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# WATER QUALITY AND STREAMFLOW GAINS AND LOSSES OF OSAGE AND PRAIRIE CREEKS, BENTON COUNTY, ARKANSAS, JULY 2001

## Water-Resources Investigations Report 03-4187

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

**Front cover:** Surface flow disappearing into the streambed of Prairie Creek. Photograph by U.S. Geological Survey

# WATER QUALITY AND STREAMFLOW GAINS AND LOSSES OF OSAGE AND PRAIRIE CREEKS, BENTON COUNTY, ARKANSAS, JULY 2001

*by Matthew W. Moix, C. Shane Barks, and Jaysson E. Funkhouser*

**U.S. GEOLOGICAL SURVEY**
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Little Rock, Arkansas
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**U.S. DEPARTMENT OF THE INTERIOR**
**GALE A. NORTON, Secretary**

**U.S. GEOLOGICAL SURVEY**
**Charles G. Groat, Director**

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# WATER QUALITY AND STREAMFLOW GAINS AND LOSSES OF OSAGE AND PRAIRIE CREEKS, BENTON COUNTY, ARKANSAS, JULY 2001

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## ABSTRACT

Osage and Prairie Creeks in Benton County, Arkansas, were studied between July 24 and July 26, 2001, to describe the surface-water quality and the streamflow gains and losses along sections of each mainstem. The creeks are located in northwestern Arkansas. Water-quality samples were collected at 12 surface-water sites on the mainstem and at 6 points of inflow for Osage Creek, and at 9 surface-water sites on the mainstem and at 4 points of inflow for Prairie Creek. Water-quality analyses were performed by Rogers Water Utilities and the Arkansas Water Resources Laboratory. Streamflow measurements were made along the mainstem of each creek and at points of inflow (prior to confluence with the mainstem) to identify gaining and losing reaches.

Water-quality data collected for Osage Creek indicated that dissolved ammonia concentrations were within the typical range of concentrations measured for streams in the Springfield and Salem Plateaus. Nitrite plus nitrate and total phosphorus concentrations were within the range of concentrations measured for several streams in the western part of the Springfield and Salem Plateaus. Total phosphorus concentrations measured on the mainstem of Osage Creek were higher downstream from the Rogers wastewater-treatment plant than upstream from the wastewater-treatment plant.

Water-quality data collected for Prairie Creek indicated that dissolved ammonia concentrations measured for three mainstem sites were above the typical level of dissolved ammonia concentrations measured for streams in the Springfield and Salem Plateaus. High concentrations of dissolved ammonia measured at these sites might be indicative of sewage disposal or organic waste. Most concentrations of nitrite plus nitrate for Prairie Creek were above the range measured for some of the least-disturbed streams of the Ozark Highlands ecoregion but were within the range that is typical for several streams in the western part of the Springfield and Salem Plateaus. Total phosphorus concentrations were below or within the range that is typical for several streams in the western part of the Springfield and Salem Plateaus with elevated concentrations measured at two sties. Elevated concentrations of total phosphorus measured might be indicative of sewage or animal metabolic waste.

Identification of losing and gaining reaches indicates that interaction exists between the local shallow unconfined ground-water aquifer and surface flow in Osage and Prairie Creeks. Measured streamflow for the mainstem of Osage Creek ranged from 2.34 to 19.1 cubic feet per second during this study. Streamflow measured at the beginning of the study reach for Osage Creek was 2.34 cubic feet per second, and streamflow measured at the downstream end of the study reach was 15.7 cubic feet per second. One losing and two gaining reaches were identified on the mainstem of Osage Creek with a net gain of 3.58 cubic feet per second upstream from the wastewater-treatment plant. Measured streamflow for the mainstem of Prairie Creek ranged from 0 to 3.17 cubic feet per second during this study. Streamflow measured at the beginning of the study reach for Prairie Creek was 0.44 cubic feet per second, and the stream bed was dry at the downstream end of the study reach. Three losing and two gaining reaches were identified on the mainstem of Prairie Creek with a net loss of 3.06 cubic feet per second.

## INTRODUCTION

The city of Rogers in northwestern Arkansas is divided hydrologically by two basins (fig. 1). Western Rogers lies within the Osage Creek Basin, and eastern

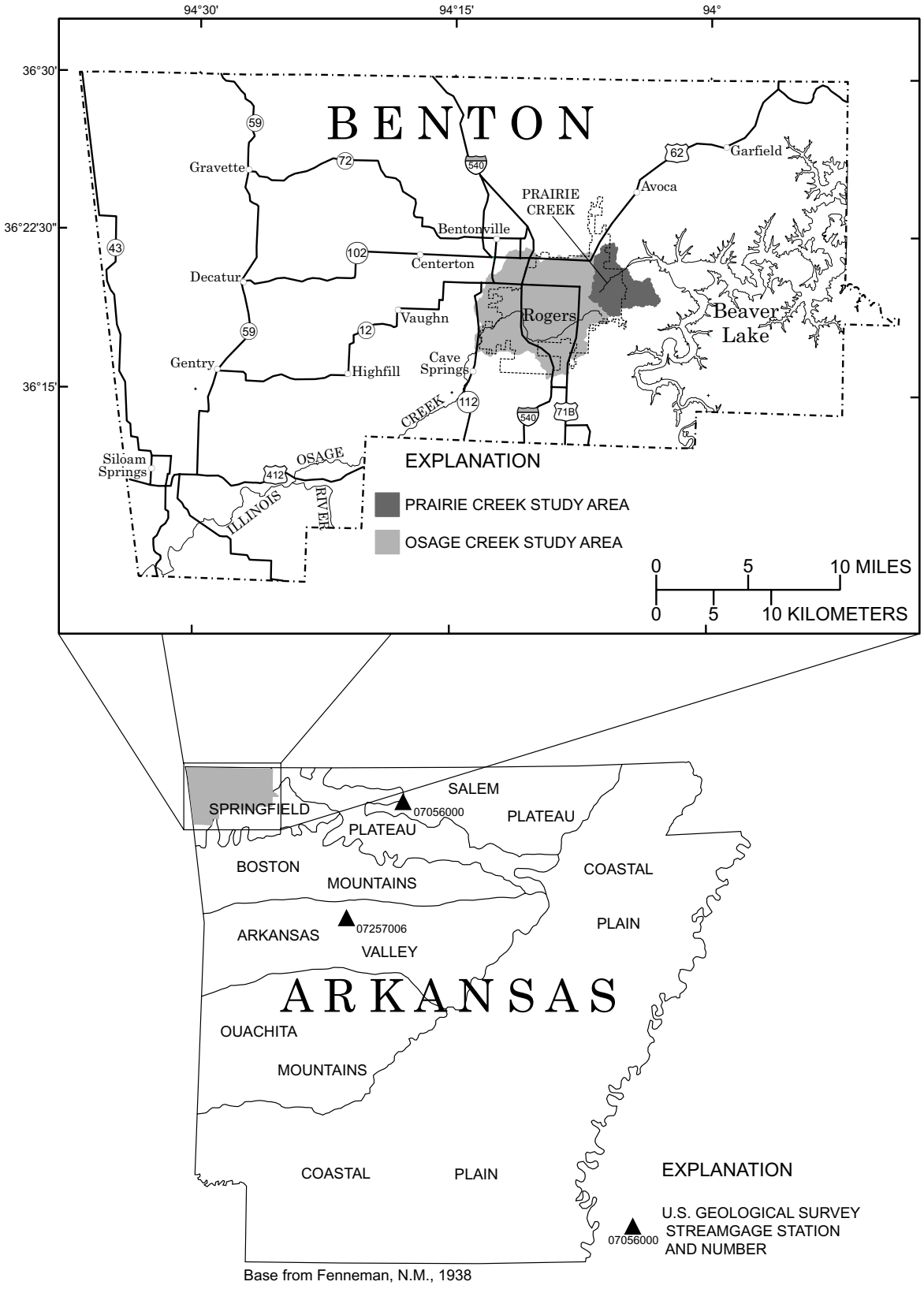


**Figure 1.** Location of study areas.

Rogers lies within the Prairie Creek Basin. The city of Rogers, Arkansas, is interested in the water quality of these streams and how that water quality is affected by interaction between surface water and ground water. In 2001, the U.S. Geological Survey (USGS), in cooperation with the Rogers Water Utilities (RWU), conducted a synoptic sampling effort to characterize the surface-water quality and streamflow gains and losses of upper Osage and Prairie Creeks. The purpose of this report is to present physical, nutrient, bacteriological, and common constituent data collected during July 2001 at various surface-water sites within each basin, present streamflow data collected during July 2001 along reaches of Osage and Prairie Creeks and their tributaries, and identify gaining and losing streamflow reaches along the mainstem of each creek.

## DESCRIPTION OF STUDY AREA

Osage and Prairie Creeks, located in northwestern Arkansas, flow in a southwesterly and northeasterly direction, respectively, through Benton County in the Springfield Plateau physiographic section (fig. 1) (Fenneman, 1938). The Springfield Plateau topography is characterized by gentle to moderate slopes, ranging from 12 to 50 percent (Fenneman, 1938). A large part of the section is dissected by streams that form V-shaped valleys. The study areas (figs. 2 and 3) for both creek basins have dendritic drainage patterns. The Osage and Prairie Creek Basins are 33.3 and 2.9 square miles, respectively, at their most downstream sampling sections within each study area.

The study reach for Osage Creek begins at the headwaters of Osage Creek and ends approximately 0.4 mile upstream from the USGS gaging station near Cave Springs, Arkansas (07194880) (fig. 2). Land-surface altitudes range from approximately 1,205 feet (ft) above NGVD 1929[1] at the headwaters to 1,135 ft above NGVD 1929 at the downstream end of the study reach. The mainstem of Osage Creek located within the study area has an approximate length of 3.8 miles with a mean gradient of 18 feet per mile (ft/mi).

The study reach for Prairie Creek begins at Frisco Spring (headwaters) and ends approximately 0.5 mile downstream from the Lake Atalanta spillway (fig. 3). Land-surface altitudes range from 1,235 ft above NGVD 1929 at Frisco Spring to 1,130 ft above NGVD 1929 at the most downstream sampling section for Prairie Creek. The study reach of Prairie Creek has an approximate length of 1.6 miles with a mean gradient of 66 ft/mi.

Osage Creek originates in southwestern Rogers, flows southwesterly approximately 4.2 miles before reaching Cave Springs, Arkansas, and then continues another 16 miles before entering the Illinois River. A National Pollution Discharge Elimination System permit has been issued to the city of Rogers (Arkansas Department of Environmental Quality, oral commun., 2003) for the discharge of treated effluent from its wastewater treatment plant (WTP). The discharge point of the Rogers WTP is located upstream from the USGS gaging station near Cave Springs within the study reach. Osage Creek receives urban storm-water runoff from the west side of Rogers.

Prairie Creek originates at Frisco Spring (also known as Pump Spring) in eastern Rogers and flows northeasterly approximately 0.5 mile before entering Lake Atalanta. As it exits the lake downstream from the USGS gaging station (07049563), Prairie Creek flows northeasterly another 1.4 miles before entering Beaver Lake. Prairie Creek receives urban storm-water runoff from the east side of Rogers.

The Osage and Prairie Creek Basins were probably drier than normal during the 2001 water year. Based upon analysis of precipitation and streamflow data collected at USGS index sites (Buffalo River near St. Joe 07056000 in northern Arkansas, and the Big Piney Creek at Highway 164 near Dover 07257006 in west-central Arkansas; fig. 1), below-average rainfall resulted in slightly below-average runoff in northern and west-central parts of Arkansas during the 2001 water year. Streamflow for the year (as a percentage of the median for the base period 1961-1990) was 75 percent for the index station on the Buffalo River near St. Joe and 96 percent for the index station on the Big Piney Creek at Highway 164 near Dover. Streamflow for July of 2001 was less than the median for the base period 1961-1990 for both index stations (Porter and others, 2002).

The surficial geology of both basins is composed mainly of the Mississippian-age Boone Formation. The thickness of the Boone Formation ranges from 304 to 388 ft in northwestern Arkansas (Sheldon, 1954) and comprises limestone, chert, and minor beds of shale and sandstone (Frezon and Glick, 1959). The residual cherty rubble of the Boone Formation typically yields

[1]In this report, vertical coordinate information is referenced to the National Geodetic Vertical Datum of 1929 (NGVD of 1929).

