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CONSTITUENT LOAD ESTIMATION IN THE LOWER OUACHITA-SMACKOVER WATERSHED

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Water quality was monitored at 21 sites in the Lower Ouachita-Smackover Watershed from 2013 November through 2014 September. The U.S. Geological Survey maintains discharge monitoring stations at two of these sites, Moro Creek (USGS 07362500) and Smackover Creek (USGS 07362100), which were sampled during base flow and storm event conditions, whereas the other sites were only sampled during baseflow. The Arkansas Water Resources Center (AWRC) estimated constituent loads for nitrate-N (NO_3^- –N), total nitrogen (TN), soluble reactive phosphorus (SRP), total phosphorus (TP) and total suspended solids (TSS) using the U.S. Geological Survey LOADEST software. LOADEST creates regression models between constituent concentrations and discharge, as well as time. The resulting models were applied to daily discharge throughout calendar years 2013 and 2014 to estimate loads. Annual and monthly loads and flow volumes for each site are summarized in this report.

INTRODUCTION

The Lower Ouachita-Smackover Watershed is one of the priority watersheds for the Arkansas Natural Resources Commission (ANRC) 319 Nonpoint Source (NPS) Program (ADEQ, 2008). The ANRC 319 NPS Program funded this project (Project 11-600) to help prioritize subwatersheds at the hydrologic unit code (HUC) 12 level, where future investments into best management practices and demonstration activities could be targeted. The prioritization of HUC 12 subwatersheds will be based on watershed modeling using the Soil Water Assessment Tool (SWAT; Gassman et al., 2007), following an approach that has been applied to several other priority watersheds in Arkansas. This project also included a water quality monitoring component, which will aid in the watershed modeling effort and subwatershed prioritization. The monitoring program consisted of two parts: 1) sampling at the HUC 12 subwatersheds to understand spatial variability in water quality, and 2) sampling at established U.S. Geological Survey gaging stations to estimate constituent loads over time. The U.S. Geological Survey gaging stations within the watershed are shown in Figure 1. The objective of this report is to detail the estimation of constituent loads, providing monthly and annual load estimates for calendar years 2013 and 2014.

METHODS

Study Sites

The Lower Ouachita-Smackover Watershed (HUC 08040201) is located in south central Arkansas and drains approximately 1800 mi^2 area, covering parts of Bradley, Calhoun, Cleveland, Columbia, Dallas, Nevada, Ouachita and Union counties. Land cover for this watershed includes areas of forest (76%), herbaceous (15%), pasture (6%), urban (2%) and water (1%).

Concentrations

Constituent concentrations were summarized with general statistics such as mean, standard deviation, percentiles, and flow-weighted concentrations (FWC). FWC's were calculated with the following equation:

$$FWC = \frac{\sum_{i=1}^{n}(C_i * Q_i)}{\sum_{i=1}^{n}(Q_i)} \quad (1)$$

where Q_i is discharge in cubic feet per second (cfs) and C_i is constituent concentration in mg L^{-1}.

LOADEST Software and the Model Selection Process

LOADEST is a FORTRAN program used to estimate constituent loads in streams and rivers (Runkel et al., 2004). Time series data for discharge, constituent concentration and possibly additional variables are used to create a regression model. The regression model can be produced in one of three ways: 1) the user selects from 11 predefined models; 2) LOADEST automatically selects the "best" model from those 11; or 3) the user can define the model. The user can select the most appropriate predefined model, from simple models using only streamflow as the explanatory variable to more complex models using many explanatory variables based on various functions of streamflow and time; this selection can be based on the user's knowledge of the hydrologic and biogeochemical characteristics of the system being studied. LOADEST also provides the option to select the "best" model that is automatically generated by the software based on automated analysis of statistics for each model. We followed a stepwise process to select the most appropriate model, both in terms of statistical output and hydrological-biogeochemical relationships in the two streams.

