Water Quality in the White River Basin

Indiana, 1992–96

U.S. Department of the Interior
U.S. Geological Survey

Circular 1150

A COORDINATED EFFORT

Coordination among agencies and organizations is an integral part of the NAWQA Program. We thank the following agencies and organizations who contributed data used in this report.

- The Indiana Department of Natural Resources provided water-withdrawal data.
- The National Oceanic and Atmospheric Administration provided precipitation data.
- The Indiana Agricultural Statistics Service provided pesticide-use data.
- The Natural Resources Conservation Service provided soil-drainage data.
- Many farmers and private landowners allowed us to drill and sample wells or tile drains on their properties.
- The Indiana Department of Environmental Management provided ammonia and phosphorus data for the White River.
- The Indiana State Department of Health, Indiana Department of Environmental Management, and Indiana Department of Natural Resources provided fish-consumption advisories.
- The Indiana Department of Natural Resources, Division of Fish and Wildlife, provided historical fish-community data.

Additionally, the findings in this report would not have been possible without the efforts of the following U.S. Geological Survey employees.

Nancy T. Baker	Derek W. Dice	Harry A. Hitchcock	Jeffrey D. Martin	Danny E. Renn
E. Randall Bayless	Nathan K. Eaton	Glenn A. Hodgkins	Rhett C. Moore	Douglas J. Schnoebelen
Jennifer S. Board	Barton R. Faulkner	David V. Jacques	Sandra Y. Panshin	Wesley W. Stone
Donna S. Carter	Jeffrey W. Frey	C.G. Laird	Patrick P. Pease	Lee R. Watson
Charles G. Crawford	John D. Goebel	Michael J. Lydy	Jeffrey S. Pigati	Douglas D. Zettwock

The summary of compound detections and concentrations section of this report (pages 26-31) was designed and prepared by Sarah J. Ryker, Jonathan C. Scott, and Alan L. Haggland.

Front cover: White River near Martinsville, Indiana. (Photograph by Charles Crawford, U.S. Geological Survey.)
Back cover: Scientists collecting fish and ground-water samples in the White River Basin. (Photographs by Jeffrey Martin, U.S. Geological Survey.)

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Information on the NAWQA Program is also available on the Internet via the World Wide Web. You may connect to the NAWQA Home Page using the Universal Resources Locator (URL)
http://wwwrvares.er.usgs.gov/nawqa/nawqa_home.html

The White River Study Unit's Home Page is at URL
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Water Quality in the White River Basin, Indiana, 1992–96

By Joseph M. Fenelon

U.S. GEOLOGICAL SURVEY CIRCULAR 1150

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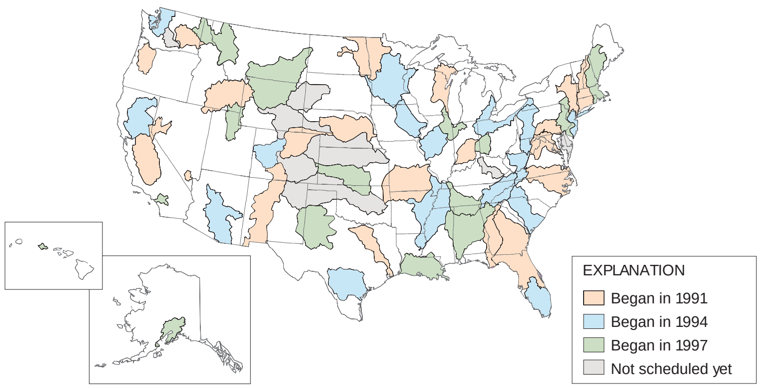
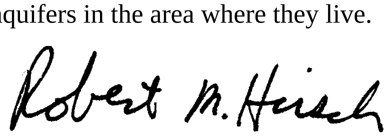


Knowledge of the quality of the Nation's streams and aquifers is important because of the implications to human and aquatic health and because of the significant costs associated with decisions involving land and water management, conservation, and regulation. In 1991, the U.S. Congress appropriated funds for the U.S. Geological Survey (USGS) to begin the National Water-Quality Assessment (NAWQA) Program to help meet the continuing need for sound, scientific information on the areal extent of the water-quality problems, how these problems are changing with time, and an understanding of the effects of human actions and natural factors on water-quality conditions.

The NAWQA Program is assessing the water-quality conditions of more than 50 of the Nation's largest river basins and aquifers, known as Study Units. Collectively, these Study Units cover about one-half of the United States and include sources of drinking water used by about 70 percent of the U.S. population. Comprehensive assessments of about one-third of the Study Units are ongoing at a given time. Each Study Unit is scheduled to be revisited every decade to evaluate changes in water-quality conditions. NAWQA assessments rely heavily on existing information collected by the USGS and many other agencies as well as the use of nationally consistent study designs and methods of sampling and analysis. Such consistency simultaneously provides information about the status and trends in water-quality conditions in a particular stream or aquifer and, more importantly, provides the basis to make comparisons among watersheds and improve our understanding of the factors that affect water-quality conditions regionally and nationally.

This report is intended to summarize major findings that emerged between 1992 and 1996 from the water-quality assessment of the White River Basin Study Unit and to relate these findings to water-quality issues of regional and national concern. The information is primarily intended for those who are involved in water-resource management. Indeed, this report addresses many of the concerns raised by regulators, water-utility managers, industry representatives, and other scientists, engineers, public officials, and members of stakeholder groups who provided advice and input to the USGS during this NAWQA Study-Unit investigation. Yet, the information contained here may also interest those who simply wish to know more about the quality of water in the rivers and aquifers in the area where they live.



Robert M. Hirsch, Chief Hydrologist


Photo by Jeffrey Martin, U.S. Geological Survey


Photo by Charles Crawford, U.S. Geological Survey

The White River Basin was one of 20 Study Units in the United States to have a water-quality assessment completed between 1992 and 1996.

A variety of pesticides were commonly found in streams throughout the White River Basin. In contrast, only a few pesticides were detected in ground water, and these were at much lower concentrations (p. 6).

In streams:
- Pesticide concentrations at urban and agricultural sites were among the highest in the Nation (p. 20).
- Twenty-five different pesticides or pesticide degradation products were detected in at least 5 percent of samples near the mouth of the White River. Atrazine and metolachlor were always detected, whereas cyanazine and alachlor were frequently detected (p. 6). In a few samples, concentrations of atrazine, alachlor, or cyanazine exceeded Federal drinking-water standards or advisories (p. 26); however, annual average concentrations of each of these compounds in the White River were below their respective standard or guideline.

In shallow ground water:
- Fourteen different pesticides were detected in a network of 94 monitoring wells; six were detected more than once (p. 6). No pesticide concentration came close to exceeding a Federal drinking-water standard or advisory.
- In cropland areas with a surficial sand and gravel aquifer that is vulnerable to contamination but is also an important source of drinking water for residents of the basin, atrazine compounds were commonly detected (found in two-thirds of monitoring wells) but only at trace levels.

The occurrence of pesticides in streams is controlled by a variety of factors (p. 8–11).

Regional patterns in pesticide use (p. 8):
- Concentrations of individual pesticides in streams are greatest where pesticide use is greatest.

Temporal patterns in pesticide use (p. 9):
- New pesticides introduced to the market can quickly show up in streams. Within 2 years of its registration in 1994, maximum concentrations of the corn herbicide acetochlor in the White River were about 2 µg/L, similar to those of other commonly used herbicides. In contrast, concentrations of alachlor in the White River are declining as alachlor use in the basin declines.

Land use (p. 10):
- Pesticide concentrations in streams differ according to land use. Lawn insecticides (such as diazinon) are more commonly detected in urban watersheds, whereas corn herbicides (such as atrazine) are more commonly detected in agricultural watersheds.

Soil drainage (p. 10–11):
- Pesticide concentrations in streams are highest in watersheds with permeable, well-drained soils, all other factors being equal. Agricultural tile drains play a major role in transporting pesticides to streams in areas with poorly drained soils where drainage has been enhanced with tile drains.

Photo by Charles Crawford, U.S. Geological Survey

Nitrate concentrations in ground water are low (commonly not detected) in some aquifer settings and high (sometimes exceeding the Federal drinking-water standard) in others. Nitrate concentrations in stream water typically are between these extremes (p. 12–15).

In streams:

- Median concentrations of nitrate at monitoring sites generally ranged from 2 to 6 mg/L—higher than those at most other NAWQA monitoring sites in the United States (p. 20). Sample concentrations rarely exceeded the Federal drinking-water standard.

In ground water:

- Surficial sand and gravel aquifers underlying cropland had high nitrate concentrations. Samples from 17 percent of shallow monitoring wells in this setting exceeded the Federal drinking-water standard of 10 mg/L. However, deeper wells (25 to 50 feet below the water table) in these unconfined aquifers typically had little or no detectable nitrate.

- In many parts of the basin, nitrate concentrations in ground water were low. For example, sand and gravel aquifers protected by overlying clay typically had low concentrations of nitrate. Such aquifers are present in more than half the basin and are a common source of water for rural domestic users.

Urban areas degrade the quality of streams and ground water (p. 16–17).

In streams:

- Concentrations of trace metals and organic compounds in streambed sediments tended to be above background concentrations in urban areas, particularly Indianapolis. Measured concentrations are generally not a human-health concern; however, fish-consumption advisories for PCBs and mercury are in effect for some areas of the basin. Several chemicals whose use has long been banned (chlordane, dieldrin, and PCBs) persist in streambed sediments and are concentrated in organisms such as freshwater clams.

- Stormwater runoff and sewer overflows are a continuing problem and have contributed to fish kills in the basin by depleting oxygen in the stream water. One such incident in the White River at Indianapolis in 1994 killed 510,000 fish.

In ground water:

- Volatile organic compounds were detected in more than half the shallow monitoring wells in urban areas, as compared to 6 percent of shallow wells in cropland areas. Chloroform was the most common volatile organic compound found in urban ground water. No volatile organic compound was measured at a concentration in ground water that exceeded a Federal drinking-water standard or guideline.

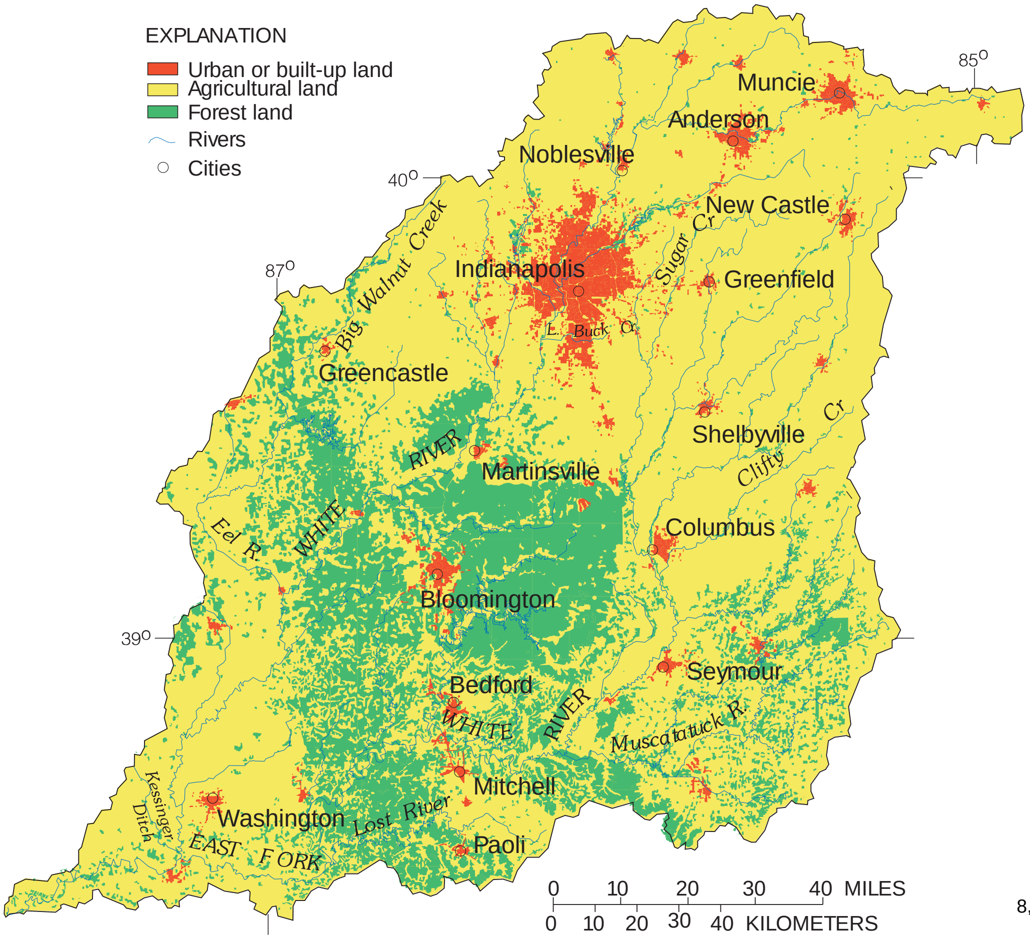
Fish communities have significantly improved since the early 1970’s. However, poor communities of fish are still found in streams with poor water quality (p. 18–19).

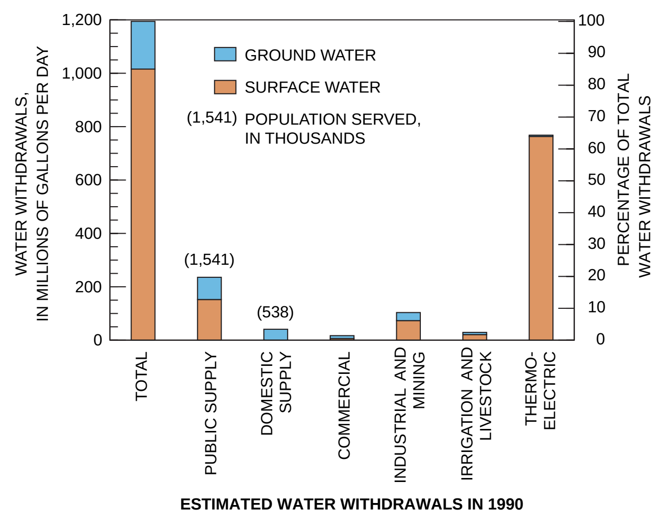
- Some streams with good fish habitat presently have poor communities of fish, a disparity indicating nonhabitat stresses (such as poor water quality). In areas where the fish communities are poorer than expected on the basis of fish habitat, nutrient and pesticide concentrations are high.

Photo by Charles Crawford, U.S. Geological Survey

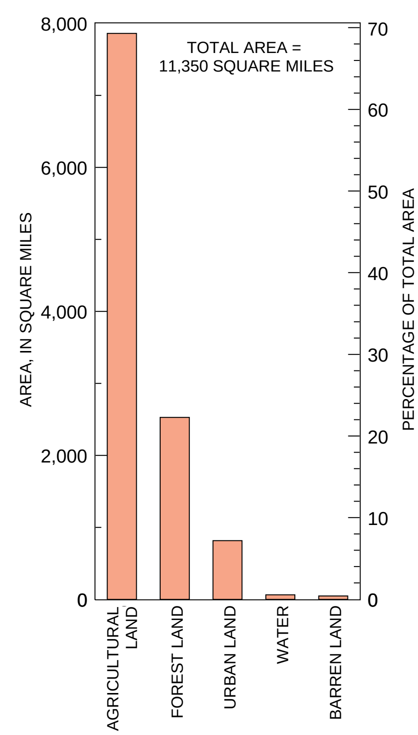
ENVIRONMENTAL SETTING IN THE WHITE RIVER BASIN

The population of the White River Basin in 1990 was approximately 2.1 million people, about three-fourths of which were concentrated in the northern part of the basin (Schnoebelen and others, in press). About 70 percent of the land-use area is agriculture. Soybean and corn production is extensive in the northern, southwestern, and southeastern parts of the basin. In 1992, these two crops accounted for 78 percent of all cropland. The south-central part of the basin is not farmed as extensively as other parts because of the steep hills and valleys; most of the forested land in the basin is in this area. Parts of the cities of Indianapolis, Muncie, and Anderson are intensively industrialized.





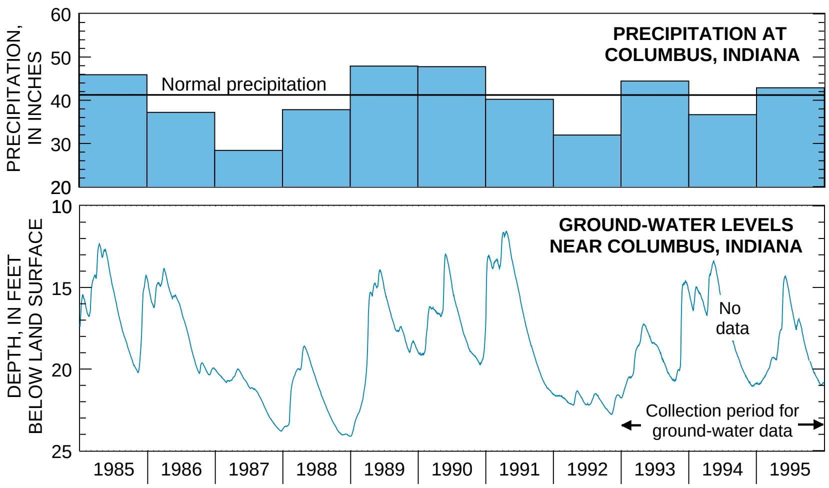
Most of the water withdrawn in the White River Basin is from surface-water sources. Most of this water is used for thermoelectric power. However, approximately 55 percent of the people in the White River Basin rely on ground water as the primary source of drinking water (Schnoebelen and others, in press).



The primary land use in the White River Basin is agriculture, which accounts for about 70 percent of the basin area.

HYDROLOGIC CONDITIONS DURING THE STUDY PERIOD

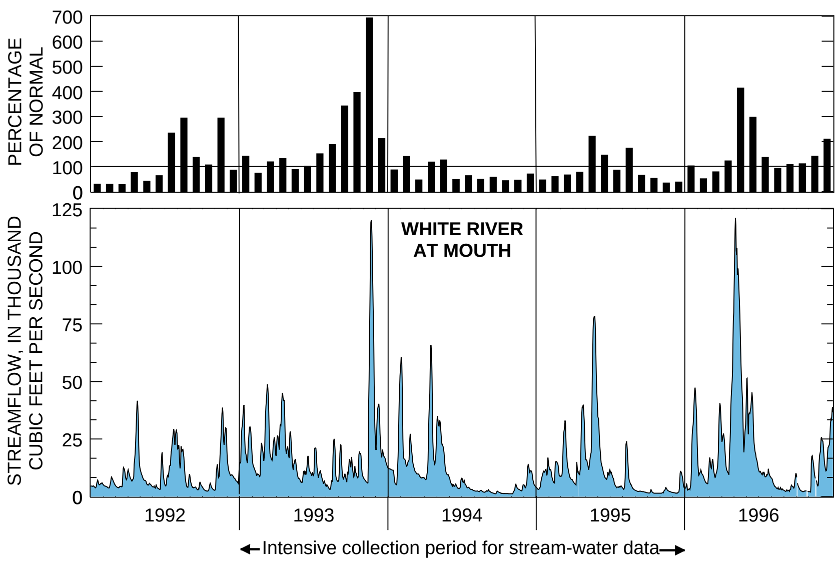
Precipitation during the period of intensive data collection (1993–95) was near normal. Average annual precipitation ranges from 38 inches in the northern part of the White River Basin to 48 inches in the south-central part and usually is distributed fairly evenly throughout the year.



