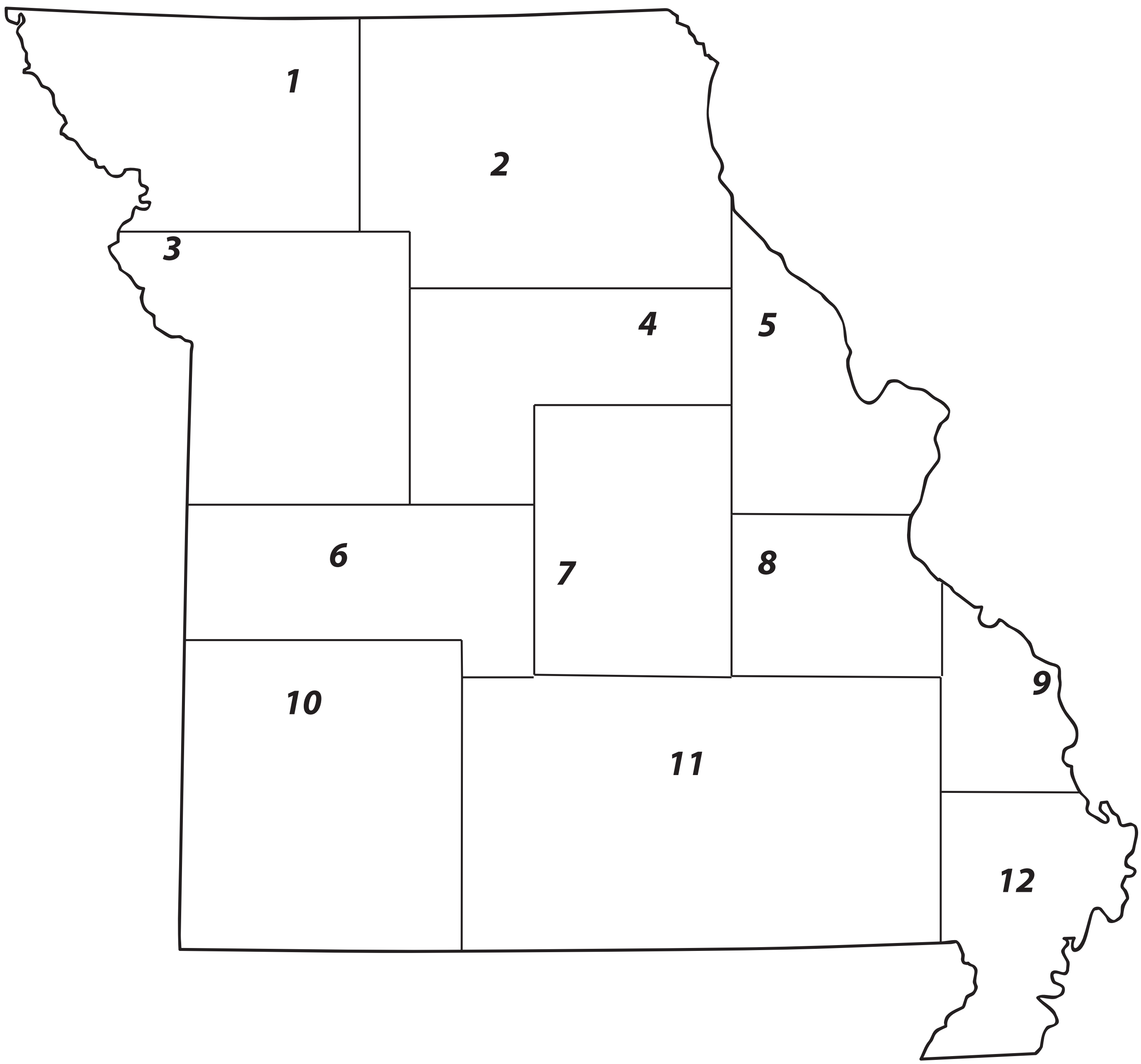
Prepared in cooperation with the Missouri Department of Natural Resources

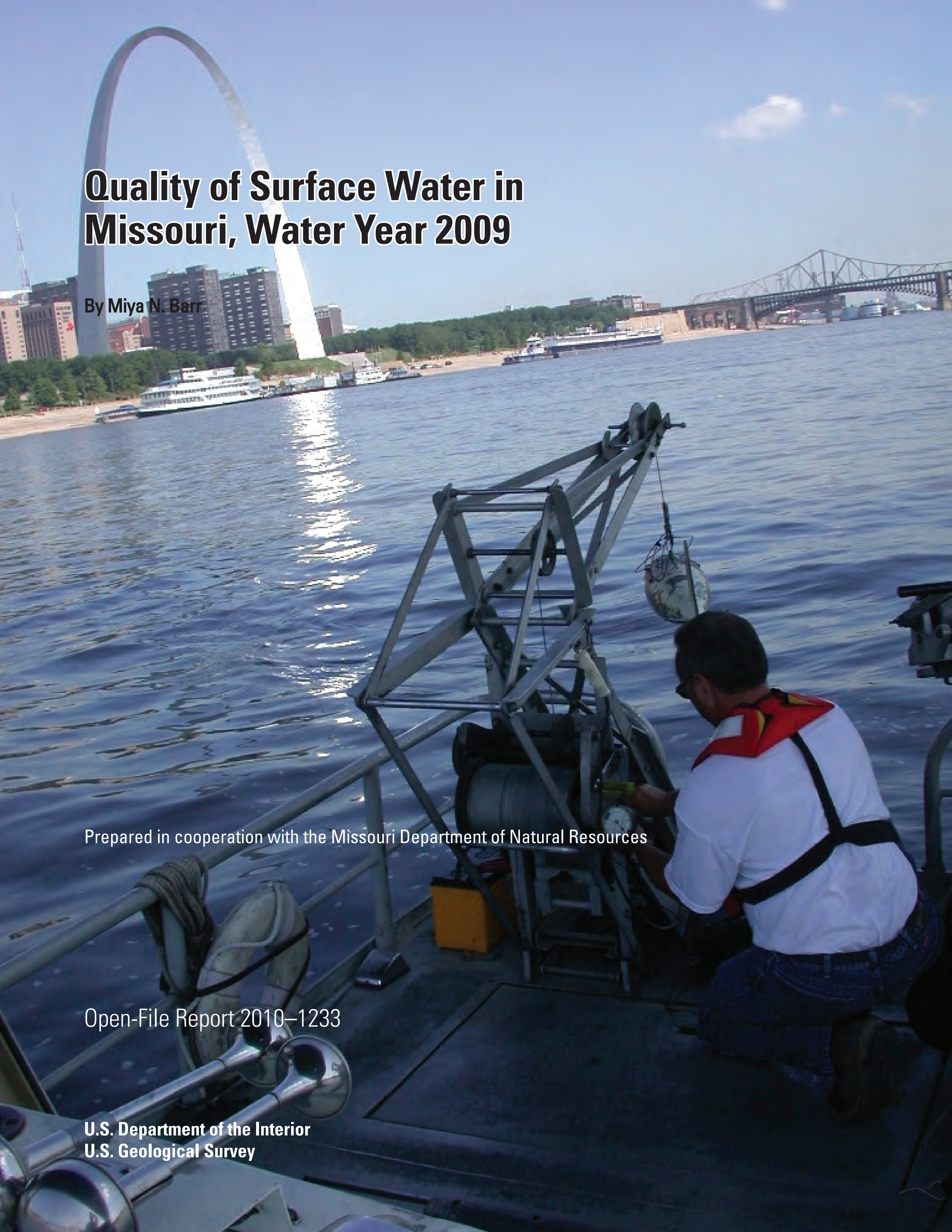
Quality of Surface Water in Missouri, Water Year 2009

Open-File Report 2010–1233

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



Cover photos. U.S. Geological Survey personnel: 1, operating a motorized boat to a site location. 2, measuring streamflow with ADCP. 3, processing fecal indicator bacteria samples. 4, measuring physical properties at site. 5, collecting streambed sediments. 6, analyzing alkalinity of a surface water-quality sample. 7, collecting a surface water-quality sample using EWI-methods. 8. boat with a sampling crane used to collect surface water-quality samples on large rivers. 9, recording field conditions at site. 10, sampling crane on boat near St. Louis, Missouri. 11, removing sample from D-96 on boat deck. 12, measuring streamflow with StreamPro.



Quality of Surface Water in Missouri, Water Year 2009

By Miya N. Barr

Prepared in cooperation with the Missouri Department of Natural Resources

Open-File Report 2010–1233

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

U.S. Department of the Interior
KEN SALAZAR, Secretary

U.S. Geological Survey
Marcia K. McNutt, Director

U.S. Geological Survey, Reston, Virginia: 2010

For more information on the USGS—the Federal source for science about the Earth, its natural and living resources, natural hazards, and the environment, visit http://www.usgs.gov or call 1-888-ASK-USGS

For an overview of USGS information products, including maps, imagery, and publications, visit http://www.usgs.gov/pubprod

To order this and other USGS information products, visit http://store.usgs.gov

Any use of trade, product, or firm names is for descriptive purposes only and does not imply endorsement by the U.S. Government.

Although this report is in the public domain, permission must be secured from the individual copyright owners to reproduce any copyrighted materials contained within this report.

Suggested citation:
Barr M.N., 2010, Quality of surface water in Missouri, water year 2009: U.S. Geological Survey Open-File Report 2010–1233 22 p.

Contents

Figures

Tables

Conversion Factors and Datum

Multiply	By	To obtain
	Length	
inch (in.)	2.54	centimeter (cm)
mile (mi)	1.609	kilometer (km)
	Area	
square mile (mi^2)	2.590	square kilometer (km^2)
	Flow rate	
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)

Temperature in degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) as follows:

$$°F=(1.8\times°C)+32$$

Horizontal coordinate information is referenced to the North American Datum of 1983 (NAD 83).

Specific conductance is given in microsiemens per centimeter at 25 degrees Celsius (µS/cm at 25 °C).

Concentrations of chemical constituents in water are given either in milligrams per liter (mg/L) or micrograms per liter (µg/L).

Quality of Surface Water in Missouri, Water Year 2009

By Miya N. Barr

Abstract

The U.S. Geological Survey, in cooperation with the Missouri Department of Natural Resources, designs and operates a series of monitoring stations on streams throughout Missouri known as the Ambient Water-Quality Monitoring Network. During the 2009 water year (October 1, 2008, through September 30, 2009), data were collected at 75 stations—69 Ambient Water-Quality Monitoring Network stations, 2 U.S. Geological Survey National Stream Quality Accounting Network stations, 1 spring sampled in cooperation with the U.S. Forest Service, and 3 stations sampled in cooperation with the Elk River Watershed Improvement Association. Dissolved oxygen, specific conductance, water temperature, suspended solids, suspended sediment, fecal coliform bacteria, *Escherichia coli* bacteria, dissolved nitrate plus nitrite, total phosphorus, dissolved and total recoverable lead and zinc, and select pesticide compound summaries are presented for 72 of these stations. The stations primarily have been classified into groups corresponding to the physiography of the State, primary land use, or unique station types. In addition, a summary of hydrologic conditions in the State including peak discharges, monthly mean discharges, and seven-day low flow is presented.

Introduction

The U.S. Geological Survey (USGS), in cooperation with the Missouri Department of Natural Resources (MDNR), collects data pertaining to Missouri's water resources each water year (October 1 through September 30). These data, stored and maintained in the USGS National Water Information System (NWIS) database, are collected as part of the Missouri Ambient Water-Quality Monitoring Network (AWQMN) and constitute a source of reliable, impartial, and timely information for developing an enhanced understanding of the State's water resources. To make this information readily available, these data were published annually from water years 1964 through 2005 (U.S. Geological Survey, 1964–2005). Published data for the 2006 through 2009 water years can be accessed at *http://wdr.water.usgs.gov*.

