; 27 carp fillets; 6 whole white sucker
Fox River	16	1984–86	8 carp fillets; 5 smallmouth bass fillets; 2 whole carp
Du Page River	24	1983, 1986	16 whole carp; 2 whole white sucker
Chlordane (technical mixture and metabolites)			
Kankakee River	138	1978, 1980–83, 1986	13 whole channel catfish; 11 channel catfish fillets; 9 carp fillets
North Branch Chicago River and Calumet Sag Channel	40	1984–86	36 whole carp; 4 undefined
Des Plaines River	116	1980–83, 1985–87	41 whole carp; 29 carp fillets; 6 whole white sucker
Fox River	67	1978, 1980–82, 1984–86	11 whole carp; 8 carp fillets; 8 smallmouth bass fillets
Du Page River	31	1981, 1983, 1986	16 whole carp; 4 carp fillets; 2 whole white sucker and 2 white sucker fillets
Oxychlordane			
Kankakee River	47	1979–80, 1982, 1984	9 carp lipid; 8 whole carp; 4 whole shorthead redhorse and 4 shorthead redhorse fillets
North Branch Chicago River and Calumet Sag Channel	0		
Des Plaines River	0		
Fox River	2	1982	2 undefined
Du Page River	0		
Dieldrin			
Kankakee River	173	1978–84, 1986	14 whole carp; 13 whole channel catfish; 11 channel catfish fillets
North Branch Chicago River and Calumet Sag Channel	40	1984–86	36 whole carp; 4 undefined
Des Plaines River	126	1978–87	40 whole carp; 29 carp fillets; 6 whole white sucker
Fox River	87	1978,1980–82, 1985–86	15 whole carp; 8 carp fillets; 5 smallmouth bass fillets
Du Page River	31	1981, 1983, 1986	16 whole carp; 4 carp fillets; 2 whole white sucker and 2 white sucker fillets

Table 27. Summary of samples exceeding the U.S. Food and Drug Administration Action Limit for polychlorinated biphenyls (PCB's) in edible portions of fish in the upper Illinois River Basin, 1978–88

Species: C, common carp; CC, channel catfish; WS, white sucker; SMB, smallmouth bass

Map reference number (fig. 12)	Station	Period of record	Number of fillet observations	Percentage of observations exceeding action limit	Species
56	Chicago Sanitary and Ship Canal at Lockport, Ill.	1986	1	100	C
57	Des Plaines River at Route 53 at Joliet, Ill.	1986–87	9	67	C,CC,WS, SMB
[1]70	Illinois River above Dresden Island				
76	Illinois River at Marseilles, Ill.	1986–87	6	50	C
	Dam near Minooka, Ill.	1987	4	50	C

[1] Map reference number 70 is shown on figure 10.

Table 28. Correlation coefficients among ranked pesticide concentrations in whole carp in the upper Illinois River Basin, 1978–87

[Ranked data were used: coefficient values have been multiplied by 100: significance level p = 0.90: --, no available data]

Pesticide	Chlordane	DDT, total	Dieldrin	Heptachlor epoxide	PCB's, total
		Raw Data			
Chlordane	100	75	47	75	64
DDT (total)		100	39	53	51
Dieldrin			100	46	27
Heptachlor epoxide				100	55
PCB's (total)					100
		Lipid Normalized			
Chlordane	100	49	30	34	46
DDT (total)		100	--	21	29
Dieldrin			100	36	--
Heptachlor epoxide				100	22
PCB's (total)					100

Table 29. Results of Wilcoxon signed-ranks test for total and dissolved concentrations of herbicides in the upper Illinois River Basin, 1990

[All concentrations are in micrograms per liter; MRL, minimum reporting level; – Ranks, total less than dissolved; + Ranks, total greater than dissolved; ties, the concentrations were equal; Min, minimum concentration; Max, maximum concentration; --, no data]

Herbicide	Total MRL concentration	Dissolved MRL concentration	Total concentration below MRL	Dissolved concentration below MRL	Minimum concentration[1]			Maximum concentration[2]			Two-tailed P[3]	
					- Ranks	+ Ranks	Ties	- Ranks	+ Ranks	Ties	Min	Max
Alachlor	0.1	0.05	1	0	17	9	1	17	9	1	0.1442	0.1513
Ametryn	.1	.05	27	27	0	0	27	0	27	0	--	--
Atrazine	.1	.05	0	0	15	12	0	15	12	0	.9044	.9044
Cyanazine	.1	.05	0	0	2	24	1	2	24	1	.0016	.0016
Metolachlor	.1	.05	0	0	14	12	1	14	12	1	.8789	.8789
Metribuzin	.1	.05	8	7	14	7	6	13	13	1	.0987	.5172
Prometon	.1	.05	27	26	1	1	25	0	27	0	--	--
Prometryn	.1	.05	27	27	0	0	27	0	27	0	--	--
Propazine	.1	.05	17	14	9	5	13	4	21	1	.1981	.0011
Simazine	.1	.05	6	5	14	5	8	14	10	3	.0043	.2531

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[1] Values less than the MRL were set to 0.00 for the purpose of this test.

[2] Values less than the MRL were set to 0.99 and 0.04 micrograms per liter for total and dissolved concentrations, respectively.

[3] The two-tailed P is a measure of the probability that the total and dissolved concentrations are the same at alpha = 0.05.

Table 30. Statistical summary of 27 samples analyzed by gas chromatography/mass spectrometry for total and dissolved herbicide concentrations in the upper Illinois River Basin, 1990

[All concentrations are in micrograms per liter; N, number; MRL, minimum reporting level; Min, minimum concentration; Max, maximum concentration; percentiles are the values one-fourth, one-half (median), and three-fourths of the way through the ordered data values; <, less than]

Herbicide	Phase	N below MRL[1]	Min	Max	Concentration at indicated percentile			Phase	N below MRL[1]	Min	Max	Concentration at indicated percentile		
					25	50	75					25	50	75
Alachlor	Total	1	<0.10	6.10	0.30	1.00	2.40	Dissolved	0	0.11	6.53	0.33	1.06	2.50
Ametryn	Total	27	<.10	<.10	<.10	<.10	<.01	Dissolved	27	<.10	<.10	<.10	<.10	<.10
Atrazine	Total	0	.80	23.0	1.90	3.80	8.50	Dissolved	0	.79	20.19	1.98	3.67	6.51
Cyanazine	Total	0	.30	19.0	1.20	2.10	7.10	Dissolved	0	.06	31.62	.32	.90	3.74
Metolachlor	Total	0	.20	7.20	.60	1.20	1.70	Dissolved	0	.07	8.35	.57	1.00	1.99
Metribuzin	Total	8	<.10	1.90	<.10	.10	.30	Dissolved	7	<.05	2.66	<.05	.19	.44
Prometon	Total	27	<.10	<.10	<.10	<.10	<.10	Dissolved	26	<.10	.05	<.10	<.10	<.10
Promtryn	Total	27	<.10	<.10	<.10	<.10	<.10	Dissolved	27	<.10	<.10	<.10	<.10	<.10
Propazine	Total	17	<.10	.20	<.10	<.10	.10	Dissolved	14	<.05	.29	<.05	.05	.10
Simazine	Total	6	<.10	.40	.10	.10	.10	Dissolved	5	<.05	1.16	.08	.13	.20

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[1] MRL for total concentration equals 0.10 micrograms per liter; MRL for dissolved concentration equals 0.05 micrograms per liter.

Table 31. Statistical summary of pesticide samples collected in the upper Illinois River Basin, 1988

[All concentrations are in micrograms per liter; N, number of samples; N detects, number of detections; Percent detects, percentage of detections; conc., concentration; --, compound not detected or range not calculated; <, less than]

	Urban stations					Agricultural stations				
Pesticide	N	N detects	Percent detects	Median conc.	Range of observations	N	N detects	Percent detects	Median conc.	Range of observations
Triazines and other nitrogen-containing herbicides										
Alachor	9	0	0	<0.10	--	1	1	100	0.10	--
Ametryn	9	0	0	<.10	--	1	0	0	<.10	--
Atrazine	9	9	100	2.0	0.10–16	1	1	100	1.0	--
Bromacil	9	4	44	<.1	<.1–30	0	--	--	--	--
Butachlor	9	0	0	<.1	--	0	--	--	--	--
Cyanazine	9	0	0	<.10	--	1	1	100	1.2	--
Cycloate	9	0	0	<.1	--	0	--	--	--	--
Diphenamid	9	0	0	<.1	--	0	--	--	--	--
Hexazinone	9	2	22	<.1	<.1–.1	0	--	--	--	--
Metolachlor	9	0	0	<.1	--	1	1	100	.8	--
Metribuzin	9	0	0	<.1	--	1	0	0	<.1	--
Prometon	9	0	0	<.1	--	1	0	0	<.1	--
Prometryn	9	0	0	<.1	--	1	0	0	<.1	--
Propachlor	9	3	33	<.1	<.1–.7	0	--	--	--	--
Propazine	9	0	0	<.10	--	1	0	0	<.10	--
Simazine	9	9	100	.20	.10–.40					
Simetryn	9	0	0	<.1	--	1	0	0	<.10	--
Terbacil	9	0	0	<.1	--	0	--	--	--	--
Trifluralin	9	0	0	<.1	--	1	0	0	<.10	--
Vernolate	9	0	0	<.1	--	0	--	--	--	--
Chlorphenoxy-acid herbicides										
2, 4-D	9	8	89	.68	<.01–1.7	0	--	--	--	--
Dicamba	9	7	78	.31	<.01–1.7	0	--	--	--	--
2, 4-DP	9	0	0	<.01	--	0	--	--	--	--
Picloram	9	0	0	<.01	--	0	--	--	--	--
Silvex	9	2	22	<.01	--	0	--	--	--	--
2,4,5-T	9	0	0	<.01	--	0	--	--	--	--
Organophosphorus insecticides										
Diazinon	8	8	100	.04	.01–.06	1	0	0	<.01	--
Ethion	8	0	0	<.01	--	1	0	0	<.01	--
Malathion	8	8	100	.03	.02–2.3	1	0	0	<.01	--
Methyl parathion	8	0	0	<.01	--	1	0	0	<.01	--
Methyl trithion	8	0	0	<.01	--	1	0	0	<.01	--
Parathion	8	1	12	<.01	[1].01	1	0	0	<.01	--
Trithion (total)	8	0	0	<.01	--	1	0	0	<.01	--

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[1] Value shown is for the observation of the compounds above the minimum reporting level only.