Ground-water levels in an unconfined outwash aquifer near Columbus were not unusually high or low during the study period. Water levels recovered in 1993 from low levels caused by a very dry year in 1992 and then followed a seasonal pattern of high levels in winter and spring and low levels during the summer and fall.

Understanding the hydrologic conditions during the study period is helpful for interpreting the water quality. For example, during wet periods, nonpoint sources (such as agricultural runoff) contribute most of the nutrients to streams in the White River Basin. Wet periods also cause ground-water levels to rise. Excess ground water sustains tile-drain flow and contributes directly to streamflow, thus having a greater influence on stream quality than during dry periods. In contrast, during dry periods, discharges from point sources (such as an industrial discharge pipe) can significantly degrade stream quality because the discharges are not diluted with large amounts of stream water from other sources.

The seasonal timing of precipitation also is important to understanding stream quality. For example, a wet May will allow more pesticides to be washed into streams than a wet January.

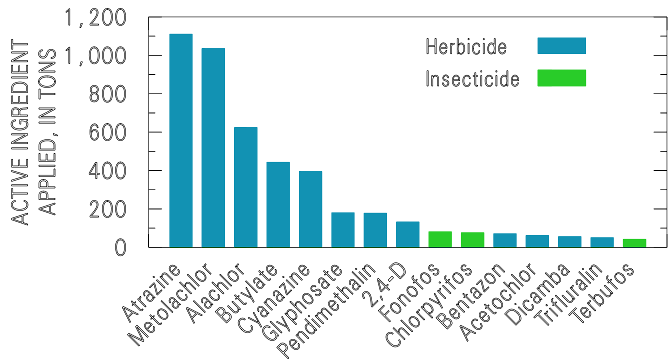


Streamflow at the mouth of the White River was well above normal during the latter half of 1993 and the spring of 1996 but was normal or near normal during the remainder of the study period.

Streamflow in the basin is typically highest in early spring and lowest in late summer and fall. This pattern of high runoff in the spring coincides with agricultural pesticide applications, often resulting in pesticides being washed into streams during storms.

OCCURRENCE OF PESTICIDES IN STREAMS AND GROUND WATER

Agriculture is the major land use in the White River Basin, and most pesticides detected in streams and ground water during the study period were used primarily in agriculture. Herbicides applied to corn and soybeans dominate pesticide use. Herbicides are applied during spring planting to virtually all of the corn and soybean crop. Insecticides are applied during the summer to about 25 percent of the corn crop.



Approximately 5,000 tons of agricultural pesticides are applied annually in the White River Basin. *(Data from Anderson and Gianessi, 1995.)*

PESTICIDES MORE COMMON IN STREAMS THAN IN GROUND WATER

Commonly used pesticides were frequently detected in White River.
[Samples from 1992–95 except where footnoted; ≥, greater than or equal to; µg/L, micrograms per liter]

Most commonly used compounds	May–July				August–April			
	Percent samples ≥ concentration listed below (µg/L)							
	0.01	0.1	1.0	10	0.01	0.1	1.0	10
Atrazine	100	100	94	6	100	94	8	0
Metolachlor	100	100	49	0	100	63	2	0
Alachlor	100	70	6	0	60	8	0	0
Butylate	40	0	0	0	8	0	0	0
Cyanazine	91	91	32	0	71	24	0	0
Glyphosate	no data	no data	no data	no data	no data	no data	no data	no data
Pendimethalin	9	0	0	0	0	0	0	0
2,4-D[1]	≥57	33	0	0	≥6	3	0	0
Fonofos	2	0	0	0	0	0	0	0
Chlorpyrifos	26	2	0	0	2	0	0	0
Bentazon[1]	≥43	33	0	0	≥3	0	0	0
Acetochlor[2]	84	47	0	0	33	6	0	0

[1]1993-95 [2]1994-95

Six pesticides were detected more than once in ground water.
[Samples collected 1994–95; ≥, greater than or equal to; µg/L, micrograms per liter]

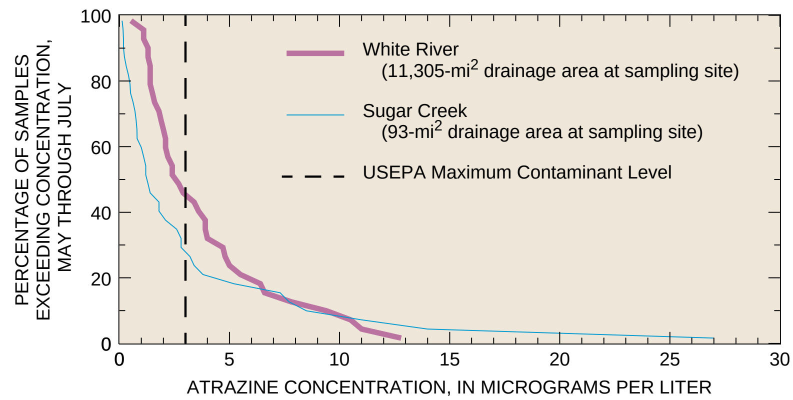
Compounds detected more than once	Percent wells ≥ 0.01 µg/L			Percent wells ≥ 0.1 µg/L		
	Surficial aquifer in agricultural area	Confined aquifer in agricultural area	Surficial aquifer in urban area	Surficial aquifer in agricultural area	Confined aquifer in agricultural area	Surficial aquifer in urban area
Atrazine	17	9	12	0	0	0
Metolachlor	4	4	4	4	0	0
Prometon	0	0	8	0	0	0
Simazine	0	0	4	0	0	0
Metribuzin	0	8	0	0	4	0
Tebuthiuron	0	0	4	0	0	0

Pesticides were commonly detected in streams in the White River Basin (Crawford, 1995; Carter and others, 1995). The highest concentrations occur between May and July when rains wash recently applied pesticides into streams. Near the mouth of the White River, 25 different pesticides or pesticide degradation products were detected in at least 5 percent of the samples. Atrazine, metolachlor, cyanazine, and alachlor were always or frequently detected. Concentrations of atrazine, alachlor, or cyanazine in some individual samples exceeded Federal drinking-water standards or advisories (p. 26); however, annual average concentrations of each of these compounds in the White River were below their respective standard or advisory. Diazinon, chlorpyrifos, and fonofos were the most commonly detected insecticides. Maximum concentrations of the insecticides diazinon and chlorpyrifos exceeded U.S. Environmental Protection Agency (USEPA) water-quality criteria for the protection of aquatic life (p. 27) (Nowell and Resek, 1994).

Pesticides are much less common in ground water than in streams (Fenelon and Moore, 1996a). Fourteen different pesticides were detected in a network of 94 shallow monitoring wells, but only six compounds (all herbicides) were detected more than once. All six herbicides have a high potential for leaching into ground water because of their physical and chemical characteristics. Concentrations of all pesticides detected were very low (less than 0.2 µg/L). USEPA drinking-water standards or advisories exist for 13 of the 14 pesticides detected; no pesticide came close to exceeding an existing standard or advisory. For example, the maximum atrazine concentration was less than 1/20th the standard. Confined aquifers protected by overlying clay soils had very few detections of pesticides. In a surficial aquifer that is an important source of drinking water, atrazine or its degradation product desethylatrazine were detected in two-thirds of the monitoring wells but only at trace levels (0.001–0.1 µg/L).

PESTICIDE CONCENTRATIONS VARY WITH STREAM SIZE

In the White River Basin, pesticide concentrations in small streams typically are extremely high or low, whereas concentrations in large rivers are moderate. For example, during the period when most pesticides are washed into streams (May through July), the maximum concentration of atrazine measured in Sugar Creek was about twice as high as in the White River. In contrast, at low concentrations, approximately 40 percent of the Sugar Creek samples were less than 1 µg/L as compared to less than 5 percent of the samples from the White River.

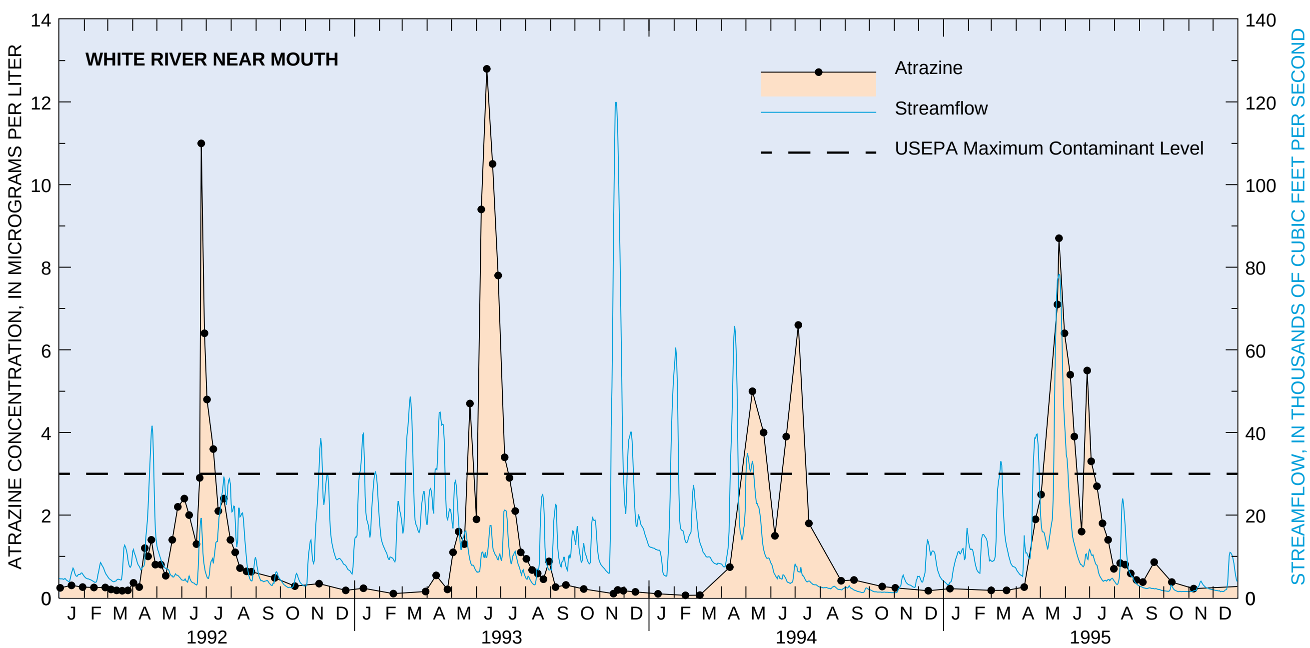


The USEPA Maximum Contaminant Level (MCL) for atrazine of 3 µg/L was exceeded in about 28 percent of the Sugar Creek samples and 45 percent of the White River samples collected during the period May through July, 1992-95.

PESTICIDE CONCENTRATIONS IN STREAMS SHOW SEASONAL PATTERN

Pesticide concentrations in streams in the White River Basin follow a seasonal pattern (Crawford and others, 1995). Herbicide concentrations are highest in late spring or early summer, whereas insecticide concentrations typically peak in midsummer. The highest pesticide concentrations typically occur during the first one or two periods of runoff following pesticide application.

Samples of stream water can exceed USEPA MCL's during seasonal peaks. For example, for about 6 weeks each year following spring herbicide application, concentrations of atrazine near the mouth of the White River are greater than the MCL of 3 µg/L. However, the annual average atrazine concentration in the White River for 1992 through 1995 never exceeded the MCL (which is based on an annual average concentration for treated water). Although the water near the mouth of the White River is not used as a drinking-water source, some communities upstream, including Indianapolis, Seymour, and Bedford, rely on water from the White or East Fork White Rivers for at least part of their drinking-water supply.



The seasonal pattern for concentrations of the herbicide atrazine in the White River Basin was typical of the pattern observed for most of the commonly used herbicides.

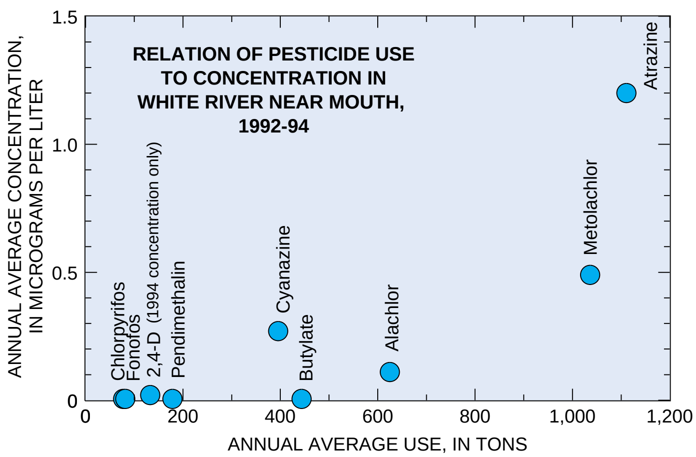
FACTORS INFLUENCING PESTICIDE OCCURRENCE IN STREAMS

Pesticide occurrence in streams in the White River Basin is influenced by land use and agricultural practices such as pesticide application, drainage of cropland, and cropping methods. Natural factors, such as the type of terrain and soil characteristics, also are important determinants of pesticide occurrence in streams. In addition, the distribution of individual pesticides in streams throughout the watershed depends on the physical and chemical properties of the pesticides that are in use—properties such as sorption (the ability of a pesticide to stick to soil particles), degradation (the ease with which a pesticide breaks down in the environment), and volatilization (the tendency of a pesticide to become gaseous and rise into the atmosphere).

Photo by Jeffrey Martin, U.S. Geological Survey

Agriculture is the primary source of pesticides found in streams in the White River Basin.

PESTICIDE PROPERTIES AFFECT CONCENTRATIONS IN STREAMS

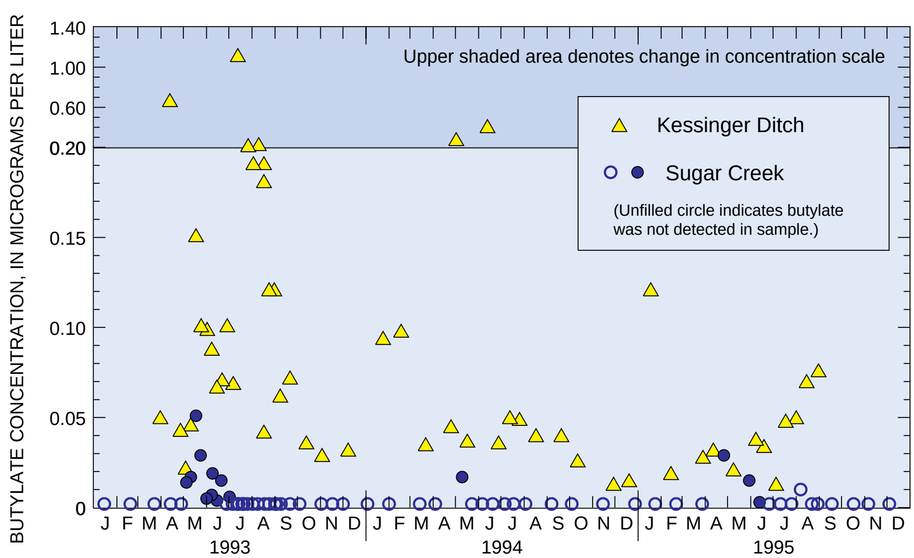


Pesticide use only partially determines pesticide concentrations in streams.

Pesticide concentrations in streams in the White River Basin generally increase with increasing use. Yet as shown in the figure to the left, the correlation between use and concentration is not strong for every compound. The properties of individual pesticides affect their behavior in the environment and, consequently, their ultimate concentrations in streams. Some pesticides stay close to areas where they are used, whereas others are mobile in water and are easily transported into streams. Pesticides that degrade quickly may not be found at concentrations that are anticipated solely on the basis of use; however, degradation products of the pesticides may be present in appreciable concentrations. The human health and ecological implications of many, though not all, pesticides found in streams can be evaluated with guidelines available from scientific and regulatory agencies. The health effects of degradation products generally are not known.

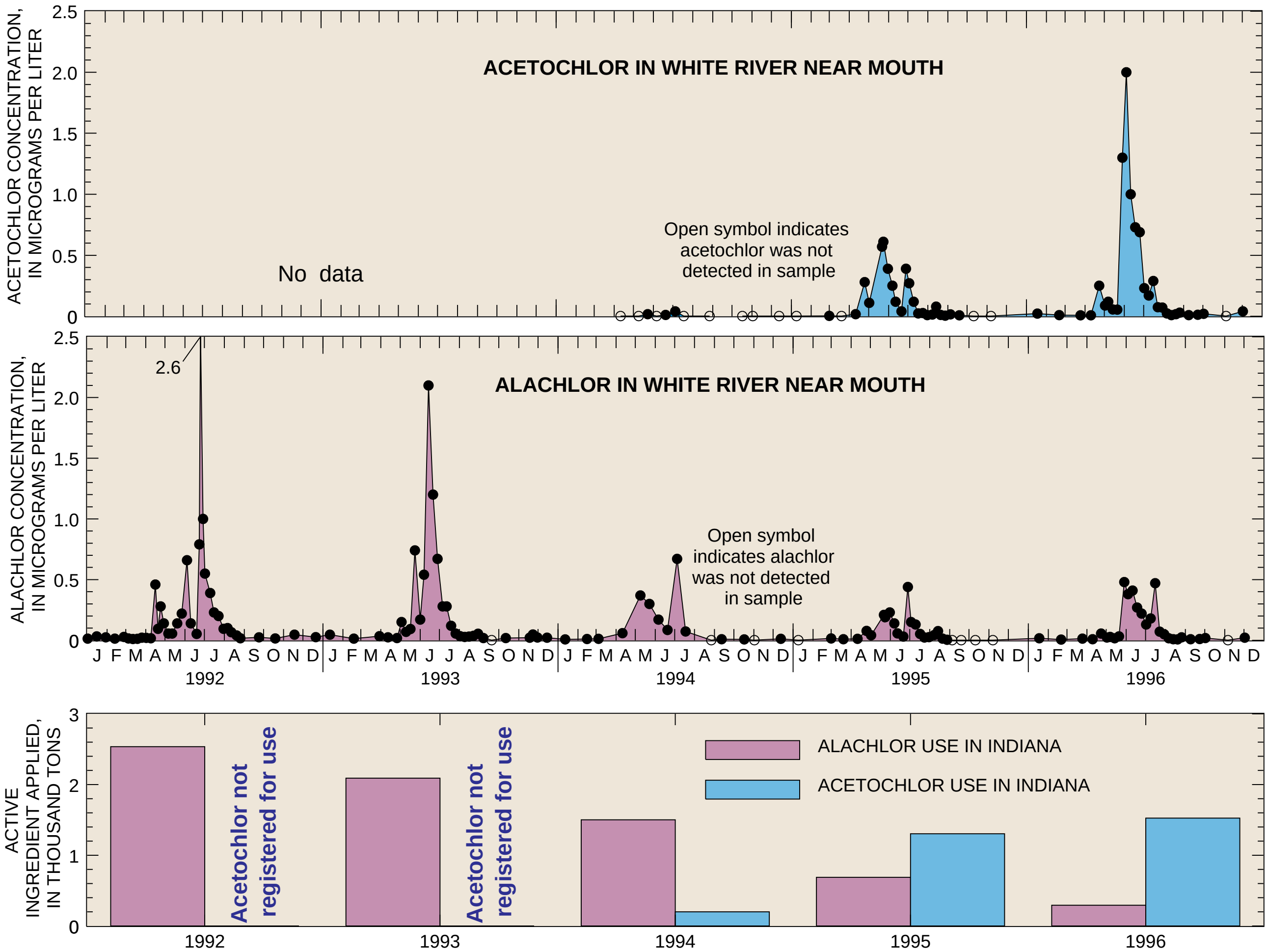
STREAM QUALITY REFLECTS REGIONAL HERBICIDE USE

Differences in butylate concentrations from streams of similar size in two different parts of the White River Basin illustrate the effect of regional patterns of pesticide use on pesticide concentrations in streams (Crawford, 1996). Butylate, a corn herbicide, was commonly applied in 1993. During 1993, about eight times as many acres were treated with butylate and four times more butylate was applied in southern Indiana than in central Indiana. This difference in use was reflected in stream quality—concentrations in Kessinger Ditch (in southern Indiana) were substantially higher than in Sugar Creek (in central Indiana).



