Arkansas Water Resources Center

WATER QUALITY SAMPLING, ANALYSIS AND ANNUAL LOAD DETERMINATIONS FOR TSS, NITROGEN AND PHOSPHORUS AT THE WASHINGTON COUNTY ROAD 195 BRIDGE ON THE WEST FORK OF THE WHITE RIVER

Submitted to the
Arkansas Soil and Water Conservation Commission

By
Marc Nelson
And
Wade Cash
Arkansas Water Resources Center
Water Quality Lab
University of Arkansas
Fayetteville, Arkansas 72701

And
Sandi Formica
Arkansas Department
Arkansas Department of Environmental Quality
Little Rock, Arkansas

November 2003

Publication No. MSC-311

Arkansas Water Resources Center
112 Ozark Hall
University of Arkansas
Fayetteville, Arkansas 72701

WATER QUALITY SAMPLING, ANALYSIS AND ANNUAL LOAD DETERMINATIONS FOR TSS, NITROGEN AND PHOSPHORUS AT THE WASHINGTON COUNTY ROAD 195 BRIDGE ON THE WEST FORK OF THE WHITE RIVER

2002 ANNUAL REPORT

Submitted to:

Arkansas Soil and Water Conservation Commission

By
Marc Nelson
And
Wade Cash
AWRC Water Quality Lab
Arkansas Water Resources Center
University of Arkansas
Fayetteville, Arkansas 72701

And
Sandi Formica
Arkansas Department of Environmental Quality
Little Rock, Arkansas

November 2003

INTRODUCTION

A water quality sampling station was installed at the Washington County Road 195 Bridge on the West Fork of the White River just above the confluence of the three main forks of the Upper White River in December 2001. The Quality Assurance Project Plan (QAPP) was approved by EPA Region Six on March 2002 and sampling was begun at that time. This station is coordinated with a USGS gauging station at the same location. This station was instrumented to collect samples at sufficient intervals across the hydrograph to accurately estimate the flux of total suspended solids, nitrogen and phosphorus into the upper end of Beaver Lake from the West Fork of the White River. The West Fork is listed on Arkansas' 1998 303d list as impaired from sediment. The Upper White was designated as the states highest priority watershed in the 1999 Unified Watershed Assessment. Accurate determination of stream nutrients and sediment is critical for future determinations of TMDLs, effectiveness of best management practices and trends in water quality.

SCOPE

This project is a cooperative effort between AWRC and the ADEQ Environmental Preservation and Planning Divisions. All aspects of the project are coordinated with and subject to technical review and comments from ADEQ. This report is for 2002 water quality sampling, water sample analysis and annual pollutant load calculations at the Washington County Road 195 Bridge on the West Fork of the White River. The parameters measured from collected samples were nitrate-nitrogen, ammonia-nitrogen, total Kjeldahl nitrogen, total phosphorus, dissolved reactive phosphorus and total suspended solids. In addition turbidity, conductivity and pH were measured in-situ and recorded in thirty-minute intervals. Also, the AWRC in conjunction with the USGS conducted cross-section sampling to determine the relationship between autosampler concentrations and cross-section concentrations.

METHODS

Initially the sampler was operated in a discrete mode taking samples at thirty-minute intervals for the first twenty-four samples and sixty-minute intervals for the next twenty-four samples. The sampler was set to begin taking samples when the stage rises to ten percent over the prior baseflow. Trigger levels were evaluated and modified based on load calculation optimization techniques. Discrete samples were collected when all twenty-four bottles were filled or within forty-eight hours after the first sample. Grab samples were taken often enough to have three samples between each storm. The sampler was operated using this protocol until three storms were adequately sampled. The results from this initial sampling phase were used to determine the sampling start (trigger) and frequency for flow-weighted composite sampling. In addition, the results were used to develop rating curves to predict pollutant concentrations as a function of discharge in order to calculate loads for inadequately sampled storm events.