Table 32. Statistical summary of pesticide samples collected in the upper Illinois River Basin, 1989

[All concentrations are in micrograms per liter; N, number of samples; N detects, number of detections; Percent detect, percentage of detections; conc., concentration; --, compound not detected or range not calculated; <, less than]

	Urban stations					Agricultural stations				
Pesticide	N	N detects	Percent detects	Median conc.	Range of obser-vations	N	N detects	Percent detects	Median conc.	Range of obser-vations
				Triazines and other nitrogen-containing herbicides						
Alachor	8	4	50	<0.10	<0.1–0.3	7	4	57	1.8	<0.1–4.7
Ametryn	8	0	0	<.10	--	7	0	0	<.10	--
Atrazine	8	8	100	.30	.1–.7	7	7	100	4.7	.2–14
Bromacil	7	6	86	.1	<.1–.9	7	0	0	<.1	--
Butachlor	7	0	0	<.1	--	7	0	0	<.1	--
Cyanazine	8	2	25	<.10	<.1–.2	7	6	86	1.0	<.1–12
Cycloate	7	0	0	<.1	--	7	0	0	<.1	--
Diphenamid	7	0	0	<.1	--	7	0	0	<.1	--
Hexazinone	7	6	86	.1	<.1–.2	7	3	43	<.1	<.1–.2
Metolachlor	8	2	25	<.1	<.1–.4	7	7	100	1.7	.1–5.6
Metribuzin	8	0	0	<.1	--	7	4	57	.2	<.1–.5
Prometon	8	6	75	.1	<.1–.2	7	3	43	<.1	<.1–.7
Prometryn	8	0	0	<.1	--	7	0	0	<.1	--
Propachlor	7	0	0	<.1	--	7	2	28	<.1	<.1–.1
Propazine	8	0	0	<.10	--	7	4	57	.10	<.1–.1
Simazine	8	8	100	.20	.1–5.5	7	3	43	<.10	<.1–.1
Simetryn	8	0	0	<.1	--	7	0	0	<.1	--
Terbacil	7	3	43	<.1	<.1–.2	7	0	0	<.1	--
Trifluralin	8	0	0	<.10	--	7	2	28	<.10	<.1–.2
Vernolate	7	0	0	<.1	--	7	2	28	<.1	<.1–.1
				Chlorphenoxy-acid herbicides						
2, 4-D	6	4	67	1.4	<.01-2.2	7	4	57	.11	<.01–.3
Dicamba	6	5	83	.17	<.01–.2	7	5	71	.25	<.01–.44
2, 4-DP	6	3	50	<.01	<.01–.06	7	0	0	<.01	--
Picloram	6	0	0	<.01	--	7	1	14	<.01	[1].01
Silvex	6	0	0	<.01	--	7	0	0	<.01	--
2,4,5-T	6	0	0	<.01	--	7	0	0	<.01	--
				Organophosphorus insecticides						
Diazinon	7	7	100	.05	.02–.14	7	1	14	<.01	.01
Ethion	7	0	0	<.01	--	7	0	0	<.01	--
Malathion	7	6	86	.09	<.01–1.	7	0	0	<.01	--
Methyl parathion	7	0	0	<.01	--	7	0	0	<.01	--
Methyl trithion	6	0	0	<.01	--	7	0	0	<.01	--
Parathion	7	0	0	<.01	--	7	0	0	<.01	--
Trithion (total)	7	0	0	<.01	--	7	0	0	<.01	--

[1] Value is for the observation of the compounds above the minimum reporting level only.

Table 33. National standards for pesticides and volatile organic compounds in water

[µg/L, micrograms per liter; mg/L, milligrams per liter; USEPA, U.S. Environmental Protection Agency; NAS, National Academy of Sciences; MCL, maximum contaminant level; MCLG, maximum contaminant level goal; --, not established]

Status code: F, published in a final rule; L, listed for regulation; P, proposed for regulation

	For protection of human health			For protection of aquatic organisms		
	USEPA Primary Drinking-Water Standards[1] (µg/L)			USEPA Water-Quality Criteria, Aquatic Organisms[2]		NAS Water Quality Criteria[3]
				Freshwater (mg/L)		Freshwater (mg/L)
Compound	**Status code**	**MCL**	**MCLG**	**Acute**	**Chronic**	
			Pesticides			
Alachlor	F	2	0	--	--	--
Atrazine	F	3	3	--	--	--
Bromacil	L	--	--	--	--	--
Cyanazine	L	--	--	--	--	--
2, 4-D	F	70	70	--	--	3
Diazinon	--	--	--	--	--	.009
Dicamba	L	--	--	--	--	200
Malathion	--	--	--	--	0.1	.008
Metolachlor	L	--	--	--	--	--
Metribuzin	L	--	--	--	--	--
Parathion	--	--	--	0.065	.013	.0004
Pentachlorophenol	F	1	0	20	13	--
Prometon	L	--	--	--	--	--
Propachlor	--	--	--	--	--	--
Propazine	--	--	--	--	--	--
Simazine	P	4	4	--	--	10
Terbacil	--	--	--	--	--	--
Trifluralin	L	--	--	--	--	--
			Volatile organic compounds			
Benzene	F	5	0	--	--	--
Bromoform	L	100	--	--	--	--
Carbon tetrachloride	F	5	0	--	--	--
Chlorodibromomethane	L	100	--	--	--	--
Chloroform	L	100	--	--	--	--
1,1-Dichloroethane	L	--	--	--	--	--
1,2-Dichloroethane	F	5	0	--	--	--
cis-1,2-Dichloroethene	F	70	70	--	--	--
1,1-Dichloroethylene	F	7	7	--	--	--
Ethylbenzene	F	700	700	--	--	--
Napthalene	--	--	--	--	--	--
Styrene	F	100	100	--	--	--
Tetrachloroethylene	F	5	0	--	--	--
Toluene	F	1,000	1,000	--	--	--
1,1,1-Trichloroethane	F	200	200	--	--	--
Trichloroethylene	F	5	0	--	--	--
1,2,4-Trimethylbenzene	--	--	--	--	--	--
1,3,5-Trimethlybenzene	--	--	--	--	--	--
Xylenes	F	10,000	10,000	--	--	--

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[1] U.S. Environmental Protection Agency (1992a).

[2] National Academy of Sciences (1972).

[3] U.S. Environmental Protection Agency (1991a).

Table 34. Statistical summary of samples collected in the Kankakee and Iroquois River Basins for analysis of selected dissolved triazine and chloro-acetanilide herbicides, 1990

[All concentrations are in micrograms per liter; N, number of observations; Min, minimum concentration; Max, maximum concentration; MRL, minimum reporting level; MCL, maximum contaminant level; <, less than; --, not applicable]

Herbicide	N	Min	Max	MRL	Number below MRL	Percentage of detections	Concentration at indicated percentile					Number above MCL[1]
							10	25	50	75	90	
Alachlor	68	<0.05	5.97	0.05	3	96	0.08	0.22	0.41	1.35	2.58	11
Ametryn	68	<.05	<.05	.05	68	0	<.05	<.05	<.05	<.05	<.05	--
Atrazine	68	.33	20.19	.05	0	100	.55	1.10	2.03	4.47	6.75	24
Cyanazine	68	<.05	36.49	.05	2	97	.09	.21	.60	1.23	4.10	--
Desethylatrazine[2]	68	.05	1.92	.05	0	100	.16	.24	.45	.83	1.31	--
Desisopropylatrazine[2]	68	<.05	2.31	.05	4	94	.07	.16	.25	.63	1.16	--
Metolachlor	68	.05	8.35	.05	0	100	.13	.19	.54	1.07	2.28	--
Metribuzin	68	<.05	2.66	.05	29	57	<.05	<.05	.10	.27	.70	--
Propazine	68	<.05	.29	.05	49	28	<.05	<.05	<.05	<.05	.11	--
Prometon	68	<.05	.28	.05	62	8.8	<.05	<.05	<.05	<.05	<.05	--
Prometryn	68	<.05	<.05	.05	68	0	<.05	<.05	<.05	<.05	<.05	--
Simazine	68	<.05	1.16	.05	21	69	<.05	<.05	.11	.19	.28	0
Terbutryn	68	<.05	<.05	.05	68	0	<.05	<.05	<.05	<.05	<.05	--

[1] Maximum contaminant level is the maximum permissible concentration of the indicated compound in water, which is delivered to any user of a public water system. Determined by the U.S. Environmental Protection Agency.

[2] These herbicides are not applied to fields; these herbicides are breakdown products of the herbicide atrazine.

Table 35. Maximum herbicide concentrations detected in the Mississippi River and selected tributaries in 1990, and in Ohio streams, 1982–85

[USGS, U.S. Geological Survey; mi^2, square miles; all concentrations are in micrograms per liter; --, not analyzed]

USGS station name or river	Drainage area (mi^2)	Alachlor	Atrazine	Cyanazine	Metolachlor	Metribuzin	Simazin
	Mississippi River and selected tributaries[1]						
White River at Hazelton, Ind.	11,305	3.2	9.2	4.40	3.3	--	0.72
Ohio River at Dam 53 near Grand Chain, Ill.	203,100	.40	2.1	.70	.95	--	.40
Mississippi River at Clinton, Iowa	85,600	.85	1.6	1.20	.87	--	.11
Illinois River at Valley City, Ill.	26,742	3.0	6.3	6.60	4.4	--	.14
Platte River at Louisville, Nebr.	85,800	3.6	10	7.30	3.1	--	.09
Missouri River at Hermann, Mo.	524,000	.92	5.7	4.70	2.0	--	.09
Mississippi River at Thebes, Ill.	713,200	.86	4.2	2.80	2.2	--	.10
Mississippi River at Baton Rouge, La.	1,125,000	.44	3.6	1.80	1.4	--	.11
	Selected Ohio streams[2]						
Maumee River	6,330	18	14	10.2	13	11	6.9
Sandusky River	1,251	26	28	6.99	42	8.2	3.4
Honey Creek	149	.75	48	14.9	91	8.2	3.6
Rock Creek	34	20	48	2.83	154	24	.83
Upper Honey Creek	17	8.7	230	86.1	29	6.9	1.2
Lost Creek	4.4	34	240	23.1	13	6.9	3.3
River Raisin	1,042	8.8	10	4.29	7.1	2.4	5
Cuyahoga River	707	1.2	3.0	6.62	5.7	1.0	11

[1] Goolsby and others (1991).

[2] Baker (1988).

Table 36. Results of Spearman's rank correlation coefficients[1] among herbicide concentrations in the Kankakee and Iroquois River Basins, 1990

[--, not significant at the α=0.10 level]

Herbicide	Correlation coefficients							
	Alachlor	Atrazine	Cyanazine	Desethylatrazine	Desisopropylatrazine	Metotachlor	Metribuzin	Simazine
Alachlor	1.00	0.76	0.44	0.43	0.24	0.75	0.27	0.20
Atrazine	--	1.00	.62	.81	.60	.88	.61	.10
Cyanazine	--	--	1.00	.57	.66	.63	.49	.07
Desethylatrazine[2]	--	--	--	1.00	.84	.79	.64	--
Desisopropylatrazine[2]	--	--	--	--	1.00	.46	.81	--
Metotachlor	--	--	--	--	--	1.00	.44	.18
Metribuzin	--	--	--	--	--	--	1.00	--
Simazine	--	--	--	--	--	--	--	1.00

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[1] Only herbicides with at least 50 percent of observations above the minimum reporting level (MRL) are listed. For the herbicides listed, specific observations below the MRL were set to one-half the MRL for the purposes of this test.