High butylate application rates near Kessinger Ditch result in high concentrations in the ditch.

TRENDS IN HERBICIDE USE WITH TIME ARE REFLECTED IN STREAM QUALITY



Alachlor concentrations in streams in the White River Basin steadily declined from 1992 through 1996, which corresponded with a decline in alachlor use in the basin. Application of acetochlor, a corn herbicide registered for use in 1994, has partially replaced the use of alachlor in the basin. Acetochlor was detected at only trace concentrations during the 1994 growing season. By 1996, acetochlor was commonly detected in the White River with a peak concentration of about 2 micrograms per liter (Crawford, 1997).

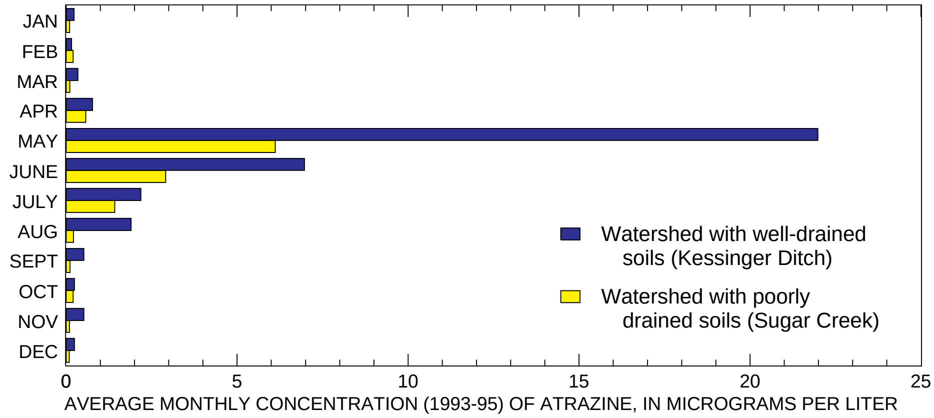
Photo by Charles Crawford, U.S. Geological Survey

Herbicides applied to corn and soybeans dominate pesticide use in the White River Basin.

BETTER DRAINED SOILS TRANSMIT MORE PESTICIDES TO STREAMS

Photo by Jeffrey Martin, U.S. Geological Survey

Clay soils in the Sugar Creek watershed cause ponding of water and inhibit drainage.

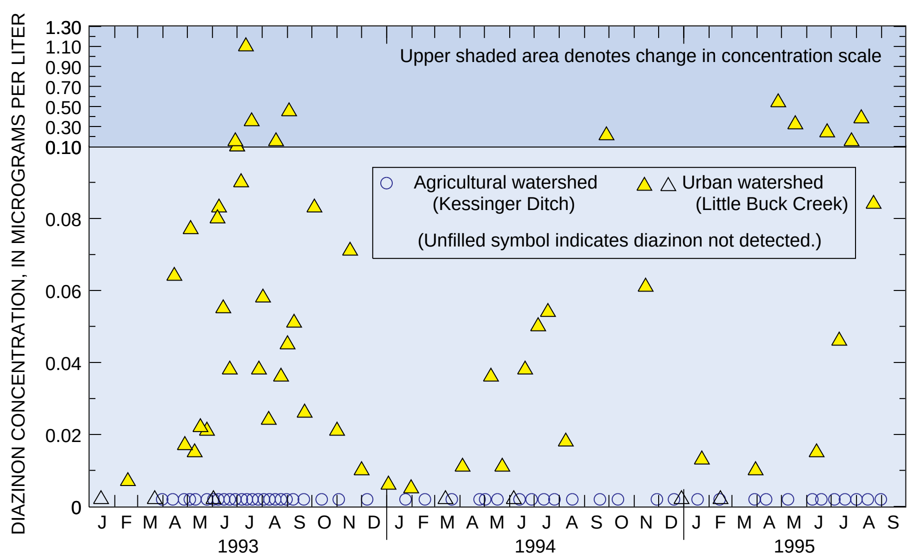


Well-drained soils in the Kessinger Ditch watershed carry more pesticides to streams than the clay soils in the Sugar Creek watershed.

Differences in atrazine concentrations in streams from two similar-sized watersheds with different soil-drainage characteristics are illustrated above. Atrazine was chosen for this illustration because of its widespread use in the White River Basin. In 1993, atrazine was applied to 90 percent of the corn crop in central and southern Indiana, and the rate of application was similar in these two areas. Because of this widespread use and similar cropping and pesticide-application practices throughout the basin, differences in concentrations of atrazine are attributed to natural factors, such as soil drainage. The Sugar Creek watershed, in central Indiana, has poorly drained clay soils; only 29 percent of the soils in the watershed are moderately well drained to well drained without artificial drainage. In contrast, 68 percent of the soils in the Kessinger Ditch watershed, in southern Indiana, are moderately well drained to well drained without artificial drainage because of coarse-textured soils and hilly terrains. Average monthly concentrations of atrazine in Kessinger Ditch, where dissolved atrazine is carried through the better drained soils into the ditch, were typically twice those in Sugar Creek.

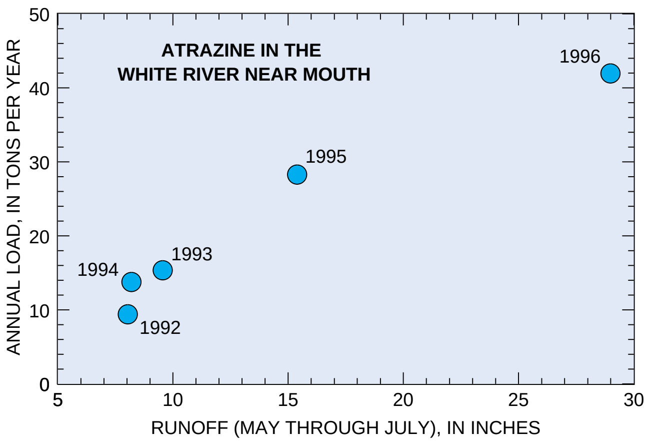
LAND USE AFFECTS TYPES OF PESTICIDES FOUND IN STREAMS

The types of land use—agricultural or urban—in a watershed help determine the types of pesticides expected in streams draining the watershed. Trends in the concentration of the insecticide diazinon illustrate the effect of land use on pesticide occurrence in streams. Diazinon is commonly applied during midsummer in Indiana to combat insect infestations in lawns and gardens. It is less commonly used for agricultural purposes in the basin. Diazinon was present in almost all samples collected from Little Buck Creek, which drains a predominantly urban watershed (57 percent urban). In contrast, diazinon was not found in Kessinger Ditch, where 94 percent of the watershed is agricultural and less than 2 percent is urban.



Common urban pesticides, such as diazinon, occur at higher concentrations in streams in urban watersheds than in streams in agricultural watersheds.

SPRING RUNOFF TRANSPORTS MOST HERBICIDES INTO STREAMS

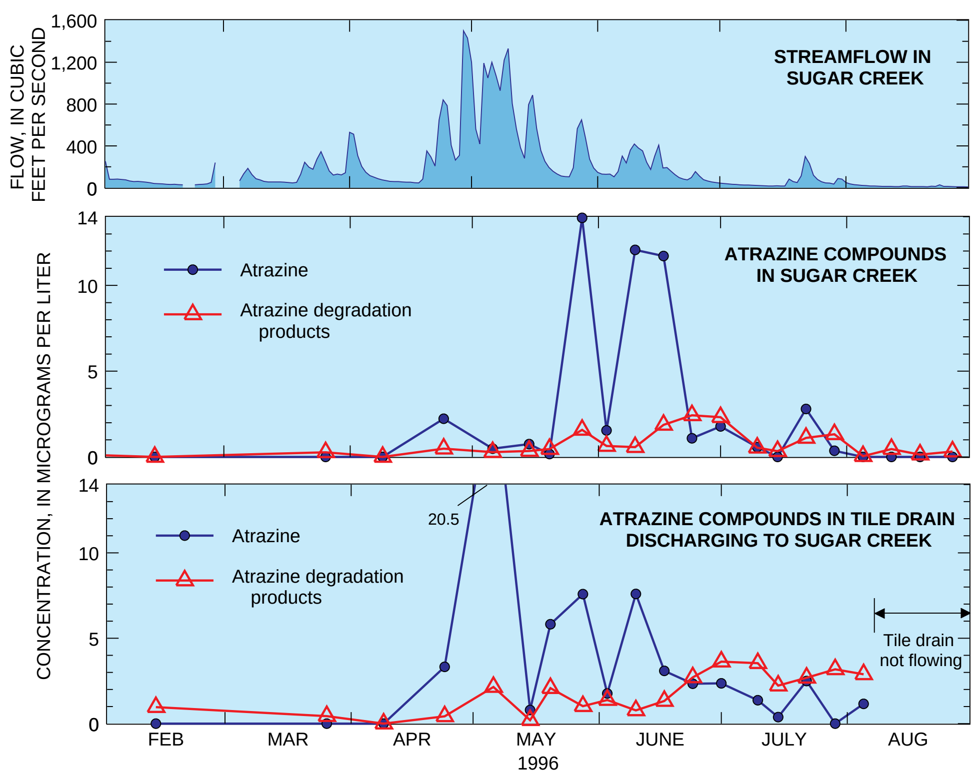


The annual amount of atrazine carried in the White River reflects the amount of runoff received from May through July.

Most of the annual herbicide load (the amount of herbicides carried by a river in one year) enters the White River between May and July. For example, from 1994 through 1996, 69 to 90 percent of the annual load of the five most commonly applied agricultural pesticides entered the river during this period. The amount of runoff from May through July is a key factor in determining the amount of herbicides, such as atrazine, in streams of the White River Basin (see illustration). During this period, which is shortly after atrazine application, atrazine concentrations in and on the soil are high, and the herbicide is susceptible to moving into streams when runoff occurs. Within 1 to 2 months, most of the applied atrazine is unavailable for transport because it is degraded or bound up in soil and plant material. Even heavy runoff at this time contributes only small amounts of atrazine to the river.

TILE DRAINS ARE SIGNIFICANT PATHWAYS FOR PESTICIDES

Agricultural tile drains provide an important pathway for the transport of pesticides to streams in the White River Basin (Fenelon and Moore, in press). Most poorly drained agricultural soils, which are common in the upper midwestern United States, contain tile-drain systems. Tile drains "short circuit" the ground-water system by intercepting water percolating through the soil and shallow ground water and rapidly transporting it to streams. Because tile drains typically flow during wet periods from late winter to early summer, they are able to transport recently applied pesticides to streams. In the example to the right, atrazine concentrations become elevated in the tile drain and the creek after atrazine is applied in early spring. Within about 2 months, as atrazine is naturally degraded, the concentration of atrazine degradation products is greater than the concentration of atrazine. In mid-August, the tile drain stops flowing and concentrations of all atrazine compounds in the creek are low.



In spring, tile-drain water with elevated concentrations of atrazine empties into Sugar Creek and raises atrazine concentrations in the creek.

NITRATE IN STREAMS AND GROUND WATER

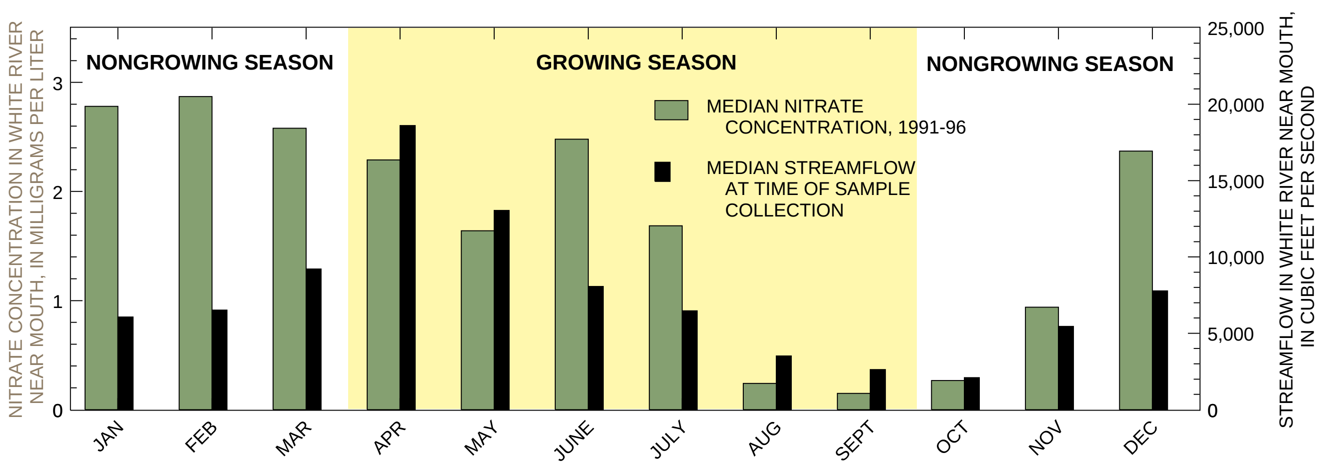
The primary source of nitrate in the White River Basin is nitrogen fertilizer (Martin and others, 1996). Most of the nitrogen fertilizer in the basin (about 90 percent) is applied to corn. Much of the remaining nitrogen fertilizer is applied to wheat. Nitrate is a public concern primarily because of its adverse effects on human health. The USEPA MCL for nitrate in drinking water is 10 mg/L. In some aquifers in the White River Basin, nitrate concentrations exceed this level (see p. 14). In streams, median nitrate concentrations generally ranged from 2 to 6 mg/L—much higher than those at most other streams monitored in the United States (see p. 20). Even so, concentrations of nitrate in streams in the White River Basin rarely exceeded 10 mg/L. The primary concern with nitrogen in streams in the basin is not drinking-water quality but its role in stimulating excessive growth of algae in lakes in Indiana and in the Gulf of Mexico. Runoff from Corn Belt States, which includes Indiana, is a possible cause of a "dead" zone in the Gulf of Mexico—one of the largest oxygen-deficient zones in the world (U.S. Environmental Protection Agency, 1997).

Photos by Jeffrey Martin and Charles Crawford, U.S. Geological Survey

Sources of nitrate, such as farm-animal manure, commercial fertilizers, and effluent from sewage-treatment plants, can stimulate excessive aquatic vegetation in lakes or streams (lower right).

NITRATE CONCENTRATIONS IN STREAMS SHOW A SEASONAL PATTERN

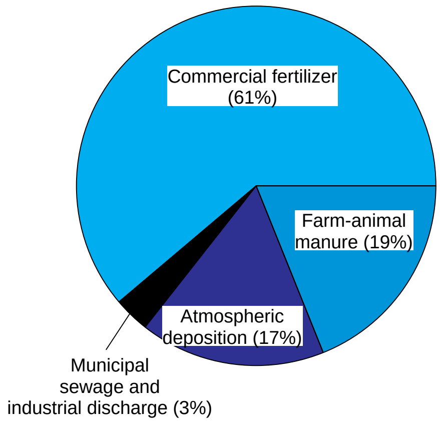
Nitrate concentrations in streams in the White River Basin have a seasonal pattern that is controlled by the transport and availability of nitrate (Martin and others, 1996). Nitrate is primarily available for transport during the nongrowing season, when it may build up in the soil because plants are not taking up large amounts of nutrients. Because nitrate is very mobile in water, it is easily flushed from saturated soils and transported to rain-swollen streams during wet periods. Nitrate concentrations in streams and streamflow are typically lowest in late summer and early fall when plants (both on land and in the streams) are using nitrate and soils are dry. As plants die or go dormant and soils regain moisture in fall, nitrate concentrations in streams begin to increase. Concentrations remain high into late spring and then start to decline as streamflow declines and plants begin to remove nitrate and water from the soils. Included in this seasonal pattern is a large rise in nitrate concentrations in June and July, soon after application of nitrogen-based fertilizer to corn crops in mid-May to mid-June.



Nitrate concentrations in the White River typically are highest during wet periods (high streamflow) and decrease during the growing season.

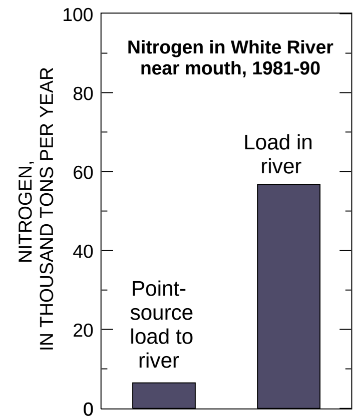
MOST NITROGEN IN WHITE RIVER IS FROM NONPOINT SOURCES

NITROGEN INPUTS TO BASIN



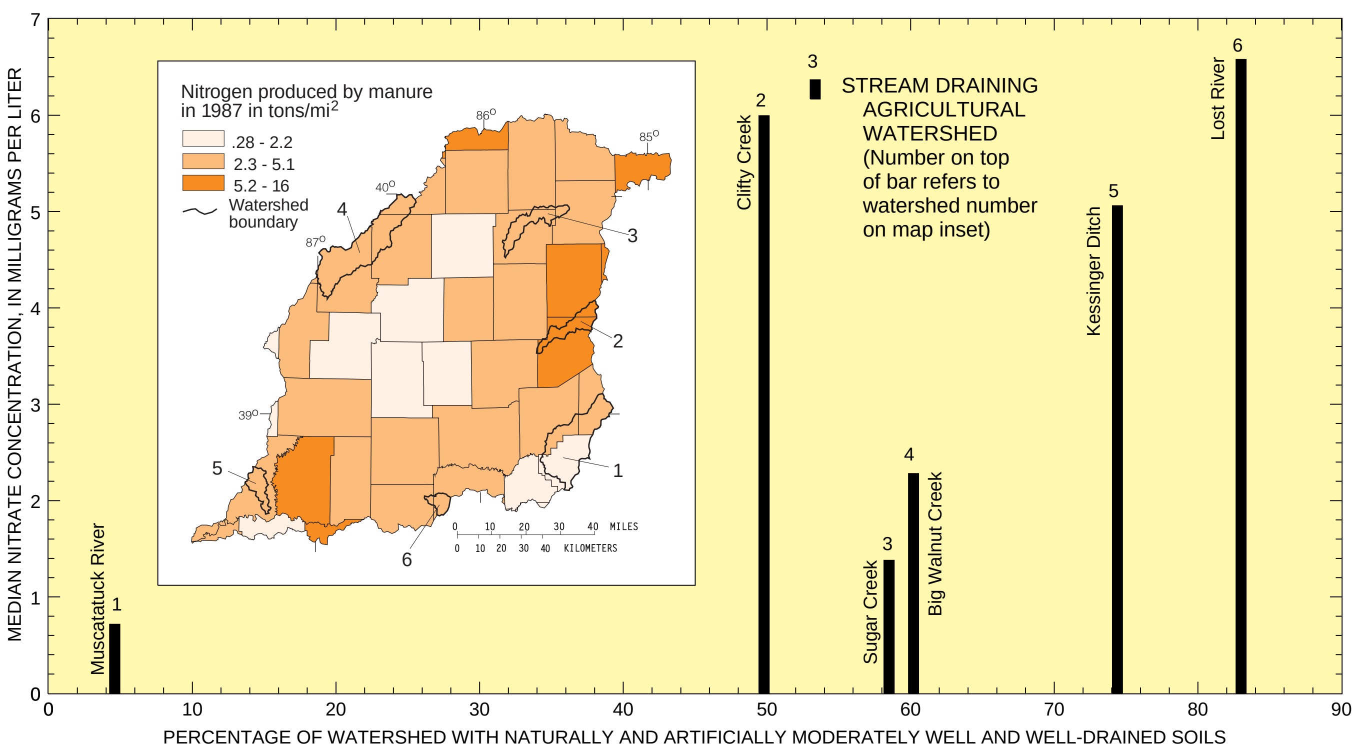
Most of the nitrogen input into the White River Basin comes from nonpoint sources, primarily from application of commercial fertilizer (Martin and others, 1996). Only about 3 percent of the nitrogen enters the basin from point sources (municipal sewage and industrial discharge).