After the initial phase, the sampler was reconfigured to take flow-weighted composite samples. The sampler began sampling after the stage exceeded a set trigger level of five feet. It took a discrete sample after a fixed volume of water had passed. The volume of water used for the flow weighted composite samples, i.e. sampling frequency, was 4 million cubic feet, as determined from the initial sampling phase. The discrete samples were composited by combining equal volumes of each into a single sample for analysis. Discrete samples were collected for compositing when all twenty-four bottles were filled or within forty-eight hours after the first sample. Storms were sampled in this manner for the period when the river stage was above the trigger level. Grab samples were taken every two weeks after the initial sampling phase. All samples were collected by AWRC Field Services Personnel and transported to the AWRC Water Quality Laboratory for analysis. All samples were analyzed for nitrate-nitrogen, ammonia-nitrogen, total Kjeldahl nitrogen, total phosphorus, dissolved reactive phosphorus and total suspended solids.

In addition to the above sampling for load determination, the AWRC in conjunction with the USGS conducted cross-section sampling to determine the relationship between autosampler concentrations and cross-section concentrations. The USGS collected evenly weighted integrated (EWI) cross section samples at the same time AWRC collected discrete autosamples. All samples were transported and analyzed by the AWRC Water Quality Lab and the results used to determine correction factors for the auto sample concentrations. Three storm flow samples were taken and compared during each year.

All samples taken and used for analysis will be done in accordance with an approved quality assurance project plan. This QAPP was prepared by the AWRC and submitted to the ASWCC for approval. The ASWCC reviewed the plan for conformance to it's Quality Management Plan and submitted the QAPP to EPA, Dallas for review and approval. The plan was approved on March 19, 2002.

RESULTS

Sampling began with the approval of the QAPP on March 11, 2002 and continued through the end of the year. During the first year, 220 individual samples were collected and analyzed. They include 20 base-flow grab samples, 143 discrete storm samples, and 4 USGS cross-section samples. The stage for 2002, as well as the concentration results from the samples, is summarized in Figure 1 and Table 1.

