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CONSTITUENT LOADS AND TRENDS IN THE UPPER ILLINOIS RIVER WATERSHED AND UPPER WHITE RIVER BASIN

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Constituent Loads and Trends in the Upper Illinois River Watershed and Upper White River Basin

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The Arkansas Natural Resources Commission (ANRC) identified two priority hydrologic unit code (HUC) 8 watersheds, the Upper White River Basin (UWRB; HUC 11010001) and the Upper Illinois River Watershed (UIRW; 11110103), in northwest Arkansas. Nonpoint source (NPS) pollution is a concern in these watersheds, such as excess nutrients from agriculture and sediment from changes in land uses. Several NPS pollution projects have been funded by ANRC, including streambank restoration on Sager Creek and best management practices (BMP) to control urban sediment in Fayetteville. The purpose of this project was to collect water samples at 19 sites in the UWRB and UIRW to estimate constituent loads and understand how water quality has been changing in these priority watersheds over time.

Sampling sites were selected because of their location within the watershed (representing a variety of land use characteristics) and most were at existing U.S. Geological Survey (USGS) stream gaging stations. Approximately 46 water samples were collected during each project year (July 1 through June 30) at each site during base-flow and surface runoff conditions, ranging from small to large storm events. Water samples were analyzed for nitrate-nitrogen nitrogen (NO_3-N), total nitrogen (TN), soluble reactive phosphorus (SRP), total phosphorus (TP), chloride (Cl), sulfate (SO_4), and total suspended solids (TSS). Constituent concentrations were paired with daily discharge and loads were estimated using the software program LOADEST. Trends in water quality also were evaluated, as monotonic changes in flow-adjusted constituent concentrations over time.

Constituent loads at the sample sites in the UWRB and UIRW were highly variable, but generally followed changes in discharge, where increasing discharge drove increasing loads. Constituent loads also were positively related to watershed area across the sampling sites. At the majority of sites, trends in nutrients and sediments generally indicated improvements in water quality (decreasing trends) or no change in water quality. However, there were some instances of increasing trends in N, P, or TSS at Richland Creek, the White River, College Branch, and Flint Creek. There were surprising trends for chloride and sulfate at most sites throughout both watersheds. Specifically, increases in flow-adjusted concentrations through time were observed for chloride, sulfate or both at 12 of the 19 sampling sites.

Long-term water-quality monitoring data are often needed to identify changes in water quality because of the lag time between the implementation of BMPs or landscape disturbances and the water-quality response. These data can be used to evaluate the effectiveness of NPS projects aimed to reduce nutrient and sediment loads and to help calibrate and validate models that can be used for future planning. This information also can provide insight in to where additional resources should be targeted, or identify potential emerging water-quality problems.

Introduction

Water chemistry can greatly influence the quality of surface waters and affect the ability for streams and rivers to meet their designated use(s). In Arkansas, many streams and rivers were placed on the 2008 303(d) list of impaired water bodies due to excess levels of nutrients, chlorides, sulfates, and sediments (ADEQ, 2008). These constituents continue to be listed as the potential cause for water-quality impairments through the most recent draft 303(d) list (ADEQ, 2014). The Arkansas Non-Point Source (NPS) Management Program wants to reduce pollutant loading from the landscape and improve water quality, where funding for projects is targeted to priority watersheds throughout the State.

The Arkansas Natural Resources Commission (ANRC) funds projects associated with reducing NPS pollution in priority watersheds. Projects include the implementation of best management practices (BMPs), technical assistance to land-owners, education outreach, and water-quality monitoring. Monitoring the water quality in priority watersheds is designed to provide information related to water-quality changes resulting from the implementation of NPS projects, state regulations and other watershed management activities that may have occurred. The NPS Management Program also uses water-quality monitoring data to help calibrate and validate models that can be used for future planning, BMP scenarios and potential assessment of NPS projects aimed to reduce nutrient and sediment loads. Long-term monitoring data are often needed to identify water-quality improvements from NPS projects because of the lag time between the implementation of management practices and the water-quality response. For example, lag time can vary considerably by site and by pollutant, where it could take years, decades, or more to observe a change in water quality after watershed management activities are implemented (Meals et al., 2010).

The Upper Illinois River Watershed (UIRW) and the Upper White River Basin (UWRB) in northwest Arkansas are listed as priority watersheds. One of the major NPS concerns in these watersheds is excess nutrients, particularly phosphorus from animal agriculture (ANRC, 2015). Excess sediment is another major issue in these watersheds due to changes in land use, where there have been and continue to be increases in residential, commercial and industrial development (ANRC, 2015). Many NPS projects have been or are currently being completed in the UIRW and UWRB, including streambank restoration on Sager Creek (project 07-900) and best management practices to control urban sediment in Fayetteville (07-600). The objectives of the current study were (1) to collect water samples at various sites in the UIRW and UWRB that add to the long-term records of water-quality data; (2) to estimate constituent loads at sites where the U.S. Geological Survey (USGS) or the Arkansas Water Resources Center (AWRC) records streamflow; and (3) to evaluate trends in water quality to help document the effects of NPS projects on downstream water quality.

Methods

Water Sample Collection

Water samples were collected manually from the bridge access at the 19 sites within the Upper Illinois River Watershed and the Upper White River Basin. An Alpha style horizontal sampler or a Kemmerer type vertical sampler was used to collect the sample at a single point representative of the stream (i.e., near the vertical centroid of flow where velocity is greatest). Samples were collected at a near-weekly frequency with approximately 46 samples per site being collected during a project year (i.e., July through June). The monitoring program was adjusted to ensure that a sufficient fraction of water samples represented surface runoff conditions (or storm events) resulting from episodic rainfall events, including small and large storm events. Thus, water samples captured potential seasonal variation in constituent concentrations as well as variation in flow. All samples were collected according to an approved quality assurance project plan (QAPP; QMP # 14-120), which was updated annually to reflect any changes during the project time period.

Lab Analysis

All water samples were delivered to the Arkansas Water Resources Center Water Quality Lab (AWRC WQL) and analyzed for nitrate-nitrogen nitrogen (NO_3-N), chloride (Cl), soluble reactive phosphorus (SRP), sulfate (SO_4), total phosphorus (TP), total nitrogen (TN), and total suspended solids (TSS) using standard analytical procedures for the analysis of water and wastewater. The AWRC WQL is certified by the Arkansas Department of Environmental Quality (ADEQ) for the analysis of water samples, including all parameters included in this water-quality monitoring project. The laboratory used standard quality assurance and quality control (QA/QC) practices were used during analyses, such as blanks, duplicates, and spikes. All water physico-chemical data was collected and analyzed following the approved QAPP and standard methods for the analysis of water samples.

Flow Measurement

The U.S. Geological Survey (USGS) operates multiple stream gaging station in northwest Arkansas, which coincided with the sampling locations used in this project. Daily mean flow values (cfs), or discharge, were available through the USGS National Water Information Systems (NWIS) at all sites that had operating gages. Daily discharge was down-loaded for each site during each project year, and then the discharge values were updated in July 2015 for the final calculation and report.

Daily discharge at two sites, Ballard Creek and Sager Creek, was estimated using stage monitoring stations operated by the AWRC. Discharge (daily mean streamflow) and stage were measured at least once a month using an acoustic Doppler current meter during base flow or wade-able conditions and also during storm events using an acoustic Doppler current profiler. These measurements were used to develop a stage-discharge relationship for both sites (Figure 1). A typical parametric model would not fit the data for the entire domain of stage sufficiently. Instead, the full range in stage was divided into low, moderate, and high ranges. Linear models relating discharge and stage were used for the low and high ranges, and a locally weighted regression (LOESS) curve was used for the moderate domain to better fit the curvilinear relationship. Any projections outside the range of paired stage and discharge values were based on the linear models for the low and high ranges. The respective models were then applied to the entire continuous stage measurement record to generate daily discharge values for both sites. Any missing pieces of the stage record due to inclement weather, equipment malfunctions or personnel errors were not estimated nor included in the final calculations for loads or trends.

Daily discharge at the White River near Goshen, Arkansas (WR45) was estimated by applying a drainage area correction factor to the daily mean flow data upstream at White River near Wyman (Wyman) in addition to effluent discharge data (Q_E) from the Paul R. Noland Wastewater Treatment Facility.

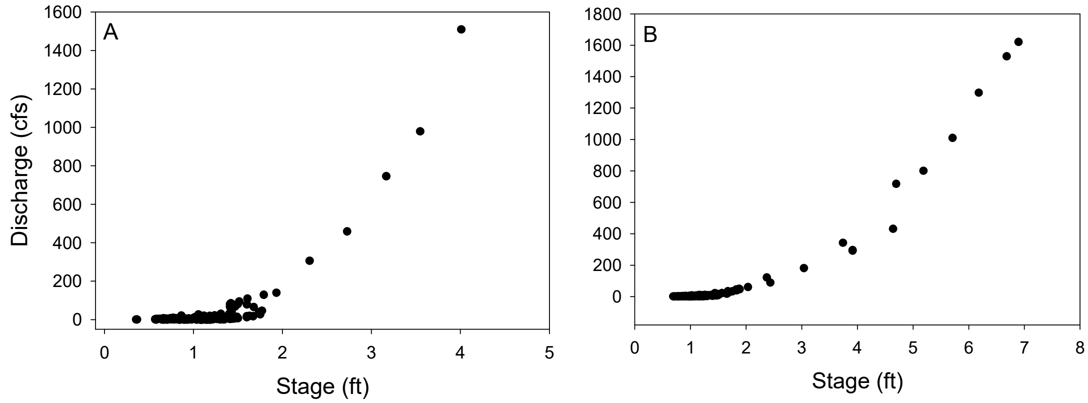


Figure 1. Scatterplot of stage vs discharge at (A) Ballard Creek and at (B) Sager Creek. Stage and discharge were measured manually from January 2011 to June 2015 during wadeable conditions and via an acoustic Doppler current profiler during greater flows.

The drainage area correction factor accounted for the increase in flow at the downstream site (Q_1) relative to flow at the upstream site (Q_2) due to the increase in drainage area ($\frac{A_1}{A_2}$). Thus, discharge at WR45 was estimated using the following equation:

$$Q_1 = \frac{A_1}{A_2}Q_2 + Q_E$$

Where A_1 is the catchment area of WR45 and A_2 is the catchment area of Wyman.

Load Estimation

Constituent loads (kg/d) were estimated at each site for the entire record of available streamflow data using LOADEST, a FORTRAN program developed by USGS (Runkel et al., 2004). LOADEST calculates observed loads (constituent concentration times daily discharge) for a given calibration data set; this represents all the sampling dates where water samples were collected and we have both concentration and discharge available. LOADEST then models observed loads with various parameters (described below), then applies the model to an estimation data set containing continuous date and discharge of a desired estimation period to estimate daily loads. Water-quality data (e.g., concentrations, discharge and loads) are often not normally distributed, so LOADEST uses log-transformation of observed loads and discharge to meet the normality requirements of regression modeling.

LOADEST has 11 built-in regression models which vary in the use of discharge (*Q*, cfs), decimal time (*dtime*, years), and a user defined period (*per*, not used in this report) to explain the variation in observed loads and then predict loads for the time and discharge record. The *dtime* parameter is used to model seasonal variation in loads (basically using Fourier's equation) that occur throughout the year and trends in loads (i.e., concentrations) over time. The available models are given in Table 1, where these equations vary from a simple linear regression model between log-transformed loads and discharge to very complex regression models. LOADEST can automatically pick the "best" model (model 0, Table 1) by comparing Akaike Information Criterion (AIC, a statistic representing the model's overall goodness of fit and simplicity) values for each model where the lowest AIC is considered the best. To select the most appropriate model, we employed a stepwise process that compares models by terms of statistical output and considered hydrological-biogeochemical relationships in the streams.

First, LOADEST was executed with model 0 to compare AIC values between all of the predefined models. The most complex models (models 8 and 9) were often selected at this step; however, the simpler models often had comparable AIC values (e.g., model 9 had AIC of 1.332 but model 4 had AIC of 1.435). To determine if a simpler model should be used, models with comparable AIC values were evaluated for load estimation bias percentage (BP) and Nash-Sutcliffe Efficiency (E). BP is a standard metric indicating the reliability of the resulting load estimations where ±25% BP is desired. E is a metric that describes the ability of the model to predict loads where E=1 is a perfect match of load estimates to load observations, E=0 indicates that the predicted loads are as accurate an estimate as using the observed mean, E<0 indicates that the observed mean is a better estimate than the regression model. Generally, BP decreased as E increased. Simpler models with slightly greater AIC values (slightly worse fit) than a complex model were chosen when the simpler model had greater E and lower BP.

Constituent loads (i.e., concentrations) might change over time where using datasets that covers several years, such as the case in this project. Several of the regression models in LOADEST have the ability to account for long-term increases or decreases in constituent loads; models 1, 2, 4, and 6 in LOADEST have a related counterpart model which includes this *dtime* parameter (models 3, 5, 7 and 8, respectively). So the last step in model selection was to include the *dtime* parameter in the load model if a significant trend in the flow-adjusted concentrations was detected during trend analysis (see below).

Table 1. Summary of available predefined regression models in LOADEST (Runkel et al., 2004). Where a_n are model coefficients; *ln* is natural logartithm; *Q* is mean daily stream flow; *lnQ* = ln(streamflow) – center of ln(streamflow); *dtime* = decimal time - center of decimal time; and *per* is period, 1 or 0, depending on user-defined period.

Specified value	Regression model
0	Automatically select best model from models 1-9
1	$a_0 + a_1 lnQ$
2	$a_0 + a_1 lnQ + a_2 lnQ^2$
3	$a_0 + a_1 lnQ + a_2 dtime$
4	$a_0 + a_1 lnQ + a_2 \sin(2\pi dtime) + a_3 \cos(2\pi dtime)$
5	$a_0 + a_1 lnQ + a_2 lnQ^2 + a_3 dtime$
6	$a_0 + a_1 lnQ + a_2 lnQ^2 + a_3 \sin(2\pi dtime) + a_4 \cos(2\pi dtime)$
7	$a_0 + a_1 lnQ + a_2 \sin(2\pi dtime) + a_3 \cos(2\pi dtime) + a_4 dtime$
8	$a_0 + a_1 lnQ + a_2 lnQ^2 + a_3 \sin(2\pi dtime) + a_4 \cos(2\pi dtime) + a_5 dtime$
9	$a_0 + a_1 lnQ + a_2 lnQ^2 + a_3 \sin(2\pi dtime) + a_4 \cos(2\pi dtime) + a_5 dtime + a_6 dtime^2$
10	$a_0 + a_1 per + a_2 lnQ + a_3 lnQ\ per$
11	$a_0 + a_1 per + a_2 lnQ + a_3 lnQ\ per + a_4 Q^2 + a_5 lnQ^2 per$

Trend Analysis

Monotonic changes in constituent concentrations over time (increasing, decreasing, or unchanging), or trends, were evaluated for each constituent across the entire sampling period. Trend analysis involved a three step process:

- First, constituent concentrations (C) and daily discharge (Q) were log-transformed (logC and logQ, respectively) to account for the log-normal distribution typically seen in water quality data. This transformation also reduced the influence of outliers.

- Second, a LOESS curve was fitted to the logC vs. logQ data in order to correct for variation in concentrations due to flow. This smoothing technique accounted for intricacies in the logC vs logQ relationship. A sampling proportion (i.e., the proportion of data LOESS uses for each local regression) was set to 0.5 and a linear function was used as the local regression method. These settings were based on literature concerning trend analysis of water quality data.

- Third, the residuals from the LOESS regression, termed here as flow-adjusted concentrations (FACs), were plotted over time. A linear regression of FACs vs time was used to detect for a significant trend at α=0.05 (i.e., whether the F-test rejects the null hypothesis that the slope is not different than zero).

If there was a significant trend, the slope from the linear regression was converted to percent change in constituent concentration per year (% change/year) using the following equation:

$$\%\ change/year = e^{slope} - 1$$

The three step process is a common approach to looking at monotonic changes in FACS over time (see White et al., 2004 for more details if desired). This technique has been used to evaluate trends in FACs for many streams and rivers, (e.g., Haggard, 2010; Scott et al., 2011), where the trends in FACs could be attributed to changes in the watershed such as improvements in effluent nutrient concentrations.

Results

Upper White River Basin

The Upper White River Basin (UWRB; HUC 11010001) is a 5747 km^2 watershed that lies in northwest Arkansas and crosses into Missouri. The UWRB has headwaters in the Boston Mountains Ecoregion, which then flow north into the Ozark Highlands Ecoregion. Parts or all of several counties in Arkansas are covered by the UWRB, including Benton, Boone, Carroll, Crawford, Franklin, Johnson, Madison, Newton and Washington counties. The White River is impounded to form Beaver Lake, which serves as the drinking water source for over 400,000 people, as well as providing recreational, tourism and industrial water uses. War Eagle Creek and Richland Creek are the other main tributary inflows into Beaver Lake.

Forest land cover (63%) dominates the UWRB, and 25% is grassland, 6.7% is transitional, 2.1% is water, and 2% is urban and suburban (arkansaswater.org, 2015). In addition to the forest land cover, this watershed has typically been characterized by its agricultural activities including pasture land, cattle grazing and poultry operations. But, in recent decades, land use conversion from forest and pasture to urban development has occurred. The human population and subsequent urban development is expected to continue to increase, which will have an effect on the hydrology and water quality of streams and lakes in the watershed.

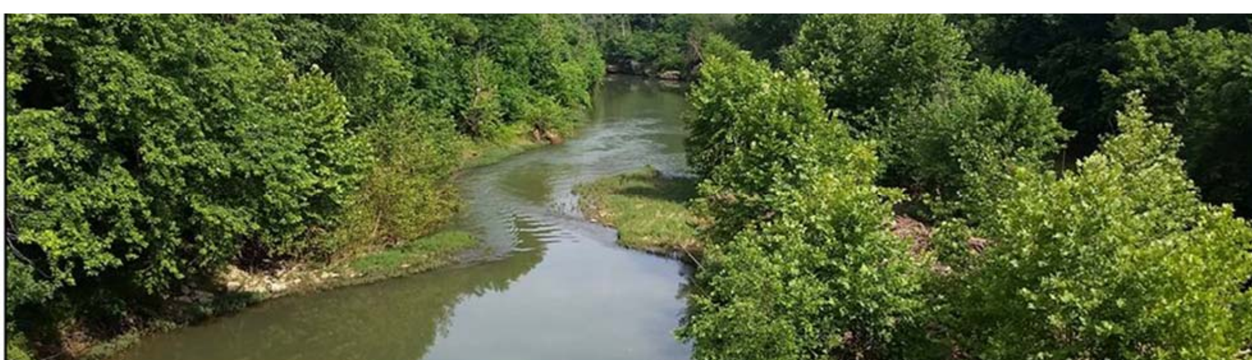
The UWRB has been identified by the Arkansas Natural Resources Commission as a 319 Non-point Source (NPS) Pollution priority catchment. The major water-quality concerns in this water-shed are nutrients, sediments, chlorides, sulfates and total dissolved solids (ANRC, 2015). There are several 319 projects in the UWRB, ranging from streambank restoration to landowner education, in an effort to reduce pollutant loads from land uses that are likely to influence water quality. Measuring the success of these 319 projects depends on the availability of long-term water quality data that can be paired with discharge data.

Most sampling occurred at sites where USGS stream gaging stations exist and daily discharge data was available. Streams that were selected for water-quality sampling also varied in catch-ment area and land use. For example, Town Branch Tributary (TBT) and College Branch (TB62) are small watersheds draining predom-inantly urban land cover (Table 2). On the other hand, the White River near Goshen (WR45), the White River near Fayetteville (Wyman) and Kings River (Kings) drain large watersheds with almost 70% forested land cover. The West Fork of the White River (WFWR) and the White River near Fayetteville are on stream segments that are on the 2008 303(d) list of impaired water bodies for chloride, sulfate and total dissolved solids. Finally, Richland Creek (RC45) and War Eagle Creek (WEC) drain a mixture of forest and pasture land cover.

Table 2. Select study sites (Site ID), USGS station number, site coordinates, drainage area and land cover as percentages of total drainage area for sites in the Upper White River Basin (HUC 11010001) and the Upper Illinois River Watershed (HUC 11110103). All water samples were collected in Arkansas (except when stated otherwise) at the following locations: the Kings River near Berryville (Kings); the White River near Goshen (WR45); the White River near Fayetteville (Wyman); War Eagle Creek near Hindsville (WEC); Richland Creek near Goshen (RC45); the West Fork of the White River east of Fayetteville (WFWR); Town Branch Tributary in Fayetteville (TBT); and College Branch in Fayetteville (TB62).

					Percent of Land Use*					
Site ID	**USGS Station**	**Latitude**	**Longitude**	**Area (km^2)**	**Urban**	**Forest**	**Grassland**	**Pasture**	**Wetlands**	**Water**
Kings	07050500	36°25'38"N	93°37'15"W	1369.1	4.2	67.0	2.4	26.0	0.3	0.1
WR45	N/A	36°06'21"N	94°00'40"W	1062.3	6.4	68.5	2.6	21.4	0.7	0.3
Wyman	07048600	36°04'23"N	94°04'52"W	1032.0	6.5	69.3	2.7	20.6	0.7	0.2
WEC	07049000	36°12'00"N	93°51'18"W	686.0	4.8	57.6	2.3	34.9	0.3	<0.05
RC45	07048800	36°06'15"N	94°00'27"W	362.0	3.8	58.0	2.4	35.4	0.3	<0.05
WFWR	07048550	36°03'14"N	94°04'59"W	317.2	13.2	59.7	2.5	23.7	0.7	0.2
TBT	07048490	36°02'54"N	94°09'44"W	3.3	85.9	13.5	0.2	0.4	0.0	<0.05
TB62	07048480	36°03'25"N	94°10'34"W	2.3	93.0	6.7	0.3	0.0	0.0	<0.05

*Land use was determined by the University of Arkansas Center for Advanced Spatial Technology (CAST) using the 2011 National Land Cover Dataset



KINGS RIVER NEAR BERRYVILLE, ARKANSAS (KINGS)

The Kings River (Kings) was sampled at the USGS stream gaging station near Berryville, Arkansas (USGS 07050500), where 245 water samples were collected and analyzed for constituents from July 2011 through June 2015. The Kings River Watershed is 1370 km^2, draining 67% forested lands, 28% pasture and grasslands, and 4% urban development. The Kings River is a tributary to the White River within the Upper White River Basin, flowing into Table Rock Lake in Missouri.

The constituent concentrations were paired with mean daily discharge and then used in the software program LOADEST to estimate constituent loads. The regression models for constituents at this site where complex, including mean daily discharge (Q) and time (t); the regression models also included coefficients to account for seasonal variations in the observed daily loads. The various statistics and specific equations used in constituent load estimation are presented in Table 3. The mean daily loads were variable across constituents, showing that nitrate-nitrogen (NO_3-N), on average, made up essentially all of the total nitrogen (TN) loads whereas soluble reactive phosphorus (SRP) loads were only 25% of the total phosphorus (TP) loads.

The mean daily loads were summed into annual loads (Table 4), which varied annually and generally followed changes in annual discharge. However, the change in constituent loads between years does reflect the use of log-transformed values and re-transformation. For example, annual discharge was similar between project years 2011 and 2013 but the change in constituent loads was not necessarily proportional to the differences in annual discharge. The annual loads were dependent upon how constituent concentrations changed over time and how discharge varied within project years, reflecting the importance of hydrology in understanding constituent transport at the Kings River.

Table 3. Regression models used for load estimations of nitrate-N (NO_3-N), total nitrogen (TN), soluble reactive phosphorus (SRP), total phosphorus (TP), total suspended solids (TSS), chloride (Cl), and sulfate (SO_4) for Kings River near Berryville, AR (Kings; USGS 07050500) from July 2011 to June 2015, with respective Akaike Information Criterion (AIC), load bias percentages (BP), Nash-Sutcliffe Efficiency index (E), and mean daily load for the estimation period with lower and upper values of the 95% confidence intervals (CI) in parentheses.

Constituent	Regression equation	AIC	BP (%)	E	Mean Daily Load (kg/d)
NO_3-N	$6.11 + 1.58lnQ - 0.19lnQ^2 - 0.17\sin(2\pi t) - 0.34\cos(2\pi t) + 0.06t$	2.34	20	0.74	1740 (1430 - 2090)
TN	$6.25 + 1.27lnQ - 0.02lnQ^2 - 0.29\sin(2\pi t) - 0.15\cos(2\pi t) + 0.02t$	1.02	12	0.83	1720 (1540 - 1910)
SRP	$2.45 + 1.05lnQ - 0.39t$	3.01	5	0.83	27 (19 - 36)
TP	$3.43 + 1.40lnQ + 1.01\sin(2\pi t) + 0.04\cos(2\pi t) - 0.17t$	2.43	-24	0.91	112 (84 - 147)
TSS	$7.91 + 1.74lnQ + 1.15\sin(2\pi t) + 0.24\cos(2\pi t) - 0.02t$	2.94	-59	0.60	41600 (23400 - 68600)
Cl	$8.13 + 0.67lnQ + 0.03lnQ^2 - 0.04\sin(2\pi t) - 0.12\cos(2\pi t) + 0.02t$	-0.25	4	0.88	4730 (4540 - 4930)
SO_4	$8.45 + 0.79lnQ + 0.03lnQ^2 - 0.14\sin(2\pi t) - 0.10\cos(2\pi t) + 0.06t$	0.10	6	0.82	8170 (7740 - 8630)

KINGS RIVER NEAR BERRYVILLE, ARKANSAS (KINGS)

Table 4. Summary of annual discharge (Q, m^3) and annual loads (kg) for nitrate-N (NO_3-N), total nitrogen (TN), soluble reactive phosphorus (SRP), total phosphorus (TP), total suspended solids (TSS), chloride (Cl), and sulfate (SO_4) for Kings River near Berryville, AR (Kings; USGS 07050500) for project years 2011-2014 (e.g., project year 2011 is July 1, 2011 - June 30, 2012).

Project Year	Annual Q (m^3)	NO_3-N (kg)	TN (kg)	SRP (kg)	TP (kg)	TSS (kg)	Cl (kg)	SO_4 (kg)
2009	711,000,000	751,000	915,000	61,200	208,000	45,800,000	2,340,000	3,630,000
2010*	846,000,000	567,000	1,170,000	47,700	234,000	105,000,000	2,320,000	4,160,000
2011	425,000,000	603,000	654,000	16,500	36,900	8,720,000	1,620,000	2,690,000
2012	306,000,000	405,000	373,000	7,330	22,300	5,930,000	1,220,000	1,980,000
2013	457,000,000	669,000	609,000	8,020	41,000	12,200,000	1,820,000	3,100,000
2014	640,000,000	860,000	872,000	7,330	63,200	34,000,000	2,250,000	4,170,000

*Constituent loads were estimated for project year 2010, but water samples were not collected during this time due to lack of funding.

All of the constituents showed that flow-adjusted concentrations changed over time at the Kings River (Table 5), that is a monotonic or linear trend occurred throughout the study period.

- NO_3-N and TN showed significant increases over time (7.3 and 3.4% change per year)
- SRP and TP showed significant decreases over time (39.4 and 23.9% change per year)
- TSS showed a significant decrease over time (10.1% change per year)
- Cl and SO_4 showed a significant increase over time (2.0 and 5.9% change per year)

The concentrations for SRP and TP were an order of magnitude greater during base flow conditions between July and December 2011, and the data were checked and double checked. The concentration data in 2011 matched what was observed between July 2009 and June 2010. The directional changes in flow-adjusted concentrations were included in the load estimation equations, where the percent change per year was relatively similarly between the regression model and the three step procedure used to evaluate monotonic changes in flow adjusted concentrations.

Table 5. Trends in flow-adjusted concentrations of nitrate-nitrogen (NO_3-N), total nitrogen (TN), soluble reactive phosphorus (SRP), total phosphorus (TP), total suspended solids (TSS), chloride (Cl), and sulfate (SO_4) for Kings River near Berryville, AR (Kings; USGS 07050500) from July 2011 to June 2015, with respective sample size (n), coefficient of determination (R^2), and p-value of the overall F-test (p-value). Percent change per year (% Change/year) is reported for significant trends (p-value<0.05) and marginally significant trends (p-value ≤ 0.10).

Constituent	n	R^2	p-value	% Change/year
NO_3-N	245	0.03	<0.01	7.3
TN	245	0.02	0.02	3.4
SRP	245	0.34	<0.01	-39.4
TP	245	0.23	<0.01	-23.9
TSS	245	0.05	<0.01	-10.1
Cl	242	0.03	0.01	2.0
SO_4	242	0.15	<0.01	5.9

WHITE RIVER NEAR GOSHEN, ARKANSAS (WR45)

The White River (WR45) was sampled from the bridge on Highway 45 near Goshen, Arkansas, where 285 water samples were collected and analyzed for constituents from July 2009 through June 2015. The White River at this site drains a large watershed (1060 km^2) with land use representing 69% forested areas, 24% pasture and grassland, 6% urban, and almost 1% wetlands. This is the most downstream site on the White River, and this site is also downstream from the effluent discharge of the Paul Noland wastewater treatment plant. This site is essentially at the upper end of Beaver Lake, especially when lake levels are relatively elevated.

The constituent concentrations were paired with mean daily discharge and then used to estimate daily loads using the software program LOADEST. The regression equations used to predict daily loads for each constituent were generally complex and used multiple discharge factors (Q and Q^2), seasonal coefficients (sin and cos) and or time (t). The regression models and associated statistics used in load estimation are presented in Table 6. The mean daily loads were variable across constituents and showed that nitrate-nitrogen (NO_3-N) loads made up a large percentage of total nitrogen (TN) loads (approximately 73%), whereas soluble reactive phosphorus (SRP) loads only made up approximately 13% of total phosphorus (TP) loads.

The mean daily loads for each constituent were summed into annual loads for each project year (Table 7) and loads varied between project years, which generally reflected changes in discharge. However, this variation was not necessarily proportional to the changes in discharge, which is a result of the log-log transformations used in the regression models. For example, annual discharge volume in 2009 was approximately 10% less than that in 2010, but annual SRP load in 2009 was approximately 50% less than the load in 2010. Annual loads generally were positively related to annual discharge across project years, demonstrating the importance of hydrology in understanding constituent transport at the White River near Goshen.

Table 6. Regression models used for load estimations of nitrate-N (NO_3-N), total nitrogen (TN), soluble reactive phosphorus (SRP), total phosphorus (TP), total suspended solids (TSS), chloride (Cl), and sulfate (SO_4) for White River near Goshen, AR from July 2009 to June 2015, with respective Akaike Information Criterion (AIC), load bias percentages (BP), Nash-Sutcliffe Efficiency index (E), and mean daily load for the estimation period with lower and upper values of the 95% confidence intervals (CI) in parentheses.

Constituent	Regression equation	AIC	BP (%)	E	Mean Daily Load (kg/d)
NO_3-N	$5.60 + 1.00lnQ - 0.01lnQ^2 + 0.01\sin(2\pi t) - 0.47\cos(2\pi t)$	2.49	35	0.76	1000 (830 - 1190)
TN	$6.05 + 0.97lnQ + 0.03lnQ^2 + 0.13\sin(2\pi t) - 0.16\cos(2\pi t)$	1.13	9	0.83	1420 (1270 - 1570)
SRP	$0.86 + 1.26lnQ + 0.04lnQ^2$	2.46	12	0.51	30 (20 - 44)
TP	$3.36 + 1.34lnQ + 0.56\sin(2\pi t) + 0.41\cos(2\pi t)$	2.14	-49	0.57	240 (180 - 300)
TSS	$8.76 + 1.51lnQ + 0.58\sin(2\pi t) + 0.66\cos(2\pi t)$	2.68	-46	0.61	122000 (78500 - 180000)
Cl	$8.09 + 0.72lnQ + 0.01lnQ^2 + 0.12\sin(2\pi t) - 0.13\cos(2\pi t)$	1.42	4	0.50	5880 (5390 - 6390)
SO_4	$8.96 + 0.83lnQ + 0.08\sin(2\pi t) - 0.09\cos(2\pi t)$	0.68	5	0.67	15700 (14800 - 16700)

WHITE RIVER NEAR GOSHEN, ARKANSAS (WR45)

Table 7. Summary of annual discharge (Q, m^3) and annual loads (kg) for nitrate-N (NO_3-N), total nitrogen (TN), soluble reactive phosphorus (SRP), total P (TP), total suspended solids (TSS), chloride (Cl), and sulfate (SO_4) for White River near Goshen, AR (USGS 07048700) for project years 2009-2014 (e.g., project year 2011 is July 1, 2011 - June 30, 2012).

Project Year	Annual Q (m^3)	NO_3-N (kg)	TN (kg)	SRP (kg)	TP (kg)	TSS (kg)	Cl (kg)	SO_4 (kg)
2009	658,000,000	527,000	698,000	12,700	115,000	51,600,000	2,900,000	7,660,000
2010	715,000,000	389,000	714,000	23,700	156,000	95,200,000	2,360,000	6,650,000
2011	376,000,000	341,000	387,000	6,350	38,000	14,100,000	1,710,000	4,460,000
2012	338,000,000	217,000	285,000	4,490	39,000	16,800,000	1,460,000	3,860,000
2013	384,000,000	294,000	357,000	5,330	43,000	17,000,000	1,820,000	4,670,000
2014	678,000,000	419,000	659,000	13,300	130,000	71,500,000	2,610,000	7,130,000

At this site on the White River (WR45), there were no monotonic or linear trends in flow-adjusted concentrations over time for any of the constituents evaluated in this study (Table 8). There are several reasons why trends observed at the White River just upstream at Wyman Bridge were not observed here, including:

- Flow estimated based off of the upstream gage, effluent discharge and change in watershed area
- This site is often under backwater conditions, and it's really part of Beaver Lake
- The effluent discharge upstream might influence concentration-flow relationships

The lack of trends should be interpreted cautiously at this site, and more influence should be placed on the upstream site when evaluating trends in constituent inputs into Beaver Lake

Table 8. Trends in flow-adjusted concentrations of nitrate-nitrogen (NO_3-N), total nitrogen (TN), soluble reactive phosphorus (SRP), total phosphorus (TP), total suspended solids (TSS), chloride (Cl), and sulfate (SO_4) for White River near Goshen, AR (WR45; USGS 07048700) from July 2009 to June 2015, with the respective sample size (n), coefficient of determination (R^2), and p-value of the overall F-test (p-value). Percent change per year (% Change/year) is reported for significant trends (p-value<0.05).