The MDNR is responsible for the implementation of the Federal Clean Water Act (CWA) in Missouri. Section 305(b) of the CWA requires that each State develop a water-quality monitoring program and periodically report the status of its water quality (U.S. Environmental Protection Agency, 1997). Water-quality status is described in terms of the suitability of the water for various uses, such as drinking, fishing, swimming, and support of aquatic life; these uses are formally defined as "designated uses" in State and Federal Regulations. Section 303(d) of the CWA requires that certain waters that do not meet applicable water-quality standards be identified, and total maximum daily loads (TMDLs) be determined for these waters (U.S. Environmental Protection Agency, 1997). TMDLs establish the maximum amount of an impairing substance that a waterbody can assimilate and still meet the water-quality standards. A TDML addresses a single pollutant for each waterbody.

Missouri has an area of approximately 69,000 square miles (mi^2) and an estimated population of 6 million people (U.S. Census Bureau, 2010). Within Missouri there are 22,370 miles (mi) of classified streams that support a variety of uses including wildlife, recreation, agriculture, industry, transportation, and public utilities. An estimated 10,454 mi of streams are adversely affected (impaired) by various physical changes or chemical contaminants to the point that criteria for at least one of the designated uses no longer can be met (Missouri Department of Natural Resources, 2009a). Of the impaired streams, about 2,048 mi have been sampled, and the impairments are documented by data that meet Missouri's 303(d) Listing Methodology. There also are about 8,406 mi of nonclassified streams for which some data have been collected but not enough to officially rate the stream as impaired. Many of the nonclassified streams have been affected or modified by agriculture (Missouri Department of Natural Resources, 2009a).

The purpose of this report is to summarize surface-water quality data collected by the USGS in cooperation with the MDNR and other Federal and local entities for water year 2009. The annual summary of select constituents provides

MDNR with current information to assess the quality of surface water within the State and to ensure that the objectives of the AWQMN are being met. This report is one in a series of annual summaries (Otero-Benítez and Davis, 2009a, 2009b). Data on the physical characteristics and water-quality constituents in samples collected at 72 surface-water stations are presented in figures and tables. These 72 stations primarily were classified into groups corresponding to the physiography of the State, primary land use, or unique station types.

The Ambient Water-Quality Monitoring Network

The USGS, in cooperation with the MDNR, designed and operates the cooperative AWQMN, which is a series of monitoring stations on streams and springs throughout Missouri. Constituent concentration data from the AWQMN have been used to determine statewide water-quality status and long-term trends (Barr and Davis, 2010) in order to meet information needs of State agencies involved in water-quality planning and management. The data collected also provide support for the design, implementation, and evaluation of preventive and remediation programs.

The objectives of the AWQMN are (1) to obtain data on the quality and quantity of surface water within the State; (2) provide a historical database of water-quality information that can be used by the State planning and management agencies to make informed decisions about anthropogenic effects (agriculture, mining, urban) on the State's surface waters; and (3) provide for consistent methodology in data collection, laboratory analysis, and data reporting.

The MDNR and the USGS established a fixed-station AWQMN in 1964 with 18 stations, 5 of which are still currently (2010) being sampled. During the 2009 water year, the program consisted of 69 stations. In addition to the AWQMN stations, water samples are collected by the USGS at two USGS National Stream Quality Accounting Network (NASQAN; a national water-quality sampling network operated by the USGS) stations, one spring sampled in cooperation with the U.S. Forest Service, and three stations sampled in cooperation with the Elk River Watershed Improvement Association (ERWIA). From these 75 stations, 72 are included in this report. Three stations from the AWQMN did not fit in the groups (classes) defined for this report and were not included. The three excluded stations were Cuivre River near Troy (05514500) and Lamine River near Pilot Grove (06907300) both located in the Ozark Plateaus border, and Lake Taneycomo at Branson (07053700). Sampling frequency (table 1) is determined by a number of factors, including drainage basin size, potential effects from agricultural activity, history of chemical change, need for short-term data, and cost. Each of the streams in the AWQMN is classified for one or more designated uses. For specific information on the designated uses applicable to the stations in the AWQMN, refer to Missouri Department of Natural Resources (2009b).

The unique eight-digit number used by the USGS to identify each surface-water station is assigned when a station is first established. The complete eight-digit number for each station includes a two-digit prefix that designates the major river system (05 is the Upper Mississippi River, 06 is the Missouri River, and 07 is the Lower Mississippi River) plus a six-digit downstream-order number. For example, the station number 05587455 indicates the station is located on the Upper Mississippi River ("05") while the remaining six digits ("587455") locate the station in downstream order. In this system, the station numbers increase downstream along the mainstem. A station on a tributary that enters between two mainstem stations is assigned a station number between them.

Methods used for collecting and processing representative water-quality samples are presented in detail in the USGS National Field Manual for the Collection of Water-Quality Data (U.S. Geological Survey, variously dated). Onsite measurements of dissolved oxygen (DO), specific conductance, and water temperature were taken at each station according to procedures described in Wilde (chapter sections variously dated). Samples were collected and analyzed for indicator bacteria [*Escherichia coli (E. coli)* and fecal coliform] using the membrane filtration procedure described in Myers and others (2007). Methods used by the USGS for collecting and processing representative samples for nutrients, major chemical constituents, trace elements, suspended solids, suspended sediment, and pesticide analysis are presented in detail in U.S. Geological Survey (2006), Guy (1969), and Wilde and others (2004). All chemical analyses were done by the USGS National Water Quality Laboratory (NWQL) in Lakewood, Colorado, according to procedures described in Fishman and Friedman (1989), Fishman (1993), and Zaugg and others (1995).

Laboratory Reporting Conventions

The NWQL uses method reporting conventions (Childress and others, 1999) for establishing the minimum concentration above which a quantitative measurement can be made. These reporting conventions are the method reporting level (MRL) and the laboratory reporting level (LRL). The MRL is defined by the NWQL as the smallest measured concentration of a substance that can be measured reliably using a given analytical method. The method detection level (MDL) is the minimum concentration of a substance that can be measured and reported with 99 percent confidence that the concentration is greater than zero. A long-term method detection limit (LT-MDL) is a detection level obtained by determining the standard deviation of 20 or more MDL spiked-sample measurements conducted over an extended period of time. The LRL is computed as twice the LT-MDL.

Table 1. U.S. Geological Survey station number, name, drainage area, and sampling frequency of 72 selected stations, water year 2009.

[mi^2, square mile; --, not applicable]

U.S. Geological Survey station number	Station name	Drainage area (mi^2)	Water year 2009 sampling frequency
05495000	Fox River at Wayland	400	6
05496000	Wyaconda River above Canton	393	6
05497150	North Fabius River near Ewing	471	6
05500000	South Fabius River near Taylor	620	12
05587455	Mississippi River below Grafton, Illinois	171,300	12
06817700	Nodaway River near Graham	1,380	6
06818000[a]	Missouri River at St. Joseph	420,100	12
06821190	Platte River at Sharps Station	2,380	6
06894100	Missouri River at Sibley	426,500	12
06896187	Middle Fork Grand River near Grant City	82.4	6
06898100	Thompson River near Mt. Moriah	891	6
06898800	Weldon River at Princeton	452	6
06899580	No Creek near Dunlap	34	12
06899950	Medicine Creek at Harris	192	12
06900100	Little Medicine Creek near Harris	66.5	12
06900900	Locust Creek near Unionville	77.5	12
06902000	Grand River near Sumner	6,880	12
06905500	Chariton River near Prairie Hill	1,870	6
06905725	Mussel Fork near Mystic	24	12
06906300	East Fork Little Chariton River near Huntsville	220	6
06917630	East Fork Dry Wood Creek at Prairie State Park	3.38	4
06918070	Osage River above Schell City	5,410	6
06918600	Little Sac River near Walnut Grove	119	12
06919500	Cedar Creek near Pleasant View	420	12
06921070	Pomme de Terre River near Polk	276	9
06921590	South Grand River at Archie	150	6
06921720	Big Creek near Blairstown	414	7
06923700	Niangua River below Bennett Spring	441	6
06926510	Osage River below St. Thomas	14,580	6
06927850	Osage Fork of Gasconade River near Lebanon	43.6	6
06928440	Roubidoux Spring at Waynesville	--	6
06930450	Big Piney River at Devil's Elbow	746	9
06930800	Gasconade River above Jerome	2,570	12
06934500[a,b]	Missouri River at Hermann	522,500	13
07014000	Huzzah Creek near Steelville	259	6
07014200	Courtois Creek at Berryman	173	6
07014500	Meramec River near Sullivan	1,475	12
07016400	Bourbeuse River above Union	808	9
07018100	Big River near Richwoods	735	9

Table 1. U.S. Geological Survey (USGS) station number, name, drainage area, and sampling frequency of 72 selected stations, water year 2009.—Continued

[mi^2, square mile; --, not applicable]

U.S. Geological Survey station number	Station name	Drainage area (mi^2)	Water year 2009 sampling frequency
07019280	Meramec River at Paulina Hills	3,920	12
07020550	South Fork Saline Creek near Perryville	55.3	6
07021000	Castor River at Zalma	423	6
07022000[b]	Mississippi River at Thebes, Illinois	713,200	13
07036100	St. Francis River near Saco	664	9
07037300	Big Creek at Sam A. Baker State Park	189	6
07042450	St. Johns Ditch near Henderson Mound	313	9
07046250	Little River Ditches near Rives	1,620	12
07050150	Roaring River Spring near Cassville	--	6
07052152	Wilson Creek near Brookline	51	12
07052250	James River near Boaz	462	6
07052345	Finley Creek below Riverdale	261	12
07052500	James River at Galena	987	12
07052820	Flat Creek below Jenkins	274	12
07053900	Swan Creek near Swan	148	8
07057500	North Fork River near Tecumseh	561	6
07057750	Bryant Creek below Evans	214	6
07061600	Black River below Annapolis	493	6
07066110	Jacks Fork above Two Rivers	425	6
07067500	Big Spring near Van Buren	--	4
07068000	Current River at Doniphan	2,040	12
07068510	Little Black River below Fairdealing	194	6
07071000[b]	Greer Spring at Greer	--	4
07071500	Eleven Point River near Bardley	793	6
07185764	Spring River above Carthage	425	12
07186480	Center Creek near Smithfield	303	9
07186600	Turkey Creek near Joplin	41.8	9
07187000	Shoal Creek above Joplin	427	12
07188653[b]	Big Sugar Creek near Powell	141	12
07188838[b]	Little Sugar Creek near Pineville	195	12
07188885[b]	Indian Creek near Lanagan	239	12
07189000[c]	Elk River near Tiff City	872	12
07189100	Buffalo Creek at Tiff City	60.8	12

[a]Additional water temperature and suspended-sediment samples were collected in cooperation with the U.S. Army Corps of Engineers.

[b]Stations 06934500, 07022000, 07071000, 07188653, 07188838, and 07188885 are not part of the Ambient Water- Quality Monitoring Network but were used in the report. Stations 06934500 and 07022000 are funded by the U.S. Geological Survey National Stream Quality Account Network; 07071000 is funded by the U.S. Forest Service; 07188653, 07188838, and 07188885 are funded by the Elk River Watershed Improvement Association.

[c]Addional sampling was conducted during the 2009 water year as part of a U.S. Geological Survey National Water-Quality Assessment study.

Data Analysis Methods

The distribution of select constituent data was graphically displayed using side-by-side boxplots (box and whiskers distributions; Helsel and Hirsch, 2002, p. 24–26). The plots show the center of the data (median, the center line of the boxplot), the variation [interquartile range (25^{th} to 75^{th} percentiles) or the height of the box], the skewness (quartile skew, which is the relative size of the box halves), the spread (upper and lower adjacent values are the vertical lines or whiskers), and the presence or absence of unusual values, or outliers (upper and lower detached and outside values). If the median equals the 25^{th} and 75^{th} percentiles, the boxplot is represented by a single horizontal line. Censored data defined as concentration values reported less than the MRL, less than the LRL, or as "E" (estimated to be below the MRL or LRL) were included in each distribution as a concentration value equal to the MRL or LRL, depending on the constituent reporting convention. Boxplots with censored data were modified by making the lower limit of the box equal to the MRL or LRL.