Much of the nitrogen throughout the basin is consumed by plant uptake and other natural processes. About 11 percent of the nitrogen in the water at the mouth of the White River comes from point-source discharges; the remainder enters the river from nonpoint sources (Martin and others, 1996).



NITRATE CONCENTRATIONS IN STREAMS RELATED TO SOIL DRAINAGE

Soil drainage is a major factor controlling the concentrations of nitrate in streams in the White River Basin. Natural drainage is a function of the coarseness of soils (a sand drains better than a clay) and the slope (hills drain better than flat areas). Drainage is artificially enhanced by ditches and tile drains. Nitrate concentrations in streams increase as the proportion of well-drained soils (both naturally and artificially well drained) increase. This pattern holds for five of six agricultural streams studied. The one exception is Clifty Creek (watershed number 2), where nitrate concentrations are much higher than would be expected on the basis of percentage of well-drained soils. In this watershed, animal waste is believed to be contributing to high nitrate concentrations in the stream. The amount of nitrogen produced by manure from farm animals in the counties drained by Clifty Creek is higher than in each of the other watersheds.



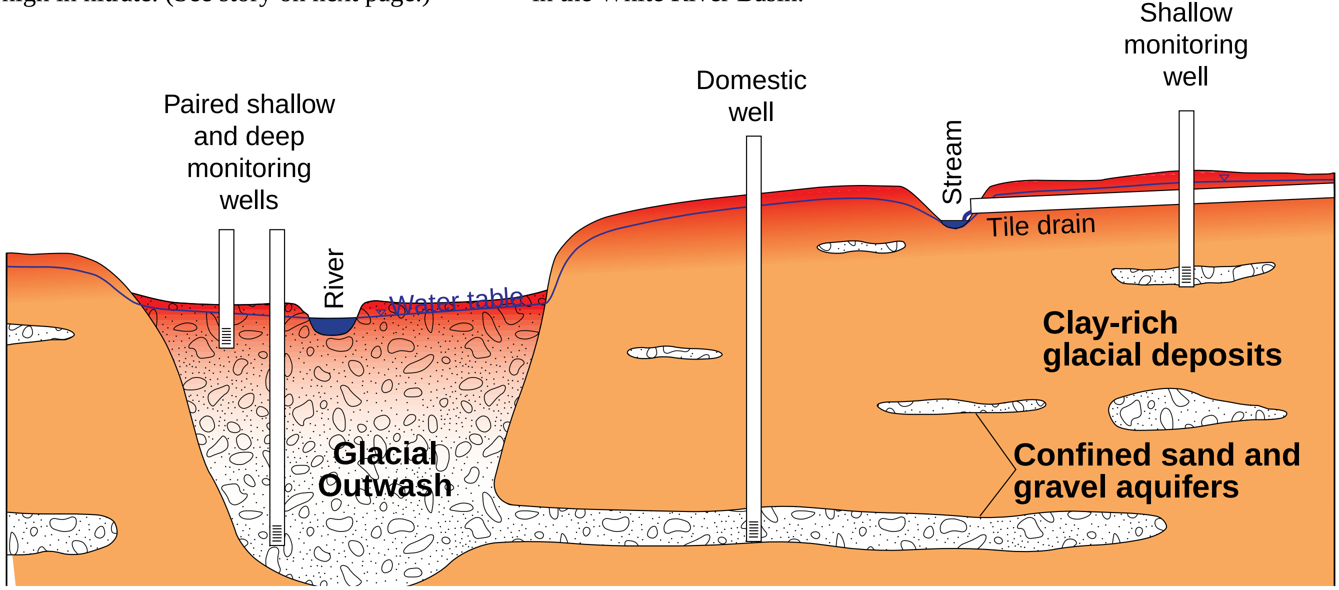
Nitrate concentrations in streams increase as the proportion of well-drained soils increases. Manure from farm animals also can increase nitrate concentrations.

AQUIFER TYPE DETERMINES VULNERABILITY TO NITRATE

Nitrate (shown in red) can leach downward into ground water when there is more nitrate in soil than plants can use. Where dissolved oxygen concentrations in ground water are low, this excess nitrate can be removed by denitrification (the biochemical conversion of nitrate to nitrogen gas by bacteria). Nitrate can also be removed by tile drains, which siphon off soil water and shallow ground water that is high in nitrate. (See story on next page.)

Ground water is most vulnerable to nitrate contamination in surficial, coarse-textured, well-drained deposits such as **glacial outwash** (sand and gravel deposited by glacial streams). However, nitrate contamination typically decreases with depth. (See story on next page.) Outwash aquifers provide a major source of drinking water in the White River Basin.

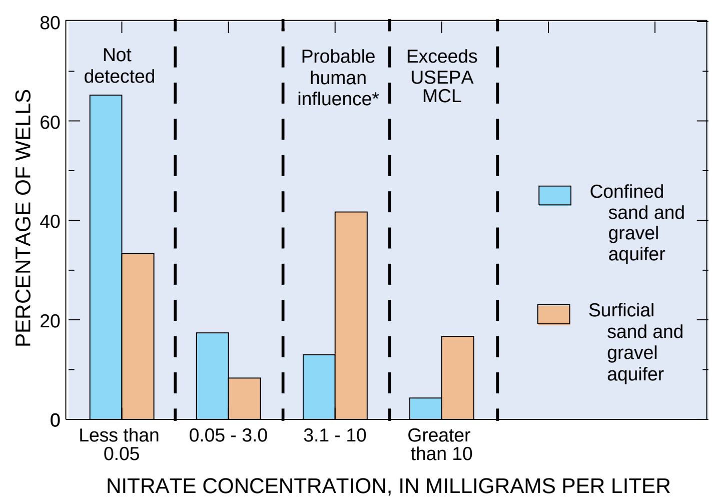
Confined (artesian) sand and gravel aquifers are protected from nitrate contamination by clay-rich glacial deposits. These confined aquifers are present in more than half the basin and are a common source of water for rural households that use domestic wells.



SURFICIAL SAND AND GRAVEL AQUIFERS ARE VULNERABLE TO NITRATE CONTAMINATION

Surficial sand and gravel aquifers (outwash aquifers) underlying row-crop agriculture are vulnerable to nitrate contamination (Moore and Fenelon, 1996). Seventeen percent of shallow wells in these aquifers had nitrate concentrations that exceeded the USEPA MCL of 10 mg/L. However, deeper parts of the aquifer had lower concentrations of nitrate. (See story on next page.) Surficial sand and gravel aquifers are vulnerable to nitrate contamination because water infiltrates through them rapidly. Rapid infiltration enables nitrate to move below the root zone before it can be taken up by plants. In addition, rapid infiltration of rainwater and snowmelt replenishes ground water with oxygen, inhibiting nitrate loss by denitrification.

Confined (artesian) sand and gravel aquifers underlying row crops in the northern part of the basin are far less vulnerable to nitrate contamination. Approximately 65 percent of the shallow wells in these aquifers had no detectable nitrate (less than 0.05 mg/L). Low concentrations of nitrate in confined aquifers are common because overlying clay-rich soils retard downward movement of nitrate and oxygen into the aquifers.

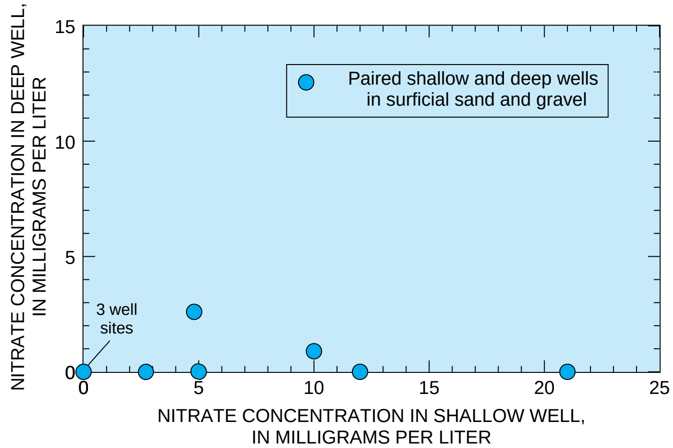


*Madison and Brunett, 1984

Surficial sand and gravel aquifers underlying row-crop agriculture can have high nitrate concentrations; confined aquifers are protected by overlying clay soils.

NITRATE CONCENTRATIONS IN GROUND WATER DECREASE WITH DEPTH

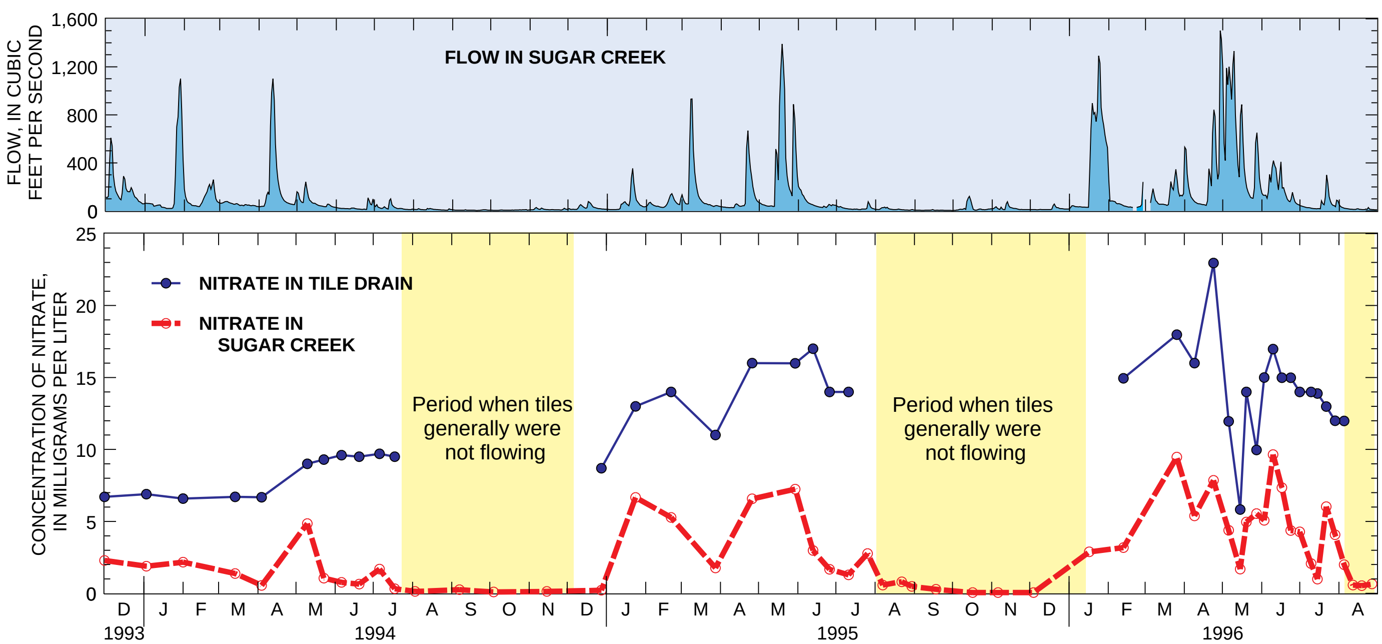
In the White River Basin, paired shallow and deep wells in surficial sand and gravel outwash (shown in diagram on previous page) showed that the highest concentrations of nitrate were in samples from the wells just below the water table. At depths of 25 to 50 feet below the water table, little or no nitrate was detected (Moore and Fenelon, 1996). Shallow ground water has high concentrations of nitrate, in part because most nitrate sources originate at land surface. Nitrate concentrations tend to decrease with depth as water containing nitrate moves downward into the ground-water system and is diluted. The decrease in nitrate concentrations with depth also is influenced by the availability of dissolved oxygen. As dissolved oxygen concentrations decrease with depth, nitrate is converted to nitrogen gas by anaerobic bacteria (bacteria that don't need oxygen to live) which use nitrate for energy production.



High concentrations of nitrate were found in shallow wells. In deep wells (25 to 50 feet below the water table), little or no nitrate was detected.

TILE DRAINS HAVE MAJOR INFLUENCE ON NITRATE CONCENTRATIONS IN STREAMS

Agricultural tile drains have a major influence on nitrate concentrations in many streams in the White River Basin. Aquifers in most of the poorly drained soils of the basin are protected by overlying clay and have low nitrate concentrations. However, the streams flowing in these areas can have elevated nitrate concentrations because of outflow from tile drains that artificially drain nitrate-rich shallow ground water and water percolating through soils (Fenelon and Moore, in press). In Sugar Creek, which flows through an agricultural watershed with poorly drained soils, nitrate concentrations are elevated when tiles are flowing. During periods when tiles go dry (midsummer to late fall), nitrate concentrations in the creek drop to background levels. These low concentrations are typical of concentrations found in the aquifers, the source of water to the creek during these periods.



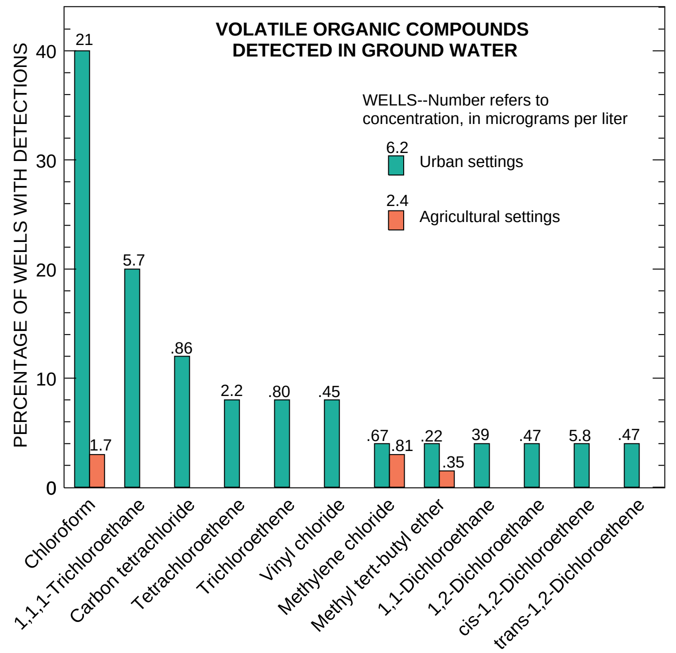
Nitrate concentrations in Sugar Creek are elevated when tile drains are flowing but drop to background levels when tiles go dry.

EFFECTS OF URBAN AREAS ON WATER QUALITY

Urban areas in the White River Basin are sources of organic compounds, trace elements (including heavy metals), and nutrients. Contaminants from urban areas commonly enter streams or ground water through point sources, such as sewers, industrial discharge pipes, landfills, or chemical spills.

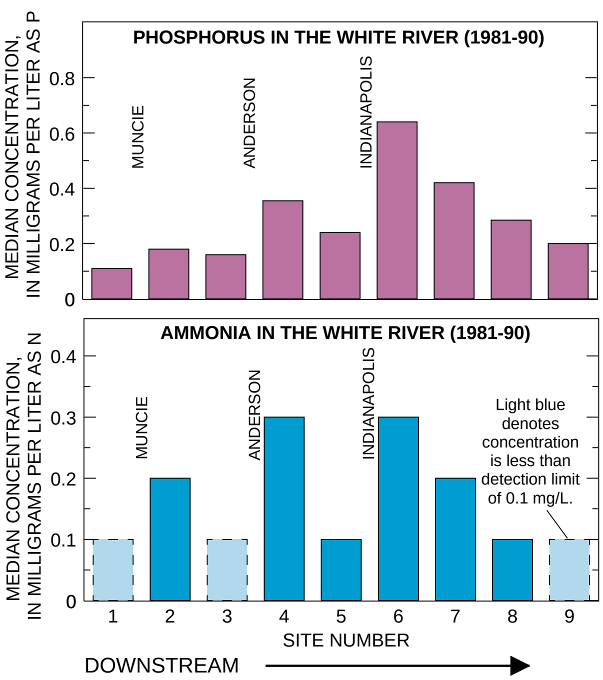
VOLATILE ORGANIC COMPOUNDS ARE COMMON IN URBAN GROUND WATER

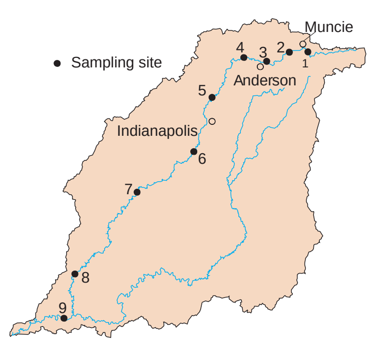
Trace levels of volatile organic compounds (VOCs) were detected in more than half the shallow monitoring wells in urban settings in the White River Basin as compared to 6 percent of shallow wells in agricultural settings (Fenelon and Moore, 1996b). Of 58 VOCs that were analyzed for, 12 were detected in at least one monitoring well. Maximum concentrations of 11 of the 12 VOCs detected in ground water were no more than half their respective USEPA MCL or lifetime health advisory; 1,1-dichloroethane does not have an MCL or advisory. Most drinking-water wells in the basin are deeper than the monitoring wells used in this study and, therefore, domestic and public water supplies are expected to be better protected from VOC contamination than shallow ground water. Chloroform was the most common VOC found in urban ground water. A likely source of the low chloroform concentrations in ground water (median detected concentration was 0.5 µg/L) is leakage into the aquifer of chlorinated public-supply water from various sources such as lawn irrigation or leaky water mains. Typical chloroform concentrations in Indianapolis public-supply water during 1993–95 were 40 to 70 µg/L—much higher than ground-water concentrations.



Volatile organic compounds were common in shallow ground water in urban settings but were almost absent in agricultural settings.

URBAN AREAS ARE SOURCE OF NUTRIENTS TO STREAMS





The nutrients phosphorus and ammonia increase downstream from major urban areas.