Constituent	n	R^2	p-value	% Change/year
NO_3-N	285	0.01	0.23	-
TN	283	<0.01	0.39	-
SRP	285	<0.01	0.39	-
TP	285	<0.01	0.45	-
TSS	285	<0.01	0.71	-
Cl	282	<0.01	0.94	-
SO_4	282	<0.01	0.41	-

WHITE RIVER NEAR FAYETTEVILLE, ARKANSAS (WYMAN)

The White River was sampled at the USGS stream gaging station on Wyman Road, near Fayetteville, Arkansas (USGS 07048600), where approximately 290 water samples were collected and analyzed for constituents from July 2009 through June 2015. The White River at this site drains a large watershed (1032 km^2) with land use representing 69% forested area, 23% pasture and grasslands, 7% urban development, and almost 1% wetlands. This site is just upstream of the wastewater effluent discharge from the Paul Noland Treatment Facility east of Fayetteville.

The constituent concentrations were paired with mean daily discharge and then used in the software program LOADEST to estimate constituent loads. The regression models for constituent loads at this site were complex and included multiple discharge factors (Q and Q^2), seasonal coefficients (sin and cos) and or time (t). The regression models and associated statistics used in load estimation are presented in Table 9. The mean daily loads were variable across constituents, showing that nitrate-nitrogen (NO_3-N) loads made up 64% of total nitrogen (TN) loads, whereas soluble reactive phosphorus (SRP) loads made up less than 10% of total phosphorus (TP) loads.

The mean daily loads for each constituent were summed into annual loads for each project year (Table 10). Loads varied between project years and generally reflected changes in discharge. However, this variation was not necessarily proportional to the changes in discharge, which is a result of the log-log transformations used in the regression models. For example, annual discharge volume in 2009 was approximately 8% less than that in 2010, but annual TSS load in 2009 was 40% less than the load in 2010. Overall, annual loads were positively related to annual discharge across project years, demonstrating the importance of hydrology in understanding constituent transport at the White River near Fayetteville.

Table 9. Regression models used for load estimations of nitrate-N (NO_3-N), total nitrogen (TN), soluble reactive phosphorus (SRP), total phosphorus (TP), total suspended solids (TSS), chloride (Cl), and sulfate (SO_4) for White River near Fayetteville, AR (USGS 07048600) from July 2009 to June 2015, with respective Akaike Information Criterion (AIC), load bias percentages (BP), Nash-Sutcliffe Efficiency index (E), and mean daily load for the estimation period with lower and upper values of the 95% confidence intervals (CI) in parentheses.

Constituent	Regression equation	AIC	BP (%)	E	Mean Daily Load (kg/d)
NO_3-N	$3.64 + 1.16lnQ - 0.01lnQ^2 - 0.26\sin(2\pi t) - 0.40\cos(2\pi t)$	1.96	28	0.84	750 (640 - 870)
TN	$4.23 + 1.09lnQ + 0.01lnQ^2 + 0.003\sin(2\pi t) - 0.18\cos(2\pi t) + 0.04t$	0.84	9	0.74	1170 (1060 - 1290)
SRP	$-0.77 + 1.24lnQ + 0.04lnQ^2 + 0.43\sin(2\pi t) - 0.07\cos(2\pi t)$	2.20	20	0.62	27 (19 - 37)
TP	$1.37 + 1.27lnQ + 0.05lnQ^2 + 0.54\sin(2\pi t) + 0.20\cos(2\pi t)$	1.89	17	0.29	320 (230 - 430)
TSS	$7.03 + 1.44lnQ + 0.64\sin(2\pi t) + 0.43\cos(2\pi t)$	2.76	-42	0.63	99200 (65400 - 144000)
Cl	$6.40 + 0.90lnQ - 0.01lnQ^2 - 0.17\sin(2\pi t) - 0.12\cos(2\pi t)$	0.89	2	0.82	4030 (3750 - 4320)
SO_4	$7.73 + 0.91lnQ - 0.01lnQ^2 + 0.05\sin(2\pi t) - 0.11\cos(2\pi t)$	1.03	2	0.82	13800 (12800 - 14800)

WHITE RIVER NEAR FAYETTEVILLE, ARKANSAS (WYMAN)

Table 10. Summary of annual discharge (Q, m^3) and annual loads (kg) for nitrate-N (NO_3-N), total nitrogen (TN), soluble reactive phosphorus (SRP), total P (TP), total suspended solids (TSS), chloride (Cl), and sulfate (SO_4) for White River near Fayetteville, AR (USGS 07048600) for project years 2009-2014 (e.g., project year 2011 is July 1, 2011 - June 30, 2012).

Project Year	Annual Q (m^3)	NO_3-N (kg)	TN (kg)	SRP (kg)	TP (kg)	TSS (kg)	Cl (kg)	SO_4 (kg)
2009	631,000,000	358,000	509,000	14,500	156,000	43,800,000	1,860,000	6,690,000
2010	686,000,000	343,000	607,000	19,000	269,000	72,800,000	1,700,000	5,670,000
2011	358,000,000	245,000	313,000	4,960	44,100	13,100,000	1,180,000	3,860,000
2012	322,000,000	159,000	235,000	3,210	34,800	14,800,000	1,020,000	3,370,000
2013	366,000,000	203,000	297,000	4,200	41,100	15,400,000	1,190,000	4,080,000
2014	680,000,000	327,000	604,000	12,300	155,000	57,400,000	1,860,000	6,530,000

At the White River near Fayetteville, only TN showed a trend in flow-adjusted concentrations over the sampling period (Table 11).

- TN showed a significant increase over time (3.7% change per year)

The directional changes in the flow-adjusted concentrations as identified by the trend analysis were included in the equations used to estimate loads, so that loads were reflective of any changes that occurred through time. The percent change per year was relatively similar between the regression model used to estimate loads and the procedure used to evaluate monotonic changes in flow-adjusted concentrations.

Table 11. Trends in flow-adjusted concentrations of nitrate-nitrogen (NO_3-N), total nitrogen (TN), soluble reactive phosphorus (SRP), total phosphorus (TP), total suspended solids (TSS), chloride (Cl), and sulfate (SO_4) for White River near Fayetteville, AR (Wyman; USGS 07048600) from July 2009 to June 2015, with the respective sample size (n), coefficient of determination (R^2), and p-value of the overall F-test (p-value). Percent change per year (% Change/year) is reported for significant trends (p-value<0.05).

Constituent	n	R^2	p-value	% Change/year
NO_3-N	289	<0.01	0.69	-
TN	288	0.03	<0.01	3.7
SRP	290	<0.01	0.45	-
TP	290	0.01	0.14	-
TSS	289	<0.01	0.74	-
Cl	287	<0.01	0.43	-
SO_4	287	<0.01	0.77	-

WAR EAGLE CREEK NEAR HINDSVILLE, ARKANSAS (WEC)

The War Eagle Creek (WEC) was sampled at the USGS stream gaging station near Hindsville, AR (USGS 07049000), where 285 water samples were collected and analyzed for constituents from July 2009 through June 2015. The WEC watershed is approximately 690 km^2, draining 57% forest, 38% pasture and grasslands, and 5% urban. War Eagle Creek receives the treated wastewater effluent from the city of Huntsville, Arkansas and it flows directly into Beaver Lake, the first large impoundment of the White River.

The constituent concentrations were paired with mean daily discharge, which were used to compute daily loads in the software program LOADEST. The regression equations used to estimate daily loads were complex and included multiple discharge factors (Q and Q^2), seasonal coefficients (sin and cos) and or time (t). The regression models and associated statistics used in load estimation are presented in Table 12. The mean daily loads were variable across constituents, and showed that nitrate-nitrogen (NO_3-N) loads made up the majority of total nitrogen (TN) loads (approximately 77%), whereas soluble reactive phosphorus (SRP) loads were only 16% of total phosphorus loads.

The mean daily loads were summed to calculate annual loads (Table 13), which varied between project years, generally following changes in annual discharge. But, this variation in constituent loads was not necessarily proportional to changes in discharge, which reflects the use of log-log transformations used in the regression models. For example, while total annual discharge in 2012 was approximately half of what is was in 2010, chloride load in 2012 was nearly 70% of that in 2010. Annual loads were generally strongly linked to annual discharge across project years, reflecting the importance of hydrology in understanding the transport of various constituents at the War Eagle Creek.

Table 12. Regression models used for load estimations of nitrate-N (NO_3-N), total nitrogen (TN), soluble reactive phosphorus (SRP), total phosphorus (TP), total suspended solids (TSS), chloride (Cl), and sulfate (SO_4) for War Eagle Creek near Hindsville, AR (USGS 07049000) from July 2009 to June 2015, with respective Akaike Information Criterion (AIC), load bias percentages (BP), Nash-Sutcliffe Efficiency index (E), and mean daily load for the estimation period with lower and upper values of the 95% confidence intervals (CI) in parentheses.

Constituent	Regression equation	AIC	BP (%)	E	Mean Daily Load (kg/d)
NO_3-N	$6.55 + 0.96lnQ - 0.04lnQ^2 - 0.01\sin(2\pi t) - 0.12\cos(2\pi t) - 0.03t$	0.88	-6	0.83	1000 (930 - 1070)
TN	$6.65 + 1.02lnQ - 0.02lnQ^2 + 0.04\sin(2\pi t) - 0.09\cos(2\pi t)$	0.53	-2	0.94	1290 (1210 - 1380)
SRP	$1.50 + 1.43lnQ + 0.33\sin(2\pi t) - 0.06\cos(2\pi t) - 0.01t$	2.00	11	0.94	22.0 (17 - 28)
TP	$3.01 + 1.51lnQ + 0.49\sin(2\pi t) - 0.32\cos(2\pi t)$	2.01	-35	0.77	140 (100 - 180)
TSS	$8.29 + 1.77lnQ + 0.65\sin(2\pi t) + 0.68\cos(2\pi t)$	2.50	-16	0.70	78000 (44600 - 127000)
Cl	$8.21 + 0.73lnQ - 0.02lnQ^2 + 0.15\sin(2\pi t) - 0.12\cos(2\pi t) - 0.01t$	0.63	0.06	0.85	4070 (3860 - 4290)
SO_4	$8.15 + 0.95lnQ - 0.03lnQ^2 - 0.06\sin(2\pi t) - 0.17\cos(2\pi t) - 0.03t$	-0.30	-0.08	0.94	4830 (4650 - 5020)

WAR EAGLE CREEK NEAR HINDSVILLE, ARKANSAS (WEC)

Table 13. Summary of annual discharge (Q, m^3) and annual loads (kg) for nitrate-N (NO_3-N), total nitrogen (TN), soluble reactive phosphorus (SRP), total P (TP), total suspended solids (TSS), chloride (Cl), and sulfate (SO_4) for War Eagle Creek near Hindsville, AR (USGS 07049000) for project years 2009-2014 (e.g., project year 2011 is July 1, 2011 - June 30, 2012).

Project Year	Annual Q (m^3)	NO_3-N (kg)	TN (kg)	SRP (kg)	TP (kg)	TSS (kg)	Cl (kg)	SO_4 (kg)
2009	344,000,000	489,000	579,000	11,000	58,900	29,200,000	1,900,000	2,040,000
2010	414,000,000	421,000	600,000	15,400	117,000	87,400,000	1,580,000	1,880,000
2011	261,000,000	355,000	440,000	6,330	28,700	10,600,000	1,440,000	1,710,000
2012	193,000,000	254,000	311,000	3,200	17,900	7,070,000	1,080,000	1,280,000
2013	270,000,000	349,000	450,000	5,470	28,800	11,200,000	1,530,000	1,860,000
2014	285,000,000	317,000	452,000	6,720	46,000	25,400,000	1,380,000	1,800,000

Several of the constituents showed significant changes over time (Table 14), when trends in flow-adjusted concentrations were evaluated. Five of the seven constituents evaluated showed changes in flow-adjusted concentrations over time, including:

- NO_3-N and TSS showed significant decreases over time (2.6 and 7.3% change per year)
- SRP and Cl showed a marginally significant decrease over time (3.7 and 2.2% change per year)
- SO_4 showed a significant increase over time (2.7% change per year)

The directional changes in the flow-adjusted concentrations as identified by the trend analysis were included in the equations used to estimate loads, so that loads were reflective of any changes that occurred through time. The percent change per year was relatively similar between the loads regression model and the procedure used to evaluate monotonic changes in flow-adjusted concentrations.

Table 14. Trends in flow-adjusted concentrations of nitrate-nitrogen (NO_3-N), total nitrogen (TN), soluble reactive phosphorus (SRP), total phosphorus (TP), total suspended solids (TSS), chloride (Cl), and sulfate (SO_4) for War Eagle Creek near Hindsville, AR (WEC; USGS 07049000) from July 2009 to June 2015, with the respective sample size (n), coefficient of determination (R^2), and p-value of the overall F-test (p-value). Percent change per year (% Change/year) is reported for significant trends (p-value<0.05).

Constituent	n	R^2	p-value	% Change/year
NO_3-N	285	0.02	0.04	-2.6
TN	284	<0.01	0.40	-
SRP	285	0.01	0.08*	-3.7
TP	285	<0.01	0.99	-
TSS	285	0.03	<0.01	-7.3
Cl	282	0.01	0.06*	-2.2
SO_4	282	0.04	<0.01	2.7

*The trend was marginally significant (p≤0.10).

RICHLAND CREEK NEAR GOSHEN, ARKANSAS (RC45)

Richland Creek (RC45) was sampled at the USGS stream gaging station near Goshen (USGS 07048800), which was recently discontinued in summer 2015 at the end of this project. There were 278 water samples collected from this site from July 2009 through June 2015, which were analyzed for the constituents at the water quality lab. The Richland Creek Watershed is 362 km^2, draining 58% forested lands, 38% pasture and grasslands, and 4% urban development. Richland Creek is one of the primary inflows into Beaver Lake on the White River and within the Upper White River Basin.

The constituent concentrations were paired with mean daily discharge and then used in the software program LOADEST to estimate constituent loads. The regression models for constituents varied in complexity at this site from a relatively simple model including discharge (Q) and time (t) to multiple discharge factors, seasonal coefficients, and time (Table 15). Almost all of the constituents (except soluble reactive phosphorus, SRP) included coefficients to account for seasonal variation in constituent loads. The mean daily loads were variable at Richland Creek, showing that nitrate-nitrogen (NO_3-N) makes up a large percentage of the total nitrogen (TN) loads whereas SRP was less than 15% of the total phosphorus (TP) loads.

The mean daily loads were summed into annual loads (Table 16), which varied across project years but generally followed the pattern in annual discharge. The change in constituent loads between years, however, does reflect the use of log-transformed values and retransformation; this influence was most profound in the estimation of total suspended solid (TSS) loads, where the change in annual load was not necessarily proportional to the change in annual discharge. The annual loads were dependent upon how discharge varied within project years, reflecting the importance of interannual variability in hydrology when estimating constituent loads. The annual loads in the final project year (2014) were not complete, reflecting only ten months out of the project year because discharge data was not available in May and June 2015. The USGS gaging station Richland Creek was in backwater conditions of Beaver Lake, which is why this site was discontinued and moved upstream out of the influence of lake levels.

Table 15. Regression equations for selected models for constituent load estimations for nitrate-N (NO_3-N), total nitrogen (TN), soluble reactive phosphorus (SRP), total phosphorus (TP), total suspended solids (TSS), chloride (Cl), and sulfate (SO_4) for Richland Creek at Goshen, AR (RC45; USGS 07048800) from July 2009 to April 2015, with respective Akaike Information Criterion (AIC), load bias percentages (BP), Nash-Sutcliffe Efficiency index (E), and mean daily load for the estimation period with lower and upper values of the 95% confidence intervals (CI) in parentheses.

Constituent	Regression equation	AIC	BP (%)	E	Mean Daily Load (kg/d)
NO_3-N	$4.31 + 1.43 lnQ - 0.11 lnQ^2 - 0.23\sin(2\pi t) - 0.53\cos(2\pi t) + 0.06t$	2.55	-2	0.27	490 (408 - 590)
TN	$4.50 + 1.20 lnQ - 0.02 lnQ^2 - 0.17\sin(2\pi t) - 0.25\cos(2\pi t) + 0.06t$	1.34	10	0.99	540 (460 - 631)
SRP	$-0.59 + 1.33 lnQ + 0.08t$	2.64	2	0.50	10 (4.8 - 17.6)
TP	$0.94 + 1.43 lnQ + 0.63\sin(2\pi t) + 0.41\cos(2\pi t) + 0.13t$	2.80	-10	0.91	70 (26 - 138)
TSS	$6.03 + 1.57 lnQ + 0.82\sin(2\pi t) + 0.71\cos(2\pi t)$	3.31	5	0.59	36200 (5944 - 121898)
Cl	$6.09 + 0.91 lnQ - 0.01 lnQ^2 - 0.14\sin(2\pi t) - 0.11\cos(2\pi t)$	-0.01	-10	0.63	1250 (1188 - 1322)
SO_4	$7.07 + 0.91 lnQ - 0.02 lnQ^2 - 0.15\sin(2\pi t) - 0.14\cos(2\pi t)$	1.43	0.6	0.88	3510 (3149 - 3895)

RICHLAND CREEK NEAR GOSHEN, ARKANSAS (RC45)

Table 16. Summary of calculated annual discharge (Q, m^3) and annual loads (kg) for nitrate-N (NO_3-N), total nitrogen (TN), soluble reactive phosphorus (SRP), total phosphorus (TP), total suspended solids (TSS), chloride (Cl), and sulfate (SO_4) for Richland Creek at Goshen, AR (RC45; USGS 07048800) for project years 2009-2014 (July 1 - June 30).

Project Year	Annual Q	NO_3-N	TN	SRP	TP	TSS	Cl	SO_4
2009	169,000,000	243,000	226,000	3,050	18,000	9,380,000	618,000	1,750,000
2010	253,000,000	145,000	342,000	10,700	86,700	58,000,000	637,000	1,660,000
2011	97,600,000	187,000	160,000	1,870	7,790	2,470,000	393,000	1,130,000
2012	85,500,000	123,000	124,000	1,600	10,600	3,590,000	326,000	921,000
2013	87,500,000	169,000	149,000	1,730	8,630	2,140,000	357,000	1,020,000
2014*	81,000,000	182,000	150,000	1,640	7,820	1,530,000	340,000	980,000

*Discharge and loads were not estimated from May 2015 to June 2015 because this site was discontinued by USGS.

Several of the constituents showed that flow-adjusted concentrations were increasing over time (Table 17), that is a monotonic or linear increase occurred throughout the study period (from July 2009 through June 2015).

- NO_3-N showed a significant increase over time (8.3% change per year)
- TN showed a significant increase over time (7.2% change per year)
- SRP showed a significant increase over time (5.9% change per year)
- TP showed a significant increase over time (7.9% change per year)

The directional changes in flow-adjusted concentrations were included in the load estimation equations, where the percent change per year was relatively similar between the regression models and the three step procedure used to evaluate monotonic changes in flow-adjusted concentrations.

Table 17. Trend analyses of nitrate-nitrogen (NO_3-N), total nitrogen (TN), soluble reactive phosphorus (SRP), total phosphorus (TP), total suspended solids (TSS), chloride (Cl), and sulfate (SO_4) for Richland Creek at Goshen, AR (RC45; USGS 07048800) from July 2009 to April 2015, with respective sample size (n), coefficient of determination (R^2), and p-value of overall F-test (p-value). Percent change per year (% Change/year) is reported for significant trends (p-value<0.05).

Constituent	n	R^2	p-value	% Change/year
NO_3-N	278	0.03	0.01	8.3
TN	276	0.07	<0.01	7.2
SRP	278	0.02	0.03	5.9
TP	278	0.03	0.01	7.9
TSS	278	<0.01	0.96	-
Cl	275	<0.01	0.28	-
SO_4	275	<0.01	0.61	-

WEST FORK OF THE WHITE RIVER EAST OF FAYETTEVILLE, ARKANSAS (WFWR)

The West Fork of the White River (WFWR) was sampled at the USGS stream gaging station East of Fayetteville (USGS 07048550), where approximately 295 water samples were collected and analyzed for constituents from July 2009 through June 2015. The WFWR watershed is 317 km^2, draining 60% forested area, 26% pasture and grasslands, 13% urban, and almost 1% wetlands. The WFWR receives the Town Branch stream in southeast Fayetteville and then flows in to the White River just downstream of Lake Sequoyah.

The constituent concentrations were paired with mean daily discharge and used to estimate loads using the software program LOADEST. The regression models for constituent loads at this site were typically complex and included multiple discharge factors (Q and Q^2), seasonal coefficients (sin and cos) and or time (t), except for total nitrogen (TN) loads, where streamflow was the only regression coefficient. The regression models and associated statistics used in load estimation are presented in Table 18. The mean daily loads were variable across constituents, showing that nitrate-nitrogen (NO_3-N) loads made up 72% of total nitrogen (TN) loads, whereas soluble reactive phosphorus (SRP) loads made up less than 10% of total phosphorus (TP) loads.

The mean daily loads were summed into annual loads for each project year (Table 19). Loads varied between project years, which generally reflected changes in discharge, with a couple of exceptions. For example, annual discharge in 2009 was 27% less than that in 2014, while NO_3-N load in 2009 was 28% greater than that in 2014. Additionally, when constituent loads did vary between years with changes in discharge, this relationship was not necessarily proportional, which is a result of the log-log transformations used in the regression models. For example, annual discharge volume in 2014 was approximately 36% greater than the discharge in 2009, but annual TP load in 2014 was approximately 85% greater than the load in 2009. Many annual load estimations were positively related to annual discharge across project years, while others were less strongly related. This suggests that hydrology and other potential factors are important in understanding constituent transport in the WFWR.

Table 18. Regression models used for load estimations of nitrate-N (NO_3-N), total nitrogen (TN), soluble reactive phosphorus (SRP), total phosphorus (TP), total suspended solids (TSS), chloride (Cl), and sulfate (SO_4) for West Fork White River east of Fayetteville, AR (USGS 07048550) from July 2009 to June 2015, with respective Akaike Information Criterion (AIC), load bias percentages (BP), Nash-Sutcliffe Efficiency index (E), and mean daily load for the estimation period with lower and upper values of the 95% confidence intervals (CI) in parentheses.

Constituent	Regression equation	AIC	BP (%)	E	Mean Daily Load (kg/d)
NO_3-N	$3.06 + 1.24lnQ - 0.03lnQ^2 - 0.16\sin(2\pi t) - 0.29\cos(2\pi t) - 0.09t$	2.70	51	0.61	270 (220 - 340)
TN	$3.78 + 1.12lnQ$	1.12	-0.01	0.80	380 (340 - 420)
SRP	$-0.86 + 1.28lnQ + 0.54\sin(2\pi t) + 0.01\cos(2\pi t)$	2.27	-20	0.60	7 (5 - 8)
TP	$1.17 + 1.37lnQ + 0.69\sin(2\pi t) + 0.53\cos(2\pi t)$	2.47	-28	0.65	90 (60 - 110)
TSS	$6.66 + 1.55lnQ + 0.84\sin(2\pi t) + 0.86\cos(2\pi t)$	2.76	-15	0.43	54000 (35800 - 78400)
Cl	$6.45 + 0.87lnQ - 0.02lnQ^2 - 0.23\sin(2\pi t) - 0.20\cos(2\pi t) - 0.06t$	1.13	-1	0.63	2200 (2040 - 2370)
SO_4	$8.02 + 0.87lnQ - 0.02lnQ^2 - 0.03\sin(2\pi t) - 0.13\cos(2\pi t) - 0.05t$	0.39	2	0.82	8670 (8240 - 9120)

WEST FORK OF THE WHITE RIVER EAST OF FAYETTEVILLE, ARKANSAS (WFWR)

Table 19. Summary of annual discharge (Q, m^3) and annual loads (kg) for nitrate-N (NO_3-N), total nitrogen (TN), soluble reactive phosphorus (SRP), total P (TP), total suspended solids (TSS), chloride (Cl), and sulfate (SO_4) for West Fork White River east of Fayetteville, AR (USGS 07048550) for project years 2009-2014 (e.g., project year 2011 is July 1, 2011 - June 30, 2012).

Project Year	Annual Q (m^3)	NO_3-N (kg)	TN (kg)	SRP (kg)	TP (kg)	TSS (kg)	Cl (kg)	SO_4 (kg)
2009	173,000,000	138,000	146,000	3,120	32,500	17,900,000	775,000	3,340,000
2010	188,000,000	122,000	172,000	3,020	48,000	35,300,000	747,000	2,960,000
2011	125,000,000	97,000	106,000	1,700	13,900	6,000,000	689,000	2,620,000
2012	106,000,000	57,400	88,100	1,240	17,500	10,200,000	565,000	2,190,000
2013	132,000,000	76,500	107,000	1,490	14,500	6,550,000	836,000	3,160,000
2014	236,000,000	108,000	210,000	3,910	60,200	42,500,000	1,200,000	4,720,000

Three of the constituents showed changes in flow-adjusted concentrations over the sampling period at the WFWR (Table 20). Specifically, monotonic or linear changes occurred in NO_3-N, chloride and sulfate.

- NO_3-N showed a significant decrease over time (6.5% change per year)
- Cl and SO_4 showed significant increases over time (6.5 and 4.1% change per year, respectively)

The directional changes in flow-adjusted concentrations from the trend analysis were included in the load estimation equations, where the percent change per year was relatively similarly between the regression model and the three step procedure used to evaluate monotonic changes in flow adjusted concentrations.

Table 20. Trends in flow-adjusted concentrations of nitrate-nitrogen (NO_3-N), total nitrogen (TN), soluble reactive phosphorus (SRP), total phosphorus (TP), total suspended solids (TSS), chloride (Cl), and sulfate (SO_4) for West Fork White River east of Fayetteville, AR (WFWR; USGS 07048550) from July 2009 to June 2015, with the respective sample size (n), coefficient of determination (R^2), and p-value of the overall F-test (p-value). Percent change per year (% Change/year) is reported for significant trends (p-value<0.05).

Constituent	n	R^2	p-value	% Change/year
NO_3-N	296	0.02	0.03	-6.5
TN	297	<0.01	0.69	-
SRP	297	<0.01	0.74	-
TP	297	<0.01	0.25	-
TSS	297	0.01	0.14	-
Cl	294	0.06	<0.01	6.5
SO_4	294	0.06	<0.01	4.1

TOWN BRANCH TRIBUTARY AT HIGHWAY 16 IN FAYETTEVILLE, ARKANSAS (TBT)

Town Branch Tributary (TBT) was sampled at the USGS stream gaging station on Highway 16 in Fayetteville, Arkansas (USGS 07048490), where approximately 185 water samples were collected and analyzed for constituents from July 2011 through May 2015. The Town Branch Tributary at this site drains a small urban watershed (3.3 km^2), where 86% of the land use is urban development, 13% is forested land and less than 1% is pasture and grassland. The Town Branch Tributary flows into Town Branch, which flows into the West Fork of the White River, which is a tributary to the White River in the Upper White River Basin. This site is one of three sampling locations where the watershed is almost entirely urban development.

The constituent concentrations were paired with mean daily discharge and then used to estimate daily loads using the software program LOADEST. The regression equations used to predict daily loads varied from simple models using only streamflow as a regression co-efficient, to more complex models using multiple discharge factors (Q and Q^2), seasonal coefficients (sin and cos) and or time (t). The regression models and associated statistics used in load estimation are presented in Table 21. Mean daily loads were relatively low compared to other sites (because of differences is watershed size) and varied across constituents. The mean daily loads for nitrate-nitrogen (NO_3-N) made up 75% of total nitrogen (TN) loads, whereas soluble reactive phosphorus (SRP) loads only made up approximately 21% of total phosphorus (TP) loads.

Mean daily loads for each constituent were summed to calculate annual loads (Table 22), which varied between project years. For most constituents, annual loads varied with annual discharge, but this variation was not necessarily proportional, which reflects the use of log-transformation in the regression models. For example, annual discharge in 2014 was 7% greater than in 2013, while TP load was 27% greater in 2014 compared to 2013. Variations in total discharge can be an important factor influencing constituent transport in Town Branch Tributary.

Table 21. Regression models used for load estimations of nitrate-N (NO_3-N), total nitrogen (TN), soluble reactive phosphorus (SRP), total phosphorus (TP), total suspended solids (TSS), chloride (Cl), and sulfate (SO_4) for Town Branch Tributary at Hwy 16 at Fayetteville, AR (USGS 07048490) from July 2011 to May 2015, with respective Akaike Information Criterion (AIC), load bias percentages (BP), Nash-Sutcliffe Efficiency index (E), and mean daily load for the estimation period with lower and upper values of the 95% confidence intervals (CI) in parentheses.

Constituent	Regression equation	AIC	BP (%)	E	Mean Daily Load (kg/d)
NO_3-N	$2.43 + 0.66lnQ$	2.13	1	0.43	15 (13 - 17)
TN	$2.82 + 0.82lnQ - 0.03lnQ^2$	1.15	-7	0.60	20 (18 - 21)
SRP	$-2.10 + 1.28lnQ + 0.54\sin(2\pi t) + 0.65\cos(2\pi t)$	1.73	-11	0.72	0.30 (0.26 - 0.36)
TP	$-1.24 + 1.47lnQ$	2.99	-15	0.36	1.4 (1.0 - 2.1)
TSS	$2.95 + 2.21lnQ + 0.11\sin(2\pi t) + 1.26\cos(2\pi t)$	3.96	64	-1.4	1960 (230 - 7480)
Cl	$4.14 + 0.59lnQ - 0.34\sin(2\pi t) - 0.50\cos(2\pi t) + 0.20t$	2.54	-5	0.29	110 (92 - 131)
SO_4	$5.11 + 0.63lnQ - 0.08lnQ^2 - 0.16\sin(2\pi t) - 0.27\cos(2\pi t) + 0.07t$	1.47	-6	0.44	182 (166 - 199)

TOWN BRANCH TRIBUTARY AT HIGHWAY 16 IN FAYETTEVILLE, ARKANSAS (TBT)

Table 22. Summary of annual discharge (Q, m^3) and annual loads (kg) for nitrate-N (NO_3-N), total nitrogen (TN), soluble reactive phosphorus (SRP), total P (TP), total suspended solids (TSS), chloride (Cl), and sulfate (SO_4) for Town Branch Tributary at Hwy 16 at Fayetteville, AR (USGS 07048490) for project years 2011-2014 (e.g., project year 2011 is July 1, 2011 - June 30, 2012).

Project Year	Annual Q (m^3)	NO_3-N (kg)	TN (kg)	SRP (kg)	TP (kg)	TSS (kg)	Cl (kg)	SO_4 (kg)
2011	2,060,000	5,350	7,100	108	523	382,000	28,700	57,900
2012	1,780,000	4,790	6,210	92	437	602,000	30,900	54,600
2013	2,090,000	5,760	7,590	104	478	484,000	46,400	75,100
2014*	2,230,000	5,550	7,380	129	610	1,330,000	51,600	72,500

* Discharge and loads were not estimated for June 2015, because this site was discontinued by USGS.

Most of the constituents that were evaluated showed no changes over time in flow-adjusted concentrations using the three step process defined in the methods. However, chloride and sulfate did show surprising changes in flow-adjusted concentrations over time (Table 23).

- Cl and SO_4 showed significant increases over time (18.8 and 8.6% change per year, respectively)

The directional changes in flow-adjusted constituent concentrations identified by trend analysis were included in the regression models that were used to estimate constituent loads, so that loads were reflective of temporal trends. The percent change per year was relatively similar between the coefficients used in the regression models and that predicted using the three step procedure to evaluate monotonic changes in flow-adjusted concentrations.

Table 23. Trends in flow-adjusted concentrations of nitrate-nitrogen (NO_3-N), total nitrogen (TN), soluble reactive phosphorus (SRP), total phosphorus (TP), total suspended solids (TSS), chloride (Cl), and sulfate (SO_4) for Town Branch Tributary at Hwy 16 at Fayetteville, AR (TBT; USGS 07048490) from July 2011 to May 2015, with the respective sample size (n), coefficient of determination (R^2), and p-value of the overall F-test (p-value). Percent change per year (% Change/year) is reported for significant trends (p-value<0.05).

Constituent	n	R^2	p-value	% Change/year
NO_3-N	185	<0.01	0.76	-
TN	183	<0.01	0.63	-
SRP	183	<0.01	0.11	-
TP	183	<0.01	0.42	-
TSS	184	<0.01	0.74	-
Cl	185	0.06	<0.01	18.8
SO_4	185	0.04	0.01	8.6

COLLEGE BRANCH AT MLK BOULEVARD AT FAYETTEVILLE, ARKANSAS (TB62)

College Branch (TB62) was sampled at the USGS stream gaging station at Martin Luther King (MLK) Boulevard at Fayetteville, Arkansas (USGS 07048480), where 175 water samples were collected and analyzed for constituents from July 2011 through May 2015. This stream drains a small urban watershed (2.3 km^2) with land use representing 93% urban development and less than 7% forested areas. College Branch is a tributary to Town Branch that flows into the West Fork of the White River, which is a tributary to the White River in the Upper White River Basin. This site is unique because it represents a watershed that is almost entirely urban development.

The constituent concentrations were paired with mean daily discharge and then used to compute daily loads in the software program LOADEST. The regression equations used to predict daily loads varied from a simple log-log regression using discharge (Q) to more complex models using multiple discharge factors, seasonal coefficients and or time (t). The various statistics and regression models used in constituent load estimation are presented in Table 24. The mean daily loads were small relative to the larger watersheds (simply because this is small watershed), but varied across the constituents. Nitrate-nitrogen (NO_3-N) loads were almost half of the total nitrogen (TN) loads at this site, whereas soluble reactive phosphorus (SRP) loads were less than 20% of the total phosphorus (TP) loads.

The mean daily loads for all constituents were summed into annual loads for each project year (Table 25), which varied between project years. The variation in annual constituent loads between years was not necessarily proportional to the changes in discharge, reflecting the use of log-transformation in the regression models. For example, the annual discharge might be similar between project years (e.g., 2013 and 2014, which is a partial record of eleven months) whereas the constituent loads vary (e.g., total suspended solids (TSS) were almost 40% greater for the partial record in 2014 when compared to 2013). This difference shows the importance of how variations in daily discharge within a year can influence constituent transport (i.e., loads) at College Branch.

Table 24. Regression models used for load estimations of nitrate-N (NO_3-N), total nitrogen (TN), soluble reactive phosphorus (SRP), total phosphorus (TP), total suspended solids (TSS), chloride (Cl), and sulfate (SO_4) for College Branch at MLK Blvd at Fayetteville, AR (USGS 07048480) from July 2011 to May 2015, with respective Akaike Information Criterion (AIC), load bias percentages (BP), Nash-Sutcliffe Efficiency index (E), and mean daily load for the estimation period with lower and upper values of the 95% confidence intervals (CI) in parentheses.

