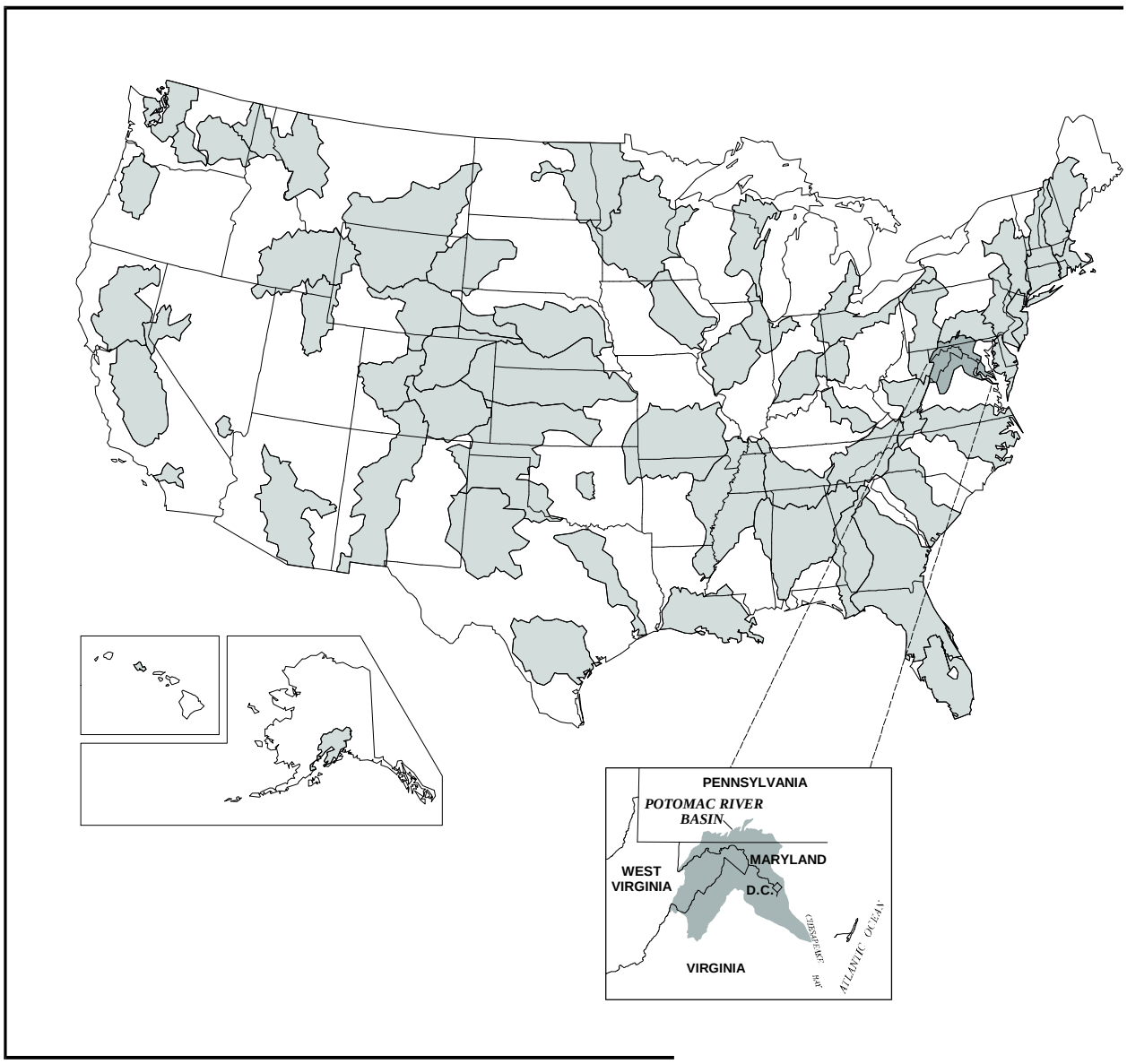
WATER-QUALITY ASSESSMENT OF THE POTOMAC RIVER BASIN: ANALYSIS OF AVAILABLE PESTICIDE DATA, 1972-90



U.S. GEOLOGICAL SURVEY
Water-Resources Investigations Report 97-4051

National Water-Quality Assessment (NAWQA) Program

Cover. Map showing the National Water-Quality Assessment (NAWQA) Program study units throughout the United States.

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By Humbert Zappia and Gary T. Fisher

U.S. GEOLOGICAL SURVEY

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Prepared as part of the

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CONVERSION FACTORS

Multiply	By	To obtain
	Length	
inch (in.)	25.4	millimeter
inches per year (in/yr)	25.4	millimeters per year
foot (ft)	0.3048	meter
mile (mi)	1.609	kilometer
	Area	
acre	4,047	square meter
acre	0.4047	hectare
square mile (mi^2)	259.0	hectare
square mile (mi^2)	2.590	square kilometer
	Temperature	
degree Fahrenheit (^oF)	$^oC = 5/9 \times (^oF-32)$	degree Celsius (^oC)

Chemical concentration in water is given in micrograms per liter (µg/L). Micrograms per liter is a unit expressing the concentration of chemical constituents in solution as weight (micrograms) of solute per unit volume (liter) of water. For concentrations less than 7,000,000 µg/L, the numerical value is the same as for concentrations in parts per billion.

Chemical concentration in bottom material is given in micrograms per kilogram (µg/kg).

Chemical concentration in biological tissue is given in milligrams per kilogram (mg/kg).

Water-Quality Assessment of the Potomac River Basin: Analysis Of Available Pesticide Data, 1972-1990

By Humbert Zappia and Gary T. Fisher

ABSTRACT

A study of available data for the period from 1972 to 1990 was conducted to characterize the occurrence and distribution of pesticides in surface water, bottom material, ground water, and fish tissue in the Potomac River Basin. The study was conducted by the Potomac River study unit of the U.S. Geological Survey's National Water-Quality Assessment (NAWQA) program. Existing data coverage was evaluated to guide future data-collection activities. Data from computer data bases and from published and unpublished reports were obtained from local, State, and Federal agencies in the four Potomac River Basin states and the District of Columbia. Data are available for all environmental media, but geographic and temporal coverage are limited. Clusters of data occur in the north-central parts of the basin, with numerous samples at discrete locations in the Shenandoah and Monocacy River Basins, along the mainstem Potomac River, in the Washington, D.C., area, and in streams along the Potomac Estuary. Much of the available surface-water and bottom-material data are from the earlier years of the period of interest, the ground-water data are from the middle years, and the fish-tissue data are distributed over much of the period. Overall, temporal coverage is not sufficient for analysis of trends. Comparisons between different sample media are possible in some areas of the Potomac River Basin, particularly in the northern end of the Great Valley.

Residual concentrations of some pesticides have been found in surface water, bottom material, ground water, and fish tissue. Samples have been analyzed for a total of at least 69 pesticides and related compounds in surface water, bottom material, ground water, and fish tissue. Most concentrations of the pesticides analyzed during the period from 1972 to 1990 were less than or equal to reporting limits.

For surface-water samples, 13 out of 41 pesticides and related compounds analyzed had concentrations equal to or greater than the reporting limits. Compounds reported in surface water included 2,4-D, atrazine, aldrin, chlordane, DDT and related compounds, dieldrin, endrin, lindane, prometone, prometryne, and simazine. For bottom material samples, 19 of 31 pesticides and related compounds analyzed had concentrations equal to or greater than the reporting limits. Compounds reported in bottom material included aldrin, chlordane, DDT and related compounds, diazinon, dieldrin, endosulfan, endrin, ethion, heptachlor, heptachlor epoxide, lindane, parathion, and toxaphene. In ground-water samples, 14 of 39 pesticides and related compounds analyzed had concentrations equal to or greater than the reporting limits. Compounds reported in ground water included 2,4-D, atrazine, chlordane, cyanazine, DDT and related compounds, diazinon, dieldrin, endosulfan, endrin, heptachlor epoxide, malathion, methyl parathion, simazine. For fish- tissue samples, 30 of the 37 pesticides and related compounds analyzed had concentrations equal to or greater than the reporting limits. Compounds reported included aldrin, chlorpyrifos, dacthal, dieldrin, endrin, HCB, heptachlor, heptachlor epoxide, methoxychlor, mirex, PCA, toxaphene, and those compounds related to chlordane, DDT, and lindane.

INTRODUCTION

The U.S. Geological Survey's (USGS) National Water-Quality Assessment (NAWQA) program began in 1986 with seven pilot studies to test and refine concepts for the design and conduct of the program (Hirsch and others, 1988). Using lessons learned during the pilot studies, and supported by recommendations by the National Academy of Science (1990), the NAWQA program began full-scale implementation in fiscal year 1991 (Leahy and others, 1990).

The goals of the NAWQA program are to:

1) Provide a nationally consistent description of current water-quality conditions for a large part of the Nation's water resources;

2) Define long-term trends (or lack of trends) in water quality;

3) Identify, describe, and explain, to the extent possible, the major natural and human factors that affect observed water-quality conditions and trends.

It is anticipated that the data and findings of the NAWQA program will provide a scientific basis for major national decisions that affect water-quality policy and regulation. It is important that such decisions be based on a sound understanding of the factors that affect water quality and that they be based on nationally consistent data and approaches. The NAWQA program is designed to provide these requirements for informed decision-making on a national level.

The NAWQA program consists of two major components--national synthesis and study units (Leahy and Wilber, 1991). The national-synthesis component will address specific water-quality issues that are of common concern in most parts of the Nation. It is designed to address these issues through comparative studies among different hydrologic settings in the Nation, using data that are collected and analyzed in a consistent manner. The data needed for national-synthesis topics will be provided, in large part, by the other major component of the NAWQA program--study units.

Fifty-nine study units covering areas of 1,200 to more than 65,000 mi^2 have been selected to include major river basins and aquifer systems. Collectively, the study units incorporate about 60 to 70 percent of the Nation's water use and population served by public water supplies. Activity in each study unit is designed to be continual, with alternating periods of intensive investigation and low-level monitoring. Each study unit will address physical, chemical, and biological characteristics of surface-water and ground-water quality. Starting in 1991, groups of 15 to 20 study units were begun at intervals of 3 years.

The Potomac River Basin study unit of the NAWQA program began in fiscal year 1991 (Gerhart, 1991). It was selected to be in the first group of 20 study units because of its national prominence, its high population (mostly in the Washington, D.C., area), and its significance to the health of the Chesapeake Bay. The first intensive phase of the Potomac River Basin study unit is scheduled for completion in fiscal year 1997, at which time the study unit will enter its first low-level monitoring phase. In fiscal year 2002, the second intensive phase of the Potomac River Basin study unit is scheduled to begin.

Purpose and Scope

The purpose of this report is to provide a retrospective analysis of pesticide data for selected environmental media in the Potomac River Basin, as part of NAWQA's objective to describe water-quality status and trends. Available data are analyzed to characterize the occurrence and distribution of pesticides. The available pesticide concentration data are evaluated for their potential to identify problem areas, document differences among basin subunits, describe trends, compare to national standards, and determine areas where sampling for the various selected environmental media overlap. In addition, an evaluation is made of existing pesticide data coverage to guide future

data-collection efforts. The report and its analysis contribute to one of the first two National Synthesis topics of NAWQA and it documents current information as a starting point for future NAWQA work in the Potomac River Basin study unit.

This report addresses available data for pesticides in surface water, bottom material, ground water, and biological tissue. Data considered are limited to those collected after 1971 to reduce problems associated with changes in laboratory methods and to maximize usage of data-collection networks and computer data bases that became common about 1972.

Description of the Potomac River Basin

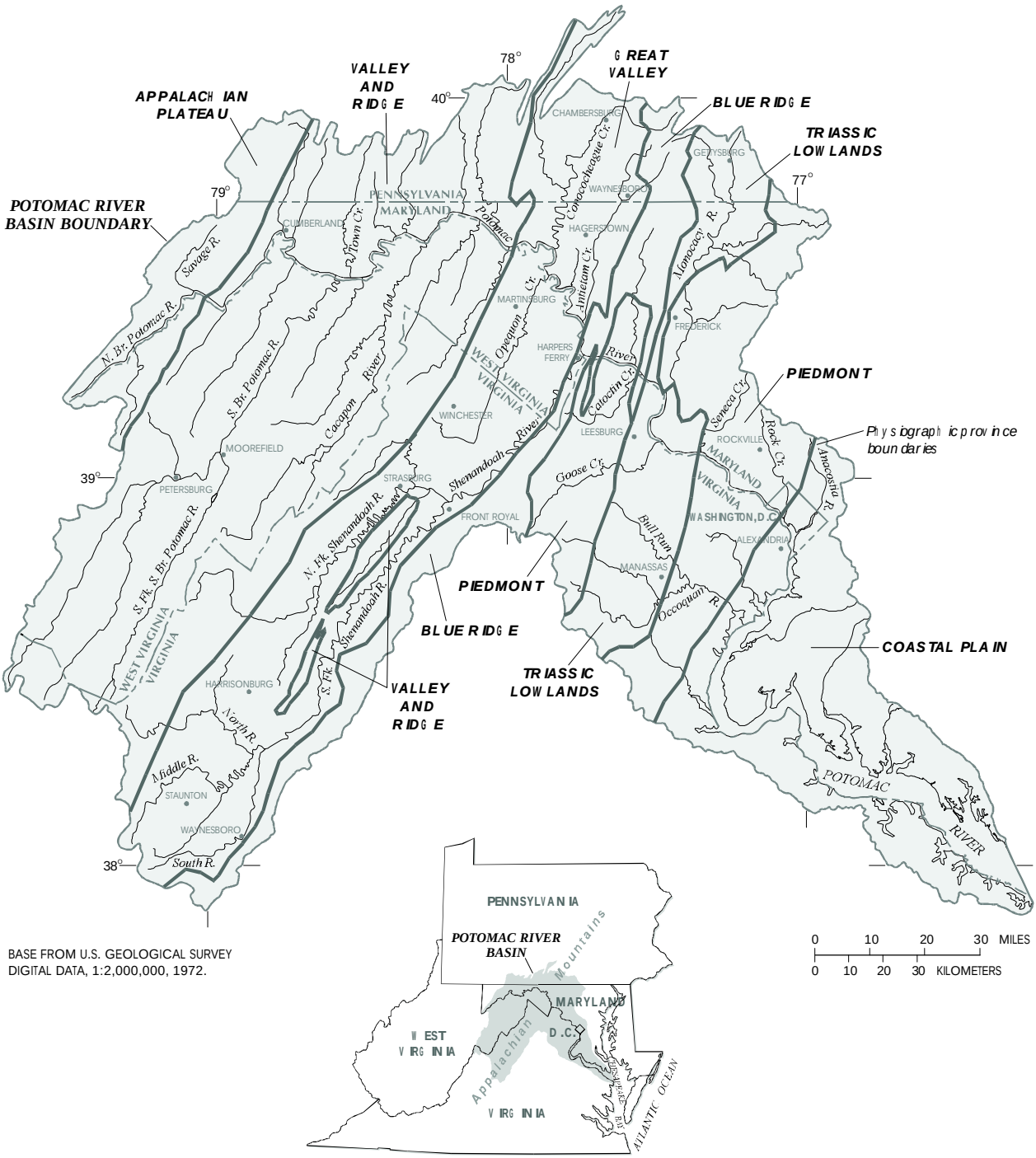
The Potomac River Basin (fig. 1) includes 14,670 mi^2 in the States of Virginia (5,723 mi^2), Maryland (3,818 mi^2), West Virginia (3,490 mi^2), and Pennsylvania (1,570 mi^2), and in the District of Columbia (69 mi^2). It has a complex environmental setting consisting of various combinations of natural and human factors that affect water quality. The basin contains parts of seven physiographic provinces and subprovinces underlain by a wide variety of rock types. Land use in 1990 was about one-half forested, one-third agricultural, and less than one-tenth urban. About two-thirds of the 4.67 million people who lived in the basin in 1990 resided in the Washington, D.C., area. About 97 percent of the water used in the basin in 1990 was from surface-water sources.

The average-annual temperature in the Potomac River Basin ranges from about 47°F in the mountainous western part of the basin to just less than 58°F in Washington, D.C. (U.S. Department of Commerce, 1991a,b,c,d). Temperatures are typically lower in the western part of the basin. In the rest of the basin, average-annual temperature ranges from about 51°F to 55°F, with no apparent areal pattern. Temperature varies considerably throughout the year. July tends to be the hottest month and January the coldest. The difference between the average monthly temperatures in July and January is about 45°F, regardless of location in the basin.

The average-annual precipitation in the basin ranges from about 32 in. in the South Branch Potomac River drainage to about 47 in. near the source of the Potomac River in the North Branch Potomac River drainage (U.S. Department of Commerce, 1991a,b,c,d). In general, precipitation in the area of the South Branch Potomac and Shenandoah Rivers averages less than 40 in/yr and precipitation in the rest of the Potomac River Basin averages more than 40 in/yr. The high western mountains of Maryland and West Virginia have the greatest areal variability in average-annual precipitation, with amounts ranging from about 37 to 47 in.

Parts of seven physiographic provinces or subprovinces lie within the Potomac River Basin: the Appalachian Plateau, Valley and Ridge and its Great Valley subprovince, Blue Ridge, Piedmont and its Triassic Lowlands subprovince, and Coastal Plain (fig. 1). The rocks in the mountainous Appalachian Plateau, and Valley and Ridge provinces are sedimentary (sandstones, shales, and limestones). The mountainous Blue Ridge and rolling Piedmont Provinces are underlain mostly by crystalline rocks. The bedrock in all four of these provinces is blanketed by a mantle of weathered rock material, or regolith, which in some places is more than 100 ft thick. The Coastal Plain Province is underlain by relatively younger, unconsolidated sediments (sand, silt, and clay) in layers that dip to the southeast.

Although the geology of the Potomac River Basin is very complex, the geologic units can be broadly categorized into four groups: unconsolidated sediments, carbonate sedimentary rocks, siliciclastic sedimentary rocks, and crystalline rocks. Unconsolidated sediments underlie about 15 percent of the basin, carbonate sedimentary rocks underlie about 17 percent, siliciclastic sedimentary rocks underlie about 42 percent, and crystalline rocks underlie about 19 percent of the basin. The remaining 7 percent consists of geologic units that contain significant portions of both carbonate and siliciclastic sedimentary rocks.The Potomac River Basin includes four major tributar-



Location of study area

Figure 1. Location of major rivers and physiographic divisions in the Potomac River Basin.

ies, the North and South Branches Potomac River, the Shenandoah River, and the Monocacy River. Other large tributaries include the Cacapon River, Conococheague Creek, and the Occoquan River. Smaller tributaries that are important for potential water-quality impacts include several tributaries to the Shenandoah River, Antietam Creek, and the Anacostia River. All of these tributaries except for the Occoquan and Anacostia Rivers are located entirely above the Fall Line, which is an irregular boundary between the Piedmont and Coastal Plain Physiographic Provinces.

Total natural runoff in most of the basin (those parts not affected by reservoirs or drainage from coal mines) ranges from about 9 to 22 in/yr (U.S. Geological Survey, 1991a,b,c,d). Runoff from less than 3 percent of the drainage area is regulated, the most significant dams being on the North Branch Potomac River and the Occoquan River. The contribution of ground-water inflow to total runoff ranges from 39 to 61 percent, and averages 52 percent, for those parts of the basin upstream from Washington, D.C. (Trainer and Watkins, 1975). Total runoff and the percentage of ground-water contribution generally are largest for areas underlain by limestone.

Ground water occurs primarily in secondary openings (joints, faults, and other fractures) in the sedimentary and crystalline rocks of the western and central parts of the basin, and in the pore spaces in the overlying regolith mantle. Ground water occurs in pore spaces in the unconsolidated sediments of the Coastal Plain Province. Of all the ground-water-producing units in the basin, the limestone units of the Valley and Ridge Province, parts of the regolith, and the sands of the Coastal Plain Province produce the most ground water.

In the mid-1970's, 51 percent of the land in the Potomac River Basin was in forest, 36 percent was used for agricultural activities, and 8 percent was urban (U.S. Geological Survey, 1979a,b,c,d, and 1980a,b,c,d) (fig. 2). By 1985, 52 percent of the land in the basin was forested, 32 percent was used for agricultural activities, and 12 percent was urban (Camacho, 1989).

Acknowledgments

The authors are grateful to a number of persons who assisted in the compilation of data for this report. Judith Wheeler of USGS did an initial pesticide-data inventory that was very helpful in determining sources of available data. The following persons provided data on pesticides in fish tissue in their respective jurisdictions: Hamid Karimi, District of Columbia Department of Consumer and Regulatory Affairs; Deirdre Murphy, Maryland Department of the Environment; Robert Frey and Tammy Schreffler, Pennsylvania Department of Environmental Protection; James Cummins, Interstate Commission on the Potomac River Basin; Jean Gregory, Virginia Department of Environmental Quality; Janice Smithson, West Virginia Department of Natural Resources; Robert Foley, U.S. Fish and Wildlife Service; and Charles Kanetsky, U.S. Environmental Protection Agency.

ANALYSIS OF AVAILABLE PESTICIDE DATA IN THE POTOMAC RIVER BASIN

Pesticide data are available from three general sources. The preferred source for our purposes is computer data bases, where data can be easily retrieved, manipulated, and analyzed. These data bases, such as the U.S. Environmental Protection Agency's STOrage and RETrieval System (STORET) and the U.S. Geological Survey's National Water Inventory System (NWIS) are most desirable because they are easy to use. Another source of data is published reports. Some reports may present analysis and interpretation of the data, but not the basic data. Reports are less desirable as a data source than computer data bases, because data must be entered into a data base or word processor for analysis and presentation. The final source of data is unpublished records. These data may exist in local computer systems, but often are in paper files. In either case, these data are least desirable because they are difficult to locate and considerable effort is required to compile the data and to perform quality-assurance analysis.

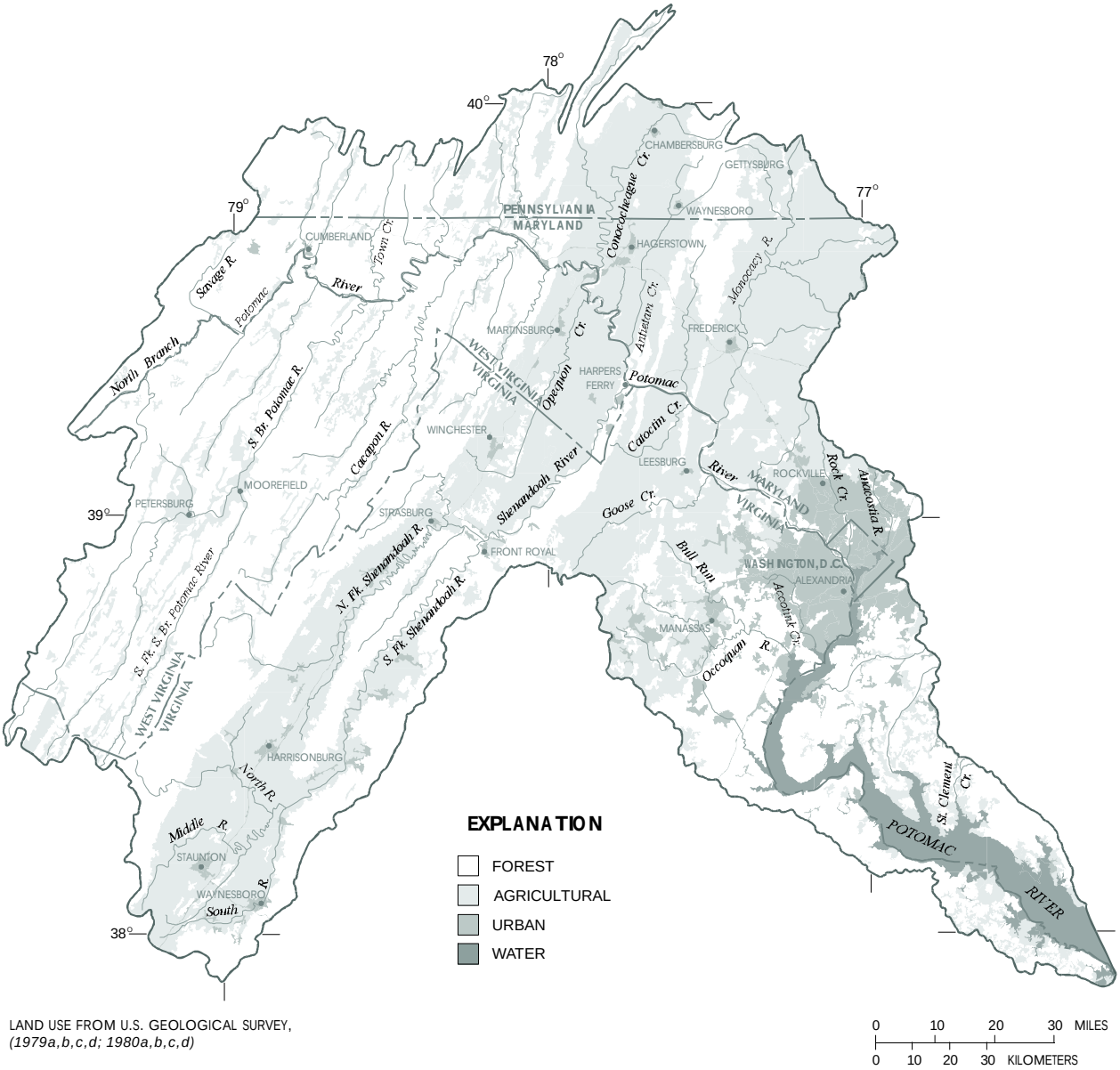


Figure 2. General land use/land cover in the Potomac River Basin.

Data on pesticides in surface water, bottom material, and ground water were obtained from both the STORET and NWIS data bases. Sufficient data for these three environmental media were available from these sources to meet the objectives of this report. Some additional data were available from local agency reports or from USGS published reports that were prepared in cooperation with local jurisdictions, but no sustained attempts were made to search other literature. Unpublished data sources for surface water, bottom material, and ground water were not considered for this report.

Some data on pesticides in biological tissue were available from STORET, but not from NWIS. These data were obtained as unpublished records or published reports directly from State and Federal agencies.

Generally, little information is obtainable on quality-assurance programs used in the collection of data used in this report. Most agencies have internal documentation on protocols and quality control for both field and laboratory procedures. It is assumed that data used in this report have been collected using generally accepted practices. Detailed evaluations of quality-assurance programs are beyond the purpose and scope of this report.

Because field and laboratory methods differ widely even within the scope of accepted practices or within agencies, no specific information is presented on detection limits, analytical accuracy, and precision. Data are presented only on total numbers of analyses made and on those which were equal to or greater than reporting limits for the particular analyses done.

Presentations of data in this report are generally qualitative and focus on the number of samples collected and the occurrence and distribution of pesticides in the basin greater than laboratory reporting limits. Information on reporting limits, although not explicitly available in many cases, was gleaned from "remarks" data fields with indicators such as "greater than (>)" or "not detected (ND)". Traditional approaches to presenting and analyzing data, such as boxplots, temporal plots, descriptive statistics, and comparisons to standards and criteria were not used in this report because of the paucity of data and inadequate information on quality assurance of the data. A table listing selected standards and criteria for water and fish tissue is included for the reader's convenience in appendix A.

Pesticide Use in the Potomac River Basin

A review of pesticide use in the Chesapeake Bay Basin (Roeser, 1988) and a national inventory (Gianessi and Puffer, 1988 and 1990), along with local knowledge and a review of pesticide sampling data, indicate that more than 100 pesticides are being or have been used in the Potomac River Basin. These include herbicides, insecticides, and fungicides. It is difficult to compile a comprehensive list of pesticides or to quantify use of specific compounds because they are distributed under multiple trade names in various formulations and are used in a variety of agricultural, domestic, and industrial applications.

The greatest usage of pesticides is for agricultural operations. Forty-seven pesticides are known to have been used on more than 10,000 acres each in the period 1982-1987 (table 1). Some of these pesticides have been restricted or banned since 1982. Large-scale applications in the Potomac River Basin include crop production, orchards, and confined poultry operations. Important herbicides include alachlor, atrazine, simazine, and metolachlor for corn and alfalfa, and 2,4-D for corn, small grains, and pasture. Paraquat is widely used in Virginia for minimum-tillage corn production. Turf is an important crop in Maryland and 2,4-D is used extensively. Carbofuran is the most used insecticide for crop production. Less widespread but important crops include apples and tobacco, for which farmers use certain specialty pesticides for weed, insect, and fungus control. Simazine is an important herbicide used in apple orchards.

Table 1. Major pesticides used in the Potomac River Basin, 1982-1987

[Use sources: Roeser (1988), Gianessi and Puffer (1988, 1990). All usage data are for the period 1982-1987. ≥ is greater than or equal to; < is less than. Pesticides in **bold** were reported used on more than 10,000 acres].

Pesticide	≥1,000 acres treated	<1,000 acres treated	Some use reported	Pesticide	≥1,000 acres treated	<1,000 acres treated	Some use reported
2,4-D	x			Flucythrinate			x
2,4-DB	x			Fluometuron		x	
2,4,5-T	x			Fluvalinate			x
Acifluorfen	x			**Fomesafen**	x		
Alachlor	x			**Fonofos**	x		
Aldicarb	x			Furadan			x
Ametryne	x			**Glyphosate**	x		
Atrazine	x			Heptachlor			x
Azinphos-methyl		x		**Imaziquin**	x		
Baygon			x	Imidan			x
Benfluralin			x	**Lactofen**	x		
Benomyl			x	Lannate		x	
Bensulide	x			**Linuron**	x		
Bentazon	x			Maeichydrazide		x	
Biphenthrin			x	Malathion			x
Bromoxynil	x			Mancozeb			x
Butylate	x			Maneb			x
Captan			x	MCPA	x		
Carbaryl	x			Mecoprop (MCCP)	x		
Carbofuran	x			Methamidothos			x
Carboxin		x		**Methomyl**	x		
Chloramben		x		**Methoxychlor**	x		
Chlorothalonil	x			Metiram			x
Chlorpropham		x		**Metolachlor**	x		
Clomazone	x			Metribuzin	x		
Cyanazine	x			**Napropamide**	x		
Cycloate		x		Naptalam		x	
Cypermethrin			x	**Norflurazon**	x		
Dalapon		x		Orthine			x
DCPA	x			**Oryzalin**	x		
Diazinon	x			**Oxamyl**	x		
Dicamba	x			**Oxyfluorfen**	x		
Dichlobenil	x			**Paraquat**	x		
Diclofop Methyl	x			Parathion			x
Dieldrin	x			Pendimethalin			x
Diethyl-Ethyl,		x		Permethrin			x
Dinoseb	x			Phosmet			x
Diphenamid	x			Phosphamidon			x
Disulfoton	x			**Picloram**	x		
Diuron	x			Profluralin			x
EPTC	x			Silvex	x		
Ethalfluralin		x		**Simazine**	x		
Ethyl Chlorimuron	x			**Thiameturon**	x		
Fenamiphos	x			Tralomethrin			x
Fenarimol			x	**Triclopyr**	x		
Fenvalerate			x	**Trifluralin**	x		
Fluazifop	x			**Vernolate**	x		

Use of pesticides in urban and developed areas is also substantial. The herbicides 2,4-D and dicamba and the insecticides carbaryl and diazinon are widely used for lawn and garden care. Glyphosate is a non-selective herbicide that is widely used in agricultural and urban settings for general weed control along roads and around buildings.

A number of insecticides have been banned or their use discontinued, but they were used at one time in the Potomac River Basin. These include aldrin, BHC, chlordane, DDT, dieldrin, endrin, and heptachlor. They are important because they all have been linked to toxic effects and because they are persistent in the environment (Smith and others, 1988, p. 27).