Figure 1. 2002 Stage and Concentrations

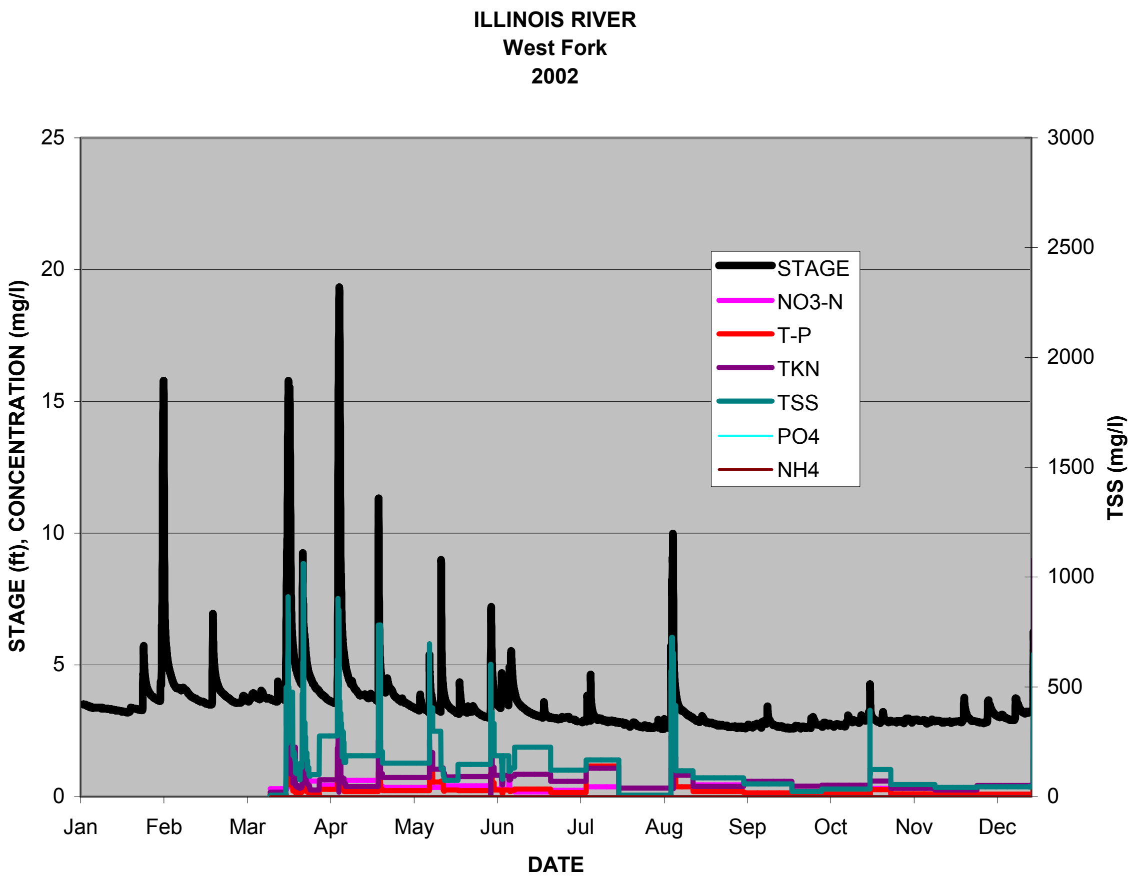


Table 1. 2002 partial year loads and mean concentrations.

parameter	Loads (kg)	Mean Concentrations (mg/l)
Nitrate-N	43,560	0.50
Total Phosphorus	46,148	0.53
Ammonia-N	4,165	0.05
TKN	90,548	1.03
Phosphate-P	6,506	0.07
TSS	29,005,061	331

Discrete storm samples were collected on 5 storms in 2000 using 190 individual samples. The results from three of these storms are illustrated in Figure 2. These results were modeled using least-squares linear regressions to determine a relationship between concentrations and stage. These relationships can be used to predict concentrations of the different constituents as a function of stage during storm events if actual measured values are unavailable due to equipment failure. The relationships determined are summarized in Table 2. Although these relationships were determined, they were not used to model any of the storm events during the project since all storms were sampled adequately.

Figure 2.