Constituent	Regression equation	AIC	BP (%)	E	Mean Daily Load (kg/d)
NO_3-N	$1.08 + 0.85 lnQ - 0.02 lnQ^2 - 0.12t$	1.64	-9	0.55	3 (2.8 - 3.5)
TN	$1.58 + 1.00 lnQ + 0.05\sin(2\pi t) + 0.13\cos(2\pi t)$	1.29	-3	0.74	6.3 (5.7 - 7.1)
SRP	$-2.66 + 1.32 lnQ + 0.48\sin(2\pi t) - 0.25\cos(2\pi t)$	2.62	-6	0.50	0.2 (0.1 - 0.3)
TP	$-1.40 + 1.47 lnQ + 0.14t$	2.76	-11	0.41	1.0 (0.7 - 1.4)
TSS	$3.56 + 1.96 lnQ + 0.31\sin(2\pi t) + 0.50\cos(2\pi t) + 0.12t$	3.81	51	-0.40	1110 (330 - 2770)
Cl	$3.90 + 0.60 lnQ + 0.28t$	2.43	-9	0.31	48 (41 - 56)
SO_4	$4.88 + 0.53 lnQ$	1.97	-4	0.42	130 (120 - 150)

COLLEGE BRANCH AT MLK BOULEVARD AT FAYETTEVILLE, ARKANSAS (TB62)

Table 25. Summary of calculated annual discharge (Q, m^3) and annual loads (kg) for nitrate-N (NO_3-N), total nitrogen (TN), soluble reactive phosphorus (SRP), total phosphorus (TP), total suspended solids (TSS), chloride (Cl), and sulfate (SO_4) for College Branch at MLK Blvd at Fayetteville, AR (TB62; USGS 07048480) for project years 2011-2014 (July 1 - June 30).

Project Year	Annual Q	NO_3-N	TN	SRP	TP	TSS	Cl	SO_4
2011	1,520,000	1,340	2,310	77	309	275,000	13,900	46,000
2012	1,800,000	1,370	2,870	79	461	602,000	20,800	51,800
2013	1,290,000	979	1,960	65	306	290,000	24,100	47,700
2014*	1,230,000	777	1,940	57	371	416,000	27,300	39,500

*Discharge and loads were not estimated for June 2015 because this site was discontinued by USGS.

Several of the constituents showed significant changes over time (Table 26), when evaluating trends in flow-adjusted concentrations using the three step process defined in the methods. Four constituents showed changes in flow-adjusted concentrations over time, including:

- NO_3-N showed a significant decrease over time (11.3% change per year)
- TP showed a significant increase over time (17.9% change per year)
- TSS showed a significant increase over time (21.2% change per year)
- Cl showed a significant increase over time (21.0% change per year)

The directional changes in constituent concentrations were included in the regression models used to estimate constituent loads, so that loads were reflective of temporal trends. The percent change per year was relatively similar between the coefficients used in the regression models and that predicted using the three step procedure to evaluate monotonic changes in flow-adjusted concentrations.

Table 26. Trend analyses of nitrate-nitrogen (NO_3-N), total nitrogen (TN), soluble reactive phosphorus (SRP), total phosphorus (TP), total suspended solids (TSS), chloride (Cl), and sulfate (SO_4) for College Branch at MLK Blvd at Fayetteville, AR (TB62; USGS 07048480) from July 2011 to May 2015, with the respective sample size (n), coefficient of determination (R^2), and p-value of the overall F-test (p-value). Percent change per year (% Change/year) is reported for significant trends (p-value<0.05).

Constituent	n	R^2	p-value	% Change $year^{-1}$
NO_3-N	175	0.06	<0.01	-11.3
TN	175	0.02	0.11	-
SRP	175	<0.01	0.87	-
TP	175	0.05	<0.01	17.9
TSS	175	0.02	0.05*	21.2
Cl	175	0.09	<0.01	21.0
SO_4	175	0.01	0.29	-

*The trend was marginally significant (p≤0.10).

Upper Illinois River Watershed

The Upper Illinois River Watershed (UIRW; HUC 11110103) is a 1952 km^2 watershed that lies in northwest Arkansas and crosses into Oklahoma. The UIRW has headwaters in the Boston Mountains Ecoregion, which then flows north into the Ozark Highlands Ecoregion before entering Oklahoma and flowing into Lake Tenkiller. This watershed includes two primary counties in Arkansas: Benton and Washington counties. The Illinois River is used for recreation, aquatic life, and the water supply for residential communities, agriculture and industry. In Arkansas, the Illinois River is designated as an ecologically sensitive water body (ESW) due to the presence of the Neosho Mucket mussel and a Scenic River in Oklahoma.

Approximately 50.3% of the UIRW is grassland, 35.9% is forest, 8.8% is urban and suburban and 4.3% is transitional and 0.3% is water (Arkansaswater.org, 2015). This watershed is largely characterized by agricultural activities including pasture land, cattle grazing and poultry operations. These agricultural activities are associated with nutrient additions, particularly phosphorus (P), to the landscape. Not only can excess nutrients be transported to surface waters via overland flow from runoff events in the short-term, "legacy" P has become an issue as well. Legacy P describes the portion that gets stored in the soils or streambed sediments. Despite the implementation of best management practices (BMPs), this legacy P can be a long-term source of P to waterbodies. Also, in recent decades, there have been increases in residential, industrial and commercial development, which will have an effect on the hydrology and water quality of streams and lakes in the watershed.

The UIRW has been identified by the Arkansas Natural Resources Commission as a 319 Non-point Source (NPS) Pollution priority catchment. The major water quality concerns in this watershed are nutrients (especially from pasture land use due to the application of poultry litter as fertilizer) and sediments (ANRC, 2015). There are several 319 projects in the UIRW, ranging from streambank restoration to landowner education, in an effort to reduce pollutant loads from land uses that are likely to influence water quality. Measuring the success of these 319 projects depends on the availability of long-term water quality data that can be paired with discharge data.

Most sampling occurred at sites where USGS stream gaging stations exist and daily discharge data was available. At Ballard and Sager Creeks, USGS stream gaging stations weren't available, so AWRC operated gaging stations. Streams that were selected for water quality sampling also varied in location within the watershed, catchment area and land use (Table 27). For example, Niokaska Creek (NC) is a small watershed (3.1 km^2) draining predominantly urban land cover, Spring Creek (Spring) has a mixture of urban (45%) and pasture (42%) land cover, and Ballard, Sager and Flint Creeks are predominantly pasture land cover (58-67%). The Illinois River, Osage Creek, Spring Creek and Sager Creek are on the 2008 303(d) list of impaired water bodies for phosphorus, nitrogen or sediments. Three sampling sites were on the Illinois River, where Savoy is the most upstream, the site at Highway 59 is in Arkansas near the border of Oklahoma, and the site at Watts is in Oklahoma, downstream from Lake Francis (a small impoundment) and the confluence with Ballard Creek.

Table 27. Select study sites (Site ID), USGS station number, site coordinates, drainage area and land cover as percentages of total drainage area for sites in the Upper Illinois River Watershed (HUC 11110103). All water samples were collected in Arkansas (except when stated otherwise) at the following locations the Illinois River near Watts, OK (Watts); the Illinois River at Savoy (Savoy); Osage Creek near Elm Springs (Osage); Flint Creek near West Siloam Springs (FCWSS); Baron Fork at Dutch Mills (Baron); Spring Creek near Springdale (Spring); Ballard Creek near Westville, OK (Ballard); Flint Creek at Springtown (FC12); Sager Creek at Siloam Springs (Sager); and Niokaska Creek in Fayetteville (NC).

					Percent of Land Use*					
Site ID	**USGS Station**	**Latitude**	**Longitude**	**Area (km^2)**	**Urban**	**Forest**	**Grassland**	**Pasture**	**Wetlands**	**Water**
Watts	07195500	36°07'47"N	94°34'18"W	1633.5	17.6	28.9	1.3	51.4	0.5	0.3
IR59	07195430	36°06'33"N	94°32'04"W	1473.2	18.6	28.5	1.2	50.9	0.4	0.3
Savoy	07194800	36°06'10"N	94°20'39"W	435.4	8.2	36.7	1.4	52.8	0.4	0.4
Osage	07195000	36°13'20"N	94°17'14"W	336.7	37.3	11.6	0.4	50.4	0.1	0.1
FCWSS	07195855	36°12'58"N	94°36'19"W	146.1	9.6	27.2	2.9	58.6	0.4	1.2
Baron	07196900	35°52'48"N	94°29'11"W	106.4	4.3	45.5	1.8	48.2	0.1	<0.05
Spring	07194933	36°14'37"N	94°14'19"W	91.8	45.2	12.1	0.2	42.3	0.1	0.1
Ballard	N/A	35°59'49"N	94°31'37"W	57.0	8.1	27.8	1.1	62.9	0.1	<0.05
FC12	07195800	36°15'22"N	94°26'01"W	38.6	6.2	24.8	2.1	66.6	0.2	0.1
Sager	N/A	36°11'42"N	94°33'49"W	35.0	38.0	3.7	<0.05	58.1	0.1	0.1
NC	07194809	36°05'43"N	94°08'05"W	3.1	83.8	14.9	1.2	0.0	0.2	<0.05

*Land use was determined by the University of Arkansas Center for Advanced Spatial Technology (CAST) using the 2011 National Land Cover Dataset

ILLINOIS RIVER NEAR WATTS, OKLAHOMA (WATTS)

The Illinois River near Watts, Oklahoma (Watts) was sampled at the USGS gaging station near Watts, Oklahoma (USGS 07195500), where 280 water samples were collected and analyzed for constituents from July 2009 through June 2015. The Watts watershed is 1,634 km^2 in area, draining 29% forested lands, 53% pasture and grasslands, and 18% urban development. Watts is an important site since the Illinois River has been a focal point for phosphorus management in the past. The Illinois River was also sampled at two locations upstream (see Illinois River south of Siloam Springs, Arkansas and Illinois River at Savoy, Arkansas). One important distinction between Watts and the site south of Siloam Springs is the remnant of Lake Francis (located between the two sites), which can behave like a small impoundment of the river.

The constituent concentrations were paired with mean daily discharge (Q) and then used in the software program LOADEST to estimate constituent loads. The regression models for constituent loads at this site were generally complex in the use of Q and time (t); the models also used coefficients to account for seasonal variations in the observed daily loads. The specific equations used in constituent load estimation and their respective regression statistics are presented in Table 28. The mean daily loads were variable across constituents, showing that nitrate-nitrogen (NO_3-N) makes up a large percentage of the total nitrogen (TN) loads whereas soluble reactive phosphorus (SRP) loads were 30% of the total phosphorus (TP) loads.

The mean daily loads were summed into annual loads for each project year (Table 29), which varied between project years but generally followed the pattern in annual Q. The discrepancy in constituent loads between years, however, does reflect the use of log-transformation and retransformation of values. This influence was most profound in total suspended solids (TSS), where the change in annual load was not necessarily proportional to the change in annual Q; TSS loads were highly variable, which is reflected in the regression statistics. Annual loads were dependent upon how discharge varied between project years, reflecting the importance of hydrology in understanding constituent transport at IR59. For example, project year 2010 had around 38% more discharge than 2009, but the 2010 TSS load was nearly eight times the 2009 load.

Table 28. Regression models used for load estimations of nitrate-N (NO_3-N), total nitrogen (TN), soluble reactive phosphorus (SRP), total phosphorus (TP), total suspended solids (TSS), chloride (Cl), and sulfate (SO_4) for Illinois River near Watts, OK (Watts; USGS 07195500) July 2009 to June 2015, with respective Akaike Information Criterion (AIC), load bias percentages (BP), Nash-Sutcliffe Efficiency index (E), and mean daily load for the estimation period with lower and upper values of the 95% confidence intervals (CI) in parentheses.

Constituent	Regression equation	AIC	BP (%)	E	Mean Daily Load (kgd)
NO_3-N	$8.69 + 0.94 lnQ - 0.08 lnQ^2 - 0.16\sin(2\pi t) - 0.16\cos(2\pi t) - 0.03t$	-0.20	-4	0.79	3460 (3330 - 3580)
TN	$8.85 + 1.03 lnQ - 0.05 lnQ^2 - 0.11\sin(2\pi t) - 0.11\cos(2\pi t)$	-0.79	-4	0.91	4240 (4110 - 4370)
SRP	$4.92 + 1.33 lnQ - 0.06t$	2.11	5	0.90	160 (117 - 216)
TP	$5.77 + 1.56 lnQ$	1.91	4	0.88	526 (355 - 753)
TSS	$10.85 + 1.91 lnQ$	2.66	79	1.03	257000 (100000 - 548000)
Cl	$10.19 + 0.66 lnQ$	1.50	12	0.68	19600 (18200 - 21200)
SO_4	$10.48 + 0.77 lnQ - 0.01 lnQ^2 - 0.04\sin(2\pi t) - 0.10\cos(2\pi t) + 0.05t$	-0.83	0.5	0.95	22500 (22000 - 23000)

ILLINOIS RIVER NEAR WATTS, OKLAHOMA (WATTS)

Table 29. Summary of annual discharge (Q, m^3) and annual loads (kg) for nitrate-N (NO_3-N), total nitrogen (TN), soluble reactive phosphorus (SRP), total P (TP), total suspended solids (TSS), chloride (Cl), and sulfate (SO_4) for Illinois River near Watts, OK (USGS 07195500) for project years 2009-2014 (e.g., project year 2011 is July 1, 2011 - June 30, 2012).

Project Year	Annual Q (m^3)	NO_3-N (kg)	TN (kg)	SRP (kg)	TP (kg)	TSS (kg)	Cl (kg)	SO_4 (kg)
2009	687,000,000	1,670,000	1,870,000	65,500	158,000	52,700,000	8,280,000	8,510,00
2010	951,000,000	1,490,000	2,040,000	149,000	608,000	399,000,000	8,280,000	9,040,00
2011	439,000,000	1,100,000	1,240,000	30,600	70,800	17,700,000	6,270,000	6,920,00
2012	429,000,000	928,000	1,130,000	31,500	87,300	26,300,000	5,760,000	6,540,00
2013	460,000,000	1,070,000	1,270,000	27,200	66,300	14,600,000	6,640,000	8,050,00
2014	664,000,000	1,310,000	1,730,000	48,700	163,000	54,000,000	7,780,000	10,300,00

Several of the constituents showed that flow-adjusted concentrations were increasing over time (Table 30), that is, a monotonic or linear increase occurred through the study period (from July 2009 to June 2015).

- NO_3-N showed a marginally significant decrease over time (1.3% change per year)
- SRP showed a significant decrease over time (7.4% change per year)
- SO_4 showed a significant increase over time (5.0% change per year)

The directional changes in flow-adjusted concentrations were included in the load estimation equations, where the percent change per year was relatively similarly between the regression model and the three step procedure used to evaluate monotonic changes in flow adjusted concentrations.

Table 30. Trends in flow-adjusted concentrations of nitrate-nitrogen (NO_3-N), total nitrogen (TN), soluble reactive phosphorus (SRP), total phosphorus (TP), total suspended solids (TSS), chloride (Cl), and sulfate (SO_4) for Illinois River near Watts, OK (Watts; USGS 07195500) from July 2009 to June 2015, with the respective sample size (n), coefficient of determination (R^2), and p-value of the overall F-test (p-value). Percent change per year (% Change/year) is reported for significant trends (p-value<0.05).

Constituent	n	R^2	p-value	% Change/year
NO_3-N	280	0.01	0.09*	-1.3
TN	277	<0.01	0.68	-
SRP	280	0.05	<0.01	-7.4
TP	280	<0.01	0.73	-
TSS	280	<0.01	0.27	-
Cl	278	<0.01	0.31	-
SO_4	278	0.23	<0.01	5.0

*The trend was marginally significant (p≤0.10).

ILLINOIS RIVER SOUTH OF SILOAM SPRINGS, ARKANSAS (IR59)

The Illinois River south of Siloam Springs (IR59) was sampled at the USGS gaging station near Siloam Springs, Arkansas on Hwy 59 (USGS 07194530), where 283 water samples were collected and analyzed for constituents from July 2009 through June 2015. The IR59 watershed is 1,473 km^2 in area, draining 29% forested lands, 52% pasture and grasslands, and 19% urban development. Aside from being the main stream in the Illinois River Watershed, IR59 is an important site due to the focus of past watershed management on reducing phosphorus concentrations and loads in this river. The Illinois River was also sampled at other sites downstream (see Illinois River near Watts, Oklahoma) and upstream (see Illinois River at Savoy, Arkansas).

The constituent concentrations were paired with mean daily discharge (Q) and then used in the software program LOADEST to estimate constituent loads. The regression models for constituent loads at this site were generally complex in the use of Q and time (t); the models also used coefficients to account for seasonal variations in the observed daily loads. The specific equations used in constituent load estimation and their respective regression statistics are presented in Table 31. The mean daily loads were variable across constituents, showing that nitrate-nitrogen (NO_3-N) makes up a large percentage of the total nitrogen (TN) loads whereas soluble reactive phosphorus (SRP) loads were roughly 35% of the total phosphorus (TP) loads.

The mean daily loads were summed into annual loads for each project year (Table 32), which varied between project years but generally followed the pattern in annual Q. The discrepancy in constituent loads between years, however, does reflect the use of log-transformation and re-transformation of values. This influence was most profound in total suspended solids (TSS), where the change in annual load was not necessarily proportional to the change in annual Q; TSS loads were highly variable, which is reflected in the regression statistics. Annual loads were dependent upon how discharge varied between project years, reflecting the importance of hydrology in understanding constituent transport at IR59. For example, project year 2010 had around 32% more discharge than 2009, but the 2010 TSS load was more than seven times the 2009 load.

Table 31. Regression models used for load estimations of nitrate-N (NO_3-N), total nitrogen (TN), soluble reactive phosphorus (SRP), total phosphorus (TP), total suspended solids (TSS), chloride (Cl), and sulfate (SO_4) for Illinois River south of Siloam Springs, AR (IR59; USGS 07195430) July 2009 to June 2015, with respective Akaike Information Criterion (AIC), load bias percentages (BP), Nash-Sutcliffe Efficiency index (E), and mean daily load for the estimation period with lower and upper values of the 95% confidence intervals (CI) in parentheses.

Constituent	Regression equation	AIC	BP	E	Mean Daily Load
			(%)		(kg/d)
NO_3-N	$8.73 + 0.92lnQ - 0.08lnQ^2 - 0.11\sin(2\pi t) - 0.12\cos(2\pi t) - 0.04t$	0.49	-0.3	0.88	3560 (3380 - 3740)
TN	$8.91 + 1.01lnQ - 0.05lnQ^2 - 0.11\sin(2\pi t) - 0.11\cos(2\pi t)$	-0.51	-3	0.94	4450 (4300 - 4610)
SRP	$5.11 + 1.42lnQ + 0.62\sin(2\pi t) + 0.22\cos(2\pi t) - 0.01t$	1.30	16	0.82	180 (150 - 220)
TP	$5.79 + 1.56lnQ$	1.89	-4	0.97	530 (380 - 720)
TSS	$10.88 + 2.20lnQ - 0.03lnQ^2 + 0.54\sin(2\pi t) + 0.66\cos(2\pi t)$	2.44	175	-6.5	452000 (202000 - 878000)
Cl	$10.30 + 0.65lnQ - 0.02lnQ^2 - 0.02\sin(2\pi t) - 0.07\cos(2\pi t) + 0.03t$	-0.21	-1	0.86	18700 (18200 - 19300)
SO_4	$10.51 + 0.77lnQ - 0.04\sin(2\pi t) - 0.11\cos(2\pi t) + 0.05t$	-0.62	4	0.88	23300 (22700 - 24000)

ILLINOIS RIVER SOUTH OF SILOAM SPRINGS, ARKANSAS (IR59)

Table 32. Summary of annual discharge (Q, m^3) and annual loads (kg) for nitrate-N (NO_3-N), total nitrogen (TN), soluble reactive phosphorus (SRP), total P (TP), total suspended solids (TSS), chloride (Cl), and sulfate (SO_4) for Illinois River south of Siloam Springs, AR (USGS 07195430) for project years 2009-2014 (e.g., project year 2011 is July 1, 2011 - June 30, 2012).

Project Year	Annual Q (m^3)	NO_3-N (kg)	TN (kg)	SRP (kg)	TP (kg)	TSS (kg)	Cl (kg)	SO_4 (kg)
2009	734,000,000	1,860,000	2,040,000	80,200	177,000	90,500,000	7,820,000	9,160,00
2010	971,000,000	1,590,000	2,180,000	158,000	567,000	667,000,000	7,310,000	9,770,00
2011	446,000,000	1,120,000	1,290,000	28,000	77,500	17,500,000	6,040,000	7,110,00
2012	450,000,000	963,000	1,220,000	33,200	99,100	52,800,000	5,620,000	6,880,00
2013	438,000,000	1,000,000	1,240,000	30,100	63,800	18,200,000	6,420,000	7,790,00
2014	671,000,000	1,260,000	1,780,000	71,500	176,000	144,000,000	7,790,000	10,400,00

Several of the constituents showed that flow-adjusted concentrations were increasing over time (Table 33), that is, a monotonic or linear increase occurred through the study period (from July 2009 to June 2015).

- NO_3-N showed a significant decrease over time (3.3% change per year)
- SRP showed a significant decrease over time (5.2% change per year)
- Cl showed a significant increase over time (2.2% change per year)
- SO_4 showed a significant increase over time (4.8% change per year)

The directional changes in flow-adjusted concentrations were included in the load estimation equations, where the percent change per year was relatively similarly between the regression model and the three step procedure used to evaluate monotonic changes in flow adjusted concentrations.

Table 33. Trends in flow-adjusted concentrations of nitrate-nitrogen (NO_3-N), total nitrogen (TN), soluble reactive phosphorus (SRP), total phosphorus (TP), total suspended solids (TSS), chloride (Cl), and sulfate (SO_4) for Illinois River south of Siloam Springs, AR (IR59; USGS 07195430) from July 2009 to June 2015, with the respective sample size (n), coefficient of determination (R^2), and p-value of the overall F-test (p-value). Percent change per year (% Change/year) is reported for significant trends (p-value<0.05).

Constituent	n	R^2	p-value	% Change/year
NO_3-N	283	0.04	<0.01	-3.3
TN	280	<0.01	0.88	-
SRP	283	0.03	0.01	-5.2
TP	283	0.01	0.26	-
TSS	282	0.01	0.21	-
Cl	281	0.03	<0.01	2.2
SO_4	281	0.19	<0.01	4.8

ILLINOIS RIVER AT SAVOY, ARKANSAS (SAVOY)

The Illinois River (Savoy) was sampled at the USGS gaging station at Savoy, Arkansas (USGS 07194800), where 279 water samples were collected and analyzed for constituents from July 2009 to June 2015. The Savoy watershed is 435 km^2 in area, draining 37% forested lands, 54% pasture and grasslands, and 8% urban development. Savoy is the most upstream Illinois River site sampled in this study, with two other sites located downstream (see Illinois River south of Siloam Springs, Arkansas and Illinois River near Watts, Oklahoma).

The constituent concentrations were paired with mean daily discharge (Q) and then used in the software program LOADEST to estimate constituent loads. The regression models for constituent loads at this site were generally complex in the use of Q and time (t); the models also used coefficients to account for seasonal variations in the observed daily loads. The specific equations used in constituent load estimation and their respective regression statistics are presented in Table 34. The mean daily loads were variable across constituents, showing that nitrate-nitrogen (NO_3-N) makes up a large percentage of the total nitrogen (TN) loads whereas soluble reactive phosphorus (SRP) loads were roughly 40% of the total phosphorus (TP) loads.

The mean daily loads were summed into annual loads for each project year (Table 35), which varied between project years but generally followed the pattern in annual Q. The discrepancy in constituent loads between years, however, does reflect the use of log-transformation and re-transformation of values. This influence was most profound in total suspended solids (TSS) loads, where the change in annual load was not necessarily proportional to the change in annual Q; TSS loads were highly variable, which is reflected in the regression statistics. Annual loads were dependent on the flow regime, reflecting the importance of hydrology in understanding constituent loads. For example, project year 2010 showed only a 13% increase in discharge from 2009 but TSS loads increased three-fold.

Table 34. Regression models used for load estimations of nitrate-N (NO_3-N), total nitrogen (TN), soluble reactive phosphorus (SRP), total phosphorus (TP), total suspended solids (TSS), chloride (Cl), and sulfate (SO_4) for Illinois River at Savoy, AR (Savoy; USGS 07194800) July 2009 to June 2015, with respective Akaike Information Criterion (AIC), load bias percentages (BP), Nash-Sutcliffe Efficiency index (E), and mean daily load for the estimation period with lower and upper values of the 95% confidence intervals (CI) in parentheses.

Constituent	Regression equation	AIC	BP (%)	E	Mean Daily Load (kg/d)
NO_3-N	$6.79 + 0.77lnQ - 0.02lnQ^2 - 0.10\sin(2\pi t) - 0.09\cos(2\pi t) - 0.07t$	0.63	-8	0.76	700 (660 - 740)
TN	$7.07 + 0.91lnQ - 0.004lnQ^2 - 0.02\sin(2\pi t) - 0.04\cos(2\pi t) - 0.03t$	0.01	3	0.95	1030 (680 - 1090)
SRP	$3.13 + 1.37lnQ - 0.07t$	2.40	3	0.89	63 (40 - 94)
TP	$4.00 + 1.45lnQ$	2.05	7	0.53	160 (110 - 230)
TSS	$8.83 + 1.74lnQ$	2.94	70	7.33	68600 (24300 - 155000)
Cl	$8.42 + 0.65lnQ - 0.004lnQ^2 + 0.04\sin(2\pi t) - 0.08\cos(2\pi t) + 0.02t$	0.01	-2	0.88	3320 (3200 - 3450)
SO_4	$8.98 + 0.82lnQ - 0.02lnQ^2 - 0.12\sin(2\pi t) - 0.13\cos(2\pi t) + 0.03t$	-0.51	-1	0.93	6120 (5920 - 6320)

ILLINOIS RIVER AT SAVOY, ARKANSAS (SAVOY)

Table 35. Summary of annual discharge (Q, m^3) and annual loads (kg) for nitrate-N (NO_3-N), total nitrogen (TN), soluble reactive phosphorus (SRP), total P (TP), total suspended solids (TSS), chloride (Cl), and sulfate (SO_4) for Illinois River at Savoy, AR (USGS 07194800) for project years 2009-2014 (e.g., project year 2011 is July 1, 2011 - June 30, 2012).

Project Year	Annual Q (m^3)	NO_3-N (kg)	TN (kg)	SRP (kg)	TP (kg)	TSS (kg)	Cl (kg)	SO_4 (kg)
2009	232,000,000	433,000	594,000	34,200	75,200	26,800,000	1,660,000	3,110,000
2010	261,000,000	317,000	556,000	62,400	170,000	93,200,000	1,310,000	2,530,000
2011	105,000,000	218,000	279,000	9,840	22,900	6,070,000	1,050,000	1,860,000
2012	95,000,000	169,000	234,000	8,670	22,200	6,180,000	888,000	1,550,000
2013	83,700,000	168,000	217,000	5,410	13,600	3,000,000	992,000	1,680,000
2014	172,000,000	234,000	380,000	16,200	48,900	15,100,000	1,390,000	2,670,000

Several of the constituents showed that flow-adjusted concentrations were increasing over time (Table 36), that is, a monotonic or linear increase occurred through the study period (from July 2009 to June 2015).

- NO_3-N showed a significant decrease over time (5.4% change per year)
- TN showed a significant decrease over time (2.6% change per year)
- SRP showed a significant decrease over time (7.3% change per year)
- Cl showed a marginally significant increase over time (1.5% change per year)
- SO_4 showed a significant increase over time (3.5% change per year)

The directional changes in flow-adjusted concentrations were included in the load estimation equations, where the percent change per year was relatively similarly between the regression model and the three step procedure used to evaluate monotonic changes in flow adjusted concentrations.

Table 36. Trends in flow-adjusted concentrations of nitrate-nitrogen (NO_3-N), total nitrogen (TN), soluble reactive phosphorus (SRP), total phosphorus (TP), total suspended solids (TSS), chloride (Cl), and sulfate (SO_4) for Illinois River at Savoy, AR (Savoy; USGS 07194800) from July 2009 to June 2015, with the respective sample size (n), coefficient of determination (R^2), and p-value of the overall F-test (p-value). Percent change per year (% Change $year^{-1}$) is reported for significant trends (p-value<0.05).

Constituent	n	R^2	p-value	% Change/year
NO_3-N	278	0.08	<0.01	-5.4
TN	276	0.04	<0.01	-2.6
SRP	279	0.03	<0.01	-7.3
TP	279	<0.01	0.67	-
TSS	279	<0.01	0.79	-
Cl	277	0.01	0.06*	1.5
SO_4	277	0.08	<0.01	3.5

*The trend was marginally significant (p≤0.10).

OSAGE CREEK NEAR ELM SPRINGS, ARKANSAS (OSAGE)

Osage Creek (Osage) was sampled at the USGS stream gaging station near Elm Springs, Arkansas (USGS 07195000), where 275 water samples were collected and analyzed for constituents from July 2009 through June 2015. The Osage Creek Watershed is 337 km^2 in area, draining 12% forested lands, 51% pasture and grasslands, and 37% urban development. Osage Creek is a tributary to the Illinois River within the Illinois River Watershed. Osage Creek was sampled downstream of the confluence with Spring Creek, and there are three wastewater facilities which discharge effluent into this stream, including the City of Rogers, City of Springdale, as well as Northwest Arkansas Conservation Authority's regional waste water treatment plant.

The constituent concentrations were paired with mean daily discharge (Q) and then used in the software program LOADEST to estimate constituent loads. The regression models for constituent loads at this site were generally complex in the use of Q and time (t); the models also used coefficients to account for seasonal variations in the observed daily loads. The specific equations used in constituent load estimation and their respective regression statistics are presented in Table 37. The mean daily loads were variable across constituents, showing that nitrate-nitrogen (NO_3-N) makes up a large percentage of the total nitrogen (TN) loads whereas soluble reactive phosphorus (SRP) loads were roughly half of the total phosphorus (TP) loads.

The mean daily loads were summed into annual loads for each project year (Table 38), which varied between project years but generally followed the pattern in annual Q. The discrepancy in constituent loads between years, however, does reflect the use of log-transformation and re-transformation of values. This influence was most profound in total suspended solids (TSS) loads, where the change in annual load was not necessarily proportional to the change in annual Q; TSS loads were highly variable, which is reflected in the regression statistics. Annual loads were dependent on the flow regime, reflecting the importance of hydrology in understanding constituent loads. For example, project year 2010 showed a 35% increase in discharge from 2009 but TP loads increased nearly three-fold.

Table 37. Regression models used for load estimations of nitrate-N (NO_3-N), total nitrogen (TN), soluble reactive phosphorus (SRP), total phosphorus (TP), total suspended solids (TSS), chloride (Cl), and sulfate (SO_4) for Osage Creek near Elm Springs, AR (USGS 07195000) July 2009 to June 2015, with respective Akaike Information Criterion (AIC), load bias percentages (BP), Nash-Sutcliffe Efficiency index (E), and mean daily load for the estimation period with lower and upper values of the 95% confidence intervals (CI) in parentheses.

Constituent	Regression equation	AIC	BP (%)	E	Mean Daily Load (kg/d)
NO_3-N	$7.68 + 0.66lnQ - 0.12\sin(2\pi t) - 0.08\cos(2\pi t) - 0.03t$	1.19	-2	0.79	1270 (1200 - 1350)
TN	$7.99 + 0.83lnQ - 0.11\sin(2\pi t) - 0.06\cos(2\pi t)$	-0.03	-1	0.96	1480 (1430 - 1540)
SRP	$4.27 + 1.25lnQ + 0.10lnQ^2 + 0.43\sin(2\pi t) + 0.10\cos(2\pi t) - 0.02t$	0.51	21	0.85	54 (44 - 66)
TP	$5.06 + 1.48nQ + 0.30\sin(2\pi t) + 0.08\cos(2\pi t)$	1.24	-12	0.95	99 (78 - 124)
TSS	$9.82 + 2.45lnQ - 0.06lnQ^2 + 0.32\sin(2\pi t) + 0.35\cos(2\pi t)$	2.91	250	-38	102000 (19800 - 317000)
Cl	$9.51 + 0.43lnQ - 0.01lnQ^2 - 0.04\sin(2\pi t) - 0.05\cos(2\pi t) + 0.04t$	0.03	-1	0.68	8960 (8680 - 9240)
SO_4	$9.64 + 0.48lnQ + 0.02lnQ^2 + 0.06\sin(2\pi t) - 0.04\cos(2\pi t) + 0.07t$	0.19	-1	0.79	10200 (9860 - 10600)

OSAGE CREEK NEAR ELM SPRINGS, ARKANSAS (OSAGE)

Table 38. Summary of annual discharge (Q, m^3) and annual loads (kg) for nitrate-N (NO_3-N), total nitrogen (TN), soluble reactive phosphorus (SRP), total P (TP), total suspended solids (TSS), chloride (Cl), and sulfate (SO_4) for Osage Creek near Elm Springs, AR (USGS 07195000) for project years 2009-2014 (e.g., project year 2011 is July 1, 2011 - June 30, 2012).

Project Year	Annual Q (m^3)	NO_3-N (kg)	TN (kg)	SRP (kg)	TP (kg)	TSS (kg)	Cl (kg)	SO_4 (kg)
2009	168,000,000	552,000	591,000	17,200	32,200	13,600,000	3,150,000	3,340,000
2010	226,000,000	528,000	659,000	53,500	93,000	167,000,000	3,050,000	3,450,000
2011	121,000,000	431,000	464,000	9,530	16,600	2,910,000	3,070,000	3,400,000
2012	125,000,000	392,000	452,000	12,700	24,800	22,600,000	3,000,000	3,450,000
2013	136,000,000	428,000	503,000	11,400	21,400	5,530,000	3,500,000	4,080,000
2014	163,000,000	455,000	577,000	13,900	29,300	11,600,000	3,850,000	4,630,000

Several of the constituents showed that flow-adjusted concentrations were increasing over time (Table 39), that is, a monotonic or linear increase occurred through the study period (from July 2009 through June 2015).

- NO_3-N showed a marginally significant decrease over time (2.5% change per year)
- SRP showed a significant decrease over time (3.0% change per year)
- Cl showed a significant increase over time (4.2% change per year)
- SO_4 showed a significant increase over time (6.1% change per year)

The directional changes in flow-adjusted concentrations were included in the load estimation equations where the percent change per year was relatively similar between the regression model and the three-step procedure used to evaluate monotonic changes in flow-adjusted concentrations over time.