[2] These compounds are not applied to fields; these compounds are breakdown products of the herbicide atrazine.

Table 37. Regression statistics describing the relations between atrazine concentrations and physical and temporal conditions in streams in the Kankakee and Iroquois River Basins, 1990

[N, number of regression data pairs; b, regression coefficient; R^2, coefficient of determination]

Condition in stream	Regression statistics[1]		
	N	b	R^2
Magnitude of discharge[2]	57	0.76	0.48
Days since herbicide application[3]	57	−1.96	.19
Suspended-sediment concentration	57	.00	.02
Limb of hydrograph[4]	57	.012	.01

---

[1] All regression equations were statistically significant at a probability level (p) = 0.05. The regression coefficient (b) is the slope of a regression equation. The coefficient of determination (R^2) is a measure of the amount of variation in the dependent variable that can be accounted for by the regression model. The coefficient of variation is a unitless measure of the amount of variation in the population. It is equal to the standard deviation of the dependent variable divided by the mean of the dependent variable times 100.

[2] The magnitude of discharge is defined as the instantaneous discharge at the time of sample collection divided by the long-term average discharge at the sampling station.

[3] The date of herbicide application was arbitrarily set as May 13, 1990.

[4] The limb of the hydrograph is defined as the limb when the sample was collected and assigned a unitless value of 0 for low-flow samples, 50 for rising-limb samples, 100 for peak samples, and 25 for falling-limb samples.

Table 38. Statistical summary of water samples analyzed for volatile organic compounds during the low-flow synoptic survey in the upper Illinois River Basin, July 1988

[All concentrations are in milligrams per liter; MRL, minimum reporting level; Min, minimum concentration; Max, maximum concentration; N, number of samples; percentiles are the values one-tenth, one-fourth, one-half (median), three-quarters, and nine-tenths of the way through the ordered data values; <, less than]

Compound	MRL	Min	Max	N	N above MRL	Concentration at indicated percentile				
						10	25	50	75	90
Benzene, total	0.2	<0.2	<0.2	31	0	<0.2	<0.2	<0.2	<0.2	<0.2
Bromobenzene, water, whole, total	.2	<.2	<.2	31	0	<.2	<.2	<.2	<.2	<.2
Bromochloromethane, total	.2	<.2	<.2	31	0	<.2	<.2	<.2	<.2	<.2
Bromoform, total	.2	<.2	<.2	31	0	<.2	<.2	<.2	<.2	<.2
n-Butylbenzene, total	.2	<.2	.4	31	1	<.2	<.2	<.2	<.2	<.2
sec-Butylbenzene, total	.2	<.2	<.2	31	0	<.2	<.2	<.2	<.2	<.2
tert-Butylbenzene, total	.2	<.2	<.2	31	0	<.2	<.2	<.2	<.2	<.2
Carbon tetrachloride, total	.2	<.2	<.2	31	0	<.2	<.2	<.2	<.2	<.2
Chlorobenzene, total	.2	<.2	<.2	31	0	<.2	<.2	<.2	<.2	<.2
Chlorodibromomethane, total	.2	<.2	.8	31	3	<.2	<.2	<.2	<.2	[1].2
Chloroform, total	.2	<.2	1.5	31	13	<.2	<.2	<.2	.5	1.0
ortho-Chlorotoluene, water, whole, total	.2	<.2	.5	31	1	<.2	<.2	<.2	<.2	<.2
para-Chlorotoluene, water, whole, total	.2	<.2	<.2	31	0	<.2	<.2	<.2	<.2	<.2
1,2-Dibromo-3-chloropropane, total	.2	<.2	<.2	31	0	<.2	<.2	<.2	<.2	<.2
Dibromomethane, water, whole, recoverable total	.2	<.2	<.2	31	0	<.2	<.2	<.2	<.2	<.2
1, 2-Dibromoethane, water, whole, total	.2	<.2	<.2	31	0	<.2	<.2	<.2	<.2	<.2
Dichlorobromomethane, total	.2	<.2	1.2	31	4	<.2	<.2	<.2	<.2	.4
1, 2-Dichlorobenzene, total	.2	<.2	<.2	31	0	<.2	<.2	<.2	<.2	<.2
1, 3-Dichlorobenzene, total	.2	<.2	<.2	31	0	<.2	<.2	<.2	<.2	<.2
1, 4-Dichlorobenzene, total	.2	<.2	1.0	31	5	<.2	<.2	<.2	<.2	.3
1, 1-Dichloroethane, total	.2	<.2	.6	31	3	<.2	<.2	<.2	<.2	[1].3
1, 2-Dichloroethane, total	.2	<.2	.8	31	3	<.2	<.2	<.2	<.2	[1].3
cis-1, 2-Dichloroethane, total	.2	<.2	.6	31	4	<.2	<.2	<.2	<.2	.4
trans-1, 2-Dichloroethene, total	.2	<.2	<.2	31	0	<.2	<.2	<.2	<.2	<.2
1, 1-Dichloroethylene, total	.2	<.2	<.2	31	0	<.2	<.2	<.2	<.2	<.2
1, 2-Dichloropropane, total	.2	<.2	<.2	31	0	<.2	<.2	<.2	<.2	<.2
1, 3-Dichloropropane, water, whole, total	.2	<.2	<.2	31	0	<.2	<.2	<.2	<.2	<.2
2, 2-Dichloropropane, water, whole, total	.2	<.2	<.2	31	0	<.2	<.2	<.2	<.2	<.2
1, 1-Dichloropropane, water, whole, total	.2	<.2	<.2	31	0	<.2	<.2	<.2	<.2	<.2
Ethylbenzene, total	.2	<.2	<.2	31	1	<.2	<.2	<.2	<.2	<.2
Hexachlorobutadiene, total	.2	<.2	<.2	31	0	<.2	<.2	<.2	<.2	<.2
Isopropylbenzene, total	.2	<.2	<.2	31	0	<.2	<.2	<.2	<.2	<.2
1, 4-Isopropyltoluene, total	.2	<.2	.4	31	1	<.2	<.2	<.2	<.2	<.2
Methylene chloride, total	1.8	<1.8	10.4	31	3	<1.8	<1.8	<1.8	<1.8	[1]2.7
Naphthalene, total	.2	<.2	.6	31	3	<.2	<.2	<.2	<.2	[1].3
n-Propylbenzene, water, whole, total	.2	<.2	.4	31	1	<.2	<.2	<.2	<.2	<.2
Styrene, total	.2	<.2	<.2	31	0	<.2	<.2	<.2	<.2	<.2
1, 1, 1, 2-Tetrachloroethane, water, whole, total	.2	<.2	<.2	31	0	<.2	<.2	<.2	<.2	<.2
1, 1, 2, 2-Tetrachloroethane, total	.2	<.2	<.2	31	0	<.2	<.2	<.2	<.2	<.2
Tetrachloroethylene, total	.2	<.2	5.5	31	9	<.2	<.2	<.2	.4	2.1
Toluene, total	.2	<.2	1.0	31	6	<.2	<.2	<.2	<.2	.4
1, 2, 3-Trichlorobenzene, total	.2	<.2	<.2	31	0	<.2	<.2	<.2	<.2	<.2
1, 2, 4-Trichlorobenzene, total	.2	<.2	<.2	31	0	<.2	<.2	<.2	<.2	<.2
1, 1, 1-Trichloroethane, total	.2	<.2	38.4	31	9	<.2	<.2	<.2	.4	1.4
1, 1, 2-Trichloroethane, total	.2	<.2	<.2	31	0	<.2	<.2	<.2	<.2	<.2
Trichloroethylene, total	.2	<.2	2.4	31	8	<.2	<.2	<.2	.2	2.1
1, 2, 3-Trichloropropane, water, whole, total	.2	<.2	<.2	31	0	<.2	<.2	<.2	<.2	<.2
1, 2, 4-Trimethylbenzene, total	.2	<.2	1.1	31	2	<.2	<.2	<.2	<.2	<.2
1, 3, 5-Trimethylbenzene, total	.2	<.2	.6	31	1	<.2	<.2	<.2	<.2	<.2
1, 2-Xylene, total	.2	<.2	.6	31	2	<.2	<.2	<.2	<.2	<.2
1, 3-Xylene, total	.2	<.2	<.2	27	0	<.2	<.2	<.2	<.2	<.2
1, 4-Xylene, total	.2	<.2	<.2	27	0	<.2	<.2	<.2	<.2	<.2

[1] The 90th percentile was a tie between a value less than the MRL and a value above the MRL. The number shown is the value above the MRL.

Table 39. Statistical summary of water samples analyzed for volatile organic compounds during fixed-station monitoring in the upper Illinois River Basin, June 1988–March 1990

[All concentrations are in milligrams per liter; MRL, minimum reporting level; Min, minimum concentration; Max, maximum concentration; N, number of samples; percentiles are the values one-fourth, one-half (median), and three-fourths of the way through the ordered data values; <, less than; --, not calculated because of insufficient sample size]

Compound	MRL	Min	Max	N	N above MRL	Concentration at indicated percentile 25	50	75
05532500 Des Plaines River at Riverside, Ill. (map reference number 40)								
Benzene, total	0.2	<0.2	<0.2	19	0	<0.2	<0.2	<0.2
Bromobenzene, water, whole, total	.2	<.2	<.2	15	0	<.2	<.2	<.2
Bromochloromethane, total	.2	<.2	<.2	4	0	--	<.2	--
Bromoform, total	.2	<.2	1.7	19	8	<.2	<.2	.4
n-Butylbenzene, total	.2	<.2	<.2	4	0	<.2	<.2	<.2
sec-Butylbenzene, total	.2	<.2	<.2	4	0	--	<.2	--
tert-Butylbenzene, total	.2	<.2	<.2	4	0	--	<.2	--
Carbon tetrachloride, total	.2	<.2	<.2	19	0	<.2	<.2	<.2
Chlorobenzene, total	.2	<.2	<.2	19	0	<.2	<.2	<.2
Chlorodibromomethane, total	.2	<.2	.5	19	9	<.2	<.2	.2
Chloroethane, total	.2	<.2	<.2	15	0	<.2	<.2	<.2
Chloroform, total	.2	<.2	.9	19	17	.3	.4	.6
ortho-Chlorotoluene, water, whole, total	.2	<.2	<.2	19	0	<.2	<.2	<.2
para-Chlorotoluene, water, whole, total	.2	<.2	<.2	19	0	<.2	<.2	<.2
1, 2-Dibromo-3-chloropropane, total	.2	<.2	<.2	4	0	--	<.2	--
Dibromomethane, water, whole, recoverable total	.2	<.2	<.2	19	0	<.2	<.2	<.2
1, 2-Dibromoethane, water, whole, total	.2	<.2	<.2	19	0	<.2	<.2	<.2
Dichlorobromomethane, total	.2	<.2	.5	19	14	<.2	.2	.4
1, 2-Dichlorobenzene, total	.2	<.2	<.2	19	0	<.2	<.2	<.2
1, 3-Dichlorobenzene, total	.2	<.2	<.2	19	0	<.2	<.2	<.2
1, 4-Dichlorobenzene, total	.2	<.2	.6	19	1	<.2	<.2	<.2
Dichlorodifluoromethane, total	.2	<.2	<.2	15	0	<.2	<.2	<.2
1, 1-Dichloroethane, total	.2	<.2	<.2	19	0	<.2	<.2	<.2
1, 2-Dichloroethane, total	.2	<.2	.4	19	4	<.2	<.2	<.2
1, 2-Dichloroethene water, whole, recoverable	.2	<.2	.2	11	7	<.2	.2	.2
cis-1, 2-Dichloroethane, total	.2	<.2	1.3	4	1	--	<.2	--
trans-1, 2-Dichloroethene, total	.2	<.2	<.2	4	0	--	<.2	--
1, 1-Dichloroethylene, total	.2	<.2	<.2	15	0	<.2	<.2	<.2
1, 2-Dichloropropane, total	.2	<.2	<.2	4	0	--	<.2	--
1, 3-Dichloropropane, water, whole, total	.2	<.2	<.2	4	0	--	<.2	--
2, 2-Dichloropropane, water, whole, total	.2	<.2	<.2	15	0	<.2	<.2	<.2
cis-1, 3-Dichloropropene, total	.2	<.2	<.2	15	0	<.2	<.2	<.2
trans-1, 3-Dichloropropene, total	.2	<.2	<.2	15	0	<.2	<.2	<.2
1, 1-Dichloropropene, water, whole, total	.2	<.2	<.2	15	0	<.2	<.2	<.2
Ethylbenzene, total	.2	<.2	.6	19	1	<.2	<.2	<.2