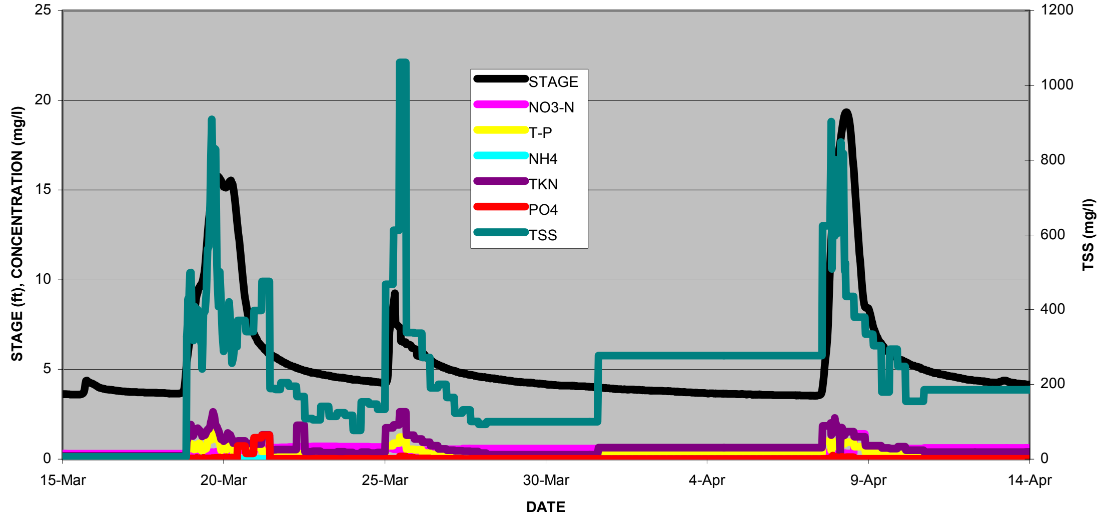


Table 2. Regression equations determined from discrete storm samples

parameter	Regression equation	Regression coefficient
Nitrate-N	y = -0.086x + 0.5135	$R^2 = 0.0682$
Total Phosphorus	y = 0.0436x + 0.2107	$R^2 = 0.4002$
Ammonia-N	y = 0.0026x + 0.0344	$R^2 = 0.1666$
TKN	y = 0.0585x + 0.7199	$R^2 = 0.2201$
Phosphate-P	y = 0.0049x + 0.0087	$R^2 = 0.1339$
TSS	y = 33.248x + 69.527	$R^2 = 0.4742$

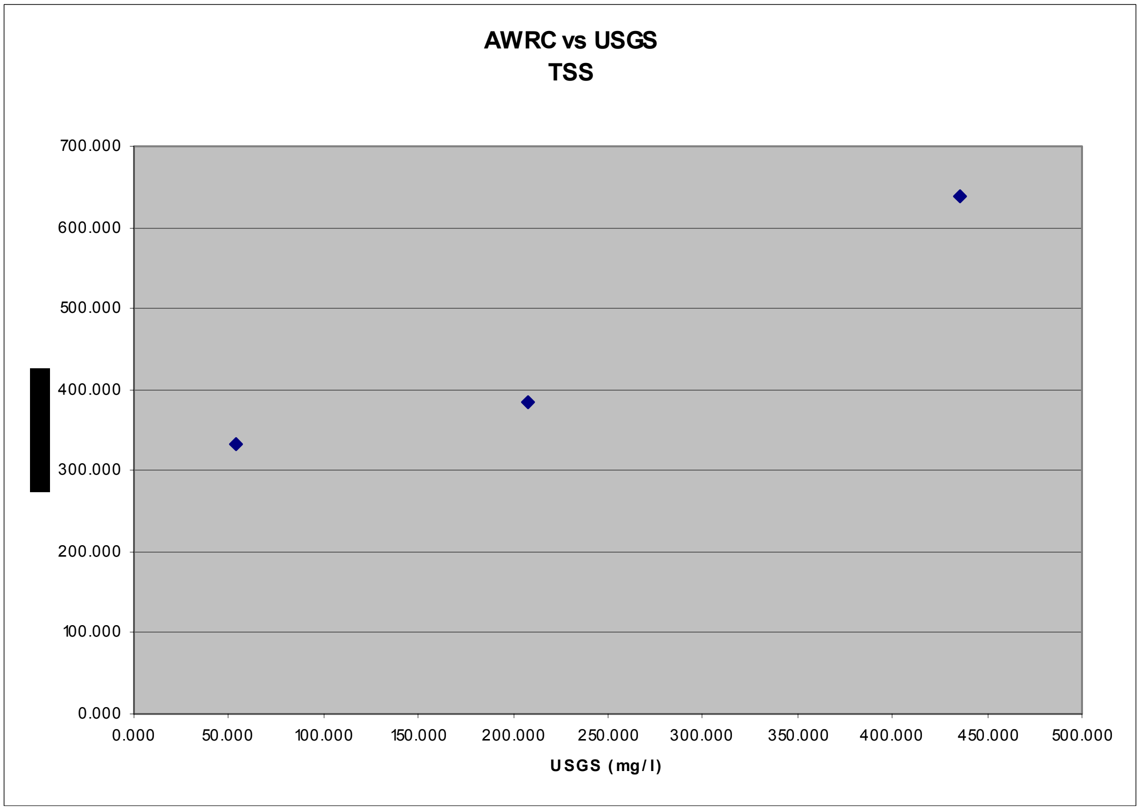
The loads and mean concentrations can be segregated into storm-flow and base-flow using the trigger level as an arbitrary distinction between flow regimes. Using the trigger level value of 4 feet, the segregated loads and mean concentrations for 2002 are shown in Table 3.