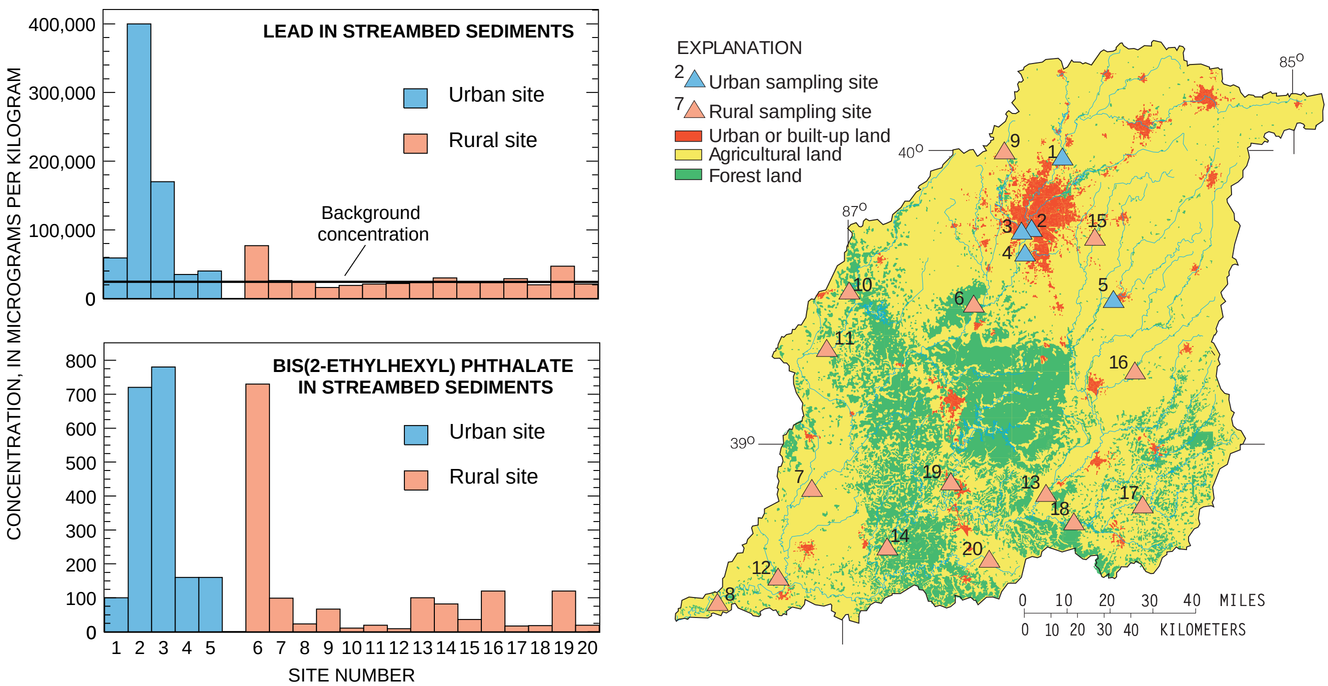
Concentrations of phosphorus and ammonia were highest at monitoring sites downstream from the major urban areas along the White River (Martin and others, 1996). High concentrations of phosphorus and ammonia downstream from Muncie, Anderson, and Indianapolis probably were caused by the discharge of treated sewage, urban runoff, and other discharges in these cities.

High concentrations of phosphorus can cause undesirable aquatic plant growth, whereas high concentrations of ammonia can kill fish. Ammonia concentrations in samples from the nine monitoring sites on the White River rarely exceeded the Indiana instantaneous water-quality criterion for ammonia. However, the 24-hour average water-quality criterion might have been exceeded in about 5 to 10 percent of the samples at sites 6, 7, and 8. (Possible exceedances of the 24-hour average criteria were estimated on the basis of one sample per 24-hour period.)

INDUSTRIAL COMPOUNDS AND METALS ARE ELEVATED IN URBAN STREAMBED SEDIMENTS

Concentrations of many trace elements and manmade organic compounds in streambed sediments are higher in urban areas than elsewhere in the basin (Wesley Stone, U.S. Geological Survey, written commun., 1997). Most of these compounds, such as lead and bis(2-ethylhexyl) phthalate, are common in urban areas. For example, lead is in batteries, paints, and pipes, whereas bis(2-ethylhexyl) phthalate is in a variety of plastic materials and in cosmetics. Industrial compounds typically reach the streambed sediments through point sources (such as municipal and industrial wastewater discharge) and nonpoint sources (such as surface runoff and atmospheric deposition). A pattern of downstream migration of many compounds from urban areas (especially Indianapolis) is evident. For example, the highest concentrations of lead and bis(2-ethylhexyl) phthalate measured in rural streambed sediments were on the White River at site 6 (see map) approximately 20 miles downstream from Indianapolis. Several chemicals whose use has long been banned (chlordane, dieldrin, and PCBs) persist in streambed sediments and are accumulated in biota such as freshwater clams. Some of these chemicals, such as dieldrin, were primarily used for agriculture.

In general, concentrations of trace elements and organic compounds in streambed sediments are not a human health concern, even in urban areas; however, fish-consumption advisories for PCBs and mercury are in effect for some areas of the basin.



Industrial compounds, such as lead and bis(2-ethylhexyl) phthalate, are common in streambed sediments near urban areas.

COMBINED-SEWER OVERFLOWS CONTINUE TO DEGRADE WATER QUALITY

Significant progress has been made toward restoration of water quality and fish communities in the White River Basin since the early 1970's (Crawford and others, 1996). However, combined-sewer overflows and stormwater runoff are continuing problems. Combined-sewer overflows and stormwater runoff have contributed to fish kills in the basin by depleting oxygen in the streamwater. One such incident in the White River at Indianapolis in 1994 killed 510,000 fish (Camp Dresser & McKee, 1995).

Photo by Charles Crawford, U.S. Geological Survey

Combined sewers can overflow during rain storms, discharging stormwater runoff and raw sewage into the White River.

FISH COMMUNITIES

Since the early 1800's, fish communities in the White River Basin have been affected by the alteration of natural stream habitat, overfishing, introduction of nonnative species, agriculture, and urbanization (Crawford and others, 1996). Raw sewage and untreated industrial wastewater were routinely discharged into the White River and its tributaries from the early to mid-1900's, causing degradation of fish communities.

Since the early 1970's, substantial public and private money has been spent on programs to improve stream quality in Indiana. These programs were directed at reductions in point-source contamination, such as improved municipal and industrial wastewater treatment, as well as nonpoint-source contamination, such as decreased soil erosion and agricultural runoff and reclamation of abandoned mine lands. Significant progress has been made towards restoration of fish communities in the White River Basin during this time as a result of these water-quality improvement programs (Crawford and others, 1996).

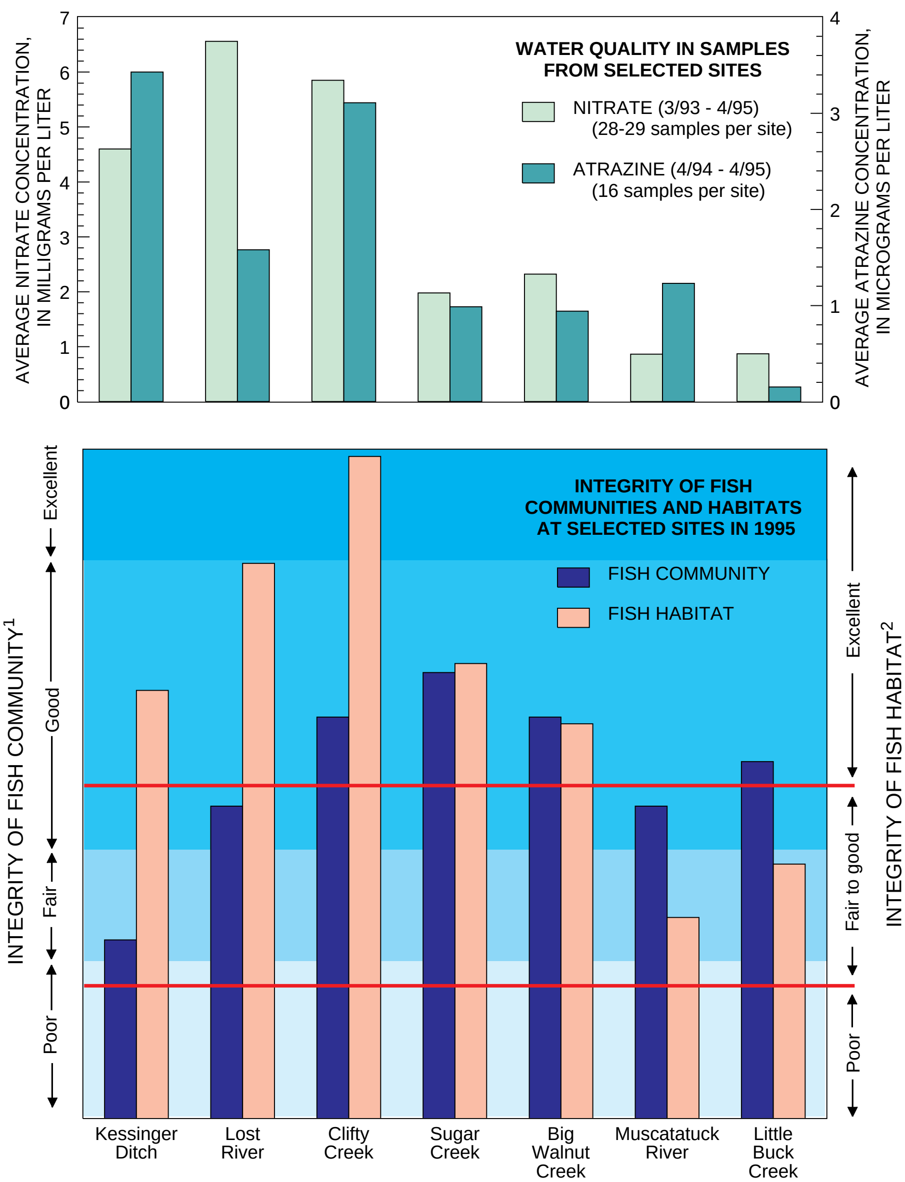
"In 1909, Mr. J.A. Smith and the writer descended White River from Indianapolis and found the condition such that it produced extreme nausea. Night camp was pitched twenty miles by river below Indianapolis, and one-fourth of a mile from the river on a tributary stream, but the effects of sewage were still very disagreeable. The decaying carcasses of several hogs which had been thrown into the river by the packing houses of Indianapolis greatly aggravated the situation. The sewage of Indianapolis at this time formed practically half the volume of the stream. The bed of the stream was covered with a coating of dark, greasy, sludge, largely organic matter, to a depth of one inch or more." **—W.M. Tucker, 1922, p. 302**

Game fish in the White River—bluegill, sunfish, smallmouth and largemouth bass, and channel and flathead catfish—provide recreational fishing opportunities.

Fish communities may be affected by nonpoint-source contamination, such as nitrate in runoff from hog farms, pesticides in tile-drain effluent, and sediment washed into streams.

Photos by Jeffrey Martin and Nancy Baker, U.S. Geological Survey

QUALITY OF FISH COMMUNITIES LESS THAN EXPECTED FOR SOME STREAMS



Kessinger Ditch, which has excellent fish habitat but only a fair community of fish, has relatively high concentrations of nonpoint-source contaminants, such as nitrate and atrazine.

Some streams with good fish habitat in the White River Basin had poorer than expected fish communities in 1995, an indication that non-habitat stresses such as poor water quality may be affecting the fish communities (Frey and others, 1996). In the figure to the left, sites in Kessinger Ditch, Lost River, and Clifty Creek have excellent fish habitats that should be able to support excellent fish communities. However, fish communities at these sites are only fair to good. A possible reason for this discrepancy is that water quality at these sites is degraded by nonpoint-source contamination. Concentrations of nitrate and atrazine—indicators of nonpoint-source contamination—at these three sites are higher than at any of the other sites shown in the figure to the left. In contrast, the Muscatatuck River and Little Buck Creek have only fair to good habitats, yet they support good communities of fish, an indication that nonhabitat stresses (such as water quality) do not have as great an effect at these sites. Correspondingly, average concentrations of nitrate and atrazine at these two sites are generally low with respect to the other five sites.

[1]The Index of Biological Integrity (IBI) was used as an index tool to evaluate fish communities.

[2]The Qualitative Habitat Evaluation Index (QHEI) was used as an index tool to evaluate fish habitats.

COMPARISON OF STREAM QUALITY IN THE WHITE RIVER BASIN WITH NATIONWIDE NAWQA FINDINGS

Seven major water-quality characteristics were evaluated for stream sites in each NAWQA Study Unit. Summary scores for each characteristic were computed for all sites that had adequate data. Scores for each site in the White River Basin were compared with scores for all sites sampled in the 20 NAWQA Study Units during 1992–95. Results are summarized by percentiles; higher percentile values generally indicate poorer quality compared with other NAWQA sites. Water-quality conditions at each site also are compared to established criteria for protection of aquatic life. Applicable criteria are limited to nutrients and pesticides in water, and semivolatile organic compounds, organochlorine pesticides, and PCBs in sediment. (Methods used to compute rankings and evaluate aquatic-life criteria are described by Gilliom and others, in press.) Water-quality data for streams in the White River Basin are presented in a national context in the tables on pages 26–31.

EXPLANATION

Ranking of stream quality relative to all stream sites — Darker colored circles generally indicate poorer quality. Bold outline of circle indicates one or more aquatic-life criteria were exceeded

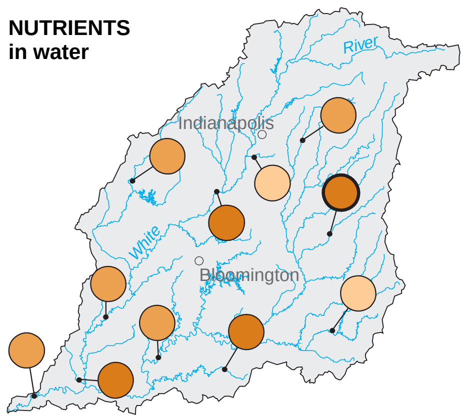
Greater than the 75th percentile (among the highest 25 percent of NAWQA stream sites)

Between the median and the 75th percentile

Between the 25th percentile and the median

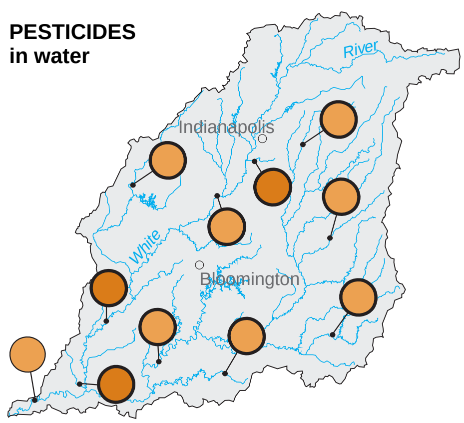
Less than the 25th percentile (among the lowest 25 percent of NAWQA stream sites)

NUTRIENTS in water



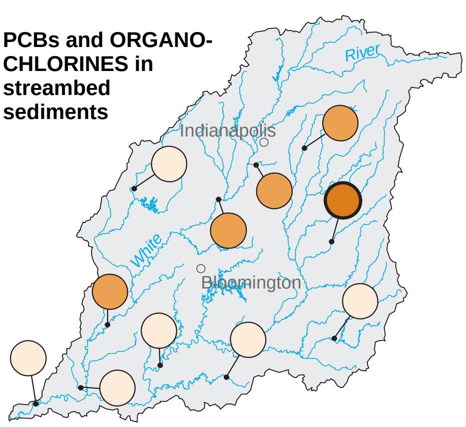
Nutrient concentrations in streams in the basin are high compared to those at other NAWQA sites nationwide. This is not unexpected, given that the White River Basin is dominated by agriculture and that agricultural practices provide a major source of nutrients to streams in the form of fertilizers or farm-animal waste. Ammonia concentrations from one sample in a small agricultural watershed with a high density of farm animals exceeded the aquatic-life criterion.

PESTICIDES in water



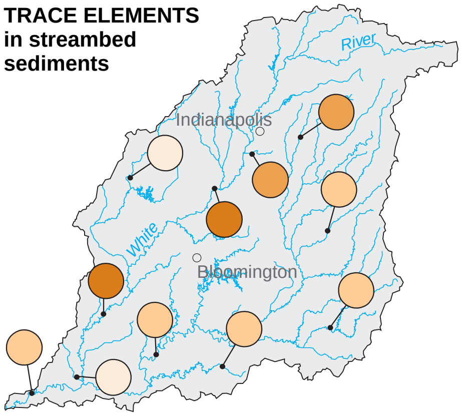
Pesticide concentrations in streams at both urban and agricultural sites were among the highest in the Nation. Aquatic-life criteria were exceeded at every site except for the mouth of the White River. The most common compounds to exceed the criteria were the herbicides atrazine and cyanazine.

PCBs and ORGANOCHLORINES in streambed sediments



Concentrations of PCBs and organochlorine pesticides in streambed sediment were elevated compared to those at NAWQA sites nationwide, primarily at sites near or downstream from Indianapolis. Sediment from sites in the southern part of the basin had very low concentrations. Total chlordane exceeded an aquatic-life criterion for sediment at one site.

TRACE ELEMENTS in streambed sediments



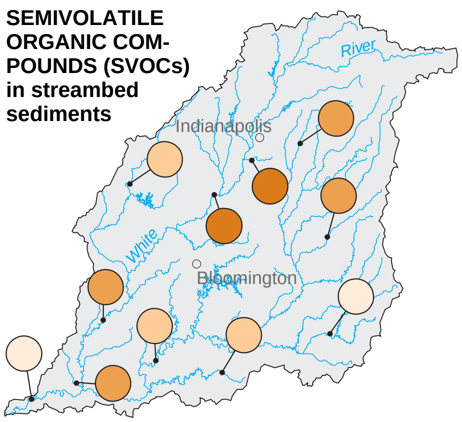
Trace element concentrations in streambed sediments at two sites on the White River downstream from Indianapolis were among the highest 25 percent of NAWQA stream sites nationwide. Most other sites in the basin ranked in the lowest 50 percent of sites throughout the country.

CONCLUSIONS

Nutrients and pesticides in streams at most of the sites in the White River Basin were high compared to those at NAWQA sites nationwide. Most of the high concentrations result from agricultural practices.

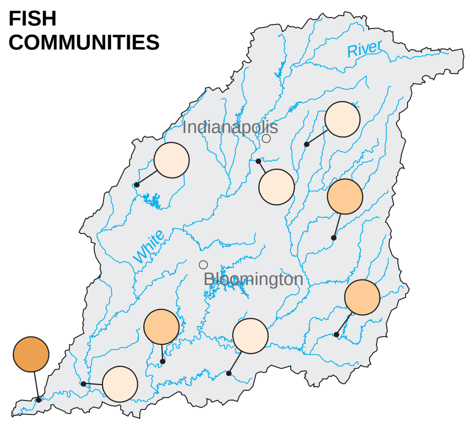
Contaminants in streambed sediment were high near and downstream from Indianapolis compared to other sites nationally; however, aquatic-life criteria were rarely exceeded.

SEMIVOLATILE ORGANIC COMPOUNDS (SVOCs) in streambed sediments

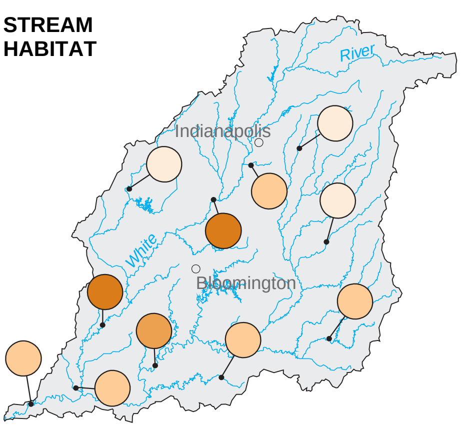


The highest concentrations of semivolatile organic compounds (SVOCs) in streambed sediment were at sites near or downstream from Indianapolis. No compound at any site exceeded an aquatic-life criterion for sediment.