Availability of Pesticide Data

Pesticide data for surface water, bottom material, ground water and fish tissue are available from State, Federal, and local agencies in the Potomac River Basin. The data were collected to address issues of national, regional, and local concern and are available in digital formats, published reports, and unpublished records.

Surface Water and Bottom Material

A data search of the STORET and NWIS data bases revealed that 506 samples have been collected for pesticides in surface water at 138 sites in the Potomac River Basin by local, State, and Federal agencies. A report by Lang (1982) discusses sampling by USGS for pesticides in the mainstem Potomac River near Washington, D.C., where another 29 samples were collected over a 30-month period. There were 309 samples collected at 137 sites for pesticides in bottom material. These data were found through searches of the STORET and NWIS data bases and from published reports for Frederick and Washington Counties, Maryland. (Dine and others, 1985; Duigon and others, 1989). Table 2 inventories data collected by USGS and other agencies and lists the number of sites sampled that are in the data base for each state. Figure 3 shows locations of sampling sites, and figure 4 shows locations of counties in the Potomac River Basin.

Ground Water

A data search of the STORET and NWIS data bases revealed that 110 samples have been collected by USGS for pesticides in wells at 87 sites in the Potomac River Basin, with very limited data available from other agencies. Other than a survey for aldrin done on 121 samples at 66 sites in Virginia east of the Shenandoah River, only a single sample for 7 pesticides in ground water was available from other agencies. Springs were sampled by USGS at 32 sites, where 63 samples were collected. Figure 5 shows locations of sampling sites known from STORET and NWIS.

Table 2. Inventory of sites sampled for pesticides in surface water or bottom material, Potomac River Basin

[USGS, U.S. Geological Survey]

	Number of sites sampled			
	Surface water		Bottom material	
State	USGS	Non-USGS	USGS	Non-USGS
District of Columbia	[1]0	0	0	0
Maryland	0	21	30	5
Pennsylvania	0	2	0	2
Virginia	7	104	12	87
West Virginia	0	4	0	1

[1] The Potomac River at Washington, D.C., site is actually located on the Virginia side of the Potomac River.

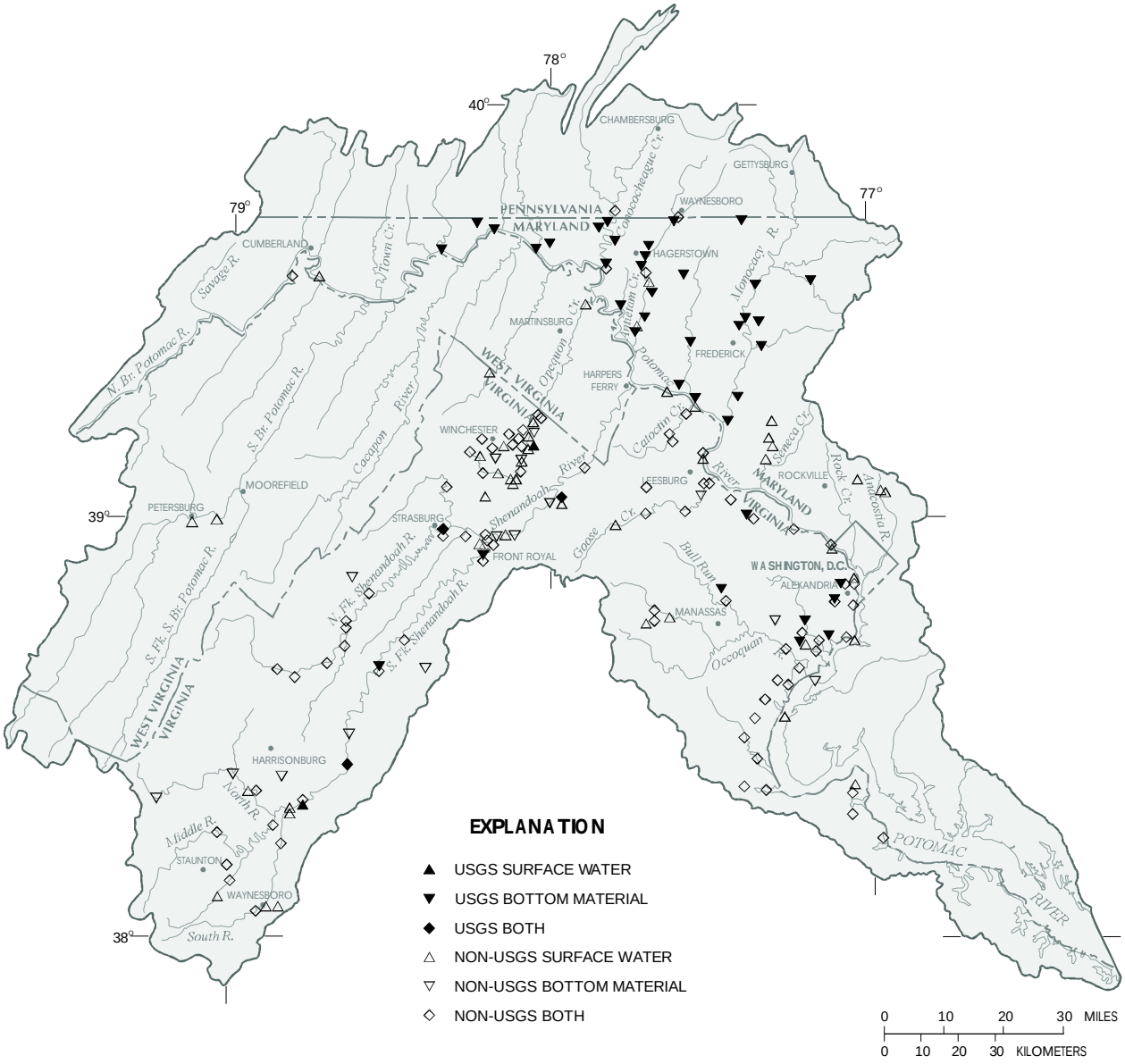


Figure 3. Locations of sampling sites for pesticides in surface water, bottom material, or both in the Potomac River Basin.

Figure 4. Locations of counties in the Potomac River Basin.

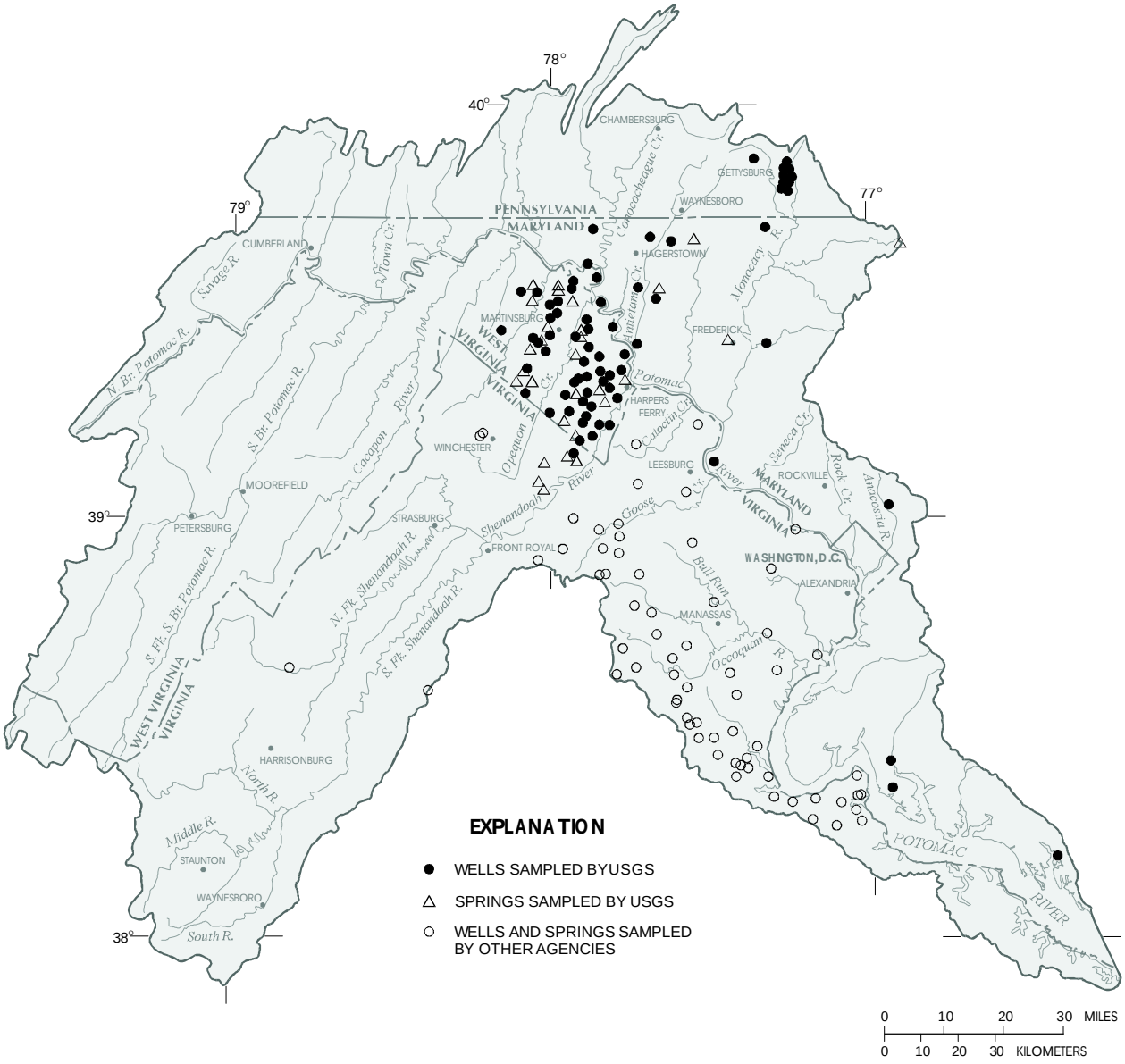


Figure 5. Locations of sampling sites for pesticides in wells and springs in the Potomac River Basin.

Several published reports were also available that provide some additional data on pesticides in ground water. Wright (1990) discussed data on pesticides in five springs and one well in Clarke County, Va. Samples were analyzed for 27 pesticides, and are included in the NWIS data base and figure 5. Duigon and others (1989) presented data on samples analyzed for 11 pesticides in 6 wells and 1 spring and 15 pesticides in 1 spring in Washington County, Md. These data are also included in NWIS and figure 5.

Several other studies collected data on pesticide concentrations in ground water that are not included in the STORET or NWIS data bases. Because precise locations of sampling are not available, none of these samples are included in figure 5 or in any data tables, but results of the other studies are discussed later in this report. Kozar and others (1991) described ground-water sampling conducted in Jefferson County, W. Va., in July 1988. Analyses were made for 20 pesticides at 29 sites. Elmore and Weaver (1987) present the results of sampling public water-supply wells in Maryland in 1983 for 14 herbicides. Two of these wells were located within the Potomac River Basin--one in Washington County, Md., and one on the eastern border of the basin near the southeastern corner of Frederick County, Md. Goodell and LoCastro (1989) present the results of sampling 60 wells in Clarke and Frederick Counties, Va., for 11 pesticides. This sampling took place in July and August 1987. Finally, Mostaghimi and others (1989) discuss pre-Best Management Practices (BMP) sampling in a 5.84-mi^2 watershed in Westmoreland County, Va., as part of a long-term (1986-1994) study of water-quality impacts of agricultural practices. Samples were collected 17 times at 8 wells during 1986 and 1987 and were analyzed for 22 pesticides.

The Pesticides in Ground Water Data Base (U.S. Environmental Protection Agency, 1992a) describes several other investigations of pesticides in ground water in the Potomac River Basin. The U.S. Department of Agriculture has conducted research on pesticides at its Beltsville Agricultural Research Center, just northeast of Washington, D.C. Virginia Polytechnic Institute and State University performed household water-quality surveys in Warren and Page Counties, Va. West Virginia University conducted a study in the orchard areas of Berkeley, Jefferson, and Hampshire Counties, W. Va. No data are included from these investigations because they were not listed in the cited report and were not available from STORET.

Biological Tissue

No data on pesticides in tissues were available from NWIS. Tissue pesticide-concentration data were available from STORET, although not all data collected were available through STORET. Published and unpublished data were obtained directly from State and Federal agencies, in tabular and digital formats, for inclusion in this report.

Although several types of biological tissue from tidal and non-tidal areas have been sampled in the Potomac River Basin, this report is focused entirely on fish-tissue samples from the non-tidal areas of the Potomac River Basin. Other types of tissue, such as mollusk tissue, have been sampled at only a few sites within non-tidal areas of the Potomac River Basin, and are not included in this report.

State and Federal agencies have sampled fish tissue in the Potomac River Basin for compounds that can bioaccumulate, such as pesticides, because of the increased possibility of detecting them at concentrations that are too low to detect in water or bottom material, because they occur episodically, eluding detection in other media (Crawford and Luoma, 1993).

Analysis for pesticides in fish tissue began in the Potomac River Basin during the mid- to late-1970's, usually as part of "core" monitoring networks recommended by the U.S. Environmental Protection Agency (USEPA) to fulfill State water-quality monitoring requirements as set forth by Section 106 (e) of the Clean Water Act (U.S. Environmental Protection Agency, 1976). In 1984, after the USEPA reevaluated the "core" monitoring programs and recommended changes in monitoring strategies, the Potomac River Basin states reevaluated their existing core monitoring

networks and subsequently discontinued some sites and initiated others (Murphy, 1988; U.S. Environmental Protection Agency, 1984; J. Gregory, Virginia Department of Environmental Quality, oral commun., 1993; C. Kanetsky, U.S. Environmental Protection Agency, oral commun., 1993). Potomac River Basin states continue to collect fish tissues as part of established water-quality monitoring networks. In addition, several special studies were conducted by Federal and State agencies to address issues of local or national concern.

Fish tissue has been sampled at 63 sites in the four Potomac River Basin states and the District of Columbia (table 3). The majority of the sampling sites are located on the mainstem Potomac River and near Washington, D.C. (fig. 6). The remainder of the sites are located on several of the Potomac River's major tributaries and on a few smaller streams with a history of contamination problems.

Typically, two types of fish tissue have been sampled in the Potomac River Basin: whole fish and fish fillets (table 3). Whole-fish tissues are used to address questions of pesticide occurrence, spatial characterization, trends, and bioavailability (Crawford and Luoma, 1993). Fish-fillet tissues are most often used to determine potential human health risk associated with fish consumption. A few sites have had other fish-tissue types collected at them, such as fish carcasses (Block and others, 1990), but are not included in this report.

The data presented in this report are mostly from Maryland, Pennsylvania, Virginia, and West Virginia State "core" monitoring networks. Also included are two Federal nationwide surveys--the U.S. Fish and Wildlife Service's (USFWS) National Contaminant Biomonitoring Program (Schmitt and others, 1990) and USEPA's National Study of Chemical Residues in Fish (U.S. Envi-

Table 3. Source agencies, numbers, and types of fish-tissue samples collected for analysis for pesticides, Potomac River Basin

Agency	Number of sites with whole-fish samples only	Number of sites with fish-fillet samples only	Number of sites with whole-fish and fish-fillet samples	Number of whole-fish samples	Number of fish-fillet samples
District of Columbia Department of Consumer and Regulatory Affairs	0	10	0	0	93
Maryland Department of the Environment	7	1	15	187	69
Pennsylvania Department of Environmental Protection	0	4	0	0	4
Virginia Department of Environmental Quality	0	0	8	10	20
West Virginia Department of Natural Resources	8	0	0	30	0
U.S. Environmental Protection Agency	3	0	1	4	1
U.S. Fish and Wildlife Service	1	0	5	35	10

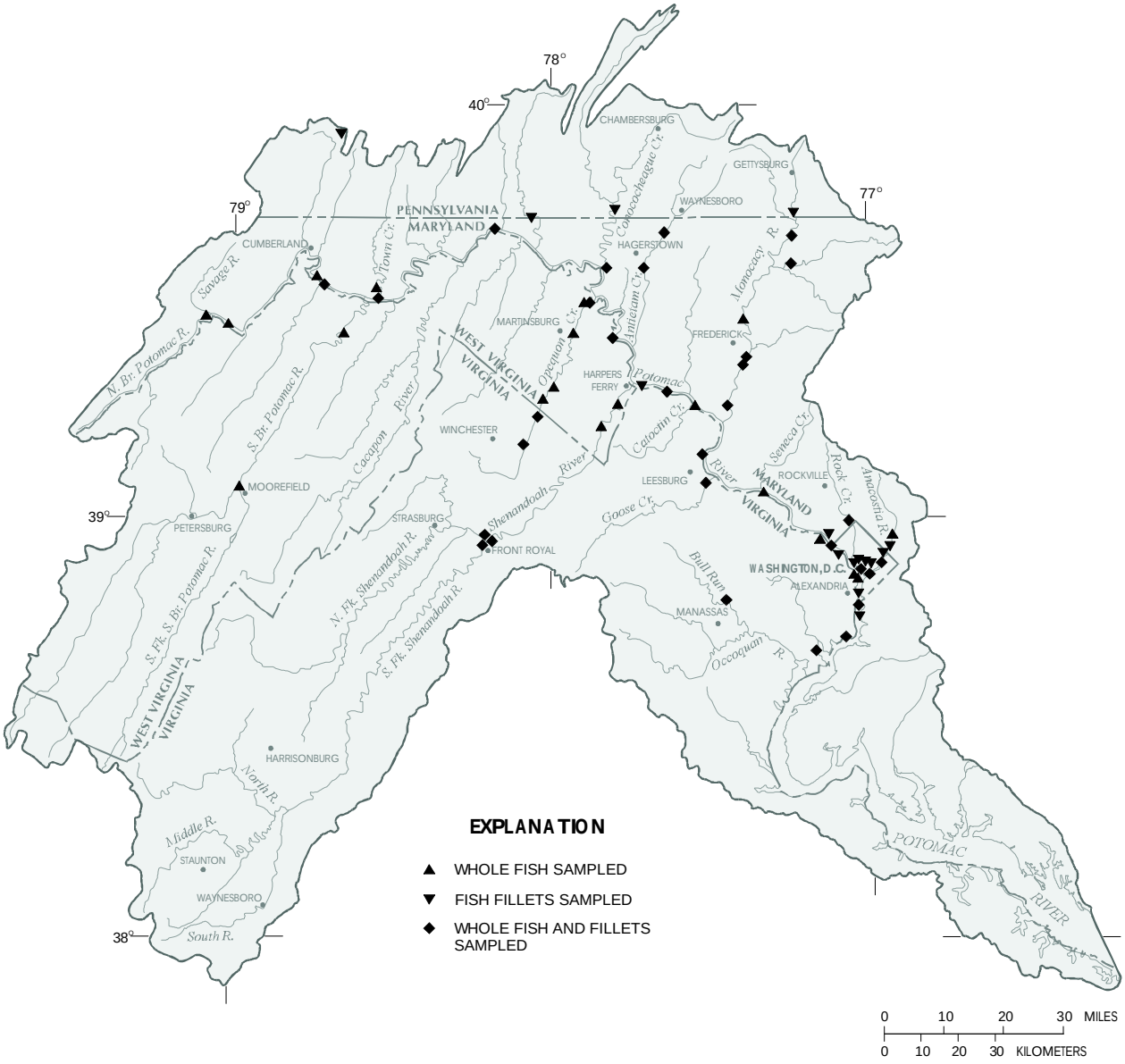


Figure 6. Locations of sampling sites for pesticides in fish tissue in the Potomac River Basin.

ronmental Protection Agency,1992b and 1992c)--and sites sampled by the District of Columbia Department of Consumer and Regulatory Affairs. Several Federal, State, and local special studies are also included (table 3).

Often, the same pesticide or its related compounds were reported in several different forms by the different agencies. DDE was reported in several various ways by the different agencies conducting sampling in the Potomac River Basin. For example, DDE was reported as o,p'-DDE, o,p'-DDE and p,p'-DDE, or simply as DDE. The data in this report are presented as they were reported by the investigating agency. Analyses of fish tissue were performed by State, local, Federal, or contract laboratories. Information on laboratory methods and quality-assurance (QA) or quality-control (QC) data in many cases is not readily available or no longer exists. Also, laboratory QA/QC and laboratory methods are complex issues, owing to the many different agencies and laboratories analyzing fish tissue, including the many changes in procedures used to analyze Potomac River Basin tissue samples. Considering the complexity of the laboratory QA/QC and laboratory methods issue and the scarcity of documentation, an in-depth compilation and discussion of laboratory QA/QC and methods is not presented in this report.

A total of 266 whole-fish samples were collected at 48 sites (table 3, fig. 6). The whole-fish samples were usually composites of three or more of a bottom feeding fish or game fish of a single species (Block and others, 1990; R. Frey, Pennsylvania Department of Environmental Protection, written and oral commun., 1993; J. Gregory, Virginia Department of Environmental Quality, written and oral commun., 1993; Schmitt and others, 1990; J. Smithson, West Virginia Department of Natural Resources, written and oral commun.,1993; U.S. Environmental Protection Agency, 1992a,b; Murphy, 1988). Some single-fish, whole-fish samples were also collected.

The whole-fish samples were analyzed for 37 pesticides and related compounds (table 4). Table 4 lists reporting limits by agency for these analyses. Of the 37 compounds analyzed, 34 were organochlorine insecticides and related compounds. Twenty of the insecticide compounds were, or were related to BHC, chlordane, or DDT. Three other compounds--HCB, a fungicide; PCA, a fungicide related compound; and dacthal, an herbicide--also were analyzed.

A total of 197 fish-fillet samples were collected at 44 sites (table 3). The fish-fillet samples were usually composites of three or more bottom or game fish of a single species, with scales removed and with skin removed or intact (Block and others, 1990; R. Frey, Pennsylvania Department of Environmental Protection, written and oral commun., 1993; J. Gregory, Virginia Department of Environmental Quality, written and oral commun., 1993: Murphy, 1988; Sommerfield and Cummins, 1989; U.S. Environmental Protection Agency, 1992a,b). Some single-fish fillet samples were also collected.

The fish-fillet samples were analyzed for 34 pesticides and their related compounds (table 5). Table 5 lists reporting limits by agency for these analyses. Of the 34 compounds analyzed, 31 were organochlorine insecticides and related compounds. Twenty-one of the insecticide compounds were, or were related to, BHC, chlordane, or DDT. Three other compounds--HCB, a fungicide; PCA, a fungicide related compound; and dacthal, an herbicide--also were analyzed.

Occurrence and Distribution of Selected Pesticides

Pesticides have been reported in surface water, bottom material, ground water, and fish tissues in the Potomac River Basin. Hydrophilic and hydrophobic pesticides have been reported, to include herbicides, fungicides, and insecticides. In addition, pesticides have been reported in many areas in the Potomac River Basin, although data coverage is often limited spatially.

Table 4. Reporting limits of selected pesticides in whole-fish tissue samples, Potomac River Basin, 1972 to 1990

[MD, Maryland Department of the Environment; VA, Virginia Department of Environmental Quality; WV, West Virginia Department of Natural Resources; PA, Pennsylvania Department of Environmental Protection; WDC, District of Columbia Department of Consumer and Regulatory Affairs; USFWS, U.S. Fish and Wildlife Service; USEPA,U.S. Environmental Protection Agency; All measurements are in milligrams per kilogram. --, no analyses performed; NA, analyses performed but value not available]

Pesticide	MD	VA	WV	PA	WDC	USFWS	USEPA
Aldrin	0.001,0.002,0.003	0.1	0.01	--	--	--	--
α-BHC[1]	.002	.1	.01	--	--	0.01	0.0025
β-BHC[1]	--	--	.01	--	--	--	--
δ-BHC[1]	--	--	.01	--	--	--	--
γ-BHC[1] (lindane)	.002	--	.01	--	--	--	.0025
Chlordane	.01	1.0	--	--	--	.01	--
Cis-chlordane	--	--	.01	--	--	.01,.05	.0025
Trans-chlordane	--	--	.01	--	--	.01	.0025
Nonachlor	--	.1	--	--	--	--	--
Cis-nonachlor	--	--	.01	--	--	.01	.0025
Trans-nonachlor	--	--	.01	--	--	.01	.0025
Oxychlordane	--	--	.01	--	--	.01	.0025
Chlorpyrifos	--	.1	--	--	--	--	.0025
Dacthal	.002,.009	--	--	--	--	.01	--
DDT[2]	.02	.1	--	--	--	--	--
o,p'-DDT[2]	--	--	.01	--	--	--	--
p,p'-DDT[2]	--	--	.01	--	--	.01	--
DDE[3]	.07	.1	--	--	--	--	--
o,p'-DDE[3]	--	--	.01	--	--	--	--
p,p'-DDE[3]	--	--	.01	--	--	.01	.0025
DDD[4]	.04	.1	--	--	--	--	--
o,p'-DDD[4]	--	--	.01	--	--	--	--
p,p'-DDD[4]	--	--	.01	--	--	.01	--
Dieldrin	.007	.1	.01	--	--	.01	.0025
Endosulfan	.004,.007	.1	NA	--	--	--	--
Endosulfan II	--	--	NA	--	--	--	--
Endosulfan sulfate	--	--	NA	--	--	--	--
Endrin	.004	.1	.01	--	--	.01	.0025
Endrin aldehyde	--	--	NA	--	--	--	--
HCB[5]	.002	.1	.01	--	--	.01	.0025
Heptachlor	.001,.007	.1	.01	--	--	.01	.0025
Heptachlor epoxide	.002,.004	.1	.01	--	--	--	.0025
Isodrin	--	--	NA	--	--	--	--
Methoxychlor	.1	.1	NA	--	--	--	.0025
Mirex	.05	.1	--	--	--	.01	.0025
PCA[6]	--	.01	--	--	--	.01	.0025
Toxaphene	.23	1.0	NA	--	--	.1,0.5	--

[1] Benzene hexachloride.
[2] dichloro-diphenyl-trichloroethane
[3] dichlorodiphenyldichloroethylene
[4] dichlorodiphenyldichloroethane
[5] Hexachlorobenzene.
[6] Pentachloranisol.

Table 5. Reporting limits of selected pesticides in fish-fillet tissue samples, Potomac River Basin, 1972 to 1990

[MD, Maryland Department of the Environment; VA, Virginia Department of Environmental Quality; WV, West Virginia Department of Natural Resources; PA, Pennsylvania Department of Environmental Protection; WDC, District of Columbia Department of Consumer and Regulatory Affairs; USFWS, U.S. Fish and Wildlife Service; USEPA, U.S. Environmental Protection Agency; All measurements are in milligrams per kilogram. --, no analyses performed]

Pesticide	MD	VA	WV	PA	WDC	USFWS	USEPA
Aldrin	0.002	0.1	--	0.005, 0.010	--	--	--
α-BHC[1]	.002	.1	--	.005, .010	--	--	0.0025
γ-BHC[1] (lindane)	.002	--	--	.005, .010	--	--	.0025
Chlordane	.01	1.0	--	--	0.01, 0.5, 0.1	--	--
Cis-chlordane	--	--	--	.005, .020	--	0.05	.0025
Trans-chlordane	--	--	--	.005, .020	--	.01	.0025
Nonachlor	--	.1	--	--	--	--	--
Cis-nonachlor	--	--	--	.005, .020	--	.01	.0025
Trans-nonachlor	--	--	--	.020	--	.01	.0025
Oxychlordane	--	--	--	.005, .020	--	.01	.0025
Total chlordene	--	--	--	.005, .020	--	--	--
α-chlordene	--	--	--	.008, .020	--	--	--
γ-chlordene	--	--	--	.005, .020	--	--	--
Chlorpyrifos	--	.1	--	--	--	--	.0025
Dacthal	.002, .009	--	--	--	--	--	--
DDT[2]	.02	.1	--	--	--	--	--
o,p'-DDT[2]	--	--	--	.040	--	--	--
p,p'-DDT[2]	--	--	--	.040	--	.01	--
DDE[3]	.07	.1	--	--	--	--	--
o,p'-DDE[3]	--	--	--	.020	--	--	--
p,p'-DDE[3]	--	--	--	.01, .020	--	.01	.0025
DDD[4]	.04	.1	--	--	--	--	--
o,p'-DDD[4]	--	--	--	.020	--	--	--
p,p'-DDD[4]	--	--	--	.01, .020	--	.01	--
Dieldrin	.001, .007	.1	--	.01, .020	--	.01	.0025
Endosulfan	.002, .004, .007	.1	--	--	--	--	--
Endrin	.001, .004	.1	--	.01, .020	--	.01	.0025
HCB[5]	.002	.1	--	--	--	--	.0025
Heptachlor	.001	.1	--	.005, .010	--	--	.0025
Heptachlor epoxide	.002, .004	.1	--	.005, .010	--	--	.0025
Methoxychlor	.1	.1	--	.05, .100	--	--	.0025
Mirex	.05	.1	--	.020	--	--	.0025
PCA[6]	--	.01	--	--	--	--	.0025
Toxaphene	.23	1.0	--	--	--	.5	--

[1] Benzene hexachloride.
[2] dichloro-diphenyl-trichloroethane
[3] dichlorodiphenyldichloroethylene
[4] dichlorodiphenyldichloroethane
[5] Hexachlorobenzene.
[6] Pentachloranisol.

Surface Water and Bottom Material

Because of dilution by streamflow, biological and photolytical degradation, and adsorption to suspended particles or bottom material, concentrations of pesticides in natural surface waters can be expected to be relatively low (Smith and others, 1988). More than one-half of the surface-water sampling and analyses by USGS were for the mainstem Potomac River at Washington, D.C. (Lang, 1982). Twenty-nine surface-water samples were analyzed for up to 33 pesticides (table 6), concentrations were equal to or greater than reporting limits in 13 samples for 2,4-D and atrazine, 8 samples for prometone, 8 samples for prometryne, and 2 samples for simazine (table 6). Water samples collected at this site are representative of discharge from the entire upstream drainage area, but contributions of specific tributaries can not be identified.

Surface-water data were also available from USGS for six sites in the Shenandoah River and Opequon Creek Basins in Virginia, and are only representative of those areas. In analyses of 27 surface-water samples for up to 33 pesticides (table 6), USGS found only one occurrence each of three pesticides where concentrations were equal to or greater than the reporting limits. These were in samples collected from Opequon Creek near Berryville, Va., in October and December 1972, where concentrations of DDT, dieldrin, and endrin were 0.01, 0.05, and 0.01 micrograms per liter (µg/L), respectively (table 7).

Other agencies, most notably the Virginia Department of Environmental Quality, have collected many more samples (table 8). Although most of the analyses of the 479 samples by other agencies for up to 23 pesticides have also reported concentrations less than reporting limits, concentrations equal to or greater than the reporting limit were reported for 7 pesticides in 45 of the analyses for those compounds. Most surface-water pesticide samples with concentrations equal to or greater than the reporting limits were collected prior to 1975. Except for a single report of atrazine in 1989, all other samples with reportable concentrations were collected prior to 1985. Many of the elevated concentrations were found in streams in the northern end of the Great Valley, most notably in Opequon, Conococheague, and Antietam Creeks and their tributaries (table 9).

Analyses for pesticides in bottom material have resulted in a greater number of detectable compounds than in surface-water samples. In analyses of 52 bottom-material samples from 42 sites for up to 26 pesticides, USGS reported 15 pesticides in 159 of the analyses for the individual compounds with concentrations equal to or greater than reporting limits (tables 10 and 11). Other agencies reported concentrations equal to or greater than reporting limits for 8 of the 14 pesticides analyzed in 257 samples (table 12). Samples with concentrations greater than the reporting limits were collected between 1972 and 1987, and have a greater spatial and temporal distribution than those samples collected from surface water (tables 11 and 13). As with the surface-water samples, many of the bottom-material samples with elevated concentrations were collected in the northern end of the Great Valley. There were also a number of bottom-material samples with elevated concentrations that were collected from the Shenandoah River and from streams in Virginia east of the Shenandoah River.