Table 3. Storm-flow and Base-flow loads and Mean Concentrations Partial Year 2002.

	Storm Loads (kg)	Base Loads (kg)	Storm Concentrations (mg/l)	Base Concentrations (mg/l)
VOLUME (M3)	50,520,135	58,716,002		
NO3-N	26,249	17,310	0.52	0.29
T-P	37,149	8,999	0.74	0.15
NH4	2,863	1,302	0.06	0.02
TKN	68,535	22,013	1.36	0.37
PO4	5,651	855	0.11	0.01
TSS	23,116,847	5,888,215	458	100

Three paired USGS and AWRC storm samples were collected during the year to investigate the relationship between single point samples and cross-section samples. The results are shown in Figure 3. The results, while preliminary, indicate that the AWRC single point samples may be overestimating the TSS concentrations during storms relative to the whole cross-section. This potential error will be further investigated in the future.

Figure 3



DISCUSSION

West Fork @ 195 Bridge site during 2002 can be compared to loads and concentrations developed in other watersheds in Northwest Arkansas. Five other watersheds have been monitored using the same monitoring and load calculation protocols. The only differences between the protocols are that trigger levels and storm composite sample volumes are different for each site. This means that the distinction between storm and base flows (defined here as the trigger level) may be relatively different at each site.

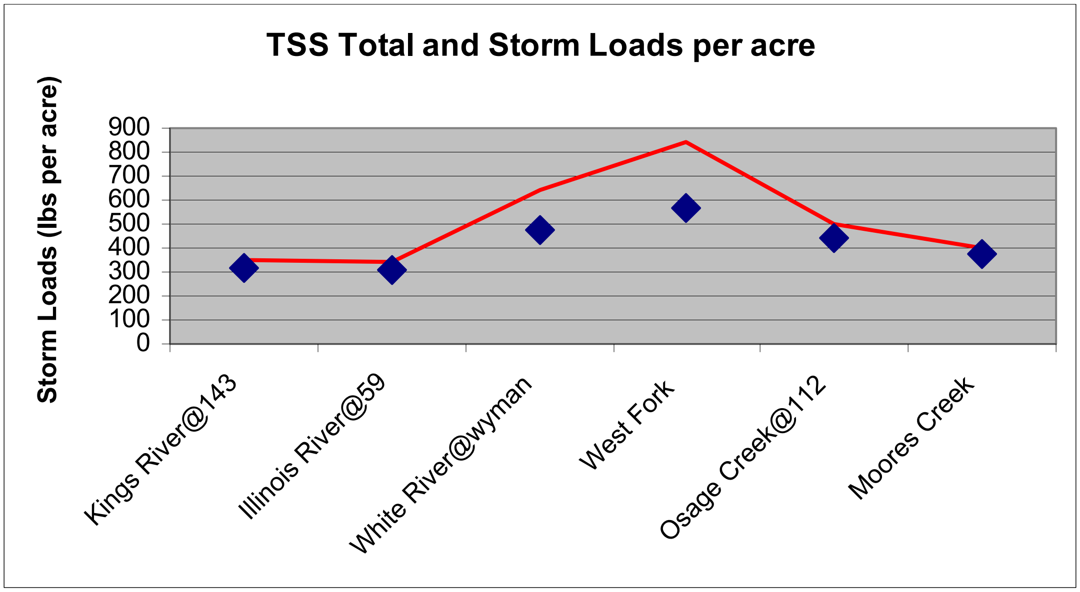
The results for the six watersheds are summarized in Table 4 and Figure 4. The results shown for the West Fork are annual values from March 11, 2002 to March 10, 2003. The table and figure show TSS and phosphorus as total annual loads per watershed acre, as storm loads per watershed acre and as base-flow concentrations. Normalizing total and storm loads to a per acre basis allows comparison between watersheds of differing sizes. The total loads indicate the mass of TSS or P that are being transported to a receiving water body. Storm loads per acre may be used to represent relative impacts from non-point sources. In Figure 4, a red line represents the total loads and blue diamonds represents the storm loads. The West Fork watershed has high levels of total TSS compared to the others and while most of the TSS is transported during storm events, a significant percentage is transported during base-flow conditions. The P load for the West Fork is similar to the other watersheds with the primary transport occurring during storm events.

