Base Flow, Water Quality, and Streamflow Gain and Loss of the Buffalo River, Arkansas, and Selected Tributaries, July and August 2003

Prepared in cooperation with the
NATIONAL PARK SERVICE

Scientific Investigations Report 2004-5274

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

Front Cover: Photographs of the Buffalo River in northern Arkansas. Photographs by Chuck Haralson, Arkansas Department of Parks and Tourism

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U.S. Department of the Interior
Gale A. Norton, Secretary

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Conversion Factors and Datum

Multiply	By	To obtain
Length		
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
Area		
square mile (mi^2)	2.590	square kilometer (km^2)
Volume		
acre-foot (acre-ft)	1,233	cubic meter (m^3)
acre-foot (acre-ft)	0.001233	cubic hectometer (hm^3)
Flow rate		
acre-foot per year (acre-ft/yr)	1,233	cubic meter per year (m^3/yr)
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)
gallon per minute (gal/min)	0.06309	liter per second (L/s)
Hydraulic gradient		
foot per mile (ft/mi)	0.1894	meter per kilometer (m/km)

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), unless otherwise noted.

Altitude, as used in this report, refers to distance above the vertical datum.

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).

Water year in USGS reports dealing with surface-water supply is the 12-month period October 1 through September 30. The water year is designated by the calendar year in which it ends and which includes 9 of the 12 months. Thus, the year ending September 30, 2003, is called the “2003 water year.”

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Abstract

A study of the Buffalo National River in north-central Arkansas was conducted between July 28-30 and August 13-15, 2003, to characterize the base-flow and water-quality characteristics and streamflow gain and loss in the Buffalo River. The study was separated into two time periods because of a precipitation event that occurred on the afternoon of July 30 causing appreciable storm runoff. Streamflow was separated to identify base-flow and surface-runoff components using the Base Flow Index hydrograph separation computer program. Base-flow separation analyses indicated annual variability in streamflow throughout the Buffalo River Basin. Based upon these analyses, total and base flow were below average for the mainstem of the river and Richland Creek during the 2003 water year. Water-quality samples were collected from 25 surface-water sites on the Buffalo River and selected tributaries. Most nutrient concentrations for the mainstem of the Buffalo River were near or below the minimum reporting level and were less than the median flow-weighted concentration for relatively undeveloped stream basins in the United States. Streamflow measurement data were collected at 44 locations along the mainstem of the Buffalo River and at points of inflow (prior to confluence with the mainstem) to identify gaining and losing reaches. Seven gaining and five losing reaches were identified for the Buffalo River. Additionally, surface flow on the mainstem of the Buffalo River was diverted to subsurface flow on the mainstem at two locations (river miles 73.6 and 131.6) where the mainstem was found to be dry. Reaches throughout the length of the river had calculated gains or losses that were less than the sum of measurement errors for the respective reaches of river.

Introduction

The Buffalo River lies within the White River Basin in north-central Arkansas. It has a length of approximately 150 mi (National Park Service, 2004) and at its mouth has a drainage area of 1,340 mi^2 (Sullavan, 1974). Most of the length of the Buffalo River lies within the boundaries of the Buffalo National River, a unit of the National Park Service (National Park Service, 2004). In July and August of 2003, the U.S. Geological Survey (USGS) in cooperation with the National Park Service conducted a study to characterize the hydrology and water-quality characteristics of the Buffalo River during base-flow conditions. The purpose of this report is to present results of a base-flow separation analysis for the Buffalo River and selected tributaries, present measured streamflow and water-quality data from1 mi upstream from the mouth to 133 mi upstream from the mouth of the Buffalo River at various locations on the Buffalo River and selected tributaries, and present analyses of streamflow gains and losses along the Buffalo River. Base-flow separation analysis was used to separate total flow into components of base flow and surface runoff. Water-quality data presented include nutrient, bacteria, and selected field parameters. Analysis of streamflow measurements were used to identify gaining, losing, and dry reaches of the Buffalo River.

Description of Study Area

The Buffalo River, located in north-central Arkansas, primarily flows in an easterly direction through Newton, Searcy, and Marion Counties (plate 1). The study reach for the Buffalo River begins at the USGS streamflow-gaging station near Boxley (07055646) and ends approximately 1 mile above the mouth of the river (plate 1). Land-surface elevations range from approximately 380 ft above NGVD of 1929[1] near the mouth of the river to 1,140 ft above NGVD of 1929 at the Boxley streamflow-gaging station. The mainstem of the Buffalo River located within the study reach has a length of 132 mi with an approximate mean gradient of 5.8 ft/mi.

The Buffalo River originates in the Boston Mountains physiographic section, and flows through the Springfield Plateau and Salem Plateau physiographic sections (plate 1). The

[1]In this report "NGVD of 1929" refers to the National Geodetic Vertical Datum of 1929—a geodetic datum derived from a general adjustment of the first-order level notes of the United States and Canada formerly called Sea Level Datum of 1929.

surficial geology of the Buffalo River Basin consists of Pennsylvanian-, Mississippian-, and Ordovician-age formations of the Ozark Plateaus system (Frezon and Glick, 1959) (fig. 1). The Boston Mountains physiographic section within the basin is at the highest elevations and is composed of Pennsylvanian- and upper Mississippian-age formations (Fenneman, 1938). The basin is dominated by the Springfield Plateau which is composed of the karstic Boone Formation (lower Mississippian-age). The lowest portion of the Buffalo River Basin consists in part of the Salem Plateau which is composed of Ordovician-age formations. The largest parts of the river within the study area flow across the Boone Formation and the St. Peter Sandstone and Everton Formation (middle Ordovician-age) (Haley and others, 1993) (fig. 1).

The Boone Formation is composed of limestone, chert, and minor beds of shale and sandstone and ranges in thickness from 50 to 375 ft (Frezon and Glick, 1959). Residual cherty rubble typically yields 2 to 5 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 St. Peter Sandstone and Everton Formation are undifferentiated in the basin and are composed mostly of sandstone and sandy dolomite and range in thickness from a beveled edge to 1,380 ft (Frezon and Glick, 1959). Where fractured and porous, dolomites and sandstones of the St. Peter Sandstone and Everton Formation commonly yield 5 to 10 gal/min, and yields from some wells may exceed 50 gal/min (Lamonds, 1972; Freiwald, 1987). Dolomites of lower Ordovician-age formations generally yield around 10 gal/min, but where solution channels have developed, larger yields are possible (Freiwald, 1987).

The karst ground-water system in northern Arkansas is underdrained by carbonate-rock aquifers that have been fractured and dissolved to form an open network of caves, enlarged fractures, bedding planes, conduits, sinkholes, sinking streams, and springs. 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 channel. In such networks, it is not unusual for medium-sized streams to disappear into rock openings and reappear at the surface in another location, thereby completely disrupting the surface drainage system (Winter and others, 1999).

Acknowledgments

This study was conducted in cooperation with the National Park Service. Several National Park Service employees provided logistical support and assisted with the collection of hydrologic data during the study; Faron Usrey, Jessica Luraas, John Petty, and Jan Hinsey were particularly helpful. The National Park Service also provided a dissolved-oxygen meter and conductivity meter used to collect water-quality data, and a canoe, square-stern boat, and boat motor used to help navigate the river when needed. Additionally, the National Park Service provided lodging for the data-collection team. The cooperation of this agency and each of these individuals is gratefully appreciated.

Methods

A base-flow separation analysis, and a streamflow and water-quality data collection effort were conducted to characterize base-flow hydrology and water quality of the Buffalo River and selected tributaries. Streamflow and water-quality data were collected during the first year of the study. A base-flow separation analysis combined with an analysis of collected streamflow and water-quality data were performed during the second year of the study.

Base-Flow Separation

Streamflow was analyzed using the Base Flow Index (BFI) hydrograph separation computer program to identify base-flow and surface-runoff components (Wahl and Wahl, 1995) for five USGS streamflow gaging stations in the Buffalo River Basin including Buffalo River near Boxley (07055646), Buffalo River near St. Joe (07056000), Richland Creek near Witts Springs (07055875), Calf Creek near Silver Hill (07055893), and Bear Creek near Silver Hill (07056515) (plate 1). Base-flow separation was based on daily streamflow data for the period of record for the five streamflow-gaging stations which are available in the USGS National Water Information System (http://water.usgs.gov/nwis). The BFI program is based on the Institute of Hydrology method of base-flow separation, which divides the water year into increments and identifies the minimum flow for each increment. A 3-day increment was used for Buffalo River near Boxley, a 5-day increment was used for Buffalo River near St. Joe, a 4-day increment was used for Richland Creek, a 2-day increment was used for Calf Creek, and a 3-day increment was used for Bear Creek. Selections of increments are influenced by the size of the drainage area and were determined based upon methods described by Wahl and Wahl (1995). Minimums are compared to adjacent minimums to determine turning points on the base-flow hydrograph. If 90 percent of a given minimum is less than both adjacent minimums, then that minimum is a turning point. Straight lines are drawn between the turning points to define the base-flow hydrograph. The area beneath the hydrograph is the estimate of the volume of base flow for the period. The ratio of the base-flow volume to the total-flow volume is the base-flow index (Wahl and Wahl, 1995).

Streamflow and Water-Quality Data Collection and Analysis

Streamflow and water-quality data were collected from the Buffalo River and selected tributaries on July 28-30 and August 13-15, 2003. The study was separated into two time periods

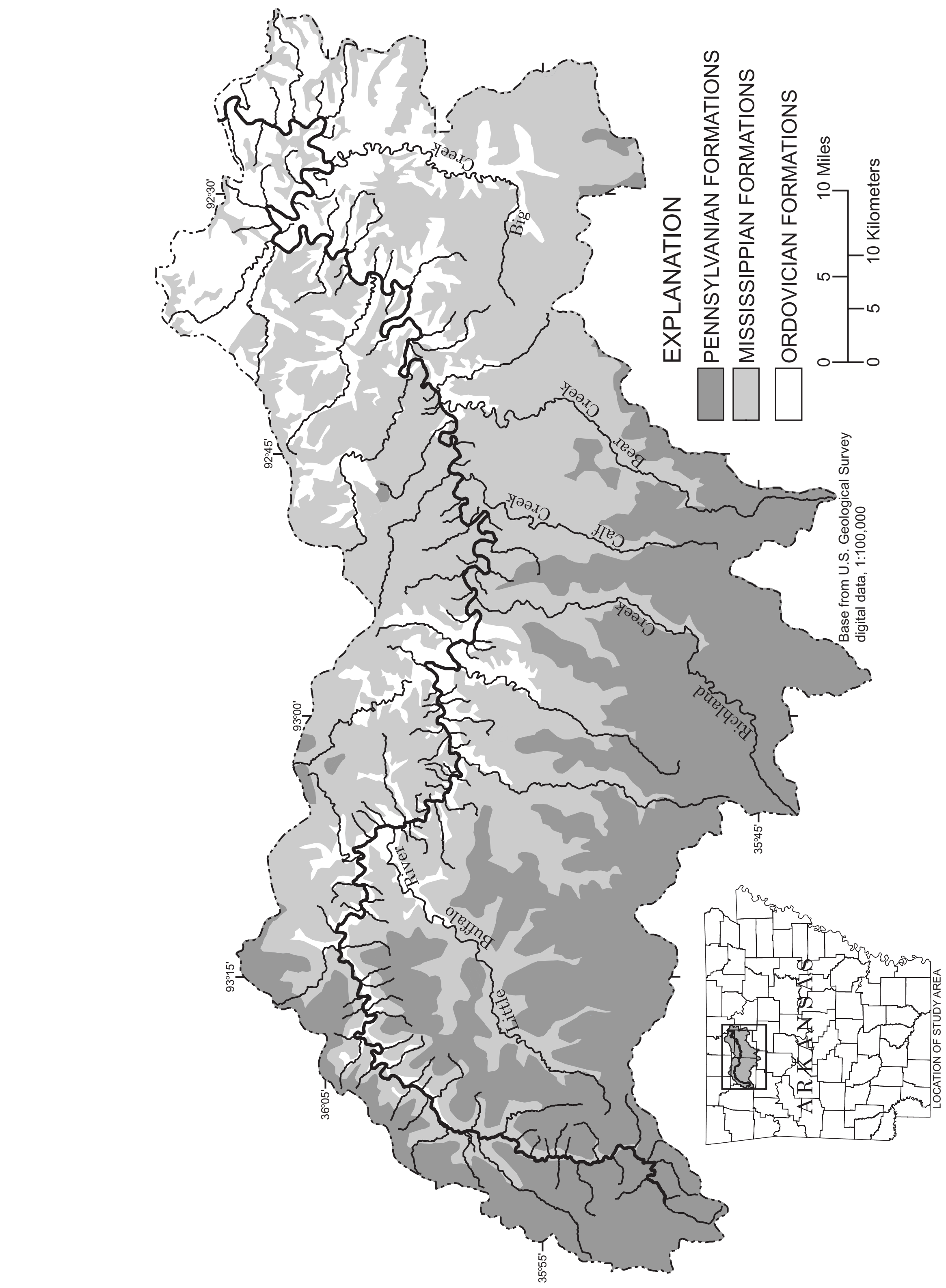

Figure 1. Generalized geology of the Buffalo River Basin.

because of a precipitation event on the afternoon of July 30 causing appreciable storm runoff. Collection of streamflow and water-quality data ended near river mile 83.4 (Mt. Hersey access). The study resumed on August 13 at the Mt. Hersey access after base-flow conditions had resumed. Precipitation also occurred in the upper part of the basin on the evening of July 29, 2003, which could have slightly affected the streamflow that was measured at sites on July 30, 2003 (between river miles 83.4 and 103.4) (plate 1, table 1, and appendix 1).

The sampling sites were chosen based on the ability to provide the best understanding of the water-quality and streamflow conditions and on accessibility of the river (table 1). Streamflow measurements at 44 locations (appendix 1) and water-quality samples at 21 locations (table 1) were collected on the mainstem of the Buffalo River during base-flow conditions. Streamflow measurements were made at approximately 2-mi, 3-mi, and 4-mi intervals for the upper, middle, and lower sections of the river, respectively. Water-quality samples were collected where the river was accessible at approximately 5-mi, 7-mi, and 8-mi intervals, respectively. Water-quality samples also were collected on four major tributaries. For most mainstem and inflow measurement locations, water temperature, specific conductance, and dissolved oxygen were measured. Data were collected from 1 mi upstream from the confluence with the White River near Buffalo City to the USGS streamflow gaging station on the Buffalo River near Boxley (07055646).

Table 1. Description of sampling locations on Buffalo River and selected tributaries where streamflow was measured and water-quality samples were collected.