Table 39. Statistical summary of water samples analyzed for volatile organic compounds during fixed-station monitoring in the upper Illinois River Basin, June 1988–March 1990—Continued

Compound	MRL	Min	Max	N	N above MRL	Concentration at indicated percentile 25	50	75
05532500 Des Plaines River at Riverside, Ill. (map reference number 40)—Continued								
Hexachlorobutadiene, total	0.2	<0.2	<0.2	4	0	--	<0.2	--
Isopropylbenzene, total	.2	<.2	.2	4	1	--	<.2	--
1, 4-Isopropyltoluene, total	.2	<.2	.6	4	1	--	<.2	--
Methylbromide (Bromomethane), total	.2	<.2	<.2	4	0	<0.2	<.2	<0.2
Methylchloride (Chloromethane), total	.2	<.2	<.2	15	0	<.2	<.2	<.2
Methylene chloride, total[1]	.2	<.2	.8	19	13	.2	.4	.6
Naphthalene, total	.2	<.2	1.7	4	2	--	[2]<.2/.3	--
n-Propylbenzene, water, whole, total	.2	<.2	.5	4	1	--	<.2	--
Styrene, total	.2	<.2	<.2	19	0	<.2	<.2	<.2
1, 1, 1, 2-Tetrachloroethane, water, whole, total	.2	<.2	<.2	15	0	<.2	<.2	<.2
1, 1, 2, 2-Tetrachloroethane, total	.2	<.2	<.2	19	0	<.2	<.2	<.2
Tetrachloroethylene, total	.2	<.2	3.0	19	11	<.2	.2	.3
Toluene, total	.2	<.2	2.3	19	16	.2	.3	.6
1, 2, 3-Trichlorobenzene, total	.2	<.2	<.2	4	0	--	<.2	--
1, 2, 4-Trichlorobenzene, total	.2	<.2	<.2	4	0	--	<.2	--
1, 1, 1-Trichloroethane, total	.2	<.2	6.1	19	8	<.2	<.2	.2
1, 1, 2-Trichloroethane, total	.2	<.2	<.2	19	0	<.2	<.2	<.2
Trichloroethylene, total	.2	<.2	11.7	19	9	<.2	<.2	.2
Trichlorofluoromethane, total	.2	<.2	<.2	15	0	<.2	<.2	<.2
1, 2, 3-Trichloropropane, water, whole, total	.2	<.2	<.2	19	0	<.2	<.2	<.2
1, 2, 4-Trimethylbenzene, total	.2	<.2	2.3	4	2	--	[2]<.2/.2	--
1, 3, 5-Trimethylbenzene, total	.2	<.2	1.1	4	2	--	[2]<.2/.2	--
Vinyl chloride, total	.2	<.2	<.2	15	0	<.2	<.2	<.2
1, 2-Xylene, total	.2	<.2	1.4	4	2	--	[2]<.2/.2	--
1, 3-Xylene, total	.2	<.2	<.2	2	0	--	<.2	--
1, 4-Xylene, total	.2	<.2	<.2	2	0	--	--	--
Xylene, total water, whole, total,	.2	<.2	.5	15	9	--	.2	.3

Table 39. Statistical summary of water samples analyzed for volatile organic compounds during fixed-station monitoring in the upper Illinois River Basin, June 1988–March 1990—Continued

Compound	MRL	Min	Max	N	N above MRL	Concentration at indicated percentile 25	50	75
05536995 Chicago Sanitary and Ship Canal at Romeoville, Ill. (map reference number 55)								
Benzene, total	0.2	<0.2	0.4	20	6	<0.2	<0.2	<0.2
Bromobenzene, water, whole, total	.2	<.2	<.2	15	0	<.2	<.2	<.2
Bromochloromethane, total	.2	<.2	<.2	4	0	--	<.2	--
Bromoform, total	.2	<.2	<.2	20	0	<.2	<.2	<.2
n-Butylbenzene, total	.2	<.2	<.2	4	0	--	<.2	--
sec-Butylbenzene, total	.2	<.2	<.2	4	0	--	<.2	--
tert-Butylbenzene, total	.2	<.2	<.2	4	0	--	<.2	--
Carbon tetrachloride, total	.2	<.2	.7	20	1	<.2	<.2	<.2
Chlorobenzene, total	.2	<.2	<.2	20	0	<.2	<.2	<.2
Chlorodibromomethane, total	.2	<.2	.3	20	12	<.2	.2	.3
Chloroethane, total	.2	<.2	<.2	15	0	<.2	<.2	<.2
Chloroform, total	.2	<.2	1.7	20	19	.8	1.0	1.3
ortho-Chlorotoluene, water, whole, total	.2	<.2	<.2	20	0	<.2	<.2	<.2
para-Chlorotoluene, water, whole, total	.2	<.2	<.2	20	0	<.2	<.2	<.2
1,2-Dibromo-3-chloropropane, total	.2	<.2	<.2	4	0	--	<.2	--
Dibromomethane, water, whole, recoverable total	.2	<.2	<.2	20	0	<.2	<.2	<.2
1, 2-Dibromoethane, water, whole, total	.2	<.2	<.2	20	0	<.2	<.2	<.2
Dichlorobromomethane, total	.2	<.2	.5	20	18	.2	.3	.4
1, 2-Dichlorobenzene, total	.2	<.2	.4	20	5	<.2	<.2	.2
1, 3-Dichlorobenzene, total	.2	<.2	<.2	20	0	<.2	<.2	<.2
1, 4-Dichlorobenzene, total	.2	<.2	.9	20	18	.2	.4	.6
Dichlorodifluoromethane, total	.2	<.2	1.0	15	1	<.2	<.2	<.2
1, 1-Dichloroethane, total	.2	<.2	.2	20	3	<.2	<.2	<.2
1, 2-Dichloroethane, total	.2	<.2	7.0	20	3	.3	1.7	2.7
1, 2-Dichloroethene water, whole, recoverable	.2	<.2	.6	11	8	<.2	.2	.4
cis-1, 2-Dichloroethane, total	.2	<.2	<.2	4	4	--	<.2	--
trans-1, 2-Dichloroethene, total	.2	<.2	<.2	4	0	--	<.2	--
1, 1-Dichloroethylene, total	.2	<.2	.2	15	0	<.2	<.2	<.2
1, 2-Dichloropropane, total	.2	<.2	<.2	4	0	--	<.2	--
1, 3-Dichloropropane, water, whole, total	.2	<.2	<.2	4	0	--	<.2	--
2, 2-Dichloropropane, water, whole, total	.2	<.2	<.2	15	0	<.2	<.2	<.2
cis-1, 3-Dichloropropene, total	.2	<.2	<.2	16	0	<.2	<.2	<.2
trans-1, 3-Dichloropropene, total	.2	<.2	<.2	16	0	<.2	<.2	<.2
1, 1-Dichloropropene, water, whole, total	.2	<.2	<.2	16	0	<.2	<.2	<.2
Ethylbenzene, total	.2	<.2	<.2	16	1	<.2	<.2	<.2
Hexachlorobutadiene, total	.2	<.2	<.2	4	0	--	<.2	--
Isopropylbenzene, total	.2	<.2	<.2	4	0	--	<.2	--
1, 4-Isopropyltoluene, total	.2	<.2	<.2	4	1	--	<.2	--
Methylbromide (Bromomethane), total	.2	<.2	<.2	16	0		<.2	
Methylchloride (Chloromethane), total	.2	<.2	<.2	16	0	<.2	<.2	<.2

Table 39. Statistical summary of water samples analyzed for volatile organic compounds during fixed-station monitoring in the upper Illinois River Basin, June 1988–March 1990—Continued

Compound	MRL	Min	Max	N	N above MRL	Concentration at indicated percentile 25	50	75
05536995 Chicago Sanitary and Ship Canal at Romeoville, Ill. (map reference number 55)—Continued								
Methylene chloride, total[1]	0.2	[3]0.7	15.9	20	19	3.4	7.2	12.0
Naphthalene, total	.2	<.2	<.2	4	0	--	<.2	--
n-Propylbenzene. water, whole, total	.2	<.2	.2	4	0	--	<.2	--
Styrene, total	.2	<.2	10.0	20	3	<.2	<.2	<.2
1, 1, 1, 2-Tetrachloroethane, water, whole, total	.2	<.2	<.2	16	0	<.2	<.2	<.2
1, 1, 2, 2-Tetrachloroethane, total	.2	<.2	<.2	20	0	<.2	<.2	<.2
Tetrachloroethylene, total	.2	.3	4.1	20	20	.5	1.3	2.4
Toluene, total	.2	<.2	3.1	20	5	<.2	<.2	.3
1, 2, 3-Trichlorobenzene, total	.2	<.2	<.2	4	0	--	<.2	--
1, 2, 4-Trichlorobenzene, total	.2	<.2	<.2	4	0	--	<.2	--
1, 1, 1-Trichloroethane, total	.2	.3	4.9	20	20	.6	1.0	2.2
1, 1, 2-Trichloroethane, total	.2	<.2	<.2	20	0	<.2	<.2	<.2
Trichloroethylene, total	.2	<.2	3.4	20	16	.3	.6	1.2
Trichlorofluoromethane, total	.2	<.2	<.2	16	0	<.2	<.2	<.2
1, 2, 3-Trichloropropane, water, whole, total	.2	<.2	<.2	20	0	<.2	<.2	<.2
1, 2, 4-Trimethylbenzene, total	.2	<.2	<.2	4	0	--	<.2	--
1, 3, 5-Trimethylbenzene, total	.2	<.2	<.2	4	0	--	<.2	--
Vinyl chloride, total	.2	<.2	<.2	16	0	<.2	<.2	<.2
1, 2-Xylene, total	.2	<.2	<.2	4	1	--	<.2	--
1, 3-Xylene, total	.2	<.2	<.2	3	0	--	<.2	--
1, 4-Xylene, total	.2	<.2	<.2	3	0	--	<.2	--
Xylene, total water, whole, total, recoverable	.2	<.2	.3	16	1	<.2	<.2	<.2

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[1] The MRL for methylene chloride was 1.8 micrograms per liter for the first four samples and 0.2 micrograms per liter for all remaining samples. Percentiles were calculated by two methods: log-probability plotting and log-normal maximum likelihood. Results were the same for each. See Helsel and Cohn (1988) for description of methods.