Table 39. Trends in flow-adjusted concentrations of nitrate-nitrogen (NO_3-N), total nitrogen (TN), soluble reactive phosphorus (SRP), total phosphorus (TP), total suspended solids (TSS), chloride (Cl), and sulfate (SO_4) for Osage Creek near Elm Springs, AR (Osage; USGS 07195000) from July 2009 to June 2015, with the respective sample size (n), coefficient of determination (R^2), and p-value of the overall F-test (p-value). Percent change per year (% Change/year) is reported for significant trends (p-value<0.05).

Constituent	n	R^2	p-value	% Change/year
NO_3-N	275	0.01	0.08*	-2.5
TN	273	<0.01	0.62	-
SRP	275	0.02	0.04	-3.0
TP	275	<0.01	0.40	-
TSS	275	<0.01	0.34	-
Cl	273	0.09	<0.01	4.2
SO_4	273	0.15	<0.01	6.1

*The trend was marginally significant (p≤0.10).

FLINT CREEK NEAR WEST SILOAM SPRINGS, OKLAHOMA (FCWSS)

Flint Creek was sampled at the USGS stream gaging station near West Siloam Springs, Oklahoma (USGS 07195855), where 271 water samples were collected and analyzed for constituents from July 2009 through June 2015. The FCWSS watershed is 146 km^2 in area, draining 27% forested lands, 62% pasture and grasslands, and 10% urban development. Flint Creek was also sampled at another location upstream (see Flint Creek at Springtown, Arkansas). Flint Creek is one of the major tributaries to the Illinois River within the Illinois River Watershed.

The constituent concentrations were paired with mean daily discharge (Q) and then used in the software program LOADEST to estimate constituent loads. The regression models for constituent loads at this site differed in their use of Q and time (t), reflecting various hydrological relationships, seasonal effects, and monotonic trends in loads. Regression statistics and models used are reported in Table 40. The mean daily loads were variable across constituents, showing that nitrate-nitrogen (NO_3-N) makes up a large percentage of the total nitrogen (TN) loads whereas soluble reactive phosphorus (SRP) loads, on average, make up half of the total phosphorus (TP) loads.

The mean daily loads were summed into annual loads (Table 41), which varied annually. Some constituent loads generally followed the pattern in discharge (e.g., NO_3-N and TN) while other loads, such as TP and total suspended solids (TSS), reflect the use of log-log relationships and seasonality coefficients in the regression models. For example, discharge volume in project year 2009 was essentially the same as discharge volume in 2010. However, the TSS load in 2010 was four times the load in 2009. Annual loads were dependent upon the flow regime of that project year, reflecting the importance of inter-annual variability in hydrology when estimating constituent loads. The regression statistics were acceptable for this site, except for SRP, TP, and TSS loads as the respective regression models had bias percentage (BP) outside of the preferred range (±25% BP).

Table 40. Regression models used for load estimations of nitrate-N (NO_3-N), total nitrogen (TN), soluble reactive phosphorus (SRP), total phosphorus (TP), total suspended solids (TSS), chloride (Cl), and sulfate (SO_4) for Flint Creek near West Siloam Springs, OK (USGS 07195855) July 2009 to June 2015, with respective Akaike Information Criterion (AIC), load bias percentages (BP), Nash-Sutcliffe Efficiency index (E), and mean daily load for the estimation period with lower and upper values of the 95% confidence intervals (CI) in parentheses.

Constituent	Regression equation	AIC	BP (%)	E	Mean Daily Load (kg/d)
NO_3-N	$5.77 + 1.21 lnQ - 0.04 lnQ^2 - 0.40\sin(2\pi t) - 0.38\cos(2\pi t) + 0.01t$	0.48	2	0.94	250 (230 - 270)
TN	$5.87 + 1.24 lnQ - 0.03 lnQ^2 - 0.40\sin(2\pi t) - 0.33\cos(2\pi t) + 0.02t$	0.16	5	0.99	290 (270 - 320)
SRP	$1.68 + 1.40 lnQ$	1.58	-40	0.84	7.0 (5.3 - 9.1)
TP	$2.22 + 1.49 lnQ$	1.58	-53	0.68	14 (10 - 19)
TSS	$6.55 + 1.83 lnQ - 0.04t$	2.50	-62	0.59	3230 (1160 - 7250)
Cl	$7.38 + 0.82 lnQ - 0.03 lnQ^2 - 0.04\sin(2\pi t) + 0.01\cos(2\pi t)$	-1.58	-2	0.90	1040 (1020 - 1060)
SO_4	$8.00 + 0.80 lnQ - 0.05 lnQ^2 - 0.08\sin(2\pi t) + 0.09\cos(2\pi t) - 0.03t$	0.26	-3	0.81	1970 (1890 - 2070)

FLINT CREEK NEAR WEST SILOAM SPRINGS, OKLAHOMA (FCWSS)

Table 41. Summary of annual discharge (Q, m^3) and annual loads (kg) for nitrate-N (NO_3-N), total nitrogen (TN), soluble reactive phosphorus (SRP), total P (TP), total suspended solids (TSS), chloride (Cl), and sulfate (SO_4) for Flint Creek near West Siloam Springs, OK (USGS 07195855) for project years 2009-2014 (e.g., project year 2011 is July 1, 2011 - June 30, 2012).

Project Year	Annual Q (m^3)	NO_3-N (kg)	TN (kg)	SRP (kg)	TP (kg)	TSS (kg)	Cl (kg)	SO_4 (kg)
2009	56,900,000	126,000	140,000	2,930	5,600	987,000	513,000	1,040,000
2010	56,300,000	113,000	149,000	5,420	12,400	4,160,000	399,000	780,000
2011	26,800,000	58,300	62,600	939	1,620	172,000	280,000	542,000
2012	31,100,000	66,200	80,000	1,930	3,960	820,000	271,000	511,000
2013	31,200,000	61,200	67,200	1,190	2,100	228,000	316,000	573,000
2014	56,200,000	122,000	141,000	2,930	5,550	722,000	499,000	875,000

Several of the constituents showed that flow-adjusted concentrations were increasing over time (Table 42), that is, a monotonic or linear increase occurred throughout the study period (from July 2009 through June 2015).

- NO_3-N showed a significant increase over time (2.8% change per year)
- TN showed a significant increase over time (2.8% change per year)
- TSS showed a significant decrease over time (5.5% change per year)
- SO_4 showed a significant decrease over time (2.1% change per year)

The directional changes in flow-adjusted concentrations were included in the load estimation equations, where the percent change per year was relatively similar between the regression model and the three step procedure used to evaluate monotonic changes in flow-adjusted concentrations (Table 1-42).

Table 42. Trends in flow-adjusted concentrations of nitrate-nitrogen (NO_3-N), total nitrogen (TN), soluble reactive phosphorus (SRP), total phosphorus (TP), total suspended solids (TSS), chloride (Cl), and sulfate (SO_4) for Flint Creek near West Siloam Springs, OK (FCWSS; USGS 07195855) from July 2009 to June 2015, with the respective sample size (n), coefficient of determination (R^2), and p-value of the overall F-test (p-value). Percent change per year (% Change/year) is reported for significant trends (p-value<0.05).

Constituent	n	R^2	p-value	% Change/year
NO_3-N	271	0.01	0.07*	2.8
TN	270	0.02	0.04	2.8
SRP	271	<0.01	0.94	-
TP	271	0.01	0.19	-
TSS	271	0.02	0.02	-5.5
Cl	269	<0.01	0.84	-
SO_4	269	0.02	0.02	-2.1

*The trend was marginally significant ($p \leq 0.10$).

BARON FORK AT DUTCH MILLS, ARKANSAS (BARON)

Baron Fork (Baron) was sampled at the USGS gaging station at Dutch Mills, Arkansas (USGS 07196900), where 275 water samples were collected and analyzed for constituents from July 2009 through June 2015. The Baron watershed is 106 km^2 in area, draining 46% forested lands, 50% pasture and grasslands, and 4% urban development. The Baron Fork is a large tributary to the Illinois River, where the confluence of the two streams is just upstream of Lake Tenkiller in Oklahoma. Baron is a unique site for the Illinois River Watershed since it has relatively little urban development in its catchment.

The constituent concentrations were paired with mean daily discharge and then used in the software program LOADEST to estimate constituent loads. The regression models for constituents at this site where complex, including mean daily discharge (Q) and time (t); the regression models also included coefficients to account for seasonal variations in the observed daily loads. The various statistics and specific equations used in constituent load estimation are presented in Table 43. The mean daily loads were variable across constituents, showing that nitrate-nitrogen (NO_3-N) makes up a large percentage of the total nitrogen (TN) loads and soluble reactive phosphorus (SRP) loads were roughly 60% of the total phosphorus (TP) loads.

The mean daily loads were summed into annual loads for each project year (Table 44), which varied between project years but generally followed the pattern in annual Q. The discrepancy in constituent loads between years, however, does reflect the use of log-transformation and re-transformation of values. This influence was most profound in total suspended solids (TSS) loads, where the change in annual load was not necessarily proportional to the change in annual Q; TSS loads were highly variable, which is reflected in the regression statistics. Annual loads were dependent on the flow regime, reflecting the importance of hydrology in understanding constituent loads at Baron. For example, project year 2010 had roughly the same discharge as 2009 but the TSS load in 2010 was nearly double the 2009 TSS load.

Table 43. Regression models used for load estimations of nitrate-N (NO_3-N), total nitrogen (TN), soluble reactive phosphorus (SRP), total phosphorus (TP), total suspended solids (TSS), chloride (Cl), and sulfate (SO_4) for Baron Fork at Dutch Mills, AR (Baron; USGS 07196900) July 2009 to June 2015, with respective Akaike Information Criterion (AIC), load bias percentages (BP), Nash-Sutcliffe Efficiency index (E), and mean daily load for the estimation period with lower and upper values of the 95% confidence intervals (CI) in parentheses.

Constituent	Regression equation	AIC	BP (%)	E	Mean Daily Load (kg/d)
NO_3-N	$4.12 + 1.29lnQ - 0.09lnQ^2 - 0.67\sin(2\pi t) - 0.66\cos(2\pi t)$	2.87	35	0.62	290 (230 - 370)
TN	$4.35 + 1.17lnQ - 0.03lnQ^2 - 0.39\sin(2\pi t) - 0.39\cos(2\pi t)$	1.44	7	0.97	250 (220 - 280)
SRP	$0.23 + 1.38lnQ - 0.07t$	2.08	27	0.36	11 (7.6 - 15)
TP	$0.97 + 1.35lnQ + 0.39\sin(2\pi t) + 0.29\cos(2\pi t)$	1.81	-29	0.75	19 (14 - 25)
TSS	$5.09 + 1.46lnQ + 0.72\sin(2\pi t) + 0.58\cos(2\pi t) - 0.01t$	3.15	-53	0.53	3030 (1250 - 6230)
Cl	$5.83 + 0.83lnQ - 0.03lnQ^2 + 0.002\sin(2\pi t) - 0.13\cos(2\pi t) + 0.01t$	-0.71	-6	0.82	470 (460 - 490)
SO_4	$6.78 + 0.91lnQ - 0.03lnQ^2 - 0.19\sin(2\pi t) - 0.24\cos(2\pi t) + 0.03t$	-0.29	-5	0.84	1430 (1380 - 1490)

BARON FORK AT DUTCH MILLS, ARKANSAS (BARON)

Table 44. Summary of annual discharge (Q, m^3) and annual loads (kg) for nitrate-N (NO_3-N), total nitrogen (TN), soluble reactive phosphorus (SRP), total P (TP), total suspended solids (TSS), chloride (Cl), and sulfate (SO_4) for Baron Fork at Dutch Mills, AR (USGS 07196900) for project years 2009-2014 (e.g., project year 2011 is July 1, 2011 - June 30, 2012).

Project Year	Annual Q (m^3)	NO_3-N (kg)	TN (kg)	SRP (kg)	TP (kg)	TSS (kg)	Cl (kg)	SO_4 (kg)
2009	54,600,000	184,000	145,000	6,010	9,320	1,430,000	269,000	781,000
2010	52,000,000	101,000	112,000	9,790	15,300	2,750,000	176,000	525,000
2011	27,600,000	125,000	87,900	2,210	3,010	321,000	163,000	512,000
2012	21,900,000	71,000	56,200	1,620	2,900	389,000	120,000	369,000
2013	14,500,000	46,300	35,200	700	1,340	149,000	97,800	282,000
2014	45,100,000	115,000	102,000	3,770	9,420	1,610,000	212,000	667,000

Several of the constituents showed that flow-adjusted concentrations were increasing over time (Table 45), that is, a monotonic or linear increase occurred through the study period (from July 2009 through June 2015).

- SRP, TP and TSS showed significant decreases over time (7.4, 3.8 and 9.8% change per year)
- Cl showed a marginally significant increase over time (1.0% change per year)
- SO_4 showed a significant increase over time (4.4% change per year)

The directional changes in flow-adjusted concentrations were included in the load estimation equations where the percent change per year was relatively similar between the regression model and the three-step procedure used to evaluate monotonic changes in flow-adjusted concentrations over time. The TP load estimation model was an exception, where the temporal coefficient from LOADEST did not agree with the decrease seen in trend analysis.

Table 45. Trends in flow-adjusted concentrations of nitrate-nitrogen (NO_3-N), total nitrogen (TN), soluble reactive phosphorus (SRP), total phosphorus (TP), total suspended solids (TSS), chloride (Cl), and sulfate (SO_4) for Baron Fork at Dutch Mills, AR (Baron; USGS 07196900) from July 2009 to June 2015, with the respective sample size (n), coefficient of determination (R^2), and p-value of the overall F-test (p-value). Percent change per year (% Change/year) is reported for significant trends (p-value<0.05).

Constituent	n	R^2	p-value	% Change/year
NO_3-N	274	<0.01	0.36	-
TN	272	0.01	0.17	-
SRP	275	0.04	<0.01	-7.4
TP	275	0.02	0.04	-3.8
TSS	275	0.03	<0.01	-9.8
Cl	273	0.01	0.09*	1.0
SO_4	273	0.08	<0.01	4.4

*The trend was marginally significant ($p \leq 0.10$).

SPRING CREEK AT HWY 112 NEAR SPRINGDALE, ARKANSAS (SPRING)

Spring Creek (Spring) was sampled at the USGS stream gaging station near Springdale, Arkansas (USGS 07194933), where 155 water samples were collected and analyzed for constituents from January 2012 through June 2015. The Spring Creek Watershed is 91.8 km^2 in area, draining 12% forested lands, 42.5% pasture and grasslands, and 45% urban development. Spring Creek is a tributary to Osage Creek which later flows into the Illinois River. Spring has interesting potential water quality impacts due to relatively high urban land use within the catchment in addition to Springdale's waste water treatment plant which discharges effluent into Spring Creek upstream.

The constituent concentrations were paired with mean daily discharge (Q) and then used in the software program LOADEST to estimate constituent loads. The regression models for constituent loads at this site differed in their use of Q and time (t), reflecting various hydrological relationships, seasonal effects, and monotonic trends in loads. Regression statistics and models used are reported in Table 46. The mean daily loads were variable across constituents, showing that nitrate-nitrogen (NO_3-N) loads make up a large percentage of total nitrogen (TN) loads while soluble reactive phosphorus (SRP) loads make up greater than 50% of total phosphorus (TP) loads.

The mean daily loads were summed into annual loads for each project year (Table 47), which varied between project years. This variation was not necessarily proportional to the changes in discharge, which is a result of log-log relationships used in the regression models. For example, annual discharge volumes were similar in project years 2013 and 2014 yet the total suspended solids (TSS) load in 2013 was more than twice the load for 2014. Several annual load estimations were highly dependent on the flow regime for the project year. The annual loads in project year 2011 were not complete since data collection began in January 2012.

Table 46. Regression models used for load estimations of nitrate-N (NO_3-N), total nitrogen (TN), soluble reactive phosphorus (SRP), total phosphorus (TP), total suspended solids (TSS), chloride (Cl), and sulfate (SO_4) for Spring Creek at Hwy 112 near Springdale, AR (USGS 07194933) January 2012 to June 2015, with respective Akaike Information Criterion (AIC), load bias percentages (BP), Nash-Sutcliffe Efficiency index (E), and mean daily load for the estimation period with lower and upper values of the 95% confidence intervals (CI) in parentheses.

Constituent	Regression equation	AIC	BP (%)	E	Mean Daily Load (kg/d)
NO_3-N	$6.44 + 0.62lnQ - 0.10lnQ^2 + 0.14\sin(2\pi t) - 0.06\cos(2\pi t) - 0.02t$	0.40	-0.2	0.68	380 (360 - 400)
TN	$6.64 + 0.81lnQ - 0.003lnQ^2 + 0.10\sin(2\pi t) - 0.09\cos(2\pi t) - 0.04t$	-0.22	-4	0.77	450 (430 - 470)
SRP	$3.50 + 1.06lnQ - 0.18\sin(2\pi t) + 0.41\cos(2\pi t) - 0.24t$	1.19	-5	0.90	18 (17 - 20)
TP	$3.72 + 1.30lnQ + 0.21lnQ^2 - 0.16\sin(2\pi t) + 0.27\cos(2\pi t) - 0.16t$	1.42	2	0.23	33 (26 - 42)
TSS	$7.79 + 2.45lnQ$	3.16	-37	0.24	6350 (1440 - 18400)
Cl	$8.79 + 0.35lnQ - 0.09lnQ^2$	1.35	3	0.42	5080 (4670 - 5520)
SO_4	$8.91 + 0.32lnQ$	2.70	31	0.08	8570 (7120 - 10200)

SPRING CREEK AT HWY 112 NEAR SPRINGDALE, ARKANSAS (SPRING)

Table 47. Summary of annual discharge (Q, m^3) and annual loads (kg) for nitrate-N (NO_3-N), total nitrogen (TN), soluble reactive phosphorus (SRP), total P (TP), total suspended solids (TSS), chloride (Cl), and sulfate (SO_4) for Spring Creek at Hwy 112 near Springdale, AR (USGS 07194933) for project years 2011-2014 (e.g., project year 2011 is July 1, 2011 - June 30, 2012).

Project Year	Annual Q (m^3)	NO_3-N (kg)	TN (kg)	SRP (kg)	TP (kg)	TSS (kg)	Cl (kg)	SO_4 (kg)
2011*	19,500,000	65,900	80,100	2,870	3,950	376,000	836,000	1,460,000
2012	42,500,000	127,000	153,000	7,050	9,960	1,360,000	1,740,000	3,000,000
2013	53,200,000	147,000	175,000	8,040	18,900	4,530,000	1,940,000	3,230,000
2014	51,200,000	144,000	165,000	5,600	9,550	1,850,000	1,970,000	3,250,000

*Data collection at Spring Creek began in January 2012; load estimations for project year 2011 are from January to June 2012.

Trend analysis of the constituents revealed several flow-adjusted concentrations decreasing over time (Table 48). Four constituents at Spring showed significant trends during the sampling period (from January 2012 through June 2015):

- NO_3-N showed a marginally significant decrease over time (4.6% change per year)
- TN showed a significant decrease over time (5.5% change per year)
- SRP showed a significant decrease over time (11.1% change per year)
- TP showed a marginally significant decrease over time (7.2% change per year)

These directional changes in flow-adjusted concentrations were included in the regression models for load estimations, where the percent change per year was relatively similar between the load estimations and the three step trend analysis procedure. These decreasing trends were likely from changes in the effluent discharge, where the City of Springdale's facility made changes to reduce nutrient inputs in Spring Creek.

Table 48. Trends in flow-adjusted concentrations of nitrate-nitrogen (NO_3-N), total nitrogen (TN), soluble reactive phosphorus (SRP), total phosphorus (TP), total suspended solids (TSS), chloride (Cl), and sulfate (SO_4) for Spring Creek at Hwy 112 near Springdale, AR (Spring; USGS 07194933) from January 2012 to June 2015, with the respective sample size (n), coefficient of determination (R^2), and p-value of the overall F-test (p-value). Percent change per year (% Change/year) is reported for significant trends (p-value<0.05).

Constituent	n	R^2	p-value	% Change/year
NO_3-N	155	0.02	0.06*	-4.6
TN	155	0.06	<0.01	-5.5
SRP	155	0.05	<0.01	-11.1
TP	155	0.02	0.09*	-7.2
TSS	155	<0.01	0.60	-
Cl	155	<0.01	0.53	-
SO_4	155	<0.01	0.78	-

*The trend was marginally significant ($p \leq 0.10$).

BALLARD CREEK NEAR WESTVILLE, OKLAHOMA (BALLARD)

Ballard Creek (Ballard) was sampled from the bridge access on Ballard Creek Road, where 250 water samples were collected and analyzed for constituents from July 2009 to June 2015. The Ballard watershed is 57 km^2 in area, draining 28% forested lands, 64% pasture and grasslands, and 8% urban development. Ballard Creek is a tributary to the Illinois River, where the confluence is located after the remnant of Lake Francis. Ballard is a unique site in the Illinois River Watershed since it is largely pasture and grassland.

The constituent concentrations were paired with mean daily discharge (Q) and then used in the software program LOADEST to estimate constituent loads. The regression models for constituent loads at this site were generally complex in the use of Q and time (t); the models also used coefficients to account for seasonal variations in the observed daily loads. The specific equations used in constituent load estimation and their respective regression statistics are presented in Table 49. The mean daily loads were variable across constituents, showing that nitrate-nitrogen (NO_3-N) makes up over 60% of the total nitrogen (TN) loads and soluble reactive phosphorus (SRP) loads were nearly 60% of the total phosphorus (TP) loads.

The mean daily loads were summed into annual loads for each project year (Table 50), which varied between project years. This variation was not necessarily proportional to the changes in discharge, which is a result of log-log relationships used in the regression models. For example, annual discharge volume in 2012 (which was a partial record of only 7 months) was 30% greater than discharge volume in 2013 yet the total suspended solids (TSS) load in 2012 was double the load for 2013. Several annual load estimations were highly dependent on the flow regime for the project year, reflecting the importance of hydrology in understanding constituent transport in Ballard Creek. SRP, TP, and TSS loads were highly variable, which is reflected in the regression statistics. Also, project years 2010, 2011, and 2012 are partial records due to unavailable discharge data (Table 50).

Table 49. Regression models used for load estimations of nitrate-N (NO_3-N), total nitrogen (TN), soluble reactive phosphorus (SRP), total phosphorus (TP), total suspended solids (TSS), chloride (Cl), and sulfate (SO_4) for Ballard Creek near Westville, OK (Ballard; not gaged by the USGS) July 2009 to June 2015, with respective Akaike Information Criterion (AIC), load bias percentages (BP), Nash-Sutcliffe Efficiency index (E), and mean daily load for the estimation period with lower and upper values of the 95% confidence intervals (CI) in parentheses.

Constituent	Regression equation	AIC	BP (%)	E	Mean Daily Load (kg/d)
NO_3-N	$2.03 + 0.96lnQ - 0.01lnQ^2 - 0.29\sin(2\pi t) - 0.29\cos(2\pi t)$	1.25	7	0.82	90 (80 - 100)
TN	$2.21 + 1.01lnQ - 0.004lnQ^2 - 0.19\sin(2\pi t) - 0.17\cos(2\pi t)$	0.49	11	0.79	140 (130 - 150
SRP	$-1.66 + 1.14lnQ + 0.47\sin(2\pi t) + 0.29\cos(2\pi t)$	2.71	-44	0.78	8.8 (5.6 - 13.2)
TP	$-1.10 + 1.14lnQ + 0.33\sin(2\pi t) + 0.29\cos(2\pi t)$	2.52	-43	0.80	15 (10- 21)
TSS	$2.57 + 1.21lnQ$	3.26	-55	0.58	1170 (580 - 2130)
Cl	$3.74 + 0.92lnQ - 0.02lnQ^2 - 0.03\sin(2\pi t) - 0.10\cos(2\pi t) + 0.03t$	-0.29	4	0.88	330 (320 - 350)
SO_4	$4.09 + 0.95lnQ - 0.01lnQ^2 - 0.34\sin(2\pi t) - 0.25\cos(2\pi t) + 0.03t$	-0.26	3	0.93	610 (580 - 640)

BALLARD CREEK NEAR WESTVILLE, OKLAHOMA (BALLARD)

Table 50. Summary of annual discharge (Q, m^3) and annual loads (kg) for nitrate-N (NO_3-N), total nitrogen (TN), soluble reactive phosphorus (SRP), total P (TP), total suspended solids (TSS), chloride (Cl), and sulfate (SO_4) for Ballard Creek near Westville, OK (not gaged by the USGS) for project years 2009-2014 (e.g., project year 2011 is July 1, 2011 - June 30, 2012).

Project Year	Annual Q (m^3)	NO_3-N (kg)	TN (kg)	SRP (kg)	TP (kg)	TSS (kg)	Cl (kg)	SO_4 (kg)
2009	15,300,000	30,600	40,400	3,650	5,530	457,000	82,900	145,000
2010*	12,100,000	20,700	30,400	2,540	4,280	302,000	67,600	112,000
2011ǂ	28,400,000	64,900	82,300	3,550	6,110	539,000	201,000	388,000
2012‡	9,420,000	18,000	25,300	1,680	2,900	220,000	63,200	110,000
2013	7,010,000	17,500	21,600	816	1,370	111,000	70,700	123,000
2014	25,600,000	45,700	65,400	5,480	9,150	656,000	163,000	276,000

*Daily flow was not available from April 25, 2011 to May 18, 2011, because of equipment failure following a large storm event; discharge volume and loads estimated for project year 2010 do not include this date range.
ǂDaily flow was not available for December 2011 because of equipment failure; discharge volume and loads were not estimated for December 2011.
‡Daily flow was not available from August 2012 to December 2012, because of equipment failure; discharge volume and loads were not estimated from August 2012 to December 2012.

Only two of the constituents showed that flow-adjusted concentrations were increasing over time (Table 51), that is, a monotonic or linear increase occurred through the study period (from July 2009 through June 2015).

- Cl showed a significant increase over time (2.1% change per year)
- SO_4 showed a significant increase over time (3.5% change per year)

The directional changes in flow-adjusted concentrations were included in the load estimation equations where the percent change per year was relatively similar between the regression model and the three-step procedure used to evaluate monotonic changes in flow-adjusted concentrations over time.

Table 51. Trends in flow-adjusted concentrations of nitrate-nitrogen (NO_3-N), total nitrogen (TN), soluble reactive phosphorus (SRP), total phosphorus (TP), total suspended solids (TSS), chloride (Cl), and sulfate (SO_4) for Ballard Creek near Westville, OK (Ballard; not gauged by USGS) from July 2009 to June 2015, with the respective sample size (n), coefficient of determination (R^2), and p-value of the overall F-test (p-value). Percent change per year (% Change/year) is reported for significant trends (p-value<0.05).

Constituent	n	R^2	p-value	% Change/year
NO_3-N	250	<0.01	0.47	-
TN	247	<0.01	0.84	-
SRP	250	0.01	0.21	-
TP	250	<0.01	0.65	-
TSS	250	<0.01	0.98	-
Cl	248	0.03	<0.01	2.1
SO_4	248	0.03	<0.01	3.5

FLINT CREEK AT SPRINGTOWN, ARKANSAS (FC12)

Flint Creek (FC12) was sampled at the USGS stream gaging station on Hwy 12 at Springtown, Arkansas (USGS 07195800), where 271 water samples were collected and analyzed for constituents from July 2009 through June 2015. The FC12 watershed is 38.6 km^2 in area, draining 25% forested lands, 69% pasture and grasslands, and 6% urban development. Flint Creek is also sampled at another location downstream (see Flint Creek near West Siloam Springs, Oklahoma). Flint Creek is one of the major tributaries to the Illinois River within the Illinois River Watershed.

The constituent concentrations were paired with mean daily discharge (Q) and then used in the software program LOADEST to estimate constituent loads. The regression models for constituent loads at this site differed in the use of Q and time (t), reflecting various hydrological relationships, seasonal effects, and monotonic trends in loads. Regression statistics and models used are reported in Table 52. The mean daily loads were variable across constituents, showing that nitrate-nitrogen (NO_3-N) makes up a large percentage of total nitrogen (TN) loads whereas soluble reactive phosphorus (SRP) loads were, on average, greater than 50% of the total phosphorus (TP) loads.

The mean daily loads were summed into annual loads (Table 53), which varied between project years. Some constituent loads generally followed the pattern in discharge (e.g., NO_3-N, TN) while other loads, such as TP and total suspended solids (TSS), reflect the use of log-log relationships and seasonality coefficients in the regression models. For example, discharge volume in 2010 was nearly 50% of the discharge volume in 2009, yet the TP load showed a 50% increase in 2010 and the 2010 TSS load was double the 2009 load. Annual loads were dependent upon how discharge varied within project years, reflecting the importance of inter-annual variability in hydrology when estimating constituent loads. Overall, the regression statistics were excellent for this site, except TSS loads as the load estimation model had bias percentage (BP) of 53%.

Table 52. Regression models used for load estimations of nitrate-N (NO_3-N), total nitrogen (TN), soluble reactive phosphorus (SRP), total phosphorus (TP), total suspended solids (TSS), chloride (Cl), and sulfate (SO_4) for Flint Creek at Springtown, AR (USGS 07195800) July 2009 to June 2015, with respective Akaike Information Criterion (AIC), load bias percentages (BP), Nash-Sutcliffe Efficiency index (E), and mean daily load for the estimation period with lower and upper values of the 95% confidence intervals (CI) in parentheses.

Constituent	Regression equation	AIC	BP (%)	E	Mean Daily Load (kg/d)
NO_3-N	$5.26 + 0.97 lnQ - 0.02 lnQ^2 - 0.07\sin(2\pi t) - 0.04\cos(2\pi t) + 0.02t$	-0.35	-6	0.89	106 (102 - 110)
TN	$5.32 + 1.02 lnQ - 0.01 lnQ^2 - 0.06\sin(2\pi t) - 0.03\cos(2\pi t) + 0.02t$	-0.66	-1	0.98	116 (112 - 121)
SRP	$1.37 + 1.41 lnQ + 0.05 lnQ^2 + 0.27\sin(2\pi t) + 0.12\cos(2\pi t) + 0.07t$	0.65	-5	0.55	4.1 (3.3 - 4.9)
TP	$1.66 + 1.51 lnQ + 0.06 lnQ^2 + 0.27\sin(2\pi t) + 0.15\cos(2\pi t) + 0.10t$	0.88	16	0.30	7.0 (5.3 - 9.1)
TSS	$4.92 + 1.97 lnQ + 0.20\sin(2\pi t) + 0.32\cos(2\pi t)$	2.59	-53	0.60	580 (190 - 1360)
Cl	$5.84 + 0.85 lnQ$	-0.41	2	0.92	198 (192 - 206)
SO_4	$5.74 + 1.09 lnQ - 0.03 lnQ^2 - 0.08\sin(2\pi t) - 0.05\cos(2\pi t) + 0.03t$	0.59	-3	0.94	177 (164 - 190)

FLINT CREEK AT SPRINGTOWN, ARKANSAS (FC12)

Table 53. Summary of annual discharge (Q, m^3) and annual loads (kg) for nitrate-N (NO_3-N), total nitrogen (TN), soluble reactive phosphorus (SRP), total P (TP), total suspended solids (TSS), chloride (Cl), and sulfate (SO_4) for Flint Creek at Springtown, AR (USGS 07195800) for project years 2009-2014 (e.g., project year 2011 is July 1, 2011 - June 30, 2012).

Project Year	Annual Q (m^3)	NO_3-N (kg)	TN (kg)	SRP (kg)	TP (kg)	TSS (kg)	Cl (kg)	SO_4 (kg)
2009	23,000,000	72,800	80,600	2,570	3,920	319,000	130,000	126,000
2010	13,500,000	40,600	47,100	2,950	5,920	644,000	76,300	70,100
2011	9,270,000	32,200	33,500	576	753	27,100	63,300	50,200
2012	8,060,000	26,700	29,500	1,110	2,000	158,000	52,000	43,500
2013	6,250,000	22,400	23,200	401	534	13,700	45,600	33,700
2014	10,600,000	37,400	41,000	1,300	2,160	110,000	67,100	63,500

Several of the constituents showed that flow-adjusted concentrations were increasing over time (Table 54), that is, a monotonic or linear increase occurred throughout the study period (from July 2009 through June 2015).

- NO_3-N and TN showed significant increases over time (2.3 and 2.4% change per year)
- SRP and TP showed significant increases over time (4.1 and 6.3% change per year)
- SO_4 showed a significant increase over time (3.2% change per year)

The directional changes in flow-adjusted concentrations were included in the load estimation equations, where the percent change per year was relatively similar between the regression model and the three step procedure used to evaluate monotonic changes in flow-adjusted concentrations (Table 54).

Table 54. Trends in flow-adjusted concentrations of nitrate-nitrogen (NO_3-N), total nitrogen (TN), soluble reactive phosphorus (SRP), total phosphorus (TP), total suspended solids (TSS), chloride (Cl), and sulfate (SO_4) for Flint Creek at Springtown, AR (FC12; USGS 07195800) from July 2009 to June 2015, with the respective sample size (n), coefficient of determination (R^2), and p-value of the overall F-test (p-value). Percent change per year (% Change/year) is reported for significant trends (p-value<0.05).

Constituent	n	R^2	p-value	% Change/year
NO_3-N	271	0.04	<0.01	2.3
TN	269	0.06	<0.01	2.4
SRP	271	0.04	<0.01	4.1
TP	271	0.07	<0.01	6.3
TSS	271	0.01	0.15	-
Cl	269	0.01	0.21	-
SO_4	269	0.03	<0.01	3.2

SAGER CREEK AT SILOAM SPRINGS, ARKANSAS (SAGER)

Sager Creek at Siloam Springs, Arkansas (Sager) was sampled from the bridge access behind (but upstream from) the City of Siloam Springs wastewater treatment plant, where 176 water samples were collected and analyzed for constituents from July 2011 through June 2015. The Sager Creek Watershed is 35 km^2 in area, draining 4% forested lands, 58% pasture and grasslands, and 38% urban development. Sager Creek is a tributary to Flint Creek, which is major tributary to the Illinois River in the Illinois River Watershed. Sager represents a unique site due to a relatively large urban influence, in which the City of Siloam Springs has taken significant measures to improve the quality of the stream.

The constituent concentrations were paired with mean daily discharge (Q) and then used in the software program LOADEST to estimate constituent loads. The regression models for constituent loads at this site differed in their use of Q and time (t), reflecting various hydrological relationships, seasonal effects, and monotonic trends in loads. Regression statistics and models used are reported in Table 55. The mean daily loads were variable across constituents, showing that, on average, nitrate-nitrogen (NO_3-N) loads make up nearly 70% of total nitrogen (TN) loads while soluble reactive phosphorus (SRP) loads make up roughly 50% of total phosphorus (TP) loads.

The mean daily loads were summed into annual loads for each project year (Table 56), which varied between project years. This variation was not necessarily proportional to the changes in discharge, which is a result of log-log relationships used in the regression models. For example, annual discharge volume in 2014 was nearly 50% greater than discharge volume in 2012 yet the total suspended solids (TSS) load in 2012 was still greater than the load for 2014. Several annual load estimations were highly dependent on the flow regime for the project year, reflecting the importance of hydrology in understanding constituent transport in Sager Creek.

Table 55. Regression models used for load estimations of nitrate-N (NO_3-N), total nitrogen (TN), soluble reactive phosphorus (SRP), total phosphorus (TP), total suspended solids (TSS), chloride (Cl), and sulfate (SO_4) for Sager Creek at Siloam Springs, AR (not gaged by USGS) July 2011 to June 2015, with respective Akaike Information Criterion (AIC), load bias percentages (BP), Nash-Sutcliffe Efficiency index (E), and mean daily load for the estimation period with lower and upper values of the 95% confidence intervals (CI) in parentheses.

Constituent	Regression equation	AIC	BP (%)	E	Mean Daily Load (kg/d)
NO_3-N	$4.56 + 0.81lnQ - 0.07lnQ^2 - 0.07\sin(2\pi t) - 0.15\cos(2\pi t)$	0.28	-2	0.86	45 (42 - 48)
TN	$4.84 + 1.00lnQ - 0.02lnQ^2 - 0.06\sin(2\pi t) - 0.10\cos(2\pi t) - 0.01t$	-0.22	-2	0.97	67 (64 - 71)
SRP	$1.20 + 1.49lnQ + 0.43\sin(2\pi t) + 0.67\cos(2\pi t)$	2.02	2	0.80	5.1 (3.3 - 7.5)
TP	$1.80 + 1.54lnQ + 0.24\sin(2\pi t) + 0.57\cos(2\pi t)$	1.66	12	0.68	9.3 (6.5 - 13.0)
TSS	$5.55 + 1.82lnQ - 0.02\sin(2\pi t) + 0.37\cos(2\pi t) - 0.33t$	2.53	-19	0.40	750 (360 - 1390)
Cl	$6.11 + 0.69lnQ - 0.02lnQ^2 - 0.07\sin(2\pi t) - 0.15\cos(2\pi t) + 0.14t$	0.58	-5	0.70	250 (240 - 270)
SO_4	$6.38 + 0.83lnQ - 0.05lnQ^2 - 0.03\sin(2\pi t) - 0.20\cos(2\pi t)$	-0.29	-1	0.94	280 (270 - 300)

SAGER CREEK AT SILOAM SPRINGS, ARKANSAS (SAGER)

Table 56. Summary of annual discharge (Q, m^3) and annual loads (kg) for nitrate-N (NO_3-N), total nitrogen (TN), soluble reactive phosphorus (SRP), total P (TP), total suspended solids (TSS), chloride (Cl), and sulfate (SO_4) for Sager Creek at Siloam Springs, AR (not gaged by USGS) for project years 2011-2014 (e.g., project year 2011 is July 1, 2011 - June 30, 2012).

Project Year	Annual Q (m^3)	NO_3-N (kg)	TN (kg)	SRP (kg)	TP (kg)	TSS (kg)	Cl (kg)	SO_4 (kg)
2011	5,510,000	9,140	12,900	475	852	116,000	42,800	59,000
2012	11,100,000	15,700	24,700	1,630	3,270	376,000	80,500	99,700
2013	11,300,000	17,700	24,800	2,190	3,620	261,000	101,000	110,000
2014	15,700,000	21,700	34,100	2,980	5,640	324,000	141,000	138,000

Several of the constituents showed that flow-adjusted concentrations changed over the sampling period at Sager (Table 57), where monotonic or linear changes likely occurred in TN, TSS, and chloride (Cl).

- TN showed a marginally significant decrease over time (2.6% change per year)
- TSS showed a significant decrease over time (12.4% change per year)
- Cl showed a significant increase over time (10.0% change per year)

The directional changes in flow-adjusted concentrations were included in the load estimation equations, where the percent change per year was relatively similar between the regression model and the three step procedure used to evaluate monotonic changes in flow-adjusted concentrations.

Table 57. Trends in flow-adjusted concentrations of nitrate-nitrogen (NO_3-N), total nitrogen (TN), soluble reactive phosphorus (SRP), total phosphorus (TP), total suspended solids (TSS), chloride (Cl), and sulfate (SO_4) for Sager Creek at Siloam Springs, AR (Sager; not gauged by USGS) from July 2011 to June 2015, with the respective sample size (n), coefficient of determination (R^2), and p-value of the overall F-test (p-value). Percent change per year (% Change/year) is reported for significant trends (p-value<0.05).

Constituent	n	R^2	p-value	% Change/year
NO_3-N	176	0.01	0.13	-
TN	176	0.02	0.07	-2.6
SRP	176	<0.01	0.69	-
TP	176	<0.01	0.92	-
TSS	176	0.03	0.04	-12.4
Cl	173	0.10	<0.01	10.0
SO_4	173	<0.01	0.70	-

*The trend was marginally significant (p≤0.10).

NIOKASKA CREEK AT TOWNSHIP ST AT FAYETTEVILLE, ARKANSAS (NC)

Niokaska Creek (NC) was sampled at the USGS stream gaging station at Township St at Fayetteville, Arkansas (USGS 07194809), where 173 samples were collected and analyzed for constituents from July 2011 to May 2015. This stream drains a small urban watershed (3.1 km^2) with land use representing 84% urban development and 15% forested areas. Niokaska Creek is a tributary to Mud Creek that flows into Clear Creek, which flows into the Illinois River. This site is unique among the IRW sites since it represents a watershed that is mostly urban development.

The constituent concentrations were paired with mean daily discharge and then used to compute daily loads in the software program LOADEST. The regression equations used to predict daily loads varied from a simple log-log regression using discharge (Q) to more complex models using multiple discharge factors, seasonal coefficients and or time (t). The various statistics and regression models used in constituent load estimation are presented in Table 58. The mean daily loads were small relative to the larger watersheds (simply because this is small watershed), but varied across the constituents. Nitrate-nitrogen (NO_3-N) loads were 60% of the total nitrogen (TN) loads at this site, whereas soluble reactive phosphorus (SRP) loads were 15% of the total phosphorus (TP) loads.

The mean daily loads for all constituents were summed into annual loads for each project year (Table 59), which varied between project years. The variation in annual constituent loads between years was not necessarily proportional to the changes in discharge, reflecting the use of log-transformation in the regression models. For example, the annual discharge might be similar between project years (e.g., 2013 and 2014, which is a partial record of eleven months) whereas the constituent loads vary (e.g., total suspended solids (TSS) were almost 60% greater for the partial record in 2014 when compared to 2013). This difference shows the importance of how variations in daily discharge within a year can influence constituent transport (i.e., loads) at College Branch. NO_3-N, SRP, and TP loads were highly variable, which is reflected in the regression statistics.

Table 58. Regression models used for load estimations of nitrate-N (NO_3-N), total nitrogen (TN), soluble reactive phosphorus (SRP), total phosphorus (TP), total suspended solids (TSS), chloride (Cl), and sulfate (SO_4) for Niokaska Creek at Township St at Fayetteville, AR (NC; USGS 07194809) July 2011 to May 2015, with respective Akaike Information Criterion (AIC), load bias percentages (BP), Nash-Sutcliffe Efficiency index (E), and mean daily load for the estimation period with lower and upper values of the 95% confidence intervals (CI) in parentheses.

Constituent	Regression equation	AIC	BP (%)	E	Mean Daily Load (kg/d)
NO_3-N	$-0.98 + 1.34lnQ - 0.05lnQ^2$	3.33	49	0.68	2.9 (1.7 - 4.5)
TN	$-0.23 + 1.30lnQ - 0.05\sin(2\pi t) + 0.23\cos(2\pi t)$	2.24	15	0.61	4.8 (3.7 - 6.2)
SRP	$-3.81 + 1.33lnQ + 0.48\sin(2\pi t) + 0.92\cos(2\pi t)$	2.56	-89	0.005	0.15 (0.10 - 0.21)
TP	$-3.00 + 1.44lnQ + 0.06lnQ^2 + 0.29\sin(2\pi t) + 0.98\cos(2\pi t)$	2.80	-39	0.06	1.0 (0.5 - 1.60)
TSS	$1.71 + 1.73lnQ + 0.47\sin(2\pi t) + 1.70\cos(2\pi t)$	3.73	-19	0.25	370 (90 - 1030)
Cl	$2.65 + 0.73lnQ - 0.40\sin(2\pi t) - 0.69\cos(2\pi t) + 0.14t$	2.16	-4	0.59	38 (32 - 45)
SO_4	$2.99 + 0.72lnQ - 0.19\sin(2\pi t) - 0.48\cos(2\pi t)$	1.93	7	0.75	41 (35 - 47)

NIOKASKA CREEK AT TOWNSHIP ST AT FAYETTEVILLE, ARKANSAS (NC)

Table 59. Summary of annual discharge (Q, m^3) and annual loads (kg) for nitrate-N (NO_3-N), total nitrogen (TN), soluble reactive phosphorus (SRP), total P (TP), total suspended solids (TSS), chloride (Cl), and sulfate (SO_4) for Niokaska Creek at Township St at Fayetteville, AR (USGS 07194809) for project years 2011-2014 (e.g., project year 2011 is July 1, 2011 - June 30, 2012).

Project Year	Annual Q (m^3)	NO_3-N (kg)	TN (kg)	SRP (kg)	TP (kg)	TSS (kg)	Cl (kg)	SO_4 (kg)
2011	806,000	776	1,210	33	204	53,600	9,190	12,600
2012	867,000	849	1,510	46	301	129,000	9,590	11,500
2013	1,180,000	1,130	1,790	60	370	134,000	16,300	17,300
2014*	1,340,000	1,380	2,380	73	489	214,000	18,900	17,100

*Discharge and loads were not estimated for June 2015, because this site was discontinued by USGS.

Chloride (Cl) was the only constituent to show that flow-adjusted concentrations (FACs) were increasing over time (Table 60), that is, a monotonic or linear increase occurred through the study period (from July 2011 to May 2015).

- Cl showed a significant increase over time (13.1% change per year).

The directional change in FACs for Cl was included in the load estimation equation, where the percent change per year was relatively similar to between the regression model and the three step procedure used to evaluate monotonic changes in FACs.

Table 60. Trends in flow-adjusted concentrations of nitrate-nitrogen (NO_3-N), total nitrogen (TN), soluble reactive phosphorus (SRP), total phosphorus (TP), total suspended solids (TSS), chloride (Cl), and sulfate (SO_4) for Niokaska Creek at Township St at Fayetteville, AR (NC; USGS 07194809) from July 2011 to May 2015, with the respective sample size (n), coefficient of determination (R^2), and p-value of the overall F-test (p-value). Percent change per year (% Change/year) is reported for significant trends (p-value<0.05).

Constituent	n	R^2	p-value	% Change/year
NO_3-N	173	<0.01	0.43	-
TN	170	0.01	0.28	-
SRP	173	0.01	0.34	-
TP	169	<0.01	0.78	-
TSS	172	<0.01	0.49	-
Cl	173	0.03	0.03	13.1
SO_4	173	<0.01	0.55	-

Summary and Considerations

Water samples were successfully collected at all the sites included in this project focused on water quality in the UIRW and UWRB. The complexities of sampling 19 sites across two HUC 8 watersheds surfaced when storm events needed to be sampled. For example, the three small urban streams (NC, MLK and TBT) were very flashy streams responding to episodic rainfall events in a matter of hours; the field services unit had to be flexible to sample these sites outside of normal business hours. The remaining sites had a little bit longer lag time before the runoff hydrograph peaked during storm events, but these sites had highly variable times to peak. The lag time to peak was dependent upon many hydrologic and meteorological factors, such as antecedent moisture conditions, rainfall intensity and duration, and even the direction the weather front moved into the watersheds. Despite these complexities, the streams were sampled across the range of discharge observed during the project period – this is one of the most important aspects of this study.

The water samples were delivered to the AWRC WQL and analyzed following standard methods and the approved QAPP. The concentration data from the WQL was paired with mean daily discharge and then used to develop regression models to estimate daily constituent loads based on discharge and time. The regression models used to estimate constituent loads varied in complexity, ranging from a simple log-log regression between load and discharge to models that included multiple discharge factors, seasonal coefficients, and trends over time. The regression statistics (AIC, BP, and E) were very good across all constituents, except TSS which showed high variability. The loads across all the sites followed the general patterns typical of watersheds, such as load:

- Annual loads generally increased with increasing annual discharge within and across sites.

- Annual loads increased with increasing watershed area.

The unit area loads (loads divided by watershed area) did not necessarily follow the decreasing pattern often seen with watershed area, likely because these watersheds had land uses across the spectrum – that is, the watersheds varied from highly urbanized to forested to pasture and grassland. The watersheds also varied topography, underlying geologic influence, and soils. The loading data from these sites will be useful in the calibration and validation of future watershed modeling efforts.

The most important use of the concentration and discharge data was estimating trends, based on the three step process: (1) log-transform data, (2) plot LOESS line, and (3) evaluate residuals or flow-adjusted concentrations over time. The constituent trends observed were variable across these sites, but some commonalities did appear across these sites. The intent of this part of the project was to understand how constituent concentrations are changing over time and whether these changes were from changes in watershed management, such as reduced nutrient inputs from effluent discharges, state regulations, or even the implementation of best management practices and educational programs by the ANRC 319 NPS Management Program. The following bullets highlight potential changes in water quality from watershed activities or that have potentially important implications in these HUC 8 watersheds, including:

- The influence of municipal effluent discharges on stream water chemistry are profound (Haggard et al., 2001, 2005) and the influence of the discharge measureable for many river km downstream, e.g. the City of Springdale's municipal facility (Haggard, 2010). The effluent discharge from Springdale's facility made some changes during the project period (January 2012 to June 2015) which have resulted in decreasing trends in SRP, TP, NO_3-N and TN concentrations at Spring Creek. The reduced nutrient inputs from the facility showed up further downstream in Osage Creek and even the Illinois River, where significant decreases in SRP and NO_3-N have occurred over time. However, total nutrient concentrations further downstream did not show significant decreases – thus, it is important to continue collecting this data at Spring Creek and downstream to the Illinois River to document further water quality improvements.

- Beaver Lake will likely violate the recent numeric criteria for chlorophyll-a and Secchi transparency depth, when assessed by ADEQ in the next cycle of the 303(d) list – algae, measured as chlorophyll-a concentrations, have been increasing in Beaver Lake (Scott and Haggard, 2015). The reason for these increases might be tied to changes in watershed inputs, climate or even lake management (i.e., changes in lake levels and releases). This project showed that watershed inputs in the main tributaries have potentially changed over time, and the direction of these changes were not how one might hope. Inputs of TN have been increasing in the White River and Richland Creek, while there was no significant change over time in War Eagle Creek; TP inputs also increased in Richland Creek. Did these increased nutrient inputs result in increases in chlorophyll-a? It is possible, because algal response in lakes is driven by watershed inputs. However, close inspection of the intricate changes in water quality show that maybe nutrient inputs have started decreasing in the latter years of the study period. Thus, it is critically important to keep collecting these data to understand how inputs into the drinking water supply, i.e. Beaver Lake, are changing over time.

- It is difficult to tie changes in water quality at the larger watershed scale to implementation of best management practices, restoration activities and or education and outreach programs. This is especially true for small time periods, as water quality improvements often take decades or longer. However, the desired improvements might surface quicker in the smaller watersheds. This might be true for the Sager Creek Watershed, where TN and TSS concentrations have been significantly decreasing over time at Sager Creek. The site on Sager Creek is not downstream from the effluent discharge, so these changes are likely the results of watershed activities and or climatic or hydrologic changes that would influence streamwater chemistry. In fact, Sager Creek and its riparian zone have undergone some major renovations – the removal of small dams and channel restoration just upstream of the sampling site, as well as channel and wetland restoration further upstream. These projects were funded by the ANRC 319 NPS Management Program and the City of Siloam Springs, and this would be a water quality success story which would not have been recorded without data post-watershed activities.

The data collected in this project are critical to understanding nutrient sources within these two watersheds, as well as how water quality (i.e., flow-adjusted concentration of various constituents) is changing over time. The ability to detect trends in water quality requires a commitment to long-term monitoring, and the ANRC 319 NPS Management Program has been funding these efforts for decades. The data collected at 13 of these sites will be continued starting with the next project funded by the ANRC 319 NPS Management Program, plus two additional sites will be added where new USGS stream gaging stations exist in these two watersheds, UIRW and UWRB.

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Appendix 1. Summary of monthly discharge (Q, m^3) and monthly loads (kg) for nitrate-N (NO_3-N), total nitrogen (TN), soluble reactive phosphorus (SRP), total P (TP), total suspended solids (TSS), chloride (Cl), and sulfate (SO_4) for each project site.

KINGS RIVER NEAR BERRYVILLE, ARKANSAS (KINGS)

Month	Year	Monthly Q m^3	NO_3-N (kg)	TN (kg)	SRP (kg)	TP (kg)	TSS (kg)	Cl (kg)	SO_4 (kg)
July	2009	8,800,000	2,660	4,140	789	1,720	122,000	52,100	55,000
Aug.	2009	4,290,000	697	1,640	358	670	33,900	36,000	34,200
Sep.	2009	46,400,000	43,200	47,500	4,420	21,200	3,220,000	163,000	222,000
Oct.	2009	199,000,000	159,000	285,000	19,900	123,000	30,600,000	552,000	921,000
Nov.	2009	41,100,000	55,400	47,600	3,570	6,450	627,000	176,000	244,000
Dec.	2009	21,500,000	28,100	24,800	1,730	1,260	85,200	114,000	155,000
Jan.	2010	40,000,000	64,700	56,100	3,220	2,230	206,000	170,000	257,000
Feb.	2010	71,100,000	121,000	109,000	5,760	4,570	539,000	245,000	405,000
Mar.	2010	98,000,000	121,000	143,000	7,840	9,960	1,820,000	289,000	495,000
Apr.	2010	50,900,000	57,500	56,600	3,810	4,420	587,000	173,000	265,000
May	2010	117,000,000	92,400	132,000	8,940	30,900	7,830,000	303,000	499,000
June	2010	12,900,000	5,850	7,470	839	1,700	162,000	64,900	77,300
July	2010	11,900,000	5,510	6,620	747	2,430	254,000	62,200	71,000
Aug.	2010	2,000,000	156	606	110	201	9,520	24,000	21,300
Sep.	2010	32,600,000	28,900	30,800	2,100	12,700	2,230,000	126,000	170,000
Oct.	2010	4,020,000	909	2,000	214	295	13,500	40,500	41,300
Nov.	2010	4,060,000	1,720	2,690	210	170	7,750	40,600	44,200
Dec.	2010	4,760,000	2,250	3,520	241	137	6,380	45,800	52,800
Jan.	2011	5,790,000	3,060	4,680	286	125	6,130	50,300	61,800
Feb.	2011	40,400,000	66,200	57,700	2,170	1,940	254,000	157,000	256,000
Mar.	2011	58,400,000	89,200	77,300	3,070	3,050	407,000	210,000	345,000
Apr.	2011	395,000,000	178,000	620,000	23,100	125,000	66,800,000	865,000	1,830,000
May	2011	271,000,000	181,000	351,000	14,800	85,400	34,900,000	626,000	1,170,000
June	2011	16,000,000	9,560	10,500	723	1,960	254,000	74,600	95,300
July	2011	2,730,000	294	913	107	226	14,400	27,600	26,900
Aug.	2011	5,120,000	1,630	2,410	204	701	59,800	39,900	41,900
Sep.	2011	5,600,000	2,860	3,340	218	676	56,000	43,000	47,000
Oct.	2011	5,070,000	1,910	2,940	187	348	21,600	46,800	51,100
Nov.	2011	61,900,000	100,000	92,600	2,600	8,690	1,550,000	235,000	381,000
Dec.	2011	66,100,000	130,000	103,000	2,640	4,830	694,000	265,000	438,000
Jan.	2012	57,300,000	93,500	103,000	2,260	3,620	779,000	212,000	378,000
Feb.	2012	49,000,000	89,600	74,000	1,820	1,990	294,000	194,000	331,000
Mar.	2012	149,000,000	166,000	254,000	5,760	14,900	5,140,000	411,000	812,000
Apr.	2012	17,900,000	16,200	16,100	586	721	89,400	86,800	126,000
May	2012	4,210,000	1,000	2,050	123	152	12,400	34,800	40,200
June	2012	1,400,000	68	395	37	54	3,160	19,100	18,300

KINGS RIVER NEAR BERRYVILLE, ARKANSAS (KINGS) Continued

Month	Year	Monthly Q m^3	NO_3-N (kg)	TN (kg)	SRP (kg)	TP (kg)	TSS (kg)	Cl (kg)	SO_4 (kg)
July	2012	574,000	7	104	14	22	936	13,200	10,700
Aug.	2012	573,000	11	115	13	25	1,030	13,800	11,100
Sep.	2012	1,790,000	182	628	44	104	5,800	25,100	24,000
Oct.	2012	3,790,000	1,540	2,210	94	210	15,300	39,000	42,800
Nov.	2012	1,780,000	203	818	41	38	1,600	28,000	29,000
Dec.	2012	3,180,000	885	2,040	72	51	2,590	38,800	45,400
Jan.	2013	22,400,000	36,500	36,900	580	964	210,000	105,000	175,000
Feb.	2013	35,900,000	65,100	50,600	884	1,070	164,000	157,000	267,000
Mar.	2013	48,400,000	77,800	65,000	1,170	1,820	348,000	189,000	327,000
Apr.	2013	79,100,000	105,000	98,900	1,900	5,940	1,680,000	254,000	452,000
May	2013	84,200,000	96,000	94,100	1,980	9,080	2,710,000	261,000	450,000
June	2013	24,800,000	22,000	21,400	545	3,010	781,000	98,400	146,000
July	2013	2,830,000	437	1,040	51	189	17,500	29,200	30,600
Aug.	2013	59,900,000	58,700	57,600	1,280	17,700	5,590,000	205,000	319,000
Sep.	2013	3,030,000	497	1,260	52	173	12,800	34,600	36,500
Oct.	2013	8,010,000	5,980	5,920	142	578	71,600	61,900	77,000
Nov.	2013	15,000,000	19,400	15,500	263	657	76,800	96,900	138,000
Dec.	2014	71,700,000	146,000	130,000	1,350	4,270	1,090,000	280,000	520,000
Jan.	2014	41,700,000	88,800	64,800	728	1,260	220,000	193,000	336,000
Feb.	2014	11,700,000	12,400	12,200	183	172	18,500	76,800	117,000
Mar.	2014	87,400,000	142,000	140,000	1,500	4,210	1,410,000	290,000	566,000
Apr.	2014	84,900,000	125,000	117,000	1,410	4,830	1,560,000	275,000	518,000
May	2014	26,900,000	25,700	23,000	400	1,510	330,000	118,000	182,000
June	2014	44,500,000	44,000	40,200	668	5,520	1,770,000	161,000	258,000
July	2014	7,580,000	2,880	3,850	99	571	84,600	53,100	65,200
Aug.	2014	3,410,000	602	1,350	41	206	20,800	35,600	38,900
Sep.	2014	2,210,000	269	840	25	94	7,300	29,900	31,300
Oct.	2014	30,900,000	47,400	37,000	409	3,670	954,000	143,000	225,000
Nov.	2014	8,690,000	7,340	7,380	100	265	28,300	71,400	97,000
Dec.	2015	23,700,000	44,900	31,300	279	627	95,500	137,000	222,000
Jan.	2015	34,000,000	72,100	54,500	406	978	224,000	166,000	295,000
Feb.	2015	14,100,000	20,700	16,900	153	219	36,300	85,200	139,000
Mar.	2015	165,000,000	297,000	287,000	1,950	7,430	3,030,000	507,000	1,080,000
Apr.	2015	45,500,000	68,300	52,800	487	1,580	413,000	181,000	322,000
May	2015	174,000,000	181,000	228,000	1,960	22,000	12,900,000	474,000	957,000
June	2015	131,000,000	118,000	151,000	1,420	25,600	16,200,000	367,000	702,000

*Constituent loads were estimated for project year 2010, but water samples were not collected during this time due to lack of funding.

WHITE RIVER NEAR GOSHEN, ARKANSAS (WR45)

Month	Year	Monthly Q (m^3)	NO_3-N (kg)	TN (kg)	SRP (kg)	TP (kg)	TSS (kg)	Cl (kg)	SO_4 (kg)
July	2009	2,460,000	1,220	2,320	13	209	56,000	26,700	49,500
Aug.	2009	6,320,000	3,930	6,200	43	864	265,000	55,600	114,000
Sep.	2009	59,800,000	45,200	71,500	1,280	17,400	7,780,000	285,000	729,000
Oct.	2009	166,000,000	147,000	230,000	5,330	49,700	23,100,000	654,000	1,790,000
Nov.	2009	40,000,000	45,000	44,500	395	4,050	1,100,000	253,000	606,000
Dec.	2009	36,500,000	42,900	39,900	425	2,670	736,000	213,000	518,000
Jan.	2010	46,600,000	50,300	46,000	498	2,760	756,000	245,000	623,000
Feb.	2010	68,000,000	63,000	63,200	844	4,460	1,380,000	297,000	804,000
Mar.	2010	72,000,000	48,900	61,500	1,080	6,520	2,590,000	272,000	763,000
Apr.	2010	39,700,000	23,700	30,700	411	3,200	1,160,000	177,000	470,000
May	2010	111,000,000	51,300	94,500	2,270	22,700	12,300,000	355,000	1,040,000
June	2010	9,850,000	4,630	7,650	65	976	324,000	67,100	151,000
July	2010	27,500,000	13,200	25,000	433	7,610	3,880,000	127,000	323,000
Aug.	2010	879,000	487	1,100	4	52	10,500	15,200	23,100
Sep.	2010	23,600,000	17,600	24,700	268	4,840	1,770,000	143,000	339,000
Oct.	2010	2,480,000	2,390	3,150	12	127	22,500	35,700	61,000
Nov.	2010	6,790,000	7,950	7,800	50	413	91,800	62,000	126,000
Dec.	2010	7,850,000	9,400	8,730	51	342	68,900	73,700	150,000
Jan.	2011	10,600,000	12,100	10,900	74	419	89,700	84,900	184,000
Feb.	2011	45,700,000	40,800	41,000	509	2,770	850,000	214,000	564,000
Mar.	2011	43,700,000	32,700	35,800	426	2,640	824,000	206,000	541,000
Apr.	2011	304,000,000	144,000	335,000	15,200	78,000	52,100,000	702,000	2,250,000
May	2011	230,000,000	103,000	212,000	6,620	57,600	35,100,000	625,000	1,930,000
June	2011	11,600,000	5,450	8,930	86	1,260	450,000	72,400	168,000
July	2011	703,000	324	836	3	34	6,880	12,100	18,300
Aug.	2011	1,930,000	1,150	2,040	11	191	50,500	22,800	40,800
Sep.	2011	1,440,000	1,110	1,800	8	98	20,200	21,600	35,300
Oct.	2011	1,350,000	1,280	1,860	7	60	10,000	23,000	36,200
Nov.	2011	58,100,000	63,700	71,200	1,010	8,430	2,870,000	288,000	737,000
Dec.	2011	67,400,000	79,100	75,600	886	6,010	1,750,000	349,000	893,000
Jan.	2012	54,300,000	56,300	56,600	829	4,100	1,330,000	251,000	658,000
Feb.	2012	48,700,000	45,600	45,000	554	2,930	877,000	232,000	609,000
Mar.	2012	124,000,000	81,100	117,000	2,910	14,800	6,880,000	389,000	1,150,000
Apr.	2012	15,700,000	9,490	12,000	116	903	273,000	91,100	220,000
May	2012	2,050,000	1,010	1,800	11	85	20,600	21,400	40,000
June	2012	1,020,000	458	1,010	5	53	12,900	13,200	22,300

WHITE RIVER NEAR GOSHEN, ARKANSAS (WR45) Continued

Month	Year	Monthly Q (m^3)	NO_3-N (kg)	TN (kg)	SRP (kg)	TP (kg)	TSS (kg)	Cl (kg)	SO_4 (kg)
July	2012	547,000	256	671	2	28	5,560	9,780	14,500
Aug.	2012	947,000	574	1,150	5	75	17,900	14,700	23,100
Sep.	2012	748,000	540	1,070	4	37	6,320	14,700	21,500
Oct.	2012	1,980,000	1,900	2,560	10	101	18,100	29,400	49,200
Nov.	2012	1,080,000	1,160	1,590	5	29	4,060	20,300	30,800
Dec.	2012	1,560,000	1,790	2,060	8	36	5,370	24,100	39,600
Jan.	2013	25,300,000	25,600	26,800	410	1,920	651,000	128,000	318,000
Feb.	2013	38,300,000	35,200	34,000	366	2,030	570,000	195,000	501,000
Mar.	2013	64,000,000	45,500	53,600	810	4,970	1,810,000	262,000	718,000
Apr.	2013	81,100,000	46,500	63,700	1,030	8,360	3,410,000	305,000	862,000
May	2013	91,900,000	43,500	73,800	1,470	16,000	7,990,000	324,000	926,000
June	2013	30,700,000	14,100	24,100	365	5,150	2,330,000	136,00	356,000
July	2013	1,080,000	530	1,180	5	69	15,500	15,800	25,700
Aug.	2013	34,200,000	19,500	33,600	514	9,890	4,560,000	163,000	416,000
Sep.	2013	1,000,000	756	1,320	5	71	15,800	16,300	25,400
Oct.	2013	5,620,000	5,500	6,440	36	461	107,000	57,800	113,000
Nov.	2013	17,600,000	20,000	19,600	145	1,430	353,000	134,000	298,000
Dec.	2013	54,400,000	62,700	62,300	846	5,000	1,560,000	271,000	694,000
Jan.	2014	39,000,000	43,200	39,600	423	2,360	645,000	214,000	535,000
Feb.	2014	10,400,000	9,700	9,390	66	344	75,000	77,100	172,000
Mar.	2014	85,500,000	58,400	77,800	1,660	8,700	3,730,000	302,000	861,000
Apr.	2014	80,200,000	46,800	64,400	1,110	8,220	3,380,000	297,000	840,000
May	2014	39,400,000	19,300	29,600	409	4,710	1,930,000	176,000	464,000
June	2014	15,400,000	7,260	11,800	110	1,760	613,000	95,500	224,000
July	2014	4,850,000	2,410	4,300	27	467	132,000	45,200	90,100
Aug.	2014	9,420,000	5,500	8,960	85	1,740	653,000	67,700	148,000
Sep.	2014	4,290,000	3,240	4,700	25	407	99,900	47,700	89,600
Oct.	2014	49,700,000	46,000	58,900	801	10,000	3,670,000	256,000	644,000
Nov.	2014	15,600,000	17,800	17,400	118	1,170	275,000	126,000	274,000
Dec.	2014	28,200,000	33,800	35,400	257	1,780	523,000	183,000	432,000
Jan.	2015	27,600,000	31,100	31,600	303	1,740	503,000	155,000	383,000
Feb.	2015	11,100,000	10,100	10,500	78	420	105,000	76,000	174,000
Mar.	2015	116,000,000	81,400	108,000	1,940	10,900	4,490,000	403,000	1,170,000
Apr.	2015	44,100,000	25,700	33,600	443	3,680	1,340,000	195,000	521,000
May	2015	236,000,000	105,000	224,000	6,330	59,300	36,400,000	636,000	1,970,000
June	2015	130,000,000	57,000	122,000	2,920	38,600	23,200,000	423,000	1,230,000

WHITE RIVER NEAR FAYETTEVILLE, ARKANSAS (WYMAN)

Month	Year	Monthly Q (m^3)	NO_3-N (kg)	TN (kg)	SRP (kg)	TP (kg)	TSS (kg)	Cl (kg)	SO_4 (kg)
July	2009	2,010,000	403	803	11	110	51,800	7,260	32,200
Aug.	2009	5,650,000	1,490	2,770	49	497	243,000	18,300	85,900
Sep.	2009	57,300,000	26,400	48,500	1,970	21,800	6,520,000	139,000	622,000
Oct.	2009	160,000,000	97,900	169,000	7,960	86,400	19,200,000	369,000	1,520,000
Nov.	2009	38,200,000	22,800	27,900	444	3,260	1,140,000	134,000	534,000
Dec.	2009	35,000,000	25,800	27,400	363	2,560	779,000	132,000	457,000
Jan.	2010	44,400,000	32,700	32,700	345	2,440	805,000	175,000	557,000
Feb.	2010	65,100,000	47,000	48,500	542	4,200	1,420,000	240,000	729,000
Mar.	2010	69,200,000	40,300	49,200	674	6,550	2,400,000	225,000	686,000
Apr.	2010	37,900,000	17,200	22,200	254	2,480	1,100,000	130,000	422,000
May	2010	107,000,000	43,200	75,900	1,870	24,700	9,860,000	262,000	919,000
June	2010	9,090,000	2,280	4,060	51	561	302,000	30,800	124,000
July	2010	26,000,000	8,140	17,000	522	6,970	3,090,000	62,700	272,000
Aug.	2010	423,000	66	167	2	18	5,420	1,750	7,960
Sep.	2010	22,400,000	8,620	15,400	382	3,830	1,610,000	62,400	288,000
Oct.	2010	1,920,000	605	988	10	69	20,800	8,630	37,700
Nov.	2010	6,120,000	3,430	4,130	45	300	100,000	25,600	98,700
Dec.	2010	7,260,000	4,100	4,610	39	247	79,800	33,700	122,000
Jan.	2011	9,790,000	6,020	6,290	49	310	102,000	46,200	153,000
Feb.	2011	43,700,000	29,400	31,600	313	2,460	875,000	167,000	509,000
Mar.	2011	41,500,000	23,300	26,700	246	2,070	834,000	158,000	486,000
Apr.	2011	295,000,000	161,000	310,000	11,700	171,000	38,800,000	613,000	1,880,000
May	2011	222,000,000	95,900	185,000	5,650	80,900	26,900,000	489,000	1,670,000
June	2011	10,700,000	2,860	5,170	67	749	405,000	34,900	138,000
July	2011	320,000	43	120	1	12	3,190	1,360	5,780
Aug.	2011	1,530,000	351	738	11	104	47,700	5,380	25,200
Sep.	2011	815,000	219	422	5	42	15,200	3,250	15,000
Oct.	2011	756,000	224	399	4	26	7,090	3,540	15,200
Nov.	2011	55,500,000	38,900	54,300	1,190	9,710	2,730,000	167,000	638,000
Dec.	2011	64,600,000	48,900	57,800	827	5,990	1,800,000	226,000	794,000
Jan.	2012	52,100,000	41,200	46,600	595	4,610	1,330,000	187,000	585,000
Feb.	2012	46,400,000	32,400	35,700	352	2,690	906,000	179,000	547,000
Mar.	2012	119,000,000	76,200	108,000	1,900	20,200	5,990,000	341,000	1,020,000
Apr.	2012	14,600,000	5,810	7,950	65	593	271,000	57,500	188,000
May	2012	1,490,000	351	630	4	42	16,800	6,570	23,300
June	2012	601,000	113	246	2	22	9,070	2,460	9,610

WHITE RIVER NEAR FAYETTEVILLE, ARKANSAS (WYMAN) Continued

Month	Year	Monthly Q (m^3)	NO_3-N (kg)	TN (kg)	SRP (kg)	TP (kg)	TSS (kg)	Cl (kg)	SO_4 (kg)
July	2012	202,000	30	82	1	8	2,710	825	3,550
Aug.	2012	508,000	118	258	3	33	13,800	1,850	8,630
Sep.	2012	195,000	38	93	1	8	2,350	835	3,820
Oct.	2012	1,390,000	446	781	7	52	16,100	6,220	27,100
Nov.	2012	590,000	181	321	2	14	2,620	3,200	12,600
Dec.	2012	1,140,000	481	662	4	22	5,300	6,400	22,500
Jan.	2013	24,000,000	18,600	22,300	289	2,320	639,000	87,600	273,000
Feb.	2013	36,600,000	23,900	27,000	221	1,650	605,000	147,000	452,000
Mar.	2013	61,500,000	35,600	46,300	496	4,560	1,740,000	213,000	650,000
Apr.	2013	77,900,000	36,700	54,900	676	7,080	3,100,000	242,000	781,000
May	2013	88,500,000	34,000	63,700	1,200	15,200	6,640,000	234,000	828,000
June	2013	29,100,000	9,380	18,500	317	3,920	1,980,000	80,100	310,000
July	2013	684,000	109	291	3	29	10,000	2,760	12,200
Aug.	2013	32,700,000	11,200	25,300	720	8,750	3,790,000	78,200	357,000
Sep.	2013	497,000	146	292	4	32	12,500	1,860	8,590
Oct.	2013	4,930,000	1,950	3,260	39	293	111,000	19,100	83,900
Nov.	2013	16,500,000	9,200	12,900	153	1,080	378,000	63,500	253,000
Dec.	2013	52,100,000	41,400	52,800	760	5,710	1,570,000	179,000	611,000
Jan.	2014	37,200,000	27,500	32,000	308	2,160	687,000	147,000	475,000
Feb.	2014	9,670,000	5,230	6,170	35	240	85,800	46,500	145,000
Mar.	2014	82,100,000	51,300	74,300	1,070	10,800	3,350,000	255,000	766,000
Apr.	2014	77,100,000	38,000	58,600	720	7,490	3,080,000	239,000	760,000
May	2014	37,700,000	13,200	23,900	303	3,460	1,740,000	116,000	415,000
June	2014	14,400,000	3,720	7,690	92	1,020	565,000	46,600	190,000
July	2014	4,360,000	914	2,130	24	254	125,000	15,300	68,200
Aug.	2014	8,710,000	2,500	5,670	108	1,190	580,000	25,400	118,000
Sep.	2014	3,650,000	1,020	2,140	26	230	95,300	13,500	63,300
Oct.	2014	47,600,000	25,700	47,400	1,120	10,300	3,370,000	130,000	556,000
Nov.	2014	14,600,000	7,820	11,400	122	841	298,000	57,700	231,000
Dec.	2014	31,600,000	21,900	27,400	262	1,750	576,000	126,000	442,000
Jan.	2015	29,200,000	21,400	26,000	245	1,700	538,000	117,000	381,000
Feb.	2015	11,000,000	6,070	7,460	44	315	116,000	50,700	157,000
Mar.	2015	117,000,000	73,900	106,000	1,270	12,100	4,170,000	372,000	1,120,000
Apr.	2015	42,200,000	18,400	29,000	277	2,760	1,280,000	144,000	469,000
May	2015	238,000,000	101,000	225,000	5,600	77,800	28,400,000	518,000	1,790,000
June	2015	132,000,000	46,500	114,000	3,170	45,900	17,900,000	291,000	1,130,000

WAR EAGLE CREEK NEAR HINDSVILLE, ARKANSAS (WEC)

Month	Year	Monthly Q (m^3)	NO_3-N (kg)	TN (kg)	SRP (kg)	TP (kg)	TSS (kg)	Cl (kg)	SO_4 (kg)
July	2009	3,300,000	5,050	5,110	26	153	36,900	38,800	19,300
Aug.	2009	1,630,000	2,430	2,510	11	53	9,620	24,600	9,680
Sep.	2009	18,700,000	28,000	33,200	633	3,500	1,460,000	134,000	109,000
Oct.	2009	97,400,000	114,000	165,000	6,210	34,000	18,800,000	428,000	471,000
Nov.	2009	25,500,000	46,900	48,700	507	1,850	411,000	207,000	192,000
Dec.	2009	17,800,000	33,200	33,200	261	828	154,000	144,000	142,000
Jan.	2010	21,600,000	39,000	38,800	281	916	175,000	153,000	169,000
Feb.	2010	46,200,000	72,400	79,000	804	3,050	780,000	233,000	315,000
Mar.	2010	39,600,000	54,600	62,900	725	3,650	1,320,000	179,000	234,000
Apr.	2010	21,500,000	32,500	34,200	265	1,360	413,000	124,000	135,000
May	2010	48,000,000	56,100	71,900	1,260	9,380	5,550,000	198,000	228,000
June	2010	3,150,000	4,580	4,700	21	126	30,800	32,500	18,700
July	2010	22,000,000	29,100	35,700	581	4,420	2,330,000	133,000	114,000
Aug.	2010	2,620,000	3,970	4,180	21	113	24,300	34,900	16,400
Sep.	2010	12,800,000	20,600	23,000	272	1,460	475,000	114,000	83,800
Oct.	2010	2,320,000	3,920	3,990	17	60	7,950	35,800	17,500
Nov.	2010	3,450,000	6,270	6,270	34	104	15,000	42,600	28,700
Dec.	2010	2,650,000	4,750	4,630	17	48	5,440	35,100	22,500
Jan.	2011	3,000,000	5,320	5,110	17	47	5,270	35,600	25,700
Feb.	2011	21,300,000	34,300	36,200	271	1,030	237,000	129,000	158,000
Mar.	2011	24,200,000	37,900	40,000	282	1,190	289,000	142,000	172,000
Apr.	2011	176,000,000	133,000	232,000	8,780	67,000	54,100,000	394,000	622,000
May	2011	134,000,000	128,000	192,000	4,980	40,300	29,700,000	410,000	562,000
June	2011	10,400,000	14,900	16,300	118	779	263,000	79,000	62,600
July	2011	2,380,000	3,310	3,590	15	88	18,900	30,000	14,500
Aug.	2011	10,300,000	15,500	17,700	183	1,140	391,000	91,500	65,200
Sep.	2011	4,120,000	6,750	7,280	50	223	46,500	50,600	30,000
Oct.	2011	2,280,000	3,730	3,930	16	57	7,340	35,100	17,800
Nov.	2011	50,200,000	71,300	92,000	1,720	7,030	2,250,000	284,000	338,000
Dec.	2011	43,000,000	68,200	79,700	966	3,400	820,000	266,000	329,000
Jan.	2012	32,800,000	46,400	56,400	720	2,740	795,000	171,000	231,000
Feb.	2012	25,700,000	40,500	44,400	349	1,280	287,000	153,000	198,000
Mar.	2012	78,200,000	82,500	118,000	2,230	12,300	5,920,000	259,000	408,000
Apr.	2012	8,220,000	12,300	12,900	62	296	66,300	62,300	58,500
May	2012	2,200,000	2,930	3,140	10	51	9,660	23,600	14,100
June	2012	1,260,000	1,540	1,740	5	29	5,340	16,200	7,470

WAR EAGLE CREEK NEAR HINDSVILLE, ARKANSAS (WEC) Continued

Month	Year	Monthly Q (m^3)	NO_3-N (kg)	TN (kg)	SRP (kg)	TP (kg)	TSS (kg)	Cl (kg)	SO_4 (kg)
July	2012	810,000	920	1,100	3	17	2,720	12,700	4,570
Aug.	2012	818,000	980	1,170	4	18	2,530	14,000	4,920
Sep.	2012	2,410,000	3,640	4,090	24	113	23,700	32,700	17,400
Oct.	2012	5,150,000	8,490	9,460	72	288	59,100	58,100	41,200
Nov.	2012	1,130,000	1,690	1,850	5	15	1,390	19,300	9,210
Dec.	2012	1,990,000	3,240	3,380	11	28	2,720	28,200	17,700
Jan.	2013	21,900,000	28,100	36,600	541	2,190	730,000	114,000	151,000
Feb.	2013	22,600,000	35,100	38,900	266	990	209,000	140,000	182,000
Mar.	2013	32,000,000	44,400	52,200	438	2,040	591,000	167,000	227,000
Apr.	2013	47,100,000	59,500	74,100	754	4,450	1,690,000	217,000	295,000
May	2013	45,900,000	53,800	70,700	911	6,540	3,240,000	210,000	261,000
June	2013	11,300,000	14,200	17,600	172	1,230	518,000	71,500	67,900
July	2013	1,080,000	1,310	1,570	6	35	7,070	15,200	6,670
Aug.	2013	32,700,000	39,400	55,100	1,040	7,560	3,880,000	193,000	188,000
Sep.	2013	1,790,000	2,510	2,910	12	52	7,810	27,900	13,100
Oct.	2013	7,280,000	11,600	13,400	108	458	102,000	78,300	59,600
Nov.	2013	11,100,000	18,600	21,000	158	549	100,000	107,000	98,900
Dec.	2013	44,800,000	60,300	80,500	1,210	4,540	1,290,000	239,000	335,000
Jan.	2014	27,400,000	42,200	49,500	416	1,430	299,000	176,000	234,000
Feb.	2014	6,930,000	11,000	11,700	46	154	22,500	60,100	62,200
Mar.	2014	54,500,000	64,200	86,300	1,060	5,430	2,030,000	225,000	353,000
Apr.	2014	53,600,000	61,300	83,100	1,020	5,960	2,450,000	221,000	328,000
May	2014	17,800,000	22,400	27,800	236	1,560	595,000	106,000	115,000
June	2014	11,100,000	14,100	17,500	147	1,050	409,000	79,300	71,200
July	2014	1,110,000	1,260	1,560	5	29	5,210	15,800	6,890
Aug.	2014	2,180,000	2,860	3,570	26	154	44,500	25,700	15,000
Sep.	2014	1,080,000	1,360	1,680	6	25	3,350	18,500	7,780
Oct.	2014	20,300,000	27,700	37,500	575	2,760	883,000	145,000	150,000
Nov.	2014	5,030,000	7,990	9,290	61	216	38,400	56,200	45,500
Dec.	2014	10,600,000	17,100	19,700	131	419	71,100	92,800	100,000
Jan.	2015	15,400,000	22,400	27,700	256	896	201,000	103,000	133,000
Feb.	2015	5,290,000	7,680	8,790	44	164	31,600	41,700	45,900
Mar.	2015	68,800,000	79,400	110,000	1,300	6,590	2,360,000	278,000	463,000
Apr.	2015	16,600,000	22,000	26,400	162	860	234,000	103,000	124,000
May	2015	96,300,000	85,400	141,000	3,000	24,300	15,700,000	314,000	476,000
June	2015	42,100,000	42,400	64,600	1,150	9,600	5,860,000	187,000	229,000

RICHLAND CREEK NEAR GOSHEN, ARKANSAS (RC45)

Month	Year	Monthly Q (m^3)	NO_3-N (kg)	TN (kg)	SRP (kg)	TP (kg)	TSS (kg)	Cl (kg)	SO_4 (kg)
July	2009	629,000	176	302	3	22	9,040	2,690	7,590
Aug.	2009	2,510,000	1,750	1,780	20	177	82,700	9,660	27,700
Sep.	2009	10,500,000	11,200	12,100	206	1,790	1,000,000	32,400	90,600
Oct.	2009	44,200,000	58,600	61,900	1,090	7,780	4,190,000	131,000	363,000
Nov.	2009	9,870,000	20,600	12,800	110	426	134,000	43,200	128,000
Dec.	2009	9,680,000	22,100	14,800	127	342	102,000	44,100	130,000
Jan.	2010	12,300,000	28,100	19,000	155	365	106,000	57,700	170,000
Feb.	2010	18,500,000	38,000	29,100	268	677	218,000	81,100	235,000
Mar.	2010	19,100,000	26,100	26,700	314	1,130	473,000	74,500	210,000
Apr.	2010	10,300,000	11,900	11,900	128	516	207,000	42,000	119,000
May	2010	29,600,000	23,300	33,500	605	4,660	2,800,000	89,600	243,000
June	2010	2,540,000	1,470	1,820	20	149	62,900	10,200	28,800
July	2010	11,900,000	9,750	11,300	193	2,230	1,290,000	36,100	99,900
Aug.	2010	1,070,000	526	661	7	59	21,600	4,380	12,500
Sep.	2010	1,780,000	1,590	1,450	14	104	34,900	7,460	21,700
Oct.	2010	424,000	155	255	2	7	1,510	2,220	6,470
Nov.	2010	572,000	477	485	3	8	1,490	3,220	9,550
Dec.	2010	569,000	481	508	3	7	1,120	3,390	10,100
Jan.	2011	847,000	900	860	5	10	1,690	5,090	15,200
Feb.	2011	8,370,000	16,400	12,700	110	291	79,300	39,100	114,000
Mar.	2011	10,100,000	16,600	14,000	128	389	113,000	45,800	132,000
Apr.	2011	148,000,000	47,900	213,000	8,350	66,800	46,700,000	296,000	723,000
May	2011	64,600,000	46,800	82,200	1,830	16,300	9,670,000	175,000	466,000
June	2011	4,980,000	3,740	4,280	53	432	173,000	18,700	52,900
July	2011	1,260,000	498	763	8	68	21,800	5,280	15,000
Aug.	2011	5,070,000	4,930	4,660	60	637	248,000	18,100	51,400
Sep.	2011	693,000	447	499	4	27	6,470	3,190	9,270
Oct.	2011	598,000	318	427	3	13	2,410	3,100	9,090
Nov.	2011	16,700,000	38,100	28,500	334	1,600	463,000	63,400	183,000
Dec.	2011	15,700,000	43,800	28,000	254	822	191,000	69,100	204,000
Jan.	2012	11,700,000	28,300	21,400	203	564	137,000	52,100	152,000
Feb.	2012	13,800,000	32,000	23,900	214	588	139,000	63,000	184,000
Mar.	2012	27,600,000	34,900	47,400	751	3,310	1,220,000	94,700	261,000
Apr.	2012	3,600,000	3,680	3,850	35	141	36,300	16,700	48,100
May	2012	648,000	216	416	4	18	4,250	3,140	8,860
June	2012	202,000	25	87	1	5	1,130	955	2,630

RICHLAND CREEK NEAR GOSHEN, ARKANSAS (RC45) Continued

Month	Year	Monthly Q (m^3)	NO_3-N (kg)	TN (kg)	SRP (kg)	TP (kg)	TSS (kg)	Cl (kg)	SO_4 (kg)
July	2012	56,900	3	17	0.16	1	236	265	706
Aug.	2012	26,500	1	7	0.06	0.40	66	126	333
Sep.	2012	232,000	56	125	1	6	1,040	1,140	3,260
Oct.	2012	768,000	688	685	5	25	4,480	3,840	11,300
Nov.	2012	293,000	113	211	1	4	488	1,710	5,000
Dec.	2012	224,000	72	163	1	2	194	1,430	4,150
Jan.	2013	3,850,000	8,680	7,000	66	192	40,700	18,100	52,900
Feb.	2013	9,500,000	21,800	16,300	140	405	81,600	45,000	132,000
Mar.	2013	14,000,000	25,400	22,600	235	892	219,000	59,700	171,000
Apr.	2013	21,200,000	30,400	31,300	395	2,160	640,000	80,000	225,000
May	2013	26,100,000	27,100	35,000	597	5,280	2,030,000	83,600	230,000
June	2013	9,190,000	8,930	10,500	162	1,600	571,000	30,900	86,000
July	2013	277,000	45	132	1	11	2,160	1,260	3,490
Aug.	2013	5,680,000	6,340	6,210	90	1,120	358,000	19,300	54,700
Sep.	2013	187,000	33	95	1	5	809	919	2,590
Oct.	2013	1,070,000	1,180	1,090	8	44	7,000	5,290	15,600
Nov.	2013	2,440,000	4,810	3,360	25	95	14,100	12,400	37,000
Dec.	2013	13,600,000	41,400	28,300	278	981	180,000	58,600	172,000
Jan.	2014	10,600,000	31,600	21,000	177	523	86,500	50,300	149,000
Feb.	2014	3,300,000	6,170	5,000	35	93	13,500	17,800	52,700
Mar.	2014	23,900,000	41,200	45,200	621	2,770	711,000	89,800	252,000
Apr.	2014	18,500,000	28,400	30,000	388	2,080	532,000	70,000	197,000
May	2014	5,390,000	5,550	6,310	79	604	160,000	21,100	59,600
June	2014	2,620,000	1,920	2,390	29	296	76,300	10,300	29,200
July	2014	718,000	256	469	5	47	9,690	3,090	8,710
Aug.	2014	739,000	543	622	7	75	16,300	3,020	8,610
Sep.	2014	913,000	775	829	8	80	15,600	3,940	11,400
Oct.	2014	8,070,000	17,900	13,400	166	1,300	274,000	30,100	87,000
Nov.	2014	3,470,000	7,850	5,310	43	203	29,500	16,700	49,900
Dec.	2014	8,870,000	28,600	17,700	148	514	72,600	42,100	125,000
Jan.	2015	9,350,000	29,400	19,700	171	547	80,500	44,300	131,000
Feb.	2015	4,480,000	9,980	7,970	66	209	31,200	22,400	65,900
Mar.	2015	32,000,000	67,200	64,900	797	3,530	723,000	124,000	351,000
Apr.	2015	12,400,000	19,700	19,600	230	1,310	277,000	50,000	142,000

*Discharge and loads were not estimated from May 2015 to June 2015 because this site was discontinued by USGS.

WEST FORK OF THE WHITE RIVER EAST OF FAYETTEVILLE, ARKANSAS (WFWR)

Month	Year	Monthly Q (m^3)	NO_3-N (kg)	TN (kg)	SRP (kg)	TP (kg)	TSS (kg)	Cl (kg)	SO_4 (kg)
July	2009	936,000	324	534	9	112	42,600	4,590	26,900
Aug.	2009	3,300,000	1,650	2,270	54	692	329,000	13,600	82,800
Sep.	2009	16,500,000	11,600	14,100	465	5,040	2,790,000	55,800	318,000
Oct.	2009	44,700,000	38,000	42,300	1,420	13,400	7,500,000	144,000	721,000
Nov.	2009	9,220,000	7,680	6,620	122	750	219,000	53,200	255,000
Dec.	2009	7,090,000	6,500	5,080	66	361	95,600	47,900	195,000
Jan.	2010	12,800,000	12,700	9,820	110	675	200,000	83,100	304,000
Feb.	2010	17,400,000	16,900	13,700	143	1,010	324,000	107,000	375,000
Mar.	2010	21,900,000	18,300	18,700	214	2,280	1,070,000	106,000	377,000
Apr.	2010	9,570,000	6,280	6,970	70	791	319,000	53,300	211,000
May	2010	28,400,000	17,700	25,200	427	7,250	4,940,000	98,500	427,000
June	2010	1,660,000	616	1,010	13	187	78,000	8,690	44,900
July	2010	11,900,000	6,320	10,400	294	5,280	3,950,000	35,300	194,000
Aug.	2010	143,000	29	67	1	10	2,570	848	4,900
Sep.	2010	5,240,000	2,960	3,930	110	1,180	560,000	22,200	129,000
Oct.	2010	581,000	267	326	5	29	6,580	4,190	21,700
Nov.	2010	2,040,000	1,330	1,290	19	99	23,100	15,200	69,700
Dec.	2010	1,940,000	1,550	1,380	18	100	28,000	14,200	56,200
Jan.	2011	5,480,000	4,500	3,840	43	235	60,800	42,500	159,000
Feb.	2011	18,400,000	16,100	14,700	154	1,160	403,000	115,000	397,000
Mar.	2011	12,700,000	9,520	9,640	92	802	284,000	81,700	291,000
Apr.	2011	67,800,000	44,300	69,400	1,200	19,400	14,900,000	215,000	781,000
May	2011	58,300,000	33,800	55,400	1,060	19,300	14,800,000	185,000	778,000
June	2011	2,940,000	1,170	1,940	27	396	182,000	15,200	75,800
July	2011	109,000	16	48	1	6	1,440	707	3,740
Aug.	2011	2,600,000	1,180	1,910	50	662	340,000	11,000	64,800
Sep.	2011	1,370,000	688	953	23	215	83,000	7,060	40,200
Oct.	2011	1,520,000	763	955	18	121	34,800	10,200	53,200
Nov.	2011	23,000,000	18,900	20,500	501	3,560	1,480,000	109,000	476,000
Dec.	2011	25,600,000	22,600	21,600	375	2,300	780,000	148,000	582,000
Jan.	2012	16,700,000	14,600	14,000	176	1,170	405,000	106,000	369,000
Feb.	2012	14,100,000	11,300	11,100	118	829	276,000	98,000	336,000
Mar.	2012	34,600,000	24,900	32,100	414	4,660	2,480,000	162,000	546,000
Apr.	2012	3,300,000	1,460	2,080	17	178	57,500	24,600	96,200
May	2012	797,000	228	435	4	41	12,500	5,950	25,700
June	2012	979,000	325	613	8	115	49,900	5,680	27,800

WEST FORK OF THE WHITE RIVER EAST OF FAYETTEVILLE, ARKANSAS (WFWR) Continued

Month	Year	Monthly Q (m^3)	NO_3-N (kg)	TN (kg)	SRP (kg)	TP (kg)	TSS (kg)	Cl (kg)	SO_4 (kg)
July	2012	719,000	200	423	7	95	39,300	4,080	22,800
Aug.	2012	1,120,000	434	766	19	225	102,000	5,590	32,500
Sep.	2012	338,000	108	196	4	36	11,600	2,140	12,200
Oct.	2012	1,030,000	481	669	14	98	30,400	6,950	36,100
Nov.	2012	457,000	149	230	3	12	2,100	4,520	20,300
Dec.	2012	981,000	484	571	6	30	6,050	9,800	39,300
Jan.	2013	4,390,000	3,210	3,410	38	252	82,500	33,600	116,000
Feb.	2013	5,130,000	3,120	3,500	29	200	54,700	45,500	157,000
Mar.	2013	19,100,000	12,400	16,300	185	1,940	891,000	112,000	382,000
Apr.	2013	29,900,000	16,800	25,200	315	4,100	2,140,000	155,000	573,000
May	2013	34,900,000	16,600	30,400	512	8,660	5,760,000	147,000	615,000
June	2013	8,270,000	3,360	6,450	109	1,820	1,070,000	38,600	182,000
July	2013	440,000	94	237	4	46	16,700	2,840	15,700
Aug.	2013	4,270,000	1,610	3,160	82	1,130	600,000	19,900	114,000
Sep.	2013	888,000	364	617	16	146	59,300	5,110	28,100
Oct.	2013	4,430,000	2,120	3,140	73	577	213,000	28,200	146,000
Nov.	2013	5,910,000	3,430	4,210	74	434	124,000	44,600	199,000
Dec.	2013	20,200,000	15,100	17,200	282	1,730	597,000	134,000	499,000
Jan.	2014	16,500,000	11,900	13,200	166	1,010	317,000	126,000	440,000
Feb.	2014	3,640,000	1,850	2,310	18	109	25,300	37,600	129,000
Mar.	2014	34,200,000	20,800	30,300	362	3,800	1,840,000	199,000	658,000
Apr.	2014	26,300,000	13,600	21,800	259	3,190	1,560,000	152,000	551,000
May	2014	11,000,000	4,340	8,350	114	1,720	915,000	61,800	263,000
June	2014	4,150,000	1,260	2,770	40	606	285,000	24,900	122,000
July	2014	481,000	92	258	4	47	16,800	3,320	17,900
Aug.	2014	723,000	165	410	7	84	30,000	4,860	27,800
Sep.	2014	3,040,000	1,080	2,070	51	503	205,000	18,500	103,000
Oct.	2014	14,600,000	7,700	12,700	384	3,370	1,580,000	71,200	349,000
Nov.	2014	3,240,000	1,540	2,170	37	221	60,500	27,500	124,000
Dec.	2014	11,600,000	7,260	8,840	130	736	213,000	95,400	364,000
Jan.	2015	8,880,000	5,630	6,870	88	520	158,000	75,800	266,000
Feb.	2015	3,390,000	1,630	2,250	18	124	33,400	35,000	118,000
Mar.	2015	45,000,000	25,700	39,500	461	4,670	2,140,000	280,000	913,000
Apr.	2015	13,400,000	5,760	10,200	109	1,310	572,000	93,800	348,000
May	2015	83,000,000	34,000	80,100	1,540	27,700	20,900,000	317,000	1,250,000
June	2015	48,200,000	17,400	44,600	1,080	20,900	16,700,000	181,000	837,000

TOWN BRANCH TRIBUTARY AT HIGHWAY 16 IN FAYETTEVILLE, ARKANSAS (TBT)

Month	Year	Monthly Q (m^3)	NO_3-N (kg)	TN (kg)	SRP (kg)	TP (kg)	TSS (kg)	Cl (kg)	SO_4 (kg)
July	2011	8,280	43	41	1	1	378	110	298
Aug.	2011	55,300	171	212	6	10	12,100	411	1,220
Sep.	2011	333,000	764	1,090	34	83	88,000	2,090	5,880
Oct.	2011	179,000	508	679	11	34	12,000	2,020	5,030
Nov.	2011	451,000	880	1,250	26	166	133,000	4,460	8,620
Dec.	2011	260,000	655	901	8	60	14,000	4,540	8,370
Jan.	2012	191,000	538	709	4	42	11,900	4,410	7,760
Feb.	2012	113,000	391	491	2	21	4,340	3,240	5,720
Mar.	2012	257,000	584	789	8	75	73,200	3,870	6,840
Apr.	2012	79,900	328	392	3	14	8,670	1,800	3,850
May	2012	48,200	206	218	2	6	5,080	866	1,920
June	2012	85,800	279	322	5	12	19,800	923	2,410
July	2012	73,200	247	283	7	13	29,100	724	1,870
Aug.	2012	108,000	289	374	14	31	56,600	848	1,990
Sep.	2012	56,800	163	180	4	9	9,180	606	1,240
Oct.	2012	53,000	157	192	3	12	5,980	761	1,460
Nov.	2012	74,300	308	365	2	9	707	2,210	4,180
Dec.	2012	109,000	391	487	3	23	4,380	3,450	5,610
Jan.	2013	161,000	366	453	4	48	26,200	3,690	4,990
Feb.	2013	170,000	494	658	3	30	5,910	4,880	7,750
Mar.	2013	233,000	571	772	8	74	72,100	4,590	7,060
Apr.	2013	273,000	619	847	11	69	107,000	3,900	7,090
May	2013	347,000	791	1,120	25	103	272,000	3,640	7,460
June	2013	124,000	390	482	7	14	12,600	1,550	3,920

TOWN BRANCH TRIBUTARY AT HIGHWAY 16 IN FAYETTEVILLE, ARKANSAS (TBT) Continued

Month	Year	Monthly Q (m^3)	NO_3-N (kg)	TN (kg)	SRP (kg)	TP (kg)	TSS (kg)	Cl (kg)	SO_4 (kg)
July	2013	105,000	374	457	9	15	15,300	1,310	3,440
Aug.	2013	136,000	347	436	17	38	111,000	1,220	2,650
Sep.	2013	74,500	188	224	8	23	37,100	824	1,470
Oct.	2013	208,000	527	709	17	63	77,200	3,050	5,740
Nov.	2013	131,000	386	482	5	25	7,290	3,160	5,170
Dec.	2013	238,000	606	820	7	62	19,400	6,320	9,020
Jan.	2014	202,000	595	801	4	36	4,670	7,220	10,200
Feb.	2014	222,000	614	845	4	36	4,950	7,300	10,500
Mar.	2014	323,000	733	1,020	10	99	110,000	7,300	10,300
Apr.	2014	150,000	469	608	5	25	12,200	3,820	6,530
May	2014	160,000	460	594	8	34	56,500	2,750	5,160
June	2014	145,000	458	592	10	23	28,100	2,150	4,780
July	2014	87,200	328	387	7	12	15,200	1,410	3,210
Aug.	2014	73,700	281	324	6	10	9,490	1,270	2,710
Sep.	2014	81,000	238	278	9	21	36,500	1,250	2,120
Oct.	2014	211,000	449	583	19	79	99,000	3,060	4,490
Nov.	2014	117,000	380	472	5	21	5,520	3,790	5,570
Dec.	2014	142,000	448	573	3	24	3,220	5,820	7,630
Jan.	2015	106,000	387	472	2	14	1,300	5,910	7,370
Feb.	2015	105,000	361	447	2	16	3,120	5,430	6,730
Mar.	2015	325,000	783	1,110	9	76	39,500	9,450	12,200
Apr.	2015	278,000	686	953	11	66	77,300	6,360	9,330
May	2015	703,000	1,210	1,780	57	271	1,040,000	7,880	11,200

* Discharge and loads were not estimated for June 2015, because this site was discontinued by USGS.

COLLEGE BRANCH AT MLK BOULEVARD AT FAYETTEVILLE, ARKANSAS (TB62)

Month	Year	Monthly Q (m^3)	NO_3-N (kg)	TN (kg)	SRP (kg)	TP (kg)	TSS (kg)	Cl (kg)	SO_4 (kg)
July	2011	17,600	22	30	1	1	748	326	1,450
Aug.	2011	81,300	83	129	6	12	10,000	809	3,170
Sep.	2011	102,000	85	146	9	23	21,100	778	2,890
Oct.	2011	108,000	112	148	6	15	5,770	1,140	4,170
Nov.	2011	260,000	202	343	20	72	57,000	1,700	5,750
Dec.	2011	125,000	111	165	6	24	11,700	1,100	3,770
Jan.	2012	67,600	57	94	2	16	11,300	672	2,360
Feb.	2012	63,700	70	101	2	10	5,100	900	3,100
Mar.	2012	260,000	215	421	8	64	78,400	2,150	6,630
Apr.	2012	129,000	119	219	4	21	19,100	1,310	4,060
May	2012	61,600	55	101	2	8	7,410	653	1,980
June	2012	232,000	210	416	12	43	47,800	2,320	6,640
July	2012	186,000	147	287	10	32	37,900	1,790	5,170
Aug.	2012	100,000	98	174	8	21	18,600	1,340	3,860
Sep.	2012	43,800	27	46	2	6	3,860	403	1,180
Oct.	2012	86,900	78	120	6	16	8,310	1,210	3,400
Nov.	2012	39,500	41	53	2	4	1,210	852	2,470
Dec.	2012	55,900	65	100	3	14	6,050	1,130	3,060
Jan.	2013	138,000	86	168	5	38	34,900	1,410	3,610
Feb.	2013	128,000	111	187	3	22	10,900	1,840	4,570
Mar.	2013	361,000	253	596	13	114	143,000	3,460	7,830
Apr.	2013	292,000	193	470	11	86	144,000	2,860	6,460
May	2013	322,000	225	574	16	101	187,000	3,360	7,360
June	2013	63,700	50	92	2	7	5,880	1,170	2,840

COLLEGE BRANCH AT MLK BOULEVARD AT FAYETTEVILLE, ARKANSAS (TB62) Continued

Month	Year	Monthly Q (m^3)	NO_3-N (kg)	TN (kg)	SRP (kg)	TP (kg)	TSS (kg)	Cl (kg)	SO_4 (kg)
July	2013	70,600	64	119	3	10	7,910	1,470	3,410
Aug.	2013	153,000	107	242	13	44	56,700	2,020	4,330
Sep.	2013	119,000	89	173	10	33	30,700	1,910	4,090
Oct.	2013	175,000	117	240	16	61	62,600	2,370	4,830
Nov.	2013	52,600	39	67	3	12	5,790	1,050	2,270
Dec.	2013	101,000	82	134	3	19	6,790	2,010	4,070
Jan.	2014	59,400	59	86	1	6	1,160	1,770	3,610
Feb.	2014	106,000	90	152	2	13	3,790	2,380	4,560
Mar.	2014	195,000	134	306	6	57	63,800	3,160	5,710
Apr.	2014	75,600	61	126	2	14	10,200	1,810	3,400
May	2014	104,000	75	181	4	25	31,300	2,140	3,850
June	2014	77,500	63	135	3	12	9,810	1,990	3,550
July	2014	49,300	41	83	2	8	6,850	1,520	2,740
Aug.	2014	39,800	31	63	2	7	5,200	1,170	2,080
Sep.	2014	62,500	38	93	6	21	20,500	1,210	2,020
Oct.	2014	131,000	65	179	14	63	54,200	1,660	2,490
Nov.	2014	28,600	17	38	2	8	3,690	503	770
Dec.	2014	54,500	43	73	2	8	1,830	1,650	2,560
Jan.	2015	73,500	60	102	1	10	1,910	2,570	3,950
Feb.	2015	69,300	54	103	1	11	4,380	2,320	3,470
Mar.	2015	221,000	144	347	6	55	37,000	4,920	6,720
Apr.	2015	129,000	89	217	3	28	23,100	3,520	4,840
May	2015	370,000	195	640	18	151	258,000	6,260	7,830

* Discharge and loads were not estimated for June 2015, because this site was discontinued by USGS.

ILLINOIS RIVER NEAR WATTS, OKLAHOMA (WATTS)

Month	Year	Monthly Q (m^3)	NO_3-N (kg)	TN (kg)	SRP (kg)	TP (kg)	TSS (kg)	Cl (kg)	SO_4 (kg)
July	2009	21,900,000	44,500	47,000	1,200	1,710	224,000	410,000	320,000
Aug.	2009	20,800,000	41,900	44,400	1,120	1,600	208,000	395,000	314,000
Sep.	2009	38,600,000	84,500	93,400	2,950	5,660	1,250,000	553,000	510,000
Oct.	2009	171,000,000	309,000	407,000	25,000	76,500	34,300,000	1,330,000	1,530,000
Nov.	2009	52,800,000	146,000	153,000	4,030	7,550	1,500,000	708,000	750,000
Dec.	2009	28,600,000	87,200	84,200	1,670	2,580	368,000	489,000	496,000
Jan.	2010	39,700,000	129,000	127,000	2,710	4,770	845,000	591,000	632,000
Feb.	2010	69,400,000	222,000	229,000	5,760	11,600	2,500,000	833,000	947,000
Mar.	2010	84,300,000	229,000	256,000	8,180	19,100	5,320,000	913,000	1,010,000
Apr.	2010	51,200,000	141,000	149,000	3,750	7,090	1,360,000	695,000	695,000
May	2010	83,200,000	185,000	219,000	7,720	17,600	4,550,000	917,000	922,000
June	2010	25,600,000	55,100	59,300	1,430	2,270	322,000	448,000	379,000
July	2010	77,300,000	138,000	176,000	7,940	20,200	6,320,000	816,000	798,000
Aug.	2010	14,600,000	26,900	29,100	661	921	105,000	313,000	250,000
Sep.	2010	31,600,000	67,800	75,200	2,010	3,660	658,000	497,000	468,000
Oct.	2010	14,400,000	31,300	32,300	638	887	99,100	312,000	278,000
Nov.	2010	16,400,000	41,400	41,900	803	1,240	167,000	327,000	317,000
Dec.	2010	16,400,000	44,900	44,000	751	1,090	127,000	340,000	337,000
Jan.	2011	16,500,000	47,300	45,900	757	1,110	133,000	339,000	340,000
Feb.	2011	32,200,000	98,600	101,000	2,050	3,890	717,000	492,000	539,000
Mar.	2011	39,600,000	117,000	121,000	2,490	4,610	792,000	595,000	637,000
Apr.	2011	388,000,000	385,000	686,000	88,100	415,000	305,000,000	1,820,000	2,340,000
May	2011	262,000,000	403,000	583,000	40,100	151,000	83,200,000	1,810,000	2,140,000
June	2011	42,500,000	91,600	104,000	2,690	5,100	884,000	621,000	593,000
July	2011	20,700,000	39,500	44,100	997	1,580	202,000	395,000	341,000
Aug.	2011	19,400,000	36,600	41,100	930	1,490	197,000	374,000	330,000
Sep.	2011	19,100,000	38,600	43,100	972	1,670	251,000	356,000	333,000
Oct.	2011	14,900,000	31,700	33,800	635	950	109,000	318,000	301,000
Nov.	2011	68,200,000	165,000	194,000	5,940	15,400	4,500,000	772,000	952,000
Dec.	2011	60,900,000	176,000	192,000	4,310	9,390	1,970,000	783,000	976,000
Jan.	2012	42,700,000	128,000	136,000	2,810	6,010	1,250,000	607,000	732,000
Feb.	2012	43,100,000	131,000	138,000	2,740	5,650	1,070,000	611,000	731,000
Mar.	2012	86,800,000	211,000	257,000	8,200	23,200	7,340,000	894,000	1,110,000
Apr.	2012	33,100,000	85,400	92,600	1,830	3,420	535,000	529,000	557,000
May	2012	17,300,000	36,700	40,200	758	1,230	152,000	349,000	320,000
June	2012	12,800,000	23,200	26,200	511	785	89,400	282,000	242,000

ILLINOIS RIVER NEAR WATTS, OKLAHOMA (WATTS) Continued

Month	Year	Monthly Q (m^3)	NO_3-N (kg)	TN (kg)	SRP (kg)	TP (kg)	TSS (kg)	Cl (kg)	SO_4 (kg)
July	2012	7,310,000	10,600	12,200	233	308	27,100	199,000	155,000
Aug.	2012	9,250,000	14,800	17,100	341	515	58,300	226,000	190,000
Sep.	2012	12,600,000	22,900	25,800	491	757	84,100	281,000	260,000
Oct.	2012	14,800,000	30,600	33,800	626	1,050	135,000	308,000	309,000
Nov.	2012	9,840,000	20,700	22,000	343	497	49,100	240,000	238,000
Dec.	2012	11,000,000	26,000	27,000	401	612	66,300	258,000	269,000
Jan.	2013	16,900,000	45,000	48,600	878	1,840	357,000	316,000	357,000
Feb.	2013	22,800,000	65,400	68,300	1,080	1,970	275,000	404,000	471,000
Mar.	2013	51,400,000	138,000	158,000	3,400	8,120	1,800,000	680,000	838,000
Apr.	2013	101,000,000	228,000	287,000	8,450	24,100	7,090,000	1,050,000	1,320,000
May	2013	135,000,000	249,000	341,000	13,200	42,800	15,500,000	1,240,000	1,540,000
June	2013	37,900,000	76,100	92,200	2,140	4,620	834,000	563,000	594,000
July	2013	18,400,000	32,100	38,400	798	1,470	210,000	357,000	339,000
Aug.	2013	59,500,000	106,000	139,000	4,270	11,400	2,930,000	729,000	830,000
Sep.	2013	17,500,000	32,900	38,500	738	1,340	180,000	344,000	353,000
Oct.	2013	27,000,000	57,700	67,300	1,360	2,870	502,000	454,000	520,000
Nov.	2013	27,100,000	66,500	74,100	1,280	2,520	371,000	463,000	562,000
Dec.	2013	59,100,000	157,000	185,000	4,080	10,900	2,650,000	727,000	1,020,000
Jan.	2014	45,900,000	132,000	147,000	2,660	6,240	1,230,000	647,000	879,000
Feb.	2014	20,900,000	57,800	61,700	891	1,670	220,000	385,000	467,000
Mar.	2014	69,600,000	174,000	212,000	5,020	14,300	3,870,000	813,000	1,100,000
Apr.	2014	47,800,000	118,000	139,000	2,700	6,290	1,170,000	665,000	821,000
May	2014	36,400,000	77,600	93,700	1,890	4,230	740,000	556,000	630,000
June	2014	30,800,000	59,300	72,600	1,470	3,090	478,000	502,000	542,000
July	2014	14,400,000	23,500	28,500	515	897	102,000	310,000	299,000
Aug.	2014	14,500,000	23,900	29,100	529	942	111,000	310,000	308,000
Sep.	2014	15,600,000	27,800	33,500	594	1,100	140,000	320,000	340,000
Oct.	2014	47,800,000	95,700	124,000	3,180	9,110	2,330,000	605,000	799,000
Nov.	2014	18,900,000	43,300	49,000	744	1,430	185,000	366,000	447,000
Dec.	2014	37,400,000	100,000	114,000	1,870	4,320	742,000	569,000	789,000
Jan.	2015	30,100,000	83,300	92,800	1,380	2,990	468,000	498,000	676,000
Feb.	2015	21,600,000	58,000	64,100	893	1,820	251,000	390,000	503,000
Mar.	2015	90,800,000	227,000	284,000	6,160	18,000	4,420,000	1,010,000	1,470,000
Apr.	2015	41,300,000	98,800	118,000	2,040	4,760	795,000	613,000	781,000
May	2015	188,000,000	307,000	465,000	17,600	66,300	24,000,000	1,530,000	2,190,000
June	2015	143,000,000	218,000	331,000	13,200	51,100	20,400,000	1,260,000	1,720,000

ILLINOIS RIVER SOUTH OF SILOAM SPRINGS, ARKANSAS (IR59)

Month	Year	Monthly Q (m^3)	NO_3-N (kg)	TN (kg)	SRP (kg)	TP (kg)	TSS (kg)	Cl (kg)	SO_4 (kg)
July	2009	21,200,000	50,700	48,800	1,500	1,590	291,000	332,000	320,000
Aug.	2009	19,100,000	45,100	43,400	1,510	1,400	249,000	311,000	302,000
Sep.	2009	37,100,000	92,100	93,500	4,520	5,440	1,950,000	472,000	505,000
Oct.	2009	185,000,000	346,000	441,000	44,500	85,700	67,100,000	1,220,000	1,730,000
Nov.	2009	52,900,000	157,000	157,000	4,100	7,400	1,080,000	685,000	772,000
Dec.	2009	27,300,000	87,100	83,800	995	2,330	108,000	463,000	494,000
Jan.	2010	40,200,000	132,000	133,000	1,380	4,760	304,000	586,000	655,000
Feb.	2010	72,600,000	231,000	245,000	2,970	12,200	1,200,000	838,000	1,000,000
Mar.	2010	95,600,000	257,000	294,000	5,410	23,000	5,560,000	919,000	1,140,000
Apr.	2010	54,100,000	156,000	164,000	2,340	7,400	1,080,000	663,000	737,000
May	2010	97,500,000	226,000	262,000	8,970	22,400	10,900,000	881,000	1,060,000
June	2010	31,500,000	77,800	79,300	2,000	2,990	614,000	443,000	453,000
July	2010	99,400,000	182,000	226,000	20,600	32,500	38,800,000	785,000	976,000
Aug.	2010	16,000,000	35,400	35,400	1,140	1,020	146,000	285,000	280,000
Sep.	2010	34,700,000	84,400	87,300	3,820	4,220	1,240,000	479,000	515,000
Oct.	2010	15,300,000	37,700	37,400	823	935	61,500	298,000	304,000
Nov.	2010	16,500,000	44,800	44,900	698	1,180	64,600	317,000	334,000
Dec.	2010	14,700,000	41,400	41,400	415	883	26,500	307,000	323,000
Jan.	2011	15,000,000	43,600	44,100	333	929	25,400	310,000	329,000
Feb.	2011	33,100,000	101,000	107,000	1,040	4,070	349,000	491,000	558,000
Mar.	2011	35,800,000	107,000	113,000	1,060	3,810	280,000	538,000	598,000
Apr.	2011	375,000,000	388,000	713,000	76,900	360,000	430,000,000	1,410,000	2,630,000
May	2011	276,000,000	431,000	629,000	48,500	153,000	195,000,000	1,570,000	2,360,000
June	2011	39,300,000	93,500	101,000	2,740	4,420	1,110,000	524,000	563,000
July	2011	18,700,000	40,300	42,300	1,220	1,290	212,000	319,000	322,000
Aug.	2011	18,300,000	39,500	41,400	1,420	1,320	232,000	317,000	324,000
Sep.	2011	18,900,000	43,200	45,600	1,530	1,590	262,000	324,000	343,000
Oct.	2011	16,100,000	38,300	39,800	886	1,030	72,800	316,000	333,000
Nov.	2011	74,200,000	176,000	212,000	8,310	18,600	5,690,000	798,000	1,030,000
Dec.	2011	59,000,000	170,000	189,000	3,240	9,050	979,000	793,000	970,000
Jan.	2012	41,200,000	121,000	135,000	1,540	5,690	502,000	608,000	726,000
Feb.	2012	41,600,000	124,000	137,000	1,360	5,280	403,000	610,000	722,000
Mar.	2012	97,000,000	220,000	287,000	6,250	28,700	8,670,000	906,000	1,220,000
Apr.	2012	31,400,000	82,900	91,600	1,050	3,030	294,000	487,000	539,000
May	2012	17,400,000	39,600	43,600	608	1,180	112,000	315,000	329,000
June	2012	12,700,000	25,600	28,300	550	744	86,200	242,000	247,000

ILLINOIS RIVER SOUTH OF SILOAM SPRINGS, ARKANSAS (IR59) Continued

Month	Year	Monthly Q (m^3)	NO_3-N (kg)	TN (kg)	SRP (kg)	TP (kg)	TSS (kg)	Cl (kg)	SO_4 (kg)
July	2012	7,930,000	13,600	15,200	362	335	28,400	175,000	175,000
Aug.	2012	10,800,000	20,400	22,500	697	617	83,400	218,000	225,000
Sep.	2012	12,000,000	24,300	26,500	737	673	62,400	249,000	260,000
Oct.	2012	13,500,000	29,900	32,600	749	888	76,600	276,000	299,000
Nov.	2012	9,620,000	21,400	23,500	313	461	14,300	229,000	248,000
Dec.	2012	11,800,000	29,100	32,000	315	659	20,100	272,000	300,000
Jan.	2013	19,300,000	49,900	58,600	624	2,340	223,000	346,000	407,000
Feb.	2013	24,600,000	69,700	78,100	600	2,120	94,600	442,000	510,000
Mar.	2013	53,000,000	137,000	167,000	2,120	8,560	1,230,000	698,000	865,000
Apr.	2013	109,000,000	235,000	313,000	7,800	28,400	11,100,000	1,050,000	1,400,000
May	2013	142,000,000	254,000	360,000	16,400	49,900	38,800,000	1,160,000	1,610,000
June	2013	36,000,000	77,700	92,100	2,450	4,100	1,080,000	511,000	578,000
July	2013	19,200,000	37,600	43,600	1,440	1,560	401,000	334,000	359,000
Aug.	2013	64,600,000	121,000	155,000	10,600	13,500	10,100,000	712,000	886,000
Sep.	2013	17,600,000	36,400	41,600	1,290	1,300	177,000	332,000	365,000
Oct.	2013	24,500,000	54,900	63,800	1,910	2,480	436,000	426,000	492,000
Nov.	2013	23,400,000	58,100	66,100	1,150	1,930	130,000	443,000	514,000
Dec.	2013	55,700,000	140,000	176,000	3,280	10,300	1,410,000	746,000	982,000
Jan.	2014	39,600,000	108,000	129,000	1,440	5,010	392,000	636,000	792,000
Feb.	2014	17,300,000	45,300	52,700	358	1,200	39,300	357,000	412,000
Mar.	2014	67,600,000	158,000	209,000	3,300	14,400	3,080,000	805,000	1,070,000
Apr.	2014	44,500,000	108,000	134,000	1,720	5,410	684,000	645,000	781,000
May	2014	36,100,000	79,300	97,900	1,820	4,060	813,000	540,000	631,000
June	2014	27,900,000	57,200	69,300	1,720	2,530	521,000	450,000	507,000
July	2014	14,500,000	26,300	31,500	839	870	119,000	287,000	310,000
Aug.	2014	13,800,000	24,900	29,700	903	814	106,000	282,000	307,000
Sep.	2014	15,000,000	28,800	34,300	1,030	994	127,000	303,000	339,000
Oct.	2014	50,700,000	102,000	135,000	6,310	9,980	3,400,000	648,000	851,000
Nov.	2014	19,500,000	45,500	53,900	870	1,440	83,600	400,000	472,000
Dec.	2014	33,700,000	86,900	106,000	1,350	3,530	223,000	594,000	742,000
Jan.	2015	26,000,000	67,900	82,400	737	2,300	105,000	503,000	615,000
Feb.	2015	19,100,000	48,300	59,000	416	1,450	56,100	389,000	466,000
Mar.	2015	86,200,000	200,000	274,000	3,990	17,000	2,950,000	1,030,000	1,410,000
Apr.	2015	37,000,000	86,300	109,000	1,310	3,860	419,000	591,000	718,000
May	2015	200,000,000	308,000	498,000	26,400	74,700	62,200,000	1,500,000	2,330,000
June	2015	156,000,000	232,000	364,000	27,400	58,700	74,700,000	1,260,000	1,860,000

ILLINOIS RIVER AT SAVOY, ARKANSAS (SAVOY)

Month	Year	Monthly Q (m^3)	NO_3-N (kg)	TN (kg)	SRP (kg)	TP (kg)	TSS (kg)	Cl (kg)	SO_4 (kg)
July	2009	2,210,000	6,840	7,060	94	146	14,900	38,800	39,000
Aug.	2009	3,110,000	8,650	9,530	176	297	42,700	48,200	51,500
Sep.	2009	15,400,000	27,300	39,400	2,190	4,650	1,510,000	122,000	185,000
Oct.	2009	69,100,000	86,300	156,000	15,900	37,400	17,100,000	330,000	645,000
Nov.	2009	12,300,000	30,800	35,900	1,040	1,920	355,000	133,000	215,000
Dec.	2009	6,530,000	20,000	20,500	423	746	112,000	88,200	139,000
Jan.	2010	16,100,000	39,100	45,600	1,630	3,210	703,000	142,000	286,000
Feb.	2010	29,800,000	64,400	80,800	3,420	6,920	1,640,000	213,000	481,000
Mar.	2010	33,500,000	63,600	86,000	4,530	9,710	2,790,000	209,000	469,000
Apr.	2010	11,400,000	28,000	32,300	948	1,820	344,000	106,000	194,000
May	2010	28,200,000	46,900	69,100	3,710	7,970	2,220,000	173,000	334,000
June	2010	3,970,000	10,700	11,800	211	369	47,800	54,200	68,400
July	2010	24,000,000	31,900	54,500	4,060	9,470	3,450,000	138,000	231,000
Aug.	2010	2,280,000	6,530	7,070	93	155	16,200	41,900	41,900
Sep.	2010	4,570,000	10,900	13,100	307	587	104,000	62,500	75,800
Oct.	2010	1,590,000	5,270	5,250	55	90	8,250	36,000	35,700
Nov.	2010	2,330,000	7,550	7,530	102	177	20,700	45,000	54,100
Dec.	2010	2,220,000	7,750	7,350	89	152	16,100	44,300	56,200
Jan.	2011	3,200,000	10,900	10,400	143	253	29,200	55,100	80,500
Feb.	2011	12,000,000	28,000	33,100	1,100	2,340	538,000	110,000	222,000
Mar.	2011	11,100,000	27,700	31,500	822	1,650	292,000	112,000	214,000
Apr.	2011	134,000,000	101,000	247,000	43,900	125,000	76,300,000	346,000	889,000
May	2011	59,300,000	68,100	126,000	11,500	29,500	12,300,000	256,000	558,000
June	2011	4,400,000	10,900	12,600	222	416	54,200	59,600	77,500
July	2011	2,010,000	5,560	6,110	72	126	12,300	37,700	38,100
Aug.	2011	1,790,000	5,010	5,500	62	107	10,300	36,500	35,000
Sep.	2011	1,750,000	5,030	5,450	62	109	10,800	37,100	36,500
Oct.	2011	1,990,000	5,990	6,290	70	124	12,100	42,600	45,000
Nov.	2011	16,000,000	30,000	41,300	1,630	3,770	985,000	146,000	261,000
Dec.	2011	18,000,000	37,900	48,500	1,600	3,560	799,000	173,000	334,000
Jan.	2012	12,800,000	29,400	35,200	1,030	2,270	479,000	131,000	257,000
Feb.	2012	11,000,000	26,000	30,500	831	1,810	364,000	113,000	225,000
Mar.	2012	29,400,000	45,800	69,300	3,980	10,000	3,270,000	179,000	411,000
Apr.	2012	6,250,000	15,600	17,700	337	684	97,700	76,300	126,000
May	2012	2,920,000	7,900	8,620	114	216	23,700	46,900	60,500
June	2012	1,510,000	4,100	4,510	52	97	10,200	29,000	30,500

ILLINOIS RIVER AT SAVOY, ARKANSAS (SAVOY) Continued

Month	Year	Monthly Q (m^3)	NO_3-N (kg)	TN (kg)	SRP (kg)	TP (kg)	TSS (kg)	Cl (kg)	SO_4 (kg)
July	2012	813,000	2,380	2,550	20	34	2,510	21,000	17,300
Aug.	2012	904,000	2,600	2,830	23	41	3,250	23,500	19,400
Sep.	2012	1,030,000	3,020	3,260	27	49	3,970	26,800	23,400
Oct.	2012	1,500,000	4,410	4,710	46	85	7,810	35,700	36,100
Nov.	2012	1,540,000	4,790	4,910	46	86	7,850	36,700	40,400
Dec.	2012	1,610,000	5,250	5,180	48	91	8,340	37,600	45,200
Jan.	2013	3,200,000	8,480	9,290	179	402	73,100	49,600	77,300
Feb.	2013	3,660,000	10,400	10,900	156	322	39,700	57,500	93,600
Mar.	2013	13,600,000	26,900	35,000	1,080	2,590	567,000	124,000	255,000
Apr.	2013	25,900,000	41,200	61,300	2,600	6,700	1,850,000	183,000	393,000
May	2013	34,100,000	45,200	75,700	4,070	11,000	3,480,000	209,000	431,000
June	2013	7,050,000	14,000	18,400	377	839	128,000	83,300	122,000
July	2013	4,300,000	9,170	11,600	180	383	47,600	64,400	78,900
Aug.	2013	3,180,000	6,490	8,490	157	356	59,000	49,400	56,900
Sep.	2013	1,910,000	4,620	5,510	67	140	16,700	39,200	40,900
Oct.	2013	3,270,000	7,800	9,320	129	277	34,500	59,700	72,600
Nov.	2013	3,380,000	8,640	9,850	129	276	32,400	62,200	83,200
Dec.	2013	12,400,000	23,400	31,700	984	2,540	603,000	129,000	248,000
Jan.	2014	10,300,000	22,200	27,500	633	1,540	282,000	120,000	232,000
Feb.	2014	5,100,000	12,900	14,400	225	505	66,800	73,400	129,000
Mar.	2014	19,900,000	32,600	47,400	1,870	5,140	1,460,000	157,000	346,000
Apr.	2014	10,000,000	19,600	25,600	596	1,460	257,000	105,000	197,000
May	2014	5,640,000	11,600	14,800	265	620	91,300	72,200	111,000
June	2014	4,220,000	8,580	11,100	175	401	53,100	60,600	80,800
July	2014	1,310,000	3,160	3,750	33	68	5,940	29,700	28,300
Aug.	2014	1,470,000	3,450	4,190	40	85	7,970	33,200	31,800
Sep.	2014	1,630,000	3,710	4,580	53	119	14,300	35,200	35,600
Oct.	2014	8,130,000	13,200	19,700	581	1,570	359,000	93,100	144,000
Nov.	2014	3,470,000	8,150	9,740	129	298	36,700	63,400	86,500
Dec.	2014	8,960,000	18,500	23,600	472	1,190	194,000	116,000	210,000
Jan.	2015	6,100,000	14,000	16,700	273	667	95,800	89,000	157,000
Feb.	2015	3,820,000	9,400	10,700	146	347	44,000	60,700	103,000
Mar.	2015	30,200,000	44,100	68,800	2,660	7,710	2,030,000	220,000	522,000
Apr.	2015	10,300,000	19,100	25,700	542	1,390	228,000	111,000	211,000
May	2015	54,100,000	56,000	109,000	6,100	18,900	6,000,000	293,000	660,000
June	2015	42,400,000	41,400	83,700	5,130	16,500	6,070,000	240,000	483,000

OSAGE CREEK NEAR ELM SPRINGS, ARKANSAS (OSAGE)

Month	Year	Monthly Q (m^3)	NO_3-N (kg)	TN (kg)	SRP (kg)	TP (kg)	TSS (kg)	Cl (kg)	SO_4 (kg)
July	2009	9,690,000	34,200	34,000	983	1,390	111,000	221,000	244,000
Aug.	2009	7,240,000	27,800	26,300	808	966	52,900	196,000	225,000
Sep.	2009	9,880,000	34,200	34,100	1,110	1,630	160,000	224,000	256,000
Oct.	2009	34,900,000	75,900	95,100	7,180	14,000	10,500,000	364,000	430,000
Nov.	2009	13,400,000	48,000	49,200	1,110	1,950	163,000	279,000	299,000
Dec.	2009	7,430,000	35,500	32,600	460	647	21,900	226,000	232,000
Jan.	2010	8,500,000	39,700	37,700	437	729	41,400	238,000	234,000
Feb.	2010	13,100,000	51,700	54,000	638	1,340	121,000	274,000	263,000
Mar.	2010	16,700,000	57,400	63,500	952	2,260	517,000	296,000	290,000
Apr.	2010	14,000,000	50,300	54,100	781	1,600	190,000	279,000	275,000
May	2010	22,000,000	60,300	71,700	1,870	4,280	1,550,000	317,000	336,000
June	2010	10,800,000	36,900	38,900	898	1,460	142,000	239,000	259,000
July	2010	12,100,000	35,600	39,100	1,390	2,490	714,000	233,000	269,000
Aug.	2010	3,690,000	17,000	15,000	432	370	10,700	148,000	180,000
Sep.	2010	10,400,000	32,900	34,700	1,290	2,110	445,000	229,000	271,000
Oct.	2010	5,510,000	24,500	22,500	519	561	15,700	193,000	224,000
Nov.	2010	7,760,000	32,600	31,600	588	829	36,200	229,000	252,000
Dec.	2010	5,840,000	29,200	26,700	358	454	12,200	211,000	224,000
Jan.	2011	6,250,000	31,700	29,500	317	441	12,800	220,000	224,000
Feb.	2011	6,680,000	32,000	30,900	306	491	21,600	211,000	209,000
Mar.	2011	7,310,000	34,200	33,400	340	535	23,800	230,000	228,000
Apr.	2011	86,900,000	113,000	195,000	34,900	57,000	127,000,000	407,000	518,000
May	2011	57,300,000	99,200	148,000	11,800	25,200	37,600,000	445,000	525,000
June	2011	15,900,000	46,100	53,400	1,340	2,550	346,000	296,000	330,000
July	2011	10,300,000	33,200	35,900	1,010	1,540	142,000	246,000	286,000
Aug.	2011	9,200,000	30,100	31,900	1,000	1,430	119,000	235,000	282,000
Sep.	2011	8,200,000	28,400	29,300	876	1,220	89,600	225,000	271,000
Oct.	2011	8,010,000	30,300	30,600	737	991	45,000	239,000	281,000
Nov.	2011	17,800,000	49,400	58,500	2,030	4,320	1,740,000	311,000	360,000
Dec.	2011	11,400,000	43,600	46,200	689	1,240	76,800	296,000	318,000
Jan.	2012	8,520,000	37,300	37,900	424	726	40,600	261,000	270,000
Feb.	2012	8,800,000	37,600	39,100	400	733	44,100	255,000	258,000
Mar.	2012	14,700,000	48,800	56,700	809	1,940	452,000	302,000	311,000
Apr.	2012	10,100,000	38,200	41,600	529	974	74,200	265,000	274,000
May	2012	7,490,000	29,000	30,500	478	724	47,600	227,000	247,000
June	2012	6,740,000	25,100	26,200	538	723	39,500	210,000	241,000

OSAGE CREEK NEAR ELM SPRINGS, ARKANSAS (OSAGE) Continued

Month	Year	Monthly Q (m^3)	NO_3-N (kg)	TN (kg)	SRP (kg)	TP (kg)	TSS (kg)	Cl (kg)	SO_4 (kg)
July	2012	4,260,000	17,900	17,300	426	406	11,500	173,000	213,000
Aug.	2012	5,870,000	21,300	21,800	647	789	61,000	197,000	247,000
Sep.	2012	6,730,000	24,300	25,100	698	864	39,400	218,000	270,000
Oct.	2012	6,900,000	26,000	26,700	640	860	50,100	227,000	277,000
Nov.	2012	4,940,000	22,600	21,800	371	419	9,480	204,000	240,000
Dec.	2012	5,440,000	25,800	25,000	328	424	12,800	221,000	248,000
Jan.	2013	7,510,000	32,000	33,400	383	687	65,700	248,000	266,000
Feb.	2013	6,560,000	29,700	30,600	290	468	17,900	230,000	239,000
Mar.	2013	11,300,000	41,000	46,700	551	1,190	183,000	291,000	304,000
Apr.	2013	23,300,000	56,900	76,200	2,180	5,460	4,530,000	352,000	389,000
May	2013	32,000,000	62,700	90,700	5,440	11,800	17,500,000	380,000	447,000
June	2013	10,200,000	31,800	36,900	794	1,340	128,000	262,000	306,000
July	2013	8,240,000	25,800	29,000	835	1,290	173,000	234,000	290,000
Aug.	2013	23,000,000	47,600	64,400	3,570	7,500	4,200,000	350,000	455,000
Sep.	2013	9,610,000	29,700	33,700	984	1,480	108,000	266,000	336,000
Oct.	2013	11,800,000	35,900	41,500	1,100	1,900	194,000	303,000	375,000
Nov.	2013	9,620,000	33,700	37,500	712	1,170	65,400	286,000	339,000
Dec.	2013	12,300,000	41,800	48,500	745	1,510	155,000	322,000	366,000
Jan.	2014	10,500,000	40,100	45,000	510	982	61,300	313,000	340,000
Feb.	2014	6,180,000	27,600	29,100	268	426	14,800	234,000	250,000
Mar.	2014	12,200,000	42,000	50,000	583	1,300	174,000	316,000	339,000
Apr.	2014	10,300,000	36,100	42,200	515	986	74,300	291,000	316,000
May	2014	12,100,000	37,000	45,100	766	1,500	182,000	304,000	347,000
June	2014	10,400,000	31,100	37,400	811	1,390	132,000	277,000	332,000
July	2014	7,080,000	23,400	26,300	653	865	46,300	238,000	300,000
Aug.	2014	6,800,000	22,600	25,100	692	867	40,100	237,000	307,000
Sep.	2014	9,370,000	28,200	32,900	943	1,430	101,000	274,000	355,000
Oct.	2014	19,000,000	43,900	58,400	2,380	5,130	1,860,000	357,000	465,000
Nov.	2014	8,450,000	30,100	33,900	599	935	41,000	283,000	344,000
Dec.	2014	10,500,000	37,300	43,200	594	1,080	58,800	325,000	376,000
Jan.	2015	8,810,000	34,800	39,200	414	736	32,000	305,000	339,000
Feb.	2015	7,400,000	30,000	33,800	315	563	25,600	264,000	288,000
Mar.	2015	15,700,000	48,700	62,200	743	1,790	258,000	376,000	412,000
Apr.	2015	12,900,000	40,200	50,600	651	1,400	149,000	334,000	373,000
May	2015	28,000,000	60,200	88,100	2,270	5,910	2,220,000	440,000	533,000
June	2015	28,800,000	55,300	82,900	3,640	8,570	6,720,000	421,000	538,000

FLINT CREEK NEAR WEST SILOAM SPRINGS, OKLAHOMA (FCWSS)

Month	Year	Monthly Q (m^3)	NO_3-N (kg)	TN (kg)	SRP (kg)	TP (kg)	TSS (kg)	Cl (kg)	SO_4 (kg)
July	2009	1,980,000	1,860	2,130	52	82	6,330	22,300	49,700
Aug.	2009	1,720,000	1,540	1,760	42	66	4,870	19,400	41,100
Sep.	2009	1,890,000	2,040	2,270	50	78	6,060	20,800	42,000
Oct.	2009	13,500,000	28,400	34,700	1,080	2,240	515,000	88,500	157,000
Nov.	2009	4,750,000	10,600	11,400	204	366	47,400	44,200	83,200
Dec.	2009	2,680,000	6,760	6,770	79	128	10,800	29,400	56,800
Jan.	2010	2,700,000	7,940	7,840	80	131	11,100	30,100	60,000
Feb.	2010	4,290,000	14,400	14,500	160	275	28,500	44,300	91,300
Mar.	2010	6,370,000	19,600	20,900	302	552	74,800	59,700	126,000
Apr.	2010	4,290,000	10,000	10,700	157	268	27,100	44,900	99,700
May	2010	9,420,000	18,300	22,300	619	1,230	239,000	74,200	158,000
June	2010	3,310,000	4,250	4,850	108	180	16,300	35,200	78,400
July	2010	2,690,000	2,920	3,450	94	162	18,100	27,700	59,200
Aug.	2010	1,260,000	1,040	1,190	28	42	2,650	14,600	29,800
Sep.	2010	1,610,000	1,690	1,880	40	62	4,400	18,000	35,200
Oct.	2010	1,420,000	1,780	1,910	32	50	3,260	16,200	30,400
Nov.	2010	1,260,000	2,080	2,150	28	43	2,730	14,700	27,200
Dec.	2010	917,000	1,680	1,690	18	26	1,460	11,200	20,600
Jan.	2011	807,000	1,640	1,630	15	21	1,140	10,100	19,100
Feb.	2011	944,000	2,130	2,120	20	29	1,750	11,800	23,400
Mar.	2011	1,070,000	2,140	2,170	22	33	2,000	13,500	27,900
Apr.	2011	21,500,000	51,600	75,700	3,440	8,420	3,390,000	93,700	167,000
May	2011	18,200,000	37,600	47,900	1,510	3,170	701,000	122,000	243,000
June	2011	4,540,000	6,450	7,470	173	298	30,000	45,400	97,400
July	2011	2,440,000	2,510	2,910	70	113	8,740	26,600	55,700
Aug.	2011	1,300,000	1,110	1,280	29	45	2,860	15,000	29,600
Sep.	2011	1,480,000	1,690	1,920	43	71	6,400	15,800	29,500
Oct.	2011	740,000	782	848	14	20	1,050	8,790	15,700
Nov.	2011	4,660,000	11,600	12,600	213	386	47,300	42,000	73,600
Dec.	2011	2,770,000	7,320	7,400	84	137	10,900	30,100	54,600
Jan.	2012	1,530,000	4,010	3,970	37	58	3,920	18,100	33,700
Feb.	2012	1,370,000	3,520	3,500	32	50	3,180	16,600	32,200
Mar.	2012	5,410,000	17,300	19,000	284	532	72,400	48,300	94,600
Apr.	2012	2,520,000	5,320	5,660	75	122	9,470	28,700	60,100
May	2012	1,670,000	2,400	2,640	42	66	4,540	19,700	41,500
June	2012	844,000	763	870	17	24	1,310	10,400	21,300

FLINT CREEK NEAR WEST SILOAM SPRINGS, OKLAHOMA (FCWSS) Continued

Month	Year	Monthly Q (m^3)	NO_3-N (kg)	TN (kg)	SRP (kg)	TP (kg)	TSS (kg)	Cl (kg)	SO_4 (kg)
July	2012	342,000	178	212	4	6	224	4,260	8,040
Aug.	2012	283,000	144	171	4	5	185	3,430	6,080
Sep.	2012	1,020,000	1,010	1,140	23	35	2,100	11,600	21,000
Oct.	2012	1,040,000	1,250	1,360	22	33	1,910	12,100	21,100
Nov.	2012	623,000	813	856	11	16	737	7,550	12,800
Dec.	2012	568,000	930	948	9	13	595	7,070	12,000
Jan.	2013	701,000	1,450	1,450	13	19	932	8,770	15,500
Feb.	2013	829,000	1,850	1,860	16	24	1,290	10,400	19,300
Mar.	2013	1,740,000	4,510	4,670	51	84	6,780	19,900	38,700
Apr.	2013	9,160,000	24,800	29,900	655	1,340	262,000	71,300	136,000
May	2013	11,900,000	25,400	33,000	1,030	2,220	531,000	83,500	158,000
June	2013	2,870,000	3,860	4,450	93	155	12,600	30,800	62,200
July	2013	1,390,000	1,340	1,590	39	64	5,090	15,300	29,300
Aug.	2013	8,000,000	11,100	14,000	468	903	132,000	63,100	112,000
Sep.	2013	1,440,000	1,510	1,700	35	53	3,230	16,300	28,800
Oct.	2013	1,380,000	1,990	2,180	36	57	4,150	15,300	25,800
Nov.	2013	2,140,000	4,220	4,440	61	99	7,040	23,300	39,100
Dec.	2013	3,730,000	11,400	11,800	136	233	20,600	37,900	63,800
Jan.	2014	2,290,000	7,040	7,100	70	115	8,790	25,300	44,100
Feb.	2014	881,000	2,010	2,020	17	26	1,290	11,100	19,900
Mar.	2014	3,410,000	10,400	11,100	136	241	23,900	34,800	65,200
Apr.	2014	2,070,000	4,230	4,510	56	90	5,930	24,200	47,400
May	2014	1,720,000	2,470	2,740	43	67	4,070	20,300	40,200
June	2014	2,750,000	3,550	4,140	89	149	11,700	29,400	57,200
July	2014	1,120,000	952	1,110	24	36	1,870	13,200	24,800
Aug.	2014	1,570,000	1,480	1,730	39	61	3,720	17,600	31,700
Sep.	2014	1,160,000	1,150	1,310	26	39	2,130	13,300	22,700
Oct.	2014	5,580,000	11,100	13,000	290	543	66,100	46,600	74,200
Nov.	2014	2,290,000	4,670	4,910	65	104	6,840	24,900	40,600
Dec.	2014	2,620,000	7,240	7,400	79	129	9,080	28,500	46,800
Jan.	2015	2,340,000	7,070	7,100	66	107	6,980	26,500	44,900
Feb.	2015	1,940,000	5,770	5,840	53	86	5,560	22,500	39,800
Mar.	2015	5,880,000	19,300	20,700	256	457	44,400	57,300	104,000
Apr.	2015	3,390,000	7,950	8,590	112	187	13,900	37,000	70,200
May	2015	15,100,000	32,000	40,600	1,110	2,250	361,000	107,000	190,000
June	2015	13,300,000	23,200	29,100	806	1,550	200,000	104,000	186,000

BARON FORK AT DUTCH MILLS, ARKANSAS (BARON)

Month	Year	Monthly Q (m^3)	NO_3-N (kg)	TN (kg)	SRP (kg)	TP (kg)	TSS (kg)	Cl (kg)	SO_4 (kg)
July	2009	293,000	155	250	7	20	2,760	2,370	4,230
Aug.	2009	343,000	231	332	11	29	4,210	2,810	5,080
Sep.	2009	7,200,000	9,230	12,200	968	1,980	382,000	30,400	72,200
Oct.	2009	13,900,000	25,800	30,000	2,190	3,660	619,000	54,100	145,000
Nov.	2009	2,710,000	9,470	7,000	163	243	25,500	19,900	53,000
Dec.	2009	1,610,000	8,090	5,040	76	90	6,930	13,500	38,800
Jan.	2010	3,620,000	25,200	14,400	261	261	20,700	23,500	77,700
Feb.	2010	6,180,000	43,200	25,100	519	515	43,000	34,500	119,000
Mar.	2010	8,730,000	38,800	29,000	992	1,130	125,000	37,700	127,000
Apr.	2010	3,160,000	11,300	8,310	202	277	29,000	18,300	53,900
May	2010	6,190,000	12,200	12,400	599	1,060	165,000	27,000	73,600
June	2010	698,000	709	850	24	56	7,600	5,070	10,700
July	2010	721,000	601	787	27	74	11,700	5,180	10,300
Aug.	2010	67,400	16	39	1	3	379	611	971
Sep.	2010	1,890,000	2,270	2,900	181	425	81,000	10,000	22,600
Oct.	2010	410,000	548	595	11	22	2,230	3,990	8,490
Nov.	2010	966,000	3,150	2,350	41	62	5,560	8,410	21,800
Dec.	2010	510,000	1,910	1,340	17	22	1,580	4,860	13,200
Jan.	2011	546,000	2,360	1,570	17	20	1,280	5,190	15,000
Feb.	2011	3,120,000	20,500	11,900	203	223	18,000	19,700	67,000
Mar.	2011	3,000,000	15,900	9,860	171	208	17,700	19,300	62,500
Apr.	2011	24,600,000	31,000	51,200	6,490	9,350	1,670,000	48,300	160,000
May	2011	15,100,000	21,400	28,600	2,590	4,770	927,000	43,600	128,000
June	2011	991,000	1,160	1,310	37	91	12,600	6,900	15,400
July	2011	213,000	92	165	4	13	1,670	1,830	3,300
Aug.	2011	428,000	294	419	12	36	5,290	3,590	6,810
Sep.	2011	315,000	287	362	8	22	2,740	2,890	5,700
Oct.	2011	503,000	763	780	14	29	2,910	4,860	10,800
Nov.	2011	4,370,000	13,700	11,900	449	713	91,100	23,800	69,700
Dec.	2011	5,170,000	27,200	18,200	414	538	51,100	31,700	103,000
Jan.	2012	3,550,000	23,000	14,000	266	299	25,100	22,300	76,900
Feb.	2012	3,480,000	23,200	13,500	225	257	20,700	22,300	77,500
Mar.	2012	7,090,000	30,700	23,400	719	923	100,000	31,900	111,000
Apr.	2012	1,600,000	5,000	3,770	65	107	10,300	11,100	32,300
May	2012	554,000	790	820	15	33	3,450	4,320	10,400
June	2012	344,000	449	496	17	41	6,270	2,120	4,950

BARON FORK AT DUTCH MILLS, ARKANSAS (BARON) Continued

Month	Year	Monthly Q (m^3)	NO_3-N (kg)	TN (kg)	SRP (kg)	TP (kg)	TSS (kg)	Cl (kg)	SO_4 (kg)
July	2012	40,600	5	17	0.38	1	144	365	569
Aug.	2012	18,200	1	6	0.13	0.47	45	168	238
Sep.	2012	66,000	18	43	1	2	233	683	1,170
Oct.	2012	224,000	225	280	4	11	1,010	2,330	4,890
Nov.	2012	321,000	589	569	7	12	940	3,450	8,350
Dec.	2012	381,000	1,080	868	8	13	804	4,080	11,100
Jan.	2013	1,080,000	6,510	3,930	56	69	5,300	8,130	26,900
Feb.	2013	1,490,000	8,730	5,090	57	74	5,250	11,800	39,400
Mar.	2013	3,740,000	18,600	12,400	242	334	31,000	21,800	74,400
Apr.	2013	7,360,000	22,600	19,400	678	1,130	147,000	32,900	107,000
May	2013	6,100,000	11,300	12,000	527	1,150	183,000	26,800	77,400
June	2013	1,080,000	1,320	1,470	37	104	14,400	7,510	17,600
July	2013	516,000	343	498	12	43	6,210	4,240	8,510
Aug.	2013	745,000	586	789	20	71	10,300	6,170	12,600
Sep.	2013	488,000	459	575	12	36	4,400	4,550	9,470
Oct.	2013	373,000	473	526	9	24	2,650	3,630	8,080
Nov.	2013	643,000	1,640	1,350	17	33	2,750	6,450	16,800
Dec.	2013	1,080,000	5,420	3,570	56	83	6,960	8,350	26,400
Jan.	2014	564,000	3,310	1,960	24	33	2,370	4,600	15,100
Feb.	2014	50,100	47	69	0.48	1	34	543	1,380
Mar.	2014	3,730,000	17,400	12,300	266	398	39,200	19,400	68,700
Apr.	2014	2,980,000	10,500	7,710	135	250	24,900	18,800	59,400
May	2014	2,550,000	5,210	4,880	125	297	39,000	15,000	42,100
June	2014	802,000	845	1,000	23	73	10,100	5,960	13,800
July	2014	206,000	88	158	3	12	1,610	1,850	3,510
Aug.	2014	75,000	20	46	1	4	433	720	1,250
Sep.	2014	65,500	18	42	1	3	268	683	1,210
Oct.	2014	1,700,000	3,330	3,430	113	286	40,600	10,600	28,400
Nov.	2014	641,000	1,680	1,370	16	35	2,860	6,420	17,200
Dec.	2014	2,550,000	14,100	8,700	115	186	14,900	20,000	66,200
Jan.	2015	1,830,000	11,300	6,600	72	107	7,730	15,100	51,800
Feb.	2015	789,000	3,850	2,410	20	31	1,960	7,230	23,900
Mar.	2015	6,590,000	33,400	22,600	430	679	64,200	35,300	130,000
Apr.	2015	2,210,000	7,170	5,370	82	169	16,400	15,100	47,300
May	2015	17,500,000	27,300	34,100	1,880	4,680	808,000	58,000	183,000
June	2015	10,900,000	12,300	16,900	1,040	3,230	647,000	41,100	114,000

SPRING CREEK AT HWY 112 NEAR SPRINGDALE, ARKANSAS (SPRING)

Month	Year	Monthly Q m^3	NO_3-N (kg)	TN (kg)	SRP (kg)	TP (kg)	TSS (kg)	Cl (kg)	SO_4 (kg)
Jan.	2012	2,210,000	8,610	10,000	360	477	28,100	112,000	217,000
Feb.	2012	3,740,000	13,400	15,300	513	634	46,100	152,000	252,000
Mar.	2012	6,400,000	18,000	24,000	884	1,410	260,000	185,000	302,000
Apr.	2012	3,610,000	12,100	14,300	466	583	27,700	156,000	258,000
May	2012	1,980,000	8,010	9,540	338	441	9,530	126,000	229,000
June	2012	1,660,000	5,750	6,910	304	401	3,980	106,000	205,000
July	2012	1,310,000	4,290	5,260	283	394	2,010	89,600	192,000
Aug.	2012	2,950,000	8,740	10,600	914	1,080	72,000	140,000	247,000
Sep.	2012	3,490,000	9,710	11,000	933	933	30,800	150,000	252,000
Oct.	2012	2,840,000	9,300	10,300	760	791	27,400	140,000	245,000
Nov.	2012	1,780,000	6,740	7,220	358	417	4,240	108,000	208,000
Dec.	2012	1,740,000	7,670	8,260	313	388	7,440	113,000	216,000
Jan.	2013	2,500,000	9,720	10,800	324	438	27,400	127,000	231,000
Feb.	2013	2,690,000	9,920	10,800	264	347	11,600	127,000	221,000
Mar.	2013	4,010,000	13,500	16,100	425	637	80,700	160,000	269,000
Apr.	2013	7,330,000	17,100	23,500	820	2,060	728,000	190,000	306,000
May	2013	7,890,000	19,000	25,400	1,040	1,720	329,000	219,000	340,000
June	2013	4,060,000	11,800	13,900	616	752	36,900	172,000	275,000
July	2013	4,330,000	10,400	12,900	820	1,260	172,000	162,000	271,000

SPRING CREEK AT HWY 112 NEAR SPRINGDALE, ARKANSAS (SPRING) Continued

Month	Year	Monthly Q m^3	NO_3-N (kg)	TN (kg)	SRP (kg)	TP (kg)	TSS (kg)	Cl (kg)	SO_4 (kg)
Aug.	2013	8,620,000	12,600	20,700	2,090	10,200	3,370,000	171,000	298,000
Sep.	2013	2,100,000	6,000	6,950	455	578	27,400	106,000	207,000
Oct.	2013	3,740,000	10,800	12,400	846	1,190	155,000	156,000	264,000
Nov.	2013	3,530,000	11,300	11,800	572	628	23,600	154,000	256,000
Dec.	2013	5,960,000	16,300	19,800	846	1,600	436,000	181,000	296,000
Jan.	2014	4,360,000	15,400	16,600	465	601	47,300	177,000	285,000
Feb.	2014	2,890,000	10,500	11,200	230	319	12,800	135,000	229,000
Mar.	2014	4,820,000	15,200	17,900	406	690	133,000	176,000	287,000
Apr.	2014	4,230,000	13,400	15,400	352	514	43,500	170,000	274,000
May	2014	4,450,000	13,300	15,700	455	662	62,600	180,000	288,000
June	2014	4,210,000	11,400	13,300	498	664	42,200	171,000	274,000
July	2014	2,630,000	7,960	8,900	381	485	11,300	142,000	245,000
Aug.	2014	2,490,000	7,930	8,680	445	535	12,400	142,000	245,000
Sep.	2014	2,860,000	8,370	8,930	486	561	15,200	142,000	243,000
Oct.	2014	5,580,000	12,700	15,500	979	1,840	427,000	172,000	287,000
Nov.	2014	2,940,000	9,910	10,100	388	464	15,300	145,000	246,000
Dec.	2014	3,280,000	12,100	12,400	357	455	22,300	159,000	264,000
Jan.	2015	2,950,000	11,500	11,700	244	340	14,900	150,000	254,000
Feb.	2015	2,790,000	9,930	10,400	173	262	11,700	132,000	226,000
Mar.	2015	4,640,000	15,200	16,900	302	475	54,100	183,000	291,000
Apr.	2015	4,490,000	13,700	15,600	303	487	57,900	176,000	281,000
May	2015	8,130,000	18,300	23,500	658	1,190	264,000	220,000	340,000
June	2015	8,260,000	16,300	22,300	884	2,450	945,000	210,000	330,000

*Data collection at Spring Creek began in January 2012; load estimations for project year 2011 are from January to June 2012.

BALLARD CREEK NEAR WESTVILLE, OKLAHOMA (BALLARD)

Month	Year	Monthly Q (m^3)	NO_3-N (kg)	TN (kg)	SRP (kg)	TP (kg)	TSS (kg)	Cl (kg)	SO_4 (kg)
July	2009	758	1	2	0.05	0.08	2	9	8
Aug.	2009	1,310	2	3	0.12	0.17	6	16	15
Sep.	2009	1,200,000	1,610	2,780	312	454	29,700	7,280	9,420
Oct.	2009	9,120,000	10,200	21,400	2,740	4,070	347,000	35,300	56,800
Nov.	2009	302,000	840	925	30	47	3,380	3,610	5,300
Dec.	2009	218,000	742	754	16	26	2,260	2,780	4,810
Jan.	2010	385,000	1,340	1,420	27	48	5,060	4,290	8,760
Feb.	2010	582,000	1,930	2,150	42	77	8,430	5,920	12,700
Mar.	2010	2,550,000	5,350	8,220	311	579	64,900	15,100	34,300
Apr.	2010	372,000	976	1,180	33	60	4,870	3,690	6,720
May	2010	432,000	825	1,150	60	103	6,620	3,720	5,620
June	2010	127,000	242	309	16	26	1,190	1,410	1,690
July	2010	38,500	66	88	6	9	379	415	451
Aug.	2010	758	1	2	0.06	0.08	2	9	9
Sep.	2010	39,800	75	95	6	9	405	462	491
Oct.	2010	5,880	15	16	1	1	39	83	100
Nov.	2010	56,400	170	178	5	7	543	749	1,120
Dec.	2010	5,730	21	20	0.33	1	49	79	141
Jan.	2011	5,800	22	20	0.29	1	42	84	151
Feb.	2011	410,000	1,120	1,450	38	70	8,230	3,290	7,470
Mar.	2011	308,000	928	1,090	24	45	4,670	3,050	6,400
Apr.	2011	4,680,000	1,460	2,420	130	234	21,100	4,890	9,680
May	2011	6,000,000	8,790	17,600	1,670	2,850	217,000	32,300	56,500
June	2011	2,310,000	4,680	7,540	624	1,010	58,200	22,700	31,300
July	2011	631,000	2,890	4,590	454	695	34,600	16,100	19,100
Aug.	2011	511,000	771	1,070	89	130	5,810	4,860	5,140
Sep.	2011	511,000	911	1,200	85	124	6,210	5,360	5,980
Oct.	2011	4,380,000	1,430	1,780	92	138	8,810	7,100	9,260
Nov.	2011	2,940,000	9,690	14,200	782	1,220	115,000	35,000	60,200
Jan.	2012	6,470,000	12,900	17,300	488	874	111,000	36,400	84,100
Feb.	2012	6,830,000	11,700	15,400	400	736	90,100	33,400	78,600
Mar.	2012	2,840,000	14,900	22,900	845	1,570	179,000	43,300	100,000
Apr.	2012	809,000	5,480	7,580	280	510	43,900	20,000	38,400
May	2012	518,000	1,330	1,770	78	135	8,570	6,270	9,600
June	2012	450,000	897	1,240	79	128	6,430	5,080	6,400
July	2012	118,000	688	962	75	115	5,080	4,380	4,830

BALLARD CREEK NEAR WESTVILLE, OKLAHOMA (BALLARD) Continued

Month	Year	Monthly Q (m^3)	NO_3-N (kg)	TN (kg)	SRP (kg)	TP (kg)	TSS (kg)	Cl (kg)	SO_4 (kg)
Jan.	2013	208,000	383	377	6	11	1,000	1,420	2,780
Feb.	2013	916,000	703	713	11	21	2,000	2,540	5,180
Mar.	2013	600,000	2,260	3,130	95	178	20,500	7,130	15,900
Apr.	2013	6,140,000	1,800	2,380	86	155	12,600	7,230	13,200
May	2013	994,000	8,530	15,900	1,260	2,190	174,000	33,200	58,700
June	2013	341,000	1,250	1,800	119	194	10,600	6,870	9,060
July	2013	323,000	547	751	57	86	3,750	3,630	3,950
Aug.	2013	164,000	534	720	56	83	3,580	3,630	3,780
Sep.	2013	338,000	360	452	28	41	1,990	2,300	2,520
Oct.	2013	342,000	770	922	45	67	3,950	4,280	5,330
Nov.	2013	1,310,000	920	1,020	33	52	3,820	4,340	6,420
Dec.	2013	688,000	3,350	4,480	154	259	29,900	11,200	22,600
Jan.	2014	281,000	2,160	2,430	53	93	10,200	7,400	15,400
Feb.	2014	1,260,000	882	905	15	27	2,660	3,220	6,630
Mar.	2014	980,000	3,530	4,720	139	259	28,000	11,800	25,700
Apr.	2014	458,000	2,130	2,730	85	155	13,100	8,540	16,000
May	2014	508,000	943	1,230	53	91	5,600	4,800	7,190
June	2014	352,000	898	1,280	89	142	7,210	5,330	6,700
July	2014	322,000	537	738	55	84	3,660	3,660	3,990
Aug.	2014	235,000	541	730	57	84	3,640	3,760	3,920
Sep.	2014	821,000	450	569	37	53	2,530	2,990	3,230
Oct.	2014	274,000	1,510	2,180	158	234	16,500	7,600	10,300
Nov.	2014	631,000	767	839	26	41	3,010	3,720	5,500
Dec.	2014	385,000	1,920	2,190	59	98	9,770	7,410	13,700
Jan.	2015	255,000	1,330	1,390	27	47	4,800	4,920	9,850
Feb.	2015	2,070,000	796	811	13	24	2,330	3,000	6,150
Mar.	2015	564,000	5,120	7,080	219	409	44,900	17,000	37,900
Apr.	2015	10,600,000	1,360	1,670	50	91	7,030	5,960	10,700
May	2015	8,590,000	16,000	32,300	3,070	5,260	414,000	63,200	114,000
June	2015	1,120,000	8,020	14,900	1,620	2,620	164,000	39,800	57,700

*Daily flow was not available from April 25, 2011 to May 18, 2011, because of equipment failure following a large storm event; discharge volume and loads estimated for project year 2010 do not include this date range.

*Daily flow was not available for December 2011 because of equipment failure; discharge volume and loads were not estimated for December 2011.

*Daily flow was not available from August 2012 to December 2012, because of equipment failure; discharge volume and loads were not estimated from August 2012 to December 2012.

FLINT CREEK AT SPRINGTOWN, ARKANSAS (FC12)

Month	Year	Monthly Q (m^3)	NO_3-N (kg)	TN (kg)	SRP (kg)	TP (kg)	TSS (kg)	Cl (kg)	SO_4 (kg)
July	2009	575,000	1,760	1,810	30	35	1,120	4,270	2,440
Aug.	2009	483,000	1,460	1,500	25	29	745	3,690	1,980
Sep.	2009	609,000	1,880	1,930	34	40	1,140	4,440	2,670
Oct.	2009	5,680,000	15,900	18,900	1,140	1,860	156,000	27,200	30,100
Nov.	2009	1,820,000	5,680	6,200	194	280	18,800	10,400	9,730
Dec.	2009	627,000	2,190	2,190	24	27	655	4,590	3,140
Jan.	2010	787,000	2,840	2,860	29	34	1,050	5,540	4,240
Feb.	2010	1,410,000	5,090	5,270	66	83	4,020	8,880	8,290
Mar.	2010	2,720,000	9,100	10,100	231	343	30,000	14,900	16,300
Apr.	2010	2,970,000	10,100	10,900	206	283	20,300	17,000	17,500
May	2010	4,570,000	14,200	16,200	552	857	83,500	24,000	25,700
June	2010	802,000	2,590	2,700	46	57	2,340	5,580	3,850
July	2010	637,000	1,980	2,060	38	47	1,560	4,610	2,850
Aug.	2010	368,000	1,120	1,150	19	22	444	2,930	1,480
Sep.	2010	510,000	1,600	1,640	29	35	812	3,820	2,240
Oct.	2010	458,000	1,490	1,500	22	26	485	3,520	2,040
Nov.	2010	537,000	1,830	1,840	24	28	587	4,000	2,600
Dec.	2010	437,000	1,540	1,530	16	18	320	3,390	2,120
Jan.	2011	398,000	1,440	1,430	13	14	255	3,130	1,960
Feb.	2011	622,000	2,300	2,330	23	28	811	4,460	3,430
Mar.	2011	490,000	1,780	1,800	17	20	494	3,710	2,520
Apr.	2011	5,330,000	14,100	18,700	2,170	4,700	544,000	22,300	28,500
May	2011	2,900,000	8,710	10,300	523	908	92,000	14,700	16,200
June	2011	820,000	2,690	2,830	51	66	2,630	5,660	4,090
July	2011	413,000	1,300	1,340	23	28	616	3,220	1,770
Aug.	2011	529,000	1,660	1,730	35	43	1,100	3,930	2,370
Sep.	2011	645,000	2,060	2,150	48	61	1,870	4,530	3,100
Oct.	2011	842,000	2,800	2,900	58	73	2,070	5,780	4,300
Nov.	2011	1,790,000	6,130	6,510	150	205	8,310	10,900	10,400
Dec.	2011	859,000	3,130	3,180	42	51	1,250	5,980	4,800
Jan.	2012	567,000	2,120	2,130	22	27	601	4,180	3,110
Feb.	2012	678,000	2,570	2,600	27	33	838	4,850	3,870
Mar.	2012	1,510,000	5,460	5,870	105	150	8,450	9,180	9,360
Apr.	2012	667,000	2,420	2,490	30	38	1,100	4,800	3,610
May	2012	398,000	1,360	1,400	18	22	464	3,120	1,880
June	2012	365,000	1,200	1,240	19	23	456	2,890	1,620

FLINT CREEK AT SPRINGTOWN, ARKANSAS (FC12) Continued

Month	Year	Monthly Q (m^3)	NO_3-N (kg)	TN (kg)	SRP (kg)	TP (kg)	TSS (kg)	Cl (kg)	SO_4 (kg)
July	2012	314,000	994	1,030	18	21	357	2,550	1,310
Aug.	2012	454,000	1,450	1,500	30	38	779	3,460	2,040
Sep.	2012	416,000	1,350	1,390	26	32	570	3,210	1,880
Oct.	2012	389,000	1,300	1,330	23	28	468	3,030	1,810
Nov.	2012	291,000	1,010	1,010	13	15	172	2,390	1,340
Dec.	2012	264,000	945	945	10	11	122	2,210	1,240
Jan.	2013	317,000	1,180	1,180	11	14	193	2,560	1,610
Feb.	2013	313,000	1,180	1,180	11	13	188	2,510	1,620
Mar.	2013	619,000	2,340	2,410	29	38	1,100	4,430	3,570
Apr.	2013	1,640,000	5,420	6,270	273	501	41,500	9,010	9,860
May	2013	2,440,000	7,440	9,050	628	1,240	111,000	12,300	14,200
June	2013	603,000	2,050	2,150	39	52	1,390	4,370	3,060
July	2013	328,000	1,060	1,110	22	28	535	2,610	1,450
Aug.	2013	874,000	2,850	3,050	87	122	4,050	5,850	4,530
Sep.	2013	229,000	737	756	14	16	160	1,950	943
Oct.	2013	334,000	1,130	1,160	20	24	348	2,650	1,570
Nov.	2013	572,000	2,060	2,100	34	43	722	4,210	3,060
Dec.	2013	693,000	2,620	2,670	38	48	938	4,940	4,040
Jan.	2014	581,000	2,240	2,280	28	35	702	4,230	3,410
Feb.	2014	291,000	1,120	1,120	11	13	160	2,370	1,530
Mar.	2014	839,000	3,220	3,380	49	68	2,220	5,670	5,220
Apr.	2014	462,000	1,720	1,770	22	28	515	3,530	2,490
May	2014	427,000	1,520	1,580	23	30	560	3,310	2,170
June	2014	622,000	2,110	2,270	56	80	2,760	4,280	3,330
July	2014	403,000	1,340	1,410	29	38	676	3,120	1,900
Aug.	2014	208,000	667	693	14	17	184	1,780	859
Sep.	2014	189,000	611	631	12	14	124	1,650	774
Oct.	2014	1,010,000	3,490	3,750	114	167	5,090	6,440	5,870
Nov.	2014	470,000	1,720	1,750	28	35	459	3,580	2,510
Dec.	2014	584,000	2,240	2,280	32	42	644	4,290	3,400
Jan.	2015	334,000	1,290	1,300	14	18	206	2,680	1,820
Feb.	2015	264,000	1,030	1,040	11	13	162	2,150	1,420
Mar.	2015	1,230,000	4,830	5,130	85	123	4,010	7,940	8,220
Apr.	2015	612,000	2,350	2,440	33	45	919	4,470	3,580
May	2015	3,290,000	10,900	12,900	689	1,270	81,900	17,100	21,000
June	2015	1,990,000	6,920	7,660	242	376	15,200	11,900	12,200

SAGER CREEK AT SILOAM SPRINGS, ARKANSAS (SAGER)

Month	Year	Monthly Q m^3	NO_3-N (kg)	TN (kg)	SRP (kg)	TP (kg)	TSS (kg)	Cl (kg)	SO_4 (kg)
July	2011	253,000	29	35	1	1	33	208	190
Aug.	2011	434,000	393	518	33	46	3,380	1,940	2,420
Sep.	2011	220,000	605	926	79	116	11,500	2,630	3,860
Oct.	2011	1,330,000	429	497	12	17	1,040	2,250	2,750
Nov.	2011	528,000	1,830	3,110	186	321	46,600	7,160	12,300
Dec.	2011	422,000	1,160	1,310	17	29	2,450	5,150	7,360
Jan.	2012	348,000	882	1,110	15	30	4,110	4,280	5,780
Feb.	2012	1,270,000	717	792	6	12	1,040	3,750	4,590
Mar.	2012	333,000	1,940	3,290	110	251	44,300	8,300	12,600
Apr.	2012	220,000	619	684	8	14	869	3,520	3,800
May	2012	128,000	372	431	7	12	716	2,360	2,300
June	2012	114,000	200	232	5	6	214	1,500	1,260
July	2012	252,000	193	225	5	7	188	1,490	1,230
Aug.	2012	537,000	653	827	49	67	3,290	3,380	3,940
Sep.	2012	1,180,000	708	836	35	46	1,950	3,700	4,310
Oct.	2012	272,000	1,900	2,700	139	209	13,700	8,100	12,000
Nov.	2012	222,000	546	583	8	11	423	3,280	3,520
Dec.	2012	244,000	539	563	4	7	292	3,420	3,530
Jan.	2013	412,000	808	897	8	15	1,040	4,670	5,220
Feb.	2013	650,000	685	720	4	9	459	4,250	4,370
Mar.	2013	2,460,000	1,770	2,550	60	133	14,300	8,940	11,200
Apr.	2013	3,110,000	2,860	5,310	369	839	122,000	14,100	18,500
May	2013	1,600,000	3,740	7,780	874	1,810	213,000	18,000	24,200
June	2013	511,000	1,330	1,690	74	122	5,940	7,130	7,770

SAGER CREEK AT SILOAM SPRINGS, ARKANSAS (SAGER) Continued

Month	Year	Monthly Q m^3	NO_3-N (kg)	TN (kg)	SRP (kg)	TP (kg)	TSS (kg)	Cl (kg)	SO_4 (kg)
July	2013	2,890,000	1,110	1,580	151	228	11,700	6,100	6,680
Aug.	2013	498,000	2,440	4,990	1,350	2,200	188,000	12,200	15,700
Sep.	2013	549,000	959	1,160	54	74	2,530	5,420	5,820
Oct.	2013	940,000	1,330	1,760	77	117	5,740	7,190	8,400
Nov.	2013	1,010,000	1,260	1,420	31	46	1,750	7,060	7,850
Dec.	2013	905,000	2,020	2,620	54	100	6,330	10,700	13,000
Jan.	2014	359,000	1,820	2,270	34	68	4,500	10,200	11,700
Feb.	2014	902,000	760	790	5	10	372	5,320	4,830
Mar.	2014	482,000	1,700	2,310	50	110	8,700	10,100	10,700
Apr.	2014	443,000	972	1,080	14	27	1,010	6,600	5,860
May	2014	1,780,000	880	1,000	22	38	1,210	6,100	5,220
June	2014	400,000	2,410	3,770	348	604	29,400	13,500	14,500
July	2014	707,000	715	817	33	47	965	5,090	4,210
Aug.	2014	524,000	1,010	1,370	126	184	6,330	6,450	6,060
Sep.	2014	2,170,000	853	1,060	65	90	2,580	5,690	5,210
Oct.	2014	506,000	2,180	4,410	636	1,040	58,500	12,800	14,900
Nov.	2014	857,000	1,080	1,160	20	29	698	7,290	6,730
Dec.	2014	786,000	1,810	2,170	39	69	2,820	11,400	11,500
Jan.	2015	505,000	1,640	1,980	29	57	2,560	10,800	10,500
Feb.	2015	1,830,000	1,060	1,170	11	22	855	7,830	6,710
Mar.	2015	787,000	3,240	4,670	119	264	15,200	20,200	20,400
Apr.	2015	5,020,000	1,490	1,750	33	65	2,190	10,600	8,940
May	2015	1,650,000	5,070	10,900	1,560	3,230	210,000	31,900	33,000
June	2015	569,000	1,580	2,640	307	544	21,600	10,900	9,760

NIOKASKA CREEK AT TOWNSHIP ST AT FAYETTEVILLE, ARKANSAS (NC)

Month	Year	Monthly Q (m^3)	NO_3-N (kg)	TN (kg)	SRP (kg)	TP (kg)	TSS (kg)	Cl (kg)	SO_4 (kg)
July	2011	2,160	1	1	0.08	0.22	72	20	44
Aug.	2011	10,700	8	13	1	3	1,730	52	122
Sep.	2011	51,800	54	91	6	30	13,400	197	423
Oct.	2011	9,660	5	6	0.24	1	115	126	241
Nov.	2011	177,000	177	291	10	73	15,800	1,320	2,160
Dec.	2011	153,000	154	188	4	18	3,280	1,920	2,690
Jan.	2012	106,000	100	133	2	11	1,850	1,790	2,210
Feb.	2012	71,800	67	82	1	5	901	1,380	1,650
Mar.	2012	177,000	179	358	7	58	13,900	1,790	2,210
Apr.	2012	25,400	17	24	1	2	484	414	567
May	2012	7,390	3	6	0.20	1	212	107	168
June	2012	13,100	10	17	1	3	1,860	73	127
July	2012	7,660	7	10	1	2	1,510	40	78
Aug.	2012	18,800	19	29	2	7	4,510	93	186
Sep.	2012	13,900	10	14	1	3	1,460	92	178
Oct.	2012	37,400	33	42	2	7	2,320	331	556
Nov.	2012	8,020	4	4	0.13	0.28	47	168	246
Dec.	2012	23,900	23	25	1	2	315	605	742
Jan.	2013	66,000	64	95	2	9	1,550	1,120	1,200
Feb.	2013	81,700	73	85	1	4	857	1,760	1,830
Mar.	2013	122,000	136	217	4	24	5,700	1,980	2,120
Apr.	2013	204,000	194	378	9	72	25,100	1,730	2,030
May	2013	222,000	256	561	21	163	81,400	1,370	1,860
June	2013	61,500	31	50	2	8	4,240	305	468

NIOKASKA CREEK AT TOWNSHIP ST AT FAYETTEVILLE, ARKANSAS (NC) Continued

Month	Year	Monthly Q (m^3)	NO_3-N (kg)	TN (kg)	SRP (kg)	TP (kg)	TSS (kg)	Cl (kg)	SO_4 (kg)
July	2013	13,900	17	26	2	6	4,130	108	188
Aug.	2013	87,100	86	177	15	86	55,900	291	512
Sep.	2013	21,200	22	34	2	10	4,480	125	204
Oct.	2013	123,000	123	224	12	90	29,700	885	1,300
Nov.	2013	126,000	116	146	5	20	4,230	1,540	1,910
Dec.	2013	226,000	228	342	7	51	7,970	3,280	3,450
Jan.	2014	125,000	119	132	2	8	1,330	2,840	2,700
Feb.	2014	63,900	49	52	1	2	320	1,780	1,620
Mar.	2014	248,000	248	469	8	78	16,600	3,550	3,300
Apr.	2014	73,400	65	95	2	9	2,770	1,140	1,170
May	2014	44,700	37	58	2	7	3,560	512	606
June	2014	27,600	20	33	2	5	3,040	248	340
July	2014	1,750	0.29	1	0.04	0.14	20	30	46
Aug.	2014	996	0.17	0.40	0.03	0.08	11	18	28
Sep.	2014	13,100	11	16	1	3	1,560	112	165
Oct.	2014	84,800	87	149	8	45	15,200	636	819
Nov.	2014	23,100	17	18	1	2	331	500	550
Dec.	2014	68,600	61	63	1	4	661	1,670	1,550
Jan.	2015	65,800	54	55	1	3	424	2,060	1,730
Feb.	2015	83,700	74	83	1	4	767	2,430	1,940
Mar.	2015	337,000	364	548	9	53	13,200	5,640	4,590
Apr.	2015	213,000	221	337	8	37	13,900	2,860	2,580
May	2015	451,000	491	1,110	43	339	168,000	2,990	3,100

*Discharge and loads were not estimated for June 2015, because this site was discontinued by USGS.