Reports of elevated concentrations of chlordane, dieldrin, lindane, and DDT and its metabolites were frequent. Data from the Virginia Department of Environmental Quality also indicated frequent detections of aldrin during a 1983 survey, but concentrations were only reported as being equal to 0.01 or 0.02 µg/kg; the concentration of 0.02 µg/kg is believed to be the actual reporting limit. Use of these pesticides has been discontinued or, in the case of lindane, restricted. It is significant that there were detections of DDT and its metabolites in bottom material as recently as 1987, although its use was discontinued in 1972.

Table 6. Summary of analyses for selected pesticides in surface-water samples collected by the U.S. Geological Survey, Potomac River Basin

[Parameter codes are from the U.S. Environmental Protection Agency's STORET data-base-management system. µg/L, micrograms per liter; ≥, greater than or equal to. Reporting limits are concentrations at which analyzing laboratories report detection of a pesticide in water samples. DDT, dichloro-diphenyl-trichloroethane; DDE, dichlorodiphenyldichloroethylene; DDD, dichlorodiphenyldichloroethane]

Pesticide	Parameter code	Total analyses performed for each pesticide	Reporting limit (µg/L)	Analyses with concentrations ≥ reporting limit
2,4-D[1]	39730	33	0.01	13
2,4,5-T[1]	39740	33	.01	0
Alachlor	77825	4	.1	0
Aldrin[1]	39330	51	.01	0
Ametryne	82184	8	.1	0
Atrazine[1]	39630	35	.1	13
γ-BHC (lindane)[1]	39340	51	.01	0
Chlordane[1]	39350	48	.01	0
Cyanazine	77825	8	.1	0
DDD[1]	39360	51	.01	0
DDE[1]	39365	51	.01	0
DDT[1]	39370	51	.01	1
Dieldrin[1]	39380	51	.01	1
Endosulfan[1]	39388	35	.01	0
Endrin[1]	39390	51	.01	1
Heptachlor[1]	39410	51	.01	0
Heptachlor epoxide[1]	39420	51	.01	0
Methomyl	39051	4	2	0
Methoxychlor[1]	39480	42	.01	0
Metolachlor	82612	8	.1	0
Mirex[1]	39755	35	.01	0
Perthane[1]	39034	35	.1	0
Prometone[1]	39056	35	.1	8
Prometryne[1]	39057	36	.1	8
Propazine	39024	8	.1	0
Propham	39052	4	2	0
Sevin (carbaryl)	39750	4	2	0
Silvex[1]	39760	33	.01	0
Simazine[1]	39055	36	.1	2
Simetryne[1]	39054	35	.1	0
Toxaphene[1]	39400	51	1	0
Trithion	39786	24	.01	0
Methyl trithion	39790	24	.01	0
Total				47

[1] Pesticides analyzed in samples from mainstem Potomac River at Washington, D.C.

Table 7. Concentrations of pesticides equal to or greater than reporting limits in surface-water samples collected by the U.S. Geological Survey, Potomac River Basin, 1972 to 1990

[µg/L, micrograms per liter; DDT, dichloro-diphenyl-trichloroethane; DDE, dichlorodiphenyldichloroethylene; DDD, dichlorodiphenyldichloroethane]

Site identification no.	Site name as reported by investigating agency	Date	Concentration (µg/L)
	2,4-D		
01646580	Potomac River at Chain Bridge at Washington, D.C.	03/22/80	0.02
		05/02/80	.03
		05/13/80	.01
		07/09/80	.07
		07/15/80	.07
		12/01/80	.02
		01/27/81	.02
		02/12/81	.05
		[1]04/14/81	.06
		[1]04/14/81	.06
		04/15/81	.04
		04/28/81	.02
		09/01/81	.11
	Atrazine		
01646580	Potomac River at Chain Bridge at Washington, D.C.	03/22/80	0.10
		05/02/80	.40
		05/13/80	.20
		06/17/80	.50
		07/09/80	.50
		07/15/80	.40
		09/17/80	.10
		10/27/80	.10
		12/01/80	.10
		02/12/81	.20
		[1]04/14/81	.20
		[1]04/14/81	.10
		09/01/81	.20
	DDT		
01615000	Opequon Creek near Berryville, Va.	12/14/72	0.01
	Dieldrin		
01615000	Opequon Creek near Berryville, Va.	10/25/72	0.05
	Endrin		
01615000	Opequon Creek near Berryville, Va.	12/14/72	0.01

Table 7. Concentrations of pesticides equal to or greater than reporting limits in surface-water samples collected by the U.S. Geological Survey, Potomac River Basin, 1972 to 1990--Continued

[µg/L, micrograms per liter; DDT, dichloro-diphenyl-trichloroethane; DDE, dichlorodiphenyldichloroethylene; DDD, dichlorodiphenyldichloroethane]

Site identification no.	Site name as reported by investigating agency	Date	Concentration (µg/L)
	Prometone		
01646580	Potomac River at Chain Bridge at Washington, D.C.	01/14/80	0.2
		03/22/80	.1
		05/02/80	.1
		05/13/80	.1
		07/09/80	.1
		07/15/80	.1
		02/12/81	.2
		09/01/81	.2
	Prometryne		
01646580	Potomac River at Chain Bridge at Washington, D.C.	03/22/80	0.1
		04/16/80	.1
		05/02/80	.1
		05/13/80	.1
		06/17/80	.3
		07/09/80	.3
		07/15/80	.2
		09/17/80	.1
	Simazine		
01646580	Potomac River at Chain Bridge at Washington, D.C.	02/12/81	0.21
		09/01/81	.20

[1] Multiple samples were collected on this date at this site.

Table 8. Summary of analyses for selected pesticides in surface-water samples collected by agencies other than the U.S. Geological Survey, Potomac River Basin

[Parameter codes are from the U.S. Environmental Protection Agency's STORET data-base-management system. µg/L, micrograms per liter; ≥, greater than or equal to. Reporting limits are concentrations at which analyzing laboratories report detection of a pesticide in water samples. DDT, dichloro-diphenyl-trichloroethane; DDE, dichlorodiphenyldichloroethylene; DDD, dichlorodiphenyldichloroethane]

Pesticide	Parameter code	Total analyses performed for each pesticide	Reporting limit (µg/L)	Analyses with concentrations ≥ reporting limit
2,4-DB	39745	71	0.2	0
2,4-D	39730	90	.2	0
2,4,5-T	39740	71	.2	0
Alachlor	77825	71	.2	0
Aldrin	39330	407	.1	3
Atrazine	39632	11	.1	11
γ-BHC (lindane)	39340	110	.1	3
γ-BHC (lindane, EPA)	39782	33	.1	2
Chlordane	39350	227	.1	20
p,p'-DDD	39310	267	.1	0
p,p'-DDE	39320	265	.1	1
p,p'-DDT	39300	288	.1	5
Dicamba	38442	71	.2	0
Dichlorprop	38451	71	.2	0
Dieldrin	39380	310	.1	0
Endosulfan	34361	78	.1	0
Endrin	39390	322	.1	0
Endrin aldehyde	34366	78	.1	0
Heptachlor	39410	104	.1	0
Heptachlor epoxide	39420	105	.1	0
Methoxychlor	39480	207	10	0
Silvex	39760	71	.2	0
Toxaphene	39400	105	.1, 1	0
Total				45

Table 9. Concentrations of pesticides equal to or greater than reporting limits in surface-water samples collected by agencies other than the U.S. Geological Survey, Potomac River Basin, 1972-1990

[µg/L, micrograms per liter; DDT, dichloro-diphenyl-trichloroethane; DDE, dichlorodiphenyldichloroethylene]

Site identification number	Site name as reported by investigating agency	Date	Concentration (µg/L)
	Aldrin		
1AGAM003.83	Gambo Creek, Va.	05/19/74	0.7
1APOH004.79	Pohink Creek, Va.	05/21/79	.13
3905500780632[1]	Opequon Creek at Route 50 bridge, Va.	06/21/74	.15
	Atrazine		
POT1471	Potomac River at Whites Ferry, Md.	10/18/82	2.78
		10/26/82	2.82
NBP0103	Potomac River west of Moores Hollow Road, Md.	10/01/82	.25
NBP0103	Potomac River west of Moores Hollow Road, Md.	10/18/82	.25
		11/01/83	3.92
ANT0203	Antietam Creek at Poffenberger Road, Md.	10/01/82	1.43
ANT0203	Antietam Creek at Poffenberger Road, Md.	10/20/82	1.43
		10/28/83	2.51
CON0005	Conococheague Creek at Md. Route 68, Md.	10/28/77	2.49
		10/28/82	1.2
WQN0501	Conococheague Creek near Worleytown, Pa.	08/08/89	.8
	γ-BHC (lindane)		
3906400781242[1]	Opequon Creek above lake at Brtnvl[2], Va.	05/08/74	0.1
3909430781510[1]	Opequon Creek at Route 620 bridge, Va.	07/24/73	1
3912180780750[1]	Redbud Run off Route 661, Va.	02/21/74	.4
	γ-BHC (lindane, EPA)		
1APOH004.79	Pohink Creek, Va.	10/23/78	0.5
		05/21/79	.16
	Chlordane		
1BSTV002.92	Stephens Run, Va.	04/21/75	0.59
3906400780953[1]	Hoge Run above Opequon Creek, Va.	09/18/73	16.1
3907330780612[1]	Buffalo Lick Run at Route 723 bridge, Va.	06/12/74	.3
3908220780526[1]	Opequon Creek at Route 655 Ford, Va.	06/21/73	.88
		08/22/73	.77
3909070781317[1]	Stribling Run at Route 621 bridge, Va.	08/22/73	.39
3909430781510[1]	Opequon Creek at Route 620 bridge, Va.	06/21/73	.213
3910100780425[1]	Opequon Creek above Abrams Creek, Va.	08/22/73	1.2
3910130781058[1]	Abrams Creek at Route 11, Va.	06/21/73	.1
3910360780808[1]	Abrams Creek above sewage treatment plant, Va.	08/22/73	1.5
3911350781255[1]	Abrams Creek below lake at Route 50, Va.	06/21/73	.15
		08/22/73	1.9
3911370780428[1]	Opequon Creek at Burnt Factory, Va.	06/21/73	.1
3912550780503[1]	Lick Run at Route 664 bridge, Va.	08/22/73	.76
3914230780235[1]	Opequon Creek at Wadeville, Va.	01/22/73	6.2
		06/21/73	.1
3914230780235[1]	Opequon Creek at Wadeville, Va.	01/22/73	6.2
		06/21/73	.1
3914550780235[1]	Opequon Creek below Turkey Run, Va.	06/21/73	.2
WQN0504	East Branch Antietam Creek near Waynesboro, Pa.	09/24/74	.6

Table 9. Concentrations of pesticides equal to or greater than reporting limits in surface-water samples collected by agencies other than the U.S. Geological Survey, Potomac River Basin, 1972-1990 --Continued

[µg/L, micrograms per liter; DDT, dichloro-diphenyl-trichloroethane; DDE, dichlorodiphenyldichloroethylene]

Site identification number	Site name as reported by investigating agency	Date	Concentration (µg/L)
	p,p'-DDE		
3906400781242[1]	Opequon Creek above lake at Brtnvl[2], Va.	05/08/74	0.2
	p,p'-DDT		
3905320780715[1]	Wrights Run above Opequon Creek, Va.	05/08/74	0.14
3905500780632[1]	Opequon Creek at Route 50 bridge, Va.	05/08/74	.15
3906400780953[1]	Hoge Run above Opequon Creek, Va.	05/08/74	.12
3906400781242[1]	Opequon Creek above lake at Brtnvl[2], Va.	05/08/74	.4
3912180780750[1]	Redbud Run off Route 661, Va.	05/08/74	.1

[1]Actual site number was not available for this site; site latitude and longitude are supplied for the convenience of the reader.
[2] Only an abbreviated site name was available for this site.

Table 10. Summary of analyses for selected pesticides in bottom-material samples collected by the U.S. Geological Survey, Potomac River Basin

[Parameter codes are from the U.S. Environmental Protection Agency's STORET data-base-management system. --, unknown; µg/kg, micrograms per kilogram; ≥, greater than or equal to. Reporting limits are concentrations at which analyzing laboratories report detection of a pesticide in bottom-material samples. DDT, dichloro-diphenyl-trichloroethane; DDE, dichlorodiphenyldichloroethylene; DDD, dichlorodiphenyldichloroethane]

Pesticide	Parameter code	Total analyses performed for each pesticide	Reporting limit (µg/kg)	Analyses with concentrations ≥ reporting limit
2,4-D	39731	32	0.1	0
2,4-DP	--	24	.1	0
2,4,5-T	39741	32	.1	0
Aldrin	39333	40	.1	4
γ-BHC (lindane)	39343	40	.1	3
Chlordane	39351	40	1	20
DDD	39363	40	.1	28
DDE	39368	40	.1	24
DDT	39373	40	.1	26
Diazinon	39571	32	.1	1
Dieldrin	39383	40	.1	30
Endosulfan	39388	26	.1	1
Endrin	39393	40	.1	8
Ethion	--	29	.1	1
Heptachlor	39413	40	.1	4
Heptachlor epoxide	39423	39	.1	7
Malathion	39531	32	.1	0
Methoxychlor	--	24	.1	0
Mirex	--	24	.1	0
Parathion	39541	32	.1	1
Methyl parathion	39601	32	.1	0
Perthane	--	14	1	0
Silvex	39761	32	.1	0
Toxaphene	39403	39	10	1
Trithion	39787	32	.1	0
Methyl trithion	39791	32	.1	0
Total				159

Table 11. Concentrations of pesticides equal to or greater than reporting limits in bottom-material samples collected by the U.S. Geological Survey, Potomac River Basin, 1972 to 1990

[µg/kg, micrograms per kilogram; DDT, dichloro-diphenyl-trichloroethane; DDE, dichlorodiphenyldichloroethylene; DDD, dichlorodiphenyldichloroethane]

Site identification number	Site name as reported by investigating agency	Date	Concentration (µg/kg)
	Aldrin		
01619000	Antietam Creek near Waynesboro, Pa.	08/20/86	0.4
01644370	Sugarland Run near Dranesville, Va.	08/29/77	.2
01652500	Fourmile Run at Alexandria, Va.	08/31/77	.1
01653000	Cameron Run at Alexandria, Va.	08/30/77	.3
	γ-BHC (lindane)		
01613545	Licking Creek near Pectonville, Md.	06/30/87	0.3
01614050	Little Conococheague Creek near Charlton, Md.	08/22/86	.1
01614500	Conococheague Creek at Fairview, Md.	08/21/86	.3
	Chlordane		
01613000	Potomac River at Hancock, Md.	05/18/72	10
		08/31/76	20
01613545	Licking Creek near Pectonville, Md.	06/30/87	24
01614500	Conococheague Creek at Fairview, Md.	08/21/86	2.0
01617800	Marsh Run at Grimes, Md.	08/20/86	4.0
01619000	Antietam Creek near Waynesboro, Pa.	08/20/86	6.0
01619150	Marsh Run at Fiddlesburg, Md.	08/20/86	1.0
01619250	Antietam Creek at Hagerstown, Md.	05/17/72	430
		08/31/76	230
01619270	Antietam Creek below Hagerstown, Md.	05/17/72	50
01619480	Little Antietam Creek at Keedysville, Md.	08/20/86	1.0
01619500	Antietam Creek near Sharpsburg, Md.	05/17/72	20
		08/31/76	4.0
01629050	South Fork Shenandoah River at Elkton, Va.	05/16/72	20
01631000	South Fork Shenandoah River at Front Royal, Va.	05/16/72	10
01652500	Fourmile Run at Alexandria, Va.	08/31/76	4
01653000	Cameron Run at Alexandria, Va.	08/30/77	1
01653800	Dogue Creek near Accotink, Va.	08/30/77	12
01655000	Accotink Creek near Accotink Station, Va.	08/30/77	2
01655390	Pohick Creek at Lorton, Va.	08/30/77	9
	DDD		
01612500	Little Tonoloway Creek near Hancock, Md.	08/26/86	1.1
01613000	Potomac River at Hancock, Md.	05/18/72	6.5
		08/31/76	95
01613540	Lanes Run near Forsythe, Md.	05/18/87	3.6
01613545	Licking Creek near Pectonville, Md.	06/30/87	11
01614500	Conococheague Creek at Fairview, Md.	08/21/86	3.2
01614575	Rush Run near Huyett, Md.	08/22/86	1.2
01614705	Conococheague Creek at Williamsport, Md.	08/21/86	.3
01617800	Marsh Run at Grimes, Md.	08/20/86	.3
01619000	Antietam Creek near Waynesboro, Pa.	08/20/86	1.7
01619150	Marsh Run at Fiddlesburg, Md.	08/20/86	.7
01619250	Antietam Creek at Hagerstown, Md.	05/17/72	590
		08/31/76	640
01619270	Antietam Creek below Hagerstown, Md.	05/17/72	71
01619350	Little Beaver Creek at Benevola, Md.	08/20/86	1.4

Table 11. Concentrations of pesticides equal to or greater than reporting limits in bottom-material samples collected by the U.S. Geological Survey, Potomac River Basin, 1972 to 1990--Continued

[µg/kg, micrograms per kilogram; DDT, dichloro-diphenyl-trichloroethane; DDE, dichlorodiphenyldichloroethylene; DDD, dichlorodiphenyldichloroethane]

Site identification number	Site name as reported by investigating agency	Date	Concentration (µg/kg)
	DDD--continued		
01619480	Little Antietam Creek at Keedysville, Md.	08/20/86	1.8
01619500	Antietam Creek near Sharpsburg, Md.	05/17/72	28
		08/31/76	3.9
01629050	South Fork Shenandoah River at Elkton, Va.	05/16/72	6.0
01629500	South Fork Shenandoah River near Luray, Va.	05/16/72	.9
01631000	South Fork Shenandoah River at Front Royal, Va.	05/16/72	4.4
01636290	Shenandoah River near Millwood, Va.	08/31/76	.3
01638500	Potomac River at Point of Rocks, Md.	05/17/72	1.5
		08/31/76	1.0
01640200	Little Pipe Creek at Keymar, Md.	07/27/82	.2
01642050	Israel Creek near Walkersville, Md.	08/11/82	.2
01652500	Fourmile Run at Alexandria, Va.	08/31/76	.5
01655390	Pohick Creek at Lorton, Va.	08/30/77	.3
	DDE		
01612500	Little Tonoloway Creek near Hancock, Md.	08/26/86	2.1
01613000	Potomac River at Hancock, Md.	05/18/72	9.9
		08/31/76	29
01613540	Lanes Run near Forsythe, Md.	05/18/87	30
01613545	Licking Creek near Pectonville, Md.	06/30/87	2.4
01614050	Little Conococheague Creek near Charlton, Md.	08/22/86	6.0
01614500	Conococheague Creek at Fairview, Md.	08/21/86	11
	Rockdale Run at Fairview, Md.	08/21/86	.4
01614575	Rush Run near Huyett, Md.	08/22/86	4.1
01614705	Conococheague Creek at Williamsport, Md.	08/21/86	.2
01619150	Marsh Run at Fiddlesburg, Md.	08/20/86	.4
01619250	Antietam Creek at Hagerstown, Md.	05/17/72	360
		08/31/76	84
01619270	Antietam Creek below Hagerstown, Md.	05/17/72	26
01619350	Little Beaver Creek at Benevola, Md.	08/20/86	3.8
01619480	Little Antietam Creek at Keedysville, Md.	08/20/86	.8
01619500	Antietam Creek near Sharpsburg, Md.	05/17/72	3.3
		08/31/76	.8
01629050	South Fork Shenandoah River at Elkton, Va.	05/16/72	1.7
01631000	South Fork Shenandoah River at Front Royal, Va.	05/16/72	.6
01636290	Shenandoah River near Millwood, Va.	08/31/76	.3
01638500	Potomac River at Point of Rocks, Md.	08/31/76	.6
01639325	Friends Creek near Emmitsburg, Md.	07/22/82	.3
01641900	Tuscarora Creek near Frederick, Md.	07/23/82	.4

Table 11. Concentrations of pesticides equal to or greater than reporting limits in bottom-material samples collected by the U.S. Geological Survey, Potomac River Basin, 1972 to 1990--Continued

[µg/kg, micrograms per kilogram; DDT, dichloro-diphenyl-trichloroethane; DDE, dichlorodiphenyldichloroethylene; DDD, dichlorodiphenyldichloroethane]

Site identification number	Site name as reported by investigating agency	Date	Concentration (µg/kg)
	DDT		
01612500	Little Tonoloway Creek near Hancock, Md.	08/26/86	1.9
01613000	Potomac River at Hancock, Md.	05/18/72	9.2
		08/31/76	27
01613540	Lanes Run near Forsythe, Md.	05/18/87	48
01613545	Licking Creek near Pectonville, Md.	06/30/87	.3
	Little Conococheague Creek near Charlton, Md.	08/22/86	2.6
01614500	Conococheague Creek at Fairview, Md.	08/21/86	.2
01614575	Rush Run near Huyett, Md.	08/22/86	12
01614705	Conococheague Creek at Williamsport, Md.	08/21/86	.2
01617800	Marsh Run at Grimes, Md.	08/20/86	1.0
01619000	Antietam Creek near Waynesboro, Pa.	08/20/86	.4
01619250	Antietam Creek at Hagerstown, Md.	05/17/72	140
		08/31/76	2,700
01619270	Antietam Creek below Hagerstown, Md.	05/17/72	190
01619480	Little Antietam Creek at Keedysville, Md.	08/20/86	0.3
01619500	Antietam Creek near Sharpsburg, Md.	05/17/72	54
		08/31/76	2.2
01636290	Shenandoah River near Millwood, Va.	08/31/76	1.0
01637500	Catoctin Creek near Middletown, Md.	08/19/82	.1
01639325	Friends Creek near Emmitsburg, Md.	07/22/82	.3
01640200	Little Pipe Creek at Keymar, Md.	07/27/82	.2
01641900	Tuscarora Creek near Frederick, Md.	07/23/82	.1
01652500	Fourmile Run at Alexandria, Va.	08/31/76	.3
01653800	Dogue Creek near Accotink, Va.	08/30/77	2.1
01655390	Pohick Creek at Lorton, Va.	08/30/77	.3
01656940	Cub Run near Centerville, Va.	08/30/77	3.0
	Diazinon		
01614500	Conococheague Creek at Fairview, Md.	08/21/86	0.1
	Dieldrin		
01612500	Little Tonoloway Creek near Hancock, Md.	08/26/86	0.3
01613000	Potomac River at Hancock, Md.	05/18/72	2.2
		08/31/76	.4
01613540	Lanes Run near Forsythe, Md.	05/18/87	.6
01613545	Licking Creek near Pectonville, Md.	06/30/87	.1
01614050	Little Conococheague Creek near Charlton, Md.	08/22/86	.5
01614500	Conococheague Creek at Fairview, Md.	08/21/86	1.2
01614525	Rockdale Run at Fairview, Md.	08/21/86	.1
01614575	Rush Run near Huyett, Md.	08/22/86	.3
01614705	Conococheague Creek at Williamsport, Md.	08/21/86	.1
01617800	Marsh Run at Grimes, Md.	08/20/86	.2
01619000	Antietam Creek near Waynesboro, Pa.	08/20/86	5.1
01619150	Marsh Run at Fiddlesburg, Md.	08/20/86	.1
01619250	Antietam Creek at Hagerstown, Md.	05/17/72	740
		08/31/76	150
01619270	Antietam Creek below Hagerstown, Md.	05/17/72	29
01619350	Little Beaver Creek at Benevola, Md.	08/20/86	.2
01619480	Little Antietam Creek at Keedysville, Md.	08/20/86	.1
01619500	Antietam Creek near Sharpsburg, Md.	05/17/72	1.3

Table 11. Concentrations of pesticides equal to or greater than reporting limits in bottom-material samples collected by the U.S. Geological Survey, Potomac River Basin, 1972 to 1990--Continued

[µg/kg, micrograms per kilogram; DDT, dichloro-diphenyl-trichloroethane; DDE, dichlorodiphenyldichloroethylene; DDD, dichlorodiphenyldichloroethane]

Site identification number	Site name as reported by investigating agency	Date	Concentration (µg/kg)
	Dieldrin--Continued		
01629050	South Fork Shenandoah River at Elkton, Va.	05/16/72	1.3
01631000	South Fork Shenandoah River at Front Royal, Va.	05/16/72	1.0
01634000	North Fork Shenandoah River near Strasburg, Va.	05/16/72	.1
01636290	Shenandoah River near Millwood, Va.	05/16/72	.2
01638500	Potomac River at Point of Rocks, Md.	05/17/72	.8
01640900	Monocacy River near Woodsboro, Md.	05/17/72	.2
01644370	Sugarland Run near Dranesville, Va.	08/29/77	.3
01652500	Fourmile Run at Alexandria, Va.	08/31/76	.6
01653800	Dogue Creek near Accotink, Va.	08/30/77	.5
01655390	Pohick Creek at Lorton, Va.	08/30/77	.2
01656940	Cub Run near Centerville, Va.	08/30/77	1.1
	Endosulfan		
01613540	Lanes Run near Forsythe, Md.	05/18/87	1.6
	Endrin		
01612500	Little Tonoloway Creek near Hancock, Md.	08/26/86	0.5
01613000	Potomac River at Hancock, Md.	05/18/72	4.8
		08/31/76	.4
01613540	Lanes Run near Forsythe, Md.	05/18/87	2.1
01613545	Licking Creek near Pectonville, Md.	06/30/87	3.6
01614500	Conococheague Creek at Fairview, Md.	08/21/86	.3
01614575	Rush Run near Huyett, Md.	08/22/86	.4
01614705	Conococheague Creek at Williamsport, Md.	08/21/86	.1
	Ethion		
01613540	Lanes Run near Forsythe, Md.	05/18/87	0.2
	Heptachlor		
01613545	Licking Creek near Pectonville, Md.	06/30/87	0.3
01614500	Conococheague Creek at Fairview, Md.	08/21/86	.2
01619000	Antietam Creek near Waynesboro, Pa.	08/20/86	.3
01656940	Cub Run near Centerville, Va.	08/30/77	.2
	Heptachlor epoxide		
01613545	Licking Creek near Pectonville, Md.	06/30/87	1.1
01614050	Little Conococheague Creek near Charlton, Md.	08/22/86	.1
01614500	Conococheague Creek at Fairview, Md.	08/21/86	.4
01617800	Marsh Run at Grimes, Md.	08/20/86	.1
01619000	Antietam Creek near Waynesboro, Pa.	08/20/86	.1
01655390	Pohick Creek at Lorton, Va.	08/30/77	.3
01656940	Cub Run near Centerville, Va.	08/30/77	.4
	Parathion		
01613540	Lanes Run near Forsythe, Md.	05/18/87	0.5
	Toxaphene		
01614050	Little Conococheague Creek near Charlton, Md.	08/22/86	20

Table 12. Summary of analyses for selected pesticides in bottom-material samples collected by agencies other than the U.S. Geological Survey, Potomac River Basin

[Parameter codes are from the U.S. Environmental Protection Agency's STORET data-base-management system. --, unknown; µg/kg, micrograms per kilogram; ≥, greater than or equal to. Reporting limits are concentrations at which analyzing laboratories report detection of a pesticide in bottom-material samples. DDT, dichloro-diphenyl-trichloroethane; DDE, dichlorodiphenyldichloroethylene; DDD, dichlorodiphenyldichloroethane]

Pesticide	Parameter code	Total analyses performed for each pesticide	Reporting limit (µg/kg)	Analyses with concentrations ≥ reporting limit
Aldrin	39333	148	--	[1]40
γ-BHC (lindane)	39343	16	--	16
γ-BHC (lindane, EPA)	39783	3	--	0
Chlordane	39351	87	1	3
DDD	39363	79	.1	0
p,p'-DDD	39311	10	--	10
DDE	39368	79	.1	0
p,p'-DDE	39321	16	--	15
DDT	39373	85	.1	1
p,p'-DDT	39301	14	--	14
Dieldrin	39383	88	.1	4
Endrin	39393	79	.1	0
Heptachlor	39413	76	.1	0
Toxaphene	39403	78	1	0
Total				103

[1] Samples analyzed for aldrin were collected in 1983 by the Virginia Department of Environmental Quality (formerly Virginia Water Control Board; Tingler and others, 1990, p. 1-8). The reporting limit for these samples is unknown, but 40 samples were reported with concentrations greater than zero; none was reported with a concentration greater than 0.02 µg/kg, which is believed to be the actual reporting limit.