Station Classification for Data Analysis

The stations primarily were classified in groups corresponding to the physiography of the State (fig. 1), primary land use (fig. 2), or unique station types (fig. 1; table 2). The physiography-based groups include the Dissected Till Plains (DTPL) in the north, the Osage Plains (OSPL) in the west, the Mississippi Alluvial Plain (MIALPL) in the southeast, and between them the Ozark Plateaus. The Ozark Plateaus (Fenneman, 1938) were further subdivided into two distinct sections based on physiographic location—the Salem Plateau Section (OZPLSA) and the Springfield Plateau Section (OZPLSP). Land-use groups include mining (MINING) and urban (URBAN) stations, whereas unique station classes refer to springs (SPRING) and the stations located on the big rivers [the Mississippi River (BRMIG and BRMIT) and the Missouri River (BRMOSJ, BRMOS and BRMOH)].

Some additional variability caused by differences in drainage area and land use was observed within physiographic regions; therefore, watershed size and land-use indicators were employed to develop a complete set of classes. The land-use indicator provides a subclassification for stations in similar regions with different land uses (fig. 1; table 2). The secondary land-use indicators are watershed indicator stations (wi), which are the most downstream stations in a large watershed, and are defined for the purposes of this report as a drainage area greater than 1,000 mi^2; forest (fo); agricultural (ag); and prairie (pr). Observations and analyses from watershed indicator stations can be interpreted as being representative of the general condition of the watershed. In some instances, both the agricultural and forest secondary land uses were present; therefore, the convention was to mention them in predominant order. For example, an agriculture and forest (ag/fo) indicator implies that the primary land use of the watershed is agriculture, although a substantial fraction of it is forest.

Summary of Hydrologic Conditions

Surface-water streamflow varies seasonally in Missouri and tends to reflect precipitation patterns. Six continuous streamflow-gaging stations (hereinafter referred to as gaging station) across the State were selected to illustrate the 2009 water year monthly mean discharge and the long-term median of monthly mean discharge (fig. 3). The selection of these gaging stations was based on their geographical distribution across the State and their long period of record. Of these six stations, two (05495000 and 07052500) are part of the AWQMN, one (06934500) is a NASQAN station, and the remaining three (06897500, 06933500, and 07067000) are gaging stations only and are not part of the AWQMN.

During the 2009 water year, the average annual precipitation of the contiguous United States was about 2.33 inches (in.) above normal, whereas precipitation amounts were at average or above average amounts for the eastern half of the country (National Oceanic and Atmospheric Administration, 2010a). Missouri experienced precipitation ranked above normal with 52.09 in. of total precipitation, 11.05 in. above average (National Oceanic and Atmospheric Administration, 2010b). Monthly mean discharges were greater than or equal to the median of the monthly mean discharges for the period of record at all stations except during November, January, and March at 06933500 (Gasconade River at Jerome), 07052500 (James River at Galena), and 07067000 (Current River at Van Buren) and during February at 05495000 (Fox River at Wayland) and 06897500 (Grand River near Gallatin). The largest differences can be observed at stations 05495000 and 06897500 (fig. 3).

Peak discharges for the 2009 water year and for the period of record are presented for nine gaging stations (table 3) selected for their geographical distribution across the State and their long period of record. Although precipitation amounts recorded during the 2009 water year were above average, the peak discharges shown in table 3 were less than the peak discharges for the period of record at all stations except Chariton River near Prairie Hill (06905500). The seven-day low flow for the period of record, and the minimum daily mean flow for the 2009 water year are presented for selected stations in table 4.

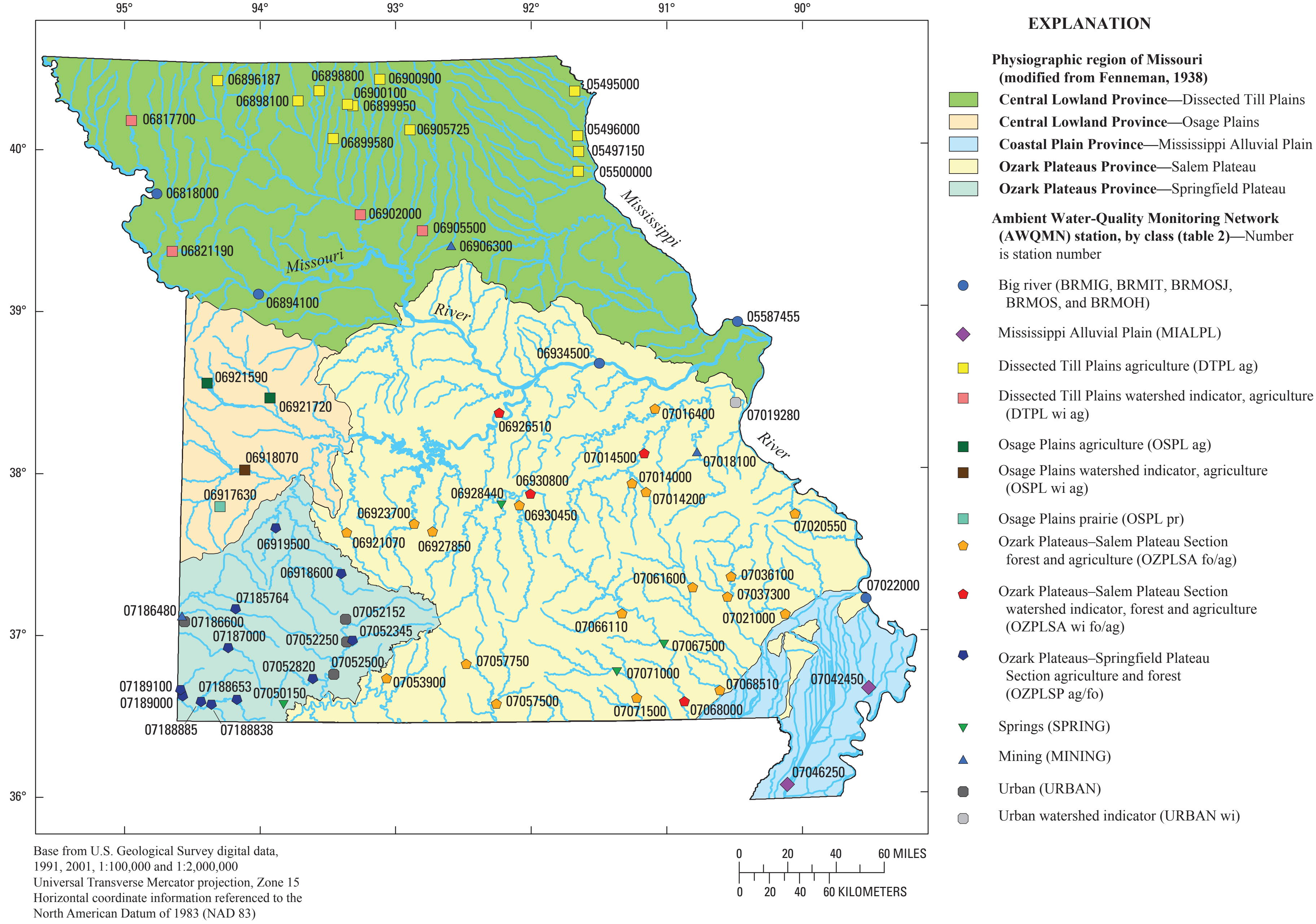


Figure 1. Location and class of selected stations and physiographic regions of Missouri, water year 2009.

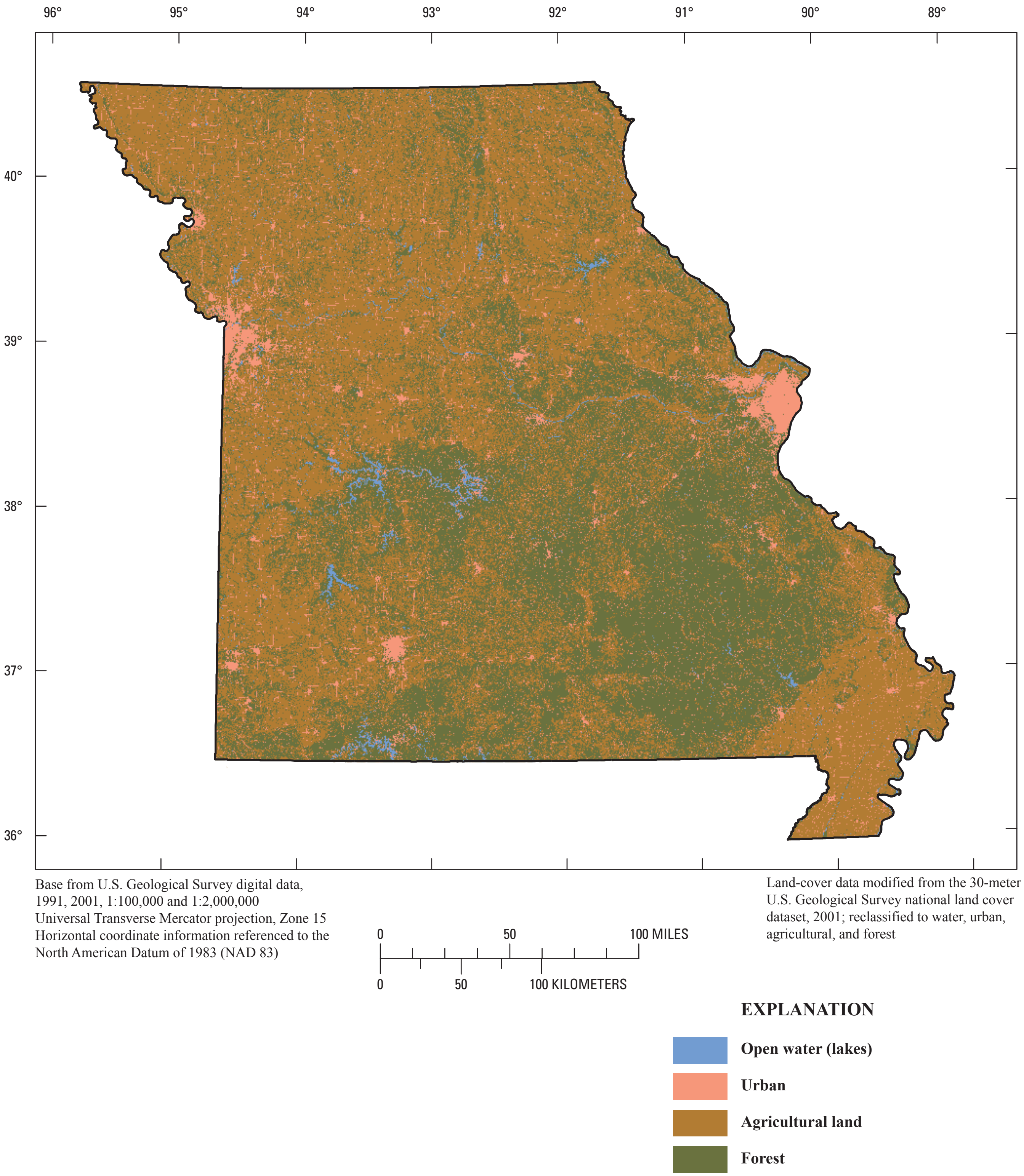
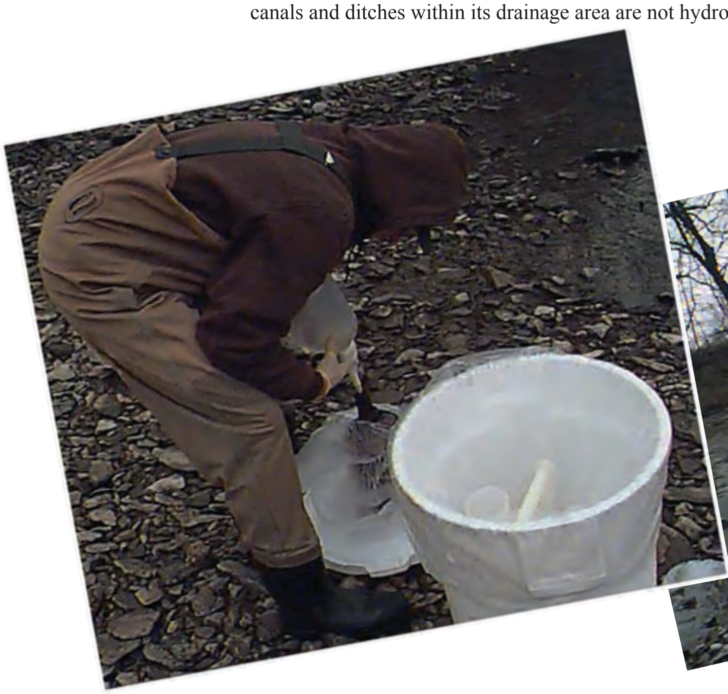


Figure 2. Land use in Missouri.