[2] Median is between indicated values.

[3] Value below the detection limit was less than 1.8 micrograms per liter (see footnote 1).

Table 40. Statistical summary of samples collected in the upper Illinois River Basin as part of the Illinois Environmental Protection Agency Industrial Solvents Subnetwork in the upper Illinois River Basin, 1988–90

[All concentrations are in micrograms per liter; Min, minimum concentration; Max, maximum concentration; N, number of samples; MRL, minimum reporting level; percentiles are the values one-fourth, one-half (median), and three-fourths of the way through the ordered data values; <, less than]

Compound	MRL	Min	Max	N	N above MRL	Concentration at indicated percentile		
						25	50	75
05528000 Des Plaines River near Gurnee, Ill. (map reference number 33)								
Bromoform	1.0	<1.0	41.0	17	10	<1.0	3.0	9.5
Chlorodibromomethane	1.0	<1.0	9.0	17	11	<1.0	1.0	2.5
Chloroform	1.0	<1.0	6.0	17	14	1.0	2.0	3.0
Dichlorobromomethane	1.0	<1.0	6.0	17	9	<1.0	1.0	3.5
1,2-Dichloroethane	1.0	<1.0	7.0	17	6	<1.0	<1.0	1.0
Methylene chloride	1.0	<1.0	2.0	17	2	<1.0	<1.0	<1.0
Tetrachloroethylene	1.0	<1.0	1.0	17	1	<1.0	<1.0	<1.0
1,1,1-Trichloroethane	1.0	<1.0	<1.0	17	0	<1.0	<1.0	<1.0
Trichloroethylene	1.0	<1.0	1.0	17	1	<1.0	<1.0	<1.0
Xylene	1.0	<1.0	<1.0	17	0	<1.0	<1.0	<1.0
05530590 Des Plaines River near Schiller Park, Ill. (map reference number 35)								
Bromoform	1.0	<1.0	3.0	17	4	<1.0	<1.0	<1.0
Chlorodibromomethane	1.0	<1.0	<1.0	17	0	<1.0	<1.0	<1.0
Chloroform	1.0	<1.0	2.0	17	4	<1.0	<1.0	<1.0
Dichlorobromomethane	1.0	<1.0	<1.0	17	0	<1.0	<1.0	<1.0
1,2-Dichloroethane	1.0	<1.0	2.0	17	1	<1.0	<1.0	<1.0
Methylene chloride	1.0	<1.0	2.0	17	2	<1.0	<1.0	<1.0
Tetrachloroethylene	1.0	<1.0	1.0	17	1	<1.0	<1.0	<1.0
1,1,1-Trichloroethane	1.0	<1.0	2.0	17	1	<1.0	<1.0	<1.0
Trichloroethylene	1.0	<1.0	<1.0	17	0	<1.0	<1.0	<1.0
Xylene	1.0	<1.0	<1.0	17	0	<1.0	<1.0	<1.0
05531500 Salt Creek at Western Springs, Ill. (map reference number 38)								
Bromoform	1.0	<1.0	<1.0	17	0	<1.0	<1.0	<1.0
Chlorodibromomethane	1.0	<1.0	<1.0	17	0	<1.0	<1.0	<1.0
Chloroform	1.0	<1.0	3.0	17	7	<1.0	<1.0	2.0
Dichlorobromomethane	1.0	<1.0	2.0	17	3	<1.0	<1.0	<1.0
1,2-Dichloroethane	1.0	<1.0	<1.0	17	0	<1.0	<1.0	<1.0
Methylene chloride	1.0	<1.0	<1.0	17	0	<1.0	<1.0	<1.0
Tetrachloroethylene	1.0	<1.0	<1.0	17	0	<1.0	<1.0	<1.0
1,1,1-Trichloroethane	1.0	<1.0	<1.0	17	0	<1.0	<1.0	<1.0
Trichloroethylene	1.0	<1.0	<1.0	17	0	<1.0	<1.0	<1.0
Xylene	1.0	<1.0	<1.0	17	0	<1.0	<1.0	<1.0
05534050 Des Plaines River at Lockport, Ill. (map reference number 42)								
Bromoform	1.0	<1.0	<1.0	21	0	<1.0	<1.0	<1.0
Chlorodibromomethane	1.0	<1.0	<1.0	21	0	<1.0	<1.0	<1.0
Chloroform	1.0	<1.0	1.0	21	1	<1.0	<1.0	<1.0
Dichlorobromomethane	1.0	<1.0	<1.0	21	0	<1.0	<1.0	<1.0
1,2-Dichloroethane	1.0	<1.0	2.0	21	1	<1.0	<1.0	<1.0
Methylene chloride	1.0	<1.0	2.0	21	4	<1.0	<1.0	<1.0
Tetrachloroethylene	1.0	<1.0	2.0	21	1	<1.0	<1.0	<1.0
1,1,1-Trichloroethane	1.0	<1.0	1.0	21	1	<1.0	<1.0	<1.0
Trichloroethylene	1.0	<1.0	<1.0	21	1	<1.0	<1.0	<1.0
Xylene	1.0	<1.0	1.0	21	1	<1.0	<1.0	<1.0
05534500 North Branch Chicago River at Deerfield, Ill. (map reference number 43)								
Bromoform	1.0	<1.0	1.0	17	2	<1.0	<1.0	<1.0
Chlorodibromomethane	1.0	<1.0	3.0	17	1	<1.0	<1.0	<1.0
Chloroform	1.0	<1.0	52.0	17	1	<1.0	<1.0	<1.0
Dichlorobromomethane	1.0	<1.0	8.0	17	1	<1.0	<1.0	<1.0
1,2-Dichloroethane	1.0	<1.0	<1.0	17	0	<1.0	<1.0	<1.0
Methylene chloride	1.0	<1.0	2.0	17	1	<1.0	<1.0	<1.0
Tetrachloroethylene	1.0	<1.0	<1.0	17	0	<1.0	<1.0	<1.0
1,1,1-Trichloroethane	1.0	<1.0	<1.0	17	0	<1.0	<1.0	<1.0
Trichloroethylene	1.0	<1.0	<1.0	17	0	<1.0	<1.0	<1.0
Xylene	1.0	<1.0	<1.0	17	0	<1.0	<1.0	<1.0

Table 40. Statistical summary of samples collected in the upper Illinois River Basin as part of the Illinois Environmental Protection Agency Industrial Solvents Subnetwork in the upper Illinois River Basin, 1988–90—Continued

Compound	MRL	Min	Max	N	N above MRL	Concentration at indicated percentile		
						25	50	75
05536000 North Branch Chicago River near Niles, Ill. (map reference number 45)								
Bromoform	1.0	<1.0	<1.0	16	0	<1.0	<1.0	<1.0
Chlorodibromomethane	1.0	<1.0	<1.0	16	0	<1.0	<1.0	<1.0
Chloroform	1.0	<1.0	4.0	16	12	<1.0	1.0	2.0
Dichlorobromomethane	1.0	<1.0	2.0	16	2	<1.0	<1.0	<1.0
1,2-Dichloroethane	1.0	<1.0	<1.0	16	0	<1.0	<1.0	<1.0
Methylene chloride	1.0	<1.0	1.0	16	1	<1.0	<1.0	<1.0
Tetrachloroethylene	1.0	<1.0	<1.0	16	0	<1.0	<1.0	<1.0
1,1,1-Trichloroethane	1.0	<1.0	5.0	16	2	<1.0	<1.0	<1.0
Trichloroethylene	1.0	<1.0	1.0	16	2	<1.0	<1.0	<1.0
Xylene	1.0	<1.0	<1.0	16	0	<1.0	<1.0	<1.0
05536195 Little Calumet River at Munster, Ind. (map reference number 49)								
Bromoform	1.0	<1.0	<1.0	20	0	<1.0	<1.0	<1.0
Chlorodibromomethane	1.0	<1.0	<1.0	20	0	<1.0	<1.0	<1.0
Chloroform	1.0	<1.0	1.0	20	1	<1.0	<1.0	<1.0
Dichlorobromomethane	1.0	<1.0	<1.0	20	0	<1.0	<1.0	<1.0
1,2-Dichloroethane	1.0	<1.0	<1.0	20	0	<1.0	<1.0	<1.0
Methylene chloride	1.0	<1.0	14.0	20	1	<1.0	<1.0	<1.0
Tetrachloroethylene	1.0	<1.0	3.0	20	1	<1.0	<1.0	<1.0
1,1,1-Trichloroethane	1.0	<1.0	<1.0	20	0	<1.0	<1.0	<1.0
Trichloroethylene	1.0	<1.0	<1.0	20	0	<1.0	<1.0	<1.0
Xylene	1.0	<1.0	<1.0	20	0	<1.0	<1.0	<1.0
05536275 Thorn Creek at Thorton, Ill. (map reference number 50)								
Bromoform	1.0	<1.0	<1.0	19	0	<1.0	<1.0	<1.0
Chlorodibromomethane	1.0	<1.0	<1.0	19	0	<1.0	<1.0	<1.0
Chloroform	1.0	<1.0	5.0	19	7	<1.0	<1.0	2.0
Dichlorobromomethane	1.0	<1.0	2.0	19	4	<1.0	<1.0	<1.0
1,2-Dichloroethane	1.0	<1.0	<1.0	19	0	<1.0	<1.0	<1.0
Methylene chloride	1.0	<1.0	<1.0	19	0	<1.0	<1.0	<1.0
Tetrachloroethylene	1.0	<1.0	<1.0	19	0	<1.0	<1.0	<1.0
1,1,1-Trichloroethane	1.0	<1.0	<1.0	19	0	<1.0	<1.0	<1.0
Trichloroethylene	1.0	<1.0	<1.0	19	0	<1.0	<1.0	<1.0
Xylene	1.0	<1.0	<1.0	19	0	<1.0	<1.0	<1.0
05537000 Chicago Sanitary and Ship Canal at Lockport, Ill. (map reference number 56)								
Bromoform	1.0	<1.0	<1.0	17	0	<1.0	<1.0	<1.0
Chlorodibromomethane	1.0	<1.0	<1.0	17	0	<1.0	<1.0	<1.0
Chloroform	1.0	<1.0	1.0	17	4	<1.0	<1.0	<1.0
Dichlorobromomethane	1.0	<1.0	<1.0	17	0	<1.0	<1.0	<1.0
1,2-Dichloroethane	1.0	<1.0	4.0	17	1	<1.0	<1.0	2.0
Methylene chloride	1.0	<1.0	15.0	17	13	<1.0	2.0	7.0
Tetrachloroethylene	1.0	<1.0	10.0	17	8	<1.0	<1.0	2.0
1,1,1-Trichloroethane	1.0	<1.0	6.0	17	1	<1.0	<1.0	1.0
Trichloroethylene	1.0	<1.0	2.0	17	0	<1.0	<1.0	<1.0
Xylene	1.0	<1.0	<1.0	17	0	<1.0	<1.0	<1.0
05537980 Des Plaines River at Route 53 at Joliet, Ill. (map reference number 57)								
Bromoform	1.0	<1.0	<1.0	24	0	<1.0	<1.0	<1.0
Chlorodibromomethane	1.0	<1.0	<1.0	24	0	<1.0	<1.0	<1.0
Chloroform	1.0	<1.0	7.0	24	8	<1.0	<1.0	1.0
Dichlorobromomethane	1.0	<1.0	<1.0	24	0	<1.0	<1.0	<1.0
1,2-Dichloroethane	1.0	<1.0	4.0	24	11	<1.0	<1.0	2.0
Methylene chloride	1.0	<1.0	14.0	24	16	<1.0	2.5	6.0
Tetrachloroethylene	1.0	<1.0	4.0	24	10	<1.0	<1.0	2.0
1,1,1-Trichloroethane	1.0	<1.0	4.0	24	9	<1.0	<1.0	1.0
Trichloroethylene	1.0	<1.0	1.0	24	3	<1.0	<1.0	<1.0
Xylene	1.0	<1.0	<1.0	24	0	<1.0	<1.0	<1.0