Table 13. Concentrations of pesticides equal to or greater than reporting limits in bottom-material samples collected by agencies other than the U.S. Geological Survey, Potomac River Basin, 1972 to 1990

[µg/kg, micrograms per kilogram; DDT, dichloro-diphenyl-trichloroethane; DDE, dichlorodiphenyldichloroethylene; DDD, dichlorodiphenyldichloroethane]

Site identification number	Site name as reported by investigating agency	Date	Concentration (µg/kg)
	Aldrin[1]		
1BSTH027.85	Shenandoah River at Route 664 at Waynesboro, Va.	06/02/83	0.02
1BCST012.32	Shenandoah River at Route 794, Va.	06/02/83	.02
1BNTH014.08	North River, Va.	06/02/83	.02
1BMDL036.08	Middle River, Va.	06/02/83	.02
1BMDL001.83	Middle River, Va.	06/02/83	.02
1BCST012.55	Christians Creek, Va.	06/02/83	.02
1BSTH007.80	South River, Va.	06/02/83	.02
1BNFS081.42	North Fork Shenandoah River, Va.	06/13/83	.01
1BNFS070.67	North Fork Shenandoah River, Va.	06/13/83	.01
1BSMT004.60	Smith Creek, Va.	06/13/83	.01
1BNFS010.34	North Fork Shenandoah River, Va.	06/08/83	.02
1BSTY001.22	Stony Creek, Va.	06/13/83	.01
1BPSG001.36	Passage Creek, Va.	06/08/83	.02
1BSHN022.63	Shenandoah River, Va.	06/08/83	.02
1AOPE025.10	Opequon Creek, Va.	06/08/83	.02
1ACAX004.57	Catoctin Creek, Va.	05/04/83	.02
1ANOC000.42	North Fork Catoctin Creek, Va.	05/04/83	.02
1ASOC001.66	South Fork Catoctin Creek, Va.	05/04/83	.02
1ATUS000.37	Tuscarora Creek, Va.	05/04/83	.02
31AGOO002.38	Goose Creek, Va.	05/04/83	.02
1AGOO022.44	Goose Creek, Va.	05/04/83	.02
1AGOO011.23	Goose Creek, Va.	05/04/83	.02
1ANOG005.69	North Fork Goose Creek, Va.	05/04/83	.02
1ASUG004.42	Sugarland Creek, Va.	05/04/83	.02
1ABRB002.15	Broad Run, Va.	05/04/83	.02
1ABUL010.28	Bull Run, Va.	05/04/83	.02
1ABRU020.12	Broad Run, Va.	05/04/83	.02
1ASOT001.44	South Run, Va.	05/04/83	.02
1AOCC002.47	Belmont Bay, Va.	05/05/83	.02
1AQUA004.46	Quantico Creek, Va.	05/05/83	.02
1ACHO003.65	Chopawamsic Creek, Va.	05/05/83	.02
1AAUA003.71	Aquia Creek, Va.	05/05/83	.02
1AAUA010.26	Aquia Creek, Va.	05/05/83	.02
1APOM002.41	Potomac Creek, Va.	05/05/83	.02
1APOM006.72	Potomac Creek, Va.	05/05/83	.02
1AUMC004.43	Upper Machodoc Creek, Va.	05/26/83	.02
1ANEA002.89	Neabsco Creek, Va.	05/05/83	.02
1ANEA000.57	Neabsco Bay, Va.	05/05/83	.02
1AMON000.96	Monroe Creek, Va.	05/19/83	.02
1AWLL001.30	Williams Creek, Va.	05/26/83	.02

Table 13. Concentrations of pesticides equal to or greater than reporting limits in bottom-material samples collected by agencies other than the U.S. Geological Survey, Potomac River Basin, 1972 to 1990--Continued

[µg/kg, micrograms per kilogram; DDT, dichloro-diphenyl-trichloroethane; DDE, dichlorodiphenyldichloroethylene; DDD, dichlorodiphenyldichloroethane]

Site identification number	Site name as reported by investigating agency	Date	Concentration (µg/kg)
	γ-BHC (lindane)		
CON0005	Conococheague Creek at bridge on Route 68, Md.	10/28/77	0.019
		10/28/82	.037
NBP0103	Potomac River west of Moores Hollow Road, Md.	10/29/79	.020
		10/15/80	.130
		10/13/81	.021
		10/18/82	.027
		11/01/83	.035
ANT0203	Potomac River at bridge on Poffenberger Road, Md.	10/31/79	.180
		10/15/80	.350
		10/13/81	.046
		10/13/81	.018
		10/20/82	.284
		10/28/83	.856
POT1471	Potomac River at Whites Ferry, Md.	10/18/82	.040
		10/26/82	.007
XEA6596	Potomac River off Indian Head Station, Md.	11/08/79	.150
	Chlordane		
3909150781038[2]	Abrams Creek below O'Sullivan Rubber, Va.	08/22/73	20
3910470780700[2]	Abrams Creek below sewage treatment plant, Va.	08/22/73	50
WQN0504	East Branch Antietam Creek near Waynesboro, Pa.	09/24/74	80
	p,p'-DDD		
3912550780503[2]	Lick Run at Route 664 bridge, Va.	03/25/74	33
3912180780750[2]	Redbud Run off Route 661, Va.	03/25/73	26
3909150781038[2]	Abrams Creek below O'Sullivan Rubber, Va.	03/25/73	12
3906400781242[2]	Opequon Creek above lake at Brtnvl[3], Va.	03/25/74	64
		05/08/74	30
3909430781510[2]	Opequon Creek at Route 620 bridge, Va.	03/25/74	3
3911350781255[2]	Abrams Creek below lake at Route 50, Va.	03/25/74	2
3910130781058[2]	Abrams Creek at Route 11, Va.	03/25/74	3
3914550780235[2]	Opequon Creek below Turkey Run, Va.	03/25/74	42
3912180780410[2]	Opequon Creek at Route 660, Va.	03/25/74	7
	p,p'-DDE		
3912550780503[2]	Lick Run at Route 664 bridge, Va.	03/25/74	26
3912180780750[2]	Redbud Run off Route 661, Va.	03/25/74	6
3911350781255[2]	Abrams Creek below lake at Route 50, Va.	08/22/73	1
		03/25/74	23
3906400781242[2]	Opequon Creek above lake at Brtnvl[3], Va.	03/25/73	19
		08/22/73	10
3909430781510[2]	Opequon Creek at Route 620 bridge, Va.	08/22/73	1
		03/25/74	19
3909150781038[2]	Abrams Creek below O'Sullivan Rubber, Va.	03/25/73	4
		08/22/73	6
3914550780235[2]	Opequon Creek below Turkey Run, Va.	08/22/73	1
		03/25/74	17
3912180780410[2]	Opequon Creek at Route 660, Va.	08/22/73	3
		03/25/74	28
3907330780612[2]	Buffalo Lick Run at Route 723 bridge, Va.	08/22/73	1

Table 13. Concentrations of pesticides equal to or greater than reporting limits in bottom-material samples collected by agencies other than the U.S. Geological Survey, Potomac River Basin, 1972 to 1990--Continued

[µg/kg, micrograms per kilogram; DDT, dichloro-diphenyl-trichloroethane; DDE, dichlorodiphenyldichloroethylene; DDD, dichlorodiphenyldichloroethane]

Site identification number	Site name as reported by investigating agency	Date	Concentration (µg/kg)
	DDT		
WQN0504	East Branch Antietam Creek near Waynesboro, Pa.	09/24/74	50
	p,p'-DDT		
3912550780503[2]	Lick Run at Route 664 bridge, Va.	03/25/74	82
3912180780750[2]	Redbud Run off Route 661, Va.	08/22/73	2
		03/25/74	34
3909150781038[2]	Abrams Creek below O'Sullivan Rubber, Va.	08/22/73	14
		03/25/74	17
3909430781510[2]	Opequon Creek at Route 620 bridge, va.	03/25/74	2
3911350781255[2]	Abrams Creek below lake at Route 50, Va.	03/25/74	18
3906400781242[2]	Opequon Creek above lake at Brtnvl[3], Va.	03/25/73	17
3910130781058[2]	Abrams Creek at Route 11, Va.	03/25/74	43
3910470780700[2]	Abrams Creek below sewage treatment plant, Va.	03/25/74	3,000
3914550780235[2]	Opequon Creek below Turkey Run, Va.	03/25/74	46
3912180780410[2]	Opequon Creek at Route 660, Va.	03/25/74	19
3908200780530[2]	Sulphur Spring Run at Opequon Creek, Va.	03/25/74	80
3907330780612[2]	Buffalo Lick Run at Route 723 bridge, Va.	03/25/74	1,670
	Dieldrin		
3912180780750[2]	Redbud Run off Route 661, Va.	03/25/74	2
3914550780235[2]	Opequon Creek below Turkey Run, Va.	08/22/73	2
3910470780700[2]	Abrams Creek below sewage treatment plant, Va.	03/25/74	2
WQN0504	East Branch Antietam Creek near Waynesboro, Pa.	09/24/74	60

[1]Samples analyzed for aldrin were collected in 1983 by the Virginia Department of Environmental Quality (formerly Virginia Water Control Board; Tingler and others, 1990, p. 1-8). The reporting limit for these samples is unknown, but 40 samples were reported with concentrations greater than zero; none was reported with a concentration greater than 0.02 µg/kg, which is believed to be the actual reporting limit.

[2]Actual site number was not available for this site, site latitude and longitude are supplied for the convenience of the reader.

[3] Only an abbreviated site name was available for this site.

Figures 7 to 9 show sampling locations and detections of dieldrin, chlordane, or DDT or its metabolites, respectively. The figures show that most sampling and detections were located in the northern end of the Great Valley, along the Shenandoah River, in the Monocacy River drainage, or in Virginia streams east of the Shenandoah River (figures 1,7,8, and 9). They also show that dieldrin, chlordane, or DDT were detected at most of the locations where samples were collected.

Ground Water

Analyses for pesticides in ground water have generally resulted in few detectable compounds. Samples have been collected by USGS from both wells and springs (table 14). In analyses of 109 well samples for 38 pesticides (table 14), 7 pesticides were reported in 18 of the analyses for individual compounds with concentrations equal to or greater than reporting limits. Only one well had more than one pesticide reported. In analyses of 60 spring samples for 35 pesticides (table 14), 10 pesticides were reported in 29 of the analyses for individual compounds with concentrations equal to or greater than reporting limits. Six springs had more than one pesticide reported. Other than a survey for aldrin done on 121 samples from 66 sites in Virginia east of the Shenandoah River, only a single sample for 7 pesticides (2,4-D, DDT, endrin, methoxychlor, lindane, silvex, toxaphene) in ground water was available from other agencies. No pesticide concentrations greater than reporting limits were reported in ground water by other agencies.

Pesticide concentrations in ground water result from transport by water flowing through permeable soils and regolith, through fractures in rock, or from direct surface connections in inadequately constructed wells. Except where there are direct surface connections, concentrations can generally be expected to be low and usually limited to hydrophilic (water-soluble or miscible) compounds. Table15 lists concentrations in wells and springs of pesticides that were greater than reporting limits. The most frequently measurable pesticide was atrazine, which was found in concentrations greater than or equal to the reporting limit in 9 of 45 well samples and 4 of 8 spring samples. Although sampling was limited, it appears that there is a good chance of finding atrazine in ground-water samples. Atrazine was detected in measurable concentrations as early as 1983, but most samples having detectable concentrations were collected in 1987 or later. Endrin, a hydrophobic pesticide, was found in measurable concentrations in 3 of 64 well samples and 4 of 52 spring samples (twice at one spring). All of the measurable concentrations of endrin were in samples collected after 1987, when the use of endrin was discontinued. All of the measurable concentrations of atrazine and endrin were in samples collected near the center of the Potomac River Basin, where most ground-water sampling has occurred. There were also measurable concentrations in isolated samples of diazinon and endosulfan, which are currently in use, and DDE, DDT, dieldrin, and heptachlor epoxide, which have been discontinued but are persistent in the environment.

Kozar and others (1991) described groundwater sampling conducted in Jefferson County, W. Va., in July 1988. Of the 20 pesticides analyzed at 29 sites, water from 6 wells and 3 springs contained concentrations greater than the reporting limits. DDE, dieldrin, endrin, and heptachlor were reported at concentrations greater than reporting limits at 1, 4, 6, and 1 sites, respectively.

Elmore and Weaver (1987) present the results of sampling public water-supply wells in Maryland in 1983 for 14 herbicides. One of these wells was located within the Potomac River Basin in Washington County, Md., and one was located on the eastern border of the basin near the southeastern corner of Frederick County, Md. Atrazine was detected in the Washington County well at a concentration of 0.4 µg/L. No other herbicides were detected at the two sites.

Goodell and LoCastro (1989) present the results of sampling 60 wells in Clarke and Frederick Counties, Va., for 11 pesticides. This sampling took place in July and August 1987. Detectable concentrations of at least one pesticide

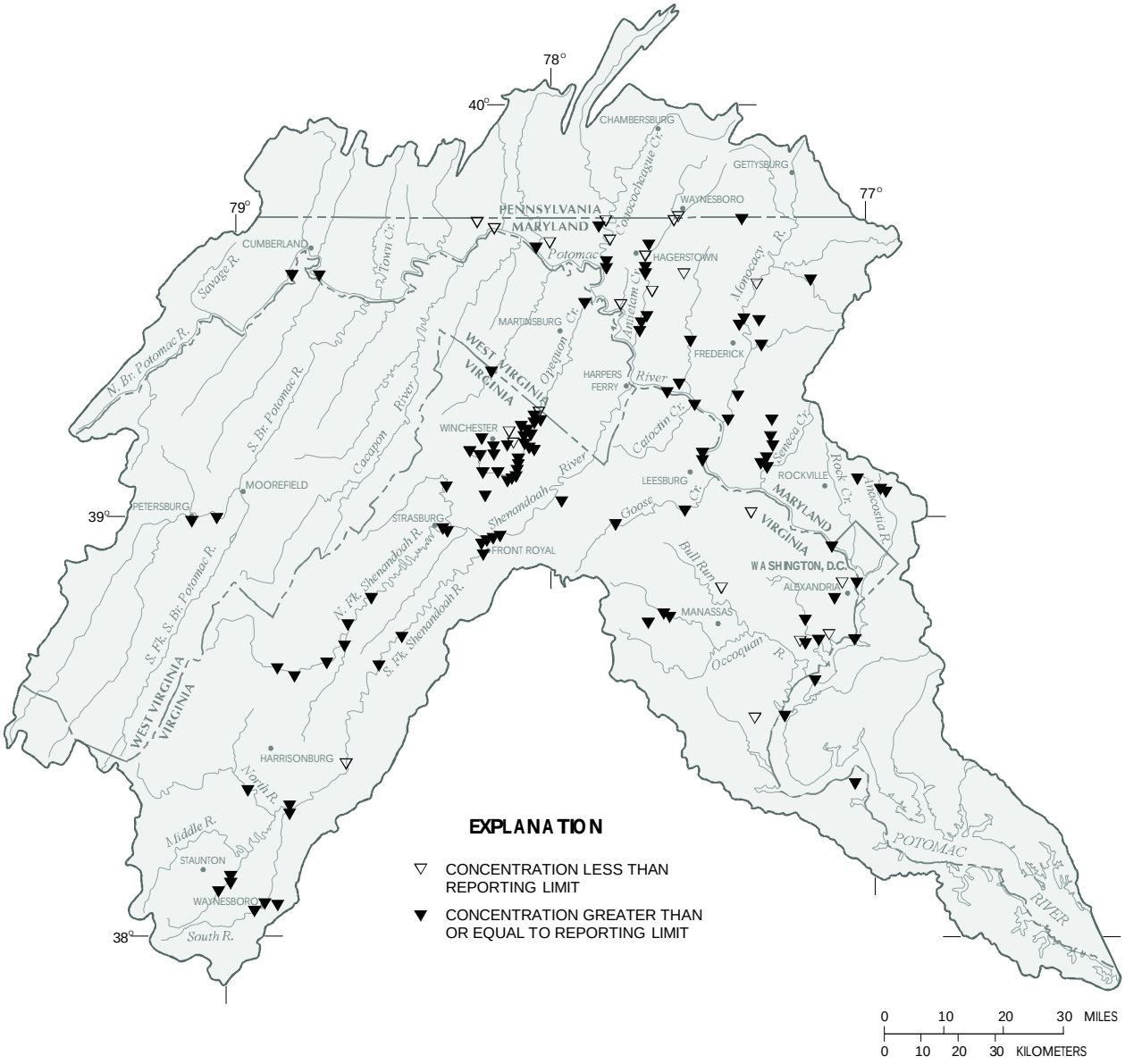


Figure 7. Locations of sampling sites where dieldrin was analyzed and reported in bottom material in the Potomac River Basin.

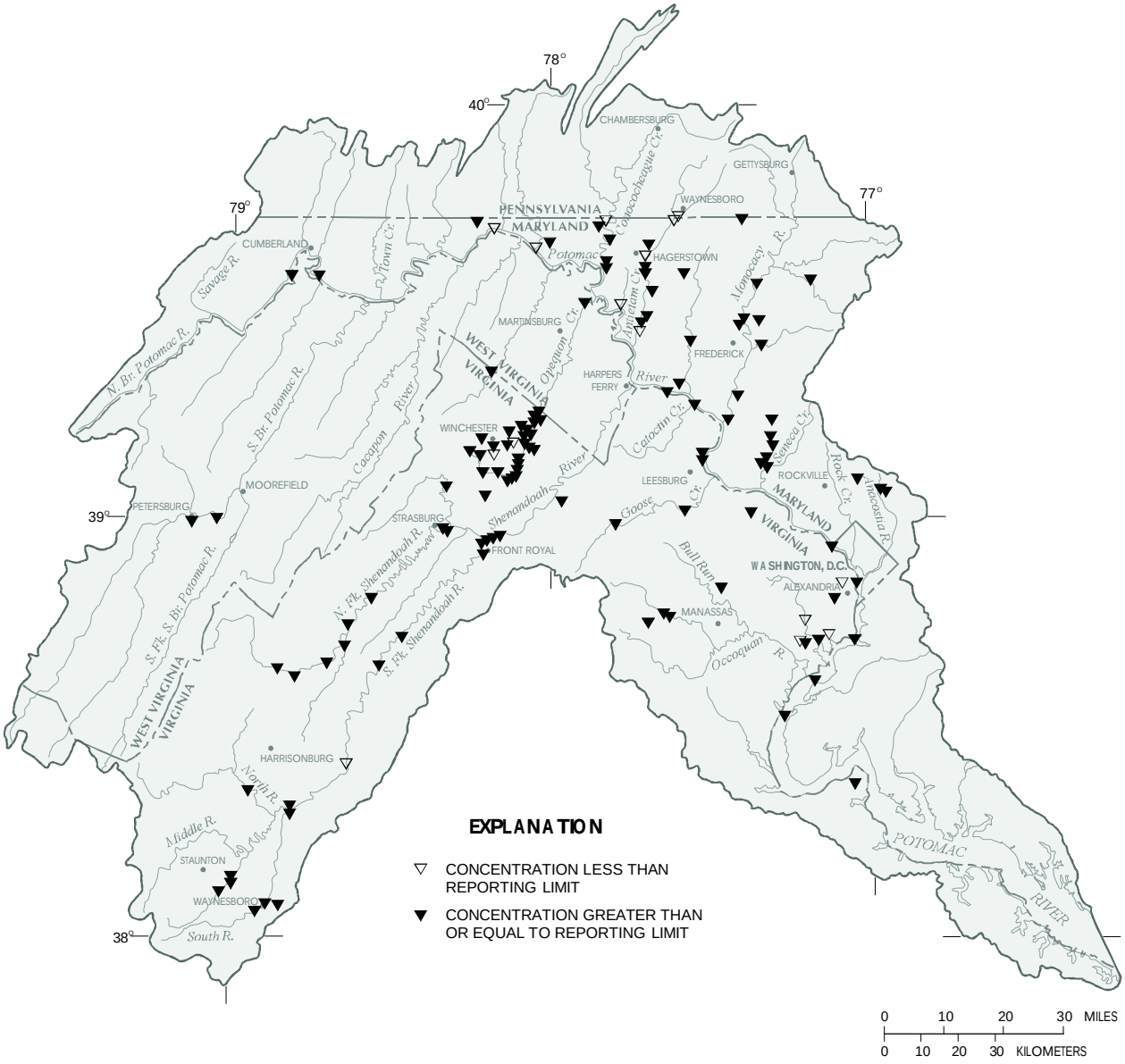


Figure 8. Locations of sampling sites where chlordane and related compounds were analyzed and reported in bottom material in the Potomac River Basin.

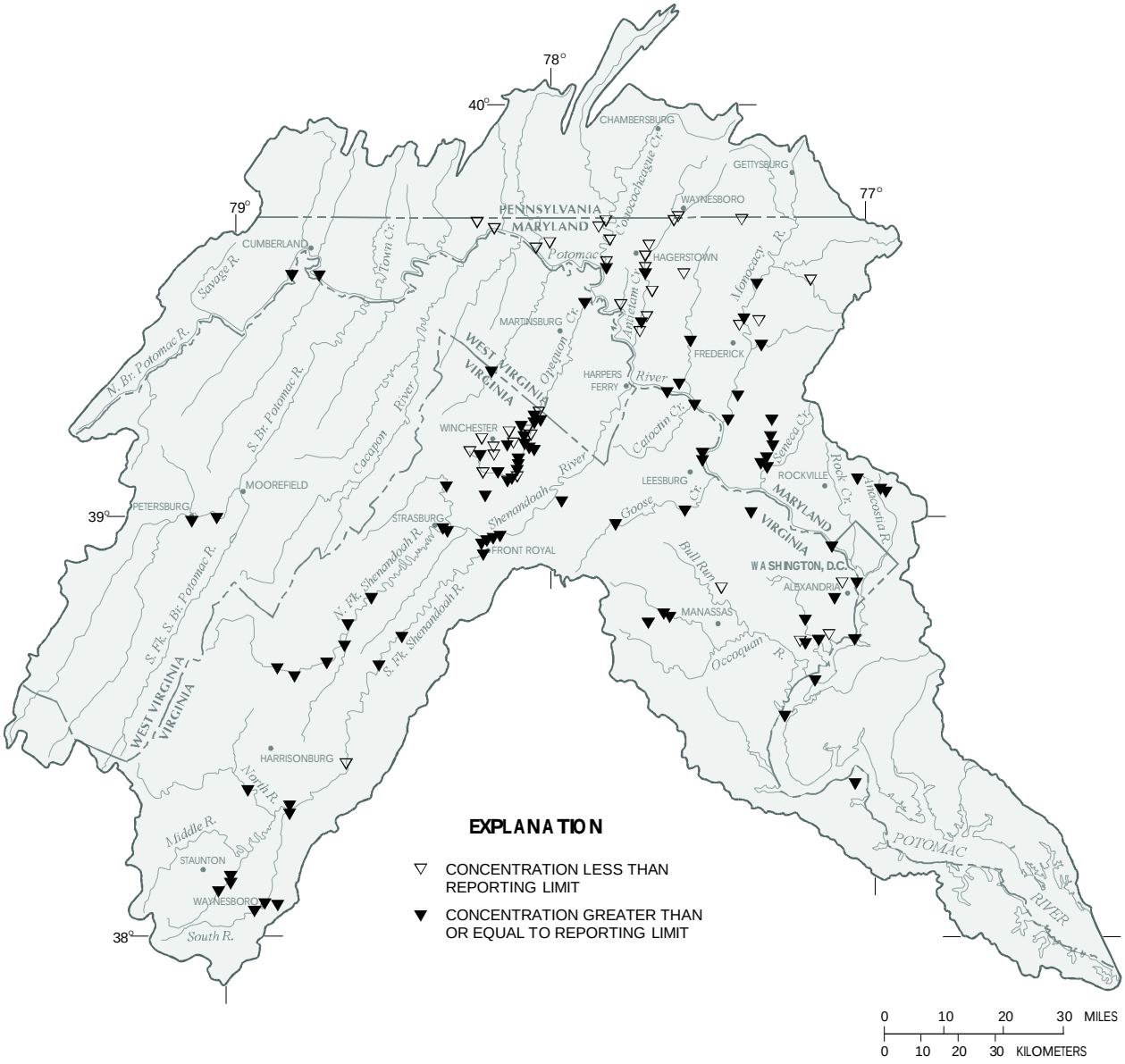


Figure 9. Locations of sampling sites where DDD, DDE, or DDT were analyzed and reported in bottom material in the Potomac River Basin.

Table 14. Summary of analyses for selected pesticides in ground-water samples collected by the U.S. Geological Survey, Potomac River Basin

[Parameter codes are from the U.S. Environmental Protection Agency's STORET data-base-management system. µg/L, micrograms per liter; ≥, greater than or equal to. Reporting limits are concentrations at which analyzing laboratories report detection of a pesticide in water samples. NA, parameter code not applicable to this media; --, compound not analyzed in this media; DDT, dichloro-diphenyl-trichloroethane; DDE, dichlorodiphenyldichloroethylene; DDD, dichlorodiphenyldichloroethane]

		Samples from wells			Samples from springs		
Pesticide	Parameter code	Total analyses performed for each pesticide	Reporting limit (µg/L)	Analyses with concentrations ≥ reporting limit	Total analyses performed for each pesticide	Reporting limit (µg/L)	Analyses with concentrations ≥ reporting limit
2,4-D	39730	24	0.01	1	5	0.01	0
2,4,5-T	39740	24	.01	0	5	.01	0
Alachlor	77825	22	.1, .2	0	6	.1, .2	0
Aldrin	39330	64	.01	0	52	.001	0
Ametryne	82184	45	.1	0	8	.1	0
Atrazine	39630	45	.1	9	8	.1	4
γ-BHC (lindane)	39340	64	.01	0	52	.001	0
Chlordane	39350	64	.1	1	52	.1	0
Cyanazine	81757	NA	NA	NA	8	.1, .2	1
Cyanazine	77825	45	.1, .2	0	NA	NA	NA
DDD	39360	64	.01	0	52	.001	0
DDE	39365	64	.01	0	52	.001	5
DDT	39370	64	.01	0	52	.001	2
Diazinon	39570	64	.01	1	52	.01	1
Dieldrin	39380	64	.01	0	52	.001	8
Endosulfan	39388	63	.01	0	52	.001	1
Endrin	39390	64	.01	3	52	.001	4
Ethion	39398	64	.01	0	52	.01	0
Heptachlor	39410	64	.01	0	52	.001	0
Heptachlor epoxide	39420	64	.01	1	52	.001	0
Malathion	39530	64	.01	2	52	.01	0
Methomyl	39051	4	2	0	--	--	--

Table 14. Summary of analyses for selected pesticides in ground-water samples collected by the U.S. Geological Survey, Potomac River Basin--Continued

[Parameter codes are from the U.S. Environmental Protection Agency's STORET data-base-management system. µg/L micrograms per liter; ≥, greater than or equal to. Reporting limits are concentrations at which analyzing laboratories report detection of a pesticide in water samples. -- compound not analyzed in this media; DDT, dichloro-diphenyl-trichloroethane; DDE, dichlorodiphenyldichloroethylene; DDD, dichlorodiphenyldichloroethane]

		Samples from wells			Samples from springs		
Pesticide	Parameter code	Total analyses performed for each pesticide	Reporting limit (µg/L)	Analyses with concentrations ≥ reporting limit	Total analyses performed for each pesticide	Reporting limit (µg/L)	Analyses with concentrations ≥ reporting limit
Methoxychlor	39480	63	0.01	0	52	.01	0
Metolachlor	82612	30	.01, .2	0	6	.1, .2	0
Mirex	39755	63	.01	0	52	.01	0
Ethyl parathion	39540	64	.01	0	52	.01	0
Methyl parathion	39600	64	.01	0	52	.01	1
Perthane	39034	63	.1	0	52	.1	0
Prometon	39056	45	.1, .2	0	8	.1, .2	0
Prometryne	39057	45	.1	0	8	.1	0
Propazine	39024	45	.1	0	8	.1	0
Propham	39052	4	2	0	--	--	--
Sevin (carbaryl)	39750	4	2	0	--	--	--
Silvex	39760	24	.01	0	5	.01	0
Simazine	39055	45	.1, .2	0	8	.1	2
Simetryne	39054	45	.1	0	8	.1	0
Toxaphene	39400	64	1	0	52	1	0
Trithion	39786	64	.01	0	52	.01	0
Methyl trithion	39790	64	.01	0	52	.01	0
Total				18			29

Table 15. Concentrations of pesticides equal to or greater than reporting limits in ground-water samples collected by the U.S. Geological Survey, Potomac River Basin, 1972 to 1990

[µg/L, micrograms per liter; Some well names were abbreviated to preserve anonymity of private owners. DDT, dichloro-diphenyl-trichloroethane; DDE, dichlorodiphenyldichloroethylene]

Site identification number	Site name as reported by investigating agency	Date	Concentration (µg/L)
	Well Samples		
	2,4-D		
394835077135001	649, Pa.	06/02/87	0.01
	Atrazine		
391809078044301	FF well, W. Va.	08/24/89	0.2
392848077530601	JN well, W. Va.	08/22/89	.3
393055078000601	DD well, W. Va.	08/23/89	.1
393150077395801	WA Ci 113, Md.	08/17/83	.4
393301077435501	WA Ci 147, Md.	05/21/87	.3
393959077370301	WA Bj 105, Md.	05/19/87	.5
394038077410201	WA Ai 74, Md.	05/21/87	.1
394149077515001	WA Ag 65, Md.	05/19/87	.1
394806077150901	601, Pa.	10/07/86	.1
	Chlordane		
391809078044301	FF well, W. Va.	08/24/89	0.1
	Diazinon		
392725077524701	ER well, W. Va.	08/21/89	0.06
	Endrin		
391332077484701	0372258 B well, W. Va.	07/27/88	0.031
391449077531401	03742 WM well, W. Va.	o7/26/88	.150
391854077484601	037106 CR well, W. Va.	07/27/88	.015
	Heptachlor epoxide		
391809078044301	FF well, W. Va.	08/24/89	0.110
	Malathion		
392725077524701	ER well, W. Va.	08/21/89	0.01
395046077142701	593, Pa.	06/03/87	.01

Table 15. Concentrations of pesticides equal to or greater than reporting limits in ground-water samples collected by the U.S. Geological Survey, Potomac River Basin, 1972 to 1990--Continued

[µg/L, micrograms per liter; Some well names were abbreviated to preserve anonymity of private owners. DDT, dichloro-diphenyl-trichloroethane; DDE, dichlorodiphenyldichloroethylene]

Site identification number	Site name as reported by investigating agency	Date	Concentration (µg/L)
	Spring Samples		
	Atrazine		
392333077550500	2005060, W. Va.	08/24/89	0.9
392717077540901	Dunn Spring, W. Va.	08/23/89	.5
392748078003202	Olean Spring at Old School, W. Va.	08/22/89	.2
393309077392201	WA Cj 126, Md.	05/21/87	.1
	Cyanazine		
392333077550501	2005060, W. Va.	08/24/89	0.1
	DDE		
391413077572301	037252 Head Spring, W. Va.	12/21/88	0.001
393335077582200	2001088, W. Va.	03/30/89	.004
		06/22/89	.002
		10/02/89	.001
		12/18/89	.004
	DDT		
393335077582200	2001088, W. Va.	03/30/89	0.003
		12/18/89	.002
	Diazinon		
01636340	Morgan Springs near Berryville, Va.	05/15/86	0.01
	Dieldrin		
391153077545001	037270, Louthan Spring, W. Va.	07/29/88	0.001
392124078050501	Isherwood Spring, W. Va.	03/29/89	.011
		06/20/89	.003
		10/03/89	.015
		12/19/89	.010
		03/06/90	.012
391840077504001	037109 flowing spring (Kane), W. Va.	07/25/88	.002
392748078003202	Olean Spring at Old School, W. Va.	08/22/89	.001
	Endosulfan		
393335077582200	2001088, W. Va.	06/22/89	0.010

Table 15. Concentrations of pesticides equal to or greater than reporting limits in ground-water samples collected by the U.S. Geological Survey, Potomac River Basin, 1972 to 1990--Continued

[µg/L, micrograms per liter; Some well names were abbreviated to preserve anonymity of private owners. DDT, dichloro-diphenyl-trichloroethane; DDE, dichlorodiphenyldichloroethylene]

Site identification number	Site name as reported by investigating agency	Date	Concentration (µg/L)
	Spring Samples--Continued		
	Endrin		
391655077493801	03788A Cattail Spring, W. Va.	07/27/88	0.018
392124078050501	Isherwood Spring, W. Va.	10/03/89	.012
		03/06/90	.015
392748078003202	Olean Spring at Old School, W. Va.	08/22/89	.005
	Methyl parathion		
391413077572301	037252 Head Spring, W. Va.	06/20/89	0.01
	Simazine		
392333077550501	2005060, W. Va.	08/24/89	0.1
392717077540901	Dunn Spring, W. Va.	08/23/89	.1

were found in 52 of the wells. Of the 720 analyses performed, there were 120 occurrences of pesticide concentrations greater than the reporting limits. Just over half of these occurrences were from wells in orchard areas. The most frequently detected pesticide was endosulfan, followed by azinophos-methyl and methyl parathion. The highest concentration was of 2,4-D in a sample attributed to urban lawn or garden care. Other pesticides found were phosmet, 2,4,5-TP, glyphosate, and simazine. Also, analyses for alachlor and paraquat were performed, but those pesticides were not reported in any samples.

Mostaghimi and others (1989) detected 21 of 22 pesticides at concentrations greater than reporting limits in their pre-BMP sampling of 8 wells in Westmoreland County, Va. Only cyanazine, which was reportedly used in the watershed, was not found in any of 136 samples. Atrazine was the most commonly found pesticide (5 wells). Other pesticides detected included paraquat, flauzifop-butyl, sethoxydim, and carbofuran. Alachlor was detected at only trace concentrations.

Fish Tissue

Fish tissue has been sampled in the Potomac River Basin to address contaminant issues of national, regional, and local concern. Various fish tissue types and groups of analytes have been used, depending on the objectives of the agency conducting the investigation. Site selection and location has also been influenced by study objectives, as well as jurisdictional constraints.

Whole fish

A total of 266 whole-fish samples at 48 sites from the Potomac River Basin were analyzed for up to 37 pesticides and their related compounds (tables 3, 16, and 17). Of those pesticides and related compounds, 30 were found at concentrations equal to or greater than reporting limits, from 38 of the 48 sites sampled.[1]

1. Pesticides or their related compounds with concentrations in whole-fish tissue samples less than the reporting limit have been included if considered as a detection of the pesticide or related compound by the investigating agency.