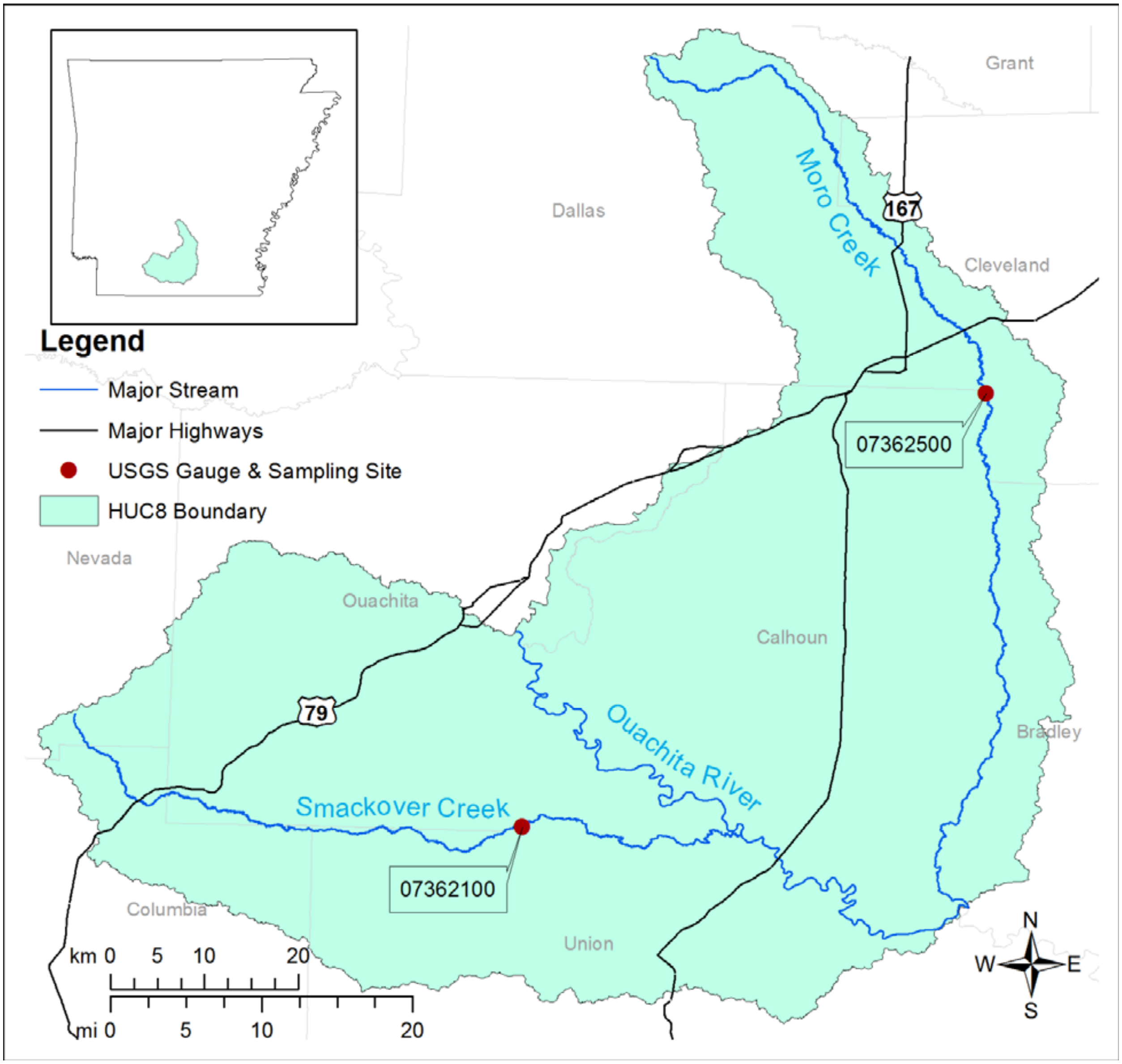

Figure 1. USGS sites sampled at Moro Creek (07362500; 33°47'32" N, 92°20'00" W) and Smackover Creek (07362100; 33°22'31" N, 92°46'36" W) within the Lower-Ouachita Smackover Watershed.

In order to identify the most appropriate model to use to estimate loads using LOADEST software, we began by running model 0 which tests all the predefined models in LOADEST (Table 1). Model 0 will produce a statistical value called the Akaike Information Criterion (AIC) for each predefined model. The AIC represents the model's overall goodness of fit and simplicity, with lower values corresponding to better fitting models. In the current study, AIC values were similar for the models for each respective constituent and only models 1 and 4 were considered further. Models 1 and 4 are simple models with either flow or flow and time as predictor variables, respectively. Given the relatively short sampling period used for calibrating the models (2013 November through 2014 September), the use of more basic models is appropriate. Next, we evaluated the bias percentages (BP), a

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	$a_0 + a_1 per + a_2 lnQ + a_3 lnQ\ per + a_4 Q^2 + a_5 lnQ^2 per$

statistical metric indicating the reliability of the resulting load estimations, and chose the model that had a significantly lower BP value. If the BP values were similar across models, the upper and lower 95% confidence intervals were evaluated, where a tighter range of values was considered a better model fit.

RESULTS AND DISCUSSION

Model Calibration

Variability exists when estimations are made based on regression models. Attempting to explain complex hydrological logistics with a regression model is a difficult task, especially when extrapolating for extreme values. One way to decrease the amount of variability when estimating loads in LOADEST is to ensure that the calibration data (i.e., discharge and constituent data used in the regression analysis) covers the range of flow data that will be used in estimating constituent loads (i.e., daily discharge reported by USGS). In the current study, the range in discharge reported by USGS was 0 to 5,100 cfs for Moro Creek while the calibration discharge data ranged from 4 to only 2,000 cfs. The discharge reported by USGS for Smackover Creek ranged from 1 to 4,900 cfs while the calibration discharge data ranged from 5 to only 2,270 cfs. Therefore, estimated load data should be used with caution because the upper range of observed discharge was not sampled for constituent concentrations.

Model Selections

All of the constituent loads were estimated using model 4 (Table 2). This model yielded the most accurate results in terms of the amount of variability explained by the model (R^2), BP, and confidence intervals when compared to other models in LOADEST. Load estimations for NO_3-N at both sites had the highest amount of variation, with BP of 22-24%, but still had strong R^2 values, with the model explaining approximately 82% of the variation in loads. Constituent load estimations for TN, SRP, TP, and TSS had R^2 values between 88-98% and BP less than ±5%.

Constituent Concentrations

Physical and chemical parameters including NO_3-N, TN, SRP, TP, and TSS were measured at Moro and Smackover Creeks over 89 samples across a range of hydrologic conditions. Descriptive statistics can be found in Table 3. In Moro Creek, FWC

Table 2. 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) and total suspended solids (TSS) for Moro Creek (USGS 07362500) and Smackover Creek (USGS 07362100) for calendar years 2013 to 2014, with respective R^2 values, Akaike Information Criterion (AIC), load bias percentages (BP), and lower and upper values of the 95% confidence intervals (CI). Model 4 was always selected as the best fit model for each load estimation.

Constituent	Regression equation	R^2 (%)	AIC	BP (%)	Lower CI (kg d^{-1})	Upper CI (kg d^{-1})
	Moro Creek					
NO_3-N	$2.74 + 1.02lnQ + 1.01\sin(2\pi dtime) + 0.27\cos(2\pi dtime)$	81.99	2.156	24	31	49
TN	$4.99 + 1.06lnQ + 0.33\sin(2\pi dtime) + 0.01\cos(2\pi dtime)$	98.34	-0.202	2	321	372
SRP	$1.15 + 0.86lnQ + 0.42\sin(2\pi dtime) - 0.14\cos(2\pi dtime)$	89.41	1.161	-4	4	6
TP	$2.88 + 0.99lnQ + 0.43\sin(2\pi dtime) - 0.03\cos(2\pi dtime)$	96.80	0.243	-3	32	38
TSS	$7.56 + 1.20lnQ + 0.82\sin(2\pi dtime) + 0.27\cos(2\pi dtime)$	88.86	1.987	-4	5254	8249
	Smackover Creek					
NO_3-N	$2.92 + 1.07lnQ + 1.16\sin(2\pi dtime) + 0.41\cos(2\pi dtime)$	82.31	2.025	22	34	54
TN	$5.20 + 1.05lnQ + 0.34\sin(2\pi dtime) + 0.08\cos(2\pi dtime$	98.12	-0.276	0.3	313	359
SRP	$0.05 + 0.95lnQ + 0.50\sin(2\pi dtime) - 0.03\cos(2\pi dtime)$	92.56	0.811	-0.5	5	7
TP	$3.19 + 1.06lnQ + 0.47\sin(2\pi dtime) + 0.13\cos(2\pi dtime)$	96.69	0.276	-0.5	41	50
TSS	$8.20 + 1.35lnQ + 0.73\sin(2\pi dtime) + 0.31\cos(2\pi dtime)$	89.29	2.009	6	10385	17424

for NO_3-N was 0.087 mg L^{-1}.This accounted for 12% of TN, which had a FWC of 0.73 mg L^{-1}. The FWC for SRP was 0.011 mg L^{-1}, 14% of TP, which had a FWC of 0.080 mg L^{-1}. The FWC for TSS was 17.6 mg L^{-1}. In Smackover Creek, FWC for NO_3-N was 0.092 mg L^{-1}, 13% of TN, which had a FWC of 0.71 mg L^{-1}. The FWC for SRP was 0.013 mg L^{-1}, 13% of TP, which had a FWC of 0.100 mg L^{-1}. The FWC for TSS was 31.5 mg L^{-1}.

FWCs for NO_3-N and TN were similar between sites and varied less than 15%. SRP, TP, and TSS FWCs were 18%, 25%, and 79% greater, respectively, at Smackover Creek in comparison to Moro Creek, and could be a result of differences in land use across the watersheds. At both Moro and Smackover Creeks, the FWCs were lower than the arithmetic average concentrations for all measured constituents except for TSS.

Nutrient and sediment concentrations varied with episodic rain events. NO_3-N and SRP concentrations were lower during higher flows at both sites. TSS concentrations tended to increase with greater flow at Smackover Creek; however, this pattern was not observed for Moro Creek.

Moro Creek Constituent Loads

Discharge volume

Annual discharge volume in Moro Creek was approximately 212,000,000 m^3 in 2013, 32% greater than in 2014 (Table 4). Monthly discharge volumes ranged from 130,000 m^3 in July 2013 to 64,160,000 m^3 in December 2013. Monthly discharge generally followed seasonal patterns with low total discharge during the summer and early fall months and higher flows during late winter and early spring (Table 5). However, one exception to this pattern occurred due to an unusually large storm event in December 2013, where total discharge volume was 64,000,000 m^3 compared to December 2014 when total discharge volume was just 3,000,000 m^3 (Table 5).

Table 3. Summary of descriptive statistics including mean, standard deviations (Std), 10, 25, 50, 75, and 90th percentiles, and flow-weighted concentration (FWC) for constituent concentrations (mg L^{-1}) of nitrate-N (NO_3-N), total nitrogen (TN), soluble reactive phosphorus (SRP), total phosphorus (TP) and total suspended solids (TSS) collected during the period of November 2013 to September 2014 at Moro Creek (USGS 07362500) and Smackover Creek (USGS 07362100).

Constituent	Mean	Std	Percentile					FWC
			10%	25%	50%	75%	90%	
Moro Creek								
NO_3^--N	0.127	0.087	0.033	0.061	0.118	0.152	0.253	0.087
TN	0.76	0.21	0.55	0.64	0.74	0.87	0.97	0.73
SRP	0.017	0.013	0.006	0.009	0.014	0.022	0.031	0.011
TP	0.093	0.034	0.050	0.068	0.092	0.116	0.128	0.080
TSS	17.4	23.0	4.3	7.7	11.3	19.9	26.5	17.6
Smackover Creek								
NO_3^--N	0.127	0.085	0.019	0.050	0.118	0.201	0.229	0.092
TN	0.75	0.22	0.49	0.62	0.74	0.85	0.94	0.71
SRP	0.017	0.010	0.008	0.011	0.014	0.021	0.030	0.013
TP	0.108	0.047	0.054	0.080	0.106	0.122	0.142	0.100
TSS	26.0	24.6	6.7	11.2	17.2	30.5	55.8	31.5

Nitrogen

Annual TN loads varied with differences in discharge volume, where the load in 2013 was approximately 139,300 kg, 23% greater than the 2014 load (Table 4). Estimated loads for NO_3-N were similar and varied less than 15% across years, where loads were approximately 13,500 and 15,000 kg for 2013 and 2014, respectively. On an annual basis, the amount of dissolved nitrogen as NO_3-N made up approximately 11% of TN.

Monthly TN and NO_3-N loads followed seasonal patterns and discharge volumes, which is expected since discharge and time of year were used in the regression analyses and model formulations. Monthly TN loads ranged from 107 to 40,200 kg. The greatest monthly TN loads generally occurred in April of both years, where loads were approximately 30,000 kg. However, monthly TN load was greatest in December 2013, which relates to the greatest monthly discharge volume during the study period. Monthly NO_3-N loads ranged from 26 to 4,480 kg, with the greatest loads occurring in April. On a monthly basis, dissolved nitrogen as NO_3-N made up 5% to 28% of TN and followed a seasonal pattern where the proportion was greatest during May through August and smallest during November through February.

Phosphorus

Total annual loads for TP varied with differences in discharge volume, where the load in 2013 was approximately 13,700 kg, 16% greater than the 2014 load (Table 4). Estimated loads for SRP were approximately 1,950 and 1,760 kg for 2013 and 2014, respectively, varying less than 15% across years. Dissolved phosphorus in the form of SRP composed approximately 15% of TP during the study period.

Monthly TP and SRP loads followed seasonal patterns and varied with discharge. The range in monthly loads of TP was 18 to 3,690 kg. The greatest monthly TP loads generally occurred in April, except in December of 2013, when loads were the highest, which corresponds to the highest monthly discharge volume during the study period. Monthly SRP loads ranged from 5 to 500 kg. Again, aside from the large storm event that resulted in very high loads in December of 2013, the highest loads occurred in April of each year. On a monthly

Table 4. Summary of calculated annual discharge (Q) and annual loads for nitrate-N (NO_3-N), total nitrogen (TN), soluble reactiv phosphorus (SRP), total phosphorus (TP) and total suspended solids (TSS) for Moro Creek (USGS 07362500) and Smackover Cree USGS 07362100) for calendar years 2013 and 2014.

Site	Year	Annual Q (m^3)	NO_3-N (kg)	TN (kg)	SRP (kg)	TP (kg)	TSS (kg)
Moro Creek	2013	211,920,000	13,500	139,300	1,950	13,700	2,454,000
	2014	159,920,000	15,000	113,000	1,760	11,800	2,384,000
Smackover Creek	2013	185,180,000	13,100	115,500	2,100	15,300	4,394,000
	2014	192,940,000	18,200	129,600	2,350	17,800	5,512,000

basis, dissolved phosphorus as SRP made up 13% to 30% of the TP loads and followed a seasonal pattern where the proportion was greatest during July through September and smallest during January through May.

Sediment

Annual TSS loads were similar across 2013 and 2014, varying less than 15%, with total annual loads of 2,454,000 and 2,384,000 kg, respectively (Table 4).

Monthly TSS loads followed seasonal patterns and varied with discharge. TSS loads ranged from 1,640 to 779,900 kg and were highest in April of both years. While the maximum monthly loads for nutrients occurred during the maximum monthly discharge (i.e. December 2013), TSS increased during this time, but loads were not greater than estimated for April of both years.

Smackover Creek

Discharge volume

Annual discharge volume was similar across both 2013 and 2014 (varied less than 15%). Smackover Creek had total annual discharge of approximately 185,000,000 m^3 in 2013 and 193,000,000 m^3 in 2014 (Table 4). Monthly discharge volumes ranged from 162,000 m^3 in August 2013 to 70,000,000 m^3 in December 2013 and generally followed seasonal patterns with less total discharge during the summer and early fall months and greater flows during late winter and early spring (Table 6). One exception to this pattern was the extremely large total monthly volume, approximately 70,000,000 m^3, in December 2013 when the watershed received an unusually large storm event, compared to total discharge volume of only 6,000,000 m^3 in December 2014 (Table 6).

Nitrogen

Total annual loads for TN were similar between 2013 and 2014, with loads of approximately 116,000 and 130,000 kg, respectively (Table 4). Total annual loads for NO_3-N were 39% greater in 2014 than in 2013, where loads were approximately 18,000 and 13,000 kg, respectively (Table 4). Dissolved nitrogen as NO_3-N made up approximately 11% of TN in 2013 and 14% of TN in 2014.

Monthly TN and NO_3-N loads followed seasonal patterns and varied with discharge. Monthly TN loads ranged from 125 to 39,000 kg in 2013 and 2014, with the greatest loads generally occurring in April. However, the exception to this trend occurred in December 2013, when total TN load was 40,000 kg, compared to just 3,000 kg in 2014. This difference is related to large variability in total discharge during December 2013 and 2014. Monthly NO_3-N loads ranged from 31 to 4,910 kg in 2013 and 2014, with the greatest loads occurring in April. NO_3-N loads were relatively high during December 2013 compared to December 2014, again, likely a result of the large difference

Table 5. Summary of calculated monthly discharge (Q) and monthly loads for nitrate-N (NO_3-N), total nitrogen (TN), soluble reactive phosphorus (SRP), total phosphorus (TP) and total suspended solids (TSS) for Moro Creek (USGS 07362500) during calendar years 2013 and 2014.

Site	Year	Month	Monthly Q (m^3)	NO_3-N (kg)	TN (kg)	SRP (kg)	TP (kg)	TSS (kg)
Moro Creek	2013	January	30,740,000	1,030	17,300	253	1,690	209,200
	2013	February	27,040,000	1,220	16,000	217	1,530	241,700
	2013	March	25,300,000	1,700	16,500	224	1,620	312,700
	2013	April	40,390,000	4,210	30,700	392	3,010	753,200
	2013	May	10,480,000	1,990	9,100	161	1,050	257,000
	2013	June	2,300,000	515	1,990	49	262	50,000
	2013	July	130,000	30	107	5	18	1,900
	2013	August	180,000	33	136	7	24	1,900
	2013	September	380,000	43	275	11	42	3,440
	2013	October	680,000	49	421	17	64	4,030
	2013	November	10,150,000	432	6,400	117	691	75,500
	2013	December	64,160,000	2,220	40,200	500	3,690	543,400
	2014	January	14,640,000	484	7,900	132	808	88,200
	2014	February	31,430,000	1,250	18,600	235	1,720	270,700
	2014	March	24,880,000	1,540	15,800	220	1,550	277,200
	2014	April	41,830,000	4,480	31,900	416	3,160	779,900
	2014	May	12,280,000	2,170	10,600	177	1,180	292,700
	2014	June	15,700,000	3,640	15,400	251	1,740	499,900
	2014	July	1,070,000	260	925	33	142	18,900
	2014	August	1,440,000	287	1,200	43	186	23,000
	2014	September	190,000	26	137	7	23	1,640
	2014	October	7,200,000	556	5,470	116	650	80,700
	2014	November	6,190,000	280	3,710	89	446	38,300
	2014	December	3,060,000	103	1,540	42	190	12,500

in discharge during that time. On a monthly basis, dissolved nitrogen as NO_3-N made up 5% to 30% of TN during the study period, following a seasonal pattern with the greatest proportion from June through August and the smallest proportion in November through February.

Phosphorus

Total annual loads for TP were similar between years, with loads of 15,300 and 17,800 kg for 2013 and 2014, respectively (Table 4). Estimated annual loads for SRP loads were also similar between 2013 and 2014 with loads of 2,100 kg and 2,350 kg, respectively. On an annual basis, dissolved phosphorus in the form of SRP made up approximately 13% of TP during the study period.

Monthly TP and SRP loads were related to discharge volumes and followed seasonal patterns. Monthly TP loads ranged from 19 to 5,170 kg (Table 6). The greatest monthly TP loads generally occurred from April to June of both years. However, the exception to this trend occurred in December 2013 when the monthly load was 4,860 kg, the highest of 2013, which related to the greatest monthly discharge volume during the study period. Total monthly loads for SRP ranged from 5 to 660 kg and followed a similar pattern to TP, where the greatest loads generally occurred from

Table 6. Summary of calculated monthly discharge (Q) and monthly loads for nitrate-N (NO_3-N), total nitrogen (TN), soluble reactive phosphorus (SRP), total phosphorus (TP) and total suspended solids (TSS) for Smackover Creek (USGS 07362100) during calendar years 2013 and 2014.

Site	Year	Month	Monthly Q (m^3)	NO_3-N (kg)	TN (kg)	SRP (kg)	TP (kg)	TSS (kg)
Smackover Creek	2013	January	21,290,000	567	10,800	192	1,290	259,800
	2013	February	13,670,000	438	7,010	124	858	159,300
	2013	March	9,190,000	462	5,180	96	667	122,900
	2013	April	24,500,000	2,160	16,700	286	2,300	672,300
	2013	May	11,080,000	1,980	9,120	181	1,360	419,000
	2013	June	17,360,000	4,310	16,300	313	2,540	1,064,000
	2013	July	837,000	210	742	22	114	20,400
	2013	August	162,000	31	125	5	19	1,670
	2013	September	379,000	41	263	9	37	3,690
	2013	October	1,840,000	122	1,170	33	155	21,000
	2013	November	14,480,000	609	8,560	182	1,080	220,600
	2013	December	70,380,000	2,210	39,600	660	4,860	1,429,000
	2014	January	13,430,000	341	6,560	125	782	125,500
	2014	February	26,340,000	843	13,800	230	1,700	379,700
	2014	March	39,870,000	2,090	23,900	378	3,100	893,900
	2014	April	52,150,000	4,910	37,100	588	5,170	1,913,000
	2014	May	22,510,000	4,040	19,000	344	2,850	1,109,000
	2014	June	12,140,000	3,050	11,200	235	1,740	605,300
	2014	July	4,920,000	1,400	4,710	119	740	208,700
	2014	August	2,630,000	604	2,330	68	355	69,300
	2014	September	1,020,000	139	769	25	110	13,500
	2014	October	3,610,000	271	2,440	64	329	57,200
	2014	November	8,130,000	328	4,660	108	583	92,900
	2014	December	6,160,000	164	3,020	68	360	43,600

April to June. However, the maximum estimated load occurred in December 2013. On a monthly basis, dissolved phosphorus as SRP made up 11% to 26% of the TP load during the study period and followed a pattern where the proportion was greatest from August through October and lowest from March through June.

Sediment

Annual TSS loads were approximately 4,300,000 kg in 2013 and 5,500,000 kg in 2014, a 25% increase between years. Total monthly TSS loads generally followed seasonal and discharge patterns. Monthly TSS loads ranged from 1,670 to 1,913,000 kg during the study period and were generally greatest in April through June. December 2013 was an exception with a load of 1,429,000 kg, which related to the greatest monthly discharge volume during the study period.

CONSIDERATIONS IN WATERSHED MODELING

The monthly constituent loads at the two USGS sites can be used to evaluate how well the watershed model is predicting the loss of nitrogen, phosphorus, and sediment. However, the modeling period and monitoring program do not overlap temporally. So, an approach must look at how these loads (model vs. regression estimates) compared over the range of monthly discharge. The monthly load-discharge relations should be relatively similar, if anthropogenic and climatic factors driving constituent transport have not changed significantly over time.

This approach has been previously applied to three ANRC 319 NPS priority watersheds, including the Poteau River, Saline River, and Strawberry River Watersheds (Haggard, 2013). This technical report has been expanded into a journal manuscript detailing the statistical and qualitative procedures for post-validation of watershed models (McCarty et al., 2015). At the other watersheds, this approach increased our confidence in the watershed model developed to prioritize HUC 12 subwatersheds in two watersheds (Poteau and Saline Watersheds). However, it suggested that the watershed model developed for the Strawberry River Watershed might need to be recalibrated based on the available monitoring data. This same approach should and can be applied to the efforts in the Lower Ouachita-Smackover Watershed.

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