Table 40. Statistical summary of samples collected in the upper Illinois River Basin as part of the Illinois Environmental Protection Agency Industrial Solvents Subnetwork in the upper Illinois River Basin, 1988–90—Continued

Compound	MRL	Min	Max	N	N above MRL	Concentration at indicated percentile		
						25	50	75
05539900 West Branch Du Page River near West Chicago, Ill. (map reference number 62)								
Bromoform	1.0	<1.0	2.0	20	1	<1.0	<1.0	<1.0
Chlorodibromomethane	1.0	<1.0	<1.0	20	0	<1.0	<1.0	<1.0
Chloroform	1.0	<1.0	2.0	20	6	<1.0	<1.0	1.0
Dichlorobromomethane	1.0	<1.0	2.0	20	1	<1.0	<1.0	<1.0
1,2-Dichloroethane	1.0	<1.0	<1.0	20	0	<1.0	<1.0	<1.0
Methylene chloride	1.0	<1.0	1.0	20	3	<1.0	<1.0	<1.0
Tetrachloroethylene	1.0	<1.0	1.0	20	2	<1.0	<1.0	<1.0
1,1,1-Trichloroethane	1.0	<1.0	<1.0	20	0	<1.0	<1.0	<1.0
Trichloroethylene	1.0	<1.0	<1.0	20	0	<1.0	<1.0	<1.0
Xylene	1.0	<1.0	<1.0	20	0	<1.0	<1.0	<1.0
05540290 Du Page River near Naperville, Ill. (map reference number 67)								
Bromoform	1.0	<1.0	<1.0	19	0	<1.0	<1.0	<1.0
Chlorodibromomethane	1.0	<1.0	1.0	19	1	<1.0	<1.0	<1.0
Chloroform	1.0	<1.0	2.0	19	9	<1.0	<1.0	1.0
Dichlorobromomethane	1.0	<1.0	2.0	19	4	<1.0	<1.0	<1.0
1,2-Dichloroethane	1.0	<1.0	<1.0	19	0	<1.0	<1.0	<1.0
Methylene chloride	1.0	<1.0	<1.0	19	0	<1.0	<1.0	<1.0
Tetrachloroethylene	1.0	<1.0	<1.0	19	0	<1.0	<1.0	<1.0
1,1,1-Trichloroethane	1.0	<1.0	<1.0	19	0	<1.0	<1.0	<1.0
Trichloroethylene	1.0	<1.0	<1.0	19	0	<1.0	<1.0	<1.0
Xylene	1.0	<1.0	<1.0	19	0	<1.0	<1.0	<1.0
05543500 Illinois River at Marseilles, Ill. (map reference number 76)								
Bromoform	1.0	<1.0	<1.0	4	0	<1.0	<1.0	<1.0
Chlorodibromomethane	1.0	<1.0	<1.0	4	0	<1.0	<1.0	<1.0
Chloroform	1.0	<1.0	<1.0	4	0	<1.0	<1.0	<1.0
Dichlorobromomethane	1.0	<1.0	<1.0	4	0	<1.0	<1.0	<1.0
1,2-Dichloroethane	1.0	<1.0	<1.0	4	0	<1.0	<1.0	<1.0
Methylene chloride	1.0	<1.0	3.0	4	1	<1.0	<1.0	<1.0
Tetrachloroethylene	1.0	<1.0	<1.0	4	0	<1.0	<1.0	<1.0
1,1,1-Trichloroethane	1.0	<1.0	<1.0	4	0	<1.0	<1.0	<1.0
Trichloroethylene	1.0	<1.0	<1.0	4	0	<1.0	<1.0	<1.0
Xylene	1.0	<1.0	<1.0	4	0	<1.0	<1.0	<1.0
05551000 Fox River at South Elgin, Ill. (map reference number 91)								
Bromoform	1.0	<1.0	<1.0	16	0	<1.0	<1.0	<1.0
Chlorodibromomethane	1.0	<1.0	<1.0	16	0	<1.0	<1.0	<1.0
Chloroform	1.0	<1.0	<1.0	16	0	<1.0	<1.0	<1.0
Dichlorobromomethane	1.0	<1.0	<1.0	16	0	<1.0	<1.0	<1.0
1,2-Dichloroethane	1.0	<1.0	<1.0	16	0	<1.0	<1.0	<1.0
Methylene chloride	1.0	<1.0	<1.0	16	0	<1.0	<1.0	<1.0
Tetrachloroethylene	1.0	<1.0	<1.0	16	0	<1.0	<1.0	<1.0
1,1,1-Trichloroethane	1.0	<1.0	<1.0	16	0	<1.0	<1.0	<1.0
Trichloroethylene	1.0	<1.0	<1.0	16	0	<1.0	<1.0	<1.0
Xylene	1.0	<1.0	<1.0	16	0	<1.0	<1.0	<1.0
05551540 Fox River at Montgomery, Ill. (map reference number 92)								
Bromoform	1.0	<1.0	<1.0	18	0	<1.0	<1.0	<1.0
Chlorodibromomethane	1.0	<1.0	<1.0	18	0	<1.0	<1.0	<1.0
Chloroform	1.0	<1.0	1.0	18	1	<1.0	<1.0	<1.0
Dichlorobromomethane	1.0	<1.0	<1.0	18	0	<1.0	<1.0	<1.0
1,2-Dichloroethane	1.0	<1.0	<1.0	18	0	<1.0	<1.0	<1.0
Methylene chloride	1.0	<1.0	1.0	18	2	<1.0	<1.0	<1.0
Tetrachloroethylene	1.0	<1.0	<1.0	18	0	<1.0	<1.0	<1.0
1,1,1-Trichloroethane	1.0	<1.0	<1.0	18	0	<1.0	<1.0	<1.0
Trichloroethylene	1.0	<1.0	<1.0	18	0	<1.0	<1.0	<1.0
Xylene	1.0	<1.0	<1.0	18	0	<1.0	<1.0	<1.0

Table 41. Statistical summary of samples for total phenolic compounds collected as part of the Illinois Environmental Protection Agency Ambient Water-Quality Monitoring Network in the upper Illinois River Basin, 1987–90

[IEPA, Illinois Environmental Protection Agency; USGS, U.S. Geological Survey; all concentrations are in micrograms per liter; N, number of observations; MRL, minimum reporting level; percentiles are the values one-tenth, one-fourth, one-half (median), three-fourths, and nine-tenths the way through the ordered data values; this table includes only those sampling stations with 9 or more observations; *, value estimated from log-normal maximum likelihood program; <, less than; --, the 10- and 90-percentile concentration values are not shown for sampling stations with 30 or less observations]

Map reference number (fig. 35)	IEPA station code	USGS station number	USGS station name	N	N of censored values	Highest MRL	Concentration at indicated percentile 10	25	50	75	90
14	F02	05520500	Kankakee River at Momence, Ill.	52	46	5	<5	<5	<5	<5	<5
28	FL02	05526000	Iroquois River near Chebanse, Ill.	46	44	5	<5	<5	<5	<5	<5
31	F01	05527500	Kankakee River near Wilmington, Ill.	46	16	5	1.6*	2.0*	2.5*	3.2*	4.0*
35	G15	05530590	Des Plaines River near Schiller Park, Ill.	33	10	5	2.5*	3.3*	4.6*	6.5	9.0
38	GL09	05531500	Salt Creek at Western Springs, Ill.	33	8	5	2.4*	3.6*	6.0	7.5	10
40	G39	05532500	Des Plaines River at Riverside, Ill.	44	23	5	2.0*	2.8*	4.1*	6.0	8.5
42	G11	05534050	Des Plaines River at Lockport, Ill.	26	1	5	--	3.9*	5.5	7.2	--
45	HCC07	05536000	North Branch Chicago River at Niles, Ill.	33	11	5	2.2*	3.2*	4.8*	6.0	12
49	HB42	05536195	Little Calumet River at Munster, Ind.	35	11	5	2.2*	3.2*	4.8*	8.0	12
54	H01	05536700	Calumet Sag Channel at Sag Bridge, Ill.	33	8	5	3.1*	4.3*	6.0	9	13
55	GI01	05536995	Chicago Sanitary and Ship Canal at Romeoville, Ill.	44	34	5	<5	<5	<5	<5	5.0
56	GI02	05537000	Chicago Sanitary and Ship Canal at Lockport, Ill.	34	9	5	2.5*	3.3*	4.5*	5.2	9.0
57	G23	05537980	Des Plaines River at Route 53 at Joliet, Ill.	45	7	5	2.7*	3.5*	4.8*	7.0	9.4
69	GB11	05540500	Du Page River at Shorewood, Ill.	48	35	5	1.0*	1.6*	2.8*	4.8*	10
74	DV04	05542000	Mazon River near Coal City, Ill.	9	2	5	--	1.8*	3.0	4.5	--
76	D23	05543500	Illinois River at Marseilles, Ill.	64	36	5	1.9*	2.4*	3.0*	3.8*	5.0
84	DT35	05546700	Fox River near Channel Lake, Ill.	32	11	5	2.1*	2.8*	3.7*	5.0	6.7
89	DT06	05550000	Fox River at Algonquin, Ill.	43	23	5	2.1*	2.6*	3.4*	4.4*	5.0
92	DT38	05551540	Fox River at Montgomery, Ill.	32	11	5	2.4*	3.0*	3.6*	4.5*	5.0
99	DT46	05552500	Fox River at Dayton, Ill.	48	28	5	1.7*	2.3*	3.2*	4.4*	5.0