Table 16. Summary of analyses for selected pesticides in whole-fish tissue samples, Potomac River Basin

[mg/kg, milligrams per kilogram; ≥, greater than or equal to; Reporting limits are concentrations at which analyzing laboratories report detections of a pesticide in fish tissue samples. BHC, Benzene hexachloride; DDT, dichloro-diphenyl-trichloroethane; DDE, dichlorodiphenyldichloroethylene; DDD, dichlorodiphenyldichloroethane; HCB, Hexachlorobenzene, PCA, Pentachloranisol; -- not available]

Pesticide	Number of sites sampled for pesticides[1]	Total analyses performed for each pesticide	Reporting limit (mg/kg)	Analyses with concentrations ≥ reporting limit[2]
Aldrin	33	87	0.001, .002, .003, .01, .1	1
α-BHC	35	236	.002, .0025, .01, .1	33
β-BHC	8	30	.01	3
γ-BHC (lindane)	43	246	.01	57
δ-BHC	8	30	.002, .0025, .01	2
Chlordane	30	197	.01, 1.0	154
Cis-chlordane	18	59	.002, .01, .05	34
Trans-chlordane	18	59	.0025, .01	32
Nonachlor	8	10	.1	0
Cis-nonachlor	18	59	.0025, .01	16
Trans-nonachlor	18	59	.0025, .01	33
Oxychlordane	18	56	.0025, .01	8
Chlorpyrifos	12	14	.0025, .1	3
Dacthal	23	199	.002, .009, .01	1
DDT	30	197	.02, .1	9
o,p'-DDT	8	30	.01	5
p,p'-DDT	14	55	.01	18
DDE	30	197	.07, .1	53
o,p'-DDE	8	30	.01	2
p,p'-DDE	18	69	.0025, .01	46
DDD	30	197	.04,.1	11
o,p'-DDD	8	30	.01	0
p,p'-DDD	14	65	.01	35
Dieldrin	48	266	.0025, .007, .01, .1	84
Endosulfan	38	227	.004, .007, .1	0
Endosulfan II	8	30	--	0
Endosulfan sulfate	8	30	--	0
Endrin	48	266	.0025, .004, .01, .1	19
Endrin aldehyde	8	30	--	0
HCB	38	106	.002, .0025, .01, .1	6
Heptachlor	38	116	.001, .0025, .007, .01, .1	6
Heptachlor epoxide	42	231	.002, .0025, .004, .01, .1	31
Isodrin	8	30	--	0
Methoxychlor	42	231	.0025, .1	1
Mirex	35	210	.0025, .01, .05,.1	2
PCA	13	23	.0025, .01	5
Toxaphene	39	252	.1,.23, .5, 1.0	13
Total				723

[1]Whole fish were sampled at a total of 48 sites in the Potomac River Basin. Analyses for multiple compounds were often conducted on a single whole-fish sample from a site.

[2]Pesticides or their related compounds with concentrations in whole-fish samples less than the reporting limit have been included if considered as a detection of the pesticide or related compound by the investigating agency.

Table 17. Concentrations of pesticides equal to or greater than reporting limits in whole-fish tissue samples, Potomac River Basin, 1972 to 1990

[mg/kg, milligrams per kilogram; USGS, U.S. Geological Survey; BHC, Benzene hexachloride; DDT, dichloro-diphenyl-trichloroethane; DDE, dichlorodiphenyldichloroethylene; DDD, dichlorodiphenyldichloroethane; HCB, Hexachlorobenzene; PCA, Pentachloranisol]

Site identification number	Site name[1] as reported by investigating agency	Year(s) reported	Range in concentration (mg/kg)
	Aldrin		
WVOP004[2]	Opequon Creek, 25 miles above mouth, W.Va.	1985	0.02
	α-BHC		
POT1471	Potomac River, at eastern terminus of Whites Ferry, Md.	1979,80,81	0.0020-0.0080
NEB0016	Anacostia River, Riverdale Road below gage, Md.	1980,84,87	.0020- .0080
POT1595	Potomac River, USGS gage 01638500, Md.	1987	.0061
MON0020	Monocacy River, Md. Route 28	1980,81,84,87	.0020 - .038
MON0138	Monocacy River, Md. Route 355	1980,81, 87	.005 - .0026
MON0269	Monocacy River, Briggs Ford Road, Md.	1980-82,87	.0020 - .0060
MON0528	Monocacy River, USGS Gage 01639000, Md.	1980-82,84,87	.0030 - .016
BPC0035	Big Pipe Creek, Md. Route 194	1981	.0020 - .0040
POT1830	Potomac River, USGS Gage 01618000, Md.	1980,87,	.0070 - .0294
POT2386	Potomac River, USGS Gage 01613000, Md.	1979,87	.0040 - .0315
ANT0203	Antietam Creek, near Funkstown, Md.	1979-80,84,87	.0060 - .2080
ANT0354	Antietam Creek, Md. Route 60	1984	.0110
CON0005	Conococheague Creek, Md. Route 68	1979-81	.0020 - .0030
TOW0013	Town Creek, Md. Route 51	1981-82,85,87	.0020 - .0270
TOW0030	Town Creek, USGS Gage 01609000, Md.	1979	.0030
NBP0103	North Branch Potomac River, Md. Route 51	1980,84,87	.0040 - .1840
WVSB008[2]	South Fork South Branch Potomac River, Moorefield, W.Va.	1983	.011
2210	East Potomac River, Washington, D.C.	1987	.00655
3147	Potomac River, Potomac Park, North of Wilson Bridge	1987	.00398
3317	Potomac River, North Branch, Westernport, Md.	1987	.00811
FWS0006[2]	Potomac River, Little Falls, Md.	1977,81,83,	.01
	β-BHC		
WVOP004[2]	Opequon Creek, 25 miles above mouth, W.Va.	1981	0.04 - 0.07
WVSH006[2]	Shenandoah River, Shannondale Ferry, W.Va.	1981	.01
	γ-BHC (lindane)		
POT147	Potomac River, at eastern terminus of Whites Ferry, Md.	1984	0.0020
NEB0016[3]	Anacostia River, Riverdale Road below gage, Md.	1987	.0017 - .0020
MON0020[3]	Monocacy River, Md. Route 28	1980,87	.0008 - .010
MON0138[3]	Monocacy River, Md. Route 355	1980-81,85,87	.0019 - .0030
MON0269	Monocacy River, Briggs Ford Road, Md.	1980,87	.0020 - .0023
MON0528	Monocacy River, USGS Gage 01639000, Md.	1984-85,87	.0030 - .0040
POT1830	Potomac River, USGS Gage 01618000, Md.	1987	.0027 - .0028
POT2386[3]	Potomac River, USGS Gage 01613000, Md.	1987	.0006 - .0023
ANT0203	Antietam Creek, near Funkstown, Md.	1984-85	.0030 - .0050
TOW0013[3]	Town Creek, Md. Route 51	1982,87	.0004 - .016
3147	Potomac River, Potomac Park, North of Wilson Bridge	1987	.0064

Table 17. Concentrations of pesticides equal to or greater than reporting limits in whole-fish tissue samples, Potomac River Basin, 1972 to 1990--Continued

[mg/kg, milligrams per kilogram; USGS, U.S. Geological Survey; BHC, Benzene hexachloride; DDT, dichloro-diphenyl-trichloroethane; DDE, dichlorodiphenyldichloroethylene; DDD, dichlorodiphenyldichloroethane; HCB, Hexachlorobenzene; PCA, Pentachloranisol]

Site identification number	Site name[1] as reported by investigating agency	Year(s) reported	Range in concentration (mg/kg)
	δ-BHC		
WVOP002[2]	Opequon Creek, near Tuscarora Creek, W.Va.	1984	0.037
WVSB008[2]	South Fork South Branch Potomac River, Moorefield, W.Va.	1984	.048
	Chlordane		
POT1342	Potomac River, end of Violets Lock Road, Md.	1978	0.010 -0.100
POT1471	Potomac River, at eastern terminus of Whites Ferry, Md.	1979-84	.026 - .268
NEB0016	Anacostia River, Riverdale Road below gage, Md.	1980-85,87	.016 - .930
RCM0111	Rock Creek, Md. Route 410	1981	.068
POT1595	Potomac River, USGS gage 01638500, Md.	1987	.040
POT1661	Potomac River, Md. Route 17	1989	.068 - .685
MON0020	Monocacy River, Md. Route 28	1979-82,84,85,87	.020 - .087
MON0138	Monocacy River, Md. Route 355	1979-85,87	.010 - .183
MON0269	Monocacy River, Briggs Ford Road, Md.	1979-85.87	.012 - .741
MON0528	Monocacy River, USGS Gage 01639000, Md.	1979-83,85	.011 - .226
BPC0035	Big Pipe Creek, Md. Route 194	1981-82	.014 - .050
POT1830	Potomac River, USGS Gage 01618000, Md.	1980-84,87,89	.012 - .174
POT2386	Potomac River, USGS Gage 01613000, Md.	1980-84,87	.010 - .088
ANT0203	Antietam Creek, near Funkstown, Md.	1979-85,87,89	.043 - .856
ANT0354	Antietam Creek, Md. Route 60	1983-84	.280 -1.295
CON0005	Conococheague Creek, Md. Route 68	1979-84	.019 - .163
TOW0013	Town Creek, Md. Route 51	1979-84,87	.010 - .119
TOW0030	Town Creek, USGS Gage 01609000, Md.	1979	.010 - .050
NBP0085	North Branch Potomac River, at Spring Gap, Md.	1989	.071
NBP0103	North Branch Potomac River, Md. Route 51	1979-84	.020 - .131
	***Cis*-chlordane**		
WVOP002[2]	Opequon Creek, near Tuscarora Creek, W.Va.	1984	0.044
WVOP004[2]	Opequon Creek, 25 miles above mouth, W.Va.	1981	.03
WVSH006[2]	Shenandoah River, Shannondale Ferry, W.Va.	1983	.15
WVSB008[2]	South Fork South Branch Potomac River, Moorefield, W.Va.	1983-84	.032 -.689
WVSB009[2]	South Branch Potomac River, Springfield, W.Va.	1978,83	.02 - .098
2210[4]	East Potomac River, Washington, D.C.	1987	.166
3147	Potomac River, Potomac Park, North of Wilson Bridge	1987	.0426
3313	Opequon Creek, Bedington, W.Va.	1987	.00842
FBH	Potomac River, Fletchers Boathouse, Washington, D.C.	1987	.07 - .12
WSC	Washington Ship Channel, Washington, D.C.	1987	.16 - .18
BRA	Anacostia River, Benning Road, Washington, D.C.	1987	.09 - .10
LA	Lower Anacostia River, Washington, D.C.	1987	.10 - .19
WB	Potomac River, Wilson Bridge, Md.	1987	.06 - .11
FWS0006[2]	Potomac River, Little Falls, Md.	1977,79,81,84	.01 - .09

Table 17. Concentrations of pesticides equal to or greater than reporting limits in whole-fish tissue samples, Potomac River Basin, 1972 to 1990--Continued

[mg/kg, milligrams per kilogram; USGS, U.S. Geological Survey; BHC, Benzene hexachloride; DDT, dichloro-diphenyl-trichloroethane; DDE, dichlorodiphenyldichloroethylene; DDD, dichlorodiphenyldichloroethane; HCB, Hexachlorobenzene; PCA, Pentachloranisol]

Site identification number	Site name[1] as reported by investigating agency	Year(s) reported	Range in concentration (mg/kg)
	Trans-chlordane		
WVOP002[2]	Opequon Creek, near Tuscarora Creek, W.Va.	1984	0.015
WVOP004[2]	Opequon Creek, 25 miles above mouth, W.Va.	1981	.03 -.09
WVSH006[2]	Shenandoah River, Shannondale Ferry, W.Va.	1983	.13
WVSB008[2]	South Fork South Branch Potomac River, Moorefield, W.Va.	1983-84	.015 -.465
WVSB009[2]	South Branch Potomac River, Springfield, W.Va.	1978,83	.01 - .052
2210	East Potomac River, Washington, D.C.	1987	.126
3147	Potomac River, Potomac Park, North of Wilson Bridge	1987	.0289
3313	Opequon Creek, Bedington, W.Va.	1987	.00433
FBH	Potomac River, Fletchers Boathouse, Washington, D.C.	1987	.05 - .13
WSC	Washington Ship Channel, Washington, D.C.	1987	.11 - .20
BRA	Anacostia River, Benning Road, Washington, D.C.	1987	.08 - .10
LA	Lower Anacostia River, Washington, D.C.	1987	.09 - .20
WB	Potomac River, Wilson Bridge, Md.	1987	.04 - .12
FWS0006[2]	Potomac River, Little Falls, Md.	1977,79,81,84	.01 - .04
	***Cis*-nonachlor**		
WVOP002[2]	Opequon Creek, near Tuscarora Creek, W.Va.	1984	0.014
WVSB008[2]	South Fork South Branch Potomac River, Moorefield, W.Va.	1983-84	.011 -.022
2210	East Potomac River, Washington, D.C.	1987	.052
3313	Opequon Creek, Bedington, W.Va.	1987	.00635
FWS0006[2]	Potomac River, Little Falls, Md.	1977,79,81,84	.01 - .03
	Trans-nonachlor		
WVOP004[2]	Opequon Creek, 25 miles above mouth, W.Va.	1985	0.03 -0.17
WVSH007[2]	Shenandoah River, near Millville, W.Va.	1978	.020
WVSB008[2]	South Fork South Branch Potomac River, Moorefield, W.Va.	1983-84	.023 -.06
WVSB009[2]	South Branch Potomac River, Springfield, W.Va.	1978	.020
2210	East Potomac River, Washington, D.C.	1987	.158
3147	Potomac River, Potomac Park, North of Wilson Bridge	1987	.0322
3313	Opequon Creek, Bedington, W.Va.	1987	.0264
FBH	Potomac River, Fletchers Boathouse, Washington, D.C.	1987	.12 - .20
WSC	Washington Ship Channel, Washington, D.C.	1987	.17 - .28
BRA	Anacostia River, Benning Road, Washington, D.C.	1987	.09 - .11
LA	Lower Anacostia River, Washington, D.C.	1987	.14 - .18
WB	Potomac River, Wilson Bridge, Md.	1987	.09 - .10
FWS0006[2]	Potomac River, Little Falls, Md.	1977,79,81,84	.01 - .04
	Oxychlordane		
2210	East Potomac River, Washington, D.C.	1987	0.00562
3313	Opequon Creek, Bedington, W.Va.	1987	.00333
FWS0006[2]	Potomac River, Little Falls, Md.	1979,81,84	.01

Table 17. Concentrations of pesticides equal to or greater than reporting limits in whole-fish tissue samples, Potomac River Basin, 1972 to 1990--Continued

[mg/kg, milligrams per kilogram; USGS, U.S. Geological Survey; BHC, Benzene hexachloride; DDT, dichloro-diphenyl-trichloroethane; DDE, dichlorodiphenyldichloroethylene; DDD, dichlorodiphenyldichloroethane; HCB, Hexachlorobenzene; PCA, Pentachloranisol]

Site identification number	Site name[1] as reported by investigating agency	Year(s) reported	Range in concentration (mg/kg)
	Chlorpyrifos		
2210	East Potomac River, Washington, D.C.	1987	0.0239
3147	Potomac River, Potomac Park, North of Wilson Bridge	1987	.0079
3313[3]	Opequon Creek, Bedington, W.Va.	1987	.0012
	Dacthal		
FWS0006[2]	Potomac River, Little Falls, Md.	1979	0.01
	DDT		
POT1342	Potomac River, end of Violets Lock Road, Md.	1978	0.020
POT1471	Potomac River, at eastern terminus of Whites Ferry, Md.	1980	.020
MON0138	Monocacy River, Md. Route 355	1980	.002
ANT0203	Antietam Creek, near Funkstown, Md.	1979-80,84,85	.046 -.205
ANT0354	Antietam Creek, Md. Route 60	1984	.020
	o,p'-DDT		
WVSH006[2]	Shenandoah River, Shannondale Ferry, W.Va.	1981	0.01 -0.02
WVSB008[2]	South Fork South Branch Potomac River, Moorefield, W.Va.	1983-84	.03 - .043
WVSB009[2]	South Branch Potomac River, Springfield, W.Va.	1978, 81,83	.019
	p,p'-DDT		
WVOP002[2]	Opequon Creek, near Tuscarora Creek, W.Va.	1984	0.056
WVSH006[2]	Shenandoah River, Shannondale Ferry, W.Va.	1983	.01
WVSB008[2]	South Fork South Branch Potomac River, Moorefield, W.Va.	1983-84	.1 - .035
WVSB009[2]	South Branch Potomac River, Springfield, W.Va.	1978,83	.017 -.03
FBH	Potomac River, Fletchers Boathouse, Washington, D.C.	1987	.05
WSC	Washington Ship Channel, Washington, D.C.	1987	.06
FWS0006[2]	Potomac River, Little Falls, Md.	1972,79,81,84	.02 - .18
	DDE		
POT1342	Potomac River, end of Violets Lock Road, Md.	1978	0.80 -0.160
POT1471	Potomac River, at eastern terminus of Whites Ferry, Md.	1983-84,89	.074- .169
NEB0016	Anacostia River, Riverdale Road below gage, Md.	1987	.016 -.097
POT1595[3]	Potomac River, USGS gage 01638500, Md.	1987	.034
POT1661[3]	Potomac River, Md. Route 17	1989	.022 -.142
MON0020[3]	Monocacy River, Md. Route 28	1979-80,84,87	.030 -.084
MON0138[3]	Monocacy River, Md. Route 355	1983,84,87	.027 -.082
MON0155	Monocacy River, Reeds Mill Road, Md.	1989	.184
MON0269	Monocacy River, Briggs Ford Road, Md.	1983.87	.074 -.076
MON0528[3]	Monocacy River, USGS Gage 01639000, Md.	1984,87	.060 -.097
POT1830[3]	Potomac River, USGS Gage 01618000, Md.	1984,87	.038 -.134
POT2386	Potomac River, USGS Gage 01613000, Md.	1987	.098
ANT0203	Antietam Creek, near Funkstown, Md.	1979-80,82-87,89	.121 -.661

Table 17. Concentrations of pesticides equal to or greater than reporting limits in whole-fish tissue samples, Potomac River Basin, 1992 to 1990--Continued

[mg/kg, milligrams per kilogram; USGS, U.S. Geological Survey; BHC, Benzene hexachloride; DDT, dichloro-diphenyl-trichloroethane; DDE, dichlorodiphenyldichloroethylene; DDD, dichlorodiphenyldichloroethane; HCB, Hexachlorobenzene; PCA, Pentachloranisol]

Site identification number	Site name[1] as reported by investigating agency	Year(s) reported	Range in concentration (mg/kg)
	DDE--Continued		
ANT0354	Antietam Creek, Md. Route 60	1983-84	0.111 -0.146
CON0005	Conococheague Creek, Md. Route 68	1981,84	.071 - .078
TOW0013[3]	Town Creek, Md. Route 51	1987	.011 - .030
NBP0103[3]	North Branch Potomac River, Md. Route 51	1987	.010
1BNSF[3 5]	N F Shenandoah River, Va. Route 340, Front Royal, Va.	1988	.026
	o,p'-DDE		
WVSH006[2]	Shenandoah River, Shannondale Ferry, W.Va.	1983	0.02
WVSB009[2]	South Branch Potomac River, Springfield, W.Va.	1981	.01
	p,p'-DDE		
WVOP004[2]	Opequon Creek, 25 miles above mouth, W.Va.	1981	0.02 - 0.11
WVSH006[2]	Shenandoah River, Shannondale Ferry, W.Va.	1981,83,	.32 - .49
WVSH007[2]	Shenandoah River, near Millville, W.Va.	1978	.09 - .13
WVSB008[2]	South Fork South Branch Potomac River, Moorefield, W.Va.	1984	.039
WVSB009[2]	South Branch Potomac River, Springfield, W.Va.	1978,83	.06 - .24
2210[4]	East Potomac River, Washington, D.C.	1987	.381
3147	Potomac River, Potomac Park, North of Wilson Bridge	1987	.0792
3313[4]	Opequon Creek, Bedington, W. Va.	1987	.200
FBH	Potomac River, Fletchers Boathouse, Washington, D.C.	1987	.21 - .55
WSC	Washington Ship Channel, Washington, D.C.	1987	.28 - .63
BRA	Anacostia River, Benning Road, Washington, D.C.	1987	.10 - .24
LA	Lower Anacostia River, Washington, D.C.	1987	.15 - .35
WB	Potomac River, Wilson Bridge, Md.	1987	.20 - .25
FWS0006[2]	Potomac River, Little Falls, Md.	1972-73,77,79,81,84	.02 - .31
	DDD		
POT1342	Potomac River, end of Violets Lock Road, Md.	1978	0.060
NEB0016	Anacostia River, Riverdale Road below gage, Md.	1983	.083 - .117
MON0269	Monocacy River, Briggs Ford Road, Md.	1983	.054
ANT0203	Antietam Creek, near Funkstown, Md.	1979-80,82-84	.06 - .750
ANT0354	Antietam Creek, Md. Route 60	1983	.095
	p,p'-DDD		
WVOP004[2]	Opequon Creek, 25 miles above mouth, W.Va.	1981	0.06
WVSH006[2]	Shenandoah River, Shannondale Ferry, W.Va.	1981,83	.02
WVSB008[2]	South Fork South Branch Potomac River, Moorefield, W.Va.	1983	.01
WVSB009[2]	South Branch Potomac River, Springfield, W.Va.	1981,83	.016 - .23
FBH	Potomac River, Fletchers Boathouse, Washington, D.C.	1987	.11 - .17
WSC	Washington Ship Channel, Washington, D.C.	1987	.22 - .36
BRA	Anacostia River, Benning Road, Washington, D.C.	1987	.11 - .12
LA	Lower Anacostia River, Washington, D.C.	1987	.13 - .20
WB	Potomac River, Wilson Bridge, Md.	1987	.09 - .12
FWS0006[2]	Potomac River, Little Falls, Md.	1972-73,77,79,81,84	.01 - .19

Table 17. Concentrations of pesticides equal to or greater than reporting limits in whole-fish tissue samples, Potomac River Basin, 1971 to 1990--Continued

[mg/kg, milligrams per kilogram; USGS, U.S. Geological Survey; BHC, Benzene hexachloride; DDT, dichloro-diphenyl-trichloroethane; DDE, dichlorodiphenyldichloroethylene; DDD, dichlorodiphenyldichloroethane; HCB, Hexachlorobenzene; PCA, Pentachloranisol]

Site identification number	Site name[1] as reported by investigating agency	Year(s) reported	Range in concentration (mg/kg)
	Dieldrin		
POT1342	Potomac River, end of Violets Lock Road, Md.	1978	0.007 - .020
POT1471	Potomac River, at eastern terminus of Whites Ferry, Md.	1979-81	.007- .010
NEB0016	Anacostia River, Riverdale Road below gage, Md.	1982-84	.007 - .042
RCM0111	Rock Creek, Md. Route 410	1981	.011
POT1595[3]	Potomac River, USGS gage 01638500, Md.	1987	.0033
MON0020	Monocacy River, Md. Route 28	1979-82,84,87	.007 - .012
MON0138	Monocacy River, Md. Route 355	1979,81,84,87	.007 - .019
MON0269	Monocacy River, Briggs Ford Road, Md.	1979,81-84.87	.007 - .019
MON0528	Monocacy River, USGS Gage 01639000, Md.	1981-82,84,87	.007 - .025
BPC0035	Big Pipe Creek, Md. Route 194	1981-82	.009
POT1830[3]	Potomac River, USGS Gage 01618000, Md.	1987	.0043
POT2386	Potomac River, USGS Gage 01613000, Md.	1981	.010
ANT0203	Antietam Creek, near Funkstown, Md.	1979-85	.009 - .130
ANT0354	Antietam Creek, Md. Route 60	1983-84	.056 - .080
CON0005	Conococheague Creek, Md. Route 68	1979	.0080
WVOP002[2]	Opequon Creek, near Tuscarora Creek, W.Va.	1981	.030
WVOP004[2]	Opequon Creek, 25 miles above mouth, W.Va.	1981	.02 - .03
2210	East Potomac River, Washington, D.C.	1987	.0731
3147	Potomac River, Potomac Park, North of Wilson Bridge	1987	.0158
3313	Opequon Creek, Bedington, W.Va.	1987	.00775
FBH	Potomac River, Fletchers Boathouse, Washington, D.C.	1987	.01 - .03
WSC	Washington Ship Channel, Washington, D.C.	1987	.04 - .04
BRA	Anacostia River, Benning Road, Washington, D.C.	1987	.01 - .02
LA	Lower Anacostia River, Washington, D.C.	1987	.02
WB	Potomac River, Wilson Bridge, Md.	1987	.02
FWS0006[2]	Potomac River, Little Falls, Md.	1972,73,77,79,81,84	.01 - .13
	Endrin		
MON0269	Monocacy River, Briggs Ford Road, Md.	1979,81.87	0.0040 -0.0060
MON0528[3]	Monocacy River, USGS Gage 01639000, Md.	1987	.0017
ANT0203	Antietam Creek, near Funkstown, Md.	1979-85,87,89	.0040
WVOP002[2]	Opequon Creek, near Tuscarora Creek, W.Va.	1984	.011
WVOP004[2]	Opequon Creek, 25 miles above mouth, W.Va.	1981	.02 - .06
2210	East Potomac River, Washington, D.C.	1987	.00902
WSC	Washington Ship Channel, Washington, D.C.	1987	.01
BRA	Anacostia River, Benning Road, Washington, D.C.	1987	.01
LA	Lower Anacostia River, Washington, D.C.	1987	.01
FWS0006[2]	Potomac River, Little Falls, Md.	1977,79,81,84	.01 - .02
	HCB		
MON0138	Monocacy River, Md. Route 355	1984,85	0.0050
MON0269	Monocacy River, Briggs Ford Road, Md.	1985	.0020
2210	East Potomac River, Washington, D.C.	1987	.00507
3147	Potomac River, Potomac Park, North of Wilson Bridge	1987	.00364
WB	South Fork South Branch Potomac River, Moorefield, W.Va.	1984	.011

Table 17. Concentrations of pesticides equal to or greater than reporting limits in whole-fish tissue samples, Potomac River Basin, 1972 to 1990--Continued

[mg/kg, milligrams per kilogram; USGS, U.S. Geological Survey; BHC, Benzene hexachloride; DDT, dichloro-diphenyl-trichloroethane; DDE, dichlorodiphenyldichloroethylene; DDD, dichlorodiphenyldichloroethane; HCB, Hexachlorobenzene; PCA, Pentachloranisol]

Site identification number	Site name[1] as reported by investigating agency	Year(s) reported	Range in concentration (mg/kg)
	Heptachlor		
WVSB008[2]	South Fork South Branch Potomac River, Moorefield, W.Va.	1983	0.035
FWS0006[2]	Potomac River, Little Falls, Md.	1977,79,81,84	.01 - 0.03
	Heptachlor epoxide		
POT1471	Potomac River, at eastern terminus of Whites Ferry, Md.	1983	0.0040 - 0.0050
NEB0016	Anacostia River, Riverdale Road below gage, Md.	1981,85	.0040 - .0920
MON0020	Monocacy River, Md. Route 28	1984	.0040
MON0138	Monocacy River, Md. Route 355	1983,84	.0060 - .0080
MON0269	Monocacy River, Briggs Ford Road, Md.	1983,84	.0040 - .0110
MON0528	Monocacy River, USGS Gage 01639000, Md.	1984	.0060
POT1830	Potomac River, USGS Gage 01618000, Md.	1983	.0040 - .0060
ANT0203	Antietam Creek, near Funkstown, Md.	1983-85	.0050 - .0080
ANT0354	Antietam Creek, Md. Route 60	1984	.0090
CON0005	Conococheague Creek, Md. Route 68	1983	.0040 - .0090
TOW0013	Town Creek, Md. Route 51	1983	.0040
WVOP004[2]	Opequon Creek, 25 miles above mouth, W.Va.	1981	.03
WVSH006[2]	Shenandoah River, Shannondale Ferry, W.Va.	1983	.02
WVSB008[2]	South Fork South Branch Potomac River, Moorefield, W.Va.	1983-84	.02 - .039
WVSB009[2]	South Branch Potomac River, Springfield, W.Va.	1983	.01
2210	East Potomac River, Washington, D.C.	1987	.0157
	Methoxychlor		
2210	East Potomac River, Washington, D.C.	1987	0.00482
	Mirex		
2210[3]	East Potomac River, Washington, D.C.	1987	0.00224
3313[3]	Opequon Creek, Bedington, W.Va.	1987	0.00083
	PCA		
2210	East Potomac River, Washington, D.C.	1987	0.0259
3147	Potomac River, Potomac Park, North of Wilson Bridge	1987	.00659
3313[3]	Opequon Creek, Bedington, W.Va.	1987	.00062
3317[3]	Potomac River, North Branch, Westernport, Md.	1987	.00178
Potomac River, Little Falls, Md.		1984	.01

Table 17. Concentrations of pesticides equal to or greater than reporting limits in whole-fish tissue samples, Potomac River Basin, 1972 to 1992--Continued

[mg/kg, milligrams per kilogram; USGS, U.S. Geological Survey; BHC, Benzene hexachloride; DDT, dichloro-diphenyl-trichloroethane; DDE, dichlorodiphenyldichloroethylene; DDD, dichlorodiphenyldichloroethane; HCB, Hexachlorobenzene; PCA, Pentachloranisol]

Site identification number	Site name[1] as reported by investigating agency	Year(s) reported	Range in concentration (mg/kg)
	Toxaphene		
MON0020	Monocacy River, Md. Route 28	1981	0.269
MON0138	Monocacy River, Md. Route 355	1981	.240
WVSH006[2]	Shenandoah River, Shannondale Ferry, W.Va.	1983	.23
WVSB009[2]	South Branch Potomac River, Springfield, W.Va.	1983	.04
FWS0006[2]	Potomac River, Little Falls, Md.	1977,79,81,84	.10 -.60

[1]Site names for some sites were abstracted from site location descriptions provided by investigating agency.
[2]Not actual site number used by investigating agency, the actual site number was not available.
[3]Concentration of pesticide or related compound in whole-fish tissue sample is below reporting limit, but was quantified and reported by investigating agency.
[4]Reported value exceeds the highest calibration standard for the investigating agency's analysis for this pesticide or related compound.
[5] Site number is abbreviated to facilitate entry into table. The actual site number is 1BNFS000.69.

The five pesticides and their related compounds that were most often greater than their reporting limits and were reported at the greatest number of sites in whole-fish samples were chlordane, DDT, dieldrin, BHC and heptachlor. In the remainder of this report, the term "chlordane" is used to include chlordane and its related compounds, *cis*-chlordane, trans-chlordane, *cis*-nonachlor, trans-nonachlor, nonachlor, and oxychlordane, singly or in combinations. DDT is used to include DDT and its related compounds, DDE, DDD, o,p'-DDT, p,p'-DDT, o,p'- DDE, p,p'-DDE, o,p'-DDD, and p,p'-DDD, singly or in combinations. Heptachlor is used to include heptachlor and its related compound, heptachlor epoxide, singly or in combinations. BHC is used to refer to γ-BHC and its related compounds, α-BHC, β-BHC, and δ-BHC, singly or in combinations. Aldrin, chlorpyrifos, dacthal, endosulfan, endosulfan II, endosulfan sulfate, endrin, endrin aldehyde, HCB, isodrin, methoxychlor, mirex, PCA, and toxaphene either were reported in none or only a relatively few analyses and will not be described in great detail here (table 16). Several other pesticides were analyzed as part of special studies in four or less samples and were not greater than reporting limits. These pesticides have not been included in this report.

Of the five most reported pesticides in whole-fish samples, chlordane was reported at the greatest number of sites and analyses for the individual compounds. Chlordane was reported at 35 of the 48 sites sampled and in 277 of 499 analyses for the individual compounds (tables 16 and 17). Chlordane was reported at sites throughout much of the Potomac River Basin, most often as total chlordane (table 17). Chlordane was reported in sites all along the mainstem Potomac River and at all but one site in the Monocacy River Basin (fig. 10). Chlordane was also reported at sites in parts of the North and South Branch Potomac River Basins, as well as at sites in the Northeast Branch Anacostia River, Anacostia River, and Rock Creek near Washington, D.C., Antietam, Town, and Conococheague Creeks draining portions of Maryland and Pennsylvania, Opequon Creek in West Virginia, and the lower Shenandoah River.

DDT was the pesticide reported at the second highest number of sites in whole-fish tissue samples in the Potomac River Basin. DDT was

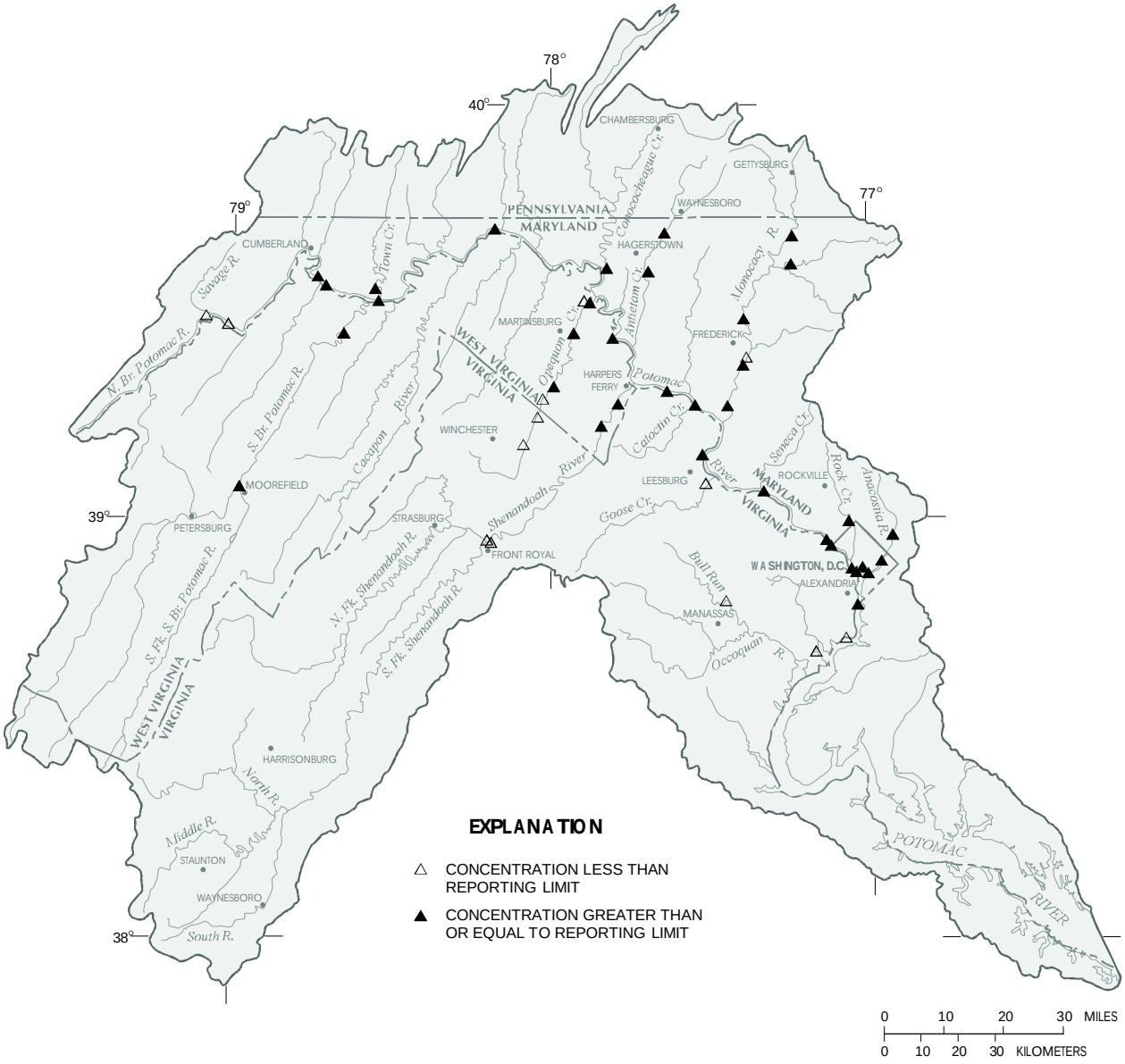


Figure 10. Locations of sampling sites where chlordane was analyzed and reported in whole-fish tissue in the Potomac River Basin.

reported at 33 of 48 sites sampled and in 179 of 870 analyses performed for the individual compounds, usually as some form of DDE (tables 16 and 17). DDT was reported at sites along the middle and lower mainstem Potomac River and nearly all sites in the Monocacy River Basin (fig. 11). DDT was also reported at sites in the North and South Branch Potomac River Basins, as well as the Northeast Branch Anacostia and mainstem Anacostia Rivers near Washington, D.C., Antietam, Town, and Conococheague Creeks draining portions of Maryland and Pennsylvania, Opequon Creek in West Virginia, and at sites in the North Fork Shenandoah River and the lower portions of the Shenandoah River.

Dieldrin was reported at the third highest number of sites in whole-fish tissue samples in the Potomac River Basin. Dieldrin was reported at 26 of 48 sites sampled and in 84 of 266 analyses performed (tables 16 and 17). Dieldrin was reported at sites along the middle and lower mainstem Potomac River and all but one site in the Monocacy River Basin (fig. 12). Dieldrin was also reported in the Northeast Branch Anacostia River, Anacostia River, and Rock Creek near Washington, D.C., Antietam, and Conococheague Creeks draining parts of Maryland and Pennsylvania, and Opequon Creek in West Virginia.

BHC was the pesticide reported at the fourth highest number of sites in whole-fish tissue samples in the Potomac River Basin. BHC was reported at 24 of 43 sites sampled and in 95 of 542 analyses performed for the individual compounds, most often as α-BHC (tables 16 and 17). BHC was reported at most of the sites along the mainstem Potomac River and all but one site in the Monocacy River Basin (fig. 13). BHC was reported at two sites in the North Branch Potomac River and one site in the South Branch Potomac River Basin, as well as at sites in the Northeast Branch Anacostia River, Antietam, Town, and Conococheague Creeks draining portions of Maryland and Pennsylvania, Opequon Creek in West Virginia, and the lower Shenandoah River.

Heptachlor was the pesticide reported at the fifth highest number of sites in whole-fish tissue samples in the Potomac River Basin. Heptachlor was reported at 17 of 43 sites sampled and in 37 of 347 analyses performed for the individual compound, usually as heptachlor epoxide (tables 16 and 17). Heptachlor was reported at several sites along the mainstem Potomac River and at all but two sites in the Monocacy River Basin (fig. 14). Heptachlor was reported at sites in the South Branch Potomac River Basin, Northeast Branch Anacostia River near Washington, D.C., Antietam, Town, and Conococheague Creeks draining portions of Maryland and Pennsylvania, Opequon Creek in West Virginia, and in the lower Shenandoah River.

Fish Fillets

A total of 197 fish-fillet samples were analyzed for up to 34 pesticides and their related compounds from 44 sites in the Potomac River Basin (tables 3, 18, and 19). Of those pesticides and related compounds, 15 were found at concentrations equal to or greater than limits, from 30 of the 44 sites sampled [2] (tables 3, 18, and 19).

The five pesticides and their related compounds that were most often greater than their reporting limits and were reported at the greatest number of sites in fish-fillet samples were chlordane, DDT, dieldrin, BHC, and heptachlor. Aldrin, chlorpyrifos, dacthal, endosulfan, endrin, HCB, methoxychlor, mirex, PCA, and toxaphene were reported in either none or only few analyses and will not be presented here.

Of the five most-reported pesticides in fish-fillet samples, chlordane was reported at the greatest number of sites and analyses for the individual compounds. Chlordane was reported at 27 of 44 sites sampled and in 94 of 275 analyses performed for the individual compounds, usually as total chlordane (tables 18 and 19). Chlordane was reported in most sites along the mainstem Potomac River and in all but one site in the Monocacy River Basin (fig. 15). Chlordane was also reported in sites in the North Branch Potomac River,

2. Pesticides or their related compounds with concentrations in fish-fillet tissue samples less than the reporting limit have been included if considered as a detection of the pesticide or related compound by the investigating agency.

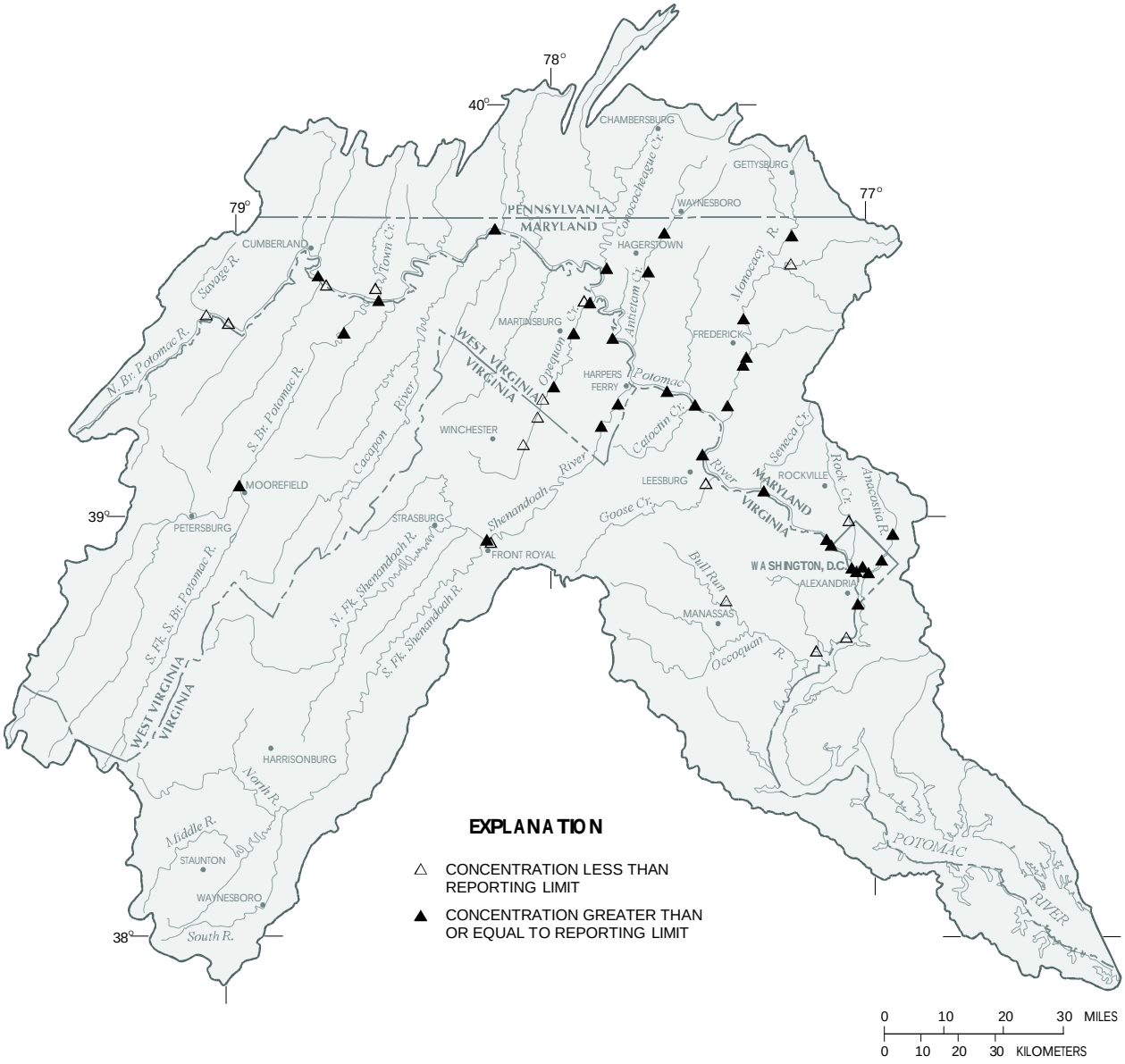


Figure 11. Locations of sampling sites where DDT was analyzed and reported in whole-fish tissue in the Potomac River Basin.

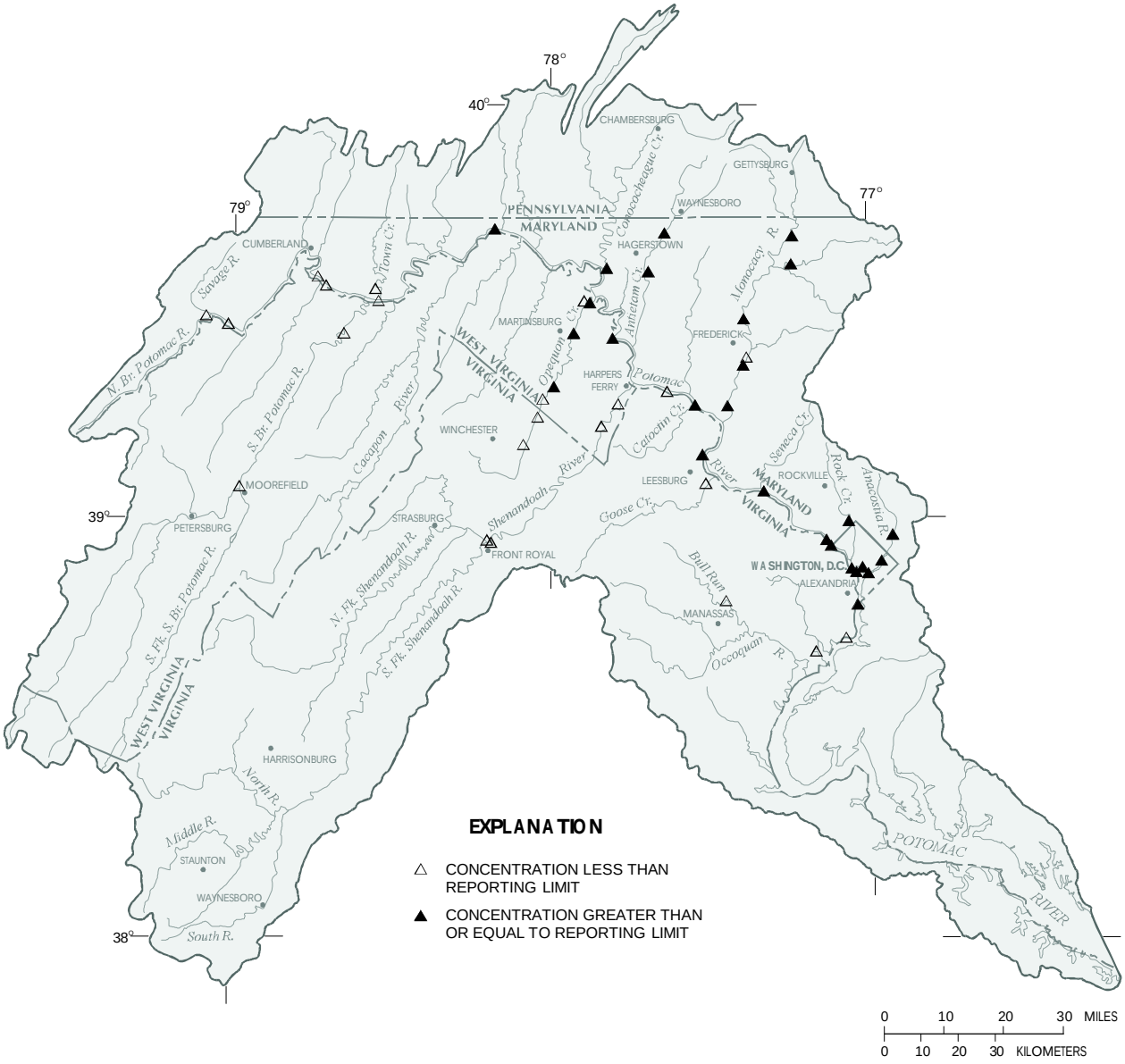


Figure 12. Locations of sampling sites where dieldrin was analyzed and reported in whole-fish tissue in the Potomac River Basin.

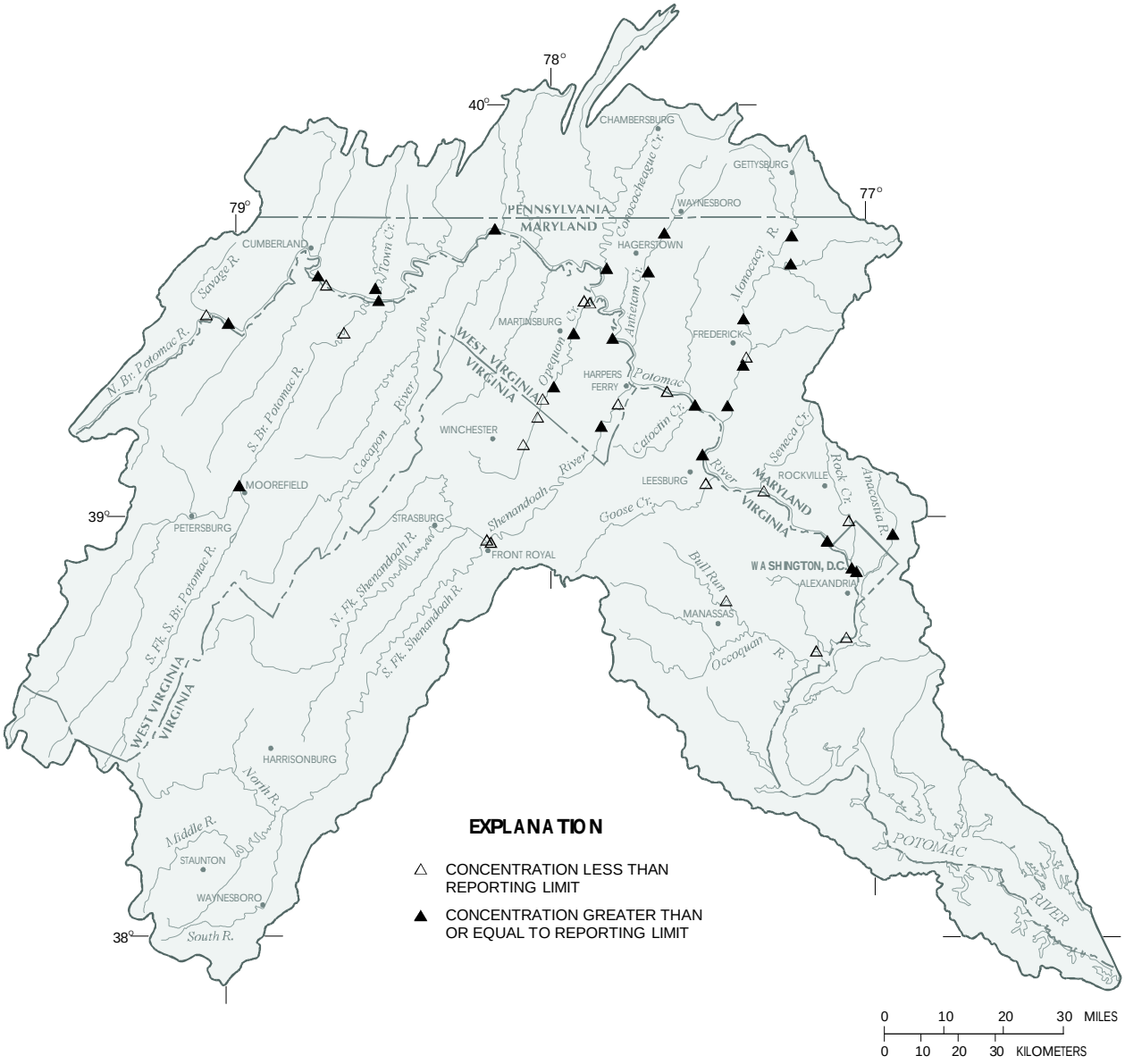


Figure 13. Locations of sampling sites where BHC was analyzed and reported in whole-fish tissue in the Potomac River Basin.

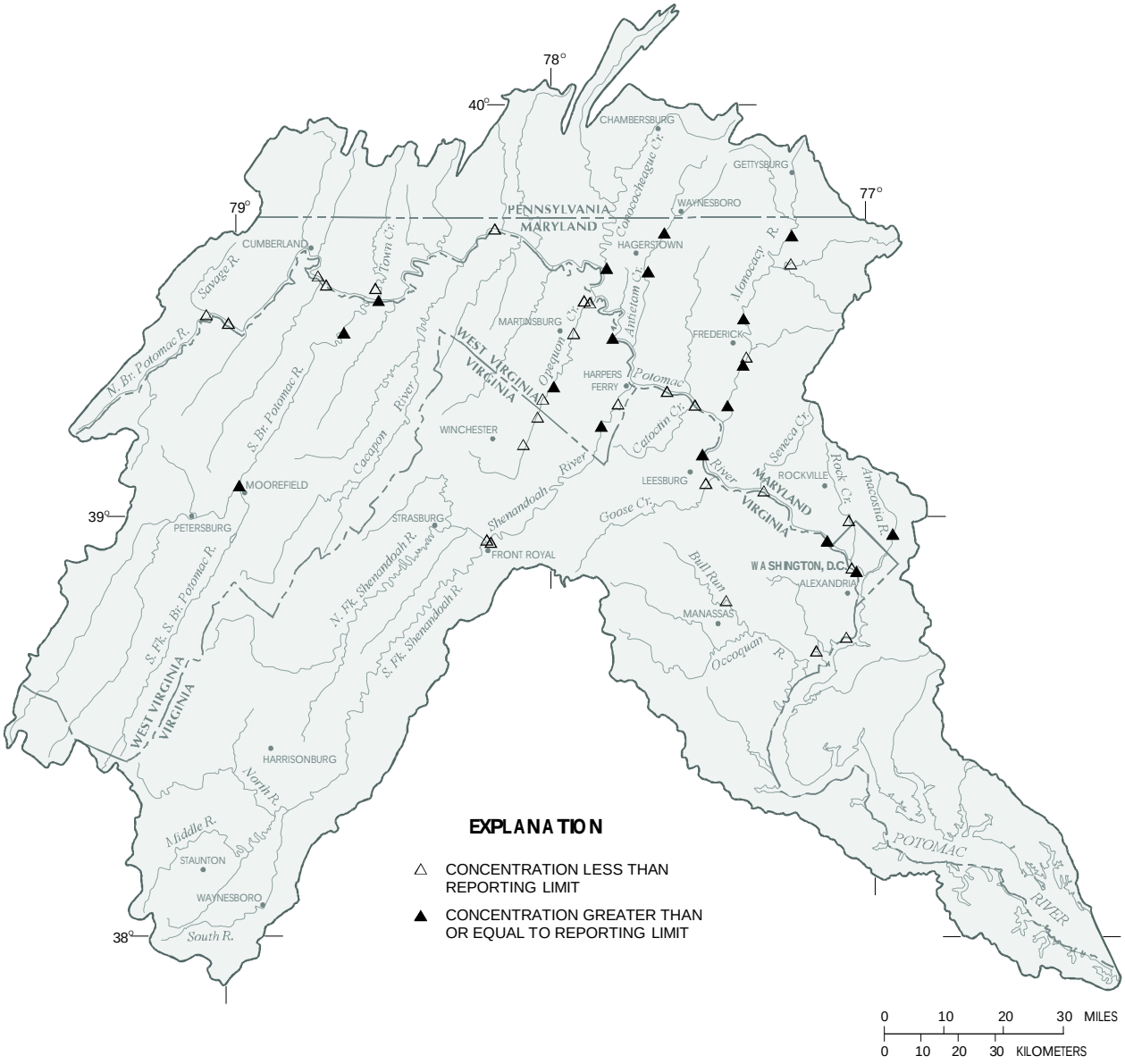


Figure 14. Locations of sampling sites where heptachlor was analyzed and reported in whole-fish tissue in the Potomac River Basin.

Table 18. Summary of analyses for selected pesticides in fish-fillet tissue samples, Potomac River Basin, 1972 to 1990

[mg/kg, milligrams per kilogram; ≥, greater than or equal to; Reporting limits are concentrations at which analyzing laboratories report detection of a pesticide in fish tissue samples. BHC, Benzene hexachloride; DDT, dichloro-diphenyl-trichloroethane; DDE, dichlorodiphenyldichloroethylene; DDD, dichlorodiphenyldichloroethane; HCB, Hexachlorobenzene; PCA, Pentachloranisol]

Pesticide	Number of sites sampled for pesticide[1]	Total analyses performed for each pesticide	Reporting limit (mg/kg)	Analyses with concentrations ≥ reporting limit[2]
Aldrin	20	47	0.002, .005, .01,.1	0
α-BHC	21	74	.002, .0025, .005, .01 ,.1	16
γ-BHC (lindane)	29	94	.002, .0025, .005, .01	3
Chlordane	34	182	.01, .1, .5, 1.0	68
Cis-chlordane	10	15	.0025, .005, .02, .05	4
Trans-chlordane	10	15	.0025, .005, .01, .02	7
Nonachlor	8	20	.1	0
Cis-nonachlor	10	15	.0025, .005, .01, .02	5
Trans-nonachlor	8	13	.0025, .01, .02	9
Oxychlordane	10	15	.0025, .005, .01, .02	1
Total chlordene	4	4	.005, .02	0
α-Chlordene	4	4	.008, .02	0
γ-Chlordene	4	4	.005, .02	0
Chlorpyrifos	9	21	.0025, .1	0
Dacthal	16	69	.002, .009	0
DDT	24	89	.02, .1	0
o,p'-DDT	2	2	.04	0
p,p'-DDT	9	14	.04, .01	3
DDE	24	89	.07, .1	21
o,p'-DDE	2	2	.02	0
p,p'-DDE	10	15	.0025, .01, .02	11
DDD	24	89	.04, .1	0
o,p'-DDD	2	2	.02	0
p,p'-DDD	9	14	.01, .02	7
Dieldrin	34	104	.001, .0025, .007, .01, .02 ,.1	19
Endosulfan	24	89	.002,. 004, .007, .1	0
Endrin	34	104	.001, .0025, .004, .01, .02, .1	0
HCB	17	44	.002, .0025, .1	0
Heptachlor	21	48	.001, .0025, .005, .01, .1	0
Heptachlor epoxide	29	94	.002, .0025, .004, .005, .01, .1	14
Methoxychlor	29	94	.0025, .05, .1	0
Mirex	27	92	.0025, .02, .05, .1	0
PCA	9	21	.0025, .01	0
Toxaphene	24	89	.23, .5, 1.0	3
Total				191

[1] Fish-fillet tissue was sampled at a total of 44 sites in the Potomac River Basin. Analyses for multiple compounds were often conducted on a single fish-fillet sample from a site.

[2] Pesticides or their related compounds with concentrations in fish-fillet samples less than the reporting limit have been included if considered as a detection of the pesticide or related compound by the investigating agency.

Table 19. Concentrations of pesticides equal to or greater than reporting limits in fish-fillet tissue samples, Potomac River Basin, 1972 to 1990

[mg/kg, milligrams per kilogram; USGS, U.S. Geological Survey; BHC, Benzene hexachloride; DDT, dichloro-diphenyl-trichloroethane; DDE, dichlorodiphenyldichloroethylene; DDD, dichlorodiphenyldichloroethane]

Site identification number	Site name[1] as reported by investigating agency	Year(s) reported	Range in concentration (mg/kg)
	α-BHC		
RCM0111	Rock Creek, Md. Route 410	1984	0.0040
MON0020	Monocacy River, Md. Route 28	1981	.0020
MON0528	Monocacy River, USGS Gage 01639000, Md.	1984,87	.0020-.0030
BPC0035	Big Pipe Creek, Md. Route 194	1981	.0030
POT1830	Potomac River, USGS Gage 01618000, Md.	1981	.0040
ANT0354	Antietam Creek, Md. Route 60	1984	.0020-.0050
CON0005	Conococheague Creek, Md. Route 68	1981	.0030
	γ-BHC (lindane)		
RCM0111	Rock Creek, Md. Route 410	1984	0.2420
MON0138[2]	Monocacy River, Md. Route 355	1987	.0010
MON0528[2]	Monocacy River, USGS Gage 01639000, Md.	1987	.0010
	Chlordane		
POT1471[3]	Potomac River, at eastern terminus of Whites Ferry, Md.	1981	0.016-0.105
RCM0111	Rock Creek, Md. Route 410	1984	.082- .328
POT1661[3]	Potomac River, Md. Route 17	1989	.010- .521
POT1707	Potomac River, US Route 340 Bridge, Md.	1977	.010- .110
MON0020	Monocacy River, Md. Route 28	1981	.014- .142
MON0138	Monocacy River, Md. Route 355	1981,87	.017- .023
MON0155	Monocacy River, Reeds Mill Road, Md.	1989	.115
MON0528	Monocacy River, USGS Gage 01639000, Md.	1981,84,87	.015- .141
BPC0035	Big Pipe Creek, Md. Route 194	1981	.019- .023
POT1830	Potomac River, USGS Gage 01618000, Md.	1981,89	.020- .071
POT2386	Potomac River, USGS Gage 01613000, Md.	1981	.033
ANT0203	Antietam Creek, near Funkstown, Md.	1981	.018
ANT0354	Antietam Creek, Md. Route 60	1984	.051- .132
CON0005	Conococheague Creek, Md. Route 68	1981,89	.016- .084
NBP0085	North Branch Potomac River, at Spring Gap, Md.	1989	.068- .093
WDC0001[3,4]	Potomac River, Fletchers Boathouse, Washington, D.C.	1986	.50
WDC0002[3,4]	Potomac River, Limit Island Marina, Washington, D.C.	1986	1.61
WDC0004[4]	Lower Anacostia River, Washington, D.C.	1986	.05
WDC0005[3,4]	Anacostia River, Benning Road, Washington, D.C.	1986	.05- 1.00
WDC0008[4]	Northeast & Northeast Anacostia River, Confluence, Md.	1986	.09- .17
WDC0010[3,4]	Potomac River, Carder Rocks, Md.	1986	.40
	***Cis*-chlordane**		
3313[2]	Opequon Creek, Bedington, W. Va.	1987	0.00073
FBH[3,5]	Potomac River, Fletchers Boathouse, Washington, D.C.	1987	.098
LA[3,5]	Lower Anacostia River, Washington, D.C.	1987	.22
WB	Potomac River, Wilson Bridge, Md.	1987	.081

Table 19. Concentrations of pesticides equal to or greater than reporting limits in fish-fillet tissue samples, Potomac River Basin, 1972 to 1990--Continued

[mg/kg, milligrams per kilogram; USGS, U.S. Geological Survey; BHC, Benzene hexachloride; DDT, dichloro-diphenyl-trichloroethane; DDE, dichlorodiphenyldichloroethylene; DDD, dichlorodiphenyldichloroethane]

Site identification number	Site name[1] as reported by investigating agency	Year(s) reported	Range in concentration (mg/kg)
	Trans-chlordane		
3313[2]	Opequon Creek, Bedington, W. Va.	1987	0.00203
FBH	Potomac River, Fletchers Boathouse, Washington, D.C.	1987	.048
WSC	Washington Ship Channel, Washington, D.C.	1987	.036
BRA	Anacostia River, Benning Road, Washington, D.C.	1987	.039
LA	Lower Anacostia River, Washington, D.C.	1987	.16
WB	Potomac River, Wilson Bridge, Md.	1987	.032-.053
	***Cis*-nonachlor**		
FBH	Potomac River, Fletchers Boathouse, Washington, D.C.	1987	0.062
WSC	Washington Ship Channel, Washington, D.C.	1987	.024
BRA	Anacostia River, Benning Road, Washington, D.C.	1987	.024
LA	Lower Anacostia River, Washington, D.C.	1987	.082
WB	Potomac River, Wilson Bridge, Md.	1987	.033
	Trans-nonachlor		
3313	Opequon Creek, Bedington, W. Va.	1987	0.00416
FBH	Potomac River, Fletchers Boathouse, Washington, D.C.	1987	.037- .15
WSC	Washington Ship Channel, Washington, D.C.	1987	.020- .033
BRA	Anacostia River, Benning Road, Washington, D.C.	1987	.017
LA	Lower Anacostia River, Washington, D.C.	1987	.16
WB	Potomac River, Wilson Bridge, Md.	1987	.037- .064
	Oxychlordane		
3313[2]	Opequon Creek, Bedington, W. Va.	1987	0.00203
	p,p'-DDT		
FBH	Potomac River, Fletchers Boathouse, Washington, D.C.	1987	0.069
LA	Lower Anacostia River, Washington, D.C.	1987	.051
WB	Potomac River, Wilson Bridge, Md.	1987	.031
	DDE		
POT1471[2]	Potomac River, at eastern terminus of Whites Ferry, Md.	1979,81,89	0.005-0.082
POT1661[2]	Potomac River, Md. Route 17	1989	.019- .132
MON0020	Monocacy River, Md. Route 28	1981	.077
MON0138[2]	Monocacy River, Md. Route 355	1987,89	.006
MON0155[2]	Monocacy River, Reeds Mill Road, Md.	1989	.012- .095
MON0528[2]	Monocacy River, USGS Gage 01639000, Md.	1987,89	.008- .044
CON0005[2]	Conococheague Creek, Md. Route 68	1979-84,89	.006- .072
1BSSF[6]	South Fork Shenandoah River, Route 340, Front Royal, Va.	1988	.11

Table 19. Concentrations of pesticides equal to or greater than reporting limits in fish-fillet tissue samples, Potomac River Basin, 1972 to 1990--Continued

[mg/kg, milligrams per kilogram; USGS, U.S. Geological Survey; BHC, Benzene hexachloride; DDT, dichloro-diphenyl-trichloroethane; DDE, dichlorodiphenyldichloroethylene; DDD, dichlorodiphenyldichloroethane]

Site identification number	Site name[1] as reported by investigating agency	Year(s) reported	Range in concentration (mg/kg)
	p,p'-DDE		
WQN0501	Conococheague Creek, near Worleytown, Pa.	1989	0.022
3313	Opequon Creek, Bedington, W. Va.	1987	.01948
FBH	Potomac River, Fletchers Boathouse, Washington, D.C.	1987	.036-.33
WSC	Washington Ship Channel, Washington, D.C.	1987	.039-.093
BRA	Anacostia River, Benning Road, Washington, D.C.	1987	.076
LA	Lower Anacostia River, Washington, D.C.	1987	.049-.31
WB	Potomac River, Wilson Bridge, Md.	1987	.051-.17
	p,p'-DDD		
FBH	Potomac River, Fletchers Boathouse, Washington, D.C.	1987	0.10
WSC	Washington Ship Channel, Washington, D.C.	1987	.034-.050
BRA	Anacostia River, Benning Road, Washington, D.C	1987	.042
LA	Lower Anacostia River, Washington, D.C.	1987	.14
WB	Potomac River, Wilson Bridge, Md.	1987	.048-.072
	Dieldrin		
POT1471	Potomac River, at eastern terminus of Whites Ferry, Md.	1981	0.0070
RCM0111	Rock Creek, Md. Route 410	1984	.0130-.0170
MON0528	Monocacy River, USGS Gage 01639000, Md.	1984	.007- .0210
POT1830	Potomac River, USGS Gage 01618000, Md.	1981	.0100
ANT0354	Antietam Creek, Md. Route 60	1984	.0120-.0200
TOW0013	Town Creek, Md. Route 51	1981	.007
FBH	Potomac River, Fletchers Boathouse, Washington, D.C.	1987	.031
WSC	Washington Ship Channel, Washington, D.C.	1987	.023
LA	Lower Anacostia River, Washington, D.C.	1987	.052
WB	Potomac River, Wilson Bridge, Md.	1987	.037- .041
	Heptachlor epoxide		
RCM0111	Rock Creek, Md. Route 410	1981,84	0.0040-0.0440
MON0528	Monocacy River, USGS Gage 01639000, Md.	1984	.0040- .0050
ANT0354	Antietam Creek, Md. Route 60	1984	.0040- .0090

Table 19. Concentrations of pesticides equal to or greater than reporting limits in fish-fillet tissue samples, Potomac River Basin, 1972 to 1990--Continued

[mg/kg, milligrams per kilogram; USGS, U.S. Geological Survey; BHC, Benzene hexachloride; DDT, dichloro-diphenyl-trichloroethane ; DDE, dichlorodiphenyldichloroethylene; DDD, dichlorodiphenyldichloroethane]

Site identification number	Site name[1] as reported by investigating agency	Year(s) reported	Range in concentration (mg/kg)
	Toxaphene		
POT1471	Potomac River, at eastern terminus of Whites Ferry, Md.	1981	0.0261
MON0020	Monocacy River, Md. Route 28	1981	.333

[1]Site names for some sites were abstracted from site location descriptions provided by investigating agency.
[2]Concentration of pesticide or related compound in fish-fillet tissue sample is below reporting limit, but was quantified and reported by investigating agency.
[3]Concentration of pesticide in fish-fillet tissue sample exceeds the action level for protection of human health as set forth by the U.S. Food and Drug Administration (Nowell and Resek, 1994).
[4]Not actual site number used by investigating agency; the actual site number was not available.
[5]For this site, all concentrations of chlordane and related compounds must be added to obtain the total concentration value in the fish-fillet tissue sample that exceeds the U.S. Food and Drug Administration's action level for protection of human health, to include chlordane, cis-chlordane, trans-chlordane, cis-nonachlor, trans-nonachlor, and oxychlordane. The individual values for each compound must be quantified to 0.02 parts per million before their values can be added (Nowell and Resek, 1994).
[6]Site number is abbreviated to facilitate entry into table. The actual site number is 1BSSF019.30.

Anacostia River, and Rock Creek near Washington, D.C., Antietam, and Conococheague Creeks draining portions of Maryland and Pennsylvania, and Opequon Creek in West Virginia.

Chlordane was the only pesticide or related compound analyzed in fish-fillet samples in the Potomac River Basin that exceeded existing Food and Drug Administration (FDA) standards for the protection of human health in edible portions. The standard for chlordane is 0.3 mg/kg (Nowell and Resek, 1994). Chlordane exceeded the FDA standard for the protection of human health at eight sites. All but one of the sites were located on the lower Potomac River, Anacostia River or Rock Creek at or near Washington, D.C. (table 19, figure 15). The remaining site, was located on the Potomac River upstream of Washington, D.C.

The District of Columbia Department of Consumer and Regulatory Affairs issued a health advisory in 1989 to encompass the portions of the Potomac River, Anacostia River, Rock Creek, and their tributaries within the District of Columbia, due to "PCB's and other contaminants" (H. Karimi, District of Columbia Department of Consumer and Regulatory Affairs, written commun., 1994). The 1989 health advisory limited consumption of catfish, carp, or eel to a half pound per week, without limits on other fish species. The District of Columbia Department of Consumer and Regulatory Affairs has recently updated the 1989 health advisory, and advises that no catfish, carp, or eel be consumed and to limit consumption of largemouth bass to one half pound per month, or one half pound of sunfish or other fish per week (H. Karimi, District of Columbia Department of Consumer and Regulatory Affairs, written commun., 1994).

DDT was the pesticide reported at the second highest number of sites in fish-fillet samples in the Potomac River Basin. DDT was reported at 15 of 34 sites sampled and in 42 of 316 analyses performed for the individual compounds, usually as some form of DDE (tables 18 and 19). DDT was reported at sites in the middle and lower mainstem Potomac River and at four sites in the Monocacy River Basin (fig. 16). DDT was also reported in the Anacostia River near Washington, D.C., Conococheague Creek draining portions of Maryland and Pennsylvania, Opequon Creek in West Virginia, and South Fork Shenandoah River.

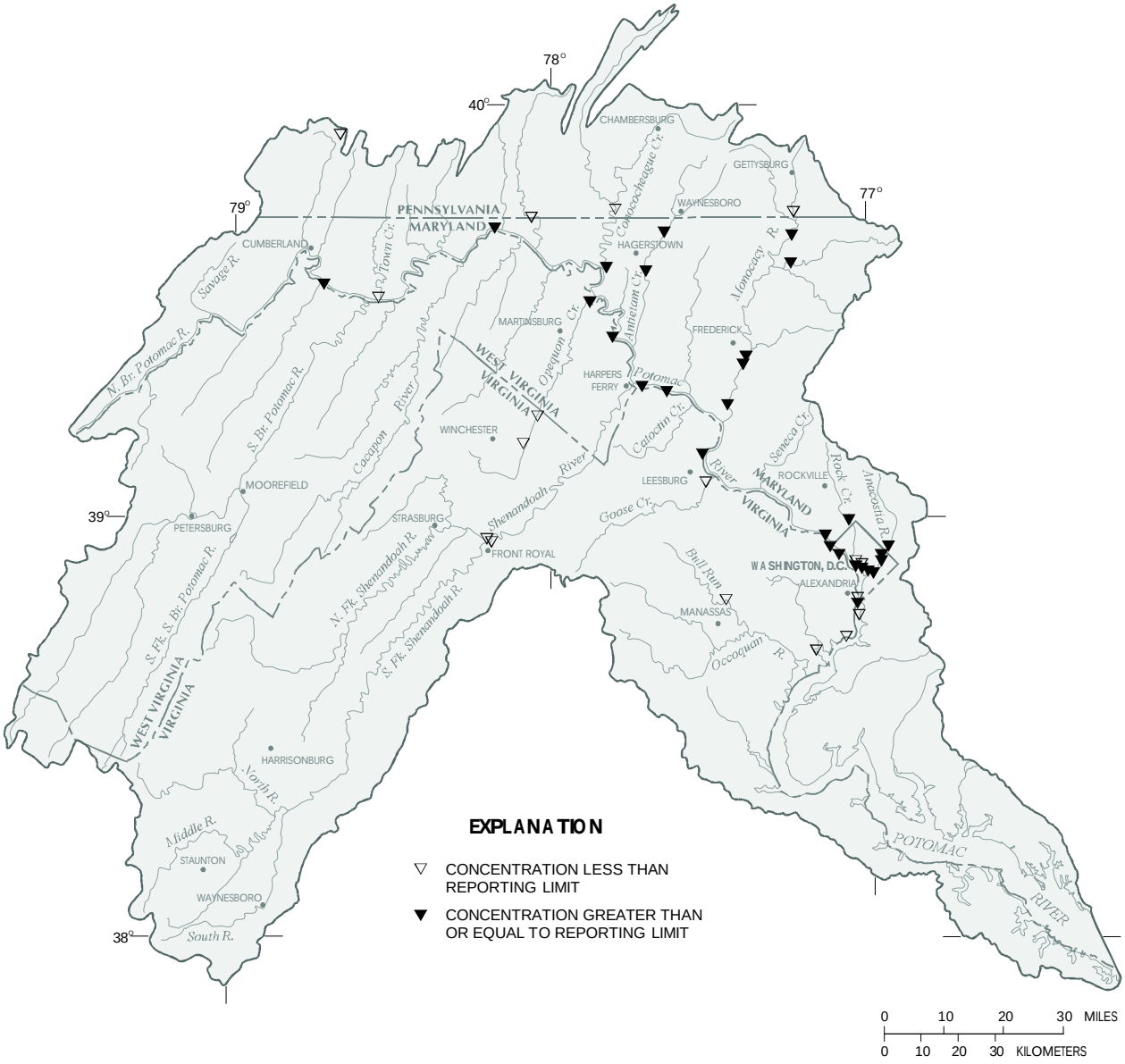


Figure 15. Locations of sampling sites where chlordane was analyzed and reported in fish-fillet tissue in the Potomac River Basin.

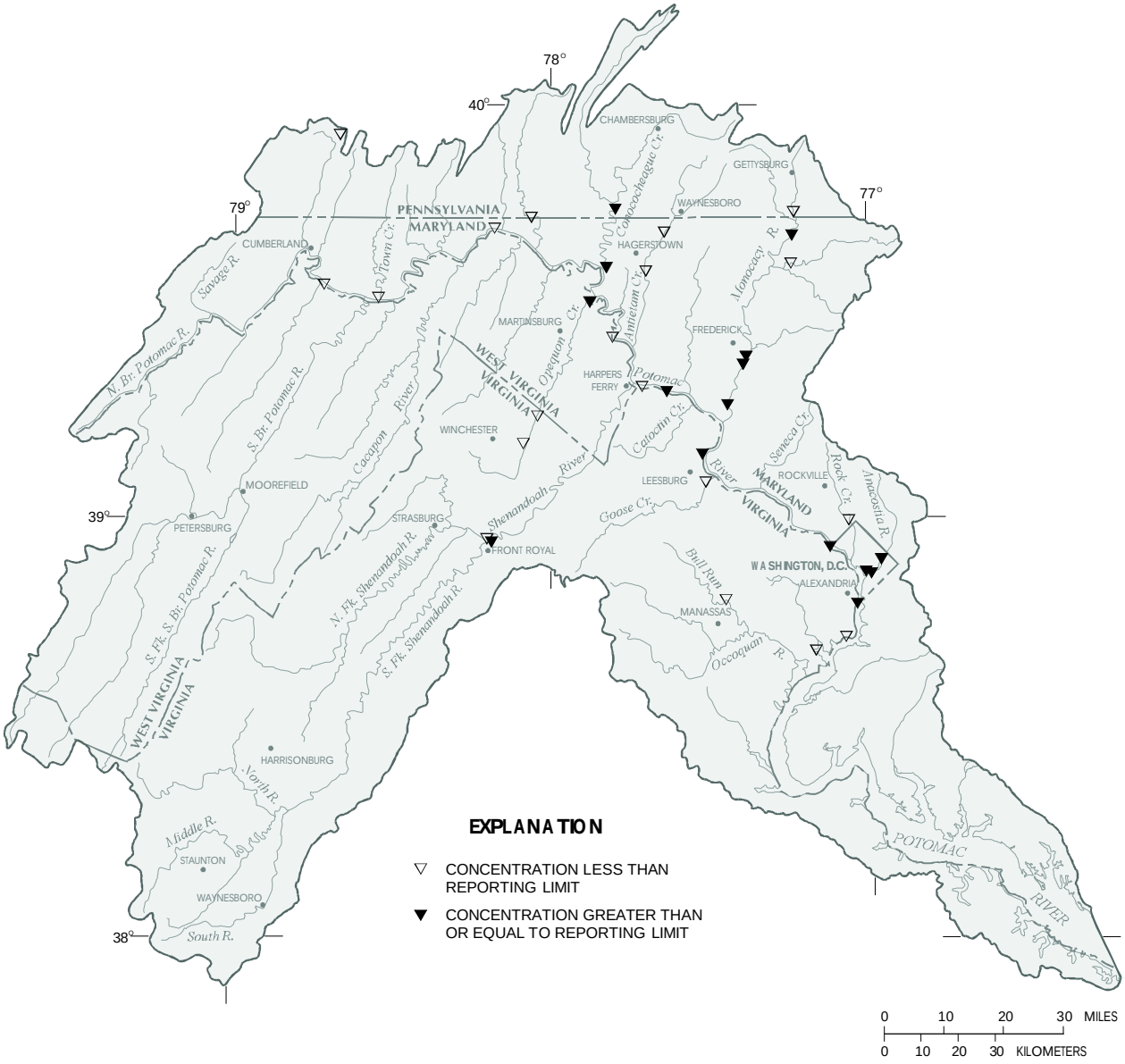


Figure 16. Locations of sampling sites where DDT was analyzed and reported in fish-fillet tissue in the Potomac River Basin.

Dieldrin was the pesticide reported at the third highest number of sites in fish-fillet samples in the Potomac River Basin. Dieldrin was reported at 10 of 34 sites sampled and in 19 of 104 analyses performed (tables 18 and 19). Dieldrin was reported at sites in the middle and lower Potomac River (fig. 17). Near Washington, D.C., dieldrin was reported in the lower Anacostia River and Rock Creek. Dieldrin was reported at one site in the Monocacy River Basin, and at Antietam and Town Creeks draining portions of Maryland and Pennsylvania.

BHC was the pesticide reported at the fourth highest number of sites in fish-fillet samples in the Potomac River Basin. BHC was reported at 8 of 29 sites sampled and in 19 of 168 analyses performed for the individual compounds (tables 18 and 19). BHC was most often reported as α-BHC (tables 18 and 19). BHC was reported at one site in the mainstem Potomac River (fig. 18). BHC was also reported at four sites in the Monocacy River Basin, in Rock Creek near Washington, D.C., and Antietam and Conococheague Creeks draining portions of Maryland and Pennsylvania.

Heptachlor was the pesticide reported at the fifth highest number of sites in fish-fillet samples in the Potomac River Basin. Heptachlor was reported 3 of 29 sites sampled and in 14 of 142 analyses performed for the individual compounds, as heptachlor epoxide (tables 3, 18 and 19). Heptachlor was reported in the Monocacy River Basin, Antietam Creek draining parts of Maryland and Pennsylvania, and in Rock Creek near Washington, D.C. (fig. 19).

Evaluation of Existing Pesticide Data Coverage

If pesticide concentration data for surface water, bottom material, ground water, and fish tissue exist on sufficient spatial and temporal scales, the data can be used for problem identification, comparison with national conditions, detection of differences between major basin subunits, and detection of trends. The assessment of the current status of water quality is a primary goal of NAWQA and the Potomac River Basin study unit. Because the uncontrolled presence of pesticides in the environment is almost always of concern, it can be said that a problem exists wherever pesticides are detected in water, bottom material, or fish tissues. Usually, however, problems are defined by comparison with a regulatory standard or other environmental benchmark. Comparisons with national conditions or between regions or other landscape subunits also helps in the definition of water-quality status. Trends detection, on the other hand, requires data from multiple samples over time for a single location.

Objective definition of water-quality problems due to pesticides in the Potomac River Basin using the available data is difficult because of differing approaches to data collection, laboratory analysis, and data management, and because regulatory standards or other satisfactory benchmarks are not available for many pesticides. Rather, discussion in this report is limited to an assessment of the usefulness of existing data for making these determinations. Comparisons with national conditions will be done by the NAWQA Pesticides National Synthesis Project. Comparisons between major basin subunits and the ability to detect trends will be addressed in the sections that follow. However, an important result of this evaluation is to identify gaps in the current knowledge of pesticides in the Potomac River Basin of future planning for NAWQA and similar activities.

Surface Water and Bottom Material

Most surface-water and bottom-material sampling has been associated with targeted studies, with a focus on the Shenandoah River, Opequon Creek, Conococheague Creek, Antietam Creek, and Monocacy River Basins, the mainstem Potomac River at Washington, D.C., and on Virginia streams tributary to the Potomac Estuary (fig. 3). There are few data available from the North and South Branches Potomac River, none for the Cacapon River, and none for Pennsylvania streams, although some bottom-material samples were collected at or downstream of the Pennsylvania State Line in Maryland (fig. 3). Also, no surface-water or bottom-material data were found for Maryland south of Washington, D.C.

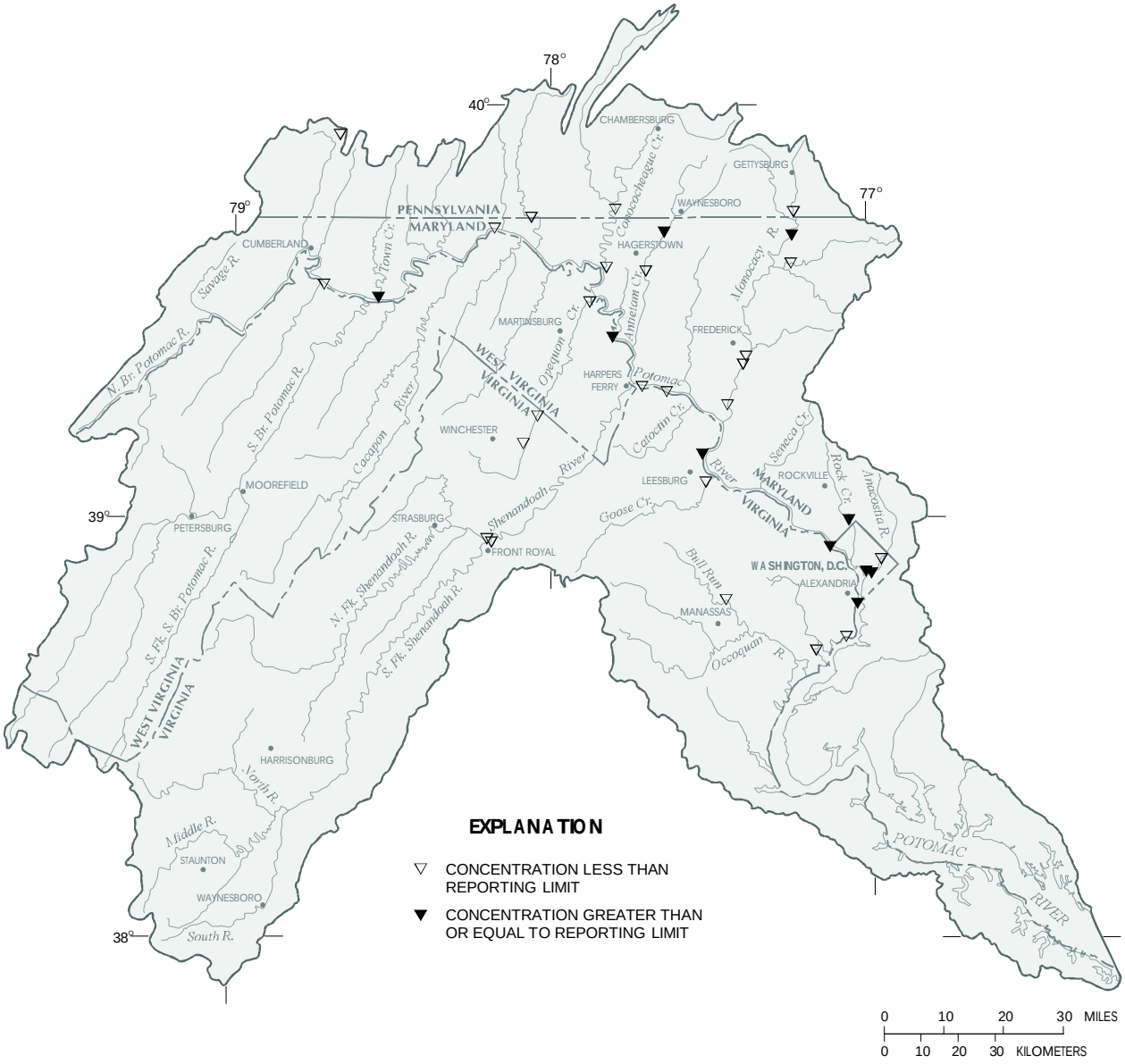


Figure 17. Locations of sampling sites where dieldrin was analyzed and reported in fish-fillet tissue in the Potomac River Basin.

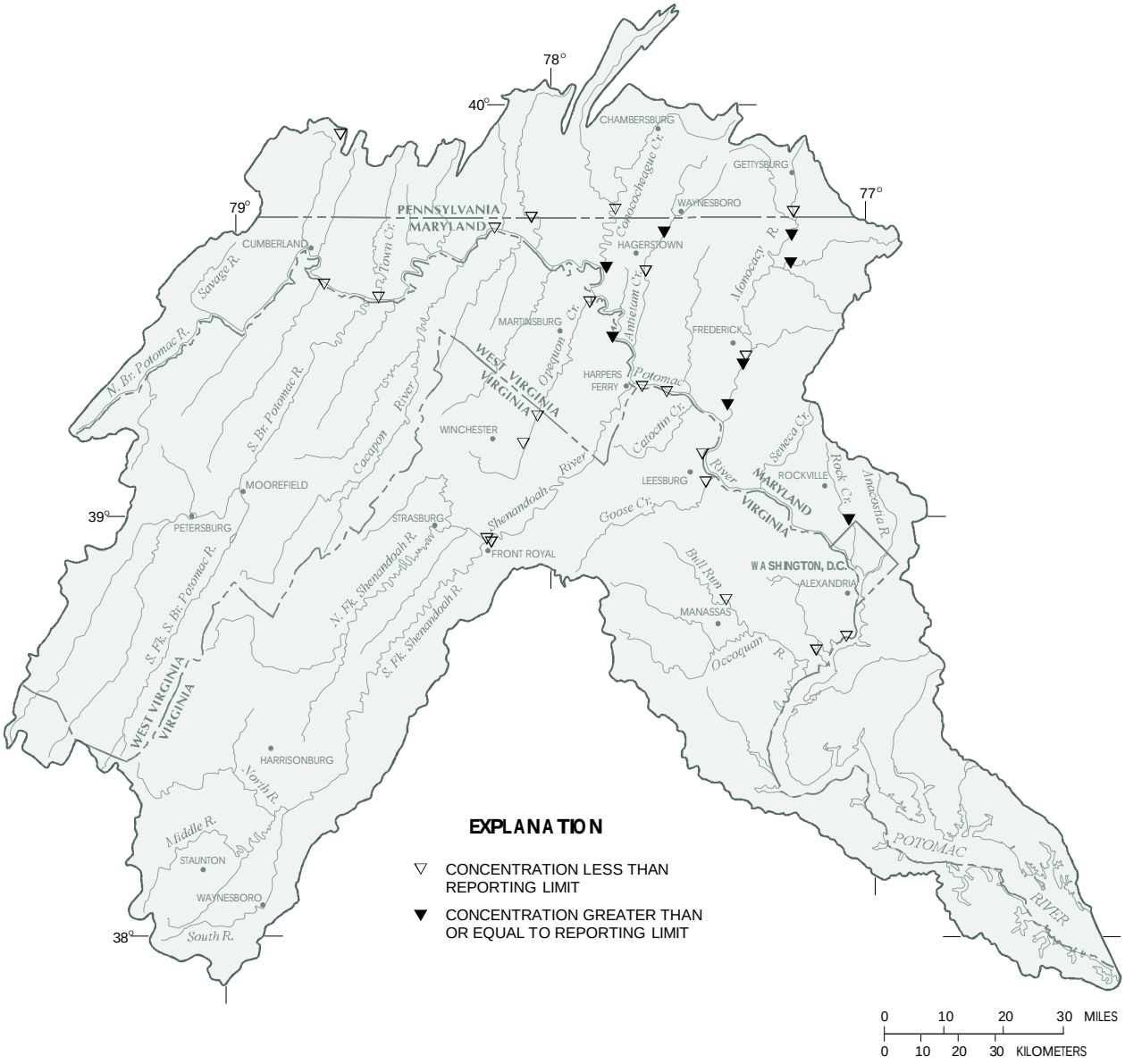


Figure 18. Locations of sampling sites where BHC was analyzed and reported in fish-fillet tissue in the Potomac River Basin.

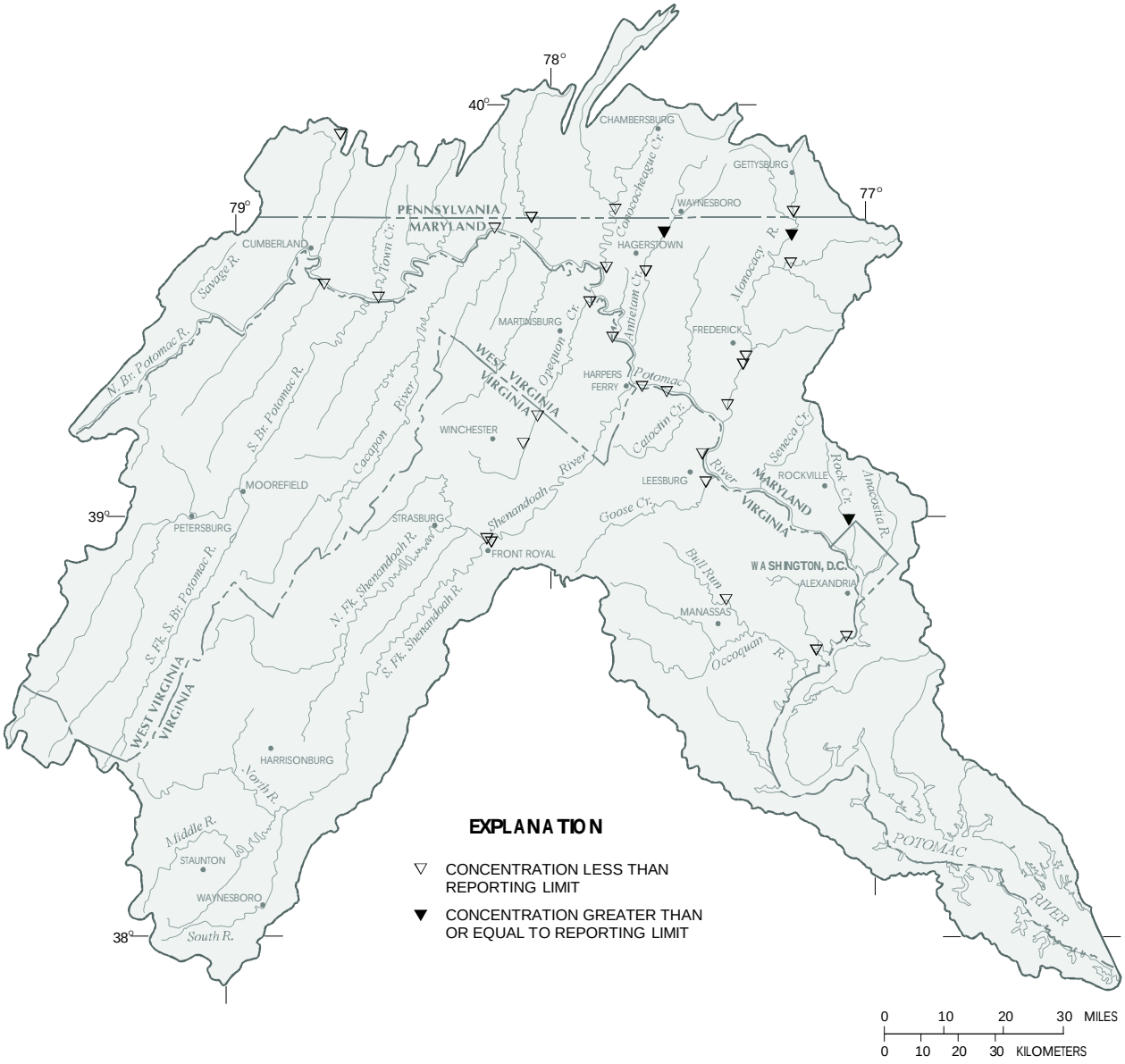


Figure 19. Locations of sampling sites where heptachlor was analyzed and reported in fish-fillet tissue in the Potomac River Basin.

With the notable exception of the Frederick and Washington County studies in Maryland (Dine and others, 1985; Duigon and others, 1989) and the longer-term data for Virginia streams tributary to the Potomac Estuary, most surface-water and bottom-material samples were collected prior to 1982, and many of the higher pesticide concentrations reported were for samples collected prior to 1975. Therefore, much of the available data bases are not useful for assessing the current status of water quality. However, the number of higher concentrations reported in these older data for the Shenandoah River, Opequon Creek, Conococheague Creek, and Antietam Creek Basins; the Potomac River at Washington, D.C.; and for several Virginia streams near Washington, D.C., (tables 7, 9, 11, and 13) may suggest a water-quality problem that should be evaluated.