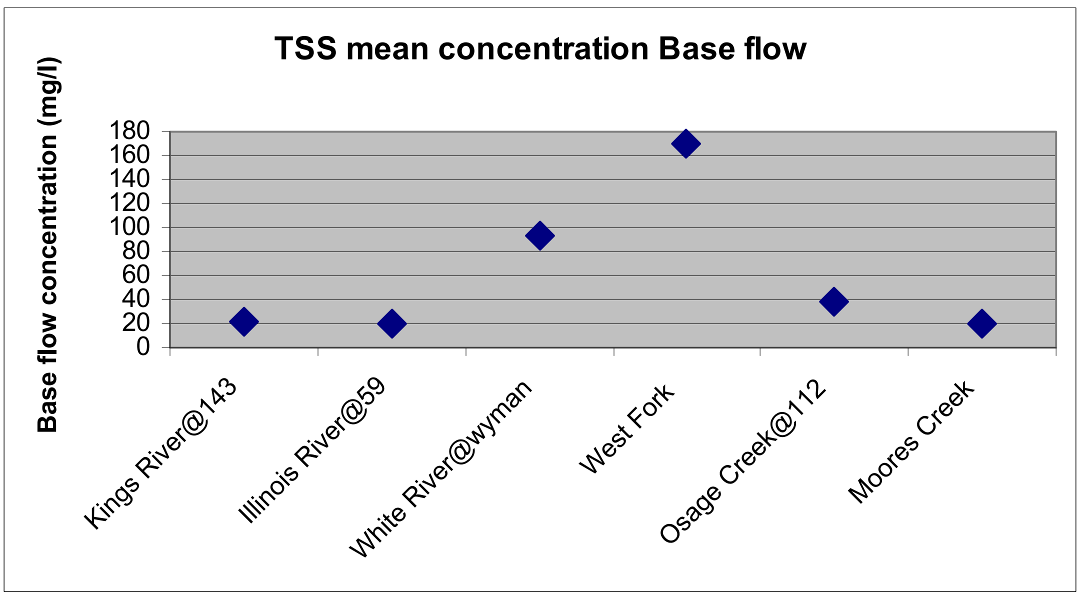
The base-flow concentrations show relative levels of TSS and P that are impacting in-stream biological activity during most of the year. These are the values that are of greatest interest for determining impacts to in-stream macro invertebrate habitat and nuisance algae production. The base-flow TSS is significantly higher than the other watersheds. The base-flow concentration of T-P is consistent with the other watersheds that have point-source discharges by WWTPs (all except Moores Creek).