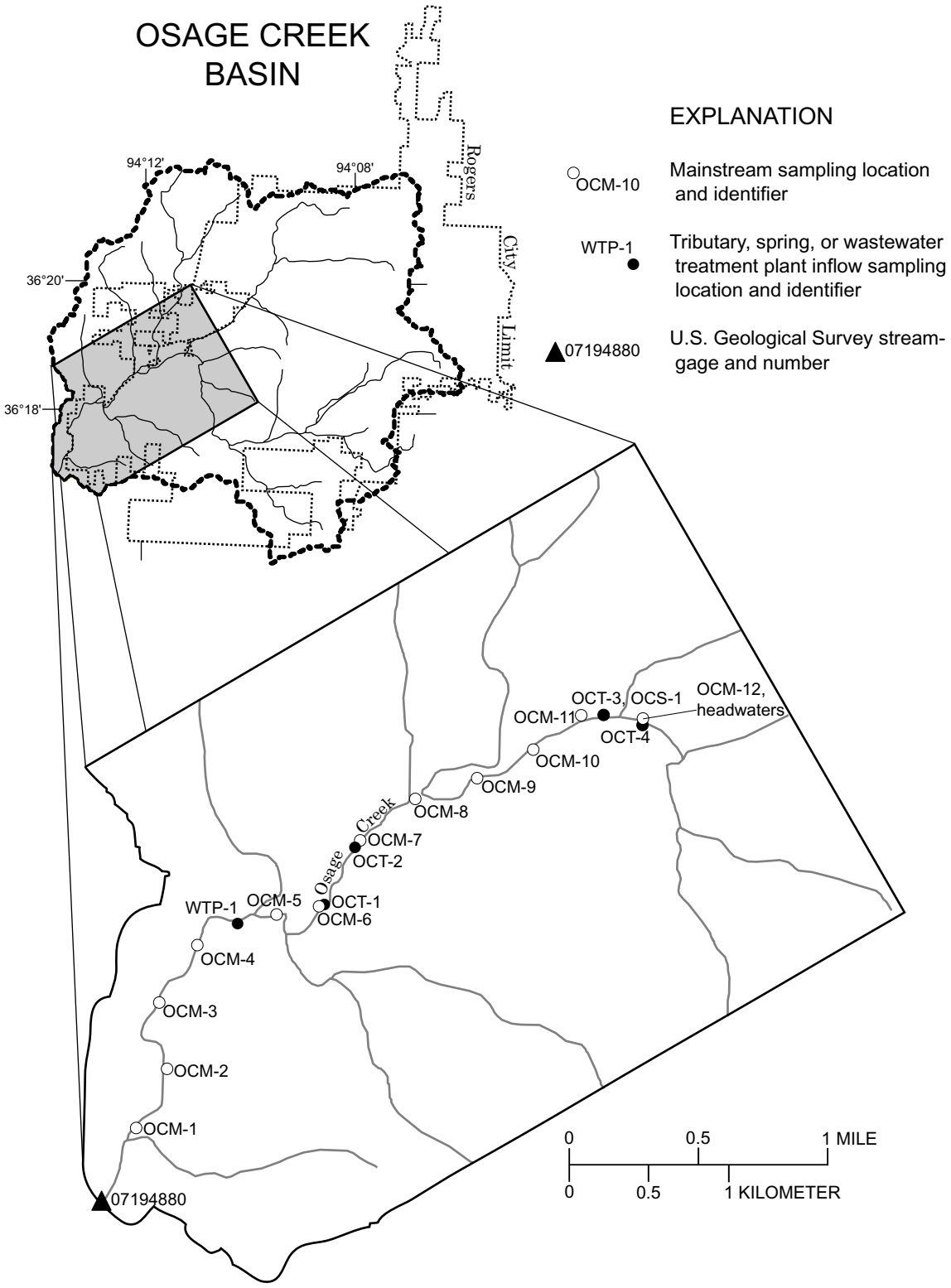


**Figure 2.** Location of Osage Creek sampling sites.

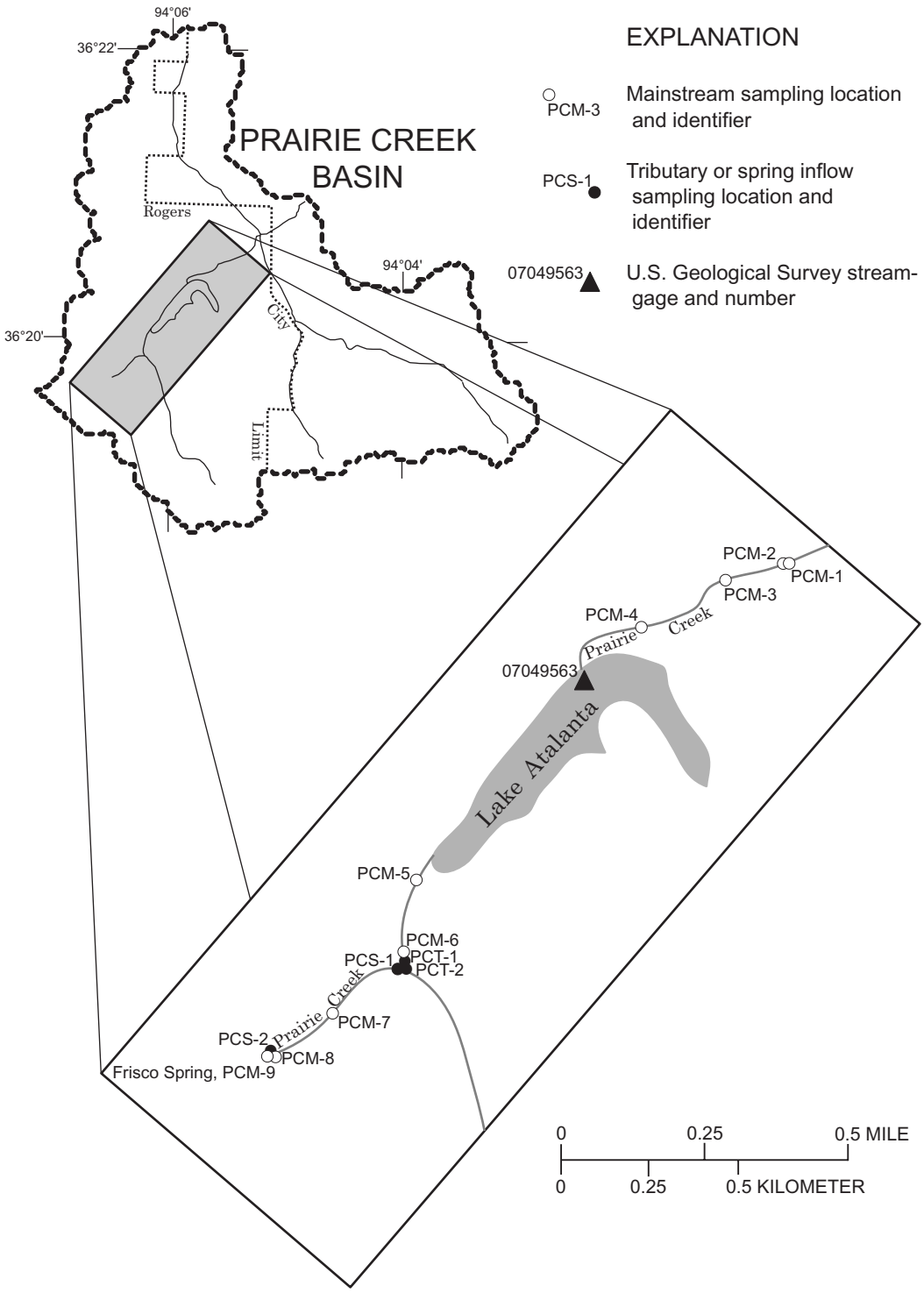


**Figure 3.** Location of Prairie Creek sampling sites.

2 to 5 gallons of water per minute (gal/min) for wells; however, many large springs and wells tap large solution channels, which can yield more than 25 gal/min (Lamonds, 1972).

The Boone Formation of northwestern Arkansas has been fractured and dissolved to form an open network of caves, enlarged fractures, bedding planes, conduits, sinkholes, sinking streams, and springs (Lamonds, 1972). The Boone Formation is underdrained by a shallow unconfined carbonate-rock aquifer known as the Springfield Plateau aquifer (Imes, 1990). This network allows for extensive interaction between ground water and surface water and can produce fluctuations (gains and losses) in streamflow that can vary greatly along the entire length of a stream. In such networks, it is not unusual for medium-sized streams to disappear into rock openings and reappear at the surface further downstream, thereby completely disrupting the surface drainage system (Winter and others, 1999) (fig. 4).

## DATA COLLECTION METHODS

Surface-water samples were collected and streamflow measurements were made within the Osage Creek Basin on July 24, 2001, and within the Prairie Creek Basin on July 25, 2001. The sampling and measurement sites were selected to provide the best understanding of existing water-quality and streamflow conditions. Water-quality samples were collected and discharge was measured at numerous locations on the mainstem of each stream and at tributary, spring, and WTP inflow points (prior to confluence with the mainstem) during low-flow conditions (no storm runoff). For the Osage Creek Basin, water-quality sampling and streamflow measurement locations began at the headwaters, and ended 0.4 mile upstream from the USGS gaging station near Cave Springs with an average mainstem reach length of 1,300 ft between sampling and measurement locations. For the Prairie Creek Basin, surface-water sampling and streamflow measurement locations began at Frisco Spring (headwaters), continued to immediately upstream from Lake Atalanta, resumed downstream from the Lake Atalanta spillway, and ended 0.3 mile downstream from the spillway with

**Figure 4.** Surface flow disappearing into the streambed of Prairie Creek.

an average mainstem reach length of 560 ft between sampling and measurement locations.

Site identifier nomenclature also was created for each sampling and measurement location to distinguish the creek, the type of site, and the relative location of each sampling site. Each site identifier consists of three alphabetical characters followed by a hyphen and one or two numerical characters (for example, PCS-1, OCM-12). The first two alphabetical characters indicate the stream: PC is Prairie Creek and OC is Osage Creek. The third alphabetical character indicates the type of site: M is mainstem, S is spring, and T is tributary. The numerical characters indicate the relative downstream location of the measurement and sampling location with the highest number being the most upstream site of its type and the lowest number being the most downstream site of its type. For example, PCS-1 is the most downstream spring site on Prairie Creek, while OCM-12 is the most upstream mainstem site on Osage Creek.

Water-quality samples were collected by hand dipping sample collection bottles into the centroid of flow at each streamflow measurement location (fig. 5). All water-quality samples were collected by RWU personnel. The water-quality samples were analyzed by the laboratories at the RWU facility and the Arkansas Water Resources Center (AWRC) in Fayetteville, Arkansas, in accordance with the RWU and AWRC Quality Assurance (QA) plans approved by the U.S Environmental Protection Agency.

Results of analyses of various water-quality parameters were compared with values measured for other streams in northern Arkansas and for other stream basins of the United States reported from other studies. Specific conductance, dissolved ammonia, dissolved nitrite plus nitrate, total phosphorus, dissolved chloride and dissolved sulfate measured for Osage and Prairie Creeks were compared with typical values measured for moderate to larger Arkansas rivers and streams of the Springfield and Salem Plateaus for water years 1975 through 1985 (Petersen, 1988). Because the studied creeks are located in the western part of the Springfield and Salem Plateaus, these parameters also are compared with typical values measured for streams in the western part of the Springfield and Salem Plateaus for which values were typically higher than values measured for streams throughout the plateaus for water years 1975 through 1985 (Petersen, 1988). Measured

**Figure 5.** Collection of a water-quality sample by the hand-dipping method.

dissolved ammonia, dissolved nitrite plus nitrate, and total phosphorus also were compared with values measured by the Arkansas Department of Environmental Quality for least-disturbed reference streams of the Ozark Highlands ecoregion for 1983 through 1986 (Arkansas Department of Pollution Control and Ecology, 1987). Spatially the Ozark Highlands ecoregion generally coincides with the Springfield and Salem Plateaus. Six least-disturbed reference streams in northwestern and north central Arkansas with drainage areas ranging between 18 and 526 square miles were used for the comparison. Measured dissolved ammonia, dissolved nitrite plus nitrate, and total phosphorus also were compared with the 75th percentile flow-weighted nutrient concentrations for these parameters in relatively undeveloped stream basins of the United States for 1990 through 1995 (Clark and others, 2000).

Dissolved-oxygen concentration, pH, and water temperature were collected hourly for a 24-hour period at one location on Osage Creek and two locations on Prairie Creek. These physical parameters were collected hourly at Osage Creek at the USGS gaging station near Cave Springs (07194880), 0.4 miles downstream from the end of the study reach, from July 24 to July 25, 2001 (fig. 2). These physical parameters also were collected hourly on Prairie Creek on the mainstem immediately upstream from Lake Atalanta and at the USGS gaging station Prairie Creek near Rogers (07049563), which is located at the Lake Atalanta spillway, from July 25 to July 26, 2001 (fig. 3).

Streamflow measurements were made with a current meter following methods described by Rantz and others (1982) (fig. 6). Comparison of successive downstream streamflow measurements were used to determine if the stream reaches were gaining or losing flow. Stream reaches are considered as gaining or losing streamflow only if the gain or loss calculated exceeds the measurement error for the reach. The collection, computation, and analysis of all streamflow measurement data were performed by USGS personnel. Approximate streamflow measurement error was 3 to 5 percent for most locations and 5 to greater than 8 percent at some locations on Osage Creek. Approximate streamflow measurement error was 5 to 8 percent for most locations and greater than 8 percent at some locations on Prairie Creek.

**Figure 6.** Collection of streamflow measurement data by the current-meter method.

## WATER QUALITY

Water-quality samples were collected during the study of each basin, and the analyses of these water-quality samples were used to describe the range in physical parameters and concentrations for various bacteriological and chemical parameters. Additionally, continuous monitoring of dissolved-oxygen concentration, pH, and water temperature conducted during each study described fluctuations of these physical parameters.

### Osage Creek

Water-quality samples were collected at 12 surface-water sites on the mainstem of Osage Creek (table 1). Water-quality samples also were collected at six points of inflow (one spring, four tributaries, and one WTP) during this study.

Specific conductance values ranged from 331 to 536 microsiemens per centimeter at 25.0 °C (µS/cm) (table 2). Specific conductance values observed at sites upstream from the WTP were similar to values typical of other streams in the Springfield and Salem Plateaus, while values observed at sites downstream from the WTP were slightly higher (table 2). Elevated values of specific conductance are caused by increased ion concentrations (i.e. chloride and sulfate) (Hem, 1992).