Table 42. Statistical summary of samples for total phenolic compounds collected by the Metropolitan Water Reclamation District of Greater Chicago in the upper Illinois River Basin, 1989

[MWRDGC, Metropolitan Water Reclamation District of Greater Chicago; N, number of observations; all concentrations are in micrograms per liter; percentiles are the values one-fourth, one-half (median), and three-fourths of the way through the data values]

MWRDGC site	Waterway	N	Concentration at indicated percentile 25	50	75
1	Chicago Sanitary and Ship Canal	12	7	9	13
2	Chicago Sanitary and Ship Canal	12	7	9	13
3	Des Plaines River	12	6	9	13
4	Des Plaines River	12	6	9	14
5	Des Plaines River	12	7	9	12
6	Des Plaines River	12	6	9	13
7	Des Plaines River	12	6	9	12
8	Des Plaines River	12	5	8	12
9	Des Plaines River	12	4	6	12
10	Des Plaines River	12	7	10	14
11	Illinois River	12	5	7	10
12	Illinois River	12	8	10	11
13	Illinois River	12	4	7	12
14	Illinois River	12	5	7	11
15	Illinois River	12	6	8	11
16	Illinois River	12	5	7	11
17	Illinois River	12	5	7	10
18	Illinois River	12	6	6	7
19	Illinois River	12	5	6	8
20	Illinois River	12	6	7	8
21	Illinois River	12	7	8	9
22	Illinois River	12	5	7	8
23	Illinois River	12	5	6	7
24	Illinois River	12	5	6	7

Table 43. Statistical summary of samples for pentachlorophenol collected as part of the Illinois Environmental Protection Agency Ambient Water-Quality Monitoring Network in the upper Illinois River Basin, 1987–90

[USGS, U.S. Geological Survey; all concentrations are in micrograms per liter; N, number of observations; MRL, minimum reporting level; *, value estimated from adjusted log-normal maximum likelihood program; <, less than; percentiles are the values one-fourth, one-half (median), and three-fourths of the way through the ordered data values; this table includes only those sampling stations with 5 or more observations; --, no data]

Map reference number	USGS station number	USGS station name	N	N below MRL	MRL	Concentration at indicated percentile 25	50	75
14	05520500	Kankakee River at Momence, Ill.	7	7	0.010	<0.010	<0.010	<0.010
31	05527500	Kankakee River near Wilmington, Ill.	31	30	.010	<.010	<.010	<.010
38	05531500	Salt Creek at Western Springs, Ill.	6	0	--	.030	.054	.085
45	05536000	North Branch Chicago River at Niles, Ill.	5	1	.010	.014	.037	.122
49	05536195	Little Calumet River at Munster, Ind.	7	2	.010	.009*	.012	.050
54	05536700	Calumet-Sag Channel at Sag Bridge, Ill.	7	5	.010	<.010	<.010	.036
56	05537000	Chicago Sanitary and Ship Canal at Lockport, Ill.	7	2	.010	.012	.078	.140
57	05537980	Des Plaines River at Route 53 at Joliet, Ill.	6	3	.010	.003*	.012	.132
76	05543500	Illinois River at Marseilles, Ill.	25	9	.010	.009*	.020	.030
84	05546700	Fox River near Channel Lake, Ill.	10	10	.010	<.010	<.010	<.010
92	05551540	Fox River at Montgomery, Ill.	8	6	.010	<.010	<.010	.012

Table 44. Concentrations of synthetic organic compounds and other constituents in selected streambed-sediment samples from the upper Illinois River Basin and from spiked sediment samples and marine-sediment reference samples

[All concentrations are in micrograms per kilogram except for organic carbon, which is in grams per kilogram; S1 and S2 refer to sample splits; Ref, reference values; ±, plus or minus; <, less than; --, not determined]

Constituent	Little Calumet River				Reference standard			Spiked samples		
	Sample 1		Sample 2			Analysis 1	Analysis 2	Analysis 1	Analysis 2	Analysis 3
	S1	S2	S1	S2	Ref					
Fluoranthene	<100	830	790	2,800	3,540±650	<420	1,200	400	<200	<200
Phenanthrene	<100	620	630	3,100	3,000±600	<420	2,100	2,100	<200	<200
Pyrene	<100	500	470	<250	3,000±600	<420	<420	<250	<200	<200
Benzo(*g,h,i*)perylene	<200	<500	<500	1,600	1,780±720	<830	<830	<500	<400	<400
Benzo(*a*)anthracene	<100	<500	<250	1,900	1,800±300	<420	<420	<250	<400	<400
bis(2-Ethylhexyl)phthalate	<100	5,500	<250	9,600	--	<420	<420	<250	<400	<400
Organic carbon	68	140	57	48	--	140	110	--	--	--

Table 45. Results of nested analysis-of-variance on ranked semivolatile organic compounds and other constituents in sediment data collected during the synoptic survey of streambed sediments in the upper Illinois River Basin, 1989

[--, percent variation attributable to this factor was less than 1 percent]

Constituent	Percent variation between splits[1]	Percent variation between replicates[2]	Percent variation between stations[3]	Percent detections
Fluoranthene	42	53	5	63
Phenanthrene	50	18	32	65
Pyrene	89	--	11	46
Benzo(*a*)anthracene	41	--	59	46
bis(2-Ethylhexyl)phthalate	82	--	18	46
Organic carbon	21	23	56	100
Oil and grease	13	--	87	100

[1] Percentage of total variation for indicated compound that is observable between sample splits.

[2] Percentage of total variation for indicated compound that is observable between discrete samples collected at the same place at the same station.

[3] Percentage of total variation for indicated compound that is observable between samples collected at different stations.

Table 46. Summary of semivolatile organic compounds for which analyzed and number of stations where detected in samples collected from 10 stations during low-flow reconnaissance sampling of streambed sediments in the upper Illinois River Basin, 1987

[N, number of stations where compound was detected]

Compound	N
Acenaphtylene	2
Acenapthene	5
Anthracene	7
Benzo(*a*)anthracene	6
Benzo(*b*)fluoranthene	6
Benzo(*k*)fluoranthene	6
Benzo(*g,h,i*)perylene	3
Benzo(*a*)pyrene	6
Benzylbutylphthalate	0
4-Bromodiphenyl ether	0
4-Chlorodiphenyl ether	0
bis(2-Chloroethyl)ether	0
bis(2-Chloroethoxy)methane	0
bis(2-Chloroisopropyl)ether	0
4-Chloro-3-methylphenol	0
2-Chloronaphthalene	0
2-Chlorophenol	0
Chrysene	7
Dibenzo(*a,h*)anthracene	3
Dibutyl phthalate	0
1,2-Dichlorobenzene	1
1,3-Dichlorobenzene	1
1,4-Dichlorobenzene	2
2,4-Dichlorophenol	0
Diethyl phthalate	0
2,4-Dimethylphenol	0
Dimethyl phthalate	0
2,4-Dinitrotoluene	0
2,4-Dinitrophenol	0
2,6-Dinitrotoluene	0
Dioctyl phthalate	0
bis(2-Ethylhexyl)phthalate	5
Fluoranthene	7
Fluorene	5
Hexachlorobenzene	0
Hexachlorobutadiene	0
Hexachlorocyclopentadiene	0
Hexachloroethane	0
Indeno(1,2,3-*cd*)pyrene	3
Isophorone	0
2-Methyl, 4,6-dinitrophenol	0
Naphthalene	6
Nitrobenzene	0
2-Nitrophenol	0
4-Nitrophenol	0
N-Nitrosodipropylamine	0
N-Nitrosodiphenylamine	2
N-Nitroso-*N,N*-dimethylamine	0
Pentachlorophenol	0
Phenfanthrene	7
Phenol	1
Pyrene	8
1,2,4-Trichlorobenzene	0
2,4,6-Trichlorophenol	0

Table 47. **Summary of semivolatile organic compounds for which analyzed and number of stations where detected in samples of streambed sediments collected at 82 stations in the upper Illinois River Basin, 1989**
[N, number of stations where compound was detected]

Compound	N	Percentage of stations
Acenaphthylene	7	8.5
Acenaphthene	18	22
Aldrin	7	8.5
Anthracene	17	21
Benzidine	0	0
Benzo(*a*)anthracene	20	24
Benzo(*b*)fluoranthene	14	17
Benzo(*k*)fluoranthene	4	4.9
Benzo(*g,h,i*)perylene	20	24
Benzo(*a*)pyrene	8	9.8
Benzylbutylphthalate	5	6.1
α-BHC	5	6.1
γ-BHC (Lindane)	6	7.3
4-Bromodiphenyl ether	0	0
Chlordane	4	4.9
4-Chlorodiphenyl ether	0	0
bis(2-Chloroethyl)ether	0	0
bis(2-Chloroethoxy)methane	0	0
bis(2-Chloroisopropyl)ether	0	0
4-Chloro-3-methylphenol	0	0
2-Chloronaphthalene	1	1.2
2-Chlorophenol	0	0
Chrysene	17	21
p,p'-DDE	25	30
p,p'-DDT	11	13
Dibenzo(*a,h*)anthracene	1	1.2
Dibutyl phthalate	2	2.4
1,2-Dichlorobenzene	0	0
1,3-Dichlorobenzene	2	2.4
1,4-Dichlorobenzene	3	3.6
3,3-Dichlorobenzidine	3	3.6
2,4-Dichlorophenol	0	0
Dieldrin	10	12
Diethyl phthalate	2	2.4
2,4-Dimethylphenol	0	0
Dimethyl phthalate	0	0
4,6-Dinitro-o-cresol	0	0
2,4-Dinitrophenol	0	0
2,4-Dinitrotoluene	0	0
2,6-Dinitrotoluene	2	2.4
Dioctyl phthalate	0	0
α-Endosulfan	3	3.6
Endrin	5	6.1
bis(2-Ethylhexyl)phthlate	37	45
Fluoranthene	44	54
Fluorene	23	28
Heptachlor	4	4.9
Heptachlor epoxide	3	3.6
Hexachlorobenzene	0	0
Hexachlorobutadiene	0	0
Hexachlorocyclopentadiene	0	0
Hexachloroethane	0	0
Indeno(1,2,3-*cd*)pyrene	14	17
Isophorone	0	0
n-Nitrosodipropylamine	0	0
n-Nitrosodiphenylamine	0	0
Naphthalene	9	11
Nitrobenzene	0	0
2-Nitrophenol	0	0
4-Nitrophenol	0	0
PCB-1221	0	0
PCB-1232	0	0
PCB-1242	7	8.5
PCB-1248	0	0
PCB-1254	11	13
PCB-1260	15	18
PCB-1016	0	0
Pentachlorophenol	0	0
Phenanthrene	45	55
Phenol	3	3.6
Pyrene	29	35
1,2,4-Trichlorobenzene	0	0
2,4,6-Trichlorophenol	0	0
Toxaphene	0	0