Table 2. Station classification system.

Class (fig. 1)	Description	Number of stations
BRMIG	Big River – Mississippi River at Grafton	1
BRMIT	Big River – Mississippi River at Thebes	1
BRMOSJ	Big River – Missouri River at St. Joseph	1
BRMOS	Big River – Missouri River at Sibley	1
BRMOH	Big River – Missouri River at Hermann	1
MIALPL[a]	Mississippi Alluvial Plain	2
OZPLSA fo/ag	Ozark Plateaus – Salem Plateau Section forest and agriculture	18
OZPLSA wi fo/ag	Ozark Plateaus – Salem Plateau Section watershed indicator, forest and agriculture	4
OZPLSP ag/fo	Ozark Plateaus – Springfield Plateau Section agriculture and forest	11
DTPL ag	Dissected Till Plains agriculture	12
DTPL wi ag	Dissected Till Plains watershed indicator, agriculture	4
OSPL ag	Osage Plains agriculture	2
OSPL wi ag	Osage Plains watershed indicator, agriculture	1
OSPL pr	Osage Plains prairie	1
SPRING	Springs	4
MINING	Mining	3
URBAN	Urban	4
URBAN wi	Urban watershed indicator	1

[a]One station in this class, Little River Ditches near Rives (07046250), has a drainage area greater than 1,000 square miles but is not considered a watershed indicator station because the manmade canals and ditches within its drainage area are not hydrologically connected.



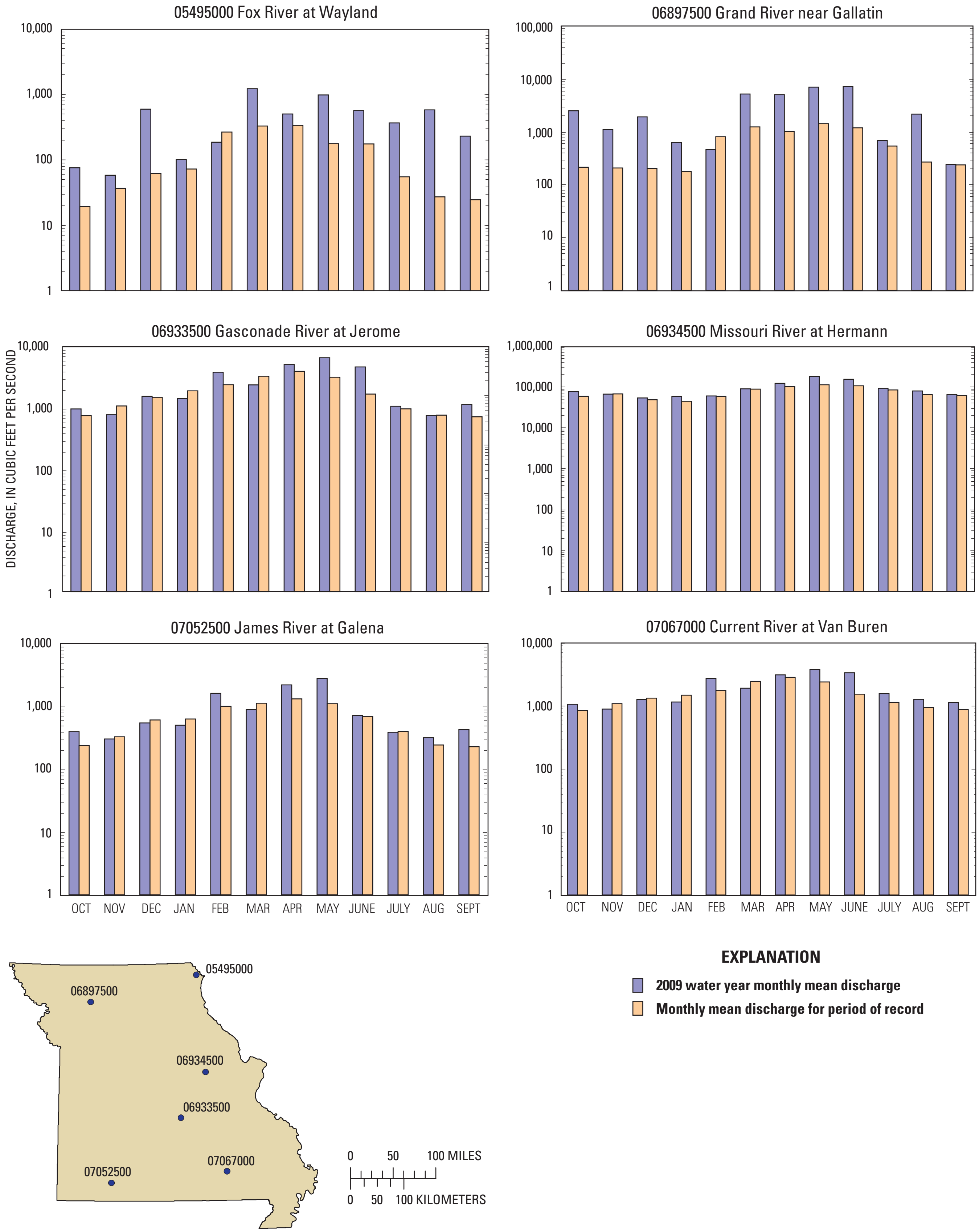


Figure 3. The 2009 water year monthly mean discharge and long-term median of monthly mean discharges at six representative streamflow-gaging stations.

Table 3. Peak discharge for the 2009 water year and period of record for selected stations.

[Peak discharge in cubic feet per second]

U.S. Geological Survey station number[a]	Station name (period of record in water years)	2009 water year		Long-term period of record	
		Peak discharge	Date	Peak discharge	Date
05495000	Fox River at Wayland (1922–2009)	9,320	May 16	26,400	Apr. 22, 1973
05587450	Mississippi River at Grafton, Ill. (1928–2009)	347,000	May 20	598,000	Aug. 1, 1993
06905500	Chariton River near Prairie Hill (1929–2009)	36,000	May 16	38,400	July 27, 2008
06933500	Gasconade River at Jerome (1923–2009)	27,500	May 9	136,000	Dec. 5, 1982
06934500	Missouri River at Hermann (1898–2009)	287,000	June 18	750,000	July 31, 1993
07019000	Meramec River near Eureka (1922–2009)	50,700	May 11	145,000	Dec. 6, 1982
07022000	Mississippi River at Thebes, Ill. (1933–2009)	603,000	May 22, 23	996,000	Aug. 7, 1993
07057500	North Fork River near Tecumseh (1945–2009)	9,680	Feb. 11	133,000	Nov. 19, 1985
07068000	Current River at Doniphan (1919–2009)	15,900	Feb. 13	122,000	Dec. 3, 1982

[a]Stations 05587450, 06933500, and 07019000 are streamflow-gaging stations only and not part of the Ambient Water-Quality Monitoring Network (AWQMN).

Table 4. Seven-day low flow for water year 2009, period of record seven-day low flow, and period of record minimum daily mean flow for selected stations.

[Flow in cubic feet per second]

U.S. Geological Survey station number[a]	Station name (period of record in water years)	Seven-day low flow		Minimum daily mean flow for period of record	
		2009	Period of record	Discharge	Date
05495000	Fox River at Wayland (1922–2009)	19	0	0	Several years
06820500	Platte River near Agency (1933–2009)	87	0	0	Several years
06921070	Pomme de Terre river near Polk (1969–2009)	12	.34	.30	Aug. 10, 1980
07016500	Bourbeuse River near Union (1921–2009)	41	13	12	Oct. 10, 1956
07067000	Current River at Van Buren (1912–2009)	832	479	476	Oct. 8, 1956
07187000	Shoal Creek above Joplin (1942–2009)	151	16	15	Sept. 7, 1954

[a]Stations 06820500, 07016500, and 07067000 are streamflow-gaging stations only and not part of the Ambient Water-Quality Monitoring Network (AWQMN).

Distribution, Concentration, and Detection Frequency of Select Constituents

The analyses presented in this report include the following constituents: DO, specific conductance, water temperature, suspended solids, suspended sediment, *E. coli* bacteria, fecal coliform bacteria, dissolved nitrate plus nitrite, total phosphorus, and dissolved and total recoverable lead and zinc. In addition, pesticide data were analyzed from 10 stations in the AWQMN. Fifteen pesticides were selected for presentation in this report: 2-chloro-4-isopropylamino-6-amino-s-triazine (CIAT; a degradation product of atrazine), 3,4 dichloraniline, acetochlor, alachlor, atrazine, metolachlor, simazine, prometon, metribuzin, prometryn, trans-propiconazole, cis-propiconazole, Ethyl dipropylthiocarbamate (EPTC), metalaxyl, and molinate. The selection of these constituents and pesticides for presentation in this report was based on: (1) values or concentrations of the select constituents are characteristic of stream-water quality in the different physiographic areas, and (2) values and concentrations of the select constituents and pesticides are above background concentrations. Boxplots of measured constituents are presented for the different classes (figs. 4–6). Pesticide data are presented in figure 7. Missouri water-quality standards are not shown on the graphs because these standards are not applicable to all streams in the AWQMN network. For specific information on Missouri water-quality standards, refer to Missouri Department of Natural Resources (2009b).

Distribution of Physical Properties, Suspended Solids, Suspended Sediment, and Indicator Bacteria

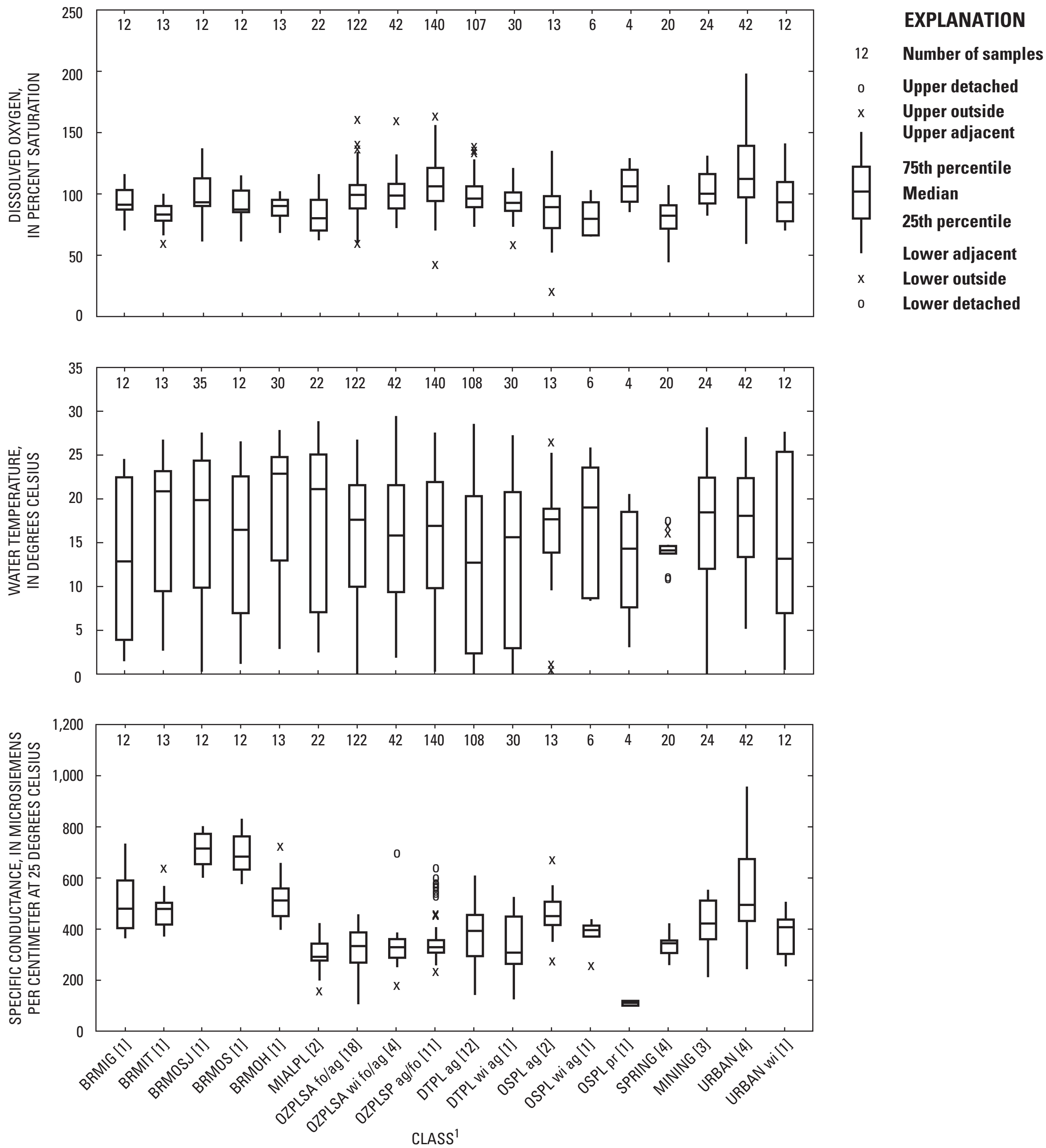
The physical properties analyzed for this report were DO, specific conductance, and water temperature. The median DO, in percent saturation ranged from 78.5 to 111 percent (fig. 4). Samples from OSP pr, OZPLSP ag/fo, and URBAN stations had the highest median DO percent saturation values, whereas samples from MIALPL and OSPL wi ag stations had the lowest (fig. 4). Median specific conductance values varied substantially among the station classes (fig. 4), ranging from 107 to 711 microsiemens per centimeter at 25 degrees Celsius. The largest median specific conductance values were measured at the Big River stations BRMOSJ and BRMOS. The OSPL pr station had the smallest median specific conductance value. Median water temperature values ranged from 12.8 to 23.0 degrees Celsius (°C), with the smallest median measured at DTPL ag stations and the largest median measured at the big river station BRMOH (fig. 4). The range in water temperature at SPRING stations was much smaller than at any other station class.