**Table 1.** Description of surface-water sampling sites in the Osage Creek Basin

| Site identifier | Site description | Latitude[1] | Longitude[1] | Distance downstream of headwaters (miles) |
|---|---|---|---|---|
| OCM-12 | Osage Creek mainstem-headwaters | 361855 | 0941102 | 0.00 |
| OCT-4 | Tributary 4 | 361855 | 0941102 | 0.01 |
| OCS-1 | Spring 1 | 361856 | 0941114 | 0.17 |
| OCT-3 | Tributary 3 | 361856 | 0941114 | 0.18 |
| OCM-11 | Osage Creek mainstem | 361856 | 0941120 | 0.28 |
| OCM-10 | Osage Creek mainstem | 361848 | 0941134 | 0.54 |
| OCM-9 | Osage Creek mainstem | 361841 | 0941150 | 0.83 |
| OCM-8 | Osage Creek mainstem | 361836 | 0941208 | 1.18 |
| OCM-7 | Osage Creek mainstem | 351826 | 0941223 | 1.50 |
| OCT-2 | Tributary 2 | 361825 | 0941225 | 1.55 |
| OCT-1 | Tributary 1 | 361809 | 0941246 | 1.90 |
| OCM-6 | Osage Creek mainstem | 361811 | 0941235 | 1.91 |
| OCM-5 | Osage Creek mainstem | 361809 | 0941247 | 2.28 |
| WTP-1 | Rogers Wastewater Treatment Plant | 361807 | 0941258 | 2.47 |
| OCM-4 | Osage Creek mainstem | 361801 | 0941310 | 2.75 |
| OCM-3 | Osage Creek mainstem | 361748 | 0941320 | 3.10 |
| OCM-2 | Osage Creek mainstem | 361732 | 0941318 | 3.49 |
| OCM-1 | Osage Creek mainstem (bottom of study reach) | 361719 | 0941327 | 3.82 |

[1]Horizontal coordinate information is referenced to the North American Datum of 1927 (NAD 27), unless otherwise noted.

**Table 2.** Discharge and water-quality data for surface-water sites located in the Osage Creek Basin[1]

[Temperature reported to the nearest 0.1 degree Celsius; °C, degrees Celsius; $ft^3/s$, cubic feet per second; µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; cols/100 mL, number of colonies per 100 milliliter of sample; <, less than; >, greater than; --, no data available]

| Site identifier | Date of sample | Time of sample | Water temperature (° C) | Discharge, instantaneous ($ft^3/s$) | Specific conductance (µS/cm) | Oxygen, dissolved (mg/L) | pH field (standard units) | Nitrogen, ammonia, dissolved (mg/L as N) | Nitrogen, nitrite, dissolved (mg/L as N) |
|---|---|---|---|---|---|---|---|---|---|
| OCM-12 | 7-24-01 | 1010 | 20.2 | 2.34 | -- | 8.1 | 7.4 | <0.01 | 0.02 |
| OCT-4 | 7-24-01 | 1005 | 18.1 | 2.50 | -- | 8.1 | 7.2 | <0.01 | 0.01 |
| OCS-1 | 7-24-01 | 1100 | 25.3 | 0.22 | 368 | -- | 8.0 | 0.01 | 0.01 |
| OCT-3 | 7-24-01 | 1045 | 24.9 | 0.22 | -- | 8.1 | 7.5 | <0.01 | 0.01 |
| OCM-11 | 7-24-01 | 1110 | 20.1 | 7.17 | 336 | 9.1 | 7.3 | <0.01 | 0.01 |
| OCM-10 | 7-24-01 | 1130 | 21.1 | 6.87 | 335 | 9.2 | 7.4 | <0.01 | 0.01 |
| OCM-9 | 7-24-01 | 1202 | 21.6 | 6.16 | 335 | 9.2 | 7.5 | <0.01 | 0.01 |
| OCM-8 | 7-24-01 | 1225 | 22.3 | 6.10 | 331 | 8.6 | 7.4 | <0.01 | 0.01 |
| OCM-7 | 7-24-01 | 1315 | 22.3 | 6.68 | 334 | 8.0 | 7.4 | <0.01 | 0.01 |
| OCT-2 | 7-24-01 | 1345 | 16.5 | 0.976 | 357 | 5.6 | 6.9 | <0.01 | 0.01 |
| OCT-1 | 7-24-01 | 1440 | 18.1 | 0.956 | 383 | 9.4 | 7.1 | <0.01 | 0.01 |
| OCM-6 | 7-24-01 | 1410 | 22.1 | 8.57 | 353 | 8.2 | 7.4 | <0.01 | 0.01 |
| OCM-5 | 7-24-01 | 1515 | 22.5 | 10.8 | 359 | 8.2 | 7.4 | <0.01 | 0.01 |
| WTP-1 | 7-24-01 | 1525 | 26.1 | -- | 536 | 8.0 | 7.5 | 0.04 | 0.01 |
| OCM-4 | 7-24-01 | 1545 | 24.6 | 19.1 | 516 | 7.6 | 7.5 | 0.02 | 0.01 |
| OCM-3 | 7-24-01 | 1645 | 25.1 | 16.7 | 515 | 8.0 | 7.6 | 0.01 | 0.02 |
| OCM-2 | 7-24-01 | 1715 | 25.6 | 17.2 | 507 | 8.7 | 7.7 | <0.01 | 0.02 |
| OCM-1 | 7-24-01 | 1740 | -- | 15.7 | 532 | 9.3 | 7.8 | 0.01 | 0.02 |
| Minimum | | | 16.5 | 0.22 | 331 | 5.6 | 6.9 | <0.01 | 0.01 |
| Maximum | | | 26.1 | 19.1 | 536 | 9.4 | 8.0 | 0.04 | 0.02 |
| Median | | | 22.3 | 7.02 | 359 | 8.2 | 7.4 | <0.01 | 0.01 |
| Typical values for Springfield and Salem Plateaus 1975-1985[2] | -- | -- | -- | -- | 150-400 | -- | -- | <0.10[a] | -- |
| Values for least-disturbed streams in Ozark Highlands ecoregion 1983-1986[3] | -- | -- | -- | -- | -- | -- | -- | <0.01-0.12 | -- |
| Values for undeveloped stream basins of the United States[4] | -- | -- | -- | -- | -- | -- | -- | 0.026[e] | -- |

**Table 2.** Discharge and water-quality data for surface-water sites located in the Osage Creek Basin[1]--Continued

[Temperature reported to the nearest 0.1 degree Celsius; °C, degrees Celsius; $ft^3/s$, cubic feet per second; µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; cols/100 mL, number of colonies per 100 milliliter of sample; <, less than; >, greater than; --, no data available]

| Site identifier | Nitrogen, ammonia + organic, dissolved (mg/L as N) | Nitrogen, nitrate, dissolved (mg/L as N) | Phosphorus, total (mg/L as P) | Ortho-phosphorus, dissolved (mg/L as P) | Coliform, fecal, 0.7-micron membrane filter (cols/100 mL) | Chloride, dissolved (mg/L as Cl) | Sulfate, dissolved (mg/L as $SO_4$) | Fluoride, dissolved (mg/L as F) | Total suspended solids (mg/L) |
|---|---|---|---|---|---|---|---|---|---|
| OCM-12 | <0.05 | 3.2 | 0.08 | <0.02 | > 110 | 6.3 | 2.9 | 0.01 | 3.4 |
| OCT-4 | <0.05 | 3.6 | 0.04 | <0.02 | > 120 | 6.8 | 2.7 | 0.02 | 14.0 |
| OCS-1 | <0.05 | 3.3 | 0.26 | <0.02 | -- | 7.5 | 3.2 | 0.03 | 7.0 |
| OCT-3 | <0.05 | 2.6 | 0.25 | <0.02 | > 120 | 8.1 | 3.2 | 0.04 | 1.8 |
| OCM-11 | <0.05 | 3.4 | 0.09 | <0.02 | > 120 | 7.2 | 2.9 | 0.01 | 2.4 |
| OCM-10 | <0.05 | 3.2 | 0.08 | <0.02 | -- | 7.3 | 3.0 | 0.01 | 5.6 |
| OCM-9 | <0.05 | 3.1 | 0.14 | <0.02 | > 170 | 7.3 | 3.0 | 0.01 | 2.0 |
| OCM-8 | <0.05 | 3.0 | 0.15 | <0.02 | -- | 7.2 | 3.0 | 0.01 | 2.2 |
| OCM-7 | <0.05 | 3.0 | 0.06 | <0.02 | -- | 7.3 | 3.1 | 0.04 | 2.6 |
| OCT-2 | <0.05 | 3.5 | 0.07 | <0.02 | > 230 | 8.1 | 4.2 | 0.04 | 6.2 |
| OCT-1 | <0.05 | 4.0 | 0.10 | <0.02 | -- | 15.0 | 6.2 | 0.03 | 1.4 |
| OCM-6 | 0.22 | 3.2 | 0.11 | 0.03 | >120 | 8.5 | 3.8 | 0.02 | 5.2 |
| OCM-5 | <0.05 | 3.3 | 0.09 | 0.03 | -- | 10.1 | 4.4 | 0.02 | 4.6 |
| WTP-1 | 0.75 | 1.7 | 0.28 | 0.17 | >170 | 62.8 | 26.4 | 0.58 | 5.4 |
| OCM-4 | 0.57 | 2.3 | 0.27 | 0.15 | -- | 47.3 | 20.0 | 0.42 | 4.4 |
| OCM-3 | 0.45 | 2.4 | 0.22 | 0.16 | >140 | 47.0 | 20.3 | 0.42 | 5.8 |
| OCM-2 | 0.59 | 2.4 | 0.25 | 0.17 | >210 | 45.2 | 18.8 | 0.35 | 7.6 |
| OCM-1 | 0.60 | 2.3 | 0.23 | 0.17 | -- | 46.9 | 19.7 | 0.40 | 5.2 |
| Minimum | <0.05 | 1.7 | 0.04 | <0.02 | >110 | 6.3 | 2.7 | 0.01 | 1.4 |
| Maximum | 0.75 | 4.0 | 0.28 | 0.17 | >230 | 62.8 | 26.4 | 0.58 | 14.0 |
| Median | <0.05 | 3.2 | .12 | <0.02 | >130 | 8.1 | 3.5 | 0.03 | 4.9 |
| Typical values for Springfield and Salem Plateaus 1975-1985[2] | -- | 0.2-0.5[b] | <0.05[c] | -- | | 5-10 | 5-10 | -- | -- |
| Values for least-disturbed streams in Ozark Highlands ecoregion 1983-1986[3] | -- | 0.19-1.92 | <0.10[d] | -- | -- | -- | -- | -- | -- |
| Values for undeveloped stream basins of the United States[4] | -- | 0.21[e,f] | 0.037[e] | -- | -- | -- | -- | -- | -- |

[1]Water-quality analyses performed by Rogers Water Utilities with the exception of analyses of chloride, fluoride, nitrate, and sulfate, which were performed by Arkansas Water Resources Laboratory.
[2]Petersen, 1988.
[3]Arkansas Department of Pollution Control and Ecology, 1987.
[4]Clark and others, 2000.
[a]Total ammonia.
[b] Nitrite plus nitrate, 1 to 4 mg/L in several streams in the western part of Springfield and Salem Plateaus.
[c]0.1 to 1 mg/L in several streams in western part of Springfield and Salem Plateaus.
[d]For all but one least-disturbed reference stream.
[e]75th percentile flow-weighted nutrient concentrations for all basins studied.
[f]Nitrite plus nitrate.

Nitrogen concentrations generally were similar to concentrations typical of other streams in the Springfield and Salem Plateaus but higher than concentrations measured for least-disturbed streams of the Ozark Highlands ecoregion (table 2). Dissolved ammonia concentrations ranged from less than 0.01 to 0.04 milligram per liter (mg/L) as nitrogen. The slight increase in dissolved ammonia concentration along the mainstem of Osage Creek occurred at the first mainstem sample location (OCM-4) downstream from the WTP (fig. 7). Dissolved ammonia concentrations for Osage Creek were within the typical range of dissolved ammonia concentrations for the Springfield and Salem Plateaus and also are within the range of dissolved ammonia concentrations measured for some of the least-disturbed streams of the Ozark Highlands ecoregion. Dissolved ammonia concentrations measured along the mainstem did not exceed the 75th percentile flow-weighted concentration for relatively undeveloped stream basins in the United States. Dissolved nitrite concentrations ranged from 0.01 to 0.02 mg/L as nitrogen. Dissolved ammonia plus organic nitrogen concentrations ranged from less than 0.05 to 0.75 mg/L as nitrogen. Dissolved nitrate concentrations ranged from 1.7 to 4.0 mg/L as nitrogen and were lower at mainstem sample locations downstream from the WTP than at mainstem locations upstream from the WTP (fig. 7). While concentrations of nitrite plus nitrate for Osage Creek were above the range that is typical for streams in the Springfield and Salem Plateaus and the range measured for least-disturbed reference streams of the Ozark Highlands ecoregion, concentrations were within the range that is typical for several streams in the western part of the Springfield and Salem Plateaus. Concentrations of nitrite plus nitrate measured for Osage Creek exceeded the 75th percentile flow-weighted concentration for relatively undeveloped stream basins in the United States.