Concentrations of pesticides in bottom material were reported as greater than laboratory-reporting limits for 11 of 14 streams sampled during 1986 and 1987 in Washington County, Md. (Duigon and others, 1989) and for 3 of 10 streams sampled during 1982 in Frederick County, Md. (Dine and others, 1985). The generally higher concentrations, the larger proportion of reported detections, and the more recent sampling of the Washington County streams suggest that there may be current water-quality problems in those and possibly other areas and that further study is needed.

Multiple samples were collected of both surface water and bottom material from Virginia streams tributary to the Potomac Estuary from about 1974 to 1990, mostly beginning in 1979 and ending in 1986. Up to 10 surface-water and 7 bottom-material samples were collected at the same sites over the time period. These data could be useful for the detection of trends for those streams. However, all reported concentrations of pesticides in the STORET data base were equal to or less than laboratory reporting limits. This suggests that there is probably not a current pesticide-related water-quality problem in those streams.

Ground Water

Most ground-water sampling has been associated with county studies, with a focus on the counties near the center of the Potomac River Basin. Because the primary sampling objectives have been to assess water-quality status in those areas rather than to study processes, little, if anything, can be said about ground-water-quality status or processes in other areas. Temporal data are lacking, so identification of trends from existing ground-water data alone is not possible. Contamination of ground-water resources by pesticides is a major environmental issue because problems can persist for many years. Unfortunately, single-sample data on pesticide concentrations in ground water only identify an existing problem, whereas data from samples taken over time can be used to track the fate or migration of contaminants or to assess the efficacy of remediation programs. Information on ground-water-quality processes is needed to better predict the impact of management practices on the resource throughout the Potomac River Basin.

On the basis of the preceding discussion, it would not be correct to say that existing pesticide data coverage in ground water is inadequate for assessment of water-quality status. Each individual well or spring measurement adequately represents the status for its local area. Samples from groups of wells can be used to characterize their common aquifer, if one exists, or the conditions that sampling efforts were designed to assess. However, no known previous sampling effort was designed to assess basinwide ground-water quality. In general, knowledge about subsurface flow systems in the basin and existing pesticide data are inadequate for developing information on these flow systems and processes within flow systems, except in areas where special studies have been conducted, such as those by Mostaghimi and others (1989) in a small, Coastal Plain watershed. Generally, existing data are also inadequate for determining trends in those areas where problems are known to exist.

Fish Tissue

Of the 48 sites sampled for whole fish, at least 27 sites have been sampled in only 1 year during the 19 years covered by this report. Eight sites have been sampled in only 2, 3, or 4 different years. Only 13 sites have been sampled more than 4 years. Several of the sites with 4 or more years of data have some inconsistencies in the species collected, differences in the number of fish composited in the samples, and often differences in the sizes of the individual(s) comprising samples (Block and others, 1990; J. Gregory, Virginia Department of Environmental Quality, written and oral commun., 1993; Murphy, 1988; Schmitt and others, 1990; J. Smithson, West Virginia Department of Natural Resources, written and oral commun., 1993; U.S. Environmental Protection Agency, 1992b,c). These inconsistencies can affect concentration data through different bioaccumulation rates associated with different species, sizes and ages of fish, and variability associated with different sample sizes, making trend analysis difficult at most Potomac River Basin sites (Murphy, 1988; Crawford and Luoma, 1993).

Comparison of whole-fish tissue concentration data between and among sites may also be difficult. As with trend analysis, differences in the species collected at individual sites, in the number of fish comprising the samples, and in the size of the fish in individual samples, impede site comparisons. Also, differences in field and laboratory processing methods and reporting limits affect the ability to compare between sites. Some of the whole-fish samples had their skin or scales removed, whereas others had scales or skin intact, for a particular species collected (Block and others, 1990; J. Gregory, Virginia Department of Environmental Quality, written and oral commun., 1993; Murphy, 1988; Schmitt and others, 1990; J. Smithson, West Virginia Department of Natural Resources, written and oral commun.,1993; U.S. Environmental Protection Agency, 1992b, c). In many species, the skin has a relatively high fat content and may contain substantial amounts of a selected pesticide. The reporting limit for individual compounds sometimes differed widely. For example, the reporting limit for *cis*-chlordane differed from 0.0025 to 0.05 mg/kg in the whole-fish samples with *cis*-chlordane reported (table 18). These differences can be potentially misleading when comparing concentration data between different geographical areas, as one site may have a greater potential for detection of a particular contaminant than another with similar contamination limits.

The geographical distribution of whole-fish sampling sites in the Potomac River Basin is somewhat limited. Many whole-fish sites are located along the mainstem Potomac River and near Washington, D.C. (fig. 6). Many of the major tributaries to the Potomac River also have whole-fish sites located on them, but the sites are usually located in the middle and lower portions of their drainage basins. Sites are generally missing from the upstream portions of many of the major tributaries to the Potomac River, such as in the South Branch Potomac River, the North and South Forks Shenandoah River, the Anacostia River Basin, and the Cacapon River Basin. Only a few of the smaller streams in the Potomac River Basin have been sampled, usually as part of special contaminant studies. In addition, many of the sites are located near urbanized areas or areas of known contamination, as part of state "core" monitoring networks or studies of compounds of local concern.

Some of the pesticides and their related compounds were analyzed on a limited geographical basis. Sites that were part of the state "core" monitoring networks tend to have a large suite of analyses performed on whole-fish samples collected at them. Sites that were part of special studies may have had samples analyzed for a limited number of compounds of local concern. For example, the sites sampled by the District of Columbia Department of Consumer and Regulatory Affairs, were analyzed for chlordane and PCB's only. Also, some sites were sampled as part of national surveys and are the only sites with analyses for a particular compound in the Potomac River Basin.

Many of the same conditions apply to fish-fillet samples in the Potomac River Basin. Trend analysis is probably only possible at a few sites, if

at all. At least 36 of the 44 sites have only been sampled once between 1972 and 1990. Those that have had fish-fillets sampled more than once often have inconsistencies in the species and sizes of the fish collected, and in the number of individuals comprising the samples (Block and others, 1990; R. Frey, Pennsylvania Department of Environmental Protection, written and oral commun., 1993; J. Gregory, Virginia Department of Environmental Quality, written and oral commun., 1993: Murphy, 1988; Sommerfield and Cummins, 1989; U.S. Environmental Protection Agency, 1992b, c).

Comparisons of fish-fillet samples between and among sites are also difficult, because the various agencies used different species of fish, different sizes of fish at different sites, and different numbers of individual fish per sample. Also, differences in field and laboratory methods exist among many sites, as well as differences in reporting limits by different agencies (Block and others, 1990; R. Frey, Pennsylvania Department of Environmental Protection, written and oral commun., 1993; J. Gregory, Virginia Department of Environmental Quality, written and oral commun., 1993: Murphy, 1988; Sommerfield and Cummins, 1989; U.S. Environmental Protection Agency, 1992b, c) (table 4).

The geographical distribution of fish-fillet sampling sites is more limited than that for whole-fish sites (fig. 6). Most of the fish-fillet sites are along the mainstem Potomac River or near Washington, D.C. Other sites are on the middle and lower sections of most of the same large tributaries to the Potomac River as the whole-fish sites. Few fish-fillet sites are in the upper portions of major tributaries and all but a few smaller streams in the Potomac River Basin. Also, state "core" monitoring sites have a large suite of pesticide analyses in fish fillets, whereas sites where fish fillets were sampled as part of studies of local or national concern have limited numbers of compounds.

Multimedia Data Evaluation

Pesticides may be found in surface water or ground water in dissolved form or in association with water-borne sediments, in bottom material, or in fish tissue. Pesticides in water are transient phenomena representing transport from some source, whereas pesticides in bottom material or fish tissue are more stable phenomena, representing a point of accumulation and storage. Pesticide chemistry and environmental processes determine the form and ultimate fate of a pesticide. Which media are evaluated in any water-quality investigation depends upon which pesticide, receptor population, or process is of interest. Where water supply or transport processes are of interest, surface and ground water are appropriate media for study. If potential long-term release of persistent pesticides is an issue, bottom materials from streams or lakes are studied. For investigations concerning ecological and human health issues, fish tissues are evaluated.

Surface water, bottom material, ground water, fish, and other biological tissue are included in the NAWQA Program's assessment of the Nation's water quality. Each of these media is important for answering questions of local, regional, or national concern. The interrelations among them are important for understanding processes of transport, transformation, and accumulation of pesticides in the environment. A better understanding of these processes is a long-term goal of NAWQA, because this understanding will enable scientists to extrapolate measurements in one medium to probable pesticide concentrations in another; results from one study area will be more transferable to another area; and more representative modeling will lead to improved decision-making.

Only a few areas in the Potomac River Basin have had samples collected from more than one medium. No comparisons are possible between surface and ground water in any area, but bottom-material/ground-water comparisons are possible in the Conococheague Creek and Antietam Creek Basins in Washington County, Md. Surface-water/bottom-material comparisons can be made in those same two basins, throughout the Shenandoah River and Goose Creek Basins, in the Occoquan River Basin, and at discrete sites on the mainstem Potomac River and on Virginia streams tributary to the Potomac Estuary. Bottom-mate-

rial/fish-tissue comparisons can be made in the Opequon Creek, Conococheague Creek, Antietam Creek, and Monocacy River Basins, and at a number of discrete sites on the mainstem Potomac River, and Anacostia River. Potential for surface-water/bottom-material/fish-tissue comparisons does exist in the Opequon Creek, Conococheague Creek, Antietam Creek, Goose Creek, and Occoquan River Basins, but some surface-water and bottom-material samples in the first three basins do not coincide in time with the tissue samples and may not be comparable.

SUMMARY AND CONCLUSIONS

This report provides a compilation and analysis of available pesticide data for selected environmental media in the Potomac River Basin, as part of the NAWQA objective to describe water-quality status and trends. Available data were analyzed to characterize the occurrence and distribution of pesticides and to evaluate existing pesticide data coverage to guide future data-collection efforts.

The analysis presented in this report addresses available data for pesticides in surface water, bottom material, ground water, and fish tissue. Data considered were limited to those collected after 1971 to reduce problems associated with changes in laboratory methods and to maximize usage of data-collection networks and computer data bases that became common about 1972. Data collected after 1990 were not considered in the evaluation. Available pesticide-concentration data were evaluated for their potential to identify problem areas, to compare with national conditions, to document differences among basin subunits, and to describe trends.

More than 100 pesticides have been used in the Potomac River Basin; 47 pesticides are known to have been used on more than 10,000 acres in the period 1982-87. Residual concentrations of some pesticides have been found in surface water, bottom material, ground water, and fish tissue. Samples have been analyzed for at least 69 pesticides and related compounds in surface water, bottom material, ground water, and fish tissue by local, State, and Federal agencies in the four Potomac River Basin states and the District of Columbia. There are 191 stream sites where surface-water or bottom-material samples have been collected. USGS has collected samples for pesticides in ground water from 87 wells and 32 springs, with very limited data available from other agencies. Fish tissue has been sampled at 63 sites.

The likelihood of a pesticide concentration being greater than laboratory reporting limits in any one analysis of surface water, bottom material, or ground water appears to be slight, with only 1 percent or less of all analyses for the individual compounds reporting detectable concentrations. However, several factors must be considered in the interpretation of these results:

1. The persistence of different pesticide compounds in the environment varies considerably;

2. Sampling-site selection may be biased toward "clean" or "dirty" sites;

3. During the period from 1972 to 1990, pesticide usage patterns, sampling protocols, and laboratory analytical limits have changed greatly.

Sampling by USGS for pesticides in surface water was relatively sparse spatially. In surface-water samples that were collected at seven sites, USGS found occurrences of six pesticides with a concentration greater than the analytical reporting limit. Other agencies collected surface-water samples at 181 sites. Although most of the analyses done by other agencies also determined pesticide concentrations in surface water as equal to or less than reporting limits, concentrations higher than the reporting limits were reported for eight pesticides. Most surface-water pesticide samples with concentrations greater than the reporting limits were collected prior to 1975. Except for a single report of atrazine in 1989, all other samples with reportable concentrations were collected prior to 1985. Many of the elevated concentrations were found in streams in the northern end of the Great Valley, most notably in Opequon, Conococheague, and Antietam Creeks and their tributaries.

In analyses of bottom-material samples, USGS reported 15 pesticides with concentrations greater than reporting limits. Other agencies reported concentrations greater than reporting limits for 8 of the 14 pesticides analyzed in their samples. As with the surface-water samples, many of the bottom-material samples with elevated concentrations were collected in the northern end of the Great Valley. A number of bottom-material samples with elevated concentrations were collected from the Shenandoah River and from streams in Virginia east of the Shenandoah River. Pesticides with elevated concentrations included lindane, chlordane, DDT and its metabolites, and dieldrin.

Most surface-water and bottom-material sampling has been associated with targeted studies, with a focus on Opequon Creek, Conococheague Creek, Antietam Creek, the Shenandoah River, and Monocacy River Basins, the mainstem Potomac River at Washington, D.C., and on Virginia streams tributary to the Potomac Estuary. There are few data available from the North and South Branches of the Potomac River, none for the Cacapon River, and none for Pennsylvania streams, although some bottom-material samples were collected at or downstream of the Pennsylvania State line in Maryland. Also, no surface-water or bottom-material data were found for Maryland south of Washington, D.C.

Because most surface-water and bottom-material samples were collected prior to 1982, and many of the higher pesticide concentrations reported were for samples collected prior to 1975, much of the available data base is not useful for assessing the current status of water quality. However, the number of higher concentrations reported in these older data for Opequon Creek, Conococheague Creek, Antietam Creek, and the Shenandoah River Basins; the mainstem Potomac River at Washington, D.C.; and for several Virginia streams near Washington, D.C., suggests a previous water-quality problem that should be re-evaluated.

The generally higher concentrations, the larger proportion of reported detections, and the timeliness of the Washington County, Md., data suggest that a current water-quality problem may exist in that area and possibly other areas and that further study is needed.

Multiple samples were collected of both surface water and bottom material from Virginia streams tributary to the Potomac Estuary from about 1974 to 1990, mostly beginning in 1979 and ending in 1986. Up to 10 surface-water and 7 bottom-material samples were collected at the same sites over the time period. These data could be useful for the detection of trends for those streams.

Ground-water samples contained fewer detectable compounds than surface-water and bottom-material samples. USGS reported 7 pesticides in wells and 10 pesticides in springs with concentrations greater than reporting limits. The most frequently reported pesticide was atrazine, which was found in concentrations greater than detection limits in 9 of 45 well samples and 4 of 8 spring samples. Endrin, a hydrophobic pesticide, was found in measurable concentrations in 3 of 64 well samples and 4 of 52 spring samples. All of the measurable concentrations of endrin were in samples collected after 1987, when the use of endrin was discontinued. All of the measurable concentrations of atrazine and endrin were in samples collected near the center of the Potomac River Basin, where most ground-water sampling has occurred.

Spatial coverage of existing ground-water-quality data is limited. Temporal data are lacking, so identification of trends from existing ground-water data alone is not possible. Information on ground-water-quality processes is needed to better predict the impact of management practices on the resource throughout the Potomac River Basin.

Pesticides appear to be more likely to be found in fish tissue at concentrations greater than reporting limits than in water and bottom material. Thirty of the 37 pesticides and related compounds analyzed in fish tissue were reported and 914 out of 5,946 analyses performed for individual compounds indicated concentrations higher than reporting limits. In the Potomac River Basin, pesticides in fish tissue may be better indicators of the presence of organochlorine pesticides in the envi-

ronment than those in the other media. Although the problem of bias in sampling-site selection must be considered in interpreting these data, the compounds analyzed in fish tissue are generally those known to be more persistent in the environment, and the time period of sampling was more uniform and more recent.

Pesticides reported included BHC, chlordane, DDT, dieldrin, and heptachlor. Many of these pesticides or related compounds were reported at sites all along the mainstem Potomac River, parts of the North and South Branch Potomac River Basins, Town, Conococheague, and Antietam Creeks draining portions of Maryland and Pennsylvania, Opequon Creek in West Virginia, the lower Shenandoah River, the Monocacy River Basin, and the Anacostia River and Rock Creek near Washington, D.C.

Chlordane was the only organochlorine pesticide analyzed in fish-tissue samples in the Potomac River Basin that exceeded existing FDA standards for the protection of human health in edible portions of 0.3 mg/kg in fish-fillet samples. The FDA standard was exceeded at six sites near Washington, D.C.

A health advisory was issued in 1989 by the District of Columbia Department of Consumer and Regulatory Affairs to encompass the portions of the Potomac River, Anacostia River, Rock Creek, and their tributaries within the District of Columbia. The 1989 health advisory limited consumption of catfish, carp, or eel to a half pound per week, without limits on other fish species. The District of Columbia Department of Consumer and Regulatory Affairs has recently updated the 1989 health advisory, and advises that no catfish, carp, or eel be consumed and to limit consumption of largemouth bass to one half pound per month, or one half pound of sunfish or other fish per week.

A majority of the 63 sites sampled for fish tissue have been sampled only 1 year during the 19 years covered by this report. Of the remaining sites, only a relatively few have been sampled more than 4 years, making trend analysis difficult at most Potomac River Basin sites. Comparison of fish-tissue concentration data between and among sites may also be difficult. As with trend analysis, differences in the species collected at individual sites, in the number of fish comprising the samples, and in the size of the fish in individual samples impede site comparisons.

The geographical distribution of whole-fish sampling sites in the Potomac River Basin is somewhat limited. Many sampling sites are located along the mainstem Potomac River, in the Monocacy River Basin, and near Washington, D.C. Generally, no sites are located on the upstream portions of many of the major tributaries to the Potomac River, such as in the South Branch Potomac River, the North and South Forks of the Shenandoah River, and the Anacostia River. Fish sampling sites are typically near populated areas or areas of known contamination.

In only a few areas in the Potomac River Basin have samples been collected from more than one medium. No areas exist where comparisons can be made between surface and ground water, but other multi-media comparisons are possible in the Opequon Creek, Conococheague Creek, Antietam Creek, Shenandoah River, Monocacy River, Goose Creek, and Occoquan River Basins, and at discrete sites on the mainstem Potomac River and Anacostia River and on Virginia streams tributary to the Potomac Estuary.

Sufficient pesticide-concentration data are available for all media to identify pesticide contaminant problems in selected areas of the Potomac River Basin during the period from 1972 to 1990. Generally, these data would be useful in comparisons of the basin to national conditions, with appropriate provisos for differences in methodologies. Because no basinwide coverage of data exists in any one media, and because methodologies used and time of sampling varies widely, only very limited comparisons among basin subunits can be made. Likewise, lack of continued sampling over time precludes trend analysis, except for selected streams.

Based on review of data available for this retrospective analysis, a systematic study of pesticides in all media throughout the Potomac River Basin and over time will be required to address regional questions regarding problem identification, differences among subunits, and trends.

REFERENCES

Block, E., Bennett, R. O., and Wolflin, J. P., 1990, Organochlorine residues and histopathological examination of fish from the Potomac and Anacostia Rivers, Washington, D.C.: U.S. Fish and Wildlife Service, Environmental Contaminants Division, Annapolis, Md., #AFO-C90-01, 14 p., appendixes.

Camacho, Rodolfo, 1989, Potomac River Basin land-use data: Evaluation and methodology to determine basin land use from non-digitized county land-use data: Interstate Commission on the Potomac River Basin Report 89-8, 38 p.

Crawford, J. K., and Luoma, S. N., 1993, Guidelines for studies of contaminants in biological tissue for the National Water-Quality Assessment Program: U.S. Geological Survey Open-File Report 92-494, p. 1-69.

Dine, J. R., Tompkins, M. D., and Duigon, M. T., 1985, Ground-water and surface-water data for Frederick County, Maryland: Maryland Geological Survey Basic Data Report No. 15, 240 p.

Duigon, M. T., Dine, J. R., and Tompkins, M. D., 1989, Ground-water and surface-water data for Washington County, Maryland: Maryland Geological Survey Basic Data Report No. 18, 273 p.

Elmore, Donald, and Weaver, K. C., 1987, Results of a Maryland ground-water herbicide reconnaissance survey: Maryland Office of Environmental Programs Technical Report No. 61, 14 p.

Gerhart, J. M., 1991, National Water-Quality Assessment Program--The Potomac River Basin: U.S. Geological Survey Open-File Report 91-157, 2 p.

Gianessi, L. P., and Puffer, C. M., 1988, Use of selected pesticides for agricultural crop production in the United States, 1982-1985: Washington, D.C., Resources for the Future, Inc., Quality of the Environment Division, 490 p.

_____1990, Herbicide use in the United States: Washington, D.C., Resources for the Future, Inc., Quality of the Environment Division, 127 p. [Revised 1991]

Goodell, H. G., and LoCastro, Richard, 1989, The effect of agricultural chemicals on ground-water quality, northern Shenandoah Valley, Virginia: Proceedings, Ground Water Issues and Solutions in the Potomac River Basin/Chesapeake Bay Region, National Water Well Association, p. 145-167.

Hirsch, R. M., Alley, W. M., and Wilber, W. G., 1988, Concepts for a national water-quality assessment program: U.S. Geological Survey Circular 1021, 42 p.

Kozar, M. D., Hobba, W. A., Jr., and Macy, J. A., 1991, Geohydrology, water availability, and water quality of Jefferson County, West Virginia, with emphasis on the carbonate area: U.S. Geological Survey Water-Resources Investigations Report 90-4118, 93 p.

Lang, D. J., 1982, Water quality of the three major tributaries to the Chesapeake Bay, the Susquehanna, Potomac, and James Rivers, January 1979 - April 1981: U.S. Geological Survey Water-Resources Investigations Report 82-32, 64 p.

Leahy, P. P., Rosenshein, J. S., and Knopman, D. S., 1990, Implementation plan for the National Water-Quality Assessment program: U.S. Geological Survey Open-File Report 90-174, 10 p.

Leahy, P. P., and Wilber, W. G., 1991, National Water-Quality Assessment program: U.S. Geological Survey Open-File Report 91-54, 2 p.

Mostaghimi, Said, McClellan, P. W., Tim, U. S., Dillaha, T. A., Byler, R. K., Shanholtz, V. O., and Flagg, J. M., 1989, Impact of agricultural activities on ground-water quality in Virginia: Proceedings, Ground Water Issues and Solutions in the Potomac River Basin/Chesapeake Bay Region, National Water Well Association, p. 421-435.

Murphy, D. L., 1988, Analysis of basic water monitoring program Fish Tissue Network: Maryland Department of the Environment, Water Management Administration, Technical Report #100, 48 p., appendixes.

National Academy of Science, 1990, A review of the USGS National Water-Quality Assessment pilot program: National Academy Press, Washington, D.C., 153 p.

Nowell, L. H. and Resek, E. A., 1994, National standards and guidelines for pesticides in water, sediment, and aquatic organisms: Application to water-quality assessments: Reviews of Environmental Contamination and Toxicology, v. 140, p. 113-122.

Roeser, L. S., 1988, Pesticide use in the Chesapeake Bay Basin: U.S. Environmental Protection Agency, Chesapeake Bay Program, Report No. CBP/TRS 23/88, Annapolis, Md., August, 1988.

Schmitt, C. J., Zajicek, J. L., and Peterman, P. H., 1990, National Contaminant Biomonitoring Program: Residues of organochlorine chemicals in U.S. freshwater fish, 1976-1984: Archive of Environmental Contaminants and Toxicology, 19 p. 748-781.

Smith, J. A., Witkowski, P. J., and Fusillo, T. V., 1988, Man-made organic compounds in the surface waters of the United States--A review of current understanding: U.S. Geological Survey Circular 1007, 92 p.

Sommerfield, M., and Cummins, J., 1989, Statistical analysis of fish tissue toxics data collected by the District of Columbia: Interstate Commission on the Potomac River Basin, Rockville, Md., 15 p.

Tingler, J. N., Galloway, R. E., Hegstrom, L. J., Seivard, L. D., and Gregory, R. A., 1990, Comprehensive review of selected toxic substance - environmental samples in Virginia: Virginia Water Control Board, Water Quality Assessments, Office of Water Resource Management, Information Bulletin #583.

Trainer, F. W., and Watkins, F. A., 1975, Geohydrologic reconnaissance of the upper Potomac River Basin: U.S. Geological Survey Water-Supply Paper 2035, 68 p.

U.S. Department of Commerce, 1991a, Climatological data, annual summary, Maryland and Delaware, 1990: National Oceanic and Atmospheric Administration, v. 94, no. 13, 15 p.

_____1991b, Climatological data, annual summary, Pennsylvania, 1990: National Oceanic and Atmospheric Administration, v. 95, no. 13, 24 p.

_____1991c, Climatological data, annual summary, Virginia, 1990: National Oceanic and Atmospheric Administration, v. 100, no. 13, 17 p.

_____1991d, Climatological data, annual summary, West Virginia, 1990: National Oceanic and Atmospheric Administration, v. 98, no. 13, 17 p.

U.S. Environmental Protection Agency, 1976, Basic water monitoring program: U.S. Environmental Protection Agency, the Standing Work Group on Water Monitoring, Publication 440/9-76-025, p. 1-32.

_____1984, Monitoring strategy, Office of Water: U.S. Environmental Protection Agency, Office of Water, Washington, D.C., p. 1-33.

_____1992a, Pesticides in ground water data base, a compilation of monitoring studies: 1971-1991, Region 3: Office of Pesticide Programs, Report No. EPA 734-12-92-001, 110 p.

_____1992b, National study of chemical residues in fish, Volume I: U.S. Environmental Protection Agency, Office of Science and Technology, Standards and Applied Science Division, Washington, D.C., 166 p., appendixes.

_____1992c, National study of chemical residues in fish, Volume II: U.S. Environmental Protection Agency, Office of Science and Technology, Standards and Applied Science Division, Washington, D.C., [variously paged], appendixes.

U.S. Geological Survey, 1979a, Land use and land cover, 1970-72, Pittsburgh, Pennsylvania: U.S. Geological Survey Land Use Series, Map L-34, 1 sheet, scale 1:250,000.

_____1979b, Land use and land cover, 1972, Harrisburg, Pennsylvania: U.S. Geological Survey Land Use Series, Map L-32, 1 sheet, scale 1:250,000.

_____1979c, Land use and land cover, 1973-77, Charlottesville, Virginia, West Virginia: U.S. Geological Survey Land Use Series, Open-File Report 79-403-1, 1 sheet, scale 1:250,000.

_____1979d, Land use and land cover, 1974-77, Roanoke, Virginia: U.S. Geological Survey Land Use Series, Open-File Report 79-407-1, 1 sheet, scale 1:250,000.

_____1980a, Land use and land cover, 1972, Washington, D.C., Maryland, Virginia: U.S. Geological Survey Land Use Series, Map L-201, 1 sheet, scale 1:250,000.

_____1980b, Land use and land cover, 1973, Cumberland, Maryland, West Virginia, Pennsylvania, Virginia: U.S. Geological Survey Land Use Series, Map L-111, 1 sheet, scale 1:250,000.

_____1980c, Land use and land cover, 1973, Richmond, Virginia, Maryland: U.S. Geological Survey Land Use Series, Map L-140, 1 sheet, scale 1:250,000.

_____1980d, Land use and land cover, 1974-76, Baltimore, Maryland, Pennsylvania, Virginia, West Virginia: U.S. Geological Survey Land Use Series, Map L-113, 1 sheet, scale 1:250,000.

_____1991a, Water resources data for Maryland and Delaware, water year 1990--volume 2: U.S. Geological Survey Water-Data Report MD-DE-90-2, 246 p.

_____1991b, Water resources data for Pennsylvania, water year 1990--volume 2: U.S. Geological Survey Water-Data Report PA-90-2, 266 p.

_____1991c, Water resources data for Virginia, water year 1990--volume 1: U.S. Geological Survey Water-Data Report VA-90-1, 407 p.

_____1991d, Water resources data for West Virginia, water year 1990: U.S. Geological Survey Water-Data Report WV-90-1, 182 p.

Wright, W. G., 1990, Ground-water hydrology and quality in the Valley and Ridge and Blue Ridge physiographic provinces of Clarke County, Virginia: U.S. Geological Survey Water-Resources Investigations Report 90-4134, 61 p.

APPENDIX

APPENDIX A

Selected standards and criteria for pesticides in water, bottom material, and fish tissue[a]

[USEPA, U.S. Environmental Protection Agency; NAS/NAE, National Academy of Science and National Academy of Engineering; USFDA, U.S. Food and Drug Administration; mg/L, milligrams per liter; mg/kg, milligrams per kilogram; OC, organic carbon; --, No standard established; BHC, Benzene hexachloride; DDT, dichloro-diphenyl-trichloroethane]

Pesticide	USEPA Maximum contaminant level in drinking water (mg/L)	USEPA Ambient freshwater-quality criteria for the protection of aquatic organisms maximum concentration (mg/L)	USEPA Freshwater sediment quality criteria for the protection of benthic organisms (mg/kg sediment OC)	NAS/NAE Recommended maximum concentration for the protection of fish-eating wildlife in whole fish tissue (mg/kg)	USFDA Action level for the protection of human health in fish-fillet tissue (mg/kg)
2,4-D	0.07	--	--	--	--
2,4,5-T	.05	--	--	--	--
Alachlor	.002	--	--	--	--
Aldrin	--	0.003	--	[1]0.1	[3]0.3
Atrazine	.003	--	--	--	--
γ-BHC (lindane)	.0002	.002	0.157	[1].1	--
Chlordane	.002	.0024	.309	[1].1	[4].3
DDT	--	.0011	.828	[2]1.0	[5]5.0
Dieldrin	--	.0025	11.0	[1].1	[3].3
Endosulfan	--	.00022	.330	[1].1	--
Endrin	.002	.00018	4.2	[1].1	.3
Heptachlor	.0004	.00052	.110	[1].1	[6].3
Heptachlor epoxide	.0002	.00052	--	[1].1	[6].3
Methoxychlor	.04	--	--	--	--
Mirex	--	--	--	--	.1
Parathion	--	.000065	.0810	--	--
Simazine	.004	--	--	--	--
Toxaphene	.003	.00073	.0647	[1].1	5.0

[1] Applies to residues for aldrin, BHC, chlordane, dieldrin, endosulfan, endrin, heptachlor, heptachlor epoxide, lindane, and toxaphene, either singly or in combination.

[2] Applies to total DDT residues, including DDD and DDE.

[3] Action level applies to aldrin and dieldrin individually or in combination. Do not add amounts of aldrin or dieldrin found <0.1 mg/kg for total concentrations in fish.

[4] Action level applies to residues of chlordane, including *cis* and trans-chlordane, *cis* and trans-nonachlor, oxychlordane, isomers of chlordene and chlordene. Levels of individual components must be quantified at 0.02 mg/kg in fish to be added to total chlordane value.

[5] Action level applies to DDT, DDD, or DDE singly or in combination. In adding amounts of DDT and its metabolites, do not count any concentration <0.2 mg/kg in fish.

[6] Action level applies to heptachlor and heptachlor epoxide individually or in combination. Do not add amounts of heptachlor or heptachlor epoxide found <0.1 mg/kg for total concentrations in fish

[a] *SOURCE: Nowell, L. H. and Resek, E. A., 1994, National standards and guidelines for pesticides in water, sediment, and aquatic organisms--Application to water-quality assessments: Reviews of Environmental Contamination and Toxicology, v. 40, 221 p.*

Zappia, Humbert and Fisher, Gary T. **WATER-QUALITY ASSESSMENT OF THE POTOMAC RIVER BASIN: ANALYSIS OF AVAILABLE PESTICIDE DATA, 1972-90** U.S. Geological Survey WRIR 97-4051