Suspended solids and suspended sediment are measures of the solid material suspended in the water column. These two measures are not considered directly comparable because of differences in collection and analytical techniques. Suspended-sediment concentrations were determined only at four Big River stations, the OSPL pr station, and one station in the OZPLSP ag/fo class; suspended-solids concentrations were determined at all other stations except BRMIT and BRMOH. Median suspended-solids concentrations varied considerably between all station classes, ranging from less than 15 to 234 milligrams per liter (mg/L). Samples collected at the BRMOSJ, BRMOS, and DTPL wi ag stations had the largest median suspended-solids concentrations, whereas samples collected at the OSPL pr station and all OZPL (SA fo/ag, SA wi fo/ag, and SP ag/fo), SPRING, MINING, and URBAN stations had median concentrations less than the LRL. Median suspended-sediment concentrations ranged from 86 to 420 mg/L at the four Big River stations. These concentrations were substantially larger than the only measured concentration of 14 mg/L at the OSPL pr station and the concentration of 3 mg/L at the OZPLSP ag/fo station (fig. 4).

Median *E. coli* bacteria densities ranged from 5 to 1,750 colonies per 100 milliliters (col/100mL) (fig. 4). The largest median densities were in samples collected at BRMOS, whereas the lowest median densities were in samples collected at OZPLSA wi fo/ag stations (fig. 4). Median fecal coliform bacteria densities (fig. 4) ranged from 12 to 1,800 col/100mL. The largest median densities were in samples collected at the BRMOS station; the smallest median densities were measured at OZPLSA (fo/ag and wi fo/ag), and SPRING stations. Median *E. coli* and fecal coliform bacteria densities varied considerably between all station classes.

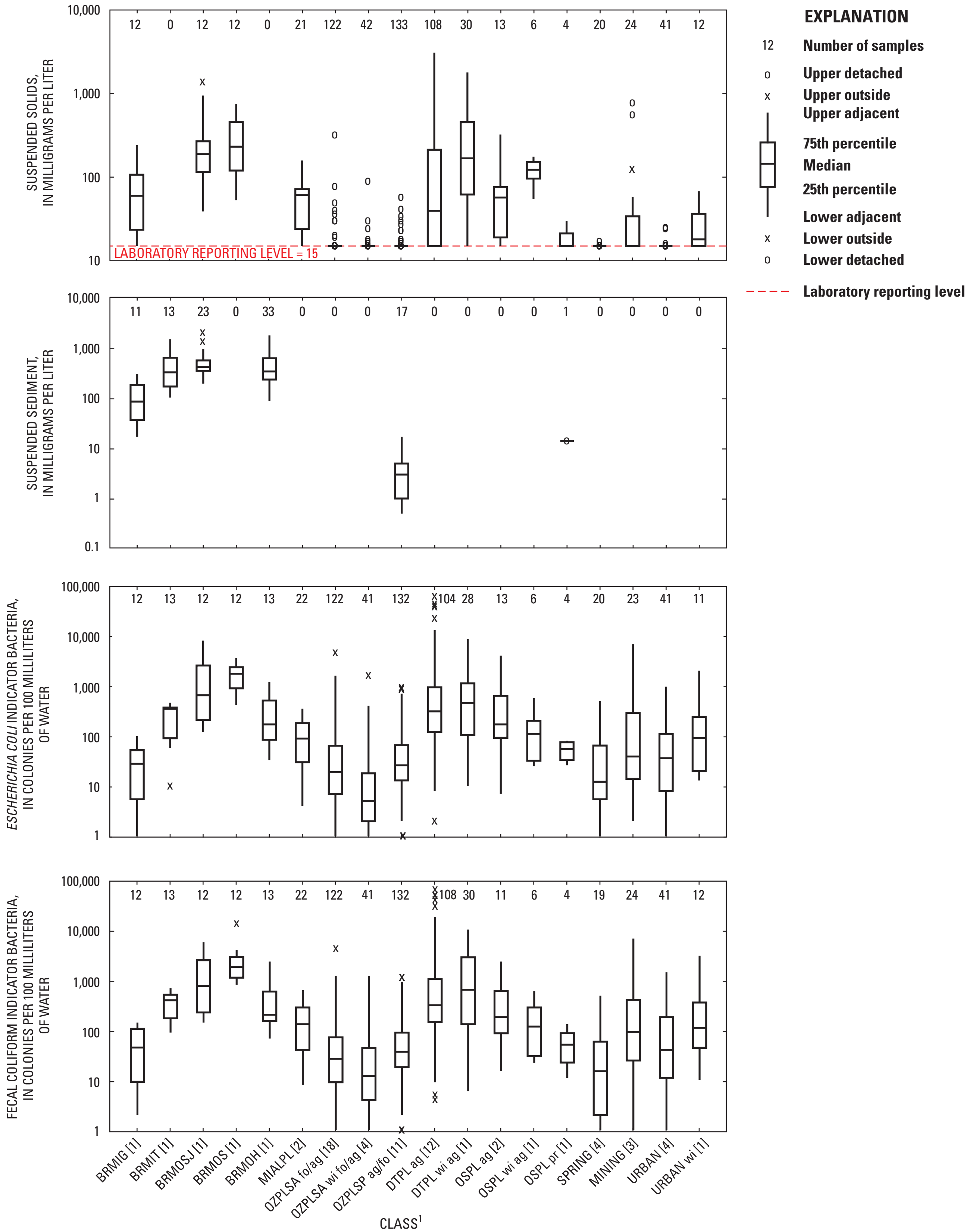
Distribution and Concentration of Dissolved Nitrate plus Nitrite and Total Phosphorus

Samples were collected at all stations for the analysis of nutrients, including dissolved nitrate plus nitrite and total phosphorus. Median dissolved nitrate plus nitrite and total phosphorus concentrations varied considerably between all station classes (fig. 5), ranging from less than 0.04 to 3.2 mg/L nitrate plus nitrite as nitrogen and from less than 0.04 to 0.42 mg/L total phosphorus as phosphorus. The largest median dissolved nitrate plus nitrite concentrations were detected in samples collected at all Big River (BRMIG having the largest median concentration), OZPLSP ag/fo, and URBAN stations; with the smallest concentrations being detected at OSPL pr (fig. 5). Similarly, median total phosphorus concentrations were among the largest at the Big River (BRMOS having the largest median concentration of the Big River stations as well as being the largest among all classes), DTPL wi ag, and MIALPL stations. The smallest median total phosphorus concentrations were detected at the OSPL pr, OZPLSA (fo/ag and wi fo/ag), OZPLSP ag/fo, and SPRING stations, all of which had median values equal to the LRL (fig. 5).



[1] Station classification system (table 2)
[number of stations in class]

Figure 4. Distribution of physical properties, suspended solids, suspended sediment, and indicator bacteria densities in samples from 72 stations, water year 2009.



[1] Station classification system (table 2)
[number of stations in class]

Figure 4. Distribution of physical properties, suspended solids, suspended sediment, and indicator bacteria densities in samples from 72 stations, water year 2009.—Continued

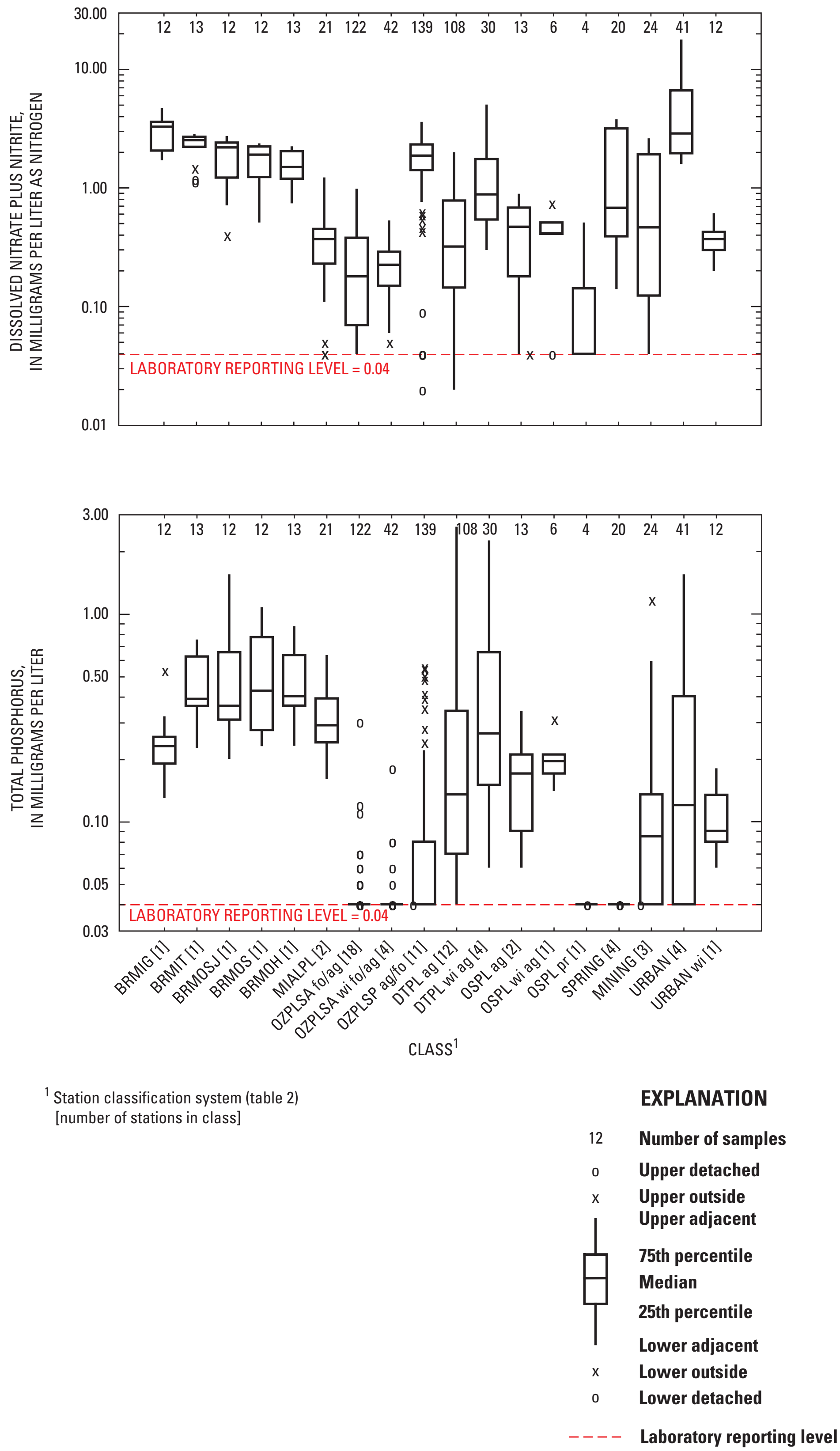
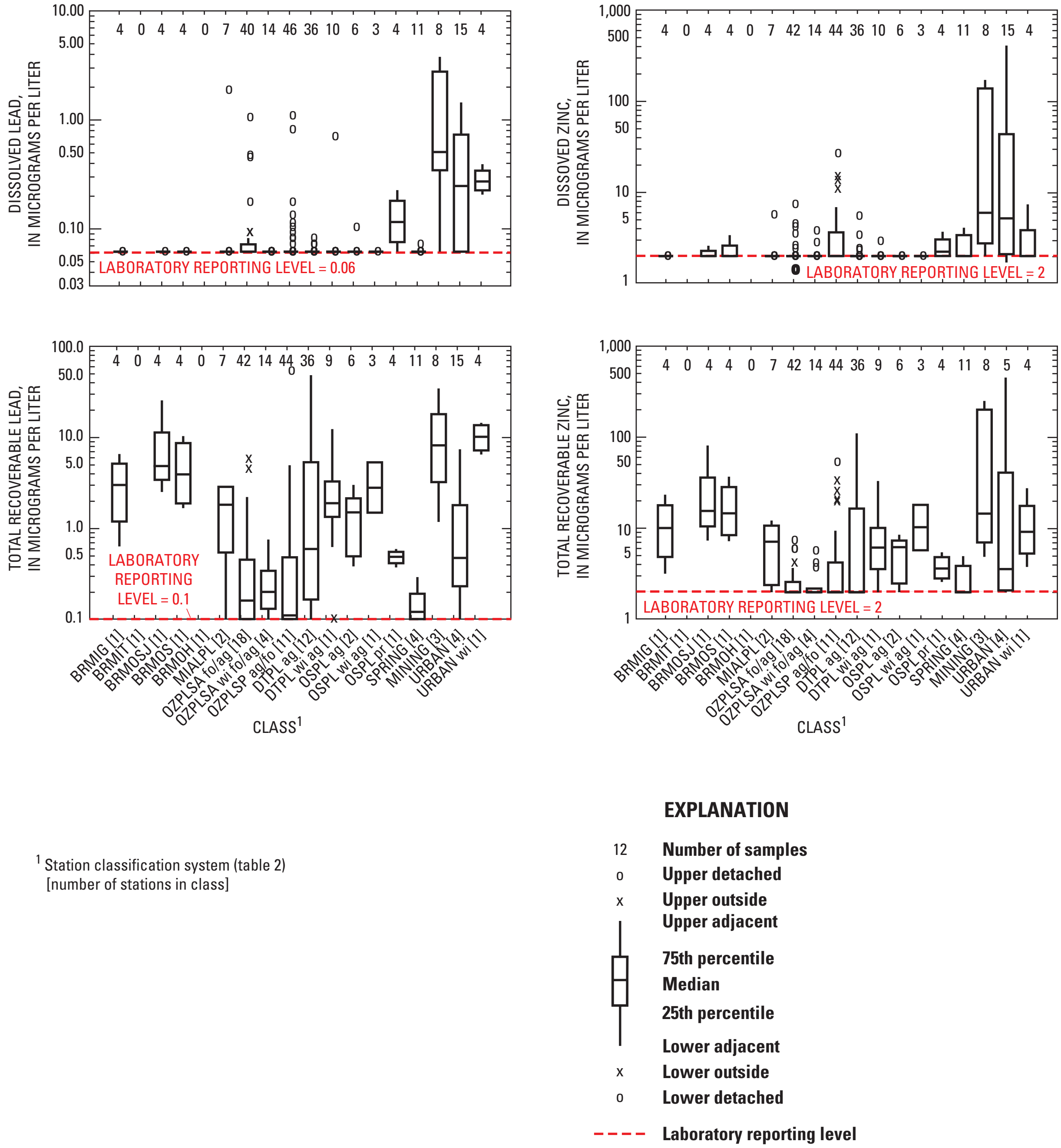
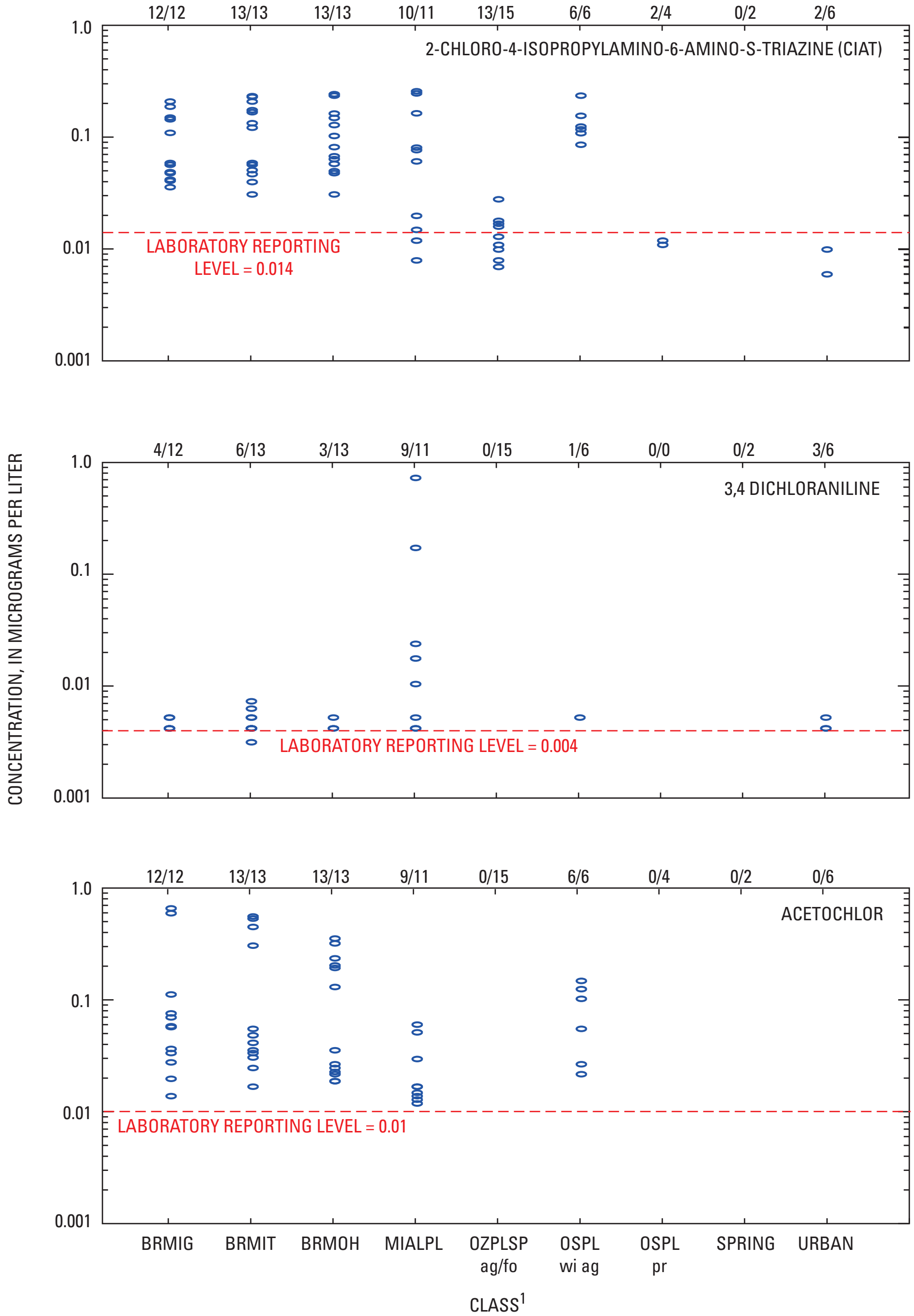


Figure 5. Concentration distribution of dissolved nitrate plus nitrite and total dissolved phosphorus in samples from 72 stations, water year 2009.



[1] Station classification system (table 2) [number of stations in class]

Figure 6. Concentration distribution of dissolved and total recoverable lead and zinc in samples from 72 stations, water year 2009.



[1] Station classification system (table 2)

EXPLANATION

Laboratory reporting level (LRL)—Concentrations less than LRL are estimated

Detection

12/12 Number of detections/total number of samples

Figure 7. Detection of select pesticides from selected stations, water year 2009.

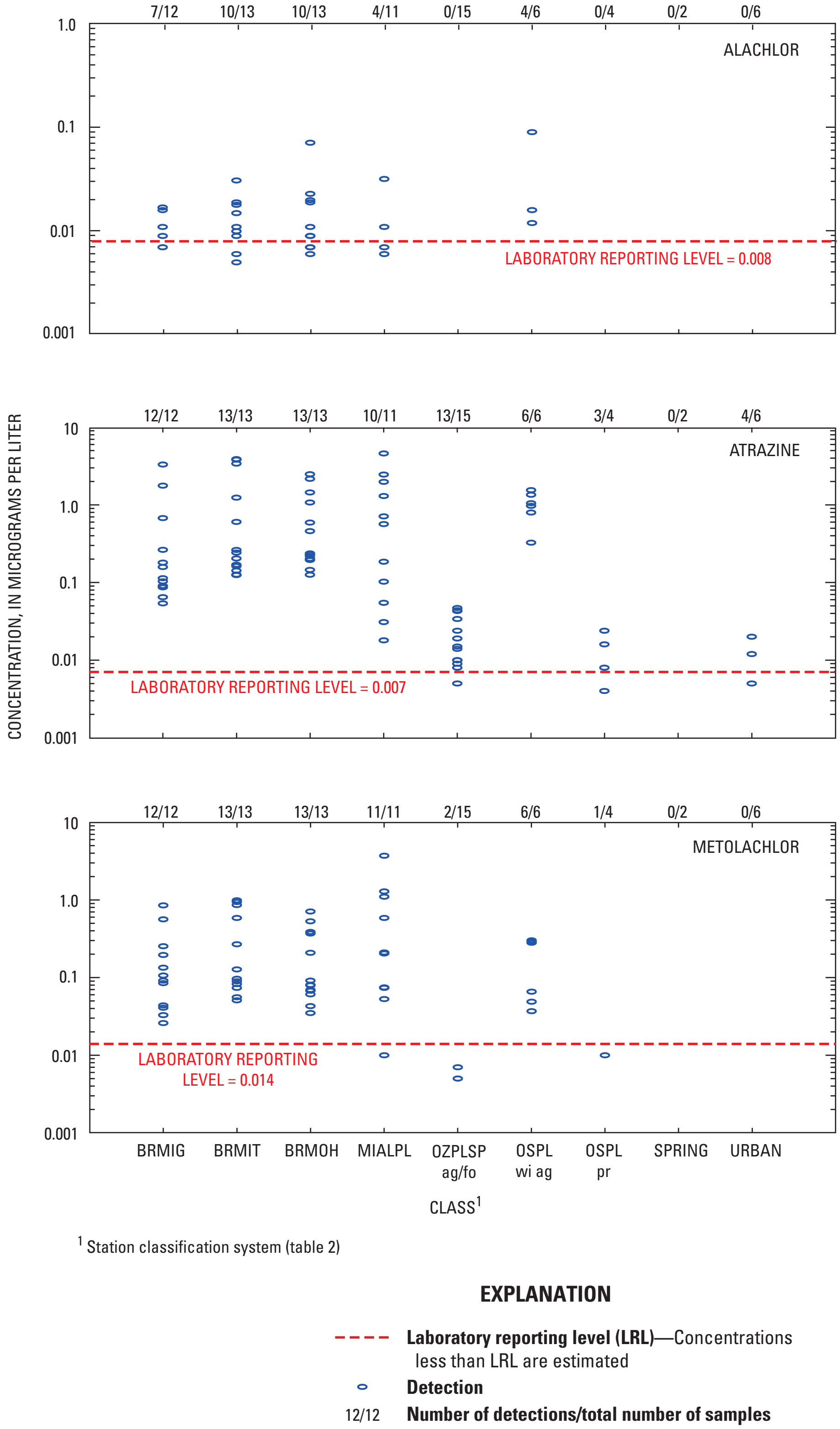
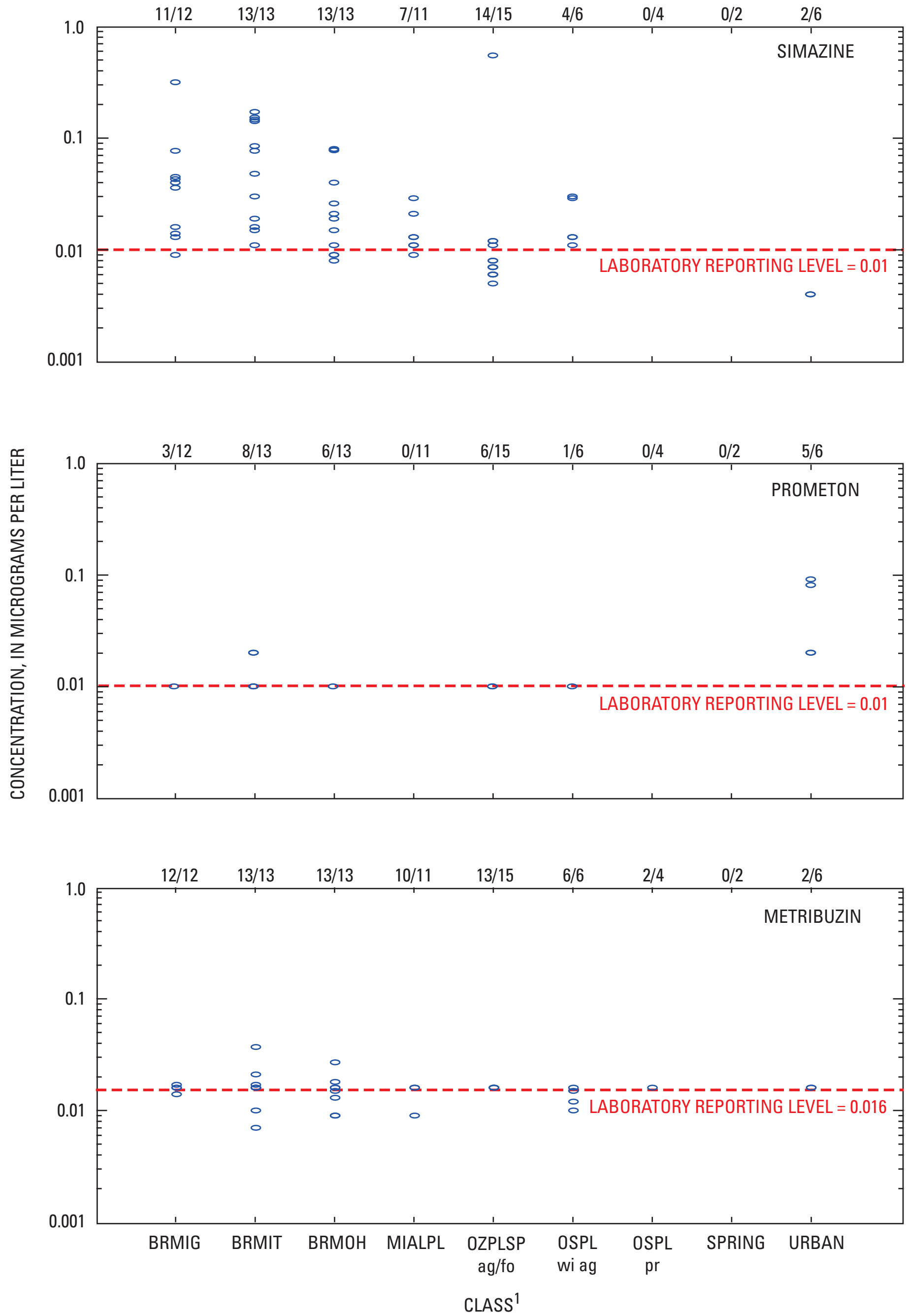


Figure 7. Detection of select pesticides from selected stations, water year 2009.—Continued



[1] Station classification system (table 2)

EXPLANATION

Laboratory reporting level (LRL)—Concentrations less than LRL are estimated

Detection

12/12 Number of detections/total number of samples

Figure 7. Detection of select pesticides from selected stations, water year 2009.—Continued

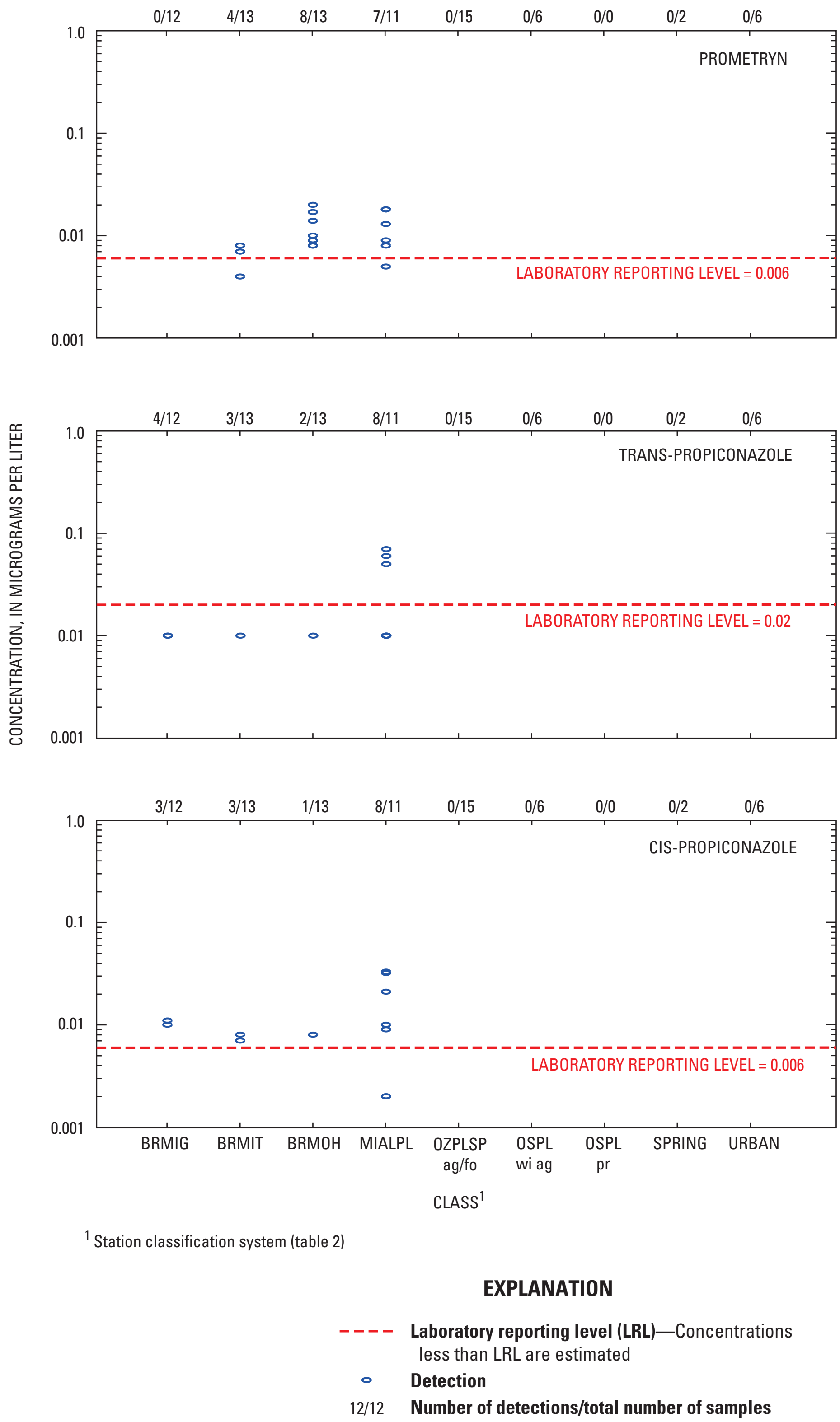


Figure 7. Detection of select pesticides from selected stations, water year 2009.—Continued

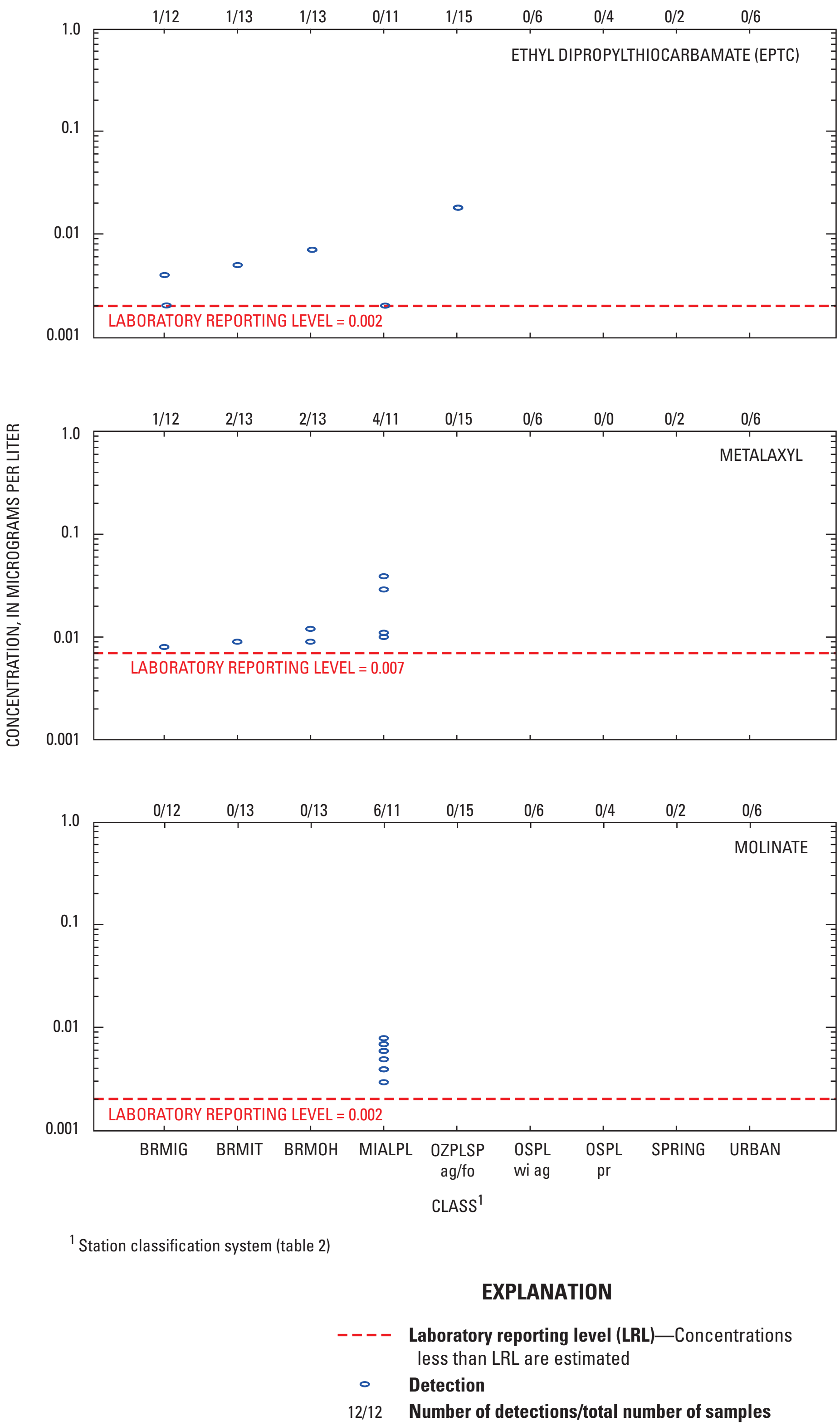


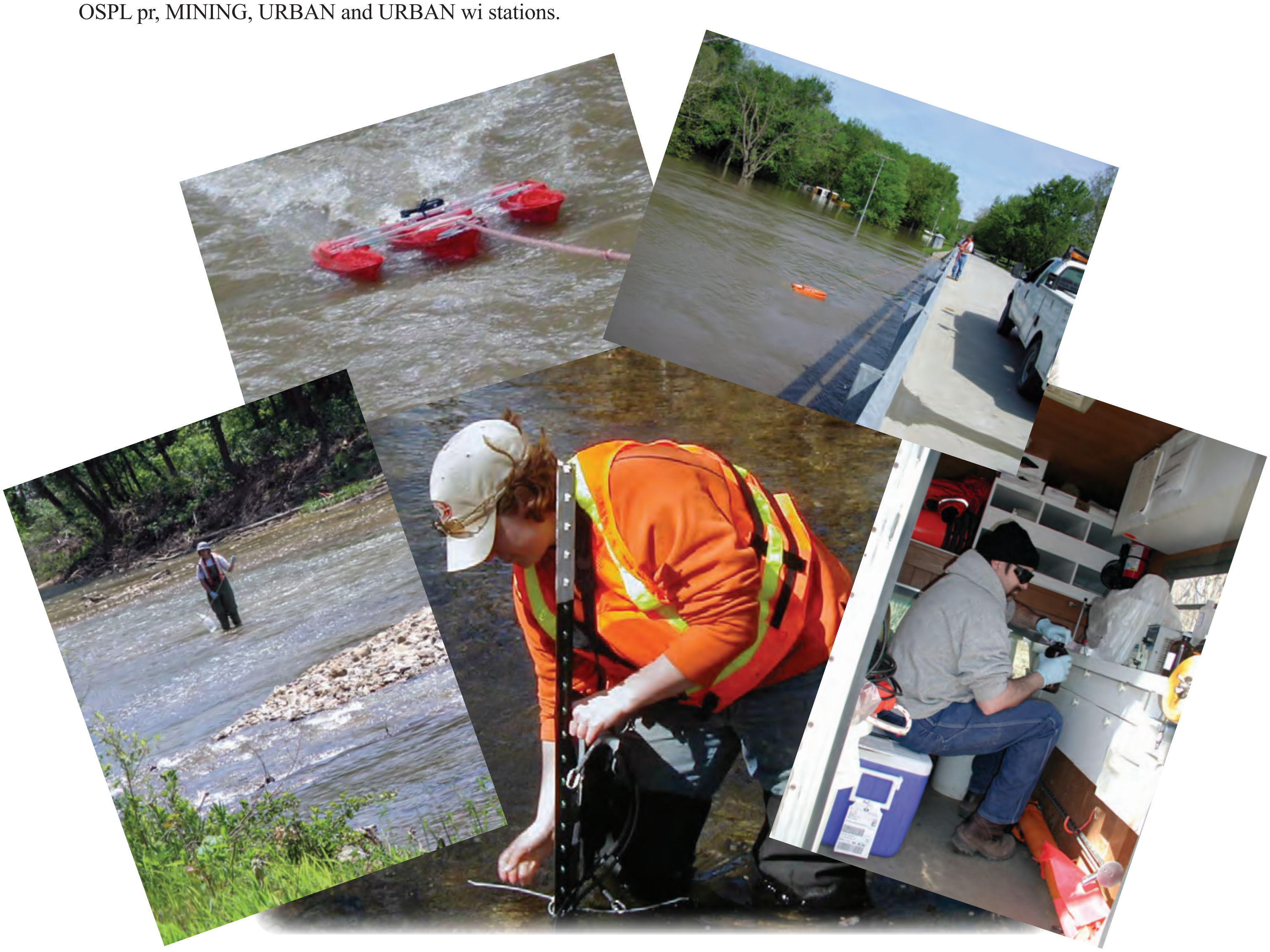
Figure 7. Detection of select pesticides from selected stations, water year 2009.—Continued

Distribution and Concentration of Dissolved and Total Recoverable Lead and Zinc

Samples were collected for the analysis of dissolved and total recoverable trace elements, including lead and zinc. No total recoverable lead and zinc samples were collected at BRMIT and BRMOH. Median concentration ranges of dissolved and total recoverable lead and zinc (fig. 6) were dissolved lead, less than 0.06 to 0.50 micrograms per liter (µg/L); total recoverable lead, 0.10 to 10.4 µg/L; dissolved zinc, less than 2.0 to 6.1 µg/L; and total recoverable zinc, less than 2 to 15.9 µg/L. The largest median concentrations for all four constituents generally were detected in samples collected at MINING, URBAN, and URBAN wi stations; although the Big River (BRMIG, BRMOSJ, and BRMOS) stations also had larger median total recoverable lead and zinc concentrations. The smallest median concentrations of dissolved and total recoverable lead and zinc generally were detected in samples collected at all OZPLSA (fo/ag and wi fo/ag), OZPLSP ag/fo, and SPRING stations (fig. 6). Most stations had median dissolved lead concentrations detected at or less than the LRL except for OSPL pr, MINING, URBAN and URBAN wi stations.

Concentration and Detection Frequency of Select Pesticides from Selected Stations

Samples for the analysis of dissolved pesticides were collected at 10 stations in the AWQMN, including 3 of the 5 Big River stations (BRMIG, BRMIT, and BRMOH), both stations in the MIALPL, the OSPL pr station, the OSPL wi ag station, 1 OZPLSP ag/fo station, 1 SPRING station, and 1 URBAN station. Twenty-six compounds were detected at concentrations greater than the LRL at one or more stations and are presented graphically in this report (fig. 7). The most-frequently detected pesticides were CIAT, 3,4-dichloroaniline, acetochlor, alachlor, atrazine, metoalachlor, simazine, and prometryn. The concentrations detected at all stations for all pesticides were less than 1.00 µg/L except atrazine at the BRMIG, BRMOH, and MIALPL stations, and metolachlor at the BRMIT and MIALPL stations. Atrazine concentrations ranged from 0.004 to 4.65 µg/L, and metolachlor concentrations ranged from 0.005 to 3.74 µg/L among all 10 stations (fig. 7).



References Cited

Barr, M.N., and Davis, J.V., 2010, Surface-water quality conditions and long-term trends at selected sites within the ambient water-quality monitoring network in Missouri, water years 1993–2008: U.S. Geological Survey Scientific Investigations Report 2010–5078, 42 p.

Childress, C.J.O., Foreman, W.T., Connor, B.F., and Maloney, T.J., 1999, New reporting procedures based on long-term method detection levels and some considerations for interpretations of water-quality data provided by the U.S. Geological Survey National Water Quality Laboratory: U.S. Geological Survey Open-File Report 99–193, 19 p.

Fenneman, N.M., 1938, Physiography of eastern United States: New York, McGraw-Hill Book Co., Inc., 689 p.

Fishman, M.J., ed., 1993, Methods of analysis by the U.S. Geological Survey National Water Quality Laboratory—Determination of inorganic and organic constituents in water and fluvial sediments: U.S. Geological Survey Open-File Report 93–125, 217 p.

Fishman, M.J., and Friedman, L.C., 1989, Methods for the determination of inorganic substances in water and fluvial sediments: U.S. Geological Survey Techniques of Water-Resources Investigations, book 5, chap. A1, 545 p.

Guy, H.P., 1969, Laboratory theory and methods for sediment analysis: U.S. Geological Survey Techniques of Water-Resources Investigations, book 5, chap. C1, accessed April 2010 at *http://pubs.usgs.gov/twri/twri5c1/.*

Helsel, D.R., and Hirsch R.M., 2002, Statistical methods in water resources: U.S. Geological Survey Techniques of Water-Resources Investigations, book 4, chap. A3, accessed April 2010 at *http://pubs.usgs.gov/twri/twri4a3/.*

Missouri Department of Natural Resources, 2009a, Missouri water quality report (Section 305(b) Report) 2008, 91 p.

Missouri Department of Natural Resources, 2009b, Missouri water quality standards—Chapter 7, Water quality: Jefferson City, Mo., Clean Water Commission, 136 p.

Myers, D.N., Stoeckel, D.M., Bushon, R.N., Francy, D.S., and Brady, A.M.G., 2007, Fecal indicator bacteria (ver. 2.0): U.S. Geological Survey Techniques of Water-Resources Investigations, book 9, chap. A7, section 7.1, accessed April 2010 at *http://pubs.water.usgs.gov/twri9A7/.*

National Oceanic and Atmospheric Administration, 2010a, 2009 Annual climate review U.S. Summary: National Cimatic Data Center database, accessed April 2010 at *http://www.ncdc.noaa.gov/oa/climate/research/2009/ann/us-summary.html.*

National Oceanic Atmospheric Administration, 2010b, 2009 Missouri climate summary: National Cimatic Data Center database, accessed April 2010 at *http://www.ncdc.noaa.gov/oa/climate/research/cag3/mo.html.*

Otero-Benítez, W., and Davis, J.V., 2009a, Quality of surface water in Missouri, water year 2007: U.S. Geological Survey Open-File Report 2009–1096, 19 p., accessed April 2010 at *http://pubs.usgs.gov/of/2009/1096/.*

Otero-Benítez, W. and Davis, J.V., 2009b, Quality of surface water in Missouri, water year 2008; U.S. Geological Survey Open-File Report 2009–1214, 18 p., accessed April 2010 at *http://pubs.usgs.gov/of/2009/1214/.*

U.S. Census Bureau, 2010, U.S. population estimates: U.S. Census Bureau database accessed April 2010 at *http://www.census.gov/popest/states/NST-ann-est.html.*

U.S. Environmental Protection Agency, 1997, Guidelines for preparation of the comprehensive state water quality assessments (305(b) reports) and electronic updates: Washington, D.C., Office of Water, EPA–841–B97–002A, variously paginated, accessed April 2010 at *http://www.epa.gov/owow/monitoring/guidelines.html*.

U.S. Geological Survey, 1964–2005, Water resources data–Missouri: variously paginated.

U.S. Geological Survey, 2006, Collection of water samples (ver. 2.0): U.S. Geological Survey Techniques of Water-Resources Investigations, book 9, chap. A4, accessed April 2010 at *http://pubs.water.usgs.gov/twri9A4.*

U.S. Geological Survey, variously dated, National field manual for the collection of water-quality data: U.S. Geological Survey Techniques of Water-Resources Investigations, book 9, chaps. A1–A9, last accessed April 2010 at *http://pubs.water.usgs.gov/twri9A.*

Wilde, F.D., ed., chapter sections variously dated, Field measurements: U.S. Geological Survey Techniques of Water-Resources Investigations, book 9, chap. A6, accessed April 2010 at *http://pubs.water.usgs.gov/twri9A6/.*

Wilde, F.D., Radtke, D.B., Gibs, Jacob, and Iwatsubo, R.T., eds., 2004, Processing of water samples (ver. 2.2): U.S. Geological Survey Techniques of Water-Resources Investigations, book 9, chap. A5, accessed April 2010 at *http://pubs.water.usgs.gov/twri9A5/*

Zaugg, S.D., Sandstrom, M.W., Smith, S.G., and Fehlberg, K.M., 1995, Methods of analysis by the U.S. Geological Survey National Water Quality Laboratory—Determination of pesticides in water by C–18 solid-phase extraction and capillary-column gas chromatography/mass spectrometry with selected-ion monitoring: U.S. Geological Survey Open-File Report 95–181, 49 p.

Publishing support provided by:
Rolla and Lafayette Publishing Service Centers

For more information concerning this publication, contact:
Director, USGS Missouri Water Science Center
1400 Independence Road
Rolla, MO 65401
(573) 308–3667

Or visit the Missouri Water Science Center Web site at:
http://mo.water.usgs.gov

USGS

Barr— **Quality of Surface Water in Missouri, Water Year 2009**—Open-File Report 2010–1233