Phosphorus concentrations generally were higher than concentrations typical of streams in the Springfield and Salem Plateaus and higher than concentrations measured for least disturbed reference streams in the Ozark Highlands ecoregion (table 2). Total phosphorus concentrations ranged from 0.04 to 0.28 mg/L. Concentrations of total phosphorus on the mainstem of Osage Creek where higher downstream from the WTP than they were upstream from the WTP (fig. 8). Most total phosphorus concentrations for Osage Creek were above the typical values for streams but were within the range that is typical for several

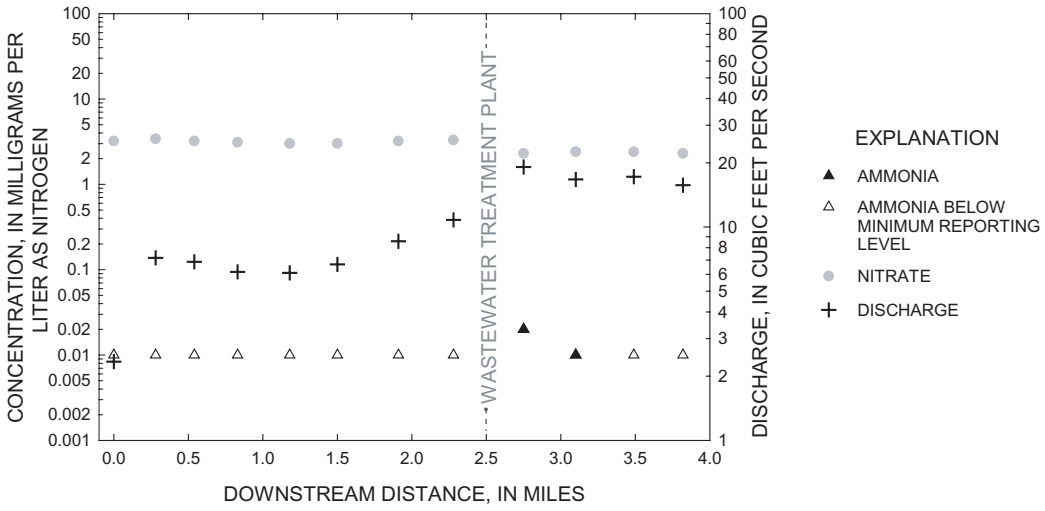


**Figure 7.** Discharge and concentrations of ammonia and nitrate along the mainstem of Osage Creek.

streams in the western part of the Springfield and Salem Plateaus. Several total phosphorus concentrations for Osage Creek were above the level measured for several of the least disturbed streams in the Ozark Highlands ecoregion. All total phosphorus concentrations measured for Osage Creek exceeded the 75th percentile flow-weighted concentration for relatively undeveloped stream basins in the United States. Dissolved orthophosphorus concentrations ranged from less than 0.02 to 0.17 mg/L as phosphorus. Concentrations of orthophosphorus on the mainstem also were higher downstream from the WTP than upstream from the WTP (fig. 8). Higher concentrations of phosphorus commonly are found downstream from WTPs (Hem, 1992).

Bacteriological analyses indicate that fecal coliform densities for surface-water sites ranged from greater than 110 to greater than 230 colonies per 100 milliliters (cols/100 mL). Fecal coliform densities were similar upstream from and downstream from the WTP.

Samples also were analyzed for chloride, fluoride, and sulfate. Dissolved chloride concentrations upstream from the WTP were similar to concentrations typical of Springfield and Salem Plateau streams, but were higher downstream from the WTP (table 2). Dissolved chloride concentrations for Osage Creek ranged from 6.3 to 15.0 mg/L upstream from the WTP and 45.2 to 47.3 mg/L downstream from the WTP (fig. 9). Dissolved fluoride concentrations for Osage Creek ranged from 0.01 to 0.04 mg/L upstream from the WTP and from 0.35 to 0.42 mg/L downstream from the WTP. Higher concentrations of fluoride downstream from the WTP may be attributed to the addition of fluoride to the municipal water supply (Sawyer and others, 1994). Dissolved sulfate concentrations ranged from 2.7 to 6.2 mg/L upstream from the WTP and from 18.8 to 20.3 mg/L downstream from the WTP (table 2; fig.9). Dissolved sulfate concentrations upstream from the WTP were similar to concentrations typical of Springfield and Salem Plateau streams, but were higher downstream from the WTP. Sulfates may be produced during organic waste treatment (Hem, 1992), and higher concentrations of sulfate downstream from the WTP may have been caused by such treatment.

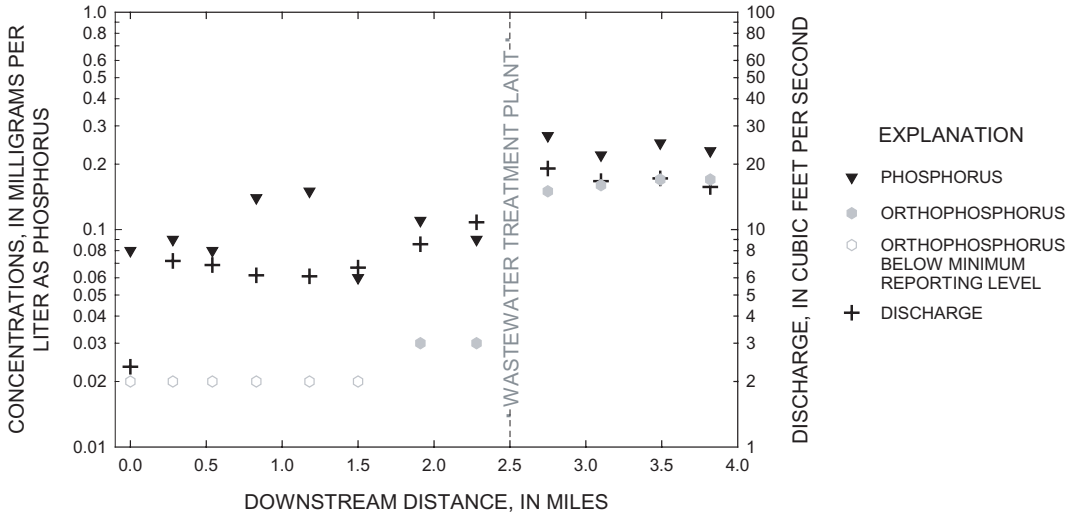


**Figure 8.** Discharge and concentrations of phosphorus and orthophosphorus along the mainstem of Osage Cree

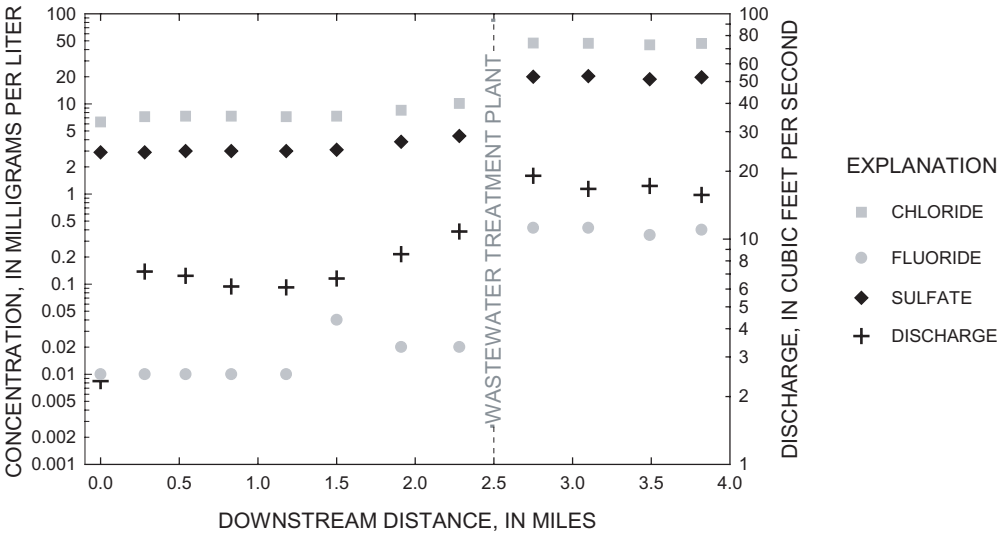


**Figure 9.** Discharge and concentrations of chloride, fluoride, and sulfate along the mainstem of Osage Creek.

Hourly dissolved-oxygen concentrations, pH, and water temperature data were collected at the USGS gaging station on Osage Creek (07194880) from July 24 to July 25, 2001 (figs. 10, 11, and 12). These data were collected to describe fluctuations of dissolved-oxygen concentrations, pH, and water temperature throughout the study. A minimum dissolved-oxygen concentration of 5.4 mg/L was recorded from 0100 to 0700 hours on July 25, and a maximum dissolved-oxygen concentration value of 8.6 mg/L was recorded at 1500 hours on July 24. A minimum pH value of 7.3 was recorded from 0200 to 0800 hours on July 25, and a maximum pH value of 7.8 was recorded from 1600 to 1700 hours on July 24. A minimum water temperature of 22.5 °C was recorded at 0800 hours on July 24, and a maximum water temperature of 27.0 °C was recorded at 1700 hours on July 24.

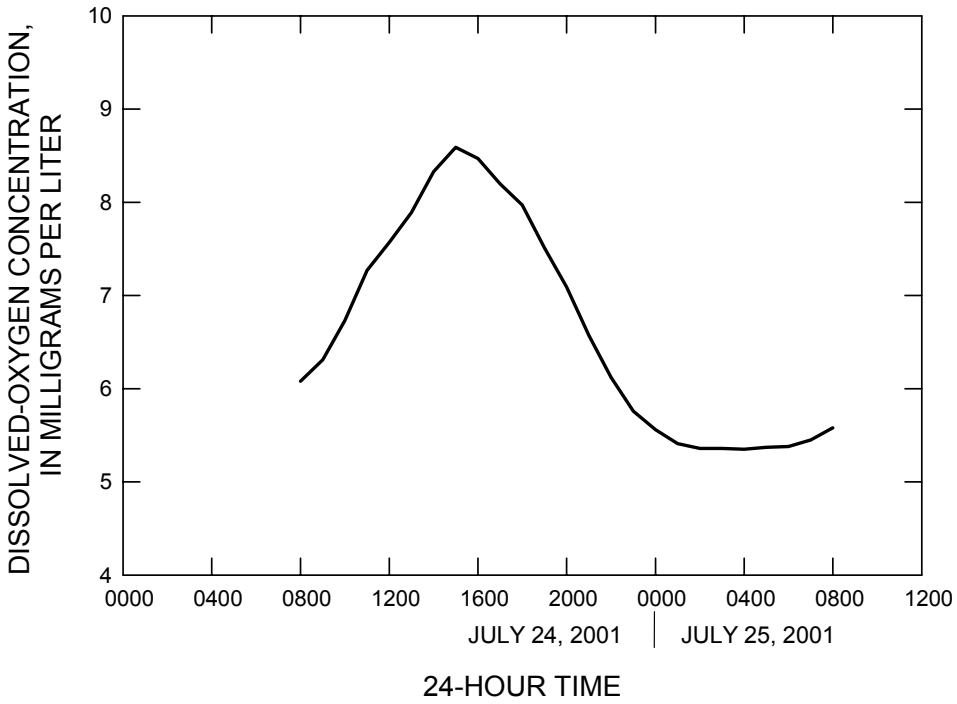


**Figure 10.** Hourly dissolved-oxygen concentrations, 09194880 Osage Creek near Cave Springs, July 24-25, 2001.

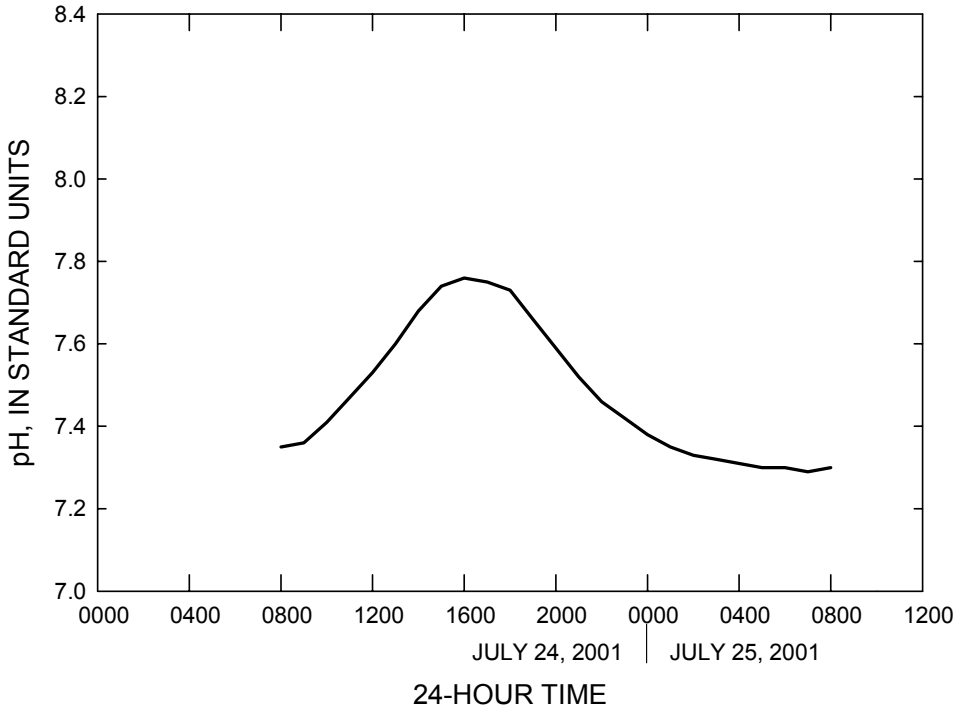


**Figure 11.** Hourly pH, 07194880 Osage Creek near Cave Springs, July 24-25, 2001.

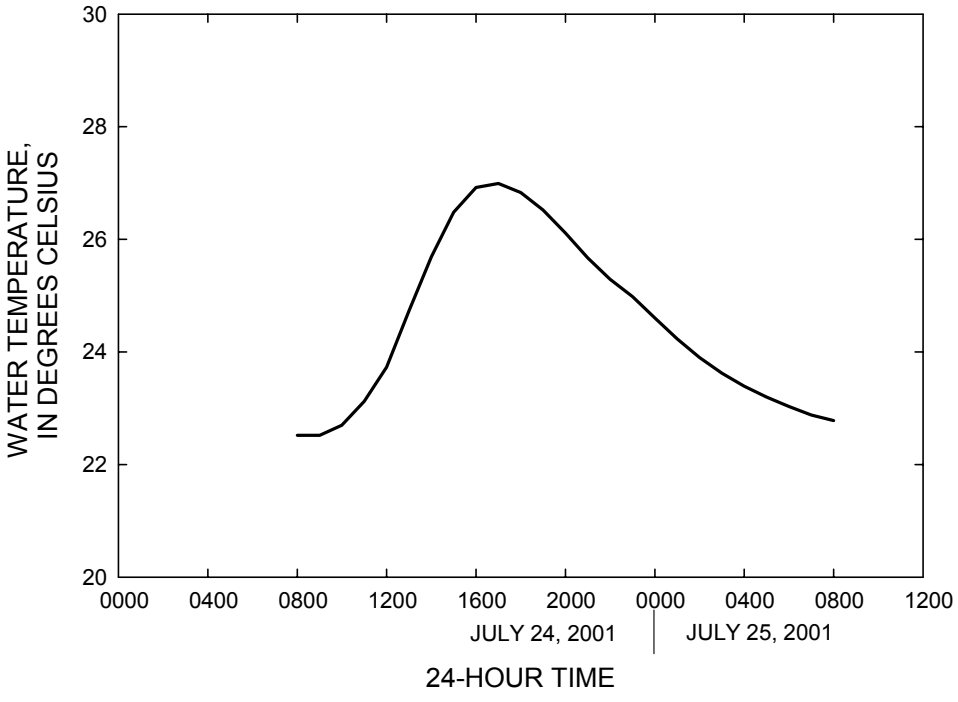


**Figure 12.** Hourly water temperature, 07194880 Osage Creek near Cave Springs, July 24-25, 2001.

## Prairie Creek

Water-quality data were collected at nine surface-water sites on the mainstem of Prairie Creek (table 3). Water-quality data also were collected at four points of inflow (two springs and two tributaries) during this study.

Specific conductance values ranged from 230 to 787 µS/cm (table 4). With the exception of sites PCS-2 and PCM-8, sites were within or near the range of values typical for streams in the Springfield and Salem Plateaus (table 4).

Nitrogen concentrations generally were similar to concentrations typical of other streams in the Springfield and Salem Plateaus and measured concentrations for least-disturbed streams of the Ozark Highlands ecoregion (table 4). Dissolved ammonia concentrations ranged from less than 0.01 to 6.8 mg/L as nitrogen. Dissolved ammonia concentrations for PCM-8 and the next two downstream mainstem sites, PCM-7 and PCM-6, had the highest concentrations that were above the typical level of dissolved ammonia concentrations for streams in the Springfield and Salem Plateaus and were above measured concentrations for least-disturbed streams of the Ozark Highlands ecoregion. All measured dissolved ammonia concentrations for the mainstem of Prairie Creek upstream from Lake Atalanta exceeded the 75th percentile flow-weighted concentration for relatively undeveloped stream basins in the United States. Generally, dissolved ammonia concentrations along the mainstem of Prairie Creek were higher upstream from Lake Atalanta (fig. 13). Dissolved ammonia plus organic nitrogen values ranged from less than 0.05 to 0.43 mg/L with the exception of site PCM-8 with a concentration of 14.3 mg/L. The high concentration of dissolved ammonia and ammonia plus organic nitrogen at site PCM-8 might be indicative of sewage disposal or organic waste (Hem, 1992). Dissolved nitrite concentrations ranged from 0.01 to 0.14 mg/L as nitrogen. Elevated concentrations of nitrite also might be indicative of sewage disposal or organic waste. Dissolved nitrate concentrations ranged from 0.55 to 3.5 mg/L as nitrogen with the highest mainstem concentrations occurring upstream from Lake Atalanta (fig. 13). Mainstem nitrate concentrations were between 383 and 536 percent higher upstream from Lake Atalanta than mainstem nitrate concentrations downstream from the lake. Most concentrations of nitrite plus nitrate for Prairie Creek were above the range measured for some of the least-disturbed streams of the Ozark Highlands ecoregion but were within the range that is typical for several streams in the western part of the Springfield and Salem Plateaus. All concentrations of nitrite plus nitrate for Prairie Creek exceeded the 75th percentile flow-weighted concentration for relatively undeveloped stream basins in the United States.

**Table 3.** Description of surface-water sampling sites in the Prairie Creek Basin

| Site identifier | Site description | Latitude[1] | Longitude[1] | Distance downstream of headwaters (miles) |
|---|---|---|---|---|
| PCM-9 | Prairie Creek mainstem-headwaters | 361946 | 0940629 | 0.00 |
| PCS-2 | Spring 2 | 361946 | 0940629 | 0.01 |
| PCM-8 | Prairie Creek mainstem | 361946 | 0940629 | 0.01 |
| PCM-7 | Prairie Creek mainstem | 361951 | 0940621 | 0.19 |
| PCS-1 | Spring 1 | 361954 | 0940615 | 0.30 |
| PCT-2 | Tributary 2 | 361954 | 0940613 | 0.32 |
| PCT-1 | Tributary 1 | 361955 | 0940613 | 0.35 |
| PCM-6 | Prairie Creek mainstem | 361957 | 0940613 | 0.38 |
| PCM-5 | Prairie Creek mainstem | 362003 | 0940611 | 0.51 |
| PCM-4 | Prairie Creek mainstem | 362028 | 0940544 | 1.20 |
| PCM-3 | Prairie Creek mainstem | 362033 | 0940534 | 1.41 |
| PCM-2 | Prairie Creek mainstem | 362035 | 0940525 | 1.56 |
| PCM-1 | Prairie Creek mainstem-bottom of study reach | 362035 | 0940524 | 1.58 |

[1]Horizontal coordinate information is referenced to the North American Datum of 1927 (NAD 27), unless otherwise noted.

**Table 4.** Discharge and water-quality data for surface-water sites located in the Prairie Creek Basin[1]

[Temperature reported to the nearest 0.1 degree Celsius; °C, degrees Celsius; $ft^3/s$, cubic feet per second; µS/cm at 25 °C, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; cols/100 mL, number of colonies per 100 milliliter of sample; <, less than; >, greater than; --, no data available]

| Site identifier | Date of sample | Time of sample | Water temperature (° C) | Discharge, instantaneous ($ft^3/s$) | Specific conductance (µS/cm at 25 °C) | Oxygen, dissolved (mg/L) | pH field (standard units) | Nitrogen, ammonia, dissolved (mg/L as N) | Nitrogen, nitrite, dissolved (mg/L as N) |
|---|---|---|---|---|---|---|---|---|---|
| PCM-9 | 7-25-01 | 0845 | 15.6 | 0.443 | 309 | 9.8 | 6.6 | 0.11 | 0.01 |
| PCS-2 | 7-25-01 | 0840 | 22.4 | 0.051 | 656 | 6.7 | 7.8 | <0.01 | 0.01 |
| PCM-8 | 7-25-01 | 0900 | 19.7 | 0.096 | 787 | 7.1 | 7.7 | 6.8 | 0.14 |
| PCM-7 | 7-25-01 | 0915 | 16.5 | 0.789 | 380 | 9.8 | 7.6 | 0.65 | 0.09 |
| PCS-1 | 7-25-01 | 0930 | 15.9 | 2.41 | 235 | 9.9 | 7.0 | <0.01 | 0.01 |
| PCT-2 | 7-25-01 | 0945 | 25.5 | 0.008 | 402 | 12.0 | 7.5 | <0.01 | 0.01 |
| PCT-1 | 7-25-01 | 1000 | 15.6 | 0.154 | 446 | 9.1 | 7.5 | <0.01 | 0.01 |
| PCM-6 | 7-25-01 | 1010 | 16.9 | 2.33 | 383 | 10.2 | 7.5 | 0.13 | 0.04 |
| PCM-5 | 7-25-01 | 1040 | 18.9 | 3.17 | 384 | 10.5 | 7.8 | 0.04 | 0.03 |
| PCM-4 | 7-25-01 | 1125 | 29.8 | 2.94 | 232 | 6.8 | 7.9 | 0.01 | 0.02 |
| PCM-3 | 7-25-01 | 1155 | 30.0 | 2.14 | 232 | 7.0 | 7.9 | <0.01 | 0.01 |
| PCM-2 | 7-25-01 | 1220 | 30.9 | 0.72 | 230 | 7.1 | 8.1 | <0.01 | 0.01 |
| PCM-1 | 7-25-01 | 1230 | -- | 0.0 | -- | -- | -- | -- | -- |
| Minimum | | | 15.6 | 0.0 | 230 | 6.7 | 6.6 | <0.01 | 0.01 |
| Maximum | | | 30.9 | 3.17 | 787 | 12.0 | 8.1 | 6.8 | 0.14 |
| Median | | | 19.3 | 0.72 | 382 | 9.4 | 7.6 | <0.01 | 0.01 |
| Typical values for Springfield and Salem Plateaus 1975-1985[2] | -- | -- | -- | -- | 150-400 | -- | -- | <0.10[a] | -- |
| Values for least-disturbed streams in Ozark Highlands ecoregion 1983-1986[3] | -- | -- | -- | -- | -- | -- | -- | <0.01-0.12 | -- |
| Values for undeveloped stream basins of the United States[4] | -- | -- | -- | -- | -- | -- | -- | 0.026[e] | -- |

**Table 4.** Discharge and water-quality data for surface-water sites located in the Prairie Creek Basin[1]--Continued

[Temperature reported to the nearest 0.1 degree Celsius; °C, degrees Celsius; $ft^3/s$, cubic feet per second; µS/cm at 25 °C, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; cols/100 mL, number of colonies per 100 milliliter of sample; <, less than; >, greater than; --, no data available]

| Site identifier | Nitrogen, ammonia + organic, dissolved (mg/L as N) | Nitrogen, nitrate, dissolved (mg/L as N) | Phosphorus, total (mg/L as P) | Ortho-phosphorus, dissolved (mg/L as P) | Chloride, dissolved (mg/L as Cl) | Sulfate, dissolved (mg/L as $SO_4$) | Fluoride, dissolved (mg/L as F) | Total suspended solids (mg/L) |
|---|---|---|---|---|---|---|---|---|
| PCM-9 | <0.05 | 3.2 | 0.05 | <0.02 | 7.8 | 2.5 | 0.03 | 0.4 |
| PCS-2 | 0.28 | 2.7 | 0.06 | 0.03 | 16.8 | 49.0 | 0.09 | 7.4 |
| PCM-8 | 14.3 | 2.8 | 0.23 | 0.19 | 22.9 | 20.5 | 0.08 | 8.4 |
| PCM-7 | 0.24 | 3.5 | <0.02 | <0.02 | 9.3 | 4.6 | 0.00 | 3.2 |
| PCS-1 | <0.05 | 3.4 | 0.22 | <0.02 | 11.3 | 5.0 | 0.02 | 0.20 |
| PCT-2 | <0.05 | 1.5 | <0.02 | <0.02 | 10.6 | 4.5 | 0.01 | 1.0 |
| PCT-1 | <0.05 | 2.8 | <0.02 | <0.02 | 11.3 | 3.9 | 0.00 | 1.4 |
| PCM-6 | <0.05 | 3.4 | 0.04 | <0.02 | 10.7 | 4.9 | 0.00 | 1.2 |
| PCM-5 | <0.05 | 3.3 | 0.05 | <0.02 | 10.9 | 4.8 | 0.01 | 2.2 |
| PCM-4 | 0.43 | 0.57 | <0.02 | <0.02 | 10.3 | 4.9 | 0.00 | 5.0 |
| PCM-3 | 0.38 | 0.58 | <0.02 | <0.02 | 10.4 | 4.8 | 0.01 | 2.4 |
| PCM-2 | 0.39 | 0.55 | <0.02 | <0.02 | 10.4 | 4.9 | 0.01 | 4.8 |
| PCM-1 | -- | -- | -- | -- | -- | -- | -- | -- |
| Minimum | <0.05 | 0.55 | <0.02 | <0.02 | 7.8 | 2.5 | 0.00 | 0.20 |
| Maximum | 14.3 | 3.5 | 0.23 | 0.19 | 22.9 | 49.0 | 0.09 | 8.4 |
| Median | 0.14 | 2.8 | 0.03 | <0.02 | 10.6 | 4.8 | 0.01 | 2.3 |
| Typical values for Springfield and Salem Plateaus 1975-1985[2] | -- | 0.2-0.5[b] | <0.05[c] | -- | 5-10 | 5-10 | -- | -- |
| Values for least-disturbed streams in Ozark Highlands ecoregion 1983-1986[3] | -- | 0.19-1.92 | <0.10[d] | -- | -- | -- | -- | -- |
| Values for undeveloped stream basins of the United States[4] | -- | 0.21[e,f] | 0.037[e] | -- | -- | -- | -- | -- |

[1]Water-quality analyses performed by Rogers Water Utilities with the exception of analyses of chloride, fluoride, nitrate, and sulfate, which were performed by Arkansas Water Resources Laboratory.
[2]Petersen, 1988.
[3]Arkansas Department of Pollution Control and Ecology, 1987.
[4]Clark and others, 2000.
[a]Total ammonia.
[b] Nitrite plus nitrate, 1 to 4 mg/L in several streams in the western part of Springfield and Salem Plateaus.
[c]0.1 to 1 mg/L in several streams in western part of Springfield and Salem Plateaus.
[d]For all but one least-disturbed reference stream.
[e]75th percentile flow-weighted nutrient concentrations for all basins studied.
[f]Nitrite plus nitrate.

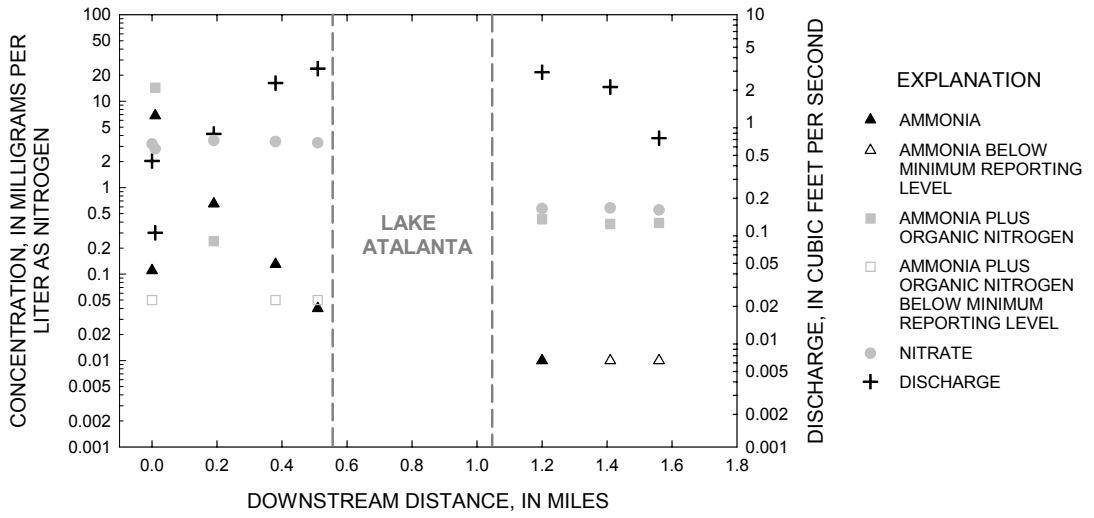


**Figure 13.** Discharge and concentrations of ammonia, ammonia plus organic nitrogen, and nitrate along the mainstem of Prairie Creek.

Phosphorus concentrations generally were similar to concentrations typical of other streams in the Springfield and Salem Plateaus and measured concentrations for least-disturbed streams of the Ozark Highlands ecoregion. Total phosphorus concentrations ranged from less than 0.02 to 0.23 mg/L with the highest concentration measured at site PCM-8 (fig. 14). Concentrations of total phosphorus at sites PCM-8 and PCS-1 were above the typical level for streams in the Springfield and Salem Plateaus, were above concentrations measured for least-disturbed streams of the Ozark Highlands ecoregion, and exceeded the 75th percentile flow-weighted concentration for relatively undeveloped stream basins in the United States. All concentrations were below or within the range typical for several streams in the western part of the Springfield and Salem Plateaus. Most measured concentrations of total phosphorus upstream from Lake Atalanta exceeded, while all measured total phosphorus concentrations downstream from the lake did not exceed, the 75th percentile flow-weighted concentration for relatively undeveloped stream basins in the United States. Elevated total phosphorus concentrations measured at sites PCM-8 and PCS-1 might be indicative of sewage or animal metabolic waste (Hem, 1992). Dissolved orthophosphorus concentrations ranged from less than 0.02 to 0.19 mg/L as phosphorus with concentrations measured above the detection limit only at sites PCM-8 and PCS-2 (fig. 14). Bacteriological analyses were not performed on Prairie Creek during the study.

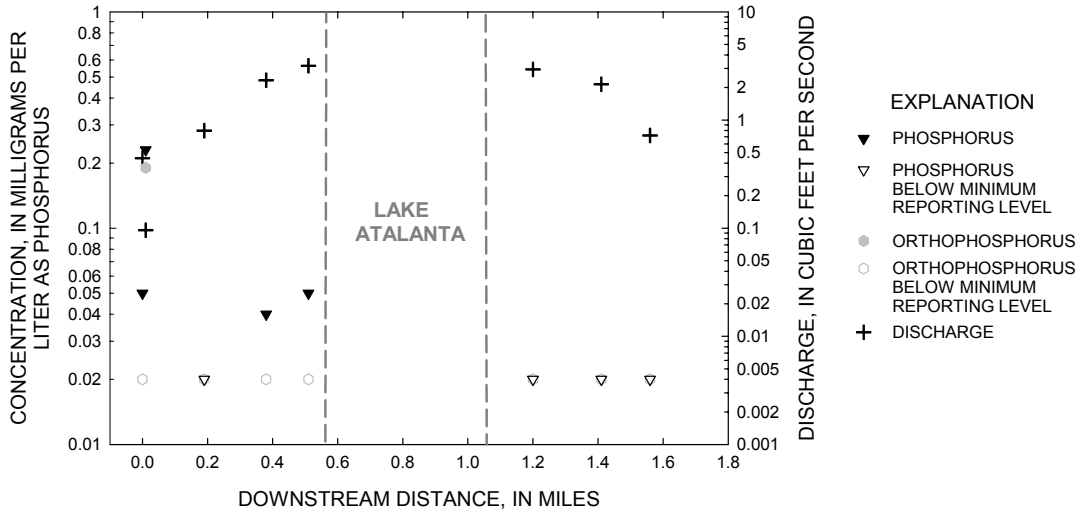


**Figure 14.** Discharge and concentrations of phosphorus and orthophosphorus along the mainstem of Prairie Creek.

Samples also were analyzed for chloride, sulfate, and fluoride. Dissolved chloride ranged from 7.8 to 22.9 mg/L with the highest concentration measured at site PCM-8 (fig. 15). With the exception of sites PCM-8 and PCS-2, concentrations of dissolved chloride for Prairie Creek were either typical or slightly elevated with respect to other streams in the Springfield and Salem Plateaus (table 4). Dissolved fluoride concentrations ranged from 0 to 0.09 mg/L, with the highest concentrations occurring at sites PCS-2 and PCM-8. Dissolved sulfate concentrations ranged from 2.5 to 49.0 mg/L with the highest concentrations measured at sites PCS-2 and PCM-8. With the exception of these two sites, concentrations of dissolved sulfate for Prairie Creek were typical with respect to other streams in the Springfield and Salem Plateaus (table 4). Sulfates may be produced during organic waste treatment (Hem, 1992), and elevated concentrations of sulfate at PCS-2 and PCM-8 may have been caused by water leaking from septic systems.

Hourly dissolved-oxygen concentration, pH, and water temperature data were collected at two locations on Prairie Creek from July 25 to July 26, 2001 (figs. 16, 17, and 18). These data were collected to describe fluctuations of dissolved-oxygen concentrations, pH, and water temperature during the study. At water-quality sampling location PCM-5, immediately upstream from Lake Atalanta, a minimum dissolved-oxygen concentration of 8.1 mg/L was recorded at 0200 hours on July 26, and a maximum dissolved-oxygen concentration of 9.9 mg/L was recorded at 1200 hours on July 25. A minimum pH value of 7.6 was recorded at 0800 and at 2200 hours on July 25 and from 0100 to 0700 hours on July 26. A maximum pH value of 7.8 was recorded from 1000 to 1900 hours on July 25. A minimum water temperature of 16.2 °C was recorded from 0200 to 0700 hours on July 26, and a maximum water temperature of 18.7 °C was recorded at 1400 hours on July 25. These low water temperatures are indicative of a large component of the streamflow derived from groundwater discharge upstream from PCM-5.