FISH COMMUNITIES



STREAM HABITAT



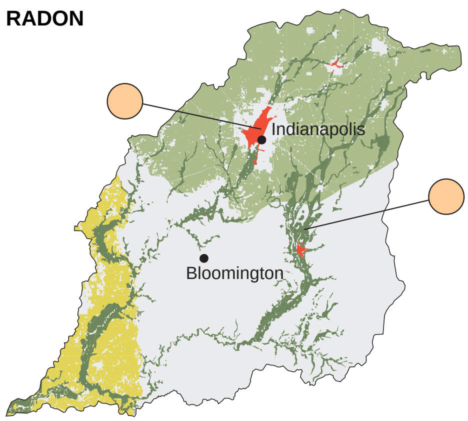
Stream habitat varied in the basin. Habitat degradation ranged from low in some small streams (Clifty, Big Walnut, and Sugar Creeks) to high at some sites on the White River. A degraded stream habitat can result from an altered stream channel, streambank erosion, and scarcity of vegetation (including trees) along the banks and edges of a stream.

Degradation of fish communities in the basin (based on the percentage of diseased, pollution-tolerant, omnivorous, and non-native fish along a stream reach) was generally low compared to other NAWQA sites nationwide. However, when additional regional factors are considered—including the number or percentage of specific species of fish; number of pollution-sensitive species; percentage of insectivores, carnivores, and pioneering species; and size of stream (as was done in assessing fish communities on page 19)—some of the sites which are ranked very good on the map above (that is, ranked among the least degraded in the Nation) are downgraded to good or fair.

COMPARISON OF GROUND-WATER QUALITY IN THE WHITE RIVER BASIN WITH NATIONWIDE NAWQA FINDINGS

Five major water-quality characteristics were evaluated for ground-water studies in each NAWQA Study Unit. Ground-water resources were divided into two categories: (1) drinking-water aquifers, and (2) shallow ground water underlying agricultural or urban areas. Summary scores were computed for each characteristic for all aquifers and shallow ground-water areas that had adequate data. Scores for each aquifer and shallow ground-water area in the White River Basin were compared with scores for all aquifers and shallow ground-water areas sampled in the 20 NAWQA Study Units during 1992–95. Results are summarized by percentiles; higher percentile values generally indicate poorer quality compared with other NAWQA ground-water studies. Water-quality conditions for each drinking-water aquifer also are compared to established drinking-water standards and criteria for protection of human health. (Methods used to compute rankings and evaluate standards and criteria are described by Gilliom and others, in press.) Ground-water-quality data from the White River Basin are presented in a national context in the tables on pages 26-31.

RADON



Radon concentrations in outwash aquifers were generally low as compared to those in other Study Units. Despite this, 70 percent of the shallow wells exceeded the proposed USEPA MCL for radon. In deeper wells (not shown on map), which may be more representative of drinking-water wells, radon concentrations were less (Fenelon and Moore, 1996c).

EXPLANATION

Drinking-water aquifers

- Outwash deposits under cropland
- Outwash deposits under urban land

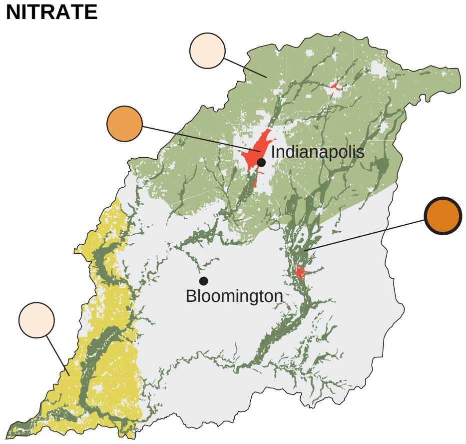
Shallow ground-water areas

- Till plain deposits under cropland
- Glacial lowland deposits under cropland

Ranking of ground-water quality relative to all NAWQA ground-water studies — Darker colored circles generally indicate poorer quality. Bold outline of circle indicates one or more standards or criteria were exceeded

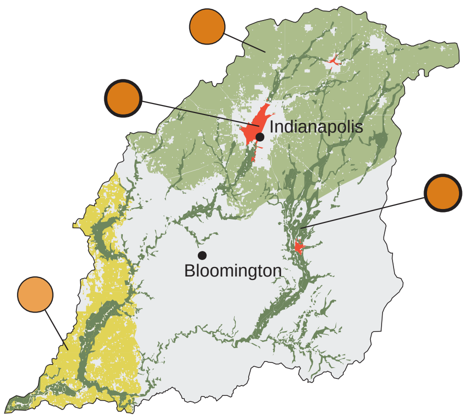
- **Greater than the 75th percentile** (among the highest 25 percent of NAWQA ground-water studies)
- **Between the median and the 75th percentile**
- **Between the 25th percentile and the median**
- **Less than the 25th percentile** (among the lowest 25 percent of NAWQA ground-water studies)

NITRATE



Nitrate concentrations were very low in ground water under clay soils (in the till plain and glacial lowland). Clay soils prevent leaching of nitrate from the land surface. In contrast, nitrate concentrations in ground water from the shallow parts of the well-drained outwash aquifer were high as compared to other drinking-water aquifers nationwide. Deeper ground-water in this drinking-water aquifer had much lower nitrate concentrations.

DISSOLVED SOLIDS



Concentrations of dissolved solids were high in ground water throughout the basin as compared to ground water in other Study Units. In the shallow parts of outwash aquifers under urban land, 72 percent of the samples exceeded the drinking-water standard. High dissolved-solids concentrations are caused primarily by high concentrations of the naturally occurring constituents bicarbonate, calcium, and magnesium, which make the water very hard.

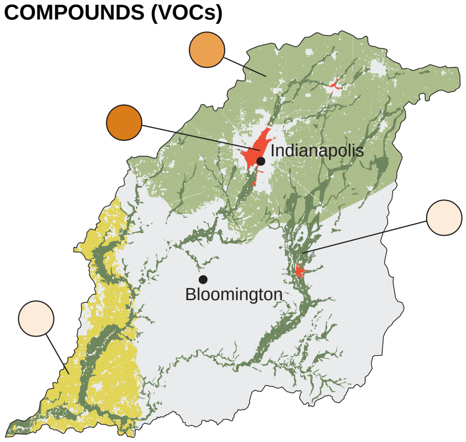
CONCLUSIONS

Ground water in the White River Basin is generally very hard and has high concentrations of dissolved solids. Although contaminants are common in some ground-water settings, contaminant concentrations (except those for nitrate) rarely exceed drinking-water standards.

Land use affects ground-water quality. For example, VOCs are common in urban areas, whereas pesticides are common in cropland areas.

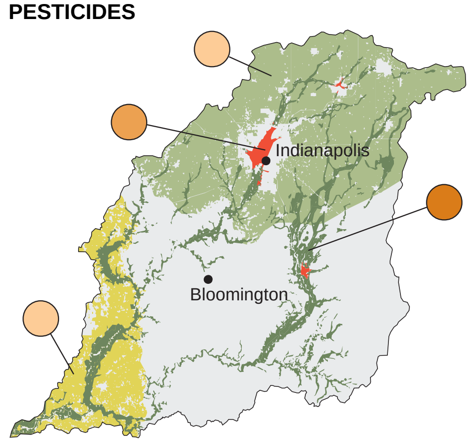
Clay soils, which are common in large areas of the basin and overlie ground-water supplies, help prevent degradation of ground water from contamination originating at the land surface. In contrast, surficial aquifers, such as the outwash aquifers, are vulnerable to contamination.

VOLATILE ORGANIC COMPOUNDS (VOCs)



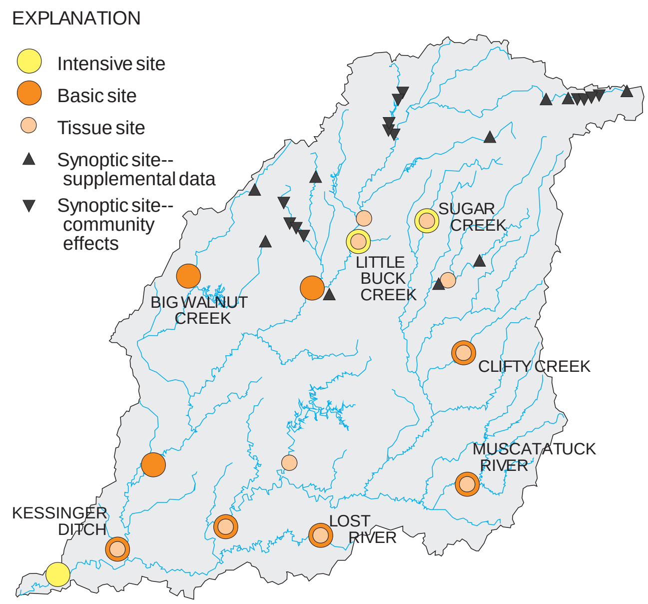
VOCs were not detected in shallow ground water under cropland areas in the glacial lowland or outwash deposits. However, 17 percent of the shallow wells under cropland in the till plain and 52 percent of the shallow wells in urban outwash deposits had at least one detectable VOC, placing these areas in the top 50 percent of the NAWQA Study Units nationwide. No VOC drinking-water standard was exceeded in any ground-water sample.

PESTICIDES



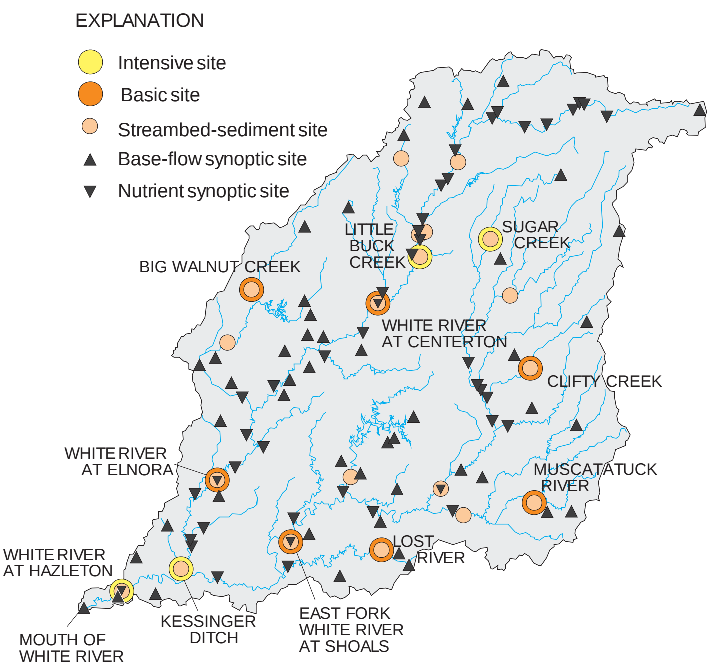
Seventy-one percent of shallow wells in the outwash aquifers under cropland contained at least one pesticide. This was among the highest frequency of detection in all Study Units for a drinking-water aquifer. However, the frequency of detection in deeper wells in the outwash deposits was less. In other areas of the basin, 38 to 44 percent of the wells had at least one detectable pesticide, typical of NAWQA Study Units nationwide. No sample of ground water in any area of the basin exceeded a pesticide drinking-water standard.

The study design used for the White River Basin study is part of a national study design (Gilliom and others, 1995). The design consists of three components—stream chemistry, stream ecology, and ground-water chemistry.



Stream Chemistry

The stream-chemistry network was designed to measure the effects of land use (primarily cropland and urban) on stream quality or to integrate the effects of multiple land uses and hydrogeologic settings on water quality. Data from basic sites were used to examine areal differences in water quality. Data from intensive sites, which were sampled more often, were used to examine seasonal changes in stream quality. Several synoptic studies were designed to examine stream and streambed quality throughout a large area of the basin in a short time period.

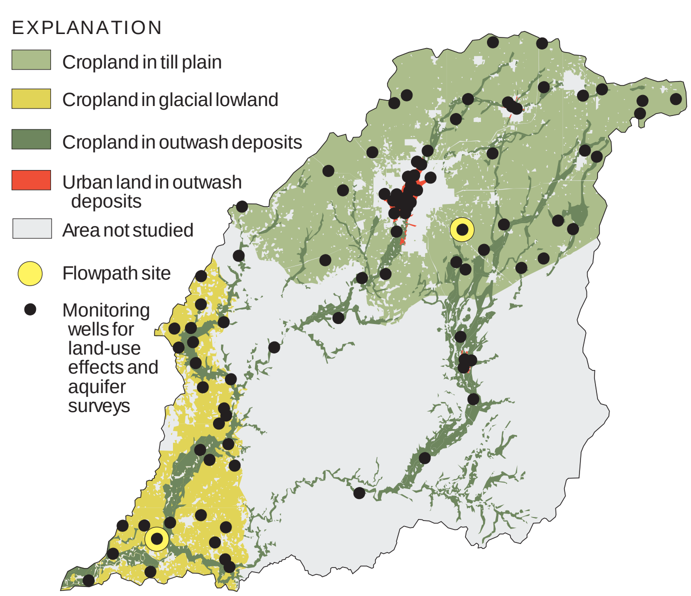


Stream Ecology

Ecological assessments were done at the basic and intensive stream-chemistry sites. Some of the assessments examined multiple reaches of a stream or were repeated over several years to determine spatial or temporal variations in the community structure of aquatic organisms. Synoptic studies were designed to evaluate spatial variability and to assess the influence of various human activities on stream ecology. For the synoptic studies, clam and fish tissue or macroinvertebrate communities were sampled at several sites in the basin in a short time period.

Ground-Water Chemistry

Four ground-water surveys examined the effects of a land use (either cropland or urban) on shallow ground water in different aquifer settings. One of the aquifer settings is unconfined outwash, a principal source of drinking water in the basin. Two small-scale flowpath sites were studied to look at the effects of agricultural practices and changes in water quality as ground water flows from recharge to discharge areas.



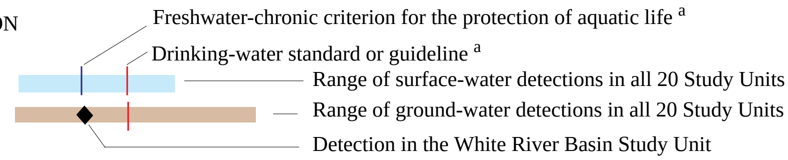
SUMMARY OF DATA COLLECTION IN THE WHITE RIVER BASIN STUDY UNIT, 1992-95

Study component	What data were collected and why	Types of sites sampled	Number of sites	Sampling frequency and period
Stream chemistry				
Basic sites—general water quality	Major ions, organic carbon, suspended sediment, nutrients, pesticides, and streamflow were determined to describe concentrations and loads of chemicals at selected sites basinwide.	Streams draining basins ranging in size from 35 to 4,900 square miles and representing agricultural and mixed land uses were sampled.	7	About 14 per year (1993-95)
Intensive sites—general water quality	The above constituents were determined to describe concentration and timing of agriculture-related compounds that run off to streams.	Streams draining basins ranging in size from 17 to 11,300 square miles and representing agricultural, urban, and mixed land uses were sampled.	4	About 26 per year (1992-95)
Base-flow synoptic study—general water quality	Nutrients, major ions, triazines, and streamflow were determined to compare water quality of base flow in small streams among the five different regions of the basin.	Small streams (drainage areas less than 24 square miles) were sampled.	48	1 (March 1992)
Nutrient synoptic study	Nutrients, major ions, chlorophyll, and flow were determined to compare sources, concentrations, transport, and transformations of nutrients in major rivers during summer and winter base flow.	Main-stem sites on White and East Fork White Rivers, sites near mouths of major tributaries, and major sewage-treatment plants were sampled.	15 main stem 24 tributary 6 sewage treatment	2 (March and August 1994)
Contaminants in streambed sediment	Trace elements and organic compounds were analyzed to determine presence of potentially toxic compounds attached to sediments in major streams.	Depositional zones of White and East Fork White Rivers and tributary streams draining less than 960 square miles were sampled.	20	1 (1992)
Stream ecology				
Basic sites—general ecology	Fish, macroinvertebrate, and algae communities were sampled and habitat was described to determine presence and community structure of aquatic species in representative streams across the basin.	Seven basic stream-chemistry sites and one intensive stream-chemistry site were sampled.	8	1 (1993 for all measures) 1 (1995 for fish only)
Intensive sites: multireach—general ecology	Fish, macroinvertebrate, and algae communities were sampled and habitat was described to determine differences in presence and community structure of aquatic species among multiple reaches of a stream.	Three reaches within a stream for three intensive stream-chemistry sites (Sugar Creek, Little Buck Creek, and White River at Hazleton) were sampled.	3	1 (1994)
Intensive sites: multiyear—general ecology	Fish, macroinvertebrate, and algae communities were sampled and habitat was described to determine temporal variations in presence and community structure of aquatic species at selected streams.	One reach within a stream at same sites as above were sampled.	3	3 (1993-95)
Supplemental data synoptic study	Macroinvertebrate communities were sampled and habitat was described to determine presence and community structure of macroinvertebrates throughout basin.	Sites in the northern part of the basin were sampled to supplement data from basic and intensive sites.	10	1 (1994)
Community-effects synoptic study	Macroinvertebrate communities were sampled and habitat was described to determine effects on and recovery of macroinvertebrate community structure from selected nonpoint-source inputs.	Sites upstream and downstream from a feedlot, a small town, and a reservoir were sampled.	13	1 (1994)
Contaminants in tissue of freshwater aquatic organisms	Asiatic clams were collected to determine presence of contaminants that can accumulate in tissues of aquatic organisms common in basin. Fish-tissue samples from multiple species were analyzed for trace elements and organic compounds for regional and national comparisons.	A subset of the streambed-sediment sites were sampled.	10	1 (1992)
Ground-water chemistry				
Land-use-effects survey—agricultural and urban	Major ions, nutrients, pesticides, volatile organic compounds, tritium, and radon (in outwash wells) were analyzed to determine the effects of specific land use on the quality of shallow ground water.	Monitoring wells in (1) shallow but typically confined aquifers in two agriculture regions and (2) unconfined outwash aquifer in urban and agricultural areas were sampled.	4 surveys 94 wells total	1 (either 1994 or 1995)
Aquifer survey—outwash	Data collected from outwash aquifer sites for land-use effects survey (mentioned above) plus samples collected from deeper wells in outwash aquifer were used to describe the overall water quality of this principal aquifer in the basin.	Monitoring wells in unconfined outwash aquifer at land-use-effects sites in agricultural and urban areas were sampled.	49 wells from land-use survey, 9 deeper wells	1 (1995)
Flowpath studies	Major ions, nutrients, pesticides, and tritium were analyzed to describe effects of agricultural land use on confined sand and gravel aquifers along ground-water flowpath from areas of recharge beneath agricultural land use to discharge to a stream.	Tile drains, lysimeters, and clusters of wells installed at various depths along ground-water flowpaths at two agricultural sites were sampled. Flowpath sites are in areas studied for ground-water land-use effects and near intensive stream-chemistry sites.	14 wells 3 tile drains 6 lysimeters	3 (1993-95)

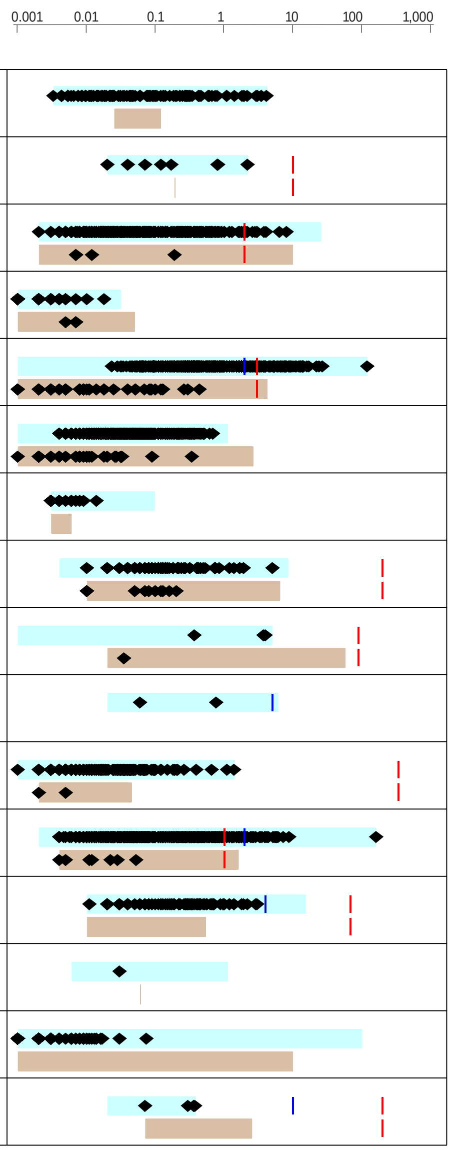
The following tables summarize data collected for NAWQA studies from 1992-1995 by showing results for the White River Basin Study Unit compared to the NAWQA national range for each compound detected. The data were collected at a wide variety of places and times. In order to represent the wide concentration ranges observed among Study Units, logarithmic scales are used to emphasize the general magnitude of concentrations (such as 10, 100, or 1,000), rather than the precise number. The complete data set used to construct these tables is available upon request.

Concentrations of herbicides, insecticides, volatile organic compounds, and nutrients detected in ground and surface waters of the White River Basin Study Unit. [mg/L, milligrams per liter; µg/L, micrograms per liter; pCi/L, picocuries per liter; %, percent; <, less than; - -, not measured; trade names may vary]

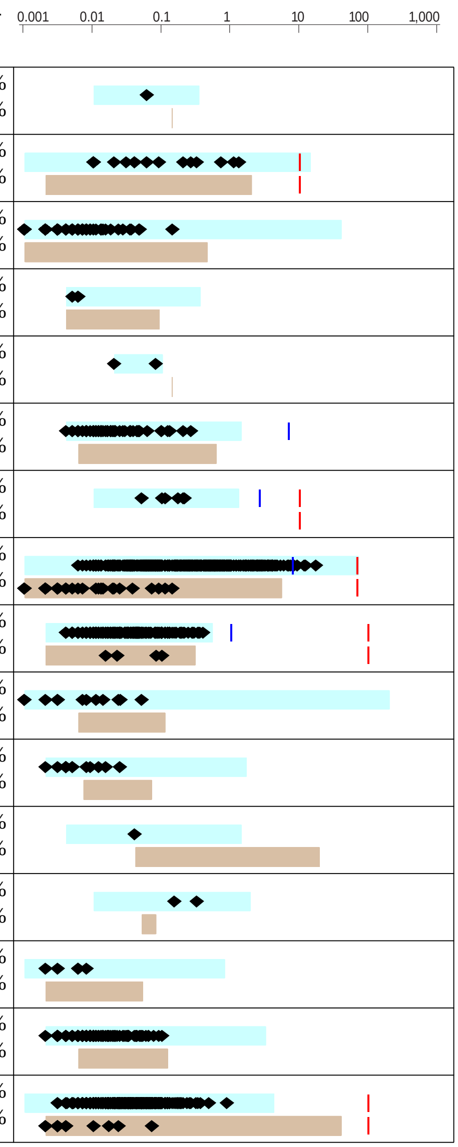
EXPLANATION



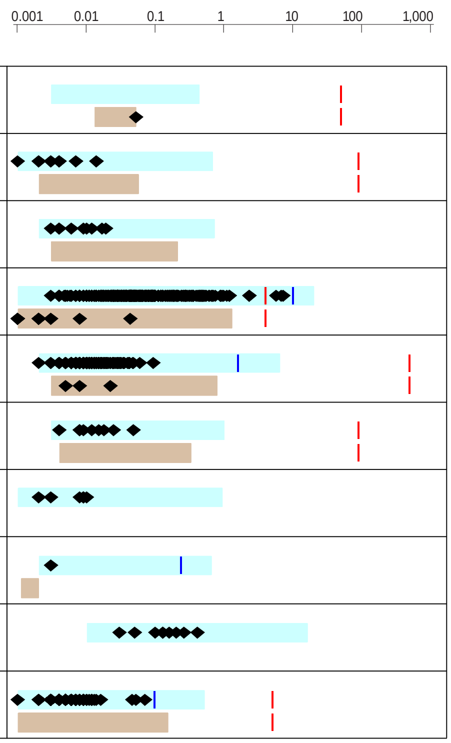
Herbicide (Trade or common name)	Rate of detection [b]	Concentration, in µg/L
Acetochlor	36% 0%	
Acifluorfen (Blazer, Tackle 2S)	2% 0%	
Alachlor (Lasso)	70% 1%	
2,6-Diethylaniline (Alachlor metabolite)	<1% <1%	
Atrazine (AAtrex, Gesaprim)	100% 14%	
Deethylatrazine[c] (Atrazine metabolite)	89% 10%	
Benfluralin (Balan, Benefin, Bonalan)	<1% 0%	
Bentazon (Basagran, bentazone)	17% 7%	
Bromacil (Hyvar X, Urox B, Bromax)	1% 1%	
Bromoxynil (Buctril, Brominal, Torch)	1% 0%	
Butylate (Sutan, Genate Plus, butilate)	21% <1%	
Cyanazine (Bladex, Fortrol)	77% 3%	
2,4-D (2,4-PA)	24% 0%	
2,4-DB (Butyrac, Embutox)	<1% 0%	
DCPA (Dacthal, chlorthal-dimethyl)	2% 0%	
Dicamba (Banvel, Mediben, dianat)	1% 0%	



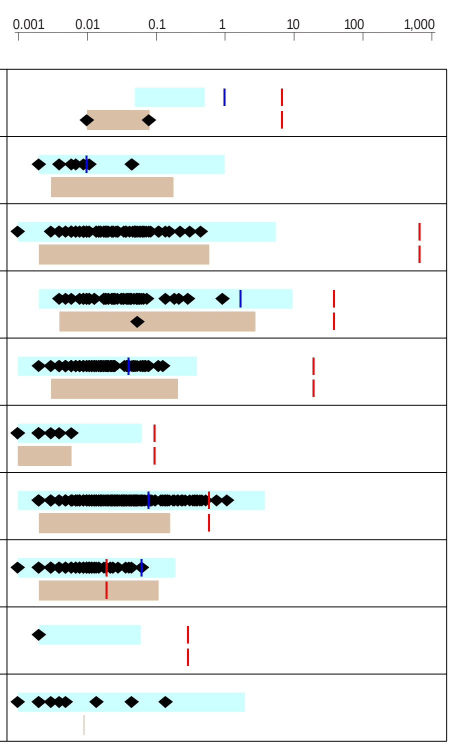
Herbicide (Trade or common name)	Rate of detection [b]	Concentration, in µg/L
Dichlorprop (2,4-DP, Seritox 50, Kildip)	<1% 0%	
Diuron (Karmex, Direx, DCMU)	5% 0%	
EPTC (Eptam)	3% 0%	
Ethalfluralin (Sonalan, Sonalen)	<1% 0%	
Fenuron (Beet-Kleen, Dybar, Urab)	1% 0%	
Linuron (Lorox, Linex, Sarclex)	7% 0%	
MCPA (Agritox, Agroxone)	2% 0%	
Metolachlor (Dual, Pennant)	99% 9%	
Metribuzin (Lexone, Sencor)	33% 3%	
Molinate (Ordram)	1% 0%	
Napropamide (Devrinol)	1% 0%	
Norflurazon (Evital, Solicam, Telok)	<1% 0%	
Oryzalin (Surflan, Dirimal, Ryzelan)	1% 0%	
Pebulate (Tillam)	<1% 0%	
Pendimethalin (Prowl, Stomp)	10% 0%	
Prometon (Gesagram, prometone)	83% 3%	



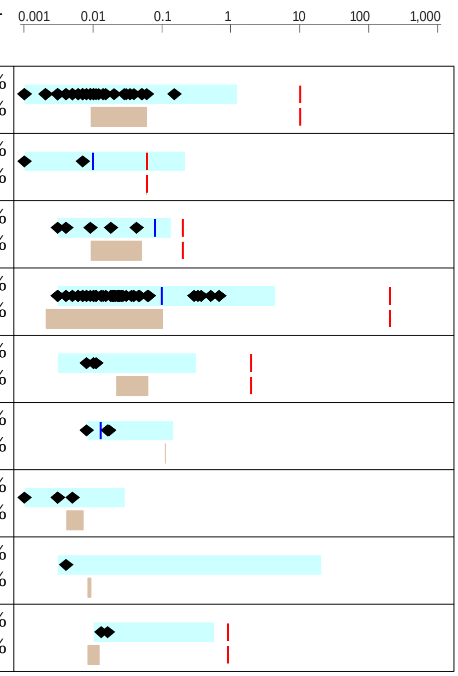
Herbicide (Trade or common name)	Rate of detection [b]	Concentration, in µg/L
Pronamide (Kerb, propyzamid)	0% 1%	
Propachlor (Ramrod, propachlore)	<1% 0%	
Propanil (Stampede, Surcopur)	1% 0%	
Simazine (Aquazine, Princep, GEsatop)	89% 1%	
Tebuthiuron (Spike, Perflan)	33% 1%	
Terbacil[c] (Sinbar)	1% 0%	
Thiobencarb (Bolero, Saturn, benthiocarb)	<1% 0%	
Triallate (Far-Go)	<1% 0%	
Triclopyr (Garlon, Grazon, Crossbow)	3% 0%	
Trifluralin (Treflan, Trinin, Elancolan)	2% 0%	



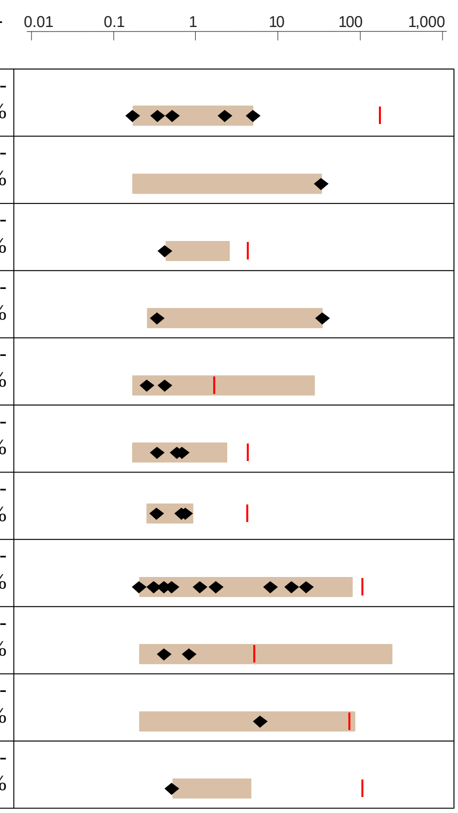
Insecticide (Trade or common name)	Rate of detection [b]	Concentration, in µg/L
Aldicarb[c] (Temik)	0% 1%	
Azinphos-methyl[c] (Guthion)	1% 0%	
Carbaryl[c] (Sevin, Savit)	11% 0%	
Carbofuran[c] (Furadan, Curaterr)	8% 1%	
Chlorpyrifos (Dursban, Lorsban)	18% 0%	
p,p'-DDE (*p,p'*-DDT metabolite)	<1% 0%	
Diazinon	38% 0%	
Dieldrin (Panoram D-31, Octalox)	6% 0%	
Disulfoton[c] (Disyston, Dithiosystox)	<1% 0%	
Ethoprop (Mocap, Prophos)	1% 0%	



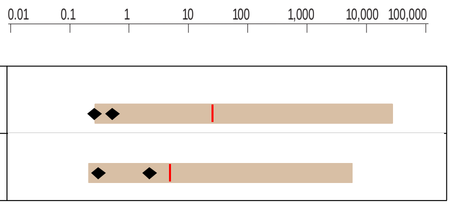
Insecticide (Trade or common name)	Rate of detection [b]	Concentration, in µg/L
Fonofos (Dyfonate)	4% 0%	
alpha-HCH (*alpha*-BHC, *alpha*-lindane)	<1% 0%	
gamma-HCH	<1% 0%	
Malathion (maldison, malathon, Cythion)	8% 0%	
Methyl parathion (Penncap-M)	<1% 0%	
Parathion (Thiophos, Bladan, Folidol)	<1% 0%	
cis-Permethrin[c] (Ambush, Pounce)	<1% 0%	
Propargite (Comite, Omite, BPPS)	<1% 0%	
Terbufos (Counter)	<1% 0%	



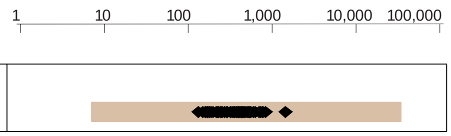
Volatile organic compound (Trade or common name)	Rate of detection [b]	Concentration, in µg/L
1,1,1-Trichloroethane	-- 5%	
1,1-Dichloroethane	-- 1%	
1,2-Dichloroethane (Ethylene dichloride)	-- 1%	
Chloroethane (Ethyl chloride)	-- 3%	
Chloroethene (Vinyl chloride)	-- 2%	
Dichloromethane (Methylene chloride)	-- 3%	
Tetrachloromethane (Carbon tetrachloride)	-- 3%	
total Trihalomethanes	-- 13%	
Trichloroethene (TCE)	-- 2%	
cis-1,2-Dichloroethene	-- 1%	
trans-1,2-Dichloroethene	-- 1%	



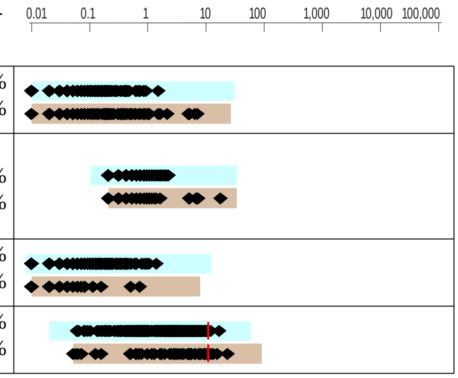
Volatile organic compound (Trade or common name)	Rate of detection [b]
Methyl *tert*-butyl[d] ether (MTBE)	-- 2%
Tetrachloroethene (Perchloroethene)	-- 2%



Other	Rate of detection [b]
Radon 222	-- 100%



Nutrient (Trade or common name)	Rate of detection [b]
Dissolved ammonia	89% 88%
Dissolved ammonia plus organic nitrogen as nitrogen	80% 38%
Dissolved phosphorus as phosphorus	83% 38%
Dissolved nitrite plus nitrate	97% 44%



Herbicides, insecticides, volatile organic compounds, and nutrients not detected in ground and surface waters of the White River Basin Study Unit.

Herbicides

2,4,5-T

2,4,5-TP (Silvex, Fenoprop)

Chloramben (Amiben, Amilon-WP, Vegiben)

Clopyralid (Stinger, Lontrel, Reclaim, Transline)

Dacthal mono-acid (Dacthal metabolite)

Dinoseb (Dinosebe)

Fluometuron (Flo-Met, Cotoran, Cottonex, Meturon)

MCPB (Thistrol)

Neburon (Neburea, Neburyl, Noruben)

Picloram (Grazon, Tordon)

Propham (Tuberite)

Insecticides

3-Hydroxycarbofuran (Carbofuran metabolite)

Aldicarb sulfone (Standak, aldoxycarb, aldicarb metabolite)

Aldicarb sulfoxide (Aldicarb metabolite)

Methiocarb (Slug-Geta, Grandslam, Mesurol)

Methomyl (Lanox, Lannate, Acinate)

Oxamyl (Vydate L, Pratt)

Phorate (Thimet, Granutox, Geomet, Rampart)

Propoxur (Baygon, Blattanex, Unden, Proprotox)

Volatile organic compounds

1,1,1,2-Tetrachloroethane (1,1,1,2-TeCA)

1,1,2,2-Tetrachloroethane

1,1,2-Trichloro-1,2,2-trifluoroethane (Freon 113, CFC 113)

1,1,2-Trichloroethane (Vinyl trichloride)

1,1-Dichloroethene (Vinylidene chloride)

1,1-Dichloropropene

1,2,3-Trichlorobenzene (1,2,3-TCB)

1,2,3-Trichloropropane (Allyl trichloride)

1,2,4-Trichlorobenzene

1,2,4-Trimethylbenzene (Pseudocumene)

1,2-Dibromo-3-chloropropane (DBCP, Nemagon)

1,2-Dibromoethane (EDB, Ethylene dibromide)

1,2-Dichlorobenzene (*o*-Dichlorobenzene, 1,2-DCB)

1,2-Dichloropropane (Propylene dichloride)

1,3,5-Trimethylbenzene (Mesitylene)

1,3-Dichlorobenzene (*m*-Dichlorobenzene)

1,3-Dichloropropane (Trimethylene dichloride)

1,4-Dichlorobenzene (*p*-Dichlorobenzene, 1,4-DCB)

1-Chloro-2-methylbenzene (*o*-Chlorotoluene)

1-Chloro-4-methylbenzene (*p*-Chlorotoluene)

2,2-Dichloropropane

Benzene

Bromobenzene (Phenyl bromide)

Bromochloromethane (Methylene chlorobromide)

Bromomethane (Methyl bromide)

Chlorobenzene (Monochlorobenzene)

Chloromethane (Methyl chloride)

Dibromomethane (Methylene dibromide)

Dichlorodifluoromethane (CFC 12, Freon 12)

Dimethylbenzenes (Xylenes (total))

Ethenylbenzene (Styrene)

Ethylbenzene (Phenylethane)

Hexachlorobutadiene

Isopropylbenzene (Cumene)

Methylbenzene (Toluene)

Naphthalene

Trichlorofluoromethane (CFC 11, Freon 11)

cis-1,3-Dichloropropene ((Z)-1,3-Dichloropropene)

n-Butylbenzene (1-Phenylbutane)

n-Propylbenzene (Isocumene)

p-Isopropyltoluene (*p*-Cymene)

sec-Butylbenzene

tert-Butylbenzene

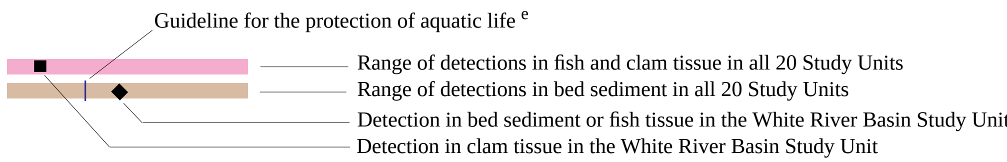
trans-1,3-Dichloropropene ((E)-1,3-Dichloropropene)

Nutrients

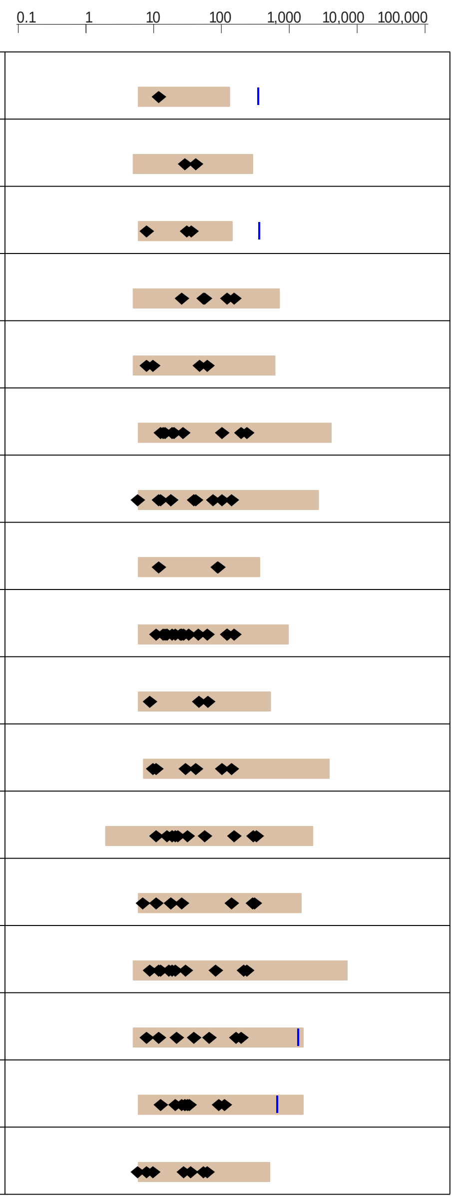
No non-detects

Concentrations of semivolatile organic compounds, organochlorine compounds, and trace elements detected in fish and clam tissue and bed sediment of the White River Basin Study Unit. [µg/g, micrograms per gram; µg/kg, micrograms per kilogram; %, percent; <, less than; - -, not measured; trade names may vary]

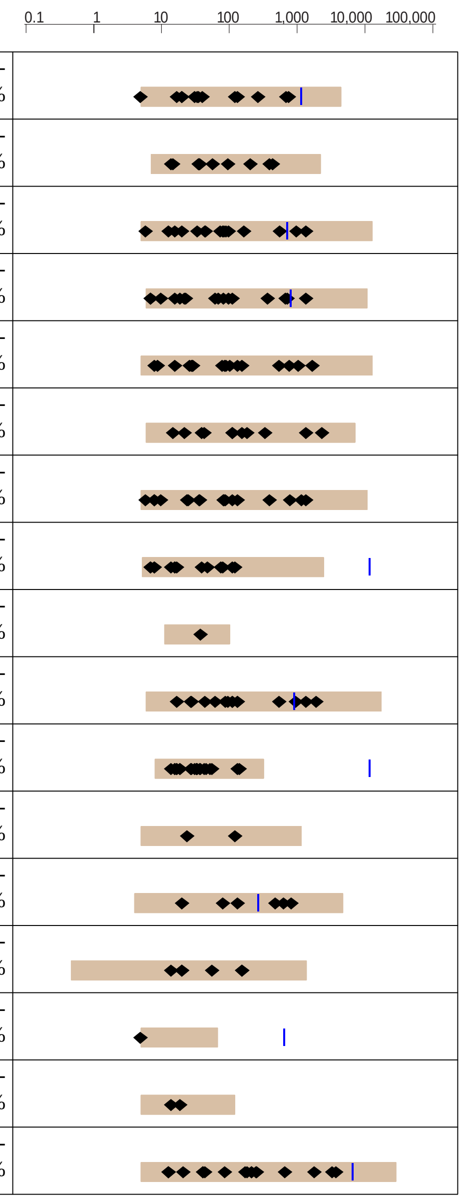
EXPLANATION



Semivolatile organic compound	Rate of detection [b]	Concentration, in µg/kg
1,2-Dichlorobenzene	-- 5%	
1,2-Dimethylnaphthalene	-- 9%	
1,4-Dichlorobenzene	-- 14%	
1,6-Dimethylnaphthalene	-- 23%	
1-Methyl-9H-fluorene	-- 18%	
1-Methylphenanthrene	-- 41%	
1-Methylpyrene	-- 45%	
2,3,6-Trimethylnaphthalene	-- 14%	
2,6-Dimethylnaphthalene	-- 82%	
2-Ethylnaphthalene	-- 14%	
2-Methylanthracene	-- 27%	
4,5-Methylenephenanthrene	-- 50%	
9H-Carbazole	-- 36%	
9H-Fluorene	-- 45%	
Acenaphthene	-- 32%	
Acenaphthylene	-- 41%	
Acridine	-- 32%	



Semivolatile organic compound	Rate of detection [b]	Concentration, in µg/kg
Anthracene	-- 59%	
Anthraquinone	-- 45%	
Benz[*a*]anthracene	-- 73%	
Benzo[*a*]pyrene	-- 73%	
Benzo[*b*]fluoranthene	-- 77%	
Benzo[*ghi*]perylene	-- 50%	
Benzo[*k*]fluoranthene	-- 77%	
Butylbenzylphthalate	-- 64%	
C8-Alkylphenol	-- 5%	
Chrysene	-- 68%	
Di- *n* -butylphthalate	-- 95%	
Di- *n* -octylphthalate	-- 9%	
Dibenz[*a,h*]anthracene	-- 27%	
Dibenzothiophene	-- 27%	
Diethylphthalate	-- 5%	
Dimethylphthalate	-- 9%	
Fluoranthene	-- 77%	



Semivolatile organic compound	Rate of detection [b]	Concentration, in µg/kg (0.1, 1, 10, 100, 1,000, 10,000, 100,000)
Indeno[1,2,3- *cd*] pyrene	-- 59%	
Naphthalene	-- 18%	
N-Nitrosodi-phenylamine	-- 5%	
Phenanthrene	-- 77%	
Phenanthridine	-- 5%	
Phenol	-- 77%	
Pyrene	-- 82%	
bis(2-Ethyl-hexyl)phthalate	-- 100%	
p-Cresol	-- 73%	

Trace element	Rate of detection [b]	Concentration, in µg/g (0.01, 0.1, 1, 10, 100, 1,000, 10,000)
Arsenic	100% 100%	
Cadmium	100% 100%	
Chromium	100% 100%	
Copper	100% 100%	
Lead	58% 100%	
Mercury	42% 96%	
Nickel	83% 100%	
Selenium	75% 100%	
Zinc	100% 100%	

Organochlorine compound (Trade name)	Rate of detection [b]	Concentration, in µg/kg (0.01, 0.1, 1, 10, 100, 1,000, 10,000, 100,000)
total-Chlordane	42% 35%	
p,p'-DDE	8% 13%	
total-DDT	8% 13%	
Dieldrin (Panoram D-31, Octalox, Com-	25% 39%	
beta-HCH (*beta*-BHC)	0% 4%	
Heptachlor epoxide	8% 4%	
PCB, total	33% 22%	

Semivolatile organic compounds, organochlorine compounds, and trace elements not detected in fish and clam tissue and bed sediment of the White River Basin Study Unit.

Semivolatile organic compounds

1,2,4-Trichlorobenzene

1,3-Dichlorobenzene (*m*-Dichlorobenzene)

2,2-Biquinoline

2,4-Dinitrotoluene

2,6-Dinitrotoluene

2-Chloronaphthalene

2-Chlorophenol

3,5-Dimethylphenol

4-Bromophenyl-phenylether

4-Chloro-3-methylphenol

4-Chlorophenyl-phenylether

Azobenzene

Benzo [*c*] cinnoline

Isophorone

Isoquinoline

N-Nitrosodi-n-propylamine

Nitrobenzene

Pentachloronitrobenzene

Quinoline

bis (2-Chloroethoxy)methane

Organochlorine compounds

Aldrin (HHDN, Octalene)

Chloroneb (chloronebe, Demosan, Soil Fungicide 1823)

DCPA (Dacthal, chlorthal-dimethyl)

Endosulfan I (*alpha*-Endosulfan, Thiodan, Cyclodan, Beosit, Malix, Thimul, Thifor)

Endrin (Endrine)

Heptachlor (Heptachlore, Velsicol 104)

Hexachlorobenzene (HCB)

Isodrin (Isodrine, Compound 711)

Mirex (Dechlorane)

Pentachloroanisole (PCA, pentachlorophenol metabolite)

Toxaphene (Camphechlor, Hercules 3956)

alpha-HCH (*alpha*-BHC, *alpha*-lindane, *alpha*-hexachlorocyclohexane, *alpha*-benzene hexachloride)

cis-Permethrin (Ambush, Astro, Pounce, Pramex, Pertox, Ambushfog, Kafil, Perthrine, Picket, Picket G, Dragnet, Talcord, Outflank, Stockade, Eksmin, Coopex, Peregin, Stomoxin, Stomoxin P, Qamlin, Corsair, Tornade)

delta-HCH (*delta*-BHC, *delta*-hexachlorocyclohexane, *delta*-benzene hexachloride)

gamma-HCH (Lindane, *gamma*-BHC, Gammexane, Gexane, Soprocide, *gamma*-hexachlorocyclohexane, *gamma*-benzene hexachloride, *gamma*-benzene)

o,p'-Methoxychlor

p,p'-Methoxychlor (Marlate, methoxychlore)

trans-Permethrin (Ambush, Astro, Pounce, Pramex, Pertox, Ambushfog, Kafil, Perthrine, Picket, Picket G, Dragnet, Talcord, Outflank, Stockade, Eksmin, Coopex, Peregin, Stomoxin, Stomoxin P, Qamlin, Corsair, Tornade)

Trace elements

No non-detects

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[a] Selected water-quality standards and guidelines documented in Gilliom and others (in press).

[b] Rates of detection are based on the number of analyses and detections in the Study Unit, not on national data. Rates of detection for herbicides and insecticides were computed by only counting detections equal to or greater than 0.01 µg/L in order to facilitate equal comparisons among compounds, which had widely varying detection limits. For herbicides and insecticides, a detection rate of "<1%" means that all detections are less than 0.01 µg/L, or the detection rate rounds to less than one percent. For other compound groups, all detections were counted and minimum detection limits for most compounds were similar to the lower end of the national ranges shown. Method detection limits for all compounds in these tables are summarized in Gilliom and others (in press).

[c] Detections of these compounds are reliable, but concentrations are determined with greater uncertainty than for the other compounds and are reported as estimated values. (Zaugg and others, 1995.)

[d] The guideline for methyl *tert*-butyl ether is between 20 and 40 µg/L; if the tentative cancer classification C is accepted, the lifetime health advisory will be 20 µg/L. (Gilliom and others, in press.)

[e] Selected sediment-quality guidelines documented in Gilliom and others (in press).

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The terms in this glossary were compiled from numerous sources. Some definitions have been modified and may not be the only valid ones for these terms.

Ammonia – A compound of nitrogen and hydrogen (NH_3) that is a common by-product of animal waste. Ammonia readily converts to nitrate in soils and streams.

Aquatic-life criteria – Water-quality guidelines for protection of aquatic life. Often refers to U.S. Environmental Protection Agency water-quality criteria for protection of aquatic organisms. *See also* Water-quality guidelines and Water-quality criteria.

Aquifer – A water-bearing layer of soil, sand, gravel, or rock that will yield usable quantities of water to a well.

Background concentration – A concentration of a substance in a particular environment that is indicative of minimal influence by human (anthropogenic) sources.

Base flow – Sustained, low flow in a stream; ground-water discharge is the source of base flow in most places.

Basic Fixed Sites – Sites on streams at which streamflow is measured and samples are collected for temperature, salinity, suspended sediment, major ions, nutrients, and organic carbon to assess the broad-scale spatial and temporal character and transport of inorganic constituents of stream water in relation to hydrologic conditions and environmental settings.

Combined-sewer overflow – A discharge of untreated sewage and stormwater to a stream when the capacity of a combined storm/sanitary sewer system is exceeded by storm runoff.

Community – In ecology, the species that interact in a common area.

Confined aquifer (artesian aquifer) – An aquifer that is completely filled with water under pressure and that is overlain by material that restricts the movement of water.

Degradation products – Compounds resulting from transformation of an organic substance through chemical, photochemical, and(or) biochemical reactions.

Dissolved solids – Minerals, such as salt, that are dissolved in water; amount of dissolved solids is an indicator of salinity and(or) hardness.

Drinking-water standard or guideline – A threshold concentration in a public drinking-water supply, designed to protect human health. As defined here, standards are U.S. Environmental Protection Agency regulations that specify the maximum contamination levels for public water systems required to protect the public welfare; guidelines have no regulatory status and are issued in an advisory capacity.

Glacial lowland – A lowland area in the southwestern part of the White River Basin with loess-covered glacial tills overlying coal-bearing shales and sandstones.

Habitat – The part of the physical environment where plants and animals live.

Health advisory – Nonregulatory levels of contaminants in drinking water that may be used as guidance in the absence of regulatory limits. Advisories consist of estimates of concentrations that would result in no known or anticipated health effects (for carcinogens, a specified cancer risk) determined for a child or for an adult for various exposure periods.

Herbicide – A chemical or other agent applied for the purpose of killing undesirable plants. *See also* Pesticide.

Insecticide – A substance or mixture of substances intended to destroy or repel insects.

Intensive Fixed Sites – Basic Fixed Sites with increased sampling frequency during selected seasonal periods and analysis of dissolved pesticides.

Load – The mass of a chemical transported by a river in a given time.

Maximum Contaminant Level (MCL) – Maximum permissible level of a contaminant in water that is delivered to any user of a public water system. MCL's are enforceable standards established by the U.S. Environmental Protection Agency. Exceedances of a MCL are based on an annual average concentration of the contaminant in the public water.

Median – The middle or central value in a distribution of data ranked in order of magnitude. The median is also known as the 50th percentile.

Micrograms per liter (μg/L) – A unit expressing the concentration of constituents in solution as weight (micrograms) of solute per unit volume (liter) of water; equivalent to one part per billion in most stream water and ground water. One thousand micrograms per liter equal 1 mg/L.

Milligrams per liter (mg/L) – A unit expressing the concentration of chemical constituents in solution as weight (milligrams) of solute per unit volume (liter) of water; equivalent to one part per million in most stream water and ground water.

Monitoring well – A well designed for measuring water levels and testing ground-water quality.

Mouth – The place where a stream or river discharges to a larger stream, river, a lake, or the sea.

Nitrate – A compound consisting of nitrogen and oxygen (NO_3^-). Nitrate is a plant nutrient and is very mobile in soils.

Nonpoint source – A pollution source that cannot be defined as originating from discrete points such as pipe discharge. Areas of fertilizer and pesticide applications, atmospheric deposition, and manure on fields are types of nonpoint sources.

Nutrient – Element or compound essential for animal and plant growth. Common nutrients in fertilizer include nitrogen, phosphorus, and potassium.

Organochlorine insecticide – A class of organic insecticides containing a high percentage of chlorine. Includes dichlorodiphenylethanes (such as DDT), chlorinated cyclodienes (such as chlordane), and chlorinated benzenes (such as lindane). Most organochlorine insecticides were banned because of their carcinogenicity, tendency to bioaccumulate, and toxicity to wildlife.

Outwash – Typically sand and gravel deposited by meltwater streams flowing beyond glacial ice.

Pesticide – A chemical applied to crops, rights of way, lawns, or residences to control weeds, insects, fungi, nematodes, rodents and other "pests."

Phosphorus – A nutrient essential for growth that can play a key role in stimulating aquatic growth in lakes and streams.

Point source – A source at a discrete location such as a discharge pipe, drainage ditch, well, or concentrated livestock operation.

Polychlorinated biphenyls (PCBs) – A mixture of chlorinated derivatives of biphenyl, marketed under the trade name Aroclor with a number designating the chlorine content (such as Aroclor 1260). PCBs were used in transformers and capacitors for insulating purposes and in gas-pipeline systems as a lubricant. Further sale for new use was banned by law in 1979.

Radon – A naturally occurring, colorless, odorless, radioactive gas formed by the disintegration of the element radium; damaging to human lungs when inhaled.

Runoff – Excess rainwater or snowmelt that is transported to streams by overland flow, tile drains, or ground water.

Semivolatile organic compounds (SVOCs) – Operationally defined as a group of synthetic organic compounds that are solvent-extractable and can be determined by gas chromatography/mass spectrometry. SVOCs include phenols, phthalates, and polycyclic aromatic hydrocarbons (PAHs).

Streambed sediment – The material that temporarily is stationary in the bottom of a stream or other watercourse.

Synoptic sites – Sites sampled during a short-term investigation of specific water-quality conditions during selected seasonal or hydrologic conditions to provide improved spatial resolution for critical water-quality conditions.

Tile drain – A buried perforated pipe designed to remove excess water from soils.

Till plain – A nearly flat-lying plain in the northern part of the White River Basin covered with thick glacial till deposits.

Tissue site – Sites where concentrations and distributions of trace elements and certain organic contaminants in tissues of aquatic organisms are measured.

Trace element – An element found in only minor amounts in water or sediment; includes arsenic, cadmium, chromium, copper, lead, mercury, nickel, and zinc.

Unconfined aquifer – An aquifer whose upper surface is the water table.

Volatile organic compounds (VOCs) – Organic chemicals that have a high vapor pressure relative to their water solubility. VOCs include components of gasoline, fuel oils, and lubricants, as well as organic solvents, fumigants, some inert ingredients in pesticides, and some by-products of chlorine disinfection.

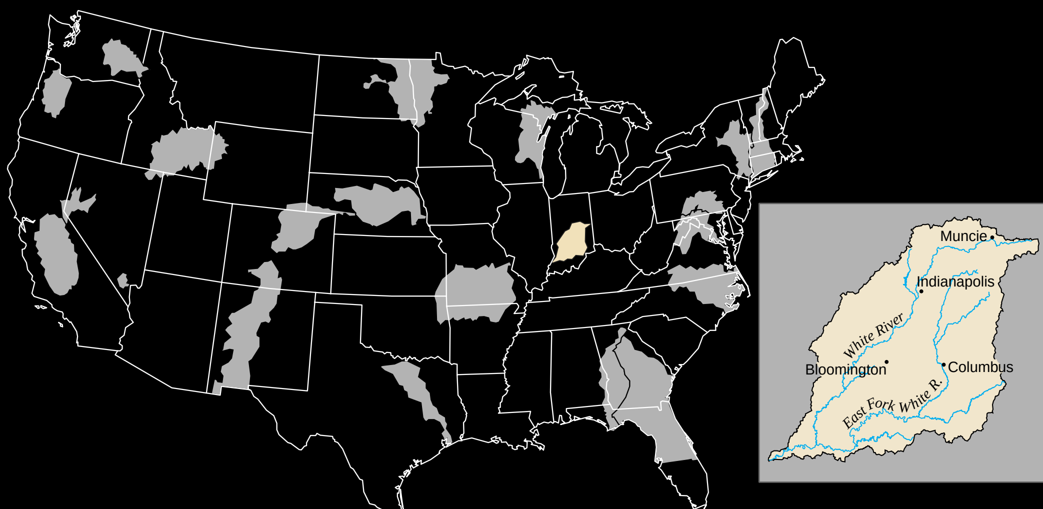
Water-quality criteria – Specific levels of water quality which, if reached, are expected to render a body of water unsuitable for its designated use. Commonly refers to water-quality criteria established by the U.S. Environmental Protection Agency. Water-quality criteria are based on specific levels of pollutants that would make the water harmful if used for drinking, swimming, farming, fish production, or industrial processes.

Water-quality guidelines – Specific levels of water quality which, if reached, may adversely affect human health or aquatic life. These are nonenforceable guidelines issued by a governmental agency or other institution.

Water table – The point below the land surface where ground water is first encountered and below which the earth is saturated. Depth to the water table is commonly less than 20 feet in the White River Basin.

NAWQA

National Water-Quality Assessment (NAWQA) Program
White River Basin



Fenelon • Water Quality in the White River Basin • USGS Circular 1150 • 1998

ISBN 0-607-89230-7
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