Site identifier	Site description	Latitude[1]	Longitude[1]	Distance upstream of mouth (miles)
07055646	Buffalo River near Boxley	355621	0932419	132.78
M40	Buffalo River near Ponca access	360112	0932117	125.14
M38	Buffalo River near Steel Creek access	360221	0932009	122.46
M35	Buffalo River near Kyles Landing access	360326	0931642	114.51
M33	Buffalo River near Erbie low-water bridge	360432	0931329	109.72
M31	Buffalo River near Ozark access	360354	0930935	103.36
M30	Buffalo River near Pruitt access	360326	0930811	101.36
T91	Tributary-Little Buffalo River	360201	0930633	97.58
M28	Buffalo River near Hasty access	360018	0930452	94.17
M26	Buffalo River near Carver access	355857	0930227	90.23
M24	Buffalo River near Mt. Hersey access	360033	0925709	83.38
M24A	Buffalo River near Mt. Hersey access	360033	0925709	83.36
M21	Buffalo River near Woolum access	355815	0925315	74.80
M18	Buffalo River near Bakers Ford access	355849	0924849	63.69
T46	Tributary-Calf Creek	355845	0924621	60.26
07056000	Buffalo River near St. Joe	355905	0924442	57.79
M15	Buffalo River near Gilbert access	355910	0924255	53.70
T40	Tributary-Bear Creek	355949	0924201	52.48
M12	Buffalo River near North Maumee access	360157	0923740	42.34
07056700	Buffalo River near Harriet	360402	0923438	32.25
M6	Buffalo River near Rush access	360718	0923300	23.61
M4	Buffalo River mainstem	360609	0922839	14.93
T10	Tributary-Big Creek	360447	0922819	12.88
M2	Buffalo River mainstem	360730	0922608	5.33
M1	Buffalo River mainstem	360948	0922504	1.00

[1]Horizontal coordinate information is referenced to the North American Datum of 1983 (NAD 83), unless otherwise noted.

Site identifier nomenclature also was created for each sampling and measurement location to distinguish the type of site and the relative location of each sampling and streamflow measurement site (table 1, appendix 1). Each site identifier consists of an alphabetical character followed by one to three numerical characters (M5, T91, S122). The first alphabetical character indicates the type of site: M is mainstem; S is spring; T is tributary. The numerical characters indicate the relative location of the measurement and sampling site with the numerical characters increasing with distance upstream from the mouth of the Buffalo River. For example, sites M40, M18, and M1 are all mainstem sites, and site M18 is upstream from M1 and downstream from M40. The created site identifier nomenclature was used for sites that were not located near an active USGS streamflow gaging station location, and the USGS station identification number was used as the site identifier in lieu of the created nomenclature for these locations.

Water-quality samples were collected and field parameters were measured at selected streamflow measurement locations to characterize base-flow water-quality conditions of the Buffalo River and selected tributaries. Water-quality samples were collected from a cross-section or a single point in the centroid of flow at selected streamflow measurement locations. Samples were analyzed for nutrients (dissolved ammonia, dissolved nitrite, dissolved ammonia plus organic nitrogen, total ammonia plus organic nitrogen, dissolved nitrite plus nitrate, total phosphorus, dissolved phosphorus and dissolved orthophosphate) and fecal indicator bacteria (*Escherichia coli (E. coli*), fecal streptococci, and fecal coliform). In addition to water-quality samples that were collected and pH that was measured at selected streamflow measurement locations, several water-quality field parameters (water temperature, specific conductance, and dissolved-oxygen concentration) were measured at all locations. Samples were collected and measurements were made following methods outlined by Wilde and Radke (1998), Wilde and others (1998a, 1998b, 1998c, 1999a, and 1999b) and Meyers and Wilde (1999). Water-quality samples were analyzed by the USGS National Water Quality Laboratory (NWQL) in Denver, Colorado.

Streamflow measurements were made with an acoustic-velocity meter following methods described by Rantz and others (1982) and SonTek/YSI, Inc.(2004). A comparison of successive downstream streamflow measurements was used to determine if the stream reaches were gaining or losing streamflow. On the middle and upper reaches of the river, to account for any possible changes in streamflow during the day, two streamflow measurements were made at selected measurement locations where one data-collection team ended data collection for the previous reach and another data-collection team started data-collection for the subsequent reach. The streamflow measurement made by the team collecting data for the previous reach was used to determine gain or loss for the previous reach while the streamflow measurement made by the team collecting data for the subsequent reach was used to determine gain or loss for the subsequent reach. The collection, computation, and analysis of all streamflow measurement data were performed by USGS personnel.

In this report, a stream reach is classified as gaining if the sum of the flows at the upstream site plus the inflows (tributaries, springs) is less than the flow at the downstream site. Conversely, a losing reach is one where the sum of flows entering the reach is more than the flow at the downstream site. Because of measurement error, a reach is classified as gaining or losing only if the sum of flows entering the reach differ from the flow exiting the reach at the downstream site by an amount that was greater than the measurement error for that reach. In lieu of determining measurement error based on the subjective method for rating streamflow measurements (good, fair, poor, etc.), measurement error for this study was quantified as the sum of the highest flow measured in a subsection of each streamflow measurement (upstream, downstream, and inflow points) made within a particular reach of river. Streamflow measurements made according to methods described by Rantz and others (1982) consist of a number of subsections that are summed to determine the total flow at a streamflow measurement site. For this study, it is assumed that the streamflow measured at a particular site can only be as accurate as the highest flow measured in a subsection of the total measurement.

For example, streamflow is measured at an upstream and downstream site for a reach of river. Streamflow measured at the upstream site is 10.0 ft^3/s with 25 subsections. In 22 of the subsections, 0.25 ft^3/s is measured, and 1.50 ft^3/s is measured in the remaining 3 subsections. At the downstream site, 5.00 ft^3/s is measured with 26 subsections. In 20 subsections, 0.15 ft^3/s is measured, in 5 subsections 0.30 ft^3/s is measured, and in 1 subsection 0.50 ft^3/s is measured. The sum of the highest flow measured for a subsection at the upstream site (1.50 ft^3/s) and the downstream site (0.50 ft^3/s) is 2.00 ft^3/s. The measurement error for this example reach of river is 2.00 ft^3/s. Streamflow entering this reach of river (10.0 ft^3/s) differs from the streamflow exiting (5.00 ft^3/s) this reach of river by 5.00 ft^3/s. Because the streamflow exiting the example reach is 5.00 ft^3/s less than the streamflow entering the reach and because this difference is greater than the measurement error (2.00 ft^3/s), this example reach would be classified as losing streamflow.

Base Flow

Streamflow in the Buffalo River Basin varies annually and seasonally. Throughout the period of a water year (October 1 to September 30), streamflow can be attributed to components that result either from direct surface runoff or from ground-water discharge (base flow) (Wahl and Wahl, 1995). In any given water year, the total flow (volume of water yielded by a stream during the period of 1 year) can vary based upon the frequency and amount of precipitation experienced within the drainage basin as well as the proportion of total flow attributed to base flow. During the water year, streamflow (surface runoff and base flow) typically is higher during the wet season (December to June) and lower during the dry season (July to November).

The total and base flow for the Buffalo River varies annually (figs. 2 and 3). The total flow at the streamflow gaging station near Boxley for the 2003 water year was 38,300 acre-ft with a base flow of 9,700 acre-ft (table 2). The base-flow index at the station near Boxley for the 2003 water year was 0.253 (25.3 percent of the total flow attributed to base flow). The total flow at the streamflow gaging station near St. Joe for the 2003 water year was 429,000 acre-ft with a base flow of 157,000 acre-ft. The base-flow index at the station near St. Joe was 0.367. Mean annual total flow and base flow for the period of record are 77,900 and 22,300 acre-ft at the station near Boxley and 758,000 and 244,000 acre-ft at the station near St. Joe, respectively (table 2 and figs. 2 and 3). The mean annual base-flow index for each station for the period of record was 0.284 and 0.333, respectively. The base flow separation analysis indicates that total and base flow for the 2003 water year at streamflow gaging stations on the Buffalo River were below average while the proportion of total flow attributed to base flow was about average for the period of record. Below average amounts of total and base flow indicate that less than average rainfall and runoff occurred in the Buffalo River Basin during the 2003 water year.

The total and base flow for selected tributaries (Richland Creek, Calf Creek and Bear Creek) of the Buffalo River also vary annually (table 2, figs. 4, 5, and 6). The total flow at the streamflow gaging station on Richland Creek near Witts Springs for the 2003 water year was 46,400 acre-ft with a base flow of 13,800 acre-ft (table 2). The base-flow index at the station on Richland Creek for the 2003 water year was 0.297. The total flow at the streamflow gaging station on Calf Creek near Silver Hill for the 2003 water year was 17,500 acre-ft with a base flow of 6,790 acre-ft. The base-flow index at the station on Calf Creek for the 2003 water year was 0.389. The total flow at the streamflow gaging station on Bear Creek near Silver Hill for the 2003 water year was 36,400 acre-ft with a base flow of 20,300 acre-ft. The base-flow index at the station on Bear Creek for the 2003 water year was 0.558. The mean annual total flow and base flow for the period of record are 74,900 and 21,400 acre-ft at the station on Richland Creek, 41,600 and 14,100 acre-ft at the station on Calf Creek, and 66,100 and 22,000 acre-ft at the station on Bear Creek (figs. 4, 5, and 6). The mean annual base-flow index for each station for the period of record was 0.288, 0.340 and 0.332, respectively. The base-flow separation analysis indicates that total and base flow for the 2003 water year at the Richland Creek streamflow gaging station were below average. The analysis also indicates that the proportion of total flow attributed to base flow was about average for Richland Creek. Below average amounts of total and base flow for the 2003 water year indicate that less than average rainfall and runoff occurred in the Richland Creek Basin during the water year. There is not enough record to formulate comparisons for Calf and Bear Creeks.

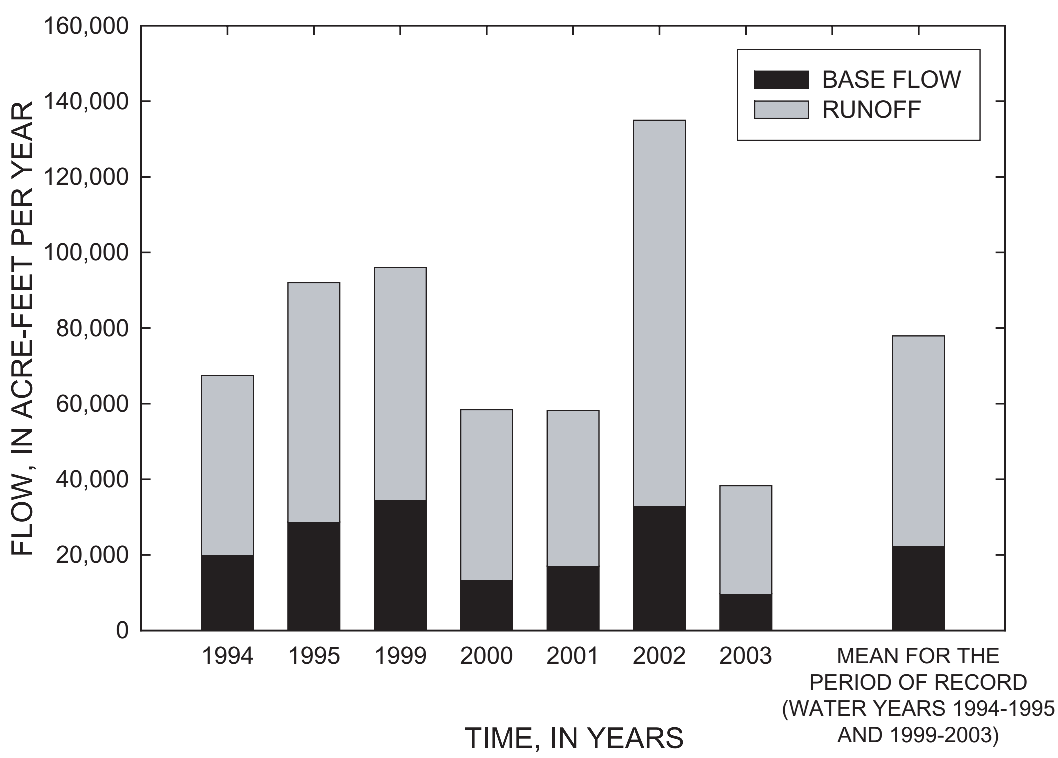

Figure 2. Base flow and runoff as components of total flow for 07055646 Buffalo River near Boxley, Arkansas.

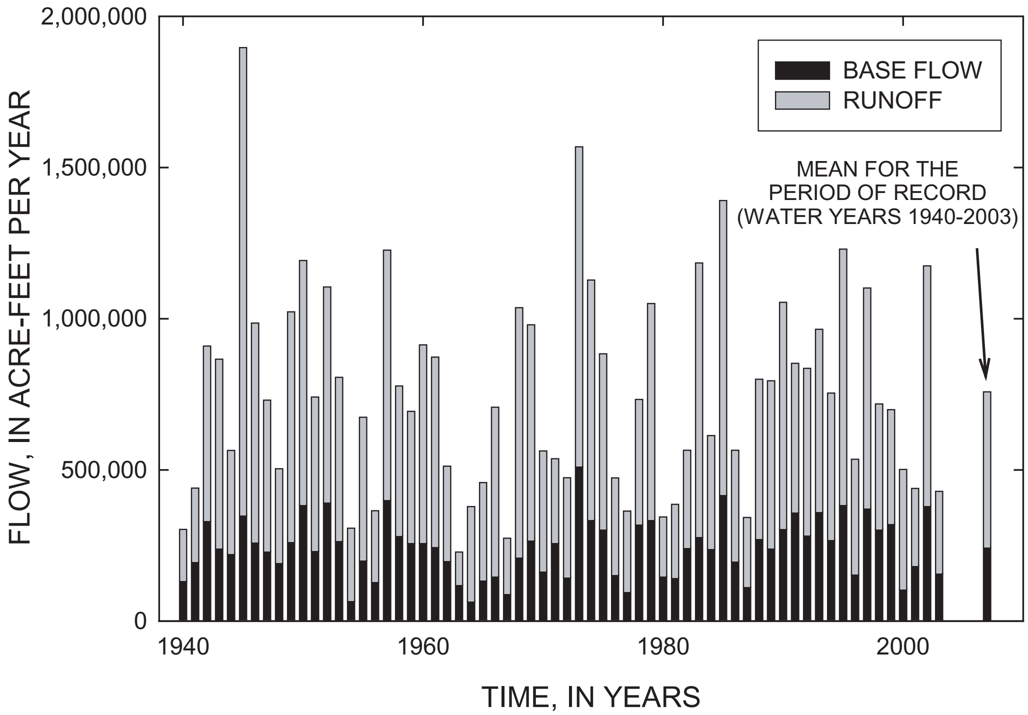

Figure 3. Base flow and runoff as components of total flow for 07056000 Buffalo River near St. Joe, Arkansas.

Table 2. Base-flow separation of the Buffalo River in northern Arkansas and selected tributaries.

	2003 water year			Period of record			
Station	**Total flow (acre-foot)**	**Base flow (acre-foot)**	**Base-flow index**	**Mean annual total flow (acre-foot/ year)**	**Mean annual base flow (acre-foot/ year)**	**Base-flow index**	**Water years**
07055646, Buffalo River near Boxley	38,300	9,700	0.253	77,900	22,300	0.284	1994-1995 1999-2003
07055875, Richland Creek near Witts Spring	46,400	13,800	0.297	74,900	21,400	0.288	1996-2003
07055893, Calf Creek near Silver Hill	17,500	6,790	0.389	41,600	14,100	0.340	2002-2003
07056000, Buffalo River near St. Joe	429,000	157,000	0.367	758,000	244,000	0.333	1940-2003
07056515, Bear Creek near Silver Hill	36,400	20,300	0.558	66,100	22,000	0.332	2000-2003

The base-flow index also can vary. The base-flow index was greater for the streamflow gaging station on Bear Creek (0.558) than for other streamflow gaging stations located in the Buffalo River Basin during the 2003 water year (table 2). This indicates less percentage of direct surface runoff in the Bear Creek Basin than in the other gaged basins of the Buffalo River for the water year. It is possible that this higher proportion of base flow for Bear Creek indicates that rainfall occurred more frequently in areas of the Bear Creek Basin with higher infiltration rates than in areas with lower infiltration rates. The higher proportion of base flow also may be attributed to a greater proportion of discharge from karstic formations in the basin. A longer period of record is needed for Bear Creek to identify any long-term trends in base flow. The Buffalo River near St. Joe has the longest period of record of the streamflow gaging stations located in the Buffalo River Basin with 64 years of record. Annual base-flow index for the Buffalo River at this location varied between 0.174 (in 1964) and 0.526 (in 1963) with a mean of 0.333 for the period of record.

Streamflow in the Buffalo River Basin also varies seasonally. Throughout the period of a water year, components of streamflow typically are higher during the wet season (December through June) and lower during the dry season (July through November) (fig. 7). Mean monthly base flow for the period of record for the Buffalo River near St. Joe varies between 71.8 ft^3/s (August) and 778 ft^3/s (April). On average, 13 percent of the total annual base flow for the Buffalo River near St. Joe occurs during the dry season and 87 percent occurs during the wet season with 51 percent of the total annual base flow occurring during the months of March, April, and May. Seasonal streamflow variance for the Buffalo River near Boxley and Richland Creek near Witts Springs are similar to the seasonal variance for the Buffalo River near St. Joe.

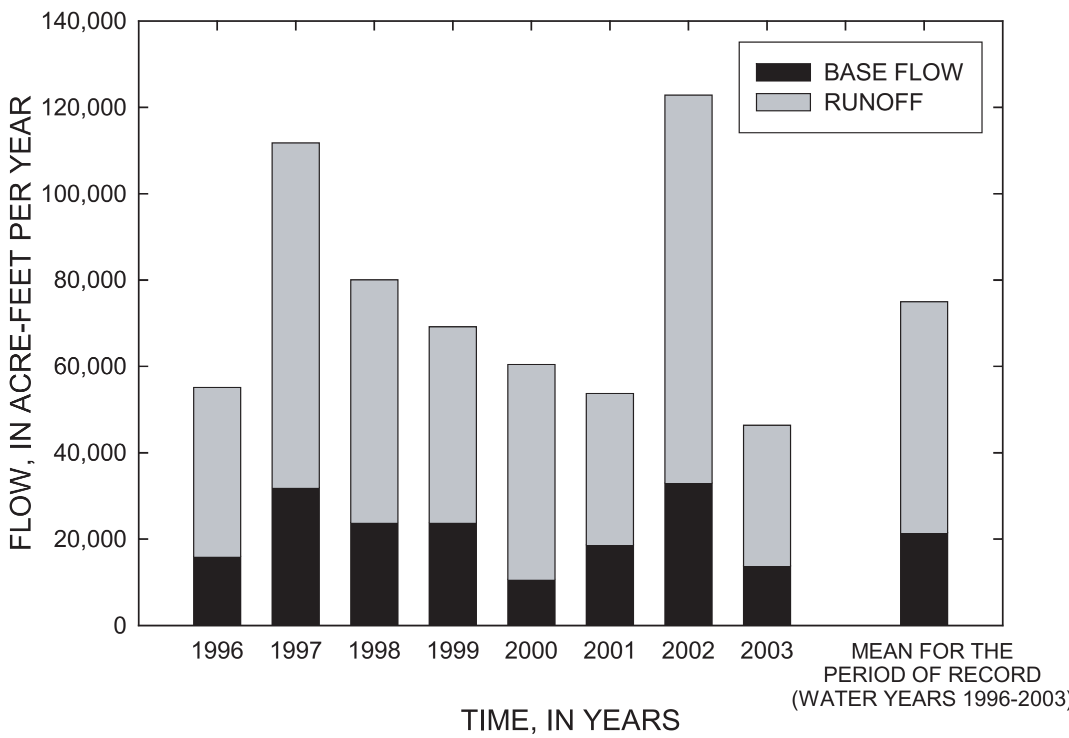

Figure 4. Base flow and runoff as components of total flow for 07055875 Richland Creek near Witts Springs, Arkansas.

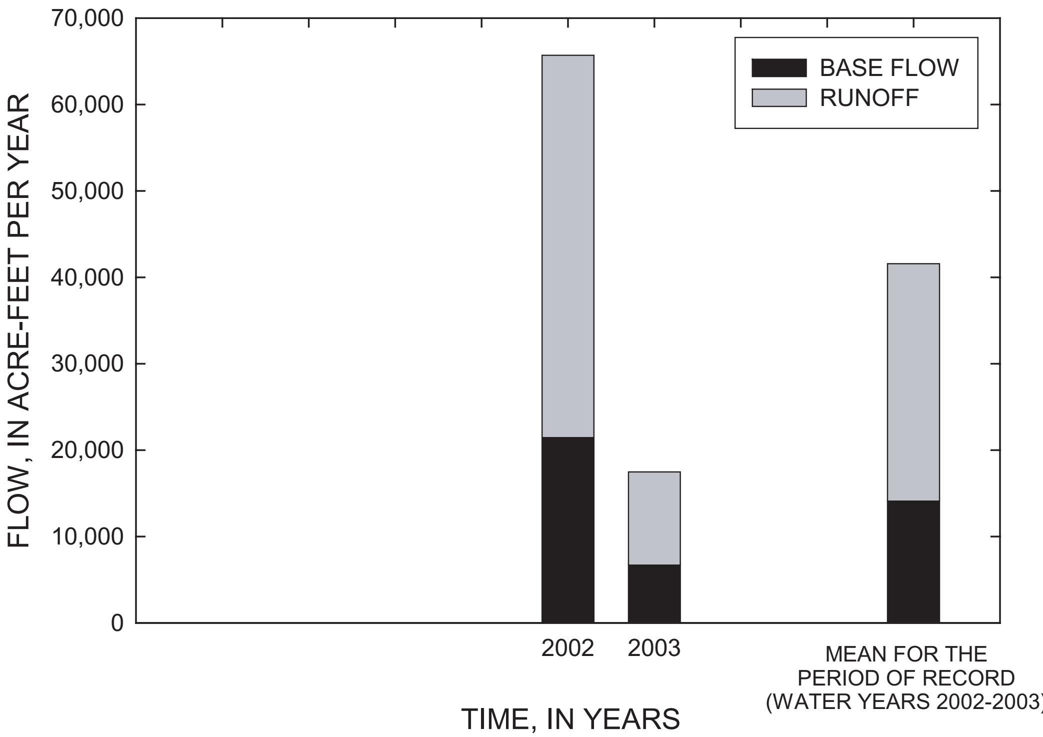

Figure 5. Base flow and runoff as components of total flow for 07055893 Calf Creek near Silver Hill, Arkansas.

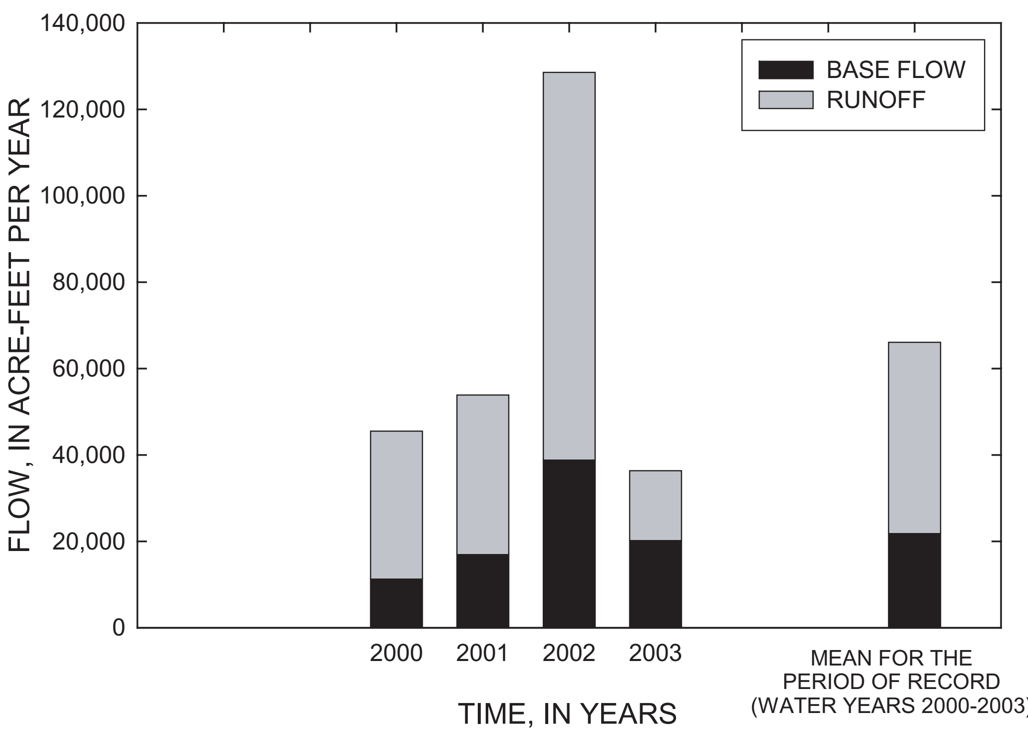

Figure 6. Base flow and runoff as components of total flow for 07056515 Bear Creek near Silver Hill, Arkansas.

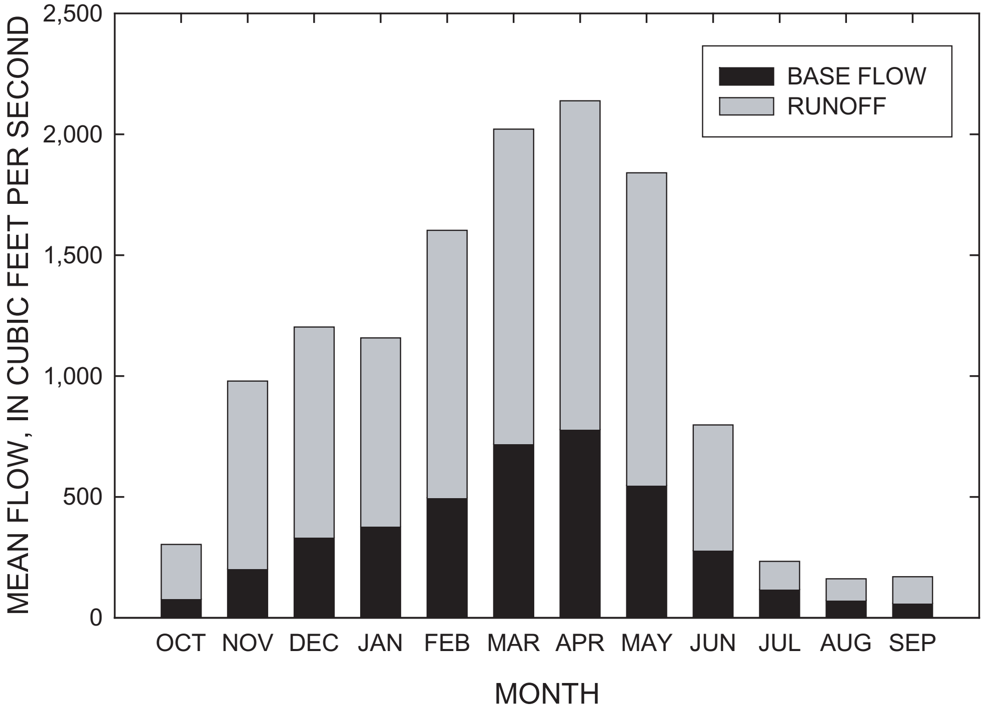

Figure 7. Mean monthly base flow and runoff for 07056000 Buffalo River near St. Joe, Arkansas, for water years 1940-2003.

Water Quality

Various water-quality field parameters were measured at all streamflow measurement sites (plate 1, table 3, appendix 1 and 2). Water temperature on the Buffalo River mainstem ranged from 25.5 to 31.2 °C for July 28-30, 2003, and from 23.3 to 31.9 °C for August 13-15, 2003. Water temperature on tributaries ranged from 15.8 to 27.5 °C for July 28-30, 2003, and from 14.0 to 28.3 °C for August 13-15, 2003. Relatively low water temperatures of a number of tributaries throughout the study area appear to indicate that they consist of largely proportionate amounts of water from springs and ground-water seepage. Dissolved-oxygen concentrations for the mainstem of the Buffalo River ranged from 5.5 to 9.2 mg/L for July 28-30, 2003, and from 6.1 to 10.5 mg/L for August 13-15, 2003. Generally, dissolved-oxygen concentrations measured later in the day were higher than values measured earlier in the day. Values of pH for the mainstem ranged from 7.7 to 8.8 while values of pH for selected tributaries ranged from 7.6 to 8.6. Generally values of pH measured later in the day were higher than values measured earlier in the day.

Specific conductance values ranged from 129 to 247 μS/cm on the mainstem (plate 1, appendix 2, and table 3). Specific conductance values on the mainstem were lowest on the most upstream reaches of the study area and were highest on reaches in the middle section of the river. Generally, specific conductance values increased between upper and middle sections of the river and decreased between middle and lower sections of the river (fig. 8). This variance in specific conductance values measured along the mainstem of the river differs from the results of analysis of long-term data collected for the Buffalo River. Analysis of long-term data collected from 1985 to 1995 shows that the median value for specific conductance increases with increasing downstream distance (Mott, 1997). This analysis includes data collected during base-flow conditions throughout all seasons over several years where as the specific conductance data presented in this report were collected during base-flow conditions in one specific season during two specific 3-day periods separated by only 13 days. While steady-state flow conditions were present on July 28-30 and August 13-15, 2003, the decrease in specific conductance values observed on the lower sections of the river may have been caused by either the presence of ground water with shorter residence time or by the mixing, dilution, and storage of surface runoff and ground water during rainfall events between July 30 and August 13, 2003. The highest specific conductance values measured were similar to average values measured for July and August from 1985 to 1995 (Mott, 1997). The highest specific conductance value measured (247 μS/cm) on the mainstem occurred on July 30, 2003, at river mile 83.4 (M24A) below the confluence with T65 (Mill Branch), which includes Mitch Hill Spring that had a specific conductance of 456 μS/cm. Specific conductance on the mainstem above the confluence with T65 was 235 μS/cm. The highest specific conductance value measured (242 μS/cm) on the mainstem not attributed to influence from a tributary occurred on August 13, 2003, at river mile 68.9 (M20) downstream from the return of the mainstem from a dry reach of river (below the Woolum access) where the mainstem mostly consisted of ground water with longer residence time. Specific conductance values ranged from 162 μS/cm (a spring (S122) near river mile 129.6 upstream from Ponca access) to 523 μS/cm (a minor tributary (T1A) inflow near river mile 1.0 at the bottom of the study area) for springs and tributaries and were higher for tributaries on lower sections of the river than for tributaries on upper sections of the river.

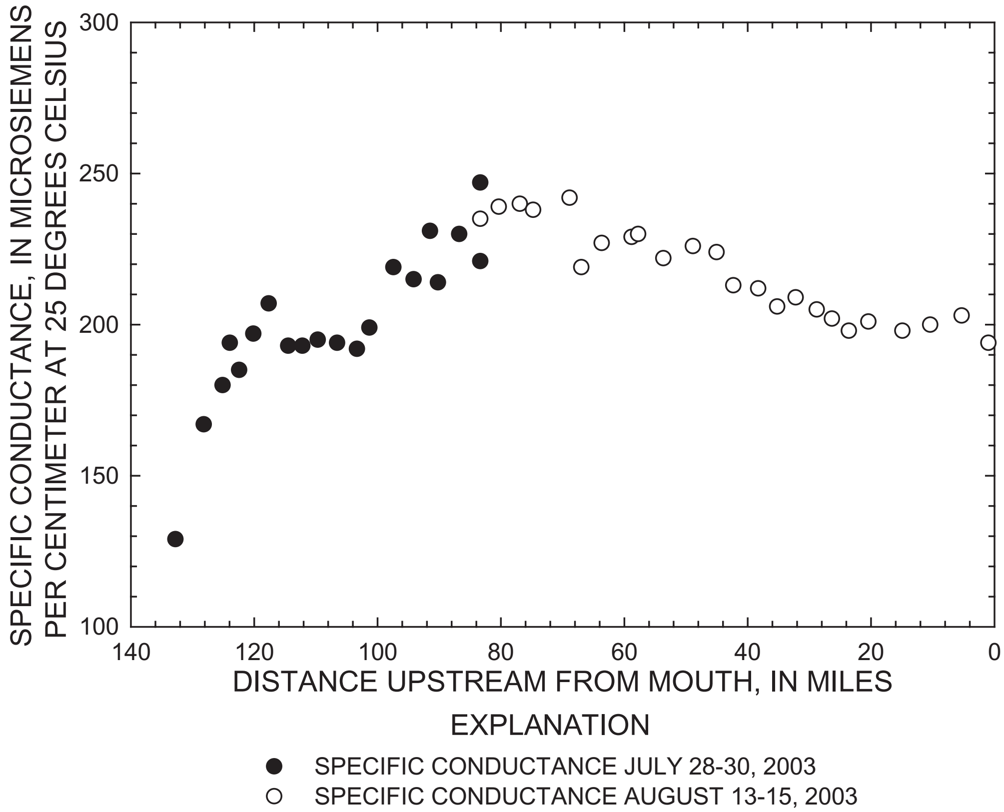

Figure 8. Measured values of specific conductance along the mainstem of the Buffalo River, July and August 2003.

Water-quality samples were collected at 21 locations on the mainstem of the Buffalo River and at 4 tributaries (Little Buffalo River and Calf, Bear, and Big Creeks) prior to confluence with the mainstem (plate 1, table 3). Water samples were analyzed for nutrients and fecal indicator bacteria.

Fecal indicator bacteria densities generally were within the typical range for streams in the Springfield and Salem Plateau physiographic sections (Petersen, 1988). *E. coli* densities ranged from less than 1 to 41 colonies per 100 milliliters (cols/100 mL) for the mainstem of the Buffalo River. *E. Coli* densities were highest for upstream sampling locations (near the Boxley streamflow gaging station to the Hasty access). *E. coli* densities for tributaries were higher than densities for the mainstem and ranged from 15 to 230 cols/100 mL with the highest density at Calf Creek. Fecal streptococci densities ranged from 1 to 87 cols/100 mL for the mainstem. Fecal streptococci densities also were highest for upstream sampling locations (near the Boxley streamflow gaging station to the Baker's Ford access). Fecal streptococci densities for tributaries were higher than densities for the mainstem and ranged from 19 to 250 cols/100 mL with the highest density at Calf Creek. Fecal coliform densities ranged from less than 1 to 56 cols/100 mL for the mainstem. Fecal coliform densities also were highest for upstream sampling locations (from Boxley to the Hasty access). Fecal coliform densities for tributaries were higher than densities for the mainstem and ranged from 13 to 160 col/100 mL with the highest density at Calf Creek. Fecal coliform densities for the mainstem were either below or within the typical range (10 to 80 col/100 mL) for streams in the Springfield and Salem Plateau physiographic sections (Petersen, 1988). The only density of fecal coliform above the typical range for streams in the Springfield and Salem Plateau physiographic sections was the density for Calf Creek.

Nutrient concentrations were near or below the reporting limit (table 3). Concentrations of dissolved ammonia, dissolved nitrite and dissolved orthophosphate were below the reporting limit. Concentrations reported for total and dissolved ammonia plus organic nitrogen, dissolved nitrite plus nitrate, and total and dissolved phosphorus were near the reporting limit and concentrations often were estimated for values below the reporting limit for these parameters.

Nitrogen concentrations generally were similar to concentrations typical of other relatively undeveloped stream basins in the United States (Clark and others, 2000). Dissolved ammonia plus organic nitrogen concentrations ranged from 0.064 to 0.194 mg/L as nitrogen for the mainstem and from 0.081 to 0.133 mg/L as nitrogen for sampled tributaries. Total ammonia plus organic nitrogen concentrations ranged from less than 0.091 to 0.175 for the mainstem and from 0.097 to 0.161 for sampled tributaries. Concentration of total ammonia plus organic nitrogen for the mainstem were greater than the median flow-weighted concentration (0.173 mg/L) for relatively

Table 3. Water-quality, quality-assurance, and streamflow data for sampled sites in the Buffalo River Basin in northern Arkansas.

[Quality assurance samples are shaded; M44E, equipment blank; M35R, M26R, and M4R, replicate samples; M21TB, trip blank; ft^3/s, cubic foot per second; temperature reported to the nearest degree Celsius; °C, degrees Celsius; µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; E. coli., *Escherichia coli*; cols/100 mL, number of colonies per 100 milliliter of sample; N, nitrogen; P, phosphorus; E, estimated; <, less than]

Site identifier	Site description	Date of sample	Time of sample	Stream-flow, instan-taneous (ft^3/s)	Water temper-ature (°C)	pH field (standard units)	Specific conduc-tance (µS/cm)	Dissolved oxygen (mg/L)	E. coli (cols/ 100 mL)	Fecal, strepto-cocci (cols/ 100 mL)	Fecal coliform (cols/ 100 mL)
M44E		07/28/03	6:30								
07055646	Buffalo River near Boxley	07/28/03	12:00	2.70	25.5	7.9	129	7.2	17	87	25
M40[1]	Buffalo River near Ponca access	07/28/03	14:30	6.80	29.5	8.3	180	9.2	32	25	36
M38	Buffalo River near Steel Creek access	07/28/03	15:30	7.48	31.2	8.1	185	7.9	3	27	4E
M35	Buffalo River near Kyles Landing access	07/29/03	8:30	8.55	28.0	7.9	193	5.9	20	31	56
M35R		07/29/03	8:40								
M33[1]	Buffalo River near Erbie low-water bridge	07/29/03	11:20	8.56	28.3	7.8	195	6.6	41	10E	55
M31[1]	Buffalo river near Ozark access	07/29/03	13:15	9.62	29.0	8.0	192	7.8	10	14E	5E
M30	Buffalo River near Pruitt access	07/30/03	7:50	10.6	27.3	7.7	199	6.0	17	2E	25
T91	Tributary-Little Buffalo River	07/30/03	8:30	8.76	27.3	7.6	224	5.6	16	19E	58
M28	Buffalo River near Hasty access	07/30/03	10:20	25.5	27.9	7.7	215	6.4	13	10E	13E
M26[1]	Buffalo River near Carver access	07/30/03	11:20	23.3	28.0	7.9	214	6.6	1	17E	5E
M26R		07/30/03	11:30								
M24[1]	Buffalo River near Mt. Hersey access	07/30/03	13:50	42.4	28.5	7.9	221	7.5	3	13E	5E
M24A[1]	Buffalo River near Mt. Hersey access	07/30/03	13:15	45.6	27.5	8.0	247	7.7	2	21E	8E
M21	Buffalo river near Woolum access	08/13/03	8:45	31.4	27.0	8.1	238	6.6	1	13E	1E
M21TB		08/13/03	8:30								
M18[1]	Buffalo River near Bakers Ford access	08/13/03	12:45	50.3	25.3	8.1	227	7.6	5E	13E	3E
T46	Tributary-Calf Creek	08/13/03	13:50	3.52	23.2	8.6	329	9.9	230	250	160
07056000	Buffalo River near St. Joe[2]	08/13/03	14:50	60.9	26.3	8.2	230	8.6	4E	4E	6E
M15[1]	Buffalo River near Gilbert access	08/13/03	16:00	64.9	27.5	8.7	222	9.1	2E	3E	6E
T40	Tributary-Bear Creek	08/14/03	9:30	11.6	24.5	8.1	260	7.4	15E	83	51
M12[1]	Buffalo River near North Maumee access	08/14/03	12:10	88.5	27.6	8.2	213	8.2	1E	2E	3E
07056700	Buffalo River near Harriet[1]	08/14/03	14:30	91.1	28.7	8.8	209	10.5	3E	3E	13E
M6[2]	Buffalo River near Rush access	08/14/03	13:20	81.4	28.5	8.2	198	7.1	<1	3E	1E
M4	Buffalo River mainstem	08/15/03	11:20	96.2	28.5	8.4	198	7.4	6E	9E	11E
M4R		08/15/03	11:30								
T10	Tributary-Big Creek	08/15/03	13:00	11.1	28.3	8.0	235	8.4	32	52	13E
M2	Buffalo River mainstem	08/15/03	15:40	100	30.0	8.1	203	8.1	<1	1E	<1
M1	Buffalo River mainstem	08/15/03	18:00	117	31.9	8.5	194	9.5	2E[3]	4E[3]	6E[3]

Table 3. Water-quality, quality-assurance, and streamflow data for sampled sites in the Buffalo River Basin in northern Arkansas.—Continued

[Quality assurance samples are shaded; M44E, equipment blank; M35R, M26R, and M4R, replicate samples; M21TB, trip blank; ft^3/s, cubic foot per second; temperature reported to the nearest degree Celsius; °C, degrees Celsius; µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; E. coli., *Escherichia coli*; cols/100 mL, number of colonies per 100 milliliter of sample; N, nitrogen; P, phosphorus; E, estimated; <, less than]

Site identifier	Site description	Dissolved ammonia (mg/L as N)	Dis-solved nitrite (mg/L as N)	Dissolved ammonia + organic nitrogen (mg/L as N)	Total ammonia + organic nitrogen (mg/L as N)	Dissolved nitrite + nitrate (mg/L as N)	Total phos-phorus (mg/L as P)	Dis-solved phos-phorus (mg/L as P)	Dissolved ortho-phos-phate (mg/L as P)
M44E		<0.041	<0.008	<0.100	<0.100	<0.060	<0.004	<0.004	<0.018
07055646	Buffalo River near Boxley	<0.041	<0.008	0.095E	<0.100	0.033E	0.003E	0.004E	<0.018
M40[1]	Buffalo River near Ponca access	<0.041	<0.008	0.088E	<0.100	0.070	0.004E	0.005	<0.018
M38	Buffalo River near Steel Creek access	<0.041	<0.008	0.081E	0.101	0.065	0.005	0.004E	<0.018
M35	Buffalo River near Kyles Landing access	<0.041	<0.008	0.154	0.120	0.043E	0.005	0.005	<0.018
M35R		<0.041	<0.008	0.165	0.146	0.039E	0.007	0.005	<0.018
M33[1]	Buffalo River near Erbie low-water bridge	<0.041	<0.008	0.098E	0.138	<0.060	0.007	0.004E	<0.018
M31[1]	Buffalo river near Ozark access	<0.041	<0.008	0.155	0.105	0.031E	0.004	0.005	<0.018
M30	Buffalo River near Pruitt access	<0.041	<0.008	0.128	0.132	0.060	0.006	0.004	<0.018
T91	Tributary-Little Buffalo River	<0.041	<0.008	0.133	0.161	0.068	0.010	0.006	<0.018
M28	Buffalo River near Hasty access	<0.041	<0.008	0.124	0.103	<0.060	0.006	0.004E	<0.018
M26[1]	Buffalo River near Carver access	<0.041	<0.008	0.134	0.118	0.052E	0.007	0.005	<0.018
M26R		<0.041	<0.008	0.102	0.133	0.045E	0.007	0.004E	<0.018
M24[1]	Buffalo River near Mt. Hersey access	<0.041	<0.008	0.096E	0.115	0.048E	0.007	0.004E	<0.018
M24A[1]	Buffalo River near Mt. Hersey access	<0.041	<0.008	0.097E	0.119	0.155	0.007	0.004	<0.018
M21	Buffalo river near Woolum access	0.024E	<0.008	0.115	0.140	0.034E	0.009	<0.004	<0.018
M21TB		<0.041	<0.008	<0.100	<0.100	<0.060	<0.004	<0.004	<0.018
M18[1]	Buffalo River near Bakers Ford access	<0.041	<0.008	0.064E	0.091E	0.031E	0.005	<0.004	<0.018
T46	Tributary-Calf Creek	<0.041	<0.008	0.086E	0.107	0.223	0.038	0.028	0.020
07056000	Buffalo River near St. Joe[2]	<0.041	<0.008	0.076E	0.099E	<0.060	0.008	0.003E	<0.018
M15[1]	Buffalo River near Gilbert access	<0.041	<0.008	0.071E	0.102	<0.060	0.008	0.002E	0.018<
T40	Tributary-Bear Creek	<0.041	<0.008	0.105	0.128	0.098	0.025	0.017	0.010E
M12[1]	Buffalo River near North Maumee access	<0.041	<0.008	0.103	0.114	<0.060	0.011	0.005	<0.018
07056700	Buffalo River near Harriet[1]	<0.041	<0.008	0.097E	0.118	<0.060	0.009	0.003E	<0.018
M6[2]	Buffalo River near Rush access	0.022E	<0.008	0.144	0.139	<0.060	0.009	0.004E	0.010E
M4	Buffalo River mainstem	<0.041	<0.008	0.165	0.175	<0.060	0.008	0.002E	<0.018
M4R		<0.041	<0.008	0.131	0.147	<0.060	0.007	0.003E	<0.018
T10	Tributary-Big Creek	<0.041	<0.008	0.081E	0.097E	0.052E	0.016	0.013	0.010E
M2	Buffalo River mainstem	<0.041	<0.008	0.194	0.145	<0.060	0.008	0.003E	<0.018
M1	Buffalo River mainstem	<0.041	<0.008	0.158	0.142	<0.060	0.006	0.003E	<0.018

[1]Streamflow measured at a different time on the same date.
[2]Streamflow measured at a different time on the following day; flow conditions were steady state.
[3]For bacteriological data, concentrations are reported as estimated when results are based on non-ideal colony counts (outside the acceptable range).

undeveloped stream basins in the United States at only one sampling location (M4, river mile 14.9, on the lower section of river approximately 2.0 miles above Big Creek). Concentrations for the other 24 mainstem and tributary sampling locations were less than the median flow-weighted concentration for relatively undeveloped stream basins in the United States (Clark and others, 2000). Concentrations of dissolved nitrite plus nitrate ranged from 0.031 to 0.155 mg/L as nitrogen for the mainstem and from 0.052 to 0.223 mg/L as nitrogen for the sampled tributaries. Concentration of dissolved nitrite plus nitrate for the mainstem was greater than the median flow-weighted concentration (0.087 mg/L) for relatively undeveloped stream basins in the United States at one site on the mainstem (M24A, below Mill Branch) and at Calf Creek. Concentrations of dissolved nitrite plus nitrate for the other 23 mainstem and tributary sites were less than the median flow-weighted concentration for relatively undeveloped streams in the United States (Clark and others, 2000). Nitrogen based nutrient concentration values were similar to average values measured from 1985-1995 in the Buffalo River (Mott, 1997).

Phosphorus concentrations were less than concentrations typical for other relatively undeveloped stream basins in the United States. Total phosphorus concentrations ranged from 0.004 to 0.011 mg/L for the mainstem and from 0.010 to 0.038 mg/L for sampled tributaries. Concentrations of total phosphorus for the mainstem were less than the 25th percentile flow-weighted concentration for relatively undeveloped stream basins in the United States (Clark and others, 2000). Concentrations of total phosphorus for tributaries were lowest for the Little Buffalo River and highest at Calf Creek. Concentrations of dissolved phosphorus were less than concentrations of total phosphorus at the same sampling locations.

Streamflow Gain and Loss

Streamflow data collected at 44 locations on the mainstem of the Buffalo River and at points of inflow indicate that overall the Buffalo River is a gaining stream along the entire study reach from the USGS streamflow gaging station near Boxley to its confluence with the White River (fig. 9, table 4). Seven gaining and five losing reaches were identified for the Buffalo River. Gains and losses were confined to the upper and middle sections of the river (above river mile 45 where the Springfield Plateau is the dominant physiography of the basin and where the river primarily flows across the Boone Formation and the St. Peter Sandstone and Everton Formations). Below river mile 45, streamflow ranged between 80 and 120 ft^3/s, and streamflow differences between measurement locations were less than measurement error. Reaches throughout the length of the Buffalo River had gains or losses that were smaller in magnitude than measurement error for respective reaches of river.

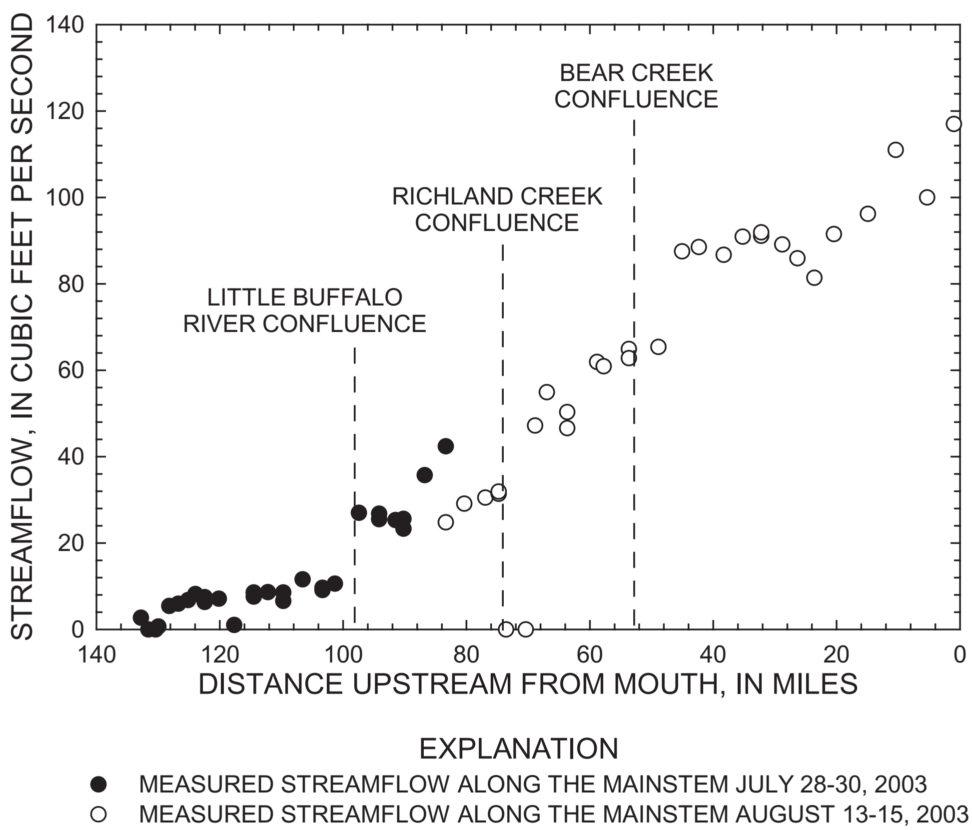

Figure 9. Measured streamflow along the mainstem of the Buffalo River, July and August 2003.

Streamflow losses occurred on the mainstem of the Buffalo River at five reaches (table 4). Losses occurred downstream from the streamflow gaging station near Boxley, downstream from M21 (Woolum access), and between measurement locations M37 and M36 (above Hemmed-in-Hollow), M34 and M33 (above Erbie low-water bridge), and between M19 and M18 (above Bakers Ford access) with losses of 2.70, 31.4, 6.28, 2.06 and 8.30 ft^3/s, respectively. Additionally, surface flow on the mainstem of the Buffalo River was diverted completely to subsurface flow on the mainstem at two locations where the Buffalo River was found to be dry. A surface flow of 2.70 ft^3/s was diverted to subsurface flow downstream from the streamgaging station near Boxley at river mile 131.6 and returned upstream from M43 at river mile 130.4 A surface flow of 31.4 ft^3/s also was diverted to subsurface flow downstream from M21 at river mile 73.6 (downstream from the Woolum access) with pools starting to emerge at river mile 72.7 and surface flow beginning to return upstream from M20 at mile 70.4. Both locations where the mainstem was found to be dry occurred where the mainstem was located in the Boone Formation. Between M37 (river mile 120.2) and M36 (river mile 117.7) surface flow did not divert to subsurface flow completely, however, 88 percent of the flow (6.28 ft^3/s) was probably lost to fractures in the St. Peter Sandstone and Everton Formation upstream from M36 near mile 118 (upstream from Hemmed-in-Hollow). Three of the five losing reaches occurred in the Boone Formation, and two of the losing reaches occurred in the St. Peter Sandstone and Everton Formation.

Streamflow gains occurred on the mainstem of the Buffalo River on seven reaches with three of the gains occurring downstream from confluences with major tributaries (table 4). The largest percentage gains occurred in reaches subsequent to the largest percentage losing or dry reaches. Between mile 130.4, where surface flow returned to the mainstem of the river upstream from M43, and mile 128.2 (M42) 5.14 ft^3/s was gained as the mainstem of the river crossed the St. Peter Sandstone and Everton Formation after flowing through the Boone Formation, and the gain in streamflow probably originated at the contact between the two formations. Between river miles 117.7 (M36, near Hemmed-In-Hollow) and 114.5 (M35, Kyles Landing access) a gain of 625 percent was experienced subsequent to a loss of 88 percent of the flow in the adjacent upstream reach; streamflow lost to fractures upstream from M36 returned along this gaining reach of river. Subsequent to a loss in all surface flow downstream from M21 (Woolum access), flow returned to the Buffalo River at river mile 70.4 (4.4 miles downstream from the Woolum access), and the mainstem continued to gain flow through river mile 67.0 (M19) with a gain of 54.9 ft^3/s. The net gain between M21 and M19 was 23.5 ft^3/s; by river mile 67.0 surface flow had returned with an additional 75 percent gain in streamflow. Although the mouth of Richland Creek, located downstream from M21, was dry, subsurface flow through fractures and solution channels in the Boone Formation that originated in the Richland Creek Basin was probably the source of the net gain in streamflow between M21 and M19. Similarly gains in streamflow occurred downstream from the confluences with the Little Buffalo River and Bear Creek (fig. 9). Gains in flow downstream from confluences may be attributed to subsurface flow that has entered the mainstem through alluvium adjacent to or underlying the tributary or through fractures and solution channels in the underlying bedrock of the tributary and mainstem. Additional sources of gains along the upper and middle sections of river may be attributed to springs and seeps that occur at or near the base of the Boone Formation.

Substantial changes in water quality were not detected below gaining and losing reaches. Nutrient concentrations were similar above and below gaining and losing reaches. Specific conductance values were highest and generally were increasing along reaches upstream from river mile 67.0. There was a larger percentage of ground-water/surface-water interaction along reaches upstream from river mile 67.0 than along reaches below the same river mile. Specific conductance values generally were decreasing along the reach downstream from river mile 67.0 where there was less ground-water/surface-water interaction.

Table 4. Streamflow balance on the Buffalo River during study, July and August 2003.

[ft^3/s, cubic foot per second; Differences, measured inflows, gains in surface streamflow, and measurement error between downstream and upstream sites are shaded and located on the row between the downstream and upstream sites referred to; A loss is represented as a negative gain; Bold numbers are gains or losses that are greater than the measurement error for that particular reach; Mainstem return refers to the location where flow first returns to mainstem but is immeasurable or to where the first fully connected pool appears upstream from measurable flow and downstream from a dry reach of river]

Site identifier	Date	Time	Distance upstream from mouth (miles)	Streamflow, instantaneous (ft^3/s)	Difference between downstream and upstream sites (ft^3/s)	Measured inflow between downstream and upstream sites (ft^3/s)	Gain in surface streamflow between downstream and upstream sites (ft^3/s)	Measurement error between downstream and upstream sites (ft^3/s)
07055646	7/28/2003	12:00	132.78	2.70				
					-2.70	0	**-2.70**	0.20
Mainstem dry	7/28/2003	12:30	131.60	0				
Mainstem return	7/28/2003	12:30	130.40	0				
					0.68	0	**0.68**	0.19
M43	7/28/2003	12:40	129.97	0.68				
					4.76	0.30	**4.46**	0.96
M42	7/28/2003	15:00	128.20	5.44				
					0.49	0	0.49	1.46
M41	7/28/2003	15:30	126.75	5.93				
					0.87	0	0.87	1.32
M40	7/28/2003	17:50	125.14	6.80				
					1.39	0.10	1.29	1.29
M39	7/28/2003	13:15	123.97	8.19				
					-0.71	0	-0.71	1.24
M38	7/28/2003	15:30	122.46	7.48				
M38	7/29/2003	7:00	122.46	6.34				
					0.75	0.10	0.65	0.98
M37	7/29/2003	9:55	120.15	7.09				
					-6.06	0.22	**-6.28**	0.66
M36	7/29/2003	13:45	117.68	1.03				
					6.54	0.10	**6.44**	1.00
M35	7/29/2003	17:00	114.51	7.57				
M35	7/29/2003	8:30	114.51	8.55				
					0.09	0	0.09	1.49
M34	7/29/2003	11:23	112.22	8.64				
					-2.06	0	**-2.06**	1.30
M33	7/29/2003	14:20	109.72	6.58				
M33	7/29/2003	8:06	109.72	8.56				
					3.04	0	**3.04**	2.81
M32	7/29/2003	11:20	106.58	11.6				
					-1.98	0	-1.98	3.15
M31	7/29/2003	15:00	103.36	9.62				
M31	7/30/2003	7:55	103.36	9.11				
					1.49	0	**1.49**	1.37
M30	7/30/2003	7:50	101.36	10.6				
					16.4	10.6	**5.80**	4.15

Table 4. Streamflow balance on the Buffalo River during study, July and August 2003.—Continued

[ft^3/s, cubic foot per second; Differences, measured inflows, gains in surface streamflow, and measurement error between downstream and upstream sites are shaded and located on the row between the downstream and upstream sites referred to; A loss is represented as a negative gain; Bold numbers are gains or losses that are greater than the measurement error for that particular reach; Mainstem return refers to the location where flow first returns to mainstem but is immeasurable or to where the first fully connected pool appears upstream from measurable flow and downstream from a dry reach of river]

Site identifier	Date	Time	Distance upstream from mouth (miles)	Streamflow, instantaneous (ft^3/s)	Difference between downstream and upstream sites (ft^3/s)	Measured inflow between downstream and upstream sites (ft^3/s)	Gain in surface streamflow between downstream and upstream sites (ft^3/s)	Measurement error between downstream and upstream sites (ft^3/s)
M29	7/30/2003	12:05	97.45	27.0				
					-0.20	0.50	-0.70	4.10
M28	7/30/2003	14:45	94.17	26.8				
M28	7/30/2003	10:20	94.17	25.5				
					-0.20	0	-0.20	3.88
M27	7/30/2003	13:40	91.52	25.3				
					0.30	0.25	0.05	3.97
M26	7/30/2003	16:10	90.23	25.6				
M26	7/30/2003	7:40	90.23	23.3				
					12.4	3.89	**8.51**	5.89
M25	7/30/2003	11:34	86.78	35.7				
					6.70	0.70	6.00	14.2
M24	7/30/2003	16:00	83.38	42.4				
M24	8/13/2003	8:30	83.38	24.8				
					4.30	3.57	0.73	5.84
M23	8/13/2003	11:42	80.37	29.1				
					1.40	0.03	1.37	4.51
M22	8/13/2003	14:03	76.97	30.5				
					1.40	0.03	1.37	4.09
M21	8/13/2003	15:52	74.80	31.9				
M21	8/13/2003	8:45	74.80	31.4				
					-31.4	0	**-31.4**	1.68
Mainstem dry	8/13/2003	10:00	72.70	0				
Mainstem return	8/13/2003	12:00	70.40	0				
					47.2	0	**47.2**	2.54
M20	8/13/2003	13:00	68.89	47.2				
					7.70	0	**7.70**	5.61
M19	8/13/2003	15:02	67.00	54.9				
					-8.30	0	**-8.30**	5.80
M18	8/13/2003	17:04	63.69	46.6				
M18	8/13/2003	8:21	63.69	50.3				
					11.6	3.52	8.08	10.1
M17	8/13/2003	12:06	58.84	61.9				
					-1.00	2.34	-3.34	9.93
07056000	8/14/2003	8:30	57.79	60.9				
					4.00	0	4.00	9.52
M15	8/13/2003	16:00	53.70	64.9				
M15	8/14/2003	8:37	53.70	62.8				
					2.60	11.6	-9.00	11.3

Table 4. Streamflow balance on the Buffalo River during study, July and August 2003.—Continued

[ft^3/s, cubic foot per second; Differences, measured inflows, gains in surface streamflow, and measurement error between downstream and upstream sites are shaded and located on the row between the downstream and upstream sites referred to; A loss is represented as a negative gain; Bold numbers are gains or losses that are greater than the measurement error for that particular reach; Mainstem return refers to the location where flow first returns to mainstem but is immeasurable or to where the first fully connected pool appears upstream from measurable flow and downstream from a dry reach of river]

Site identifier	Date	Time	Distance upstream from mouth (miles)	Streamflow, instantaneous (ft^3/s)	Difference between downstream and upstream sites (ft^3/s)	Measured inflow between downstream and upstream sites (ft^3/s)	Gain in surface streamflow between downstream and upstream sites (ft^3/s)	Measurement error between downstream and upstream sites (ft^3/s)
M14	8/14/2003	11:30	48.89	65.4				
					22.1	0.38	**21.7**	15.3
M13	8/14/2003	14:47	45.06	87.5				
					1.00	0.01	0.99	16.3
M12	8/14/2003	9:41	42.34	88.5				
					-1.80	0.17	-1.97	16.8
M11	8/14/2003	12:35	38.32	86.7				
					4.20	3.97	0.23	15.4
M10	8/14/2003	14:52	35.24	90.9				
					1.00	3.51	-2.51	13.2
07056700	8/14/2003	17:15	32.25	91.9				
07056700	8/14/2003	10:42	32.25	91.1				
					-2.00	0.31	-2.31	12.3
M8	8/14/2003	13:34	28.84	89.1				
					-3.20	0.01	-3.21	13.0
M7	8/14/2003	15:54	26.37	85.9				
					-4.50	0	-4.50	13.1
M6	8/15/2003	9:02	23.61	81.4				
					10.1	1.95	8.15	14.5
M5	8/15/2003	9:04	20.45	91.5				
					4.70	0.01	4.69	15.8
M4	8/15/2003	11:20	14.93	96.2				
					14.8	11.3	3.50	16.5
M3	8/15/2003	13:13	10.43	111				
					-11.0	0.48	-11.5	14.9
M2	8/15/2003	15:40	5.33	100				
					17.0	0.19	16.8	19.6
M1	8/15/2003	18:00	1.00	117				

Summary

A study of the Buffalo National River in north-central Arkansas was conducted between July 28-30, 2003, and August 13-15, 2003, to characterize the base flow and water quality and streamflow gain and loss in the Buffalo River. The study was separated into two time periods because of a precipitation event that occurred on the afternoon of July 30 causing appreciable storm runoff. Precipitation also occurred in the upper part of the basin on the evening of July 29, 2003, which could have slightly affected the streamflow that was measured at sites on July 30, 2003 (between river miles 83.4 and 103.4).

Streamflow was analyzed using the Base Flow Index (BFI) hydrograph separation computer program to identify base-flow and surface run-off components. Base-flow separation analyses indicated annual variability in streamflow throughout the Buffalo River Basin. Based upon these analyses, total and base flow were below average for the mainstem of the river and Richland Creek during the 2003 water year. For the mainstem of the Buffalo River and Richland Creek, proportions of base flow as a component of total flow were about average in comparison with mean annual values for the period of record. Below average amounts of total and base flow indicate that less than average rainfall and runoff occurred in the Buffalo River Basin during the 2003 water year. There is not enough record to formulate annual comparisons for Calf and Bear Creeks.

Water-quality samples were collected from 25 surface-water sites on the Buffalo River and selected tributaries. Fecal coliform densities for the mainstem were either below or within the typical range for streams in the Springfield and Salem Plateau physiographic sections. The only density of fecal coliform above the typical range for streams in the Springfield and Salem Plateau physiographic sections was the density at Calf Creek. Most nutrient concentrations for the mainstem of the Buffalo River were near or below the minimum reporting level and were less than the median flow-weighted concentration for relatively undeveloped stream basins in the United States. Nutrient concentrations were below the reporting limit for dissolved ammonia, dissolved nitrite and dissolved orthophosphate. Concentrations of total ammonia plus organic nitrogen and dissolved nitrite plus nitrate generally were less than the median flow-weighted concentration for relatively undeveloped stream basins in the United States at the majority of sampling locations. Concentrations of total phosphorus for the mainstem were less than the 25th percentile flow-weighted concentration for relatively undeveloped stream basins in the United States.

Streamflow measurement data were collected at 44 locations along the mainstem and at points of inflow (prior to confluence with the mainstem) to identify gaining and losing reaches. Seven gaining and five losing reaches were identified for the Buffalo River. Gains and losses (larger in magnitude than the sum of measurement errors for a particular reach) were confined to the upper and middle sections of the river (above river mile 45) where the Springfield Plateau is the dominant physiography of the basin and where the river primarily flows across the Boone Formation and the St. Peter Sandstone and Everton Formation. Additionally, surface flow on the mainstem of the Buffalo River was diverted completely to subsurface flow on the mainstem at two locations where the mainstem was found to be dry. The mainstem was found to be dry downstream from the streamgaging station near Boxley at river mile 131.6 and downstream from the Woolum access at river mile 73.6. Both locations where the mainstem was found to be dry occurred where the mainstem was located in the Boone Formation. Additionally, 88 percent of the flow probably was lost to fractures in the St. Peter Sandstone and Everton Formation near river mile 118 upstream from Hemmed-in-Hollow. The largest percentage of streamflow gains occurred in river reaches subsequent to the largest percentage losing or dry reaches. Streamflow gains occurred downstream from confluences with the Little Buffalo River and Bear Creek. Gains in flow downstream from confluences may be attributed to subsurface flow that has entered the mainstem through alluvium adjacent to or underlying the tributary or through fractures and solution channels in the underlying bedrock of the tributary and mainstem. Reaches throughout the length of the river had calculated gains or losses that were less than the measurement error for respective reaches of river.

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APPENDIXES

Appendix 1. Description of surface-water measurement locations in the Buffalo River Basin.

Site identifier	Site description	Latitude[1]	Longitude[1]	Distance upstream from mouth (miles)
07055646	Buffalo River near Boxley[2]	355621	0932419	132.78
T125	Tributary-Beech Creek	355800	0932415	130.58
M43	Buffalo River mainstem	355820	0932349	129.97
T124	Tributary-Arrington Creek	355821	0932348	129.96
T123	Tributary	355832	0932349	129.76
S122	Spring	355843	0932349	129.56
T122	Tributary-Moore Creek	355847	0932354	129.45
M42	Buffalo River mainstem	355941	0932324	128.20
T121	Tributary-Whiteley Creek	355948	0932320	128.04
M41	Buffalo River mainstem	360013	0932211	126.75
T120	Tributary-Dry Creek	360010	0932206	126.66
T119	Tributary-Running Creek	360012	0932158	126.54
T118	Tributary-Clark Creek	360024	0932152	126.28
T117	Tributary	360042	0932130	125.80
M40	Buffalo River mainstem-Ponca access[2]	360112	0932117	125.14
T116	Tributary-Leatherwood Creek	360119	0932116	125.05
T115	Tributary-Ponca Creek	360116	0932118	125.03
M39	Buffalo River mainstem	360158	0932041	123.97
M38	Buffalo River mainstem-Steel Creek access[2]	360221	0932009	122.46
T114	Tributary-Steel Creek	360219	0932006	122.40
T113	Tributary	360301	0932014	121.45
S112	Spring	360301	0931957	121.21
M37	Buffalo River mainstem	360247	0931921	120.15
T112A	Tributary	360244	0931924	120.07
T112	Tributary-Beech Creek	360231	0931906	119.66
T111	Tributary-Sneeds Creek	360332	0931833	118.13
T110	Tributary-Hemmed-In-Hollow Creek	360350	0931825	117.70
M36	Buffalo River mainstem	360349	0931825	117.68
T109B	Tributary	360324	0931754	116.71
T109A	Tributary	360305	0931737	116.16
T109	Tributary-Indian Creek	360257	0931709	115.46
T108	Tributary-Bear Creek	360323	0931657	114.79
T107	Tributary	360328	0931647	114.63
M35	Buffalo River mainstem-Kyles Landing access[2]	360326	0931642	114.51
T106A	Tributary	360308	0931616	113.92

Appendix 1. Description of surface-water measurement locations in the Buffalo River Basin.—Continued

Site identifier	Site description	Latitude[1]	Longitude[1]	Distance upstream from mouth (miles)
T106	Tributary	360331	0931611	113.31
T105	Tributary-Shop Creek	360331	0931518	112.35
T104	Tributary-Dry Creek	360333	0931514	112.24
M34	Buffalo River mainstem	360336	0931512	112.22
T103	Tributary-Cecil Creek	360432	0931333	109.79
M33	Buffalo River mainstem-Erbie low-water bridge[2]	360432	0931329	109.72
T102	Tributary-Webb Creek	360430	0931319	109.56
T101	Tributary	360442	0931227	108.19
M32	Buffalo River mainstem	360350	0931126	106.58
T100	Tributary	360322	0931111	103.67
T99	Tributary	360330	0931105	103.52
T98	Tributary	360318	0931035	104.85
T97	Tributary	360340	0930947	103.69
T96	Tributary	360354	0930936	103.40
M31	Buffalo River mainstem-Ozark access[2]	360354	0930935	103.36
M30	Buffalo River mainstem-Pruitt access[2]	360326	0930811	101.36
T95	Tributary-Mill Creek	360331	0930757	101.07
S94	Spring	360321	0930727	99.81
T94A	Tributary	360313	0930713	99.55
T94	Tributary	360301	0930703	99.22
T93	Tributary	360238	0930624	98.38
S92	Spring	360237	0930624	98.36
T92	Tributary	360223	0930618	98.07
T91	Tributary-Little Buffalo River[2]	360201	0930633	97.58
M29	Buffalo River mainstem	360152	0930626	97.45
T90	Tributary	360137	0930627	97.16
T89	Tributary-Wells Creek	360127	0930606	96.75
T88	Tributary	360117	0930610	96.55
T87	Tributary	360046	0930602	95.89
T86	Tributary	360024	0930520	94.90
T85	Tributary	360019	0930450	94.19
M28	Buffalo River mainstem-Hasty access[2]	360018	0930452	94.17
T84	Tributary-Rock Creek	360004	0930455	93.89
T83	Tributary-Sheldon Branch	355939	0930449	93.38
T82	Tributary	355934	0930423	92.89

Appendix 1. Description of surface-water measurement locations in the Buffalo River Basin.—Continued

Site identifier	Site description	Latitude[1]	Longitude[1]	Distance upstream from mouth (miles)
T81	Tributary	355923	0930346	92.18
T80	Tributary	355922	0930328	91.87
M27	Buffalo River mainstem	355904	0930327	91.52
T79	Tributary	355904	0930328	91.51
T78	Tributary	355904	0930306	90.85
M26	Buffalo River mainstem-Carver access[2]	355857	0930227	90.23
T77	Tributary-Big Creek	355856	0930227	90.21
T76	Tributary	355923	0930144	89.10
T75	Tributary	355924	0930109	88.51
T74	Tributary	355926	0930101	88.38
T73	Tributary	355942	0930035	87.88
T72	Tributary-Lick Creek	355945	0930000	86.95
M25	Buffalo River mainstem	355939	0925950	86.78
T71	Tributary	355951	0925925	96.27
T70	Tributary	355959	0925920	86.09
T69	Tributary	355958	0925903	85.82
T68	Tributary	355947	0925849	85.53
T67	Tributary	360002	0925829	85.05
T66	Tributary-Davis Creek	360033	0925711	83.42
M24	Buffalo River mainstem-Mt Hersey access[2]	360033	0925709	83.38
T65	Tributary-Mill Branch	360034	0925708	83.37
M24A	Buffalo River mainstem-Mt Hersey access[2]	360033	0925709	83.36
T64	Tributary-Cave Creek	355856	0925717	80.95
M23	Buffalo River mainstem	355920	0925631	80.37
T63	Tributary-Cane Branch	355917	0925554	79.64
T62	Tributary	355833	0925554	78.72
T61	Tributary	355820	0925549	78.44
T60	Tributary	355816	0925542	78.33
M22	Buffalo River mainstem	355756	0925420	76.97
T59	Tributary	355826	0925419	76.05
T58A	Tributary	355840	0925359	75.65
S58	Spring	355840	0925354	75.58
M21	Buffalo River mainstem-Woolum access[2]	355815	0925315	74.80
T58	Tributary-Richland Creek	355809	0925315	74.72
T57	Tributary	355823	0925248	74.08

Appendix 1. Description of surface-water measurement locations in the Buffalo River Basin.—Continued

Site identifier	Site description	Latitude[1]	Longitude[1]	Distance upstream from mouth (miles)
T56	Tributary-Jamison Creek	355838	0925138	72.75
T55	Tributary	355752	0925150	71.68
T54	Tributary-Ben Branch	355731	0925143	71.26
T53	Tributary	355809	0925050	69.96
M20	Buffalo River mainstem	355757	0924956	68.89
T52	Tributary	355719	0925005	68.14
M19	Buffalo River mainstem	355748	0924932	67.00
T51	Tributary	355735	0924831	65.61
T50	Tributary	355826	0924859	64.24
T49	Tributary	355827	0924904	64.20
M18	Buffalo River mainstem Bakers Ford access[2]	355849	0924849	63.69
T48	Tributary	355852	0924832	63.38
T47	Tributary	355844	0924734	62.00
T46	Tributary-Calf Creek[2]	355845	0924621	60.26
M17	Buffalo River mainstem	355902	0924607	58.84
T45	Tributary-Mill Creek	355923	0924602	59.40
T44	Tributary	355914	0924524	58.69
07056000	Buffalo River near St. Joe[2]	355905	0924442	57.79
T43	Tributary	355903	0924416	57.26
T42	Tributary-Dry Creek	355906	0924306	53.90
M15	Buffalo River mainstem-Gilbert access[2]	355910	0924255	53.70
T41	Tributary	355947	0924212	52.67
T40	Tributary-Bear Creek[2]	355949	0924201	52.48
T39	Tributary	355952	0924154	52.37
T38	Tributary-Brush Creek	355959	0924121	51.82
T37	Tributary	360003	0924121	51.75
M14	Buffalo River mainstem	360054	0923931	48.89
T36	Tributary-Tomahawk Creek	360122	0924031	47.92
T35	Tributary	360118	0923830	45.39
T34	Tributary-Rocky Creek	360107	0923826	45.12
M13	Buffalo River mainstem	360103	0923826	45.06
T33	Tributary-Little Rocky Creek	360045	0923817	44.60
M12	Buffalo River mainstem-North Maumee access[2]	360157	0923740	42.34
T32	Tributary	360215	0923812	41.68
M11	Buffalo River mainstem	360113	0923548	38.32

Appendix 1. Description of surface-water measurement locations in the Buffalo River Basin.—Continued

Site identifier	Site description	Latitude[1]	Longitude[1]	Distance upstream from mouth (miles)
T31	Tributary-Spring Creek	360113	0923519	37.80
T30	Tributary	360158	0923536	36.18
M10	Buffalo River mainstem	360231	0923523	35.24
T29	Tributary	360228	0923457	34.85
T28	Tributary-Kimball Creek	360252	0923432	34.22
T27	Tributary-Water Creek	360259	0923435	34.13
07056700	Buffalo River near Harriet[2]	360402	0923438	32.25
T26	Tributary	360404	0923431	32.13
T25	Tributary	360406	0923410	31.79
T24	Tributary-Rock Creek	360406	0923324	31.03
T23	Tributary-Hickory Creek	360419	0923314	30.63
T22	Tributary-Panther Creek	360508	0923319	29.34
M8	Buffalo River mainstem	360456	0923252	28.84
T21	Tributary-Ingram Creek	360452	0923233	28.51
M7	Buffalo River mainstem	360603	0923208	26.37
M6	Buffalo River mainstem-Rush access[2]	360718	0923300	23.61
T20	Tributary-Rush Creek	360727	0923256	23.43
T19	Tributary-Clabber Creek	360743	0923244	23.13
T18	Tributary	360716	0923211	22.42
T17	Tributary-Cabin Creek	360736	0923138	21.75
T16	Tributary-Cedar Creek	360755	0923049	20.91
T15	Tributary-Boat Creek	360751	0923040	20.78
M5	Buffalo River mainstem	360732	0923049	20.45
T14A	Tributary	360624	0923124	18.94
T14	Tributary	360640	0923026	17.95
T13	Tributary	360542	0922957	16.42
T12	Tributary-Brush Creek	360608	0922920	15.66
M4	Buffalo River mainstem[2]	360609	0922839	14.93
T11	Tributary	360527	0922841	14.40
T10	Tributary-Big Creek[2]	360447	0922819	12.88
T9	Tributary	360455	0922808	12.68
M3	Buffalo River mainstem	360536	0922644	10.43
T8	Tributary	360518	0922638	10.08
T7	Tributary-Middle Creek	360508	0922539	9.17
T6	Tributary-Short Creek	360538	0922546	8.60

Appendix 1. Description of surface-water measurement locations in the Buffalo River Basin.—Continued

Site identifier	Site description	Latitude[1]	Longitude[1]	Distance upstream from mouth (miles)
T5	Tributary-Leatherwood Creek	360634	0922544	7.20
M2	Buffalo River mainstem[2]	360730	0922608	5.33
T4	Tributary-Brush Creek	360732	0922602	5.30
T3	Tributary-Cow Creek	360759	0922553	4.70
T2	Tributary-Stewart Creek	360912	0922449	2.39
T1A	Tributary	360950	0922503	1.01
M1	Buffalo River mainstem[2]	360948	0922504	1.00
T1	Tributary	360944	0922536	0.49

[1]Horizontal coordinate information is referenced to the North American Datum of 1983 (NAD 83), unless otherwise noted.
[2]Water-quality sample collected at the measurement location.

Appendix 2. Streamflow and water-quality data for streamflow measurement sites in the Buffalo River Basin in northern Arkansas, July and August 2003.

[ft^3/s, cubic foot per second; temperature reported to the nearest 0.1 degree Celsius; °C, degrees Celsius; µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; mm Hg, millimeters of mercury; E, estimated; --, data not available]

Site identifier	Date of sample	Time of sample	Streamflow instantaneous (ft^3/s)	Water temperature (°C)	pH field (standard unit)	Specific conductance (µS/cm)	Dissolved oxygen (mg/L)	Barometric pressure (mm Hg)
07055646 Buffalo River near Boxley	07/28/03	12:00	2.70	25.5	7.9	129	7.2	735
T125	07/28/03	--	Dry	--	--	--	--	--
M43	07/28/03	12:40	0.68	26.0	--	--	--	--
T124	07/28/03	--	Dry	--	--	--	--	--
T123	07/28/03	--	Dry	--	--	--	--	--
S122	07/28/03	--	<0.10	16.6	--	162	--	--
T122	07/28/03	13:48	<0.20	--	--	--	--	--
M42	07/28/03	15:00	5.44	27.9	--	167	9.0	--
T121	07/28/03	--	Dry	--	--	--	--	--
M41	07/28/03	15:30	5.93	29.9	--	--	--	--
T120	07/28/03	--	Dry	--	--	--	--	--
T119	07/28/03	--	Dry	--	--	--	--	--
T118	07/28/03	--	Dry	--	--	--	--	--
T117	07/28/03	--	Dry	--	--	--	--	--
M40	07/28/03	14:30	--	29.5	8.3	180	9.2	738
M40	07/28/03	17:50	6.80	--	--	--	--	--
T116	07/28/03	--	Dry	--	--	--	--	--
T115	07/28/03	11:45	<0.10	26.2	--	259	11.6	--
M39	07/28/03	13:15	8.19	27.9	--	194	7.1	--
M38	07/28/03	15:30	7.48	31.2	8.1	185	7.9	739
M38	07/29/03	7:00	6.34	27.0	--	--	--	--
T114	07/29/03	8:00	E<0.10	20.3	--	305	5.0	--
T113	07/29/03	--	Dry	--	--	--	--	--
M37	07/29/03	9:55	7.09	27.7	--	197	8.3	--
T112A	07/29/03	--	Dry	--	--	--	--	--
T112	07/29/03	--	Dry	--	--	--	--	--
T111	07/29/03	12:15	0.22	23.9	--	241	8.0	--

Appendix 2. Streamflow and water-quality data for streamflow measurement sites in the Buffalo River Basin in northern Arkansas, July and August 2003.—Continued

[ft^3/s, cubic foot per second; temperature reported to the nearest 0.1 degree Celsius; °C, degrees Celsius; µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; mm Hg, millimeters of mercury; E, estimated; --, data not available]

Site identifier	Date of sample	Time of sample	Streamflow instantaneous (ft^3/s)	Water temperature (°C)	pH field (standard unit)	Specific conductance (µS/cm)	Dissolved oxygen (mg/L)	Barometric pressure (mm Hg)
T110	07/29/03	--	Dry	--	--	--	--	--
M36	07/29/03	13:45	1.03	30.3	--	207	7.5	--
T109B	07/29/03	15:00	E<0.10	--	--	--	--	--
T109A	07/29/03	--	Dry	--	--	--	--	--
T109	07/29/03	--	Dry	--	--	--	--	--
T108	07/29/03	--	Dry	--	--	--	--	--
T107	07/29/03	--	Dry	--	--	--	--	--
M35	07/29/03	8:30	8.55	28.0	7.9	193	5.9	741
M35	07/29/03	17:00	7.57	--	--	--	--	--
T106A	07/29/03	--	Dry	--	--	--	--	--
T106	07/29/03	--	Dry	--	--	--	--	--
T105	07/29/03	--	Dry	--	--	--	--	--
T104	07/29/03	--	Dry	--	--	--	--	--
M34	07/29/03	11:23	8.64	27.5	--	193	8.1	--
T103	07/29/03		Dry	--	--	--	--	--
M33	07/29/03	8:06	8.56	--	--	--	--	--
M33	07/29/03	11:20	--	28.3	7.8	195	6.6	743
M33	07/29/03	14:20	6.58	28.5	--	198	6.8	--
T102	07/29/03	--	Dry	--	--	--	--	--
T101	07/29/03	--	Dry	--	--	--	--	--
M32	07/29/03	11:30	11.6	28.0	--	194	5.5	--
T100	07/29/03	--	Dry	--	--	--	--	--
T99	07/29/03	--	Dry	--	--	--	--	--
T98	07/29/03	--	Dry	--	--	--	--	--
T97	07/29/03	--	Dry	--	--	--	--	--
T96	07/29/03	--	Dry	--	--	--	--	--
M31	07/29/03	13:15	--	29.0	8.0	192	7.8	743
M31	07/29/03	15:00	9.62	--	--	--	--	--
M31	07/30/03	7:55	9.11	27.2	--	213	6.1	--

Appendix 2. Streamflow and water-quality data for streamflow measurement sites in the Buffalo River Basin in northern Arkansas, July and August 2003.—Continued

[ft^3/s, cubic foot per second; temperature reported to the nearest 0.1 degree Celsius; °C, degrees Celsius; µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; mm Hg, millimeters of mercury; E, estimated; --, data not available]

Site identifier	Date of sample	Time of sample	Streamflow instantaneous (ft^3/s)	Water temperature (°C)	pH field (standard unit)	Specific conductance (µS/cm)	Dissolved oxygen (mg/L)	Barometric pressure (mm Hg)
M30	07/30/03	7:50	10.6	27.3	--	199	6.0	744
T95	07/30/03	8:20	1.68	24.0	--	338	6.7	--
S94	07/30/03	10:30	0.01	--	--	--	--	--
T94A	07/30/03	--	Dry	--	--	--	--	--
T94	07/30/03	--	Dry	--	--	--	--	--
T93	07/30/03	--	Dry	--	--	--	--	--
S92	07/30/03	10:40	0.10	--	--	--	--	--
T92	07/30/03	--	Dry	--	--	--	--	--
T91	07/30/03	8:30	--	27.3	7.6	224	5.6	--
T91	07/30/03	11:30	8.76	--	--	222	7.7	--
M29	07/30/03	12:05	27.0	26.9	--	219	7.2	--
T90	07/30/03	--	Dry	--	--	--	--	--
T89	07/30/03	13:15	E0.50	--	--	--	--	--
T88	07/30/03	--	Dry	--	--	--	--	--
T87	07/30/03	--	Dry	--	--	--	--	--
T86	07/30/03	--	Dry	--	--	--	--	--
T85	07/30/03	--	Dry	--	--	--	--	--
M28	07/30/03	10:20	25.5	27.9	7.7	215	6.4	745
M28	07/30/03	14:45	26.8	28.9	--	214	7.9	--
T84	07/30/03	--	Dry	--	--	--	--	--
T83	07/30/03	--	Dry	--	--	--	--	--
T82	07/30/03	--	Dry	--	--	--	--	--
T81	07/30/03	--	Dry	--	--	--	--	--
T80	07/30/03	--	Dry	--	--	--	--	--
M27	07/30/03	13:40	25.3	28.3	--	231	7.1	--
T79	07/30/03	13:40	0.25	15.8	--	322	10.1	--
T78	07/30/03	--	Dry	--	--	--	--	--
M26	07/30/03	7:40	23.3	--	--	--	--	--
M26	07/30/03	11:40	--	28.0	7.9	214	6.6	747

Appendix 2. Streamflow and water-quality data for streamflow measurement sites in the Buffalo River Basin in northern Arkansas, July and August 2003.—Continued

[ft^3/s, cubic foot per second; temperature reported to the nearest 0.1 degree Celsius; °C, degrees Celsius; µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; mm Hg, millimeters of mercury; E, estimated; --, data not available]

Site identifier	Date of sample	Time of sample	Streamflow instantaneous (ft^3/s)	Water temperature (°C)	pH field (standard unit)	Specific conductance (µS/cm)	Dissolved oxygen (mg/L)	Barometric pressure (mm Hg)
M26	07/30/03	16:10	25.6	--	--	--	--	--
T77	07/30/03	8:38	3.88	27.5	--	246	6.0	
T76	07/30/03	--	Dry	--	--	--	--	--
T75	07/30/03	--	Dry	--	--	--	--	--
T74	07/30/03	--	Dry	--	--	--	--	--
T73	07/30/03	--	Dry	--	--	--	--	--
T72	07/30/03	11:15	0.01	--	--	--	--	--
M25	07/30/03	11:34	35.7	27.7	--	230	6.3	--
T71	07/30/03	--	Dry	--	--	--	--	--
T70	07/30/03	--	Dry	--	--	--	--	--
T69	07/30/03	--	Dry	--	--	--	--	--
T68	07/30/03	--	Dry	--	--	--	--	--
T67	07/30/03	--	Dry	--	--	--	--	--
T66	07/30/03	14:50	0.70	23.5	--	427	7.1	--
T66	08/13/03	8:10	0.16	20.4	--	434	4.3	--
M24	07/30/03	13:50	--	28.5	7.9	221	7.5	752
M24	07/30/03	16:00	42.4	--	--	--	--	--
M24	08/13/03	8:30	24.8	25.0	--	235	7.4	--
T65	07/30/03	15:03	3.18	17.1	--	456	10.2	--
T65	08/13/03	9:08	2.57	16.0	--	446	8.0	--
M24A	07/30/03	13:15	--	27.5	8.0	247	7.7	752
M24A	07/30/03	16:15	45.6	--	--	--	--	--
T64	08/13/03	10:32	1.00	24.2	--	226	5.2	--
M23	08/13/03	11:42	29.1	25.6	--	239	7.1	--
T63	08/13/03	--	Dry	--	--	--	--	--
T62	08/13/03	--	Dry	--	--	--	--	--
T61	08/13/03	13:06	E0.03	19.7	--	329	6.4	--
T60	08/13/03	--	Dry	--	--	--	--	--
M22	08/13/03	14:03	30.5	26.3	--	240	6.1	--

Appendix 2. Streamflow and water-quality data for streamflow measurement sites in the Buffalo River Basin in northern Arkansas, July and August 2003.—Continued

[ft^3/s, cubic foot per second; temperature reported to the nearest 0.1 degree Celsius; °C, degrees Celsius; µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; mm Hg, millimeters of mercury; E, estimated; --, data not available]

Site identifier	Date of sample	Time of sample	Streamflow instantaneous (ft^3/s)	Water temperature (° C)	pH field (standard unit)	Specific conductance (µS/cm)	Dissolved oxygen (mg/L)	Barometric pressure (mm Hg)
T59	08/13/03	--	Dry	--	--	--	--	--
T58A	08/13/03	--	Dry	--	--	--	--	--
S58	08/13/03	15:21	E0.03	17.5	--	291	6.8	
M21	08/13/03	8:45	31.4	27.0	--	238	6.6	752
M21	08/13/03	15:52	31.9	27.0	--	235	6.3	--
T58	08/13/03	--	Dry	--	--	--	--	--
T57	08/13/03	--	Dry	--	--	--	--	--
T56[1]	08/13/03	--	Dry	--	--	--	--	--
T55[1]	08/13/03	--	Dry	--	--	--	--	--
T54[1]	08/13/03	--	Dry	--	--	--	--	--
T53	08/13/03	--	Dry	--	--	--	--	--
M20	08/13/03	13:00	47.2	23.3	--	242	7.2	--
T52	08/13/03	--	Dry	--	--	--	--	--
M19	08/13/03	15:02	54.9	25.2	--	219	9.1	--
T51	08/13/03	--	Dry	--	--	--	--	--
T50	08/13/03	--	Dry	--	--	--	--	--
T49	08/13/03	--	Dry	--	--	--	--	--
M18	08/13/03	8:21	50.3	--	--	--	--	--
M18	08/13/03	12:45	--	25.3	8.1	227	7.6	753
M18	08/13/03	17:04	46.6	--	--	--	--	--
T48	08/13/03	--	Dry	--	--	--	--	--
T47	08/13/03	--	Dry	--	--	--	--	--
T46	08/13/03	11:04	3.52	21.6	--	330	7.9	
T46	08/13/03	13:50	--	23.2	8.6	329	9.9	754
M17	08/13/03	12:06	61.9	25.2	--	229	7.3	--
T45	08/13/03	13:00	2.34	19.4	--	368	9.4	
T44	08/13/03	--	Dry	--	--	--	--	--
07056000 Buffalo River near St. Joe	08/13/03	14:50	--	26.3	8.2	230	8.6	754

Appendix 2. Streamflow and water-quality data for streamflow measurement sites in the Buffalo River Basin in northern Arkansas, July and August 2003.—Continued

[ft^3/s, cubic foot per second; temperature reported to the nearest 0.1 degree Celsius; °C, degrees Celsius; μS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; mm Hg, millimeters of mercury; E, estimated; --, data not available]

Site identifier	Date of sample	Time of sample	Streamflow instantaneous (ft^3/s)	Water temperature (°C)	pH field (standard unit)	Specific conductance (μS/cm)	Dissolved oxygen (mg/L)	Barometric pressure (mm Hg)
07056000 Buffalo River near St. Joe	08/14/03	8:30	60.9	--	--	--	--	--
T43	08/13/03	--	Dry	--	--	--	--	--
T42	08/13/03	--	Dry	--	--	--	--	--
M15	08/13/03	16:00	64.9	27.5	8.7	222	9.1	755
M15	08/14/03	8:37	62.8	25.7	--	222	6.7	--
T41	08/14/03	--	Dry	--	--	--	--	--
T40	08/14/03	9:49	11.6	24.5	8.1	260	7.4	753
T39	08/14/03	--	Dry	--	--	--	--	--
T38	08/14/03	--	Dry	--	--	--	--	--
T37	08/14/03	--	Dry	--	--	--	--	--
M14	08/14/03	11:30	65.4	26.6	--	226	6.7	--
T36	08/14/03	12:54	0.06	24.6	--	339	7.4	--
T35	08/14/03	--	Dry	--	--	--	--	--
T34	08/14/03	14:20	0.32	21.8	--	350	7.5	--
M13	08/14/03	14:47	87.5	28.4	--	224	8.8	--
T33	08/14/03	15:43	0.01	15.3	--	354	8.8	--
M12	08/14/03	9:41	88.5	26.5	--	217	7.0	752
M12	08/14/03	12:10	--	27.6	8.2	213	8.2	752
T32	08/14/03	10:36	0.17	14.9	--	336	9.2	--
M11	08/14/03	12:35	86.7	27.4	--	212	8.5	--
T31	08/14/03	13:22	3.97	17.8	--	322	9.4	--
T30	08/14/03	--	Dry	--	--	--	--	--
M10	08/14/03	14:52	90.9	28.9	--	206	9.8	--
T29	08/14/03	--	Dry	--	--	--	--	--
T28	08/14/03	--	Dry	--	--	--	--	--
T27	08/14/03	16:07	3.51	27.7	--	261	7.8	--
07056700 Buffalo River near Harriet	08/14/03	10:42	91.1	--	--	--	--	--

Appendix 2. Streamflow and water-quality data for streamflow measurement sites in the Buffalo River Basin in northern Arkansas, July and August 2003.—Continued

[ft^3/s, cubic foot per second; temperature reported to the nearest 0.1 degree Celsius; °C, degrees Celsius; µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; mm Hg, millimeters of mercury; E, estimated; --, data not available]

Site identifier	Date of sample	Time of sample	Streamflow instantaneous (ft^3/s)	Water temperature (°C)	pH field (standard unit)	Specific conductance (µS/cm)	Dissolved oxygen (mg/L)	Barometric pressure (mm Hg)
07056700 Buffalo River near Harriet	08/14/03	14:30	--	28.7	8.8	209	10.5	752
07056700 Buffalo River near Harriet	08/14/03	17:15	91.9	29.5	--	205	10.4	--
T26	08/14/03	--	Dry	--	--	--	--	--
T25	08/14/03	--	Dry	--	--	--	--	--
T24	08/14/03	12:20	E<0.10	15.0	--	324	7.6	--
T23	08/14/03	--	Dry	--	--	--	--	--
T22	08/14/03	12:57	0.21	15.2	--	315	8.1	--
M8	08/14/03	13:34	89.1	27.7	--	205	9.3	--
T21	08/14/03	14:40	<0.05	16.1	--	472	3.4	--
M7	08/14/03	15:54	85.9	29.8	--	202	9.6	--
M6	07/14/03	13:20	--	28.5	8.2	198	7.1	755
M6	08/15/03	9:02	81.4	--	--	--	--	--
T20	08/15/03	8:21	0.72	21.1	--	365	--	--
T19	08/15/03	8:20	0.73	23.8	--	429	7.5	--
T18	08/15/03	8:50	<0.05	14.0	--	333	9.1	--
T17	08/15/03	9:00	E0.10	19.4	--	417	8.6	--
T16	08/15/03	9:14	0.19	22.1	--	428	6.6	--
T15	08/15/03	9:30	E<0.20	20.7	--	447	6.8	--
M5	08/15/03	9:04	91.5	27.6	--	201	6.9	--
T14A	08/15/03	10:05	E<0.01	19.9	--	317	9.3	--
T14	08/15/03	--	Dry	--	--	--	--	--
T13	08/15/03	--	Dry	--	--	--	--	--
T12	08/15/03	--	Dry	--	--	--	--	--
M4	08/15/03	11:20	96.2	28.5	8.4	198	7.4	763
T11	08/15/03	--	Dry	--	--	--	--	--
T10	08/15/03	11:43	11.1	--	--	--	--	--
T10	08/15/03	13:00	--	28.3	8.0	235	8.4	--
T9	08/15/03	12:30	E<0.20	21.9	--	501	7.2	--

Appendix 2. Streamflow and water-quality data for streamflow measurement sites in the Buffalo River Basin in northern Arkansas, July and August 2003.—Continued

[ft^3/s, cubic foot per second; temperature reported to the nearest 0.1 degree Celsius; °C, degrees Celsius; µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; mm Hg, millimeters of mercury; E, estimated; --, data not available]

Site identifier	Date of sample	Time of sample	Streamflow instantaneous (ft^3/s)	Water temperature (°C)	pH field (standard unit)	Specific conductance (µS/cm)	Dissolved oxygen (mg/L)	Barometric pressure (mm Hg)
M3	08/15/03	13:13	111	31.1	--	200	10.3	--
T8	08/15/03	--	Dry	--	--	--	--	--
T7	08/15/03	15:00	E0.30	24.1	--	436	7.4	--
T6	08/15/03	--	Dry	--	--	--	--	--
T5	08/15/03	15:38	0.18	25.2	--	380	--	--
M2	08/15/03	15:40	100	30.0	8.1	203	8.1	--
T4	08/15/03	--	Dry	--	--	--	--	--
T3	08/15/03	--	Dry	--	--	--	--	--
T2	08/15/03	17:45	E0.09	26.7	--	423	6.6	--
T1A	08/15/03	18:30	E<0.10	21.3	--	523	5.7	--
M1	08/15/03	18:00	117	31.9	8.5	194	9.5	761
T1	08/15/03	--	Dry	--	--	--	--	--

[1]Tributary was assumed to be dry.

Moix, M.W., and Galloway, J.M.,2004, Base flow, water quality, and streamflow gain and loss
of the Buffalo River, Arkansas, and selected tributaries, July and August 2003

Prepared in cooperation with the
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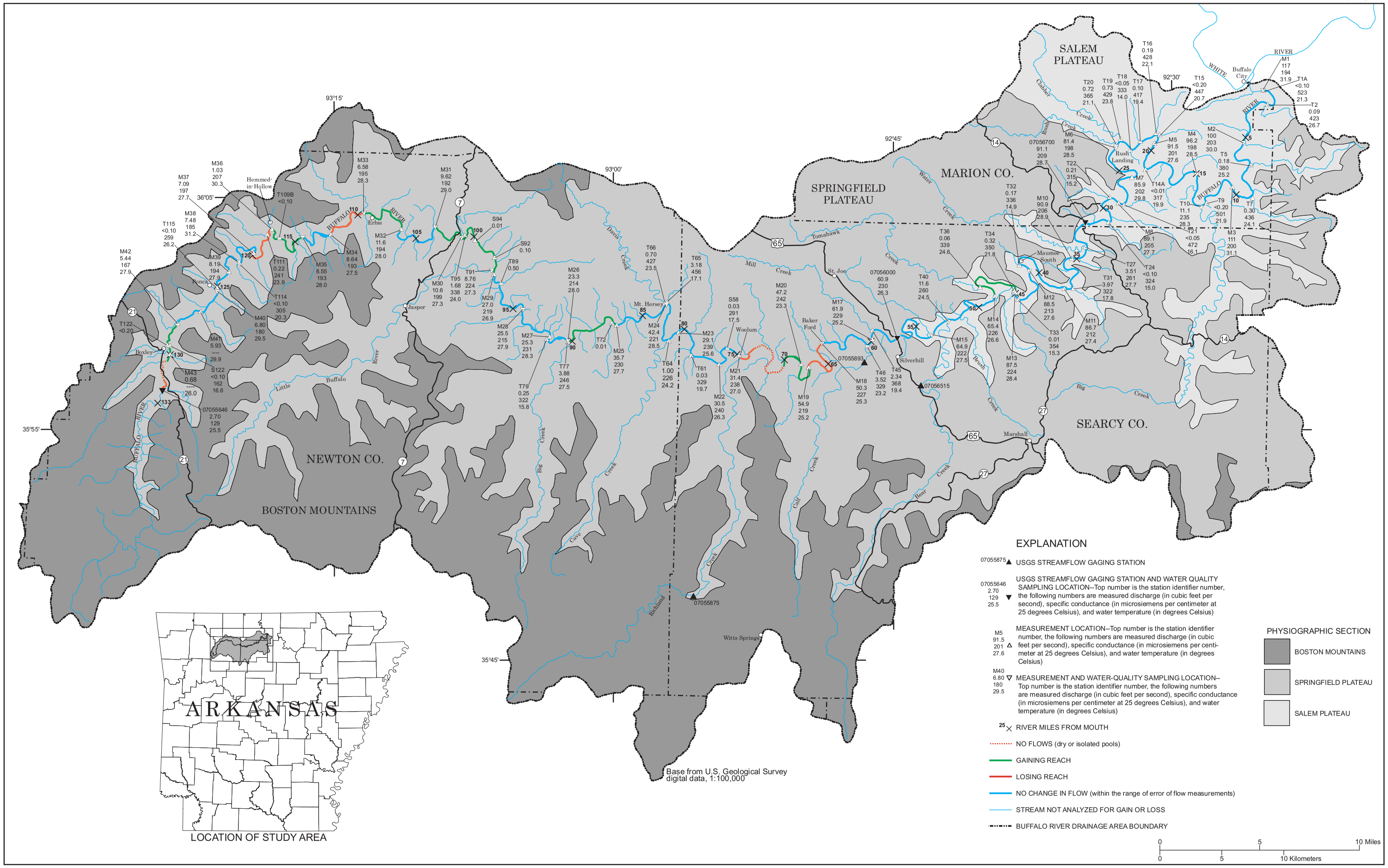

LOCATIONS OF STREAMFLOW MEASUREMENT AND WATER-QUALITY SAMPLING SITES FOR THE BUFFALO RIVER BASIN, JULY 28-30 AND AUGUST 13-15, 2003

Moix, M.W., and Galloway, J.M.—BASE FLOW, WATER QUALITY, AND STREAMFLOW GAIN AND LOSS OF THE BUFFALO RIVER, ARKANSAS, AND SELECTED TRIBUTARIES, JULY AND AUGUST 2003—U.S. Geological Survey Scientific Investigations Report 2004-5274

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