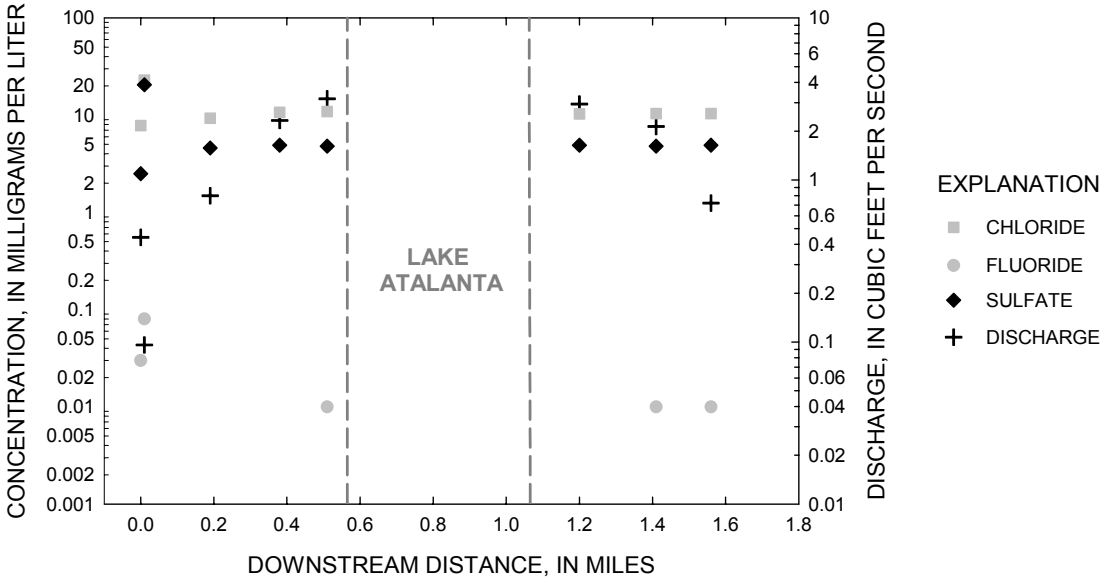


**Figure 15.** Discharge and concentrations of chloride, fluoride, and sulfate along the mainstem of Prairie Creek.

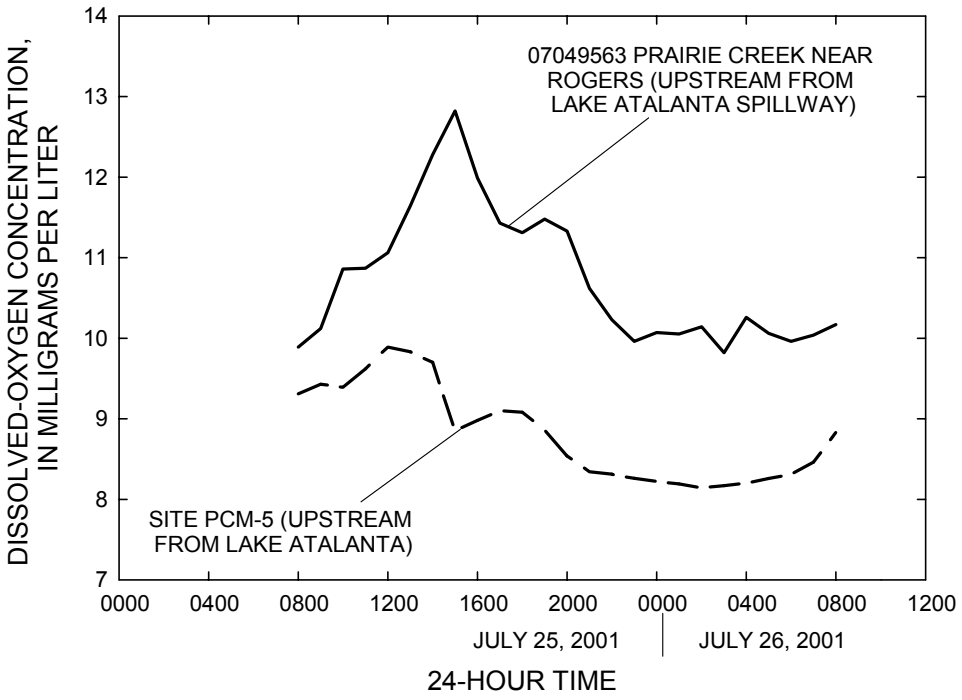


**Figure 16.** Hourly dissolved-oxygen concentrations at PCM-5 and 07049563 Prairie Creek near Rogers, July 25-26, 2001.

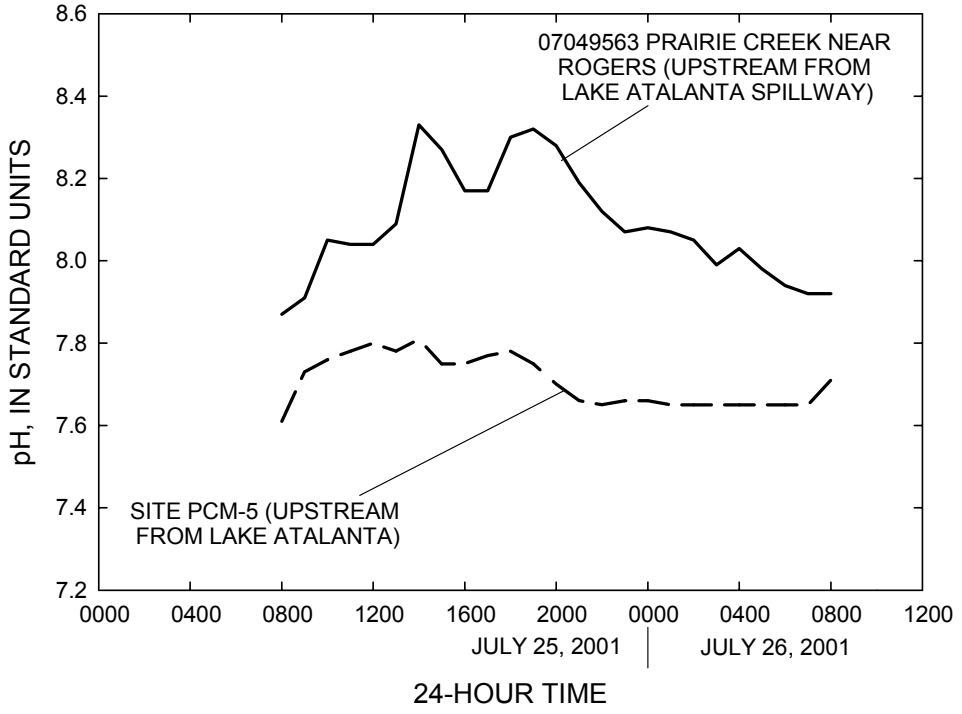


**Figure 17.** Hourly pH values at PCM-5 and 07049563 Prairie Creek near Rogers, July 25-26, 2001.

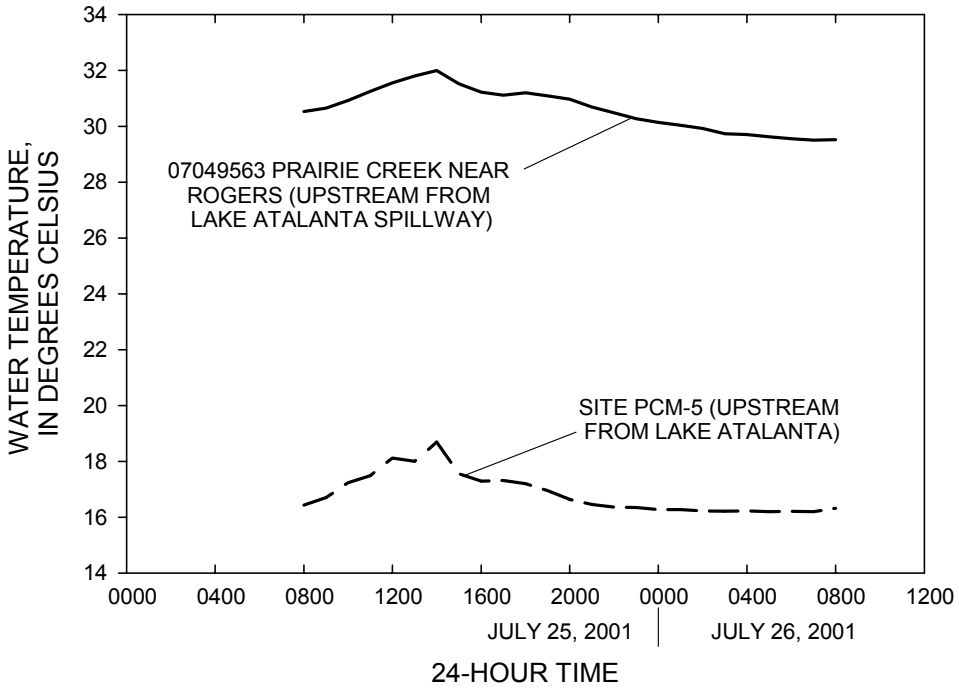


**Figure 18.** Hourly water temperature at PCM-5 and 07049563 Prairie Creek near Rogers, July 25-26, 2001.

At the USGS gaging station on Prairie Creek, a minimum dissolved-oxygen concentration of 9.8 mg/L was recorded at 0300 on July 26, and a maximum dissolved-oxygen concentration of 12.8 mg/L was recorded at 1500 hours on July 25. A minimum pH value of 7.9 was recorded from 0800 to 0900 hours on July 25 and from 0600 to 0800 hours on July 26. A maximum pH value of 8.3 was recorded from 1400 to 1500 hours and 1800 to 2000 hours on July 25. A minimum water temperature of 29.5 °C was recorded from 0700 to 0800 hours on July 26, and a maximum water temperature of 32.0 °C was recorded at 1400 hours on July 25. Dissolved-oxygen concentrations, pH, and temperature values were higher at the USGS gaging station upstream from the Lake Atalanta spillway than at PCM-5 during this study.

## STREAMFLOW GAIN AND LOSS

Streamflow measurements were made at 18 locations in the Osage Creek Basin on July 24, 2001, and 13 locations in the Prairie Creek Basin on July 25, 2001. Comparison of successive downstream streamflow measurements was used to determine if the stream reaches were gaining or losing flow.

### Osage Creek

Streamflow measurements were made at 12 sites along the mainstem of Osage Creek and at 6 points of inflow (1 spring, 4 tributaries, and 1 WTP) during the study.[2] Measured flow for the mainstem of Osage Creek ranged from 2.34 to 19.1 cubic feet per second ($ft^3/s$) (table 5; fig. 19).

Streamflow at OCM-12 (headwaters) was 2.34 $ft^3/s$, and the streamflow at OCM-1 (the downstream end of the study reach) was 15.7 $ft^3/s$. The lower reaches of Osage Creek in this study have been identified as having a 7-day, 10-year low flow ranging between 1.0 and 10 $ft^3/s$ (Hunrichs, 1983). Streamflow measured at the downstream end of the study reach

[2]Flow conditions at the location where the outflow of WTP-1 was measured were beyond the limitations of the current meter used, and therefore, inflow from WTP-1 could not be determined according to U.S. Geological Survey methods.

**Table 5.** Streamflow balance on Osage Creek during study on July 24, 2001

[$ft^3/s$, cubic foot per second; **bold** numbers are gains or losses greater than the measurement error for that particular reach; NA, unknown]

| Site identifier | Time | Streamflow, instantaneous, ($ft^3/s$) | Difference between downstream and upstream streamflow, ($ft^3/s$) | Measured inflow between downstream and upstream sites, ($ft^3/s$) | Measurement error between downstream and upstream sites ($ft^3/s$) | Gain in surface streamflow, ($ft^3/s$) |
|---|---|---|---|---|---|---|
| OCM-12 | 1015 | 2.34 | | | | |
| | | | 4.83 | 2.94 | 1.11 | **1.89** |
| OCM-11 | 1135 | 7.17 | | | | |
| | | | -0.30 | 0 | 0.70 | -0.30 |
| OCM-10 | 1100 | 6.87 | | | | |
| | | | -0.71 | 0 | 0.65 | **-0.71** |
| OCM-9 | 1210 | 6.16 | | | | |
| | | | -0.06 | 0 | 0.61 | -0.06 |
| OCM-8 | 1210 | 6.10 | | | | |
| | | | 0.58 | 0 | 0.84 | 0.58 |
| OCM-7 | 1320 | 6.68 | | | | |
| | | | 1.89 | 1.94 | 1.65 | -0.05 |
| OCM-6 | 1415 | 8.57 | | | | |
| | | | 2.23 | 0 | 1.23 | **2.23** |
| OCM-5 | 1425 | 10.8 | | | | |
| | | | 8.30 | NA[1] | NA | NA |
| OCM-4 | 1540 | 19.1 | | | | |
| | | | -2.40 | 0 | 2.86 | -2.40 |
| OCM-3 | 1625 | 16.7 | | | | |
| | | | 0.50 | 0 | 2.76 | 0.50 |
| OCM-2 | 1640 | 17.2 | | | | |
| | | | -1.50 | 0 | 2.12 | -1.50 |
| OCM-1 | 1800 | 15.7 | | | | |

[1]Flow conditions at the location where the outflow of WTP-1 was measured were beyond the limitations of the current meter used, and therefore, inflow from WTP-1 could not be determined according to U.S. Geological Survey methods.

indicated that streamflow at Osage Creek during the study was near, but above the 7-day, 10-year low-flow range.

A previous streamflow gain and loss study on Osage Creek, which began just downstream from the WTP, indicated that Osage Creek is probably a gaining stream; however, because wastewater treatment plant discharges were highly variable during the study, an accurate determination of gaining and losing reaches was not able to be made (Freiwald, 1987). A better determination of gaining and losing reaches was able to be made during the current (2001) study. One losing and two gaining reaches were identified along the mainstem of Osage Creek (table 5; fig. 20). The study reach upstream from the WTP had a net gain of 3.58 $ft^3/s$ from the ground-water system; there were no gaining or losing reaches identified downstream from the WTP.

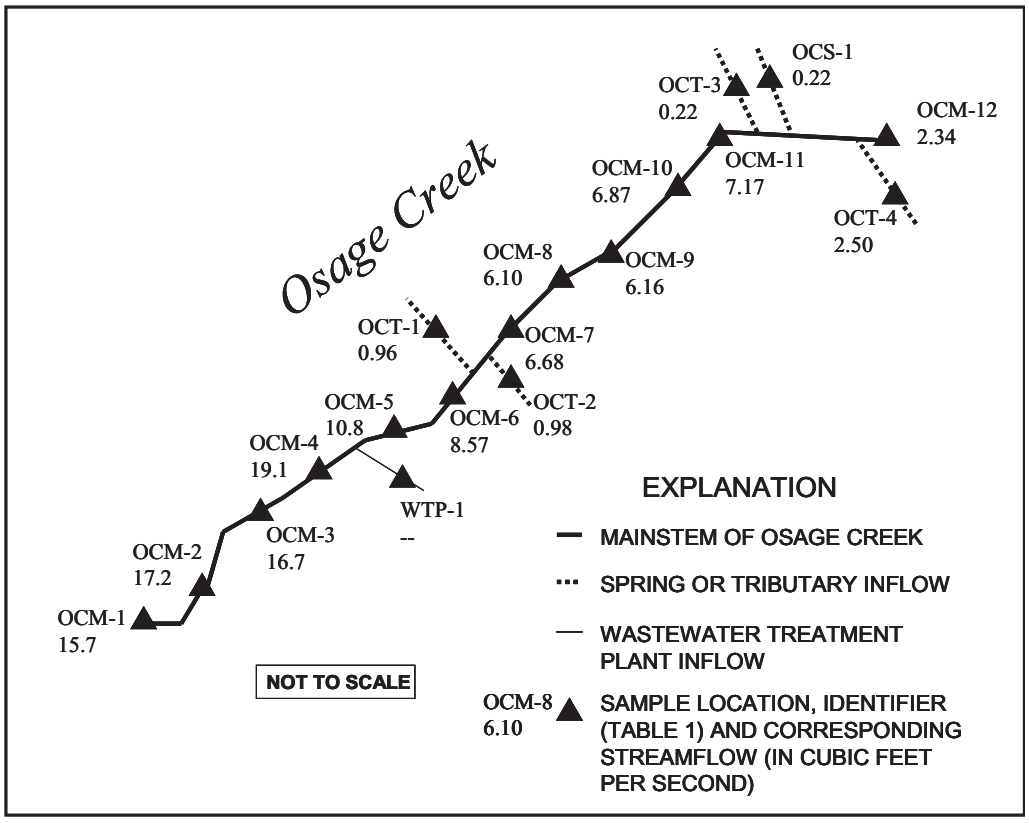


**Figure 19.** Streamflow at mainstem and inflow sample locations on Osage Creek, July 24, 2001.

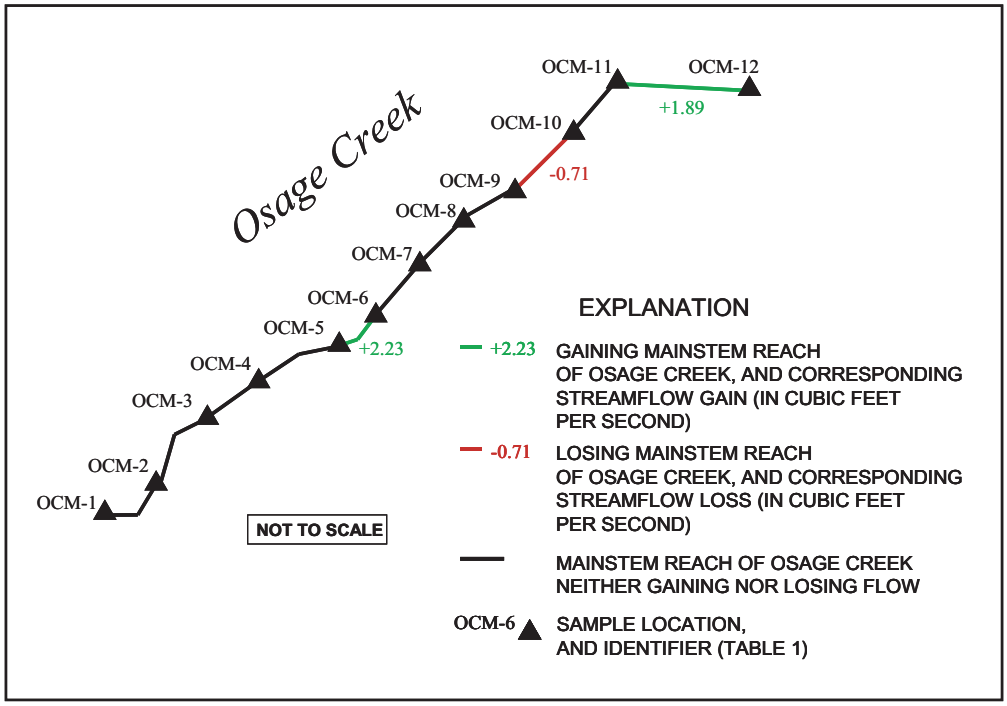


**Figure 20.** Gains and losses in surface flow between mainstem sample locations on Osage Creek, July 24, 2001.

While no sections of the Osage Creek streambed were dry and surface flow was present at all sites, gaining and losing reaches were identified. The presence of gaining and losing reaches along the mainstem indicates interaction between the Springfield Plateau aquifer and surface flow of Osage Creek.

## Prairie Creek

Nine streamflow measurements were made along the mainstem of Prairie Creek and four streamflow measurements (two springs, two tributaries) were made at points of inflow during the study. Measured flow for Prairie Creek during the study ranged from 0 to 3.17 $ft^3/s$ (table 6; fig. 21).

Three losing and two gaining reaches were identified along the mainstem of Prairie Creek during the study (fig. 22). Streamflow at PCM-9 (headwaters) was 0.44 $ft^3/s$, and streamflow at PCM-1 (the downstream end of the study reach) was 0 $ft^3/s$. The study reach had a net loss of 3.06 $ft^3/s$ to the ground-water system.

At site PCM-1, the downstream end of the study reach, surface flow disappeared, and the streambed was dry for the remaining 0.8 mile of Prairie Creek to Beaver Lake. The presence of gaining and losing reaches along the mainstem indicate interaction between the Springfield Plateau aquifer and surface flow of Prairie Creek.

**Table 6.** Streamflow balance on Prairie Creek during study on July 25, 2001

[$ft^3/s$, cubic foot per second; **bold** numbers are gains or losses greater than the measurement error for that particular reach]

| Site identifier | Time | Streamflow, instantaneous, ($ft^3/s$) | Difference between downstream and upstream streamflow, ($ft^3/s$) | Measured inflow between downstream and upstream sites, ($ft^3/s$) | Measurement error between downstream and upstream sites ($ft^3/s$) | Gain in surface streamflow, ($ft^3/s$) |
|---|---|---|---|---|---|---|
| PCM-9 | 0840 | 0.44 | | | | |
| | | | -0.34 | 0.05 | 0.14 | **-0.39** |
| PCM-8 | 0855 | 0.10 | | | | |
| | | | 0.69 | 0 | 0.23 | **0.69** |
| PCM-7 | 0905 | 0.79 | | | | |
| | | | 1.54 | 2.57 | 0.49 | **-1.03** |
| PCM-6 | 1010 | 2.33 | | | | |
| | | | 0.84 | 0 | 0.37 | **0.84** |
| PCM-5 | 1040 | 3.17 | | | | |
| | | | -0.23 | 0 | 0.49 | -0.23 |
| PCM-4 | 1125 | 2.94 | | | | |
| | | | -0.80 | 0 | 0.41 | **-0.80** |
| PCM-3 | 1200 | 2.14 | | | | |
| | | | -1.42 | 0 | 0.23 | **-1.42** |
| PCM-2 | 1215 | 0.72 | | | | |
| | | | -0.72 | 0 | 0.06 | **-0.72** |
| PCM-1 | 1230 | 0 | | | | |

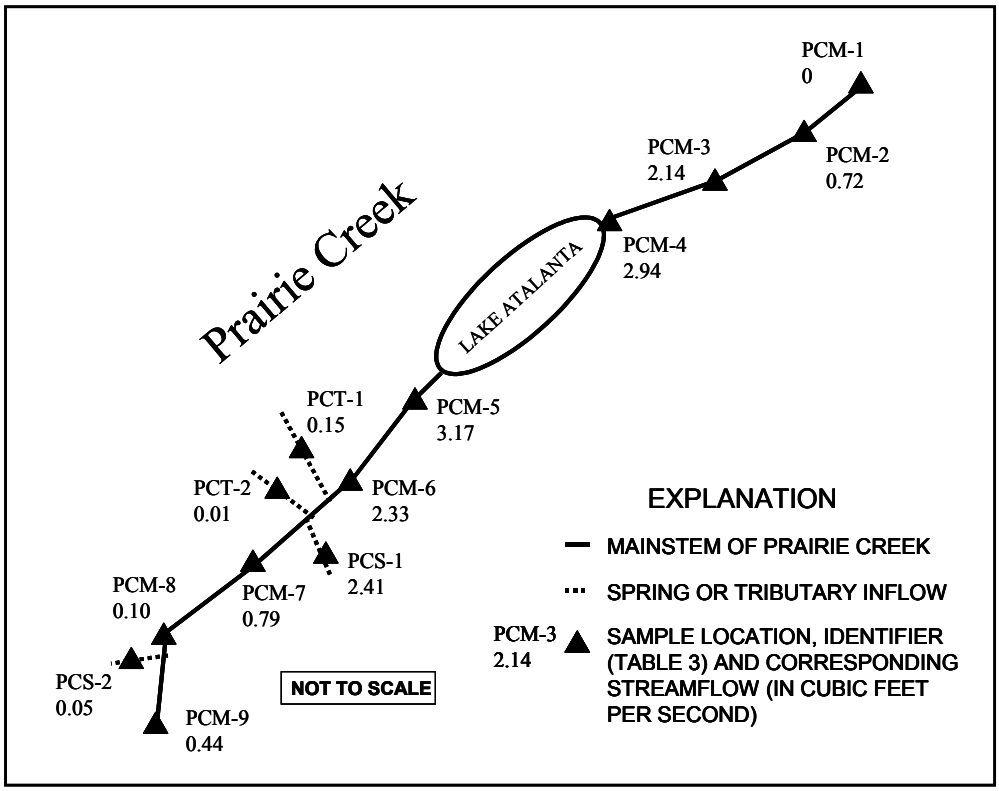


**Figure 21.** Streamflow at mainstem and inflow sample locations on Prairie Creek, July 25, 2001.

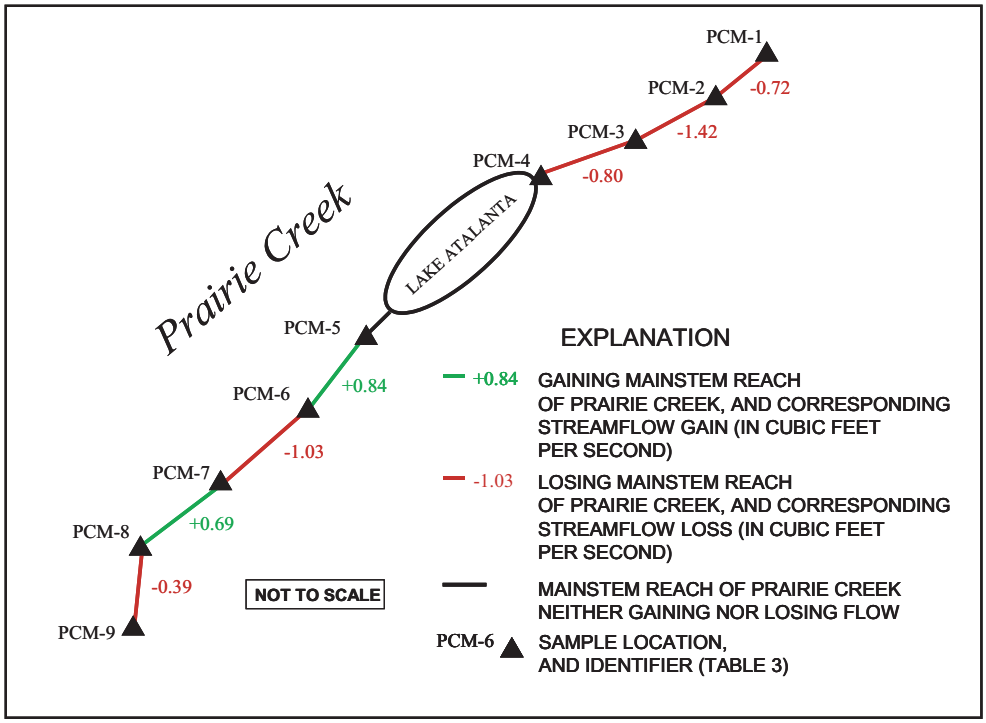


**Figure 22.** Gains and losses in surface flow between mainstem sample locations on Prairie Creek, July 25, 2001.

## SUMMARY

A study of water quality and streamflow gains and losses within Osage and Prairie Creeks, Benton County, Arkansas, was undertaken from July 24 to July 26, 2001. The creeks are located in northwestern Arkansas. Water-quality samples collected during the study were analyzed to describe the range in physical parameters and concentrations for various bacteriological (Osage Creek only) and chemical parameters. Water-quality analyses were performed by Rogers Water Utilities and the Arkansas Water Resources Laboratory. Streamflow measurements were made along the mainstem of each creek and at points of inflow (prior to confluence with the mainstem). Comparison of successive downstream streamflow measurements was used to determine if the stream reaches were gaining or losing flow.

Water-quality data were collected at 12 surface-water sites on the mainstem of Osage Creek and at 6 points of inflow. Dissolved ammonia concentrations ranged from less than 0.01 to 0.04 mg/L as nitrogen and were within the typical range of dissolved ammonia concentrations for the Springfield and Salem Plateaus and within the range measured for some of the least-disturbed streams of the Ozark Highlands ecoregion. Dissolved nitrate concentrations ranged from 1.7 to 4.0 mg/L as nitrogen. While concentrations of nitrite plus nitrate for Osage Creek were above the range that is typical for streams in the Springfield and Salem Plateaus and the range measured for least-disturbed reference streams of the Ozark Highlands ecoregion, concentrations were within the range that is typical for several streams in the western part of the Springfield and Salem Plateaus. Total phosphorus concentrations ranged from 0.04 to 0.28 mg/L and were higher at sites located downstream from the WTP than upstream from the WTP. Most total phosphorus concentrations for Osage Creek were within the range that is typical for several streams in the western part of the Springfield and Salem Plateaus.

Hourly dissolved-oxygen concentration, pH, and water temperature data were collected for a 24-hour period at the USGS gaging station on Osage Creek near Cave Springs, Arkansas (07194880), to describe the fluctuations that occurred in these parameters at Osage Creek during the study. Dissolved-oxygen concentrations ranged from 5.4 to 8.6 mg/L, pH values ranged from 7.3 to 7.8, and water temperatures ranged from 22.5 to 27.0 °C at this site.

Water-quality data were collected at nine surface-water sites on the mainstem of Prairie Creek and at four points of inflow. Dissolved ammonia concentrations ranged from less than 0.01 to 6.8 mg/L as nitrogen with the highest concentration measured at site PCM-8. Dissolved ammonia concentrations for PCM-8 and subsequent mainstem sites, PCM-7 and PCM-6, were above the typical level of dissolved ammonia concentrations measured for streams in the Springfield and Salem Plateaus. High concentration of dissolved ammonia measured at site PCM-8 and the next two downstream mainstem sites might be indicative of sewage disposal or organic waste. Dissolved nitrate concentrations ranged from 0.55 to 3.5 mg/L as nitrogen with the highest mainstem concentrations occurring upstream from Lake Atalanta. Most concentrations of nitrite plus nitrate for Prairie Creek were above the range measured for some of the least-disturbed streams of the Ozark Highlands ecoregion but were within the range that is typical for several streams in the western part of the Springfield and Salem Plateaus. Total phosphorus concentrations ranged from less than 0.02 to 0.23 mg/L with the highest concentration measured at site PCM-8. Total phosphorus concentrations were below or within the range that is typical for several streams in the western part of the Springfield and Salem Plateaus. Elevated concentrations of total phosphorus measured at sites PCM-8 and PCS-1 might be indicative of sewage or animal metabolic waste.

Hourly dissolved-oxygen concentrations, pH, and water temperature also were collected for a 24-hour period at an upstream site and a downstream site on the mainstem of Prairie Creek to describe the fluctuations that occurred in these parameters during the study. Dissolved-oxygen concentrations ranged from 8.1 to 9.9 mg/L, pH values ranged from 7.6 to 7.8, and water temperatures ranged from 16.2 to 18.7 °C at the upstream site. Dissolved-oxygen concentrations ranged from 9.8 to 12.8 mg/L, pH values ranged from 7.9 to 8.3, and water temperatures ranged from 29.5 to 32.0 ° C at the downstream site.

Identification of losing and gaining reaches indicates that interaction exists between the local shallow unconfined ground-water aquifer and surface flow in Osage and Prairie Creeks. Measured streamflow for the mainstem of Osage Creek ranged from 2.34 to 19.1 $ft^3/s$ during this study. Streamflow measured at the beginning of the study reach for Osage Creek was 2.34 $ft^3/s$, and streamflow measured at the downstream end of the study reach was 15.7 $ft^3/s$. One losing and two gaining

reaches were identified on the mainstem of Osage Creek with a net gain of 3.58 $ft^3/s$ from the ground-water system upstream from the WTP; there were no gaining or losing reaches identified downstream from the WTP. Measured streamflow for the mainstem of Prairie Creek ranged from 0 to 3.17 $ft^3/s$ during this study. Streamflow measured at the beginning of the study reach for Prairie Creek was 0.44 $ft^3/s$, and the streambed was dry at the downstream end of the study reach. Three losing and two gaining reaches were identified on the mainstem of Prairie Creek with a net loss of 3.06 $ft^3/s$ to the ground-water system.

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