Table 48. Correlation coefficients among concentrations of synthetic organic compounds and other constituents detected in more than 50 percent of fish-tissue samples from the upper Illinois River Basin, 1989–90

[Only those compounds with p less than or equal to 0.1 are shown; --, no data]

Constituent	*trans*-Nonachlor	*cis*-Chlordane	*p,p'*-DDE	Dieldrin	*p,p'*-DDD	Lipid content
trans-Nonachlor	1.00					
cis-Chlordane	.90	1.00				
p,p'-DDE	.66	.69	1.00			
Dieldrin	.58	.53	--	1.00		
p,p'-DDD	.54	.55	.66	.45	1.00	
Lipid content	.80	.81	.64	.67	.48	1.00

Constituent	Heptachlor epoxide	*trans*-Chlordane	*trans*-Nonachlor	*cis*-Chlordane	*p,p'*-DDE	Dieldrin	*o,p'*-DDD	*p,p'*-DDD	Lipid content
Heptachlor epoxide	1.00								
trans-Chlordane	--	1.00							
trans-Nonachlor	.36	.88	1.00						
cis-Chlordane	--	.95	.88	1.00					
p,p'-DDE	--	.78	.79	.82	1.00				
Dieldrin	.61	.62	.69	.54	--	1.00			
o,p'-DDD	--	.71	.65	.77	.80	--	1.00		
p,p'-DDD	--	.73	.67	.83	.86	--	.92	1.00	
Lipid content	--	.82	.73	.79	.68	.50	.55	.60	1.00

Table 49. National standards for selected synthetic organic compounds detected in aquatic biota collected in the upper Illinois River Basin, 1989–90

[NAS, National Academy of Sciences; USFDA, U.S. Food and Drug Administration; USEPA, U.S. Environmental Protection Agency; mg/kg, milligrams per kilogram; --, no standard]

Compound	For protection of fish-eating birds and mammals (based on whole-fish samples)	For protection of human health (based on edible portions of fish)	
	NAS Recommended Maximum Tissue Concentrations[1] (mg/kg)	USFDA Action Level[2] (mg/kg)	USEPA Fish Tissue Concentrations[3] (mg/kg)
α-BHC	--	--	0.0017
Chlordane	0.1	0.3	.0083
p,p'-DDD,	--	--	--
p,p'-DDE	1.0	5	.0316
p,p'-DDT	1.0	5	.0316
Dieldrin	.1	.3	.00067
Heptachlor epoxide	--	.3	.0012
Hexachlorobenzene	--	--	.00673
PCB's	[4]3.0	5.0	--

[1] National Academy of Sciences (1972).

[2] U.S. Food and Drug Administration (1990, 1991a, 1991b, 1991c, 1991d).

[3] Toxic Substance Spreadsheet (U.S. Environmental Protection Agency, 1992c).

[4] McLane and Hughes (1980).

Table 50. Summary of concentrations of organochlorine compounds in whole-fish samples from the upper Illinois River Basin, 1989–90

[Data presented are for whole fish collected as part of the upper Illinois River Basin NAWQA project.; all concentrations are in microgram per gram, wet weight; NAWQA, National Water-Quality Assessment; NCBP, National Contaminant Biomonitoring Program; NSCRF, National Study of Chemical Residues in Fish; DDT, dichlorodiphenyltrichloroethane; DDD, dichlorodiphenyldichloroethane; DDE, dichlorodiphenyldichloroethylene; PCB, polychlorinated biphenyl; <, less than; NR, not reported]

Compound	Upper Illinois River Basin NAWQA			NCBP	NSCRF
	Maximum	Mean	Median	Mean[1]	Mean[2]
cis-Chlordane	0.20	0.05	0.03	0.03	0.021
trans-Chlordane	.27	.03	.02	.02	.017
Chlordane-related compounds	.63	.14	.10	.12	NR
o,p'-DDD	.24	.04	.01	NR	NR
p,p'-DDD	1.5	.17	.03	.06	NR
o,p'-DDE	<.01	<.01	<.01	NR	NR
p,p'-DDE	.84	.15	.08	.19	.30
o,p'-DDT	.05	<.01	<.01	NR	NR
p,p'-DDT	.07	<.01	<.01	.03	NR
DDD, DDE, and DDT	2.56	.37	.15	.26	NR
Dicofol	<.01	<.01	<.01	NR	.001
Dieldrin	.52	.07	.05	.04	.028
Endrin	<.01	<.01	<.01	<.01	.002
Heptachlor epoxide	.03	.01	<.01	.01	.002
Hexachlorobenzene	.02	<.01	<.01	NR	.006
α-Hexachlorocyclohexane	<.01	<.01	<.01	<.01	.002
β-Hexachlorocyclohexane	<.01	<.01	<.01	NR	NR
γ-Hexachlorocyclohexane (Lindane)	<.01	<.01	<.01	<.01	.003
δ-Hexachlorocyclohexane	<.01	<.01	<.01	NR	NR
Kepone	<.01	<.01	<.01	NR	NR
Mirex	<.01	<.01	<.01	<.01	.004
cis-Nonachlor	.04	.01	<.01	.02	.009
trans-Nonachlor	.11	.01	<.01	.03	.017
Octachlorostyrene	<.01	<.01	<.01	NR	.002
Oxychlordane	.02	<.01	<.01	.01	.005
PCB's (total)	3.3	.73	.38	.39	7.6
Toxaphene	<.01	<.01	<.01	.14	NR

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[1] Schmitt and other (1990).

[2] U.S. Environmental Protection Agency (1992a).

Table 51. Selected organochlorine compounds for which analyzed in biota and sediment in the upper Illinois River Basin, 1989

[ND, compound not detected; X, compound detected in sediment, concentration uncertain; number is concentration in biota in micrograms per kilogram; letter(s) refers to whether or not compound was detected in sediment]

HCB: hexachlorobenzene BHC: hexachlorocyclohexane

Station name (map reference number)	Species of biota	HCB	α-BHC	γ-BHC	Heptachlor epoxide	Toxa- phene	Total chlordane	PCB's	*p,p'*-DDE	Diel- drin	Endrin	*p,p'*-DDT
Kankakee River at Shelby, Ind. (11)	Carp	ND/ ND	ND/ ND	ND/ ND	ND/ ND	ND/ ND	0.17/ ND	ND/ ND	0.06/ ND	0.16/ ND	ND/ ND	ND/ ND
Kankakee River at Momence, Ill. (14)	Smallmouth bass	ND/ ND	ND/ ND	ND/ ND	ND/ ND	ND/ ND	.05/ ND	0.80/ ND	.42/ ND	.02/ ND	ND/ ND	ND/ ND
Salt Creek at Western Springs, Ill. (38)	Crayfish	ND/ ND	ND/ ND	ND/ ND	ND/ ND	ND/ ND	ND/ ND	ND/ ND	.04/ X	ND/ ND	ND/ ND	ND/ X
Des Plaines River at Riverside, Ill. (40)	Goldfish	0.01/ ND	ND/ ND	ND/ ND	ND/ ND	ND/ ND	.43/ ND	2.3/ X	.74/ X	.07/ ND	ND/ ND	0.03/ X
North Branch Chicago River at Deerfield, Ill. (43)	Crayfish	ND/ ND	ND/ ND	ND/ ND	ND/ ND	ND/ ND	.01/ ND	ND/ ND	.02/ X	ND/ ND	ND/ ND	ND/ ND
Little Calumet River at Halsted Ave. at Harvey, Ill. (52)	Carp	.02/ ND	ND/ X	ND/ ND	ND/ X	ND/ ND	.33/ X	2.5/ X	.15/ X	.15/ X	ND/ X	ND/ X
Des Plaines River above Brandon Road Dam at Joliet, Ill. (58)	Carp	ND/ ND	ND/ ND	ND/ X	ND/ X	ND/ ND	.20/ ND	2.9/ ND	.16/ X	.03/ X	ND/ ND	ND/ ND
Du Page River at Hamel Woods at Shorewood, Ill. (68)	Smallmouth bass	ND/ ND	ND/ ND	ND/ ND	ND/ ND	ND/ ND	.03/ ND	.23/ ND	.04/ ND	.03/ ND	ND/ ND	ND/ ND
Illinois River at Marseilles, Ill. (76)	Carp	ND/ ND	ND/ ND	ND/ ND	ND/ X	ND/ ND	.19/ X	3.3/ X	.25/ ND	.10/ X	ND/ X	ND/ ND
Fox River at Algonquin, Ill. (89)	Carp	ND/ ND	ND/ ND	ND/ ND	ND/ ND	ND/ ND	.03/ ND	.62/ ND	.09/ ND	.01/ ND	ND/ ND	ND/ ND

Table 52. Polynuclear aromatic hydrocarbon compounds for which analyzed in biota and sediment in the upper Illinois River Basin, 1989

[ND, compound not detected; X, compound detected in sediment, concentration uncertain; number is concentration in biota in micrograms per kilogram; letter(s) refers to whether or not compound was detected in sediment]

Station name (map reference number)	Species of biota	Naphthalene	Fluorene	Phenanthrene	Anthracene	Fluoranthene	Pyrene	Chrysene	Benzo (*b*) fluoranthene	Benzo (*k*) fluoranthene	Benzo (*a*) pyrene	Benzo (*g,h,i*) perylene	Dibenzo (*a,h*) anthracene
Salt Creek at Western Springs, Ill. (38)	Crayfish	ND/ND	ND/X	ND/X	ND/X	ND/X	0.02/X	0.01/ND	0.01/ND	ND/ND	0.01/ND	0.01/X	0.01/ND
Des Plaines River at Riverside, Ill. (40)	Crayfish	ND/X	0.01/X	0.05/X	0.01/ND	0.06/X	.06/ND	.02/X	.01/X	ND/ND	.01/X	.01/ND	ND/ND
North Branch Chicago River at Deerfield, Ill. (43)	Plants	ND/ND	ND/X	.01/X	ND/ND	.03/X	.04/X	.03/X	.01/X	0.01/ND	.01/ND	.01/X	ND/ND
North Branch Chicago River at Deerfield, Ill. (43)	Snails	ND/ND	ND/X	ND/X	.01/ND	.02/X	.01/X	.02/X	.01/X	.01/ND	.02/ND	.02/X	.01/ND
Little Calumet River at Halsted Ave. at Harvey, Ill. (52)	Crayfish	ND/X	ND/X	.03/X	ND/X	.03/X	.03/X	.01/X	ND/X	ND/X	.01/X	ND/X	ND/X
Du Page River ar Hamel Woods at Shorewood, Ill. (68)	Crayfish	ND/ND	ND/ND	ND/ND	ND/ND	ND/X	.01/ND	.01/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND
Fox River at Algonquin, Ill. (89)	Crayfish	ND/ND	ND/ND	ND/ND	ND/ND	ND/X	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND