Water Quality in the Ozark Plateaus

Arkansas, Kansas, Missouri, and Oklahoma, 1992–95

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

Circular 1158

A COORDINATED EFFORT

Coordination among agencies and organizations is an integral part of the NAWQA Program. We thank the following agencies and organizations that contributed data used in this report, participated in the study liaison committee, or assisted in field work.

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Arkansas Game and Fish Commission
Arkansas Geological Commission
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Arkansas Water Resources Research Center
Kansas Department of Health and Environment
Kansas Geological Survey
Kansas Water Office
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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://water.usgs.gov/lookup/get?nawqa/

The Ozark Plateaus Study Unit's Home Page is at URL:
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Front cover: Waterfall and small stream in the Buffalo River Basin. (Photograph courtesy of A.C. Haralson, Arkansas Department of Parks and Tourism.)
Back cover: Surveying stream geometry of Buffalo River near Boxley, Arkansas. Measuring streamflow of Yocum Creek near Oak Grove, Arkansas.

Water Quality in the Ozark Plateaus, Arkansas, Kansas, Missouri, and Oklahoma, 1992—95

By James C. Petersen, James C. Adamski, Richard W. Bell, Jerri V. Davis, Suzanne R. Femmer, David A. Freiwald, and Robert L. Joseph

U.S. GEOLOGICAL SURVEY CIRCULAR 1158

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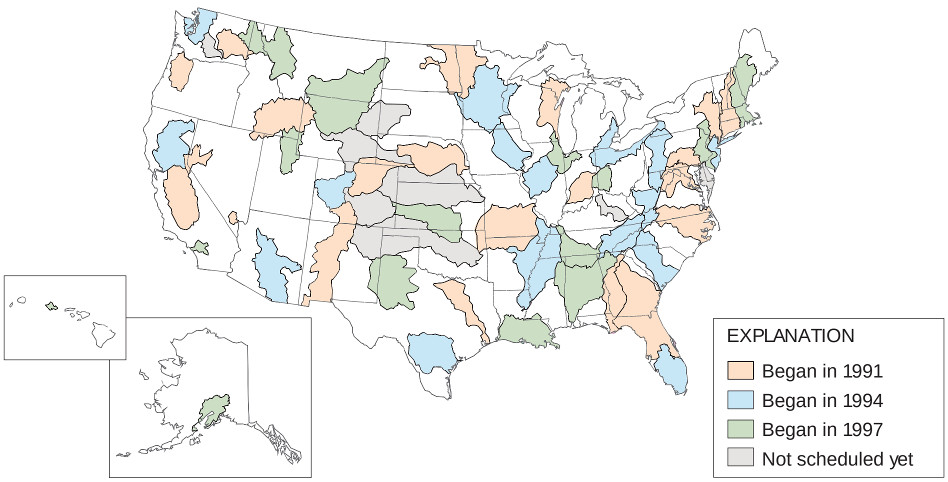
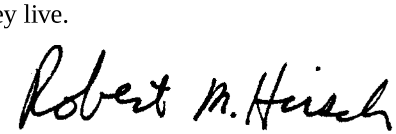


Knowledge of the quality of the Nation's streams and aquifers is important because of the implications to human and aquatic health and because of the significant costs associated with decisions involving land and water management, conservation, and regulation. In 1991, the U.S. Congress appropriated 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 1995 from the water-quality assessment of the Ozark Plateaus 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

"As the state geologist of "The Natural State," I have a special interest in its water resources and a commitment to further our geohydrologic knowledge. Data collected through the NAWQA Program are helpful in evaluating, protecting, and managing our bountiful water resources.

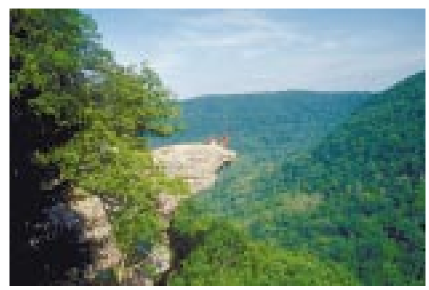
William V. Bush, State Geologist, Arkansas Geological Commission

The NAWQA approach of relating surface-water quality to land use will help us manage water resources in portions of the Missouri Ozarks now undergoing significant land-use change.

John Ford
Missouri Department of Natural Resources

Are streams and ground water being contaminated by nutrients and bacteria? (p. 6)

- Nutrient concentrations in streams are higher in areas with greater agricultural land use or downstream from wastewater-treatment plants than in forested areas. These higher concentrations may result in increased algal growth in streams.
- Nutrient concentrations in ground water are higher in areas with greater agricultural land use than in forested areas. These higher concentrations seldom exceed drinking-water standards.
- Bacteria concentrations in streams are higher in basins with greater agricultural land use (mostly pasture). Fecal coliform bacteria concentrations occasionally exceed State water-quality standards for whole-body contact recreation.
- Nutrient and bacteria concentrations are affected by hydrologic and geologic factors. Stream discharge and the presence or absence of confining geologic layers are two factors that are important in predicting concentrations.



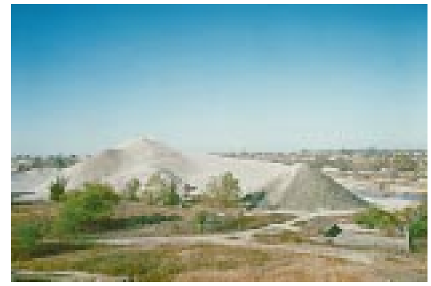
Are pesticides and other organic compounds more prevalent in the water, bed sediment, and fish or clam tissue from some land-use settings than from other settings? (p. 10)

- In streams and ground water, pesticides were more prevalent in agricultural areas than in forested areas. Concentrations generally were low and seldom exceeded U.S. Environmental Protection Agency drinking-water criteria or standards, or criteria for the protection of aquatic life.
- In bed sediment, the greatest numbers of pesticides and other organic compounds generally were detected at sites downstream from urban areas. No concentrations exceeded U.S. Environmental Protection Agency criteria for the protection of aquatic life.
- In biological tissue, pesticides were detected at 5 of 26 stream sites. Chlordane was detected downstream from Springfield, Mo. DDT, DDE, or dieldrin was detected at four sites in agricultural basins.

Are historical or active mining sites affecting the quality of surface water? (p. 12)

- Concentrations of sulfate and some trace elements in water from streams in areas of active or historical lead-zinc mining tend to be higher than in areas where mining has not occurred. These trace element concentrations decrease with increasing distance downstream from the mining activity. Concentrations usually did not exceed Federal standards or criteria for the protection of drinking water, human health, or aquatic life.

- Concentrations of lead and zinc in bed sediment and fish or clam tissue are substantially higher at sites with mining activities (historical or active) in the basin. Concentrations are high enough to suggest potential adverse biological effects. The State of Missouri has issued a fish consumption advisory for some streams.

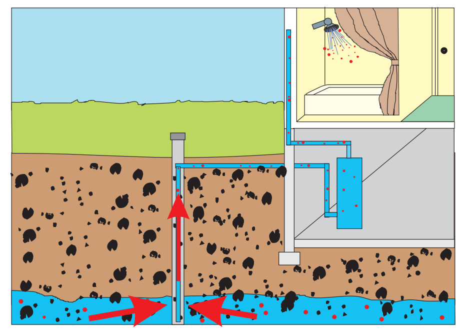


Are naturally occurring radionuclides present in ground-water supplies? (p. 14)

- Radium (a product formed by the radioactive decay of uranium) is present in the confined part of the Ozark aquifer. However, the levels of radium seldom exceeded the U.S. Environmental Protection Agency drinking-water standard.

- Radon (a gas produced by the radioactive decay of radium) levels exceeded a proposed (but withdrawn) U.S. Environmental Protection Agency drinking-water standard in nearly one-half of the samples. Radon can enter homes through their water systems. Homes served by private domestic wells and small public waterworks using ground water can be particularly vulnerable.

- Radon levels are greater in the Springfield Plateau aquifer and the unconfined part of the Ozark aquifer than in the confined part of the Ozark aquifer.



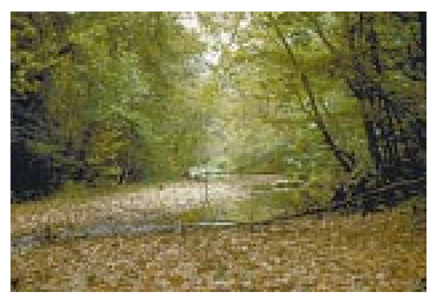
What are some factors that affect aquatic (instream and riparian) habitats of Ozark streams? (p. 15)

- Several factors can affect aquatic habitats, which then affect biological communities. Many habitat characteristics appeared to be influenced more by basin size than by land use.

- Small streams in agricultural areas generally have fewer trees and other woody plants in the riparian zone than do small streams in forested areas. This results in more sunlight reaching the streams in the agricultural areas. More sunlight and the higher nutrient concentrations probably result in faster growing attached algae in these streams.

- Some other habitat characteristics were different between the agricultural and forested sites studied. Of these characteristics, some are not likely the result of agricultural practices, while others (canopy angle, channel width, and sinuosity) may, at least in part, result from agricultural practices. These characteristics can affect biological communities.

- Although the effects of instream gravel mining in the Ozarks were not studied by the NAWQA Program, some studies suggest that gravel mining has detrimental effects on instream habitat.

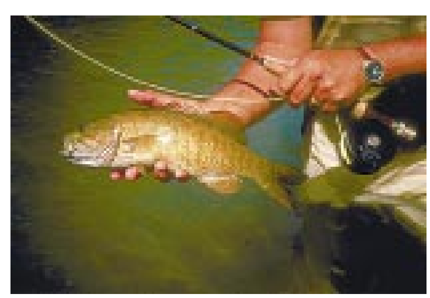


Are fish communities being affected by land-use activities? (p. 16)

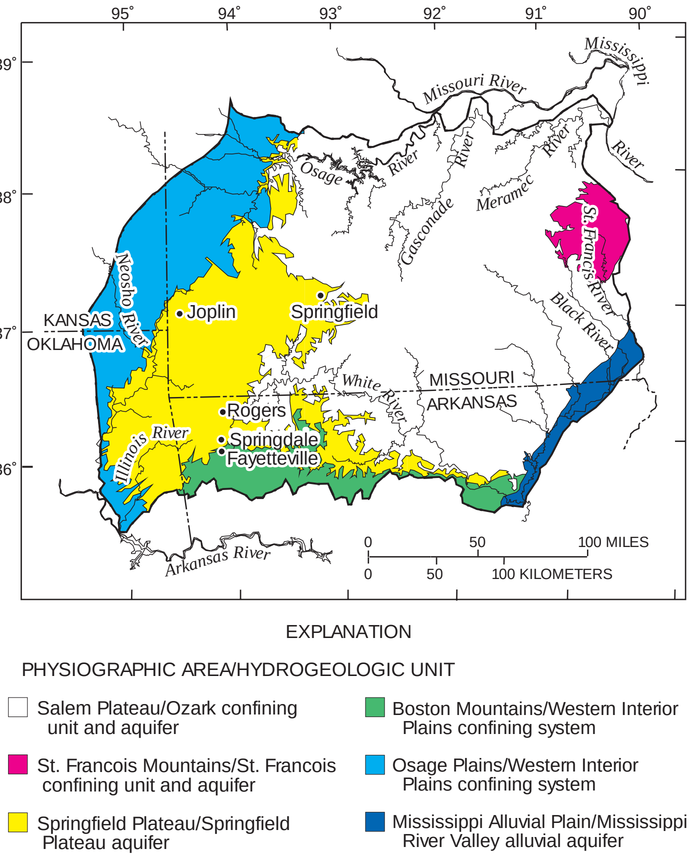
- Stonerollers make up a greater percentage of the fish at agricultural sites than at forested sites. Stonerollers graze on algae attached to rocks and other surfaces. More algae probably grow on these surfaces because of the higher nutrient concentrations and greater amounts of sunlight reaching these streams.

- Sunfish (including the black basses) and darters make up a smaller percentage of fish at agricultural sites than at forested sites. Members of the sunfish family (particularly smallmouth bass) are important game fish. Several species of darters that live in the Ozarks exist nowhere else in the world.

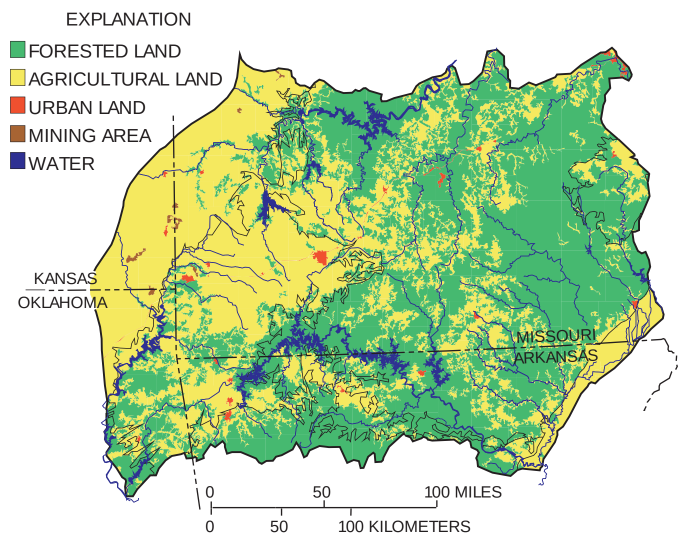
- Fish community composition appears to be related to stream size, canopy angle, substrate, and water chemistry. Some of these factors are affected by human activities.



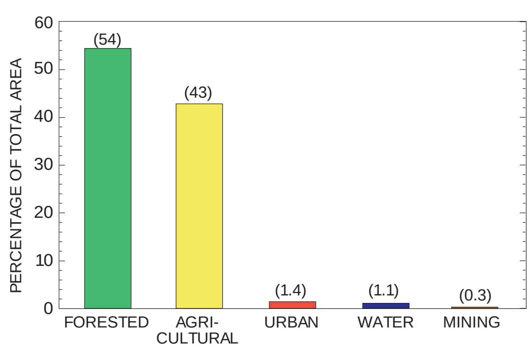
Several river systems drain the Study Unit. Most drain radially away from south-central Missouri or northward from the Boston Mountains. Aquifers in the Study Unit generally coincide with the physiographic areas (Fenneman, 1938), but the extensive Springfield Plateau and Ozark aquifers also dip beneath other aquifers or confining units in physiographic areas to the west and south.



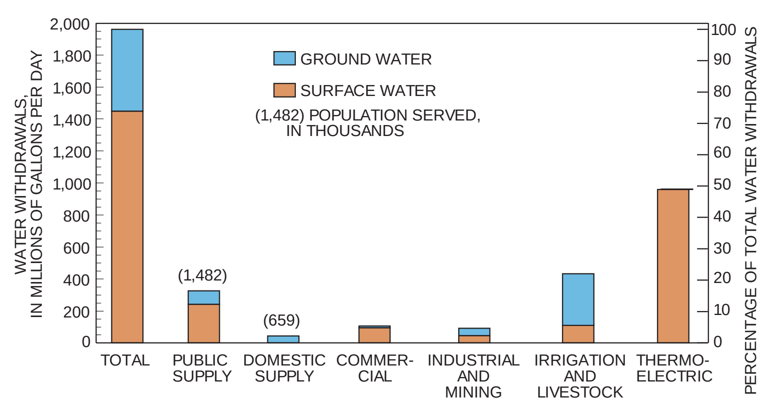
MAJOR HYDROLOGIC FEATURES WITHIN THE OZARK PLATEAUS STUDY UNIT



LAND USE IN THE OZARK PLATEAUS STUDY UNIT



ESTIMATED LAND USE



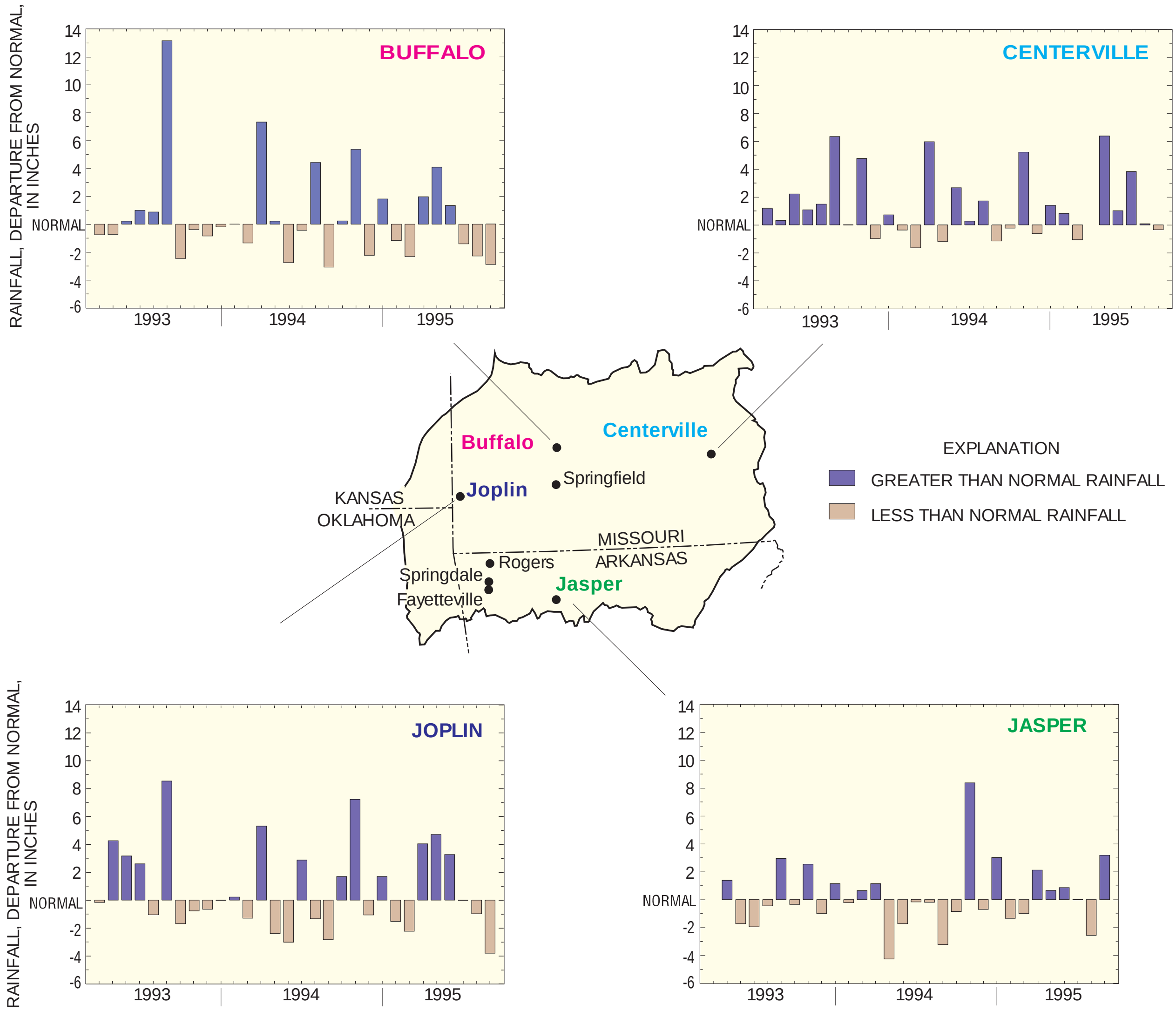
ESTIMATED WATER WITHDRAWALS IN 1990

Land use is almost equally divided between forested and agricultural land, but is not distributed evenly across the Study Unit (Adamski and others, 1995). The Salem Plateau, Boston Mountains, and St. Francois Mountains are primarily forested, while agricultural land is most common in other areas. Most of the agricultural land in the Salem and Springfield Plateaus and in the Boston Mountains is pastureland associated with production of poultry and cattle. Lead and zinc mining occurs or has occurred in some areas. Large urban areas are not common. Only the five cities on the map above have populations exceeding 20,000 (U.S. Department of Commerce, 1990). These land uses affect the physical, chemical, and biological properties of the water and land.

Approximately 50 percent of the water use in the Study Unit is surface water used (nonconsumptively) for thermoelectric cooling. Almost 25 percent of the water use is for irrigation and livestock; most of this water is ground water used for irrigation in the Mississippi Alluvial Plain. Most of the remaining water use is for public and domestic supplies (drinking and related water uses). About 30 percent of the 2.1 million people in the Study Unit get their drinking water from relatively shallow domestic wells.

Streamflow is an important factor affecting water quality. During wet-weather periods, runoff carries materials into the stream from the land; concentrations of nutrients, bacteria, pesticides, and sediment can be elevated above the more typical concentrations for that stream. Higher streamflows can dilute concentrations of materials in streams if the source of the materials is not runoff. For example, nutrient concentrations in a stream affected primarily by a wastewater-treatment plant usually decrease during wet-weather periods. During dry periods, concentrations of materials contributed by runoff are lower, while concentrations of materials from wastewater-treatment plants or other similar sources usually are higher because of less water for dilution.

Shallow ground water can also be affected similarly by periods of wet or dry weather. The extent to which ground water is affected depends on the hydrologic connection between the land surface and ground water; this is affected by factors such as local soils and geology. Karst features (springs, seeps, sinkholes, and caves) are abundant in much of the Springfield and Salem Plateaus. These features allow rapid movement of ground water and substantial movement of water between the surface-water and ground-water environments.



Hydrologic conditions (illustrated here as rainfall departure from normal) during the most intense period of sample collection (April 1993-September 1995) were relatively normal overall. However, during certain periods rainfall and streamflow were far from normal in some parts of the Study Unit. For example, in September 1993 rainfall in the northern part of the Ozarks exceeded normal amounts by as much as 6 to 13 inches. This caused streamflows at several stations in the northern Ozarks to reach levels that would be expected to occur (on average) once every 10 or more years. In April 1994 rainfall in the northern part of the Ozarks exceeded normal amounts by 6 to nearly 11 inches. In November 1994 rainfall generally exceeded normal amounts by 4 to 8 inches throughout the Study Unit. Extended periods (greater than 2 months) of less than normal rainfall occurred infrequently and in few areas during the study period.

Nitrogen and phosphorus are essential plant nutrients. However, elevated concentrations of these nutrients can cause excessive growth of aquatic plants and can have detrimental effects upon desired uses of water. Contamination of water in the Study Unit by nutrients has been a concern of many agencies and the public for several years. Major sources of nitrogen and phosphorus in the Study Unit are poultry and cattle wastes, human wastes, and fertilizers. The U.S. Environmental Protection Agency (EPA) has established a maximum contaminant level (MCL) of 10 milligrams per liter (mg/L) for nitrate (as nitrogen) in drinking water (U.S. Environmental Protection Agency, 1988). Very high concentrations of nitrate (a compound of nitrogen and oxygen, and usually the most abundant form of nitrogen in water) can cause blue-baby syndrome in infants. Very few ground-water samples (less than 1 percent) and no surface-water samples in the Study Unit exceeded the MCL. In general, shallow wells (less than about 300 feet) or springs in agricultural areas are most likely to produce ground water with nitrate concentrations approaching or exceeding the nitrate MCL.

Elevated nitrogen concentrations can result in several water-quality problems, such as algal blooms, oxygen depletion, and fishkills. The EPA has not made recommendations for nitrate concentrations that would limit detrimental effects on aquatic communities. The EPA has made recommendations for maximum ammonia concentrations to protect aquatic life. Ammonia concentrations generally are well below the recommended maximum in Ozark streams.

The EPA recommends that total phosphorus should not exceed 0.1 mg/L in streams and that total phosphates (as phosphorus) should not exceed 0.05 mg/L in streams where they enter a lake or reservoir. Concentrations of total phosphorus and orthophosphate in streams in agricultural areas sometimes exceed these recommended concentrations.

Elevated nitrate and phosphorus concentrations may be linked with differences between fish communities at sites in agricultural basins and sites in forested basins (see page 16). One of the major differences is a tendency for more algae-eating fish to inhabit the sites in agricultural basins.

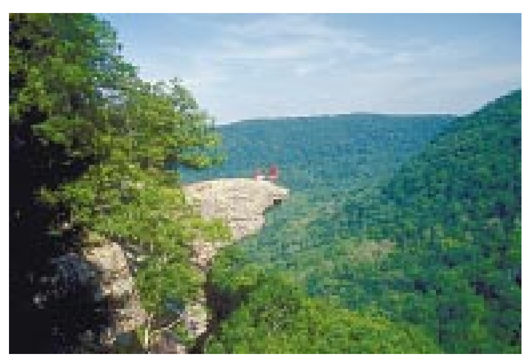
Fecal coliform bacteria live in the intestines of warm-blooded animals. The presence of these bacteria in water is indicative of contamination by fecal matter. Sources of these bacteria include animal manure, wastewater-treatment plants, and septic tanks.

Nutrient concentrations in streams are higher in areas with greater agricultural land use or downstream from wastewater-treatment plants than in forested areas. These higher concentrations may result in increased algal growth in streams.

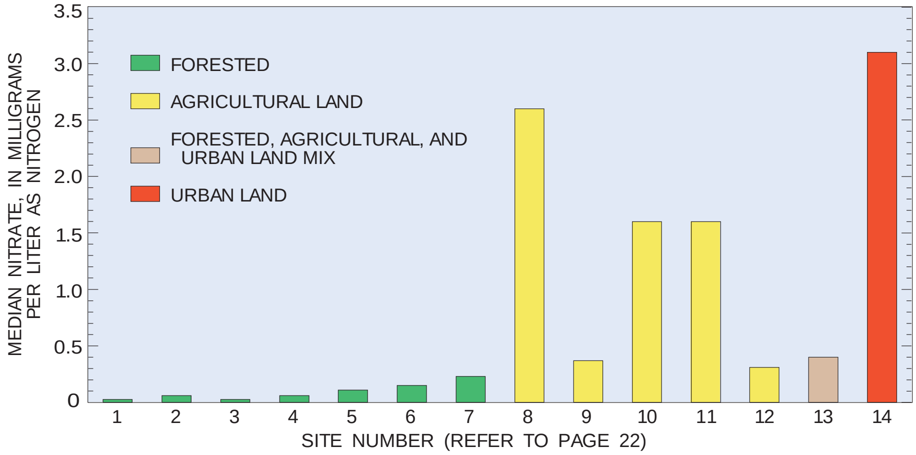
NAWQA data collected in 1993-95 at stream sites chosen to represent selected combinations of land use, physiographic area, and basin size indicate land-use effects on nutrient concentrations. Median dissolved nitrate and total phosphorus concentrations are higher at sites representing agricultural (mostly poultry and cattle production) basins than at sites in forested basins. Nitrate concentrations generally increase as the percentage of agricultural land use increases. The range of nutrient concentrations at two sites with differing amounts and types of urban activities in their basins indicates that streams downstream from wastewater-treatment plants or urban areas may have nutrient concentrations that are substantially higher than concentrations in agricultural basins.

Poultry production is an extremely important industry in northwestern Arkansas, southwestern Missouri, and northeastern Oklahoma. Poultry litter can be a substantial source of nutrients and bacteria to water.

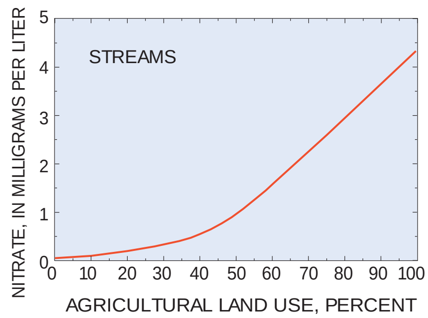
Beef and dairy cattle, which are important to the economy of the Ozarks, also are sources of nutrients and bacteria.



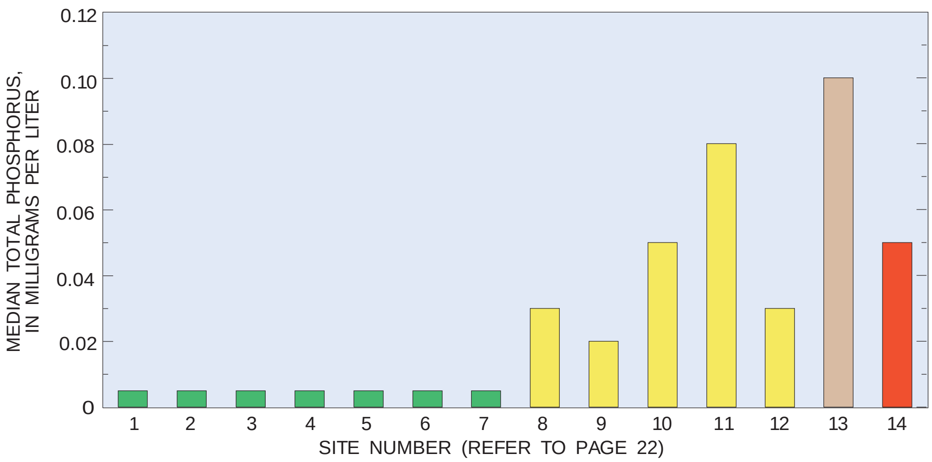
Forested areas protect water quality and are an economic and recreational asset for the Ozarks. (Photograph courtesy of A.C. Haralson, Arkansas Department of Parks and Tourism.)



Nitrate concentrations in streams are lowest in streams draining forested areas. Samples collected 1993-95.

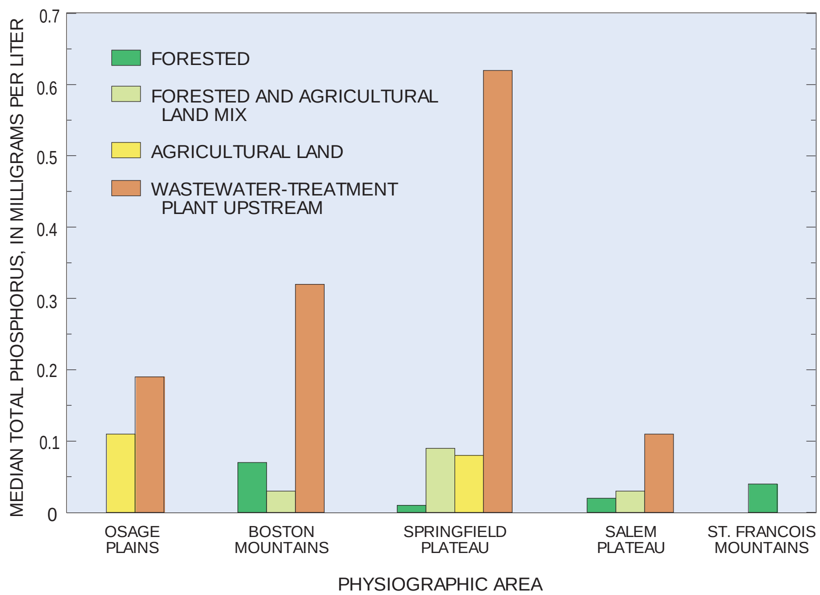


Nitrate concentrations generally are higher in streams draining basins with greater percentages of agricultural land. Samples collected 1993-95.



Phosphorus concentrations in streams also are lowest in streams draining forested areas. Samples collected 1993-95.

Recent historical data from 1980 to 1990 (Davis and others, 1995) also indicate that nutrient concentrations in streams in the Ozark Plateaus and the adjacent part of the Osage Plains generally were significantly greater in agricultural basins or downstream from wastewater-treatment plants than in forested basins.

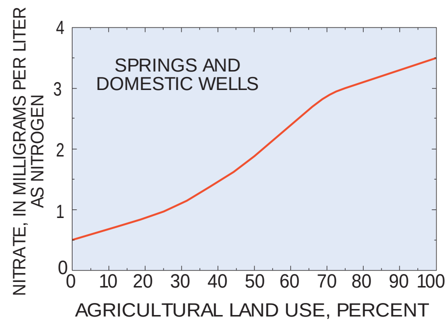


Phosphorus concentrations in streams during the 1980's were highest downstream from wastewater-treatment plants and lowest in forested areas.

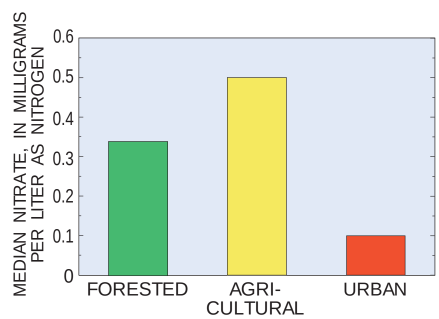
Nutrient concentrations in ground water are higher in areas with greater agricultural land use than in forested areas. These higher concentrations seldom exceed drinking-water standards.

NAWQA data collected in 1993-95 from wells and springs in the Springfield Plateau and Ozark aquifers also indicate that land use affects nutrient concentrations (Adamski, 1997a; 1997b). Nitrate concentrations were strongly associated with the percentage of agricultural land near the wells or springs. Concentrations in samples from “relatively pristine” sites (nearby forest cover greater than 90 percent) almost always were less than 1 mg/L (as nitrogen). Concentrations increased as the percentage of agricultural land increased; concentrations at sites with greater than 75 percent agricultural land use generally were about 3 mg/L, but ranged from about 1 to 10 mg/L.

Median nutrient concentrations in ground water (wells and springs) sampled from 1970 to 1992 also were less in forested areas than in agricultural areas (Davis and others, 1995). The median nitrate concentration in ground water from urban settings was lower than in agricultural or forested areas. The wells in these urban settings commonly are drilled through thick layers of confining rock before reaching the more productive confined aquifer.



Nitrate concentrations generally are higher in wells and springs in areas with greater agricultural land use. Samples collected 1993-95.

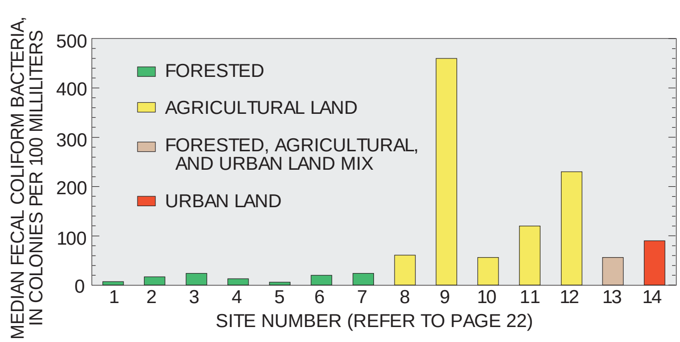


As was observed in streams, nitrate concentrations in water from wells and springs were higher in agricultural areas. Many wells in urban settings are deep public-supply wells overlain by layers of confining rock. Samples collected 1970-92.

Bacteria concentrations in streams are higher in basins with greater agricultural land use (mostly pasture). Fecal coliform bacteria concentrations occasionally exceed State water-quality standards for whole-body contact recreation.

Fecal coliform bacteria concentrations in NAWQA samples collected in 1993-95 generally are higher at stream sites representative of agricultural basins than at sites in forested basins. Data for other bacteria and discharge suggest that poultry and cattle are primary sources of the fecal coliform bacteria. Median concentrations ranged from about 10 to 20 colonies per 100 milliliters (col/100 mL) at forested sites and about 60 to 460 col/100 mL at agricultural sites.

State water-quality standards vary from State to State, by time of year, and with use of the water body. However, median fecal coliform bacteria concentrations at some sites in agricultural areas are greater than concentrations allowable by State regulatory agencies for public swimming areas or for primary contact. At most sites in agricultural areas, more than 25 percent of the samples contained concentrations of fecal coliform bacteria greater than 200 col/100 mL.



Bacteria concentrations are highest in agricultural areas. Samples collected 1993-95.

Nutrient and bacteria concentrations are affected by hydrologic and geologic factors. Stream discharge and the presence or absence of confining geologic layers are two factors that are important in predicting concentrations.

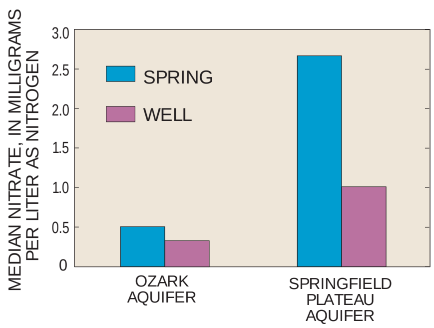
Concentrations of nutrients and bacteria in streams and springs are affected by discharge (Davis and others, 1995). Depending on the source and constituent, concentrations may increase or decrease with discharge. For example, nutrients and bacteria concentrations downstream from wastewater-treatment plants generally are lower during periods of higher discharge because of dilution. Concentrations of bacteria and nutrients in streams and springs may increase with increasing discharge in response to rainfall in areas where nonpoint sources are the major contributors.

Median nitrate and phosphorus concentrations generally are higher in springs than in wells because water from springs generally follows shallower flow paths and thus is more susceptible to surface contamination (Davis and others, 1995; Adamski, 1997b). Median nitrate concentrations of NAWQA samples collected in 1993 were about 0.5 mg/L in Ozark aquifer springs and about 0.3 mg/L in Ozark aquifer wells. Median nitrate concentrations in Springfield Plateau aquifer springs and wells were about 2.6 and 1.0 mg/L, respectively. Median concentrations of total phosphorus also were higher in springs (about 0.02 mg/L) than in wells (less than 0.01 mg/L).

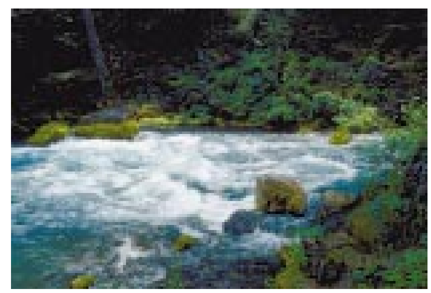
Differences also were detected in median concentrations of total phosphorus and nitrate in different aquifers and in confined and unconfined parts of the same aquifer (Davis and others, 1995). Concentrations generally were higher in the Western Interior Plains confining system and the Springfield Plateau aquifer. Concentrations generally were higher in the unconfined parts of the Springfield Plateau and Ozark aquifers than in the confined parts of these two aquifers. These differences probably are the result of land-use differences and the presence or absence of a protective confining layer between the aquifer and the land surface.

Karst features in the Springfield and Salem Plateaus result in substantial interaction between surface water and ground water. The quality of surface water or ground water commonly is affected by the quality of the other.

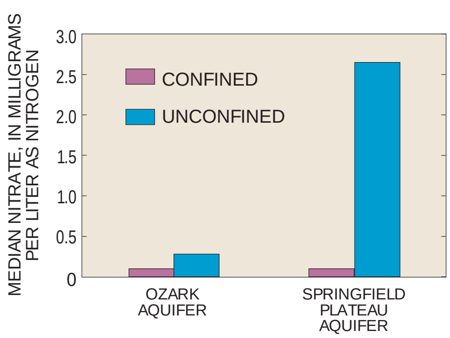
Many Ozark streams gain or lose substantial amounts of their flow through interactions with ground water. All of the water in this stream is going underground in this pool. (Photograph by J. Van Brahana, U.S. Geological Survey.)



Nitrate (shown here) and phosphorus concentrations are higher in springs than in well water. Samples collected 1993.

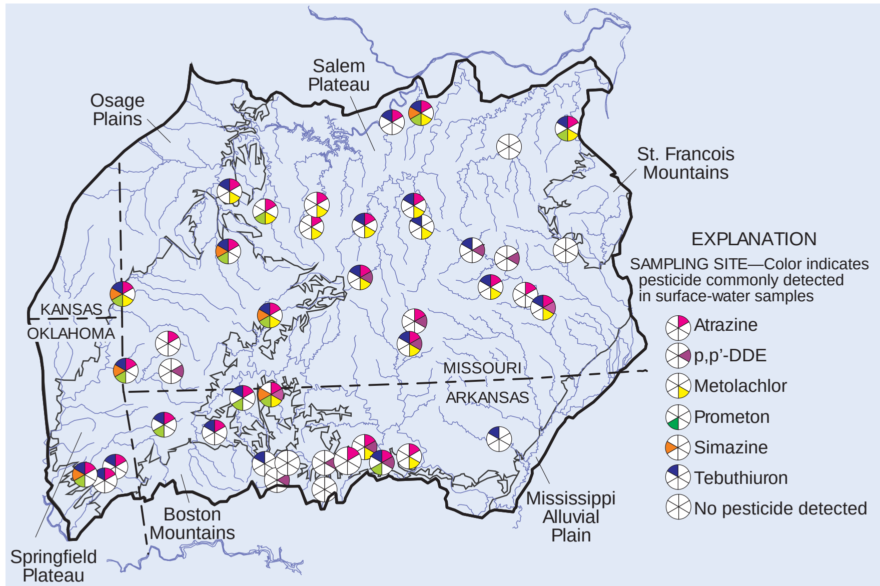


Springs are abundant in much of the Ozarks and are vulnerable to contamination. (Permission granted by the Missouri Division of Tourism.)



Nitrate (shown here) and phosphorus concentrations are higher in parts of aquifers near the land surface (unconfined) than in parts of aquifers that are deeper (and protected by an overlying confining layer). Samples collected 1970-92.

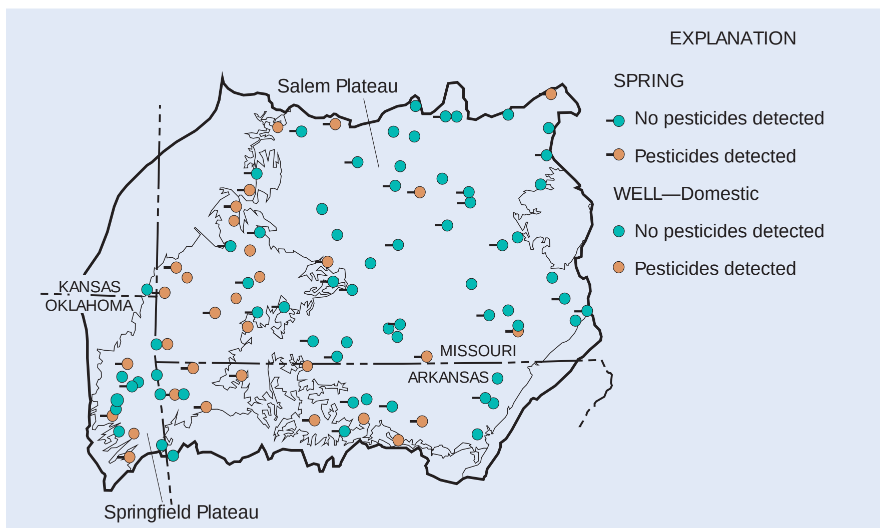
More than 1,000 organic compounds are contained in various products used to control pests in urban, agricultural, and forested areas and along rights of way. Most pesticides introduced in recent years are more water soluble and more degradable in the environment than many pesticides used extensively in the past. Most presently used compounds tend to be found more often in water, whereas many formerly used compounds are found more in sediment and biological tissue. In addition, numerous other organic compounds (such as phenols, polyaromatic hydrocarbons, and phthalate esters) are used for various industrial and manufacturing processes. Many of these compounds tend to associate with sediment particles rather than water.



The greatest number of pesticides was found in the streams of the more agricultural Springfield Plateau. Concentrations were usually relatively low. Samples collected 1994-95.

In streams and ground water, pesticides were more prevalent in agricultural areas than in forested areas. Concentrations generally were low and seldom exceeded U.S. Environmental Protection Agency drinking-water criteria or standards, or criteria for the protection of aquatic life.

Concentrations of pesticides in streams and ground water were usually below method detection limits and when detected were usually relatively low compared to detection limits and concentrations in samples from other NAWQA Study Units (p. 24-25). Concentrations seldom exceeded U.S. Environmental Protection Agency (EPA) maximum contaminant levels or lifetime health-advisory levels for drinking water, EPA or National Academy of Sciences/National Academy of Engineering (NAS/NAE) ambient water-quality criteria for the protection of aquatic life, or related State criteria. However, no standards or criteria exist for about one-third of the detected pesticides. Dieldrin concentrations in two ground-water samples exceeded levels estimated by EPA to increase the risk of cancer (Nowell and Resek, 1994).



In springs and wells, more pesticides were found in the Springfield Plateau and in other agricultural areas. Concentrations were usually relatively low. Samples collected 1993.

In water samples collected in 1994-95, pesticides were detected more commonly and in higher concentrations in streams in agricultural basins than in streams in forested basins (Bell and others, 1997). Data for a limited number of sites downstream from nearby urban areas indicate that pesticide detection frequencies and concentrations in urban basins are similar to those in agricultural basins. For most individual pesticides, the highest percentages of detections and the highest concentrations were in samples from streams in larger, more agricultural basins. Atrazine (one of the more commonly used herbicides in the Study Unit) and its metabolites (breakdown products) were the most commonly detected organic pesticide compounds in both forested and agricultural basins. Pesticides were detected at 39 of the 43 sites.

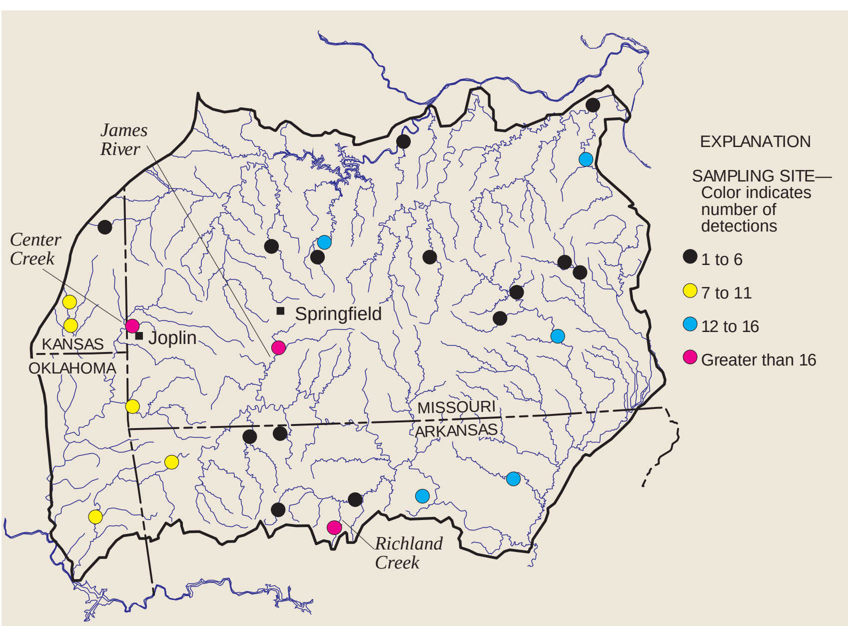
The presence of pesticides in ground water in the Springfield and Salem Plateaus also is related to land use. Springs and domestic wells were sampled for pesticides in 1993-95 (Adamski, 1997b). Pesticides were detected more frequently at sites associated with greater percentages of agricultural land use. Pesticides were more likely to be detected in samples from springs than in samples from domestic wells.

In bed sediment, the greatest numbers of pesticides and other organic compounds generally were detected at sites downstream from urban areas. No concentrations exceeded U.S. Environmental Protection Agency criteria for the protection of aquatic life.

No organic compounds detected in the bed-sediment samples exceeded either the preliminary sediment-quality criteria developed by the EPA or concentrations expected to have a high probability of adverse effects on aquatic life (U.S. Environmental Protection Agency, 1996). Criteria or adverse effects levels have not been established for most of the detected compounds. Most of the compounds detected had maximum concentrations of less than 100 micrograms per kilogram (parts per billion).

Pesticides and semivolatile organic compounds (SVOCs) in 27 bed-sediment samples collected in 1992-95 were more frequently detected at sites downstream from urban areas (Bell and others, 1997). Samples were analyzed for 95 organic compounds. Two pesticides (chlordane compounds) and 44 SVOCs were detected. Samples from three sites contained detectable concentrations of more than 16 compounds. Two of these sites (one from the James River downstream from Springfield, Mo., one from Center Creek downstream from Joplin, Mo.) were in urban basins. In the sample from the James River, 39 compounds were detected; in the sample from Center Creek, 17 compounds were detected. The third sample contained 23 compounds and was from Richland Creek near Witts Spring, Ark., in a forested basin.

Sites with detected compounds are distributed throughout the Study Unit, with respect to both physiography and land use. Sites with 12 or more organic compounds detected are located in each physiographic area and major land-use category.



In bed sediment, the greatest number of pesticides and other organic compounds was found near urban areas. Concentrations were usually relatively low. Samples collected in 1992-95.

In biological tissue, pesticides were detected at 5 of 26 stream sites. Chlordane was detected downstream from Springfield, Mo. DDT, DDE, or dieldrin was detected at four sites in agricultural basins.

Tissue samples from fish and freshwater clams at 26 sites were analyzed for 26 organic compounds. Six compounds were detected at five sites (Bell and others, 1996). Three chlordane compounds were detected in Asiatic clam tissue at a site on the James River downstream from Springfield, Mo. These compounds frequently are present downstream from urban areas. DDT, DDE, or dieldrin was detected in tissue at four widely separated sites.

The concentrations in the tissues were below guidelines recommended as maximum concentrations to protect fish-eating wildlife (National Academy of Sciences and National Academy of Engineering, 1973). The sum of the three chlordane compound concentrations (0.0223 milligram per kilogram [mg/kg]) was below the recommended chlordane concentration of 0.1 mg/kg. The DDT, DDE, and dieldrin concentrations were well below the recommended maximum concentrations.

Parts of the Ozark Plateaus have a history as major producers of lead and zinc. Mining in the Study Unit has occurred primarily in four main lead-zinc mining districts—the Southeastern District (Old Lead Belt, Viburnum Trend, and the Fredericktown subdistricts), the Tri-State District, the Central District, and the North Arkansas District. By far the most important ore deposits were in the Southeastern and Tri-State Districts. The Viburnum Trend subdistrict is the only area still mined for lead or zinc.

Concentrations of sulfate and some trace elements in water from streams in areas of historical or active lead-zinc mining tend to be higher than in areas where mining has not occurred. These trace element concentrations decrease with increasing distance downstream from the mining activity. Concentrations usually did not exceed Federal standards or criteria for the protection of drinking water, human health, or aquatic life.

In water samples collected in 1992-95, dissolved sulfate and several trace elements were detected more commonly and were detected in higher concentrations at sites in areas of historical or ongoing lead-zinc mining than at sites in other areas. Sulfate, barium, copper, manganese, molybdenum, and zinc concentrations were higher in samples from sites downstream from mining areas. Lead concentrations were not higher in mining areas. Concentrations of sulfate and trace elements generally decreased with increasing distance downstream from a mining activity.

At most sites, concentrations usually did not exceed U.S. Environmental Protection Agency drinking-water standards or criteria for protection of human health or aquatic life. However, zinc concentrations often exceeded freshwater aquatic life criteria in Center Creek.

Concentrations of lead and zinc in bed sediment and fish or clam tissue are substantially higher at sites with mining activities (historical or active) in the basin. Concentrations are high enough to suggest potential adverse biological effects. The State of Missouri has issued a fish consumption advisory for some streams.

Lead and zinc concentrations in bed sediment at sites downstream from lead-zinc mines in the Tri-State District, the Old Lead Belt, and the Viburnum Trend may have adverse biological effects on benthic organisms. Long and Morgan (1991) developed guidelines called “effects range thresholds” for use in assessing potential adverse effects on biota. In general, the “effects range-low” threshold can be considered to have adverse effects on some benthic organisms, while the “effects range-median” threshold can be considered frequently or always to have adverse effects on these organisms. In at least one bed-sediment sample from each of the three mining areas, concentrations of lead and zinc were equal to or higher than the effects range-low threshold. Lead and zinc concentrations from sites downstream from the Tri-State District and the Old Lead Belt commonly were substantially higher than the effects-range median threshold.

Concentrations of lead and zinc in bed sediment were highest at sites downstream from historical lead-zinc mining areas. Concentrations of both elements are similar at sites downstream from the historical mining areas in the Tri-State District and the Old Lead Belt and at sites downstream from mining areas in the Viburnum Trend.

Lead and zinc concentrations in water, bed sediment, and fish or clam tissue from mining and background areas of the Ozark Plateaus

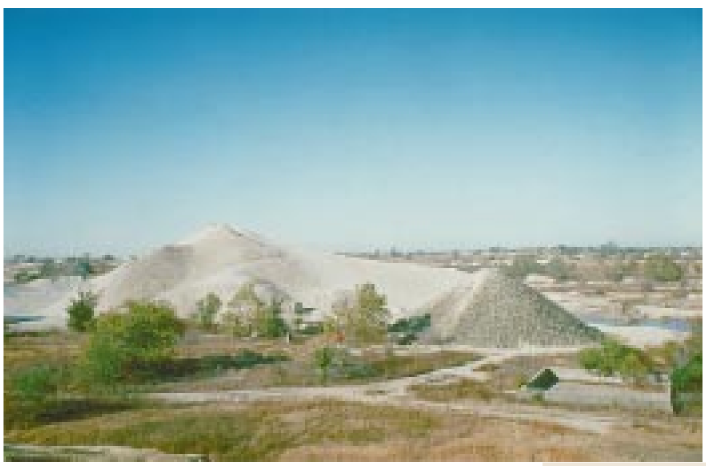
[Background values are minimum and maximum concentrations associated with sites not considered to be influenced by mining in these or other areas. Sites immediately upstream from mining areas are not included in background sites. Tissue concentrations are in fish liver or soft tissue of Asiatic clam. Values in red substantially exceed background concentration data collected 1992-95. µg/L, micrograms per liter; µg/g, micrograms per gram; <, less than; --, not measured or not applicable]

Site	Mining area	Lead			Zinc		
		Water (µg/L)	Bed sediment (µg/g)	Tissue (µg/g)	Water (µg/L)	Bed sediment (µg/g)	Tissue (µg/g)
Center Creek	Tri-State	<1	370	0.3	67-270	5,600	770
Big River	Old Lead Belt	<1	2,300	134	8-19	670	514
Meramec River	Old Lead Belt	--	180	12.2	--	140	296
West Fork of Black River	Viburnum Trend	<1-11	100-950	0.5-8.3	13-33	120-460	70-110
Strother Creek	Viburnum Trend	<1-3	200	0.7	33-148	1.200	150
Background	--	<1-20	15-28	<0.1-0.6	<1-44	43-140	57-230

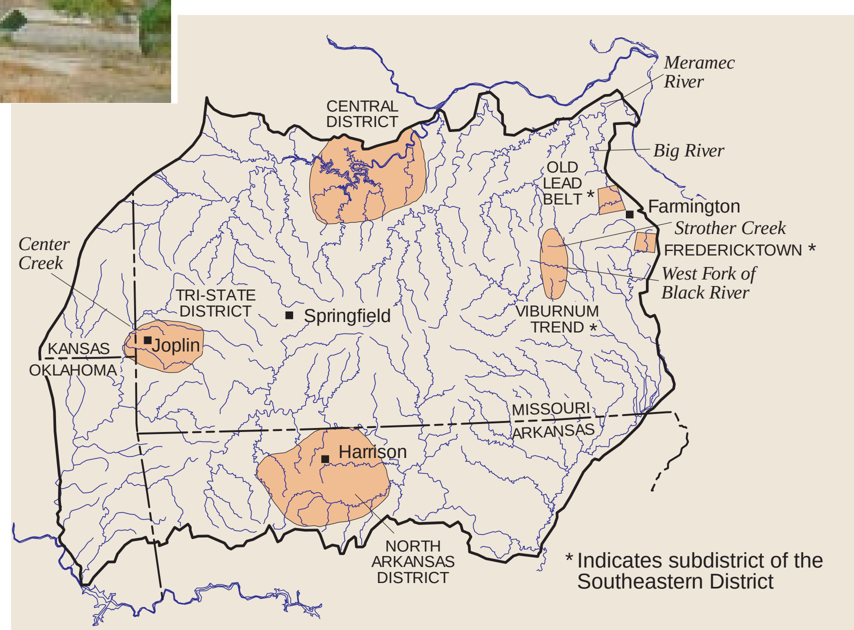
Lead concentrations in bed sediment were substantially higher than background at sites within, or downstream from, the Tri-State District and the Old Lead Belt subdistrict and in the Viburnum Trend subdistrict. In the Viburnum Trend subdistrict, concentrations of lead returned to background levels at sites about 15 miles downstream from mine discharges.

Zinc concentrations in bed sediment were highest at one site downstream from the Tri-State District and one site downstream from the Old Lead Belt. Concentrations at sites just downstream from mines in the Viburnum Trend were higher than concentrations at sites upstream from these mines or farther downstream; however, these concentrations were not higher than the maximum background concentrations at sites throughout the Study Unit. At sites about 15 miles downstream from mines in the Viburnum Trend, bed-sediment concentrations of zinc were similar to concentrations upstream from the mines.

The relation between tissue concentrations at background sites and sites downstream from mining areas is similar to the relation between bed-sediment concentrations at these same sites. Lead concentrations in tissue were somewhat higher than background concentrations at some sites in the Viburnum Trend and substantially higher at sites downstream from the Old Lead Belt. The lead concentration at the site in the Tri-State District was at background levels and substantially lower than at sites downstream from the Old Lead Belt. Zinc concentrations were not higher than background concentrations at sites in the Viburnum Trend, but were somewhat higher than background concentrations at sites in the Tri-State District and downstream from the Old Lead Belt. The elevated lead and zinc concentrations in tissue and reduced enzyme activity in fish exposed to lead in mining areas of the Ozark Plateaus (Schmitt and others, 1993) suggest that both elements are available to fish and Asiatic clams for biological processing. The State of Missouri currently (1998) advises the public to not eat some species of fish from some rivers affected by past mining in the Old Lead Belt (Gale Carlson, Missouri Department of Health, written commun., 1998).

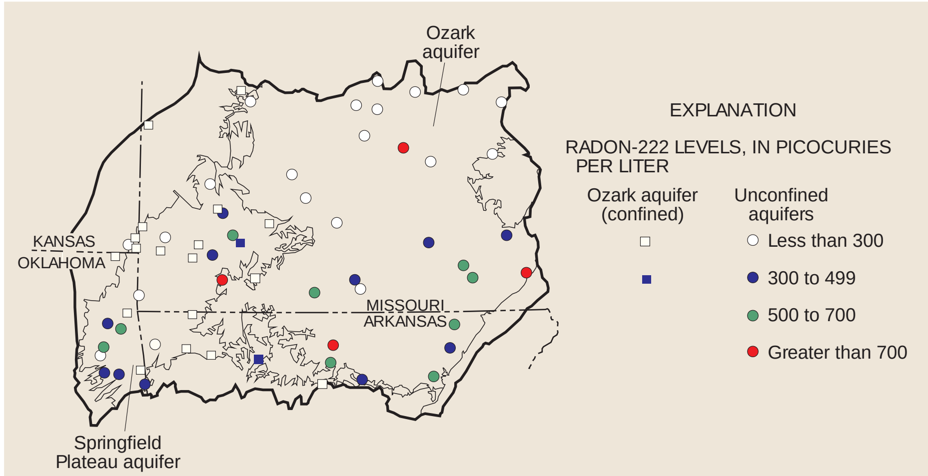


Lead-zinc mining tailings near Joplin, Mo. Downstream from mining areas, concentrations of lead, zinc, and other elements generally are relatively low in water but are elevated in bed sediment and in fish and clam tissue. In bed sediment, concentrations at some locations may be harmful to aquatic wildlife.

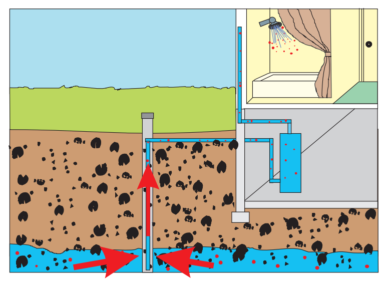


Lead-zinc mining areas of the Ozark Plateaus. The Viburnum Trend subdistrict is the only area currently (1998) being mined for lead or zinc.

Radium and radon are naturally occurring radioactive elements that result from the radioactive decay of uranium, which is present in small levels in common rocks and minerals.



Radon levels exceeded 300 picocuries per liter in almost one-half of the water samples from domestic and municipal-supply wells.



Radon entering a home through a water system (modified from Otton and others, 1993).

Radium is present in the confined part of the Ozark aquifer. However, the levels of radium seldom exceeded the U.S. Environmental Protection Agency drinking-water standard.

Water samples collected from 20 randomly selected municipal-supply wells in the confined part of the Ozark aquifer were analyzed for the presence of radium (Adamski, 1997c). Radium levels ranged from 0.1 to 14 picocuries per liter (pCi/L). One sample had a level exceeding the interim U.S. Environmental Protection Agency (EPA) maximum contaminant level (MCL) of 5 pCi/L. No levels exceeded the proposed MCL of 20 pCi/L for radium in drinking water.

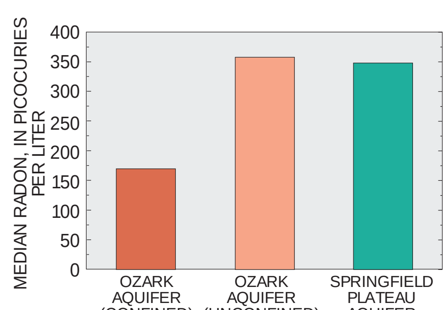
Radon levels exceeded a proposed (but withdrawn) U.S. Environmental Protection Agency drinking-water standard in nearly one-half of the samples. Radon can enter homes through their water systems. Homes served by private domestic wells and small public waterworks using ground water can be particularly vulnerable.

Water samples were collected from 53 domestic wells in the unconfined parts of the Springfield Plateau and Ozark aquifers, and 20 municipal supply wells in the confined part of the Ozark aquifer (Adamski, 1997c). In samples from these 73 wells, radon levels ranged from 99 to 2,065 pCi/L with a median of 269 pCi/L. A proposed MCL of 300 pCi/L was recently (1997) withdrawn by the EPA, pending further review. Radon levels exceeded that level in nearly 44 percent of the samples but are lower than levels in many other aquifers in the Nation (p. 20).

Exposure to radon has been recognized as a health risk, primarily as a cause of lung cancer. One pathway by which radon can enter a home is through its water system, especially if ground water is the water source. Small public water systems and private domestic wells often have closed systems and short transit times that do not remove radon from water or permit it to decay. Exposures can occur from water used for drinking, showering, and other common household purposes. Radon gas also can enter buildings from surrounding rock and soil through foundation cracks.

Radon levels are greater in the Springfield Plateau aquifer and the unconfined part of the Ozark aquifer than in the confined part of the Ozark aquifer.

Hydrogeology appears be significant in determining radon levels. Levels in the samples from unconfined aquifers (Springfield Plateau aquifer and part of the Ozark aquifer) were substantially higher than levels in samples from the confined part of the Ozark aquifer.



Radon levels are lowest in the confined part of the Ozark aquifer.

Habitat characteristics can affect biological communities in many different ways. For example, trees along streambanks provide shade, erosion protection, and leaf litter to a stream. These factors often affect the density and diversity of fish (p. 16-17), aquatic insects, and algae.

Several factors can affect aquatic habitats, which then affect biological communities. Many habitat characteristics appeared to be influenced more by basin size than by land use.

Physiography, geology, basin size, and land use are among the factors that can affect aquatic habitats. Most habitat characteristics appeared to be more influenced by basin size than by land use (Femmer, 1997). Sites with larger basins tend to be wider, deeper, more sinuous streams with greater water velocity and larger canopy angles. Sites with smaller basins tend to have steeper basin and stream gradients.

Small streams in agricultural areas generally have fewer trees and other woody plants in the riparian zone than do small streams in forested areas. This results in more sunlight reaching the streams in the agricultural areas. More sunlight and the higher nutrient levels probably result in faster growing attached algae in these streams.

Cleared pastureland commonly extends to (or nearly to) streambanks in agricultural areas, resulting in narrow or absent riparian vegetation zones. Small streams in agricultural basins generally had lower mean woody-plant densities than small streams in forested basins (Femmer, 1997). Small streams in agricultural basins also generally were more open to sunlight because of larger canopy angles than small streams in forested basins. More sunlight and higher nutrient levels (p. 6) in streams in agricultural areas probably result in faster growing attached algae in these streams.

Compared to smaller streams, larger streams are wider and have gravel bars extending farther from the edge of water to the streambanks. Therefore, larger streams in forested and agricultural basins tend to be more separated from their riparian zones.

Some other habitat characteristics were different between the agricultural and forested sites studied. Of these characteristics, some are not likely the result of agricultural practices, while others (canopy angle, channel width, and sinuosity) may, at least in part, result from agricultural practices. These characteristics can affect biological communities.

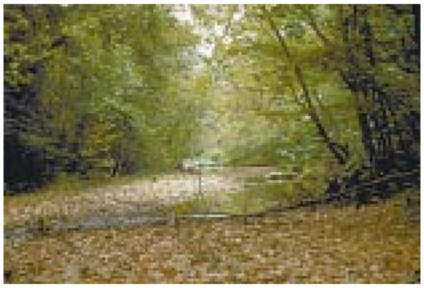
Habitat characteristics that seem to differ between agricultural and forested sites (Femmer, 1997), but are not the result of agricultural activities, include water velocity, sideslope gradient, and flood-plain width. Some characteristics that may be influenced by land use are canopy angle (discussed above), channel width, and channel sinuosity. Mean channel width and mean channel sinuosity both tended to be greater at agricultural sites.

Although the effects of instream gravel mining in the Ozarks were not studied by the NAWQA Program, some studies suggest that gravel mining has detrimental effects on instream habitat.

A study (Brown and Lyttle, 1992) of several instream (between the banks of streams) gravel-mining sites on streams in the Arkansas part of the Ozark Plateaus indicated that stream channels were altered as pools became shallower and larger and riffles were less frequent downstream from the mining sites. Game-fish biomass and abundance of game fish and silt-sensitive fish were lower at and downstream from these sites than at upstream reference locations. On the basis of Arkansas Game and Fish Commission data, Arkansas State University (1996) reported similar differences in fish communities in gravel mining areas of the Spring River in northeastern Arkansas. Brown and Lyttle (1992) also reported differences between benthic invertebrate (animals such as bottom-dwelling insects) communities at mining sites and communities at reference locations. Kanehl and Lyons (1992) reported similar physical and biological effects in other streams of the United States.

The severity of the effects of gravel mining on streams probably is dependent on several factors. These factors include hydrology, channel shape, and gravel removal methods and related activities.

Small streams in agricultural areas commonly have a narrow (or absent) band of riparian trees.



Small streams in forested areas generally have a wider band of riparian trees. Here an overhead canopy shades much of the stream.

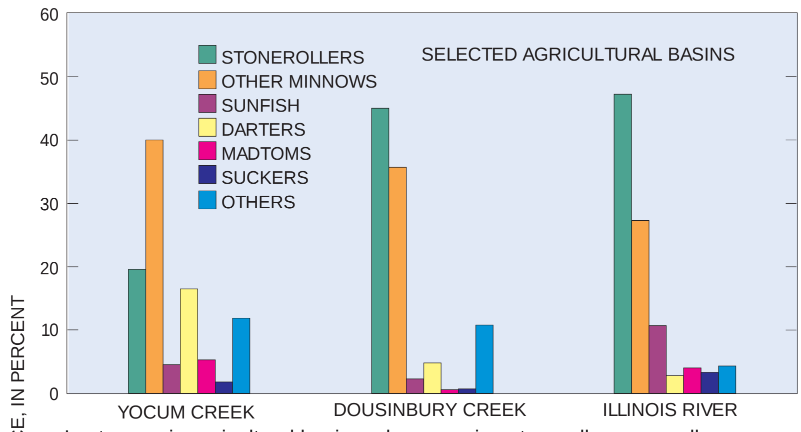
Larger streams often are more open to sunlight—either because of wide gravel bars or simply because the streams are wider.

Compared to other parts of the United States, many fish species live in the Ozark Plateaus. Approximately 175 species (including introduced species) are present in the Ozark Plateaus province part of the Study Unit; at least 16 of these species exist nowhere else in the world. Many of these 175 species are intolerant of habitat or water-chemistry degradation.

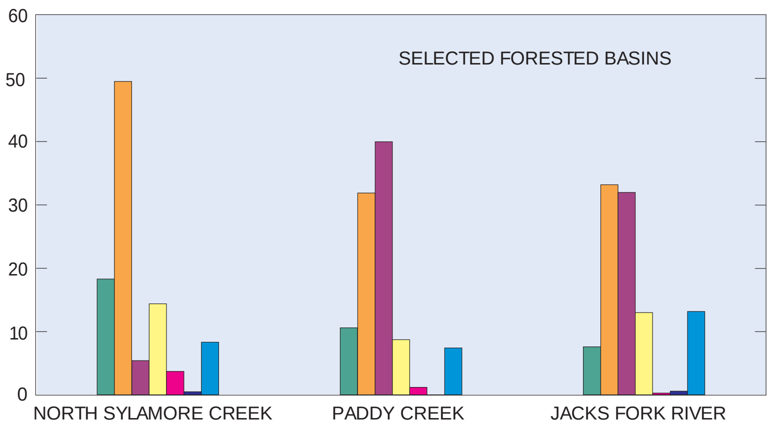
Fish communities are a useful tool in assessing water-chemistry and habitat conditions of streams. Many fish species are sensitive to a wide array of stresses that are integrated over their lifetimes, are relatively widely distributed, and are relatively easy to identify.

Stonerollers make up a greater percentage of the fish at agricultural sites than at forested sites. Stonerollers graze on algae attached to rocks and other surfaces. More algae probably grow on these surfaces because of the higher nutrient concentrations and greater amounts of sunlight reaching these streams.

A major difference between the composition of fish communities at sites in forested basins and agricultural basins is the difference in the relative abundance (percentage of total individuals in the community) of two types of minnows called "stonerollers" that are among the most abundant fish species in Ozark streams. Stonerollers graze on algae attached to rocks and other submerged surfaces. Streams in agricultural basins typically have high concentrations of nutrients and less riparian shading (which allows more sunlight to reach the streambed), promoting algal growth. Greater amounts of this food source encourage greater numbers of stonerollers. The median relative abundance of stonerollers at forested sites (in 1995) was 14 percent; the median abundance at agricultural sites was 35 percent. Whether this greater abundance can have detrimental effects on the aquatic community is unknown, although apparently stonerollers selectively graze on different types of algae and affect the density and composition of benthic invertebrates (Gelwick and Matthews, 1992).



In streams in agricultural basins, algae-grazing stonerollers generally are the most abundant type of fish. Generally, 20 to 50 percent of the fish are stonerollers.



In streams in forested basins, minnows (other than stonerollers), sunfish, and darters are a larger percentage of the fish community than in agricultural basins. Generally, 10 to 20 percent of the fish are stonerollers.

The increased abundance of stonerollers is an indication of increased nutrients in Ozark streams. Other factors (including toxicity and changes in channel shape) can also affect stoneroller abundance. The relative abundance (17 percent) of stonerollers at a site on Center Creek, downstream from a lead-zinc mining area and from industrial and municipal wastewater-treatment plant discharges near Joplin, Mo., may be lowered because of toxicity. The abundance (46 percent) of stonerollers at a site on the Kings River, downstream from a small wastewater-treatment plant and instream gravel mining, may be elevated because of nutrient enrichment and other habitat changes.

Stonerollers are very common in the Ozarks. They generally are more abundant in streams in agricultural basins.

Sunfish (including the black basses) and darters make up a smaller percentage of fish at agricultural sites than at forested sites. Members of the sunfish family (particularly smallmouth bass) are important game fish. Several species of darters that live in the Ozarks exist nowhere else in the world.

Stonerollers are more abundant (relative to other species) at sites in agricultural basins, and sunfish (including the black basses—smallmouth, largemouth, and spotted bass) are less abundant at these sites. Many of the sunfish species in the Ozarks are sensitive to degraded water chemistry or habitat. Much of this decrease in relative abundance (percentage of total individuals) is because of the greater relative abundance of stonerollers; but even after discounting the stoneroller data, sunfish generally have lower relative abundance values at agricultural sites than at forested sites. The median relative abundance of sunfish at forested sites was 11 percent (26 percent of individuals other than stonerollers); whereas, the median relative abundance at agricultural sites was 4 percent (6 percent of other than stonerollers). Members of the sunfish family, especially smallmouth bass, are important game fish in Ozark streams. Spotted bass, largemouth bass, longear sunfish, Ozark bass, shadow bass, and rock bass are less important, either because of fewer numbers or smaller size.

Darters also comprise a smaller percentage of the communities at sites in agricultural basins. As with sunfish, much of this is because of the greater relative abundance of stonerollers; but after discounting the stoneroller data, darters generally remain relatively less abundant at sites in agricultural basins. The median relative abundance of darters at forested sites was 14 percent (18 percent of other than stonerollers). The median relative abundance at agricultural sites was 4 percent (8 percent of other than stonerollers). Darters generally are considered to be sensitive to water-chemistry or habitat degradation. At least seven species of darters in the Ozarks (Arkansas saddled darter, yoke darter, yellowcheek darter, stippled darter, bluestripe darter, Missouri saddled darter, and Niangua darter) exist nowhere else in the world. The Niangua darter, which is found in only a few tributaries of the Osage River in central Missouri, is a federally listed threatened species under the Endangered Species Act.

Smallmouth bass, an important game fish, are sensitive to degraded habitat or water chemistry. (Photograph courtesy of Gregg Patterson.)

Fish community composition appears to be related to stream size, canopy angle, substrate, and water chemistry. Some of these factors are affected by human activities.

Results of several statistical procedures (multivariate analyses, correlation, and regression) used to group and compare the fish communities at 18 sites in the Study Unit indicate that these communities are substantially affected by their habitat. However, the procedures used to group sites often do not completely separate sites in agricultural areas from those in forested areas. This indicates that factors related to land use are important in determining community structure, but that other factors also are important.

Darters also are sensitive to degraded habitat or water chemistry. This Niangua darter is one of seven species of darter found only in the Ozarks. (Photograph courtesy of Missouri Department of Conservation.)

Several measures of stream size appear related to community composition. These measures include stream width and depth, width-to-depth ratio, and stream order. This result is reasonable, considering that several species of fish have preferences for smaller, steeper gradient, lower order streams, while others have preferences for larger, lower gradient, higher order streams. Several other factors that can be affected by stream size and land use also appeared to be related to community structure at the 18 sites. These factors were canopy angle, substrate size, sinuosity, and velocity.

Several water-chemistry factors appeared to be related to the fish community composition. Phosphorus, sediment, and nitrate concentrations were related to the community composition in results from at least one of the multivariate procedures.

Many of these factors probably affect spawning success and food availability. Smallmouth bass, some other sunfish, many minnows, and most darters are intolerant of turbidity or siltation. Stonerollers are favored by increased algal growth, which results from elevated nutrient concentrations and large (open) canopy angles.

The site on Center Creek (map, p. 19) has one of the highest percentages in the study area of individuals tolerant of degraded water chemistry or habitat. The site also has a relatively low percentage of stonerollers for a site with elevated nutrient concentrations and an open canopy. This site, which is downstream from lead-zinc mining and urban areas, has elevated concentrations of lead, zinc (table, p. 12), and semivolatile organic compounds (p. 11) in bed sediment. These chemicals may be a major factor affecting the Center Creek fish community.

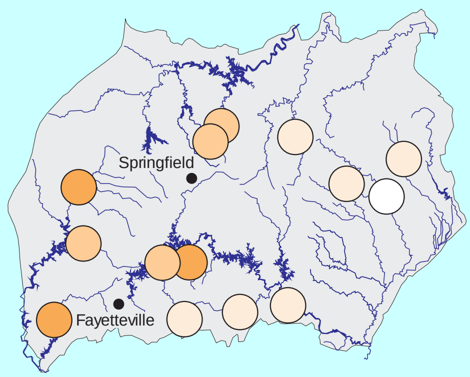
Seven major water-quality characteristics were evaluated for stream sites in each NAWQA Study Unit. Summary scores for each characteristic were computed for all sites that had adequate data. Scores for each site in the Ozark Plateaus Study Unit were compared with scores for all sites sampled in the 20 NAWQA Study Units during 1992–95. Results are summarized by percentiles; higher percentile values generally indicate poorer quality compared with sites in the 20 Study Units. 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.)

EXPLANATION

Ranking of stream quality relative to all NAWQA stream sites — Darker colored circles generally indicate poorer quality.

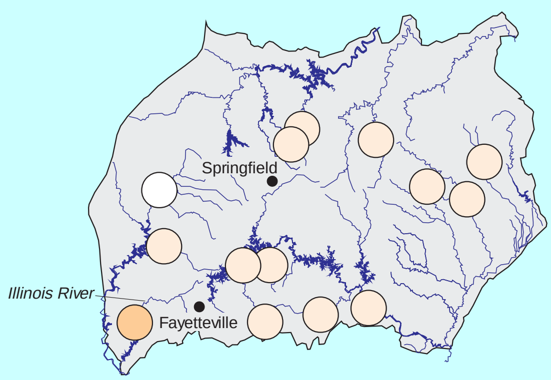
- **Greater than the 75th percentile** (among the highest 25 percent of NAWQA stream sites)
- **Between the median and the 75th percentile**
- **Between the 25th percentile and the median**
- **Less than the 25th percentile** (among the lowest 25 percent of NAWQA stream sites)
- **Insufficient data for analysis**

NUTRIENTS in water



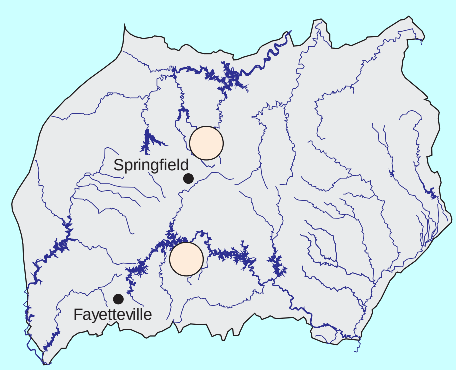
Nutrient concentrations in two streams draining basins with predominantly agricultural land use and one stream downstream from a wastewater-treatment plant were higher than the national median. Beef cattle, dairy cattle, and poultry production provides a major source of nutrients to streams. Ammonia concentrations did not exceed the EPA criterion for protection of aquatic life at any of the agricultural sites. Nutrient concentrations in streams draining basins with predominantly forested land use were among the lowest in the 20 Study Units.

ORGANOCHLORINE PESTICIDES and PCBs in bed sediment and biological tissue



Organochlorine pesticides and PCBs were rarely detected in bed sediment or biological tissue. DDE, a breakdown product of DDT, was detected at a low concentration in fish tissue from the Illinois River.

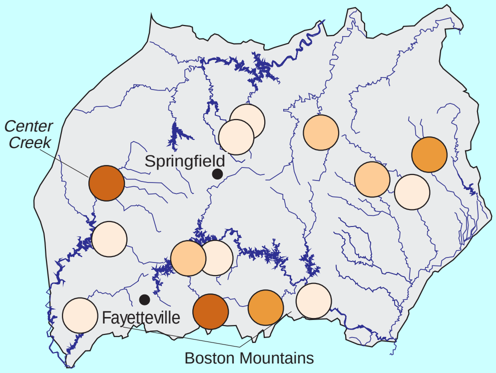
PESTICIDES in water



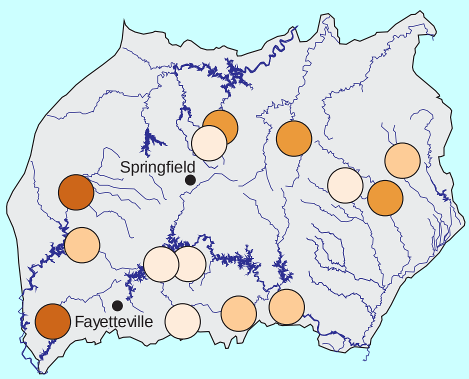
Pesticide concentrations in two intensively sampled streams in agricultural basins were among the smallest in the 20 Study Units. No exceedances of existing criteria occurred. The herbicides atrazine and simazine were the most commonly detected pesticides.

The bed sediment at sites located in lead-zinc mining areas and in or near the Boston Mountains had concentrations of trace elements at a higher level than most other sites in the 20 Study Units. Zinc concentrations and lead concentrations at Center Creek near Smithfield, Mo., were substantially higher than the national median zinc (about 50 times higher) and lead (about 15 times higher) concentrations.

TRACE ELEMENTS in bed sediment



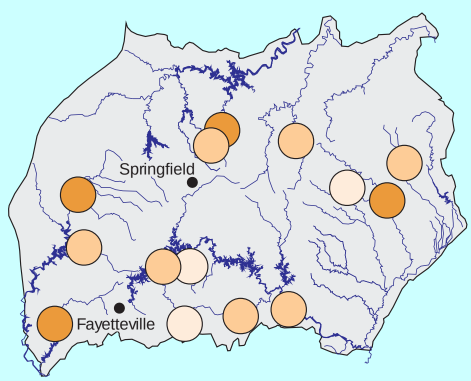
SEMIVOLATILE ORGANIC COMPOUNDS in bed sediment



Summed concentrations of semivolatile organic compounds in bed sediment at most sites were lower than at most sites in the 20 Study Units. None of the sites had concentrations above which there is a high probability of adverse effects on aquatic organisms. Two sites with concentrations exceeding the national Study Unit median are in forested areas. The two sites with the highest concentrations are in basins containing some of the more urban areas of the Study Unit.

Fish communities at most sites were less degraded (fewer diseased, tolerant, and omnivorous fish) than at most other sites in the 20 Study Units. Sites with most degradation in the Study Unit generally are on larger rivers affected by agricultural, mining, or urban activities. The fourth site is in a forested basin and was considered to have a degraded fish community because of the large percentage of omnivorous fish such as gizzard shad and common carp.

FISH COMMUNITY DEGRADATION

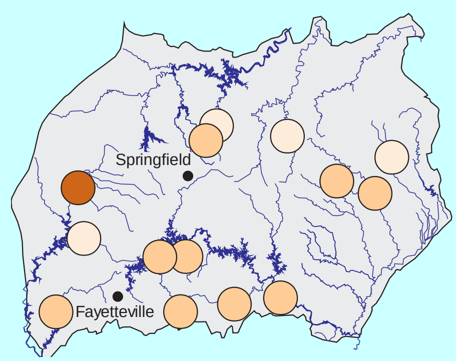


CONCLUSIONS

Compared with other NAWQA Study Units:

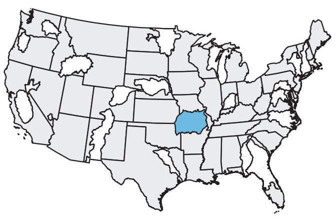
- Nutrient concentrations in streams draining forested basins were among the lowest in the Nation; concentrations in some streams draining basins with other land uses were higher than most other sites in the Nation.
- Concentrations of pesticides and other organic compounds in water, bed sediment, and tissue generally were lower than at sites in other Study Units. Concentrations of semivolatile organic compounds in bed sediment at sites downstream from urban areas were among the highest in the Nation.
- Trace element concentrations in bed sediment in lead-zinc mining areas were among the highest in the Nation.
- The quality of stream habitats and fish communities at most sites was better than at most other sites in the Nation.

STREAM HABITAT DEGRADATION



A well-vegetated riparian corridor contributes substantially to healthy habitat scores at many sites in the Study Unit. Gravel and lead-zinc mining probably have contributed to modified channels and increased sedimentation at some sites. A site on Center Creek, which flows through an area of agricultural land use and historical lead-zinc mining, is the only site that was more degraded than the median of sites in the 20 Study Units.

Comparison of Ground-Water Quality in the Ozark Plateaus Study Unit 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 (in the Ozark Plateaus Study Unit, generally from wells less than 300 feet deep). Summary scores were computed for each characteristic for all aquifers and shallow ground-water areas that had adequate data. Scores for each aquifer in the Ozark Plateaus Study Unit 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 ground-water studies in the 20 Study Units. Water-quality conditions for each sampled 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 were described by Gilliom and others, in press.) With the exception of the confined part of the Ozark aquifer (which is not considered shallow ground water), all groups of ground-water data for the Ozark Plateaus Study Unit could have been compared to both the national drinking-water aquifer scores and the national shallow ground-water scores. The results of the drinking-water aquifer comparisons are shown below.

EXPLANATION

Ozark aquifer (confined)—(OZ-C)

Ozark aquifer (unconfined)—(OZ-U)

Springfield Plateau aquifer (unconfined)—(SP)

Springfield Plateau aquifer, unconfined, pasture (cattle)—(SP-Ca)

Springfield Plateau aquifer, unconfined, pasture (poultry)—(SP-P)

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

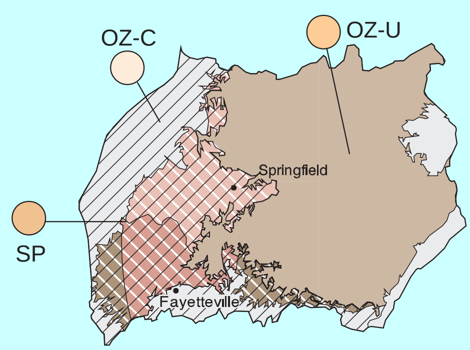
Greater than the 75th percentile
(among the highest 25 percent of NAWQA ground-water studies)

Between the median and the 75th percentile

Between the 25th percentile and the median

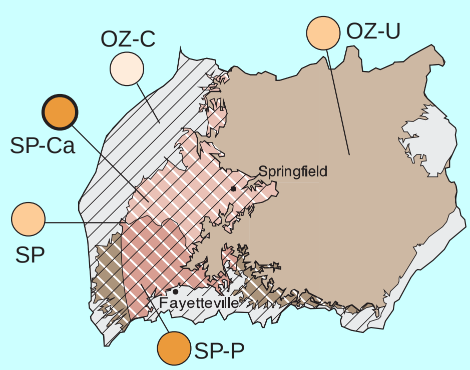
Less than the 25th percentile
(among the lowest 25 percent of NAWQA ground-water studies)

RADON



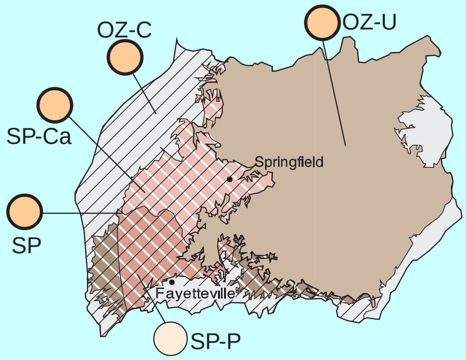
Radon levels in water from the unconfined Springfield Plateau aquifer and the confined and unconfined parts of the Ozark aquifer were lower than levels in most other aquifers in the 20 NAWQA Study Units.

NITRATE



Water from the Ozark aquifer had nitrate concentrations lower than the median value for all NAWQA Study Units. However, water from parts of the Springfield Plateau aquifer, which lies beneath a primarily agricultural area, had higher nitrate concentrations, greater than the national median. U.S. Environmental Protection Agency drinking-water standards were exceeded in less than 1 percent of Springfield Plateau aquifer samples.

DISSOLVED SOLIDS



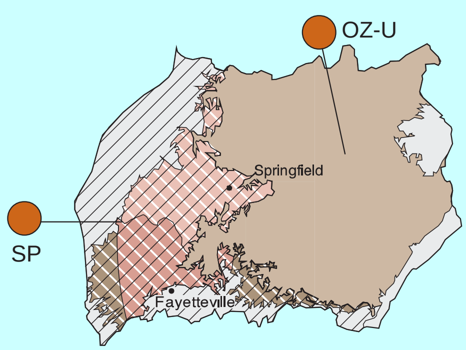
Median dissolved-solids concentrations in water from sampled wells were less than the NAWQA national median. However, samples from nearly all groups of data occasionally exceeded the U.S. Environmental Protection Agency drinking-water guideline. A small percentage of the samples from the Springfield Plateau aquifer and unconfined part of the Ozark aquifer had concentrations exceeding the guideline; however, 15 percent of the samples from the confined part of the Ozark aquifer exceeded the guideline. Dissolved-solids concentrations in the confined aquifer were greatest near the western boundary of the Study Unit.

CONCLUSIONS

Compared with other NAWQA Study Units:

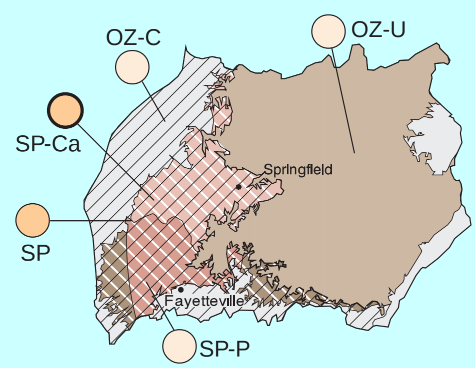
- Radon levels were lower than in most other drinking-water aquifers.
- Nitrate concentrations in parts of the Springfield Plateau aquifer were higher than in most other drinking-water aquifers. This aquifer lies beneath an agricultural area.
- Dissolved-solids concentrations were less than in most other drinking-water aquifers.
- Volatile organic compounds were detected more frequently than in most other drinking-water aquifers. Concentrations generally were relatively low.
- Pesticides were detected less frequently than in most other drinking-water aquifers.

VOLATILE ORGANIC COMPOUNDS



Volatile organic compound (VOC) detections were more frequent in samples from the Springfield Plateau aquifer and part of the Ozark aquifer than in most other drinking-water aquifers sampled nationally by NAWQA. Detections of VOCs did not appear to be related to regional land use, but could be related to very localized land uses at some sites or could be an artifact of well construction or sample collection. Concentrations generally were low relative to detection limits or drinking-water standards or guidelines.

PESTICIDES



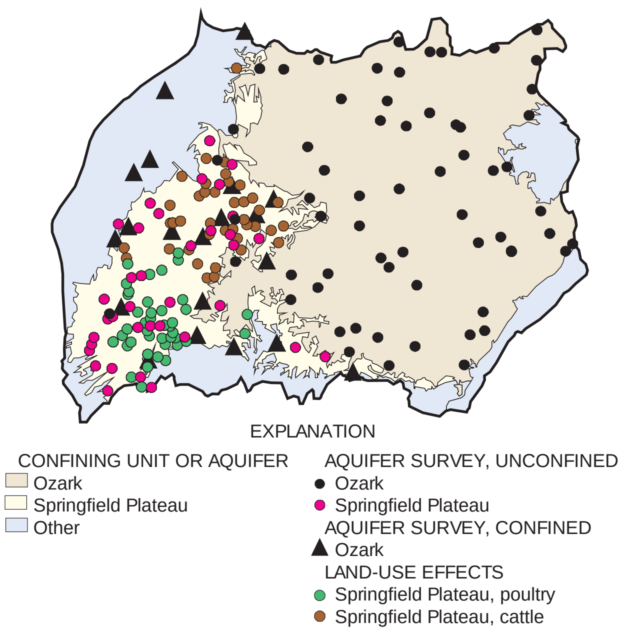
Pesticides were detected less frequently in the Springfield Plateau and Ozark aquifers than in most other drinking-water aquifers in the 20 Study Units. However, pesticides were detected more frequently in water in the Springfield Plateau aquifer (a mostly unconfined aquifer underlying areas with primarily agricultural land use). Concentrations generally were low relative to detection limits and concentrations in other Study Units and exceeded drinking-water standards or guidelines in less than 1 percent of samples.

Different study designs were used for collecting data associated with stream chemistry and ecology and ground-water chemistry. For streams, sites were selected to represent specific environmental settings (combinations of physiography, land use, and stream size). Ground-water networks and sites can be described in terms of their environmental setting (characteristics of hydrogeology and land use). Physiography, land use, stream size, and hydrogeology are all factors that should be considered because of their effects on water quality.

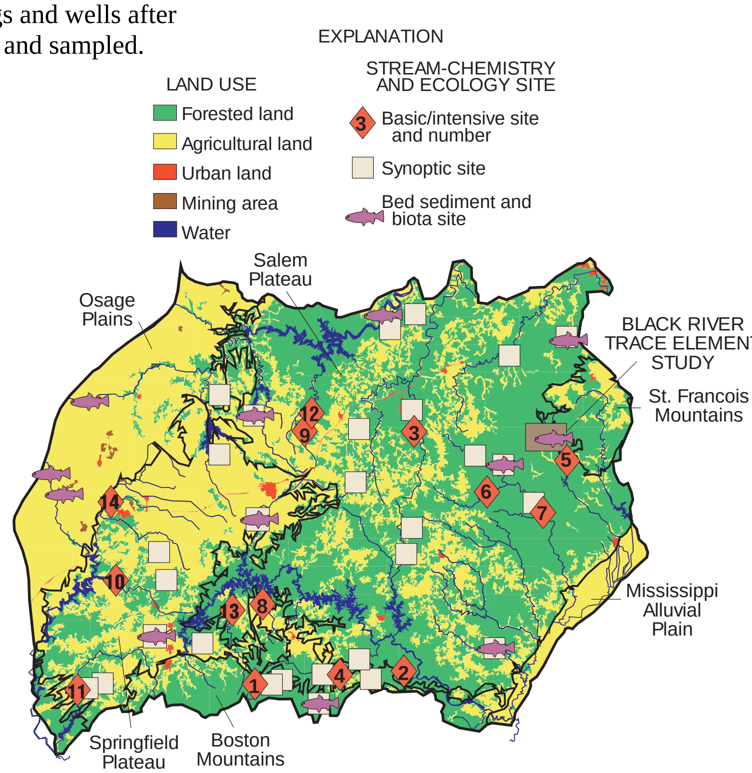
To the extent practical, stream sites represent areas of relatively homogeneous physiography and land use. Sampling sites were first classified by physiographic area, then by predominant land use and basin size.

Springs and wells in the Springfield Plateau aquifer and unconfined part of the Ozark aquifer were randomly selected for sampling as part of the unconfined aquifer survey. Several public-supply wells in the confined part of the Ozark aquifer also were selected for sampling. To aid study of the effects of land use and hydrogeology on ground-water chemistry, springs and wells were randomly selected in a poultry-production area and a cattle-production area of the Springfield Plateau. Land-use and hydrogeologic information was used to characterize springs and wells after they were selected and sampled.

An emphasis of the NAWQA design is the use of multiple lines of evidence to describe water-quality conditions (Gilliom and others, 1995). Thus, data have been collected for chemistry of streams and ground water, bed sediment, and biological tissue (tissue from clams and fish); stream ecological conditions; and environmental factors such as land-use percentages and human population. The sampling sites associated with the various study components are shown on the appropriate maps, and the designs of the individual study components are described in the table on the following page.



LOCATION OF GROUND-WATER SITES



LOCATION OF STREAM SITES

List of basic and intensive stream-chemistry and ecology sites

[Contaminants in bed sediment and aquatic biota also sampled at all of these sites]

Site number (see figure above right)	Site name	Site number (see figure above right)	Site name
1	Buffalo River near Boxley, Ark.	8	Yocum Creek near Oak Grove, Ark.
2	North Sylamore Creek near Fifty-Six, Ark.	9	Dousinbury Creek near Wall Street, Mo.
3	Paddy Creek above Slabtown Spring, Mo.	10	Elk River near Tiff City, Mo.
4	Buffalo River near St. Joe, Ark.	11	Illinois River near Tahlequah, Okla.
5	Black River near Lesterville, Mo.	12	Niangua River at Windyville, Mo.
6	Jacks Fork River at Alley Spring, Mo.	13	Kings River near Berryville, Ark.
7	Current River at Van Buren, Mo.	14	Center Creek near Smithfield, Mo.

SUMMARY OF DATA COLLECTION IN THE OZARK PLATEAUS STUDY UNIT, 1992-95

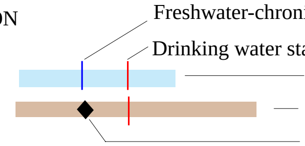
Study component	What data were collected and why	Types of sites sampled	Number of sites	Sampling frequency and period
Stream Chemistry				
Basic sites—general water chemistry	Continuous streamflow, nutrients, major ions, trace metals, bacteria, organic carbon, suspended sediment, and physical parameters to describe concentrations and seasonal variations.	Streams draining predominant land-use types across Study Unit: forested, agriculture, mining, and urban.	14	Monthly plus storms Apr. 1993-Sept. 1995 (one site activated Jan. 1995)
Intensive sites—pesticides, nutrients, bacteria	In addition to the above constituents, 82 dissolved pesticides to determine concentrations and seasonal variations.	Subset of basic sites draining agricultural land-use areas.	2	Weekly to monthly Feb. 1994-Jan. 1995
Synoptic sites—water chemistry	Streamflow, nutrients, major ions, trace metals, pesticides, bacteria, organic carbon, suspended sediment, and physical parameters during high or low flow conditions to describe concentration and spatial distribution.	Streams draining forested, agricultural, and urban land-use areas.	29	Three in 1994-95
Contaminants in bed sediments	Trace elements and hydrophobic organic compounds to determine occurrence and spatial distribution.	Depositional zones for all basic and intensive sites and many synoptic sites.	27	Once in 1992-95
Contaminants in aquatic biota	Trace elements in clams (soft tissue) and fish livers and organic compounds in clams (soft tissue) and whole fishes to determine occurrence and spatial distribution.	All basic and intensive sites and some synoptic sites. Samples were taken from fish and clam species generally common across the Study Unit.	25	Once in 1992-95
Stream Ecology				
Intensive assessments	Fish, macroinvertebrates, algae, and aquatic and riparian habitat to assess biological communities in different land uses.	Stream reaches were collocated with basic and intensive sites. Sites represent the variety of land uses within the Study Unit.	14	Once annually in 1993-95; three reaches sampled at each of three sites one year
Synoptic assessments	Similar to intensive assessments, except only one reach per site and fish were sampled at only four sites, for areal comparison of habitat and community composition.	Stream reaches were collocated with a subset of synoptic stream chemistry sites.	27	Once in 1994
Ground-Water Chemistry				
Aquifer survey—bedrock, unconfined	Nutrients, major ions, trace elements, pesticides, volatile organic compounds (wells), and radionuclides to determine overall water quality and natural chemical patterns in unconfined parts of Springfield Plateau and Ozark aquifers.	Domestic wells (49) and springs (50).	99	Once in 1993
Aquifer survey—bedrock, confined	Nutrients, major ions, trace elements, pesticides, volatile organic compounds, and radionuclides to determine overall water quality and natural chemical patterns in the confined part of the Ozark aquifer.	Public supply wells located in northwestern Arkansas, southeastern Kansas, southwestern Missouri, and northeastern Oklahoma.	20	Once in 1993-94
Land-use effects—agricultural	Nutrients, major ions, pesticides, and radionuclides to determine the effect of agricultural practices (poultry and cattle) on the quality of ground water in the Springfield Plateau aquifer.	Domestic wells (20) and springs (22) for a study that focused on land used for confined poultry; domestic wells (20) and springs (20) for a study that focused on land used for raising cattle.	82	Once in 1994-95
Special Studies				
Black River trace element study—water, bed-sediment, and tissue chemistry; stream ecology	Similar to data collected for the study components for stream chemistry: basic sites, contaminants in bed sediment, and contaminants in fish tissue; and for stream ecology: synoptic assessments. The data were collected to describe effects of lead-zinc mining on water quality, bed sediment, aquatic biota, and biological communities.	Streams, depositional zones, and stream reaches located within an area of lead-zinc mining.	10	Once in 1995
Small-basin study (not shown on map)	Nutrients, major ions, and pesticides to describe, on a local scale, occurrence and distribution in a small Springfield Plateau basin.	Domestic (18) and monitoring (11) wells, springs (4), and streams (3) within the Flint Creek Basin.	36	Once in 1995

SUMMARY OF COMPOUND DETECTIONS AND CONCENTRATIONS

The following tables summarize data collected for NAWQA studies during 1992-95 by showing results for the Ozark Plateaus 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 dataset used to construct these tables is available upon request. These tables were designed and compiled by Sarah Ryker, Jonathon Scott, and Alan Hagland, U.S. Geological Survey.

Concentrations of herbicides, insecticides, volatile organic compounds, and nutrients detected in ground and surface waters of the Ozark Plateaus 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



Freshwater-chronic criterion for the protection of aquatic life [a]

Drinking water standard or guideline [a]

Range of surface-water detections in all 20 Study Units

Range of ground-water detections in all 20 Study Units

Detection in the Ozark Plateaus Study Unit

Herbicide (Trade or common name)	Rate of detection [b]	Concentration, in µg/L (0.001, 0.01, 0.1, 1, 10, 100, 1,000)
Alachlor (Lasso)	1% 0%	
Atrazine (AAtrex, Gesaprim)	21% 3%	
Deethylatrazine[c] (Atrazine metabolite)	3% 3%	
Benfluralin (Balan, Benefin, Bonalan)	<1% <1%	
Bentazon (Basagran, bentazone)	0% 1%	
Bromacil (Hyvar X, Urox B, Bromax)	1% 0%	
Butylate (Sutan, Genate Plus, butilate)	1% 0%	
Cyanazine (Bladex, Fortrol)	1% 0%	
2,4-D (2,4-PA)	2% 0%	
DCPA (Dacthal, chlorthal-dimethyl)	<1% <1%	
Diuron (Karmex, Direx, DCMU)	0% 1%	
EPTC (Eptam)	<1% 0%	
Metolachlor (Dual, Pennant)	1% 1%	
Molinate (Ordram)	1% 0%	
Prometon (Gesagram, prometone)	6% 7%	

Herbicide (Trade or common name)	Rate of detection [b]	Concentration, in µg/L (0.001, 0.01, 0.1, 1, 10, 100, 1,000)
Propanil (Stampede, Surcopur)	<1% 1%	
Simazine (Aquazine, Princep, GEsatop)	5% 3%	
Tebuthiuron (Spike, Perflan)	8% 6%	
Terbacil[c] (Sinbar)	<1% 0%	
Thiobencarb (Bolero, Saturn, benthiocarb)	<1% 0%	
Trifluralin (Treflan, Trinin, Elancolan)	<1% <1%	

Insecticide (Trade or common name)	Rate of detection [b]	Concentration, in µg/L (0.001, 0.01, 0.1, 1, 10, 100, 1,000)
Carbaryl[c] (Sevin, Savit)	1% 1%	
Carbofuran[c] (Furadan, Curaterr)	1% 0%	
Chlorpyrifos (Dursban, Lorsban)	<1% 1%	
p,p'-DDE (*p,p'*-DDT metabolite)	<1% <1%	
Diazinon	2% 0%	
Dieldrin (Panoram D-31, Octalox)	<1% 1%	

Insecticide (Trade or common name)	Rate of detection [b]	Concentration, in µg/L (0.001, 0.01, 0.1, 1, 10, 100, 1,000)
gamma-HCH	0% 1%	
cis-Permethrin[c] (Ambush, Pounce)	<1% 0%	
Propargite (Comite, Omite, BPPS)	0% <1%	

Volatile organic compound	Rate of detection [b]	Concentration, in µg/L (0.01, 0.1, 1, 10, 100, 1,000)
1,1,2-Trichloro-1,2,2-trifluoroethane (Freon	-- 2%	
Dichloromethane (Methylene chloride)	-- 2%	
Methylbenzene (Toluene)	-- 6%	
total Trihalomethanes	-- 13%	

Volatile organic compound	Rate of detection [b]	Concentration, in µg/L (0.01, 0.1, 1, 10, 100, 1,000, 10,000, 100,000)
Tetrachloroethene (Perchloroethene)	-- 2%	

Nutrient	Rate of detection [b]	Concentration, in mg/L (0.01, 0.1, 1, 10, 100, 1,000, 10,000, 100,000)
Dissolved ammonia as nitrogen	67% 79%	
Dissolved ammonia plus organic nitrogen as nitrogen	12% 3%	
Dissolved phosphorus as phosphorus	51% 44%	
Dissolved nitrite plus nitrate as nitrogen	81% 86%	

Other	Rate of detection [b]	Concentration, in pCi/L (1, 10, 100, 1,000, 10,000, 100,000)
Radon 222	100%	

Herbicides, insecticides, volatile organic compounds, and nutrients not detected in ground and surface waters of the Ozark Plateaus Study Unit.

Herbicides

2,4,5-T

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

2,4-DB (Butyrac, Butoxone, Embutox Plus, Embutone)

2,6-Diethylaniline (Metabolite of Alachlor)

Acetochlor (Harness Plus, Surpass)

Acifluorfen (Blazer, Tackle 2S)

Bromoxynil (Buctril, Brominal)

Chloramben (Amiben, Amilon-WP, Vegiben)

Clopyralid (Stinger, Lontrel, Reclaim, Transline)

Dacthal mono-acid (Dacthal metabolite)

Dicamba (Banvel, Dianat, Scotts Proturf)

Dichlorprop (2,4-DP, Seritox 50, Kildip, Lentemul)

Dinoseb (Dinosebe)

Ethalfluralin (Sonalan, Curbit)

Fenuron (Fenulon, Fenidim)

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

Linuron (Lorox, Linex, Sarclex, Linurex, Afalon)

MCPA (Rhomene, Rhonox, Chiptox)

MCPB (Thistrol)

Metribuzin (Lexone, Sencor)

Napropamide (Devrinol)

Neburon (Neburea, Neburyl, Noruben)

Norflurazon (Evital, Predict, Solicam, Zorial)

Oryzalin (Surflan, Dirimal)

Pebulate (Tillam, PEBC)

Pendimethalin (Pre-M, Prowl, Weedgrass Control, Stomp, Herbadox)

Picloram (Grazon, Tordon)

Pronamide (Kerb, Propyzamid)

Propachlor (Ramrod, Satecid)

Propham (Tuberite)

Triallate (Far-Go, Avadex BW, Tri-allate)

Triclopyr (Garlon, Grandstand, Redeem, Remedy)

Insecticides

3-Hydroxycarbofuran (Carbofuran metabolite)

Aldicarb sulfone (Standak, aldoxycarb, aldicarb metabolite)

Aldicarb sulfoxide (Aldicarb metabolite)

Aldicarb (Temik, Ambush, Pounce)

Azinphos-methyl (Guthion, Gusathion M)

Disulfoton (Disyston, Di-Syston, Frumin AL, Solvirex, Ethylthiodemeton)

Ethoprop (Mocap, Ethoprophos)

Fonofos (Dyfonate, Capfos, Cudgel, Tycap)

Malathion (Malathion)

Methiocarb (Slug-Geta, Grandslam, Mesurol)

Methomyl (Lanox, Lannate, Acinate)

Methyl parathion (Penncap-M, Folidol-M, Metacide, Bladan M)

Oxamyl (Vydate L, Pratt)

Parathion (Roethyl-P, Alkron, Panthion, Phoskil)

Phorate (Thimet, Granutox, Geomet, Rampart)

Propoxur (Baygon, Blattanex, Unden, Proprotox)

Terbufos (Contraven, Counter, Pilarfox)

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

Volatile organic compounds

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

1,1,1-Trichloroethane (Methylchloroform)

1,1,2,2-Tetrachloroethane

1,1,2-Trichloroethane (Vinyl trichloride)

1,1-Dichloroethane (Ethylidene dichloride)

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-Dichloroethane (Ethylene dichloride)

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)

Chloroethane (Ethyl chloride)

Chloroethene (Vinyl chloride)

Chloromethane (Methyl chloride)

Dibromomethane (Methylene dibromide)

Dichlorodifluoromethane (CFC 12, Freon 12)

Dimethylbenzenes (Xylenes (total))

Ethenylbenzene (Styrene)

Ethylbenzene (Phenylethane)

Hexachlorobutadiene

Isopropylbenzene (Cumene)

Methyl *tert*-butyl ether[d] (MTBE)

Naphthalene

Tetrachloromethane (Carbon tetrachloride)

Trichloroethene (TCE)

Trichlorofluoromethane (CFC 11, Freon 11)

cis-1,2-Dichloroethene ((Z)-1,2-Dichloroethene)

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

n-Butylbenzene (1-Phenylbutane)

n-Propylbenzene (Isocumene)

p-Isopropyltoluene (*p*-Cymene)

sec-Butylbenzene

tert-Butylbenzene

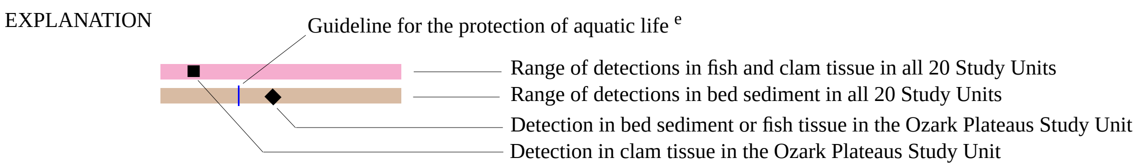
trans-1,2-Dichloroethene ((E)-1,2-Dichlorothene)

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

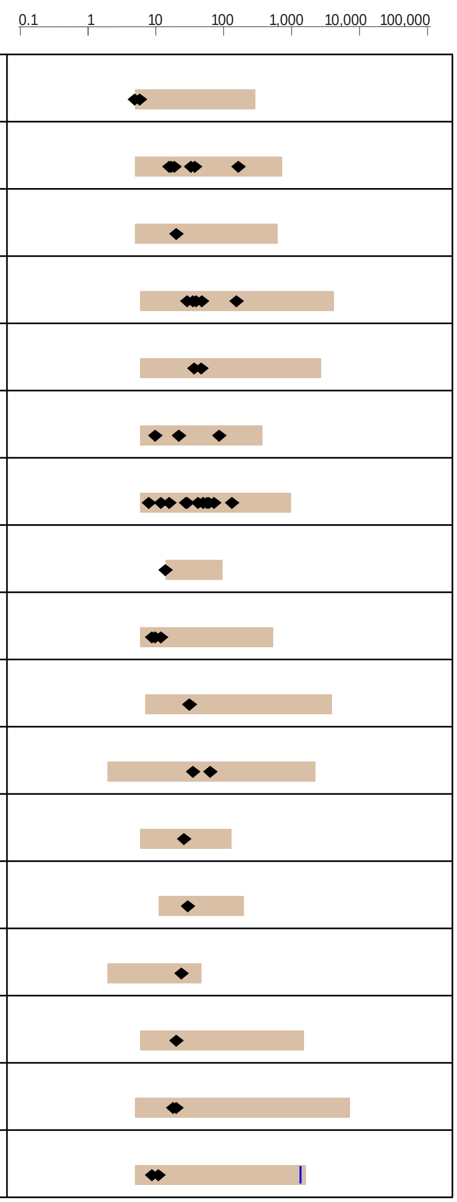
Nutrients

No non-detects

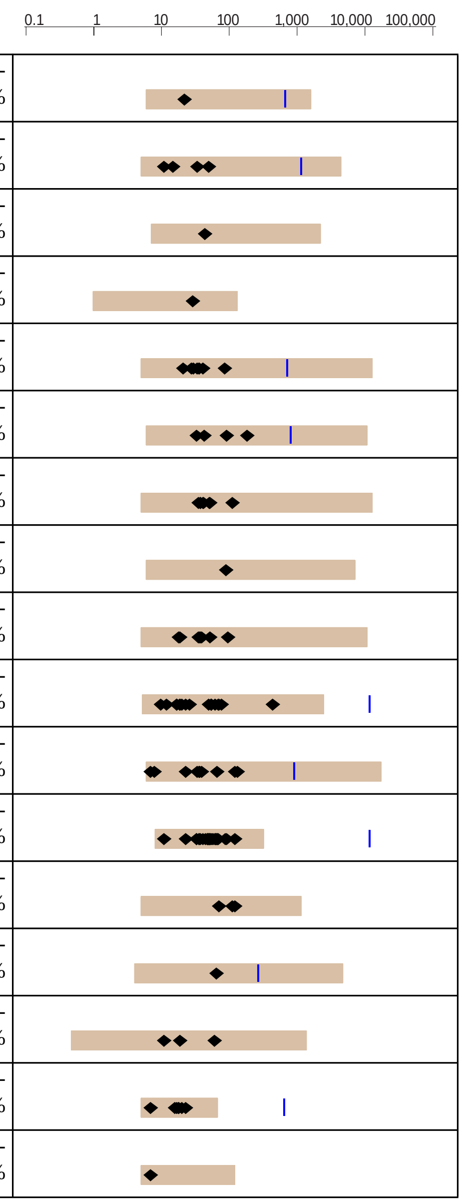
Concentrations of semivolatile organic compounds, organochlorine compounds, and trace elements detected in fish and clam tissue and bed sediment of the Ozark Plateaus Study Unit. [µg/g, micrograms per gram; µg/kg, micrograms per kilogram; %, percent; <, less than; --, not measured; trade names may vary]



Semivolatile organic compound	Rate of detection [b]	Concentration, in µg/kg
1,2-Dimethylnaphthalene	-- 7%	
1,6-Dimethylnaphthalene	-- 21%	
1-Methyl-9H-fluorene	-- 3%	
1-Methylphenanthrene	-- 17%	
1-Methylpyrene	-- 7%	
2,3,6-Trimethylnaphthalene	-- 14%	
2,6-Dimethylnaphthalene	-- 41%	
2,6-Dinitrotoluene	-- 3%	
2-Ethylnaphthalene	-- 10%	
2-Methylanthracene	-- 7%	
4,5-Methylenephenanthrene	-- 7%	
4-Bromophenyl-phenylether	-- 3%	
4-Chloro-3-methylphenol	-- 3%	
4-Chlorophenyl-phenylether	-- 3%	
9H-Carbazole	-- 3%	
9H-Fluorene	-- 7%	
Acenaphthene	-- 7%	



Semivolatile organic compound	Rate of detection [b]	Concentration, in µg/kg
Acenaphthylene	-- 3%	
Anthracene	-- 14%	
Anthraquinone	-- 3%	
Azobenzene	-- 3%	
Benz[*a*]anthracene	-- 28%	
Benzo[*a*]pyrene	-- 14%	
Benzo[*b*]fluoranthene	-- 28%	
Benzo[*ghi*]perylene	-- 3%	
Benzo[*k*]fluoranthene	-- 28%	
Butylbenzylphthalate	-- 62%	
Chrysene	-- 34%	
Di- *n* -butylphthalate	-- 100%	
Di- *n* -octylphthalate	-- 10%	
Dibenz[*a,h*]anthracene	-- 3%	
Dibenzothiophene	-- 10%	
Diethylphthalate	-- 24%	
Dimethylphthalate	-- 3%	



Semivolatile organic compound	Rate of detection [b]	Concentration, in µg/kg (0.1, 1, 10, 100, 1,000, 10,000, 100,000)
Fluoranthene	-- 41%	
Indeno[1,2,3- *cd*] pyrene	-- 14%	
N-Nitrosodi-phenylamine	-- 7%	
Nitrobenzene	-- 3%	
Phenanthrene	-- 31%	
Phenol	-- 72%	
Pyrene	-- 41%	
bis(2-Ethyl-hexyl)phthalate	-- 97%	
p-Cresol	-- 52%	

Trace element	Rate of detection [b]	Concentration, in µg/g (0.01, 0.1, 1, 10, 100, 1,000, 10,000)
Arsenic	93% 100%	
Cadmium	97% 100%	
Chromium	90% 100%	
Copper	100% 100%	
Lead	30% 100%	
Mercury	60% 79%	
Nickel	83% 100%	
Selenium	87% 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	3% 3%	
p,p'-DDE	6% 0%	
total-DDT	10% 0%	
Dieldrin (Panoram D-31, Octalox)	3% 0%	

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

Semivolatile organic compounds

1,2,4-Trichlorobenzene

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

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

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

2,2-Biquinoline

2,4-Dinitrotoluene

2-Chloronaphthalene

2-Chlorophenol

3,5-Dimethylphenol

Acridine

Benzo [*c*] cinnoline

C8-Alkylphenol

Isophorone

Isoquinoline

N-Nitrosodi-*n*-propylamine

Naphthalene

Pentachloronitrobenzene

Phenanthridine

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 epoxide (Heptachlor metabolite)

Heptachlor (Heptachlore, Velsicol 104)

Hexachlorobenzene (HCB)

Isodrin (Isodrine, Compound 711)

Mirex (Dechlorane)

PCB, total

Pentachloroanisole (PCA, pentachlorophenol metabolite)

Toxaphene (Camphechlor, Hercules 3956)

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

beta-HCH (*beta*-BHC, *beta*-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

[a] Selected water-quality standards and guidelines (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 1 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 (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.

Algae - Chlorophyll-bearing nonvascular, primarily aquatic species that have no true roots, stems, or leaves; most algae are microscopic, but some species can be as large as vascular plants.

Anomalies - As related to fish, externally visible skin or subcutaneous disorders, including deformities, eroded fins, lesions, and tumors.

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.

Benthic invertebrates - Insects, mollusks, crustaceans, worms, and other organisms without a backbone that live in, on, or near the bottom of lakes, streams, or oceans.

Biomass - The amount of living matter, in the form of organisms, present in a particular habitat, usually expressed as weight per unit area.

Blue-baby syndrome - A condition that can be caused by ingestion of high amounts of nitrate resulting in the blood losing its ability to effectively carry oxygen. It is most common in young infants and certain elderly people.

Breakdown product - A compound derived by chemical, biological, or physical action upon a pesticide. The breakdown is a natural process which may result in a more toxic or a less toxic compound and a more persistent or less persistent compound.

Canopy angle - Generally, a measure of the openness of a stream to sunlight. Specifically, the angle formed by an imaginary line from the highest structure (for example, tree, shrub, or bluff) on one bank to eye level at midchannel to the highest structure on the other bank.

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.

Criterion - A standard rule or test on which a judgment or decision can be based.

Detection limit - The concentration below which a particular analytical method cannot determine, with a high degree of certainty, a concentration.

Dissolved solids - Amount of minerals, such as salt, that are dissolved in water; amount of dissolved solids is an indicator of salinity 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.

Fecal bacteria - Microscopic single-celled organisms (primarily fecal coliforms and fecal streptococci) found in the wastes of warm-blooded animals. Their presence in water is used to assess the sanitary quality of water for body-contact recreation or for consumption. Their presence indicates contamination by the wastes of warm-blooded animals and the possible presence of pathogenic (disease producing) organisms.

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

Human health advisory - Guidance provided by U.S. Environmental Protection Agency, State agencies or scientific organizations, in the absence of regulatory limits, to describe acceptable contaminant levels in drinking water or edible fish.

Karst - A type of topography that results from dissolution and collapse of carbonate rocks such as limestone and dolomite, and characterized by closed depressions or sinkholes, caves, and underground drainage.

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.

Mean - The average of a set of observations, unless otherwise specified.

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.

Method detection limit - The minimum concentration of a substance that can be accurately identified and measured with present laboratory technologies.

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 streamwater and ground water. One thousand micrograms per liter equals 1 mg/L.

National Academy of Sciences/National Academy of Engineering (NAS/NAE) recommended maximum concentration in water - Numerical guidelines recommended by two joint NAS/NAE committees for the protection of freshwater and marine aquatic life, respectively. These guidelines were based on available aquatic toxicity studies, and were considered preliminary even at the time (1972). The guidelines used in this report are for freshwater.

Nonpoint source - A contamination source that cannot be defined as originating from discrete points such as pipe discharge. Areas of fertilizer and pesticide applications, atmospheric deposition, manure, and natural inputs from plants and trees are types of nonpoint-source contamination.

Physiography - A description of the surface features of the Earth, with an emphasis on the origin of landforms.

Picocurie (pCi) - One trillionth (10^{-12}) of the amount of radioactivity represented by a curie (Ci). A curie is the amount of radioactivity that yields 3.7 x 10^{10} radioactive disintegrations per second (dps). A picocurie yields 2.22 disintegrations per minute (dpm) or 0.037 dps.

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.

Polycyclic aromatic hydrocarbon (PAH) - A class of organic compounds with a fused-ring aromatic structure. PAHs result from incomplete combustion of organic carbon (including wood), municipal solid waste, and fossil fuels, as well as from natural or anthropogenic introduction of uncombusted coal and oil. PAHs include benzo(a)pyrene, fluoranthene, and pyrene.

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

Relative abundance - The number of organisms of a particular kind present in a sample relative to the total number of organisms in the sample.

Riparian zone - Pertaining to or located on the bank of a body of water, especially a stream.

Sediment - Particles, derived from rocks or biological materials, that have been transported by a fluid or other natural process, and are suspended or settled in water.

Semivolatile organic compound (SVOC) - 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).

Sideslope gradient - The representative change in elevation in a given horizontal distance (usually about 300 yards) perpendicular to a stream; the valley slope along a line perpendicular to the stream (near the water-quality or biological sampling point).

Sinuosity - The ratio of the channel length between two points on a channel to the straight-line distance between the same two points; a measure of meandering.

Stream order - A ranking of the relative sizes of streams within a watershed based on the nature of their tributaries. The smallest unbranched tributary is called first order, the stream receiving the tributary is called second order, and so on.

Substrate size - The diameter of streambed particles such as clay, silt, sand, gravel, cobble, and boulders.

Tolerant species - Those species that are adaptable to (tolerant of) human alterations to the environment and often increase in number when human alterations occur.

Trace element - An element found in only minor amounts (concentrations less than 1.0 milligram per liter) in water or sediment; includes arsenic, cadmium, chromium, copper, lead, mercury, nickel, and zinc.

Unconfined aquifer - An aquifer whose upper surface is a water table; an aquifer containing unconfined ground water.

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.

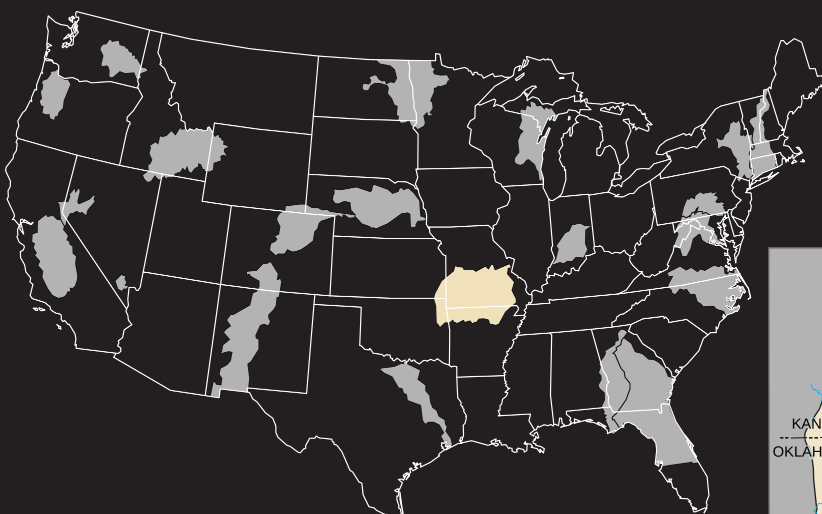
Water-quality criteria - Specific levels of water quality which, if reached, are expected to render a body of water unsuitable for its designated use. Commonly refers to water-quality criteria established by the U.S. Environmental Protection Agency. Water-quality criteria are based on specific levels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

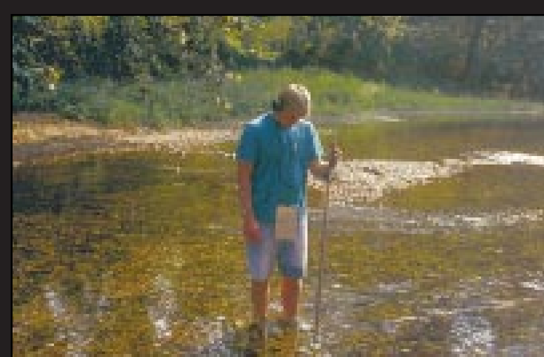
Water-quality guidelines - Specific levels of water quality which, if reached, may adversely affect human health or aquatic life. These are nonenforceable guidelines issued by a governmental agency or other institution.

Water-quality standards - State-adopted and U.S. Environmental Protection Agency-approved ambient standards for water bodies. Standards include the use of the water body and the water-quality criteria that must be met to protect the designated use or uses.

NAWQA

National Water-Quality Assessment (NAWQA) Program
Ozark Plateaus





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