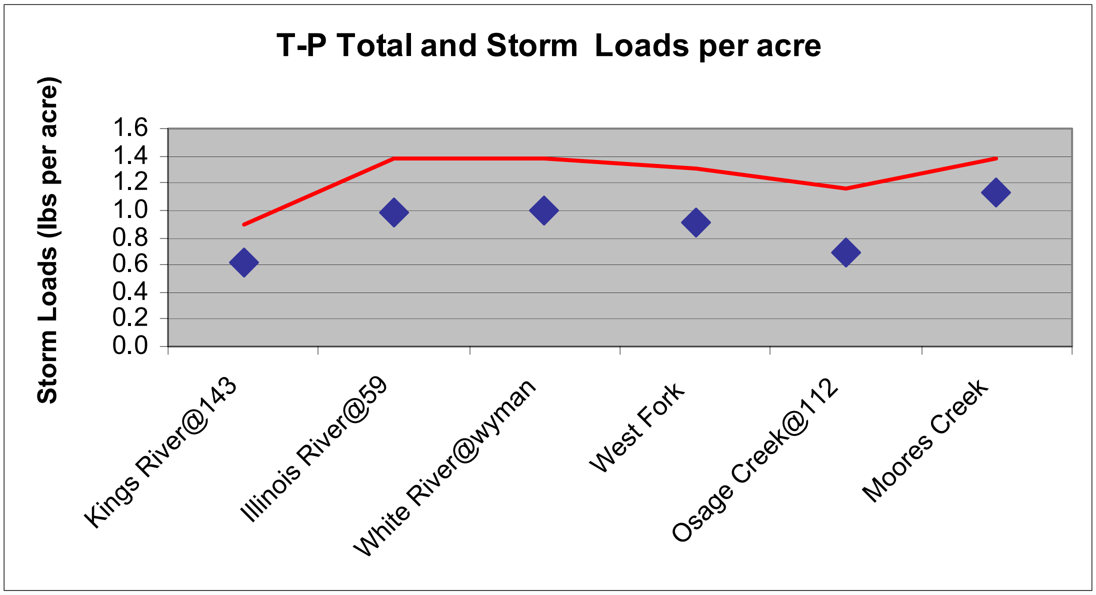
Table 4. Comparison of results to other Northwest Arkansas Watersheds.

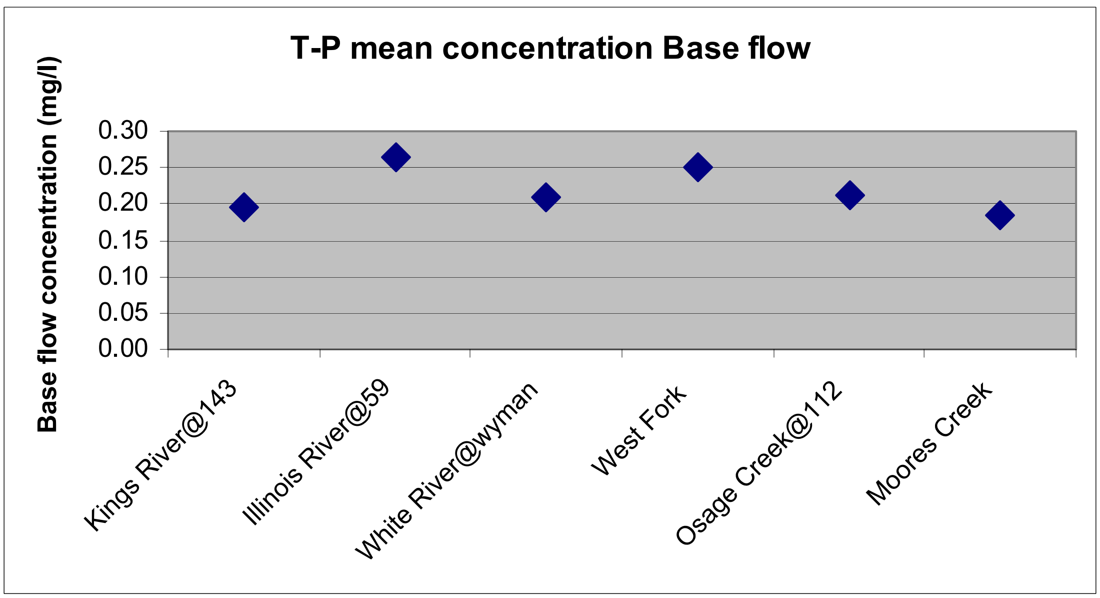
	Kings River@143	Illinois River@59	White River@wyman	West Fork	Osage Creek@112	Moores Creek
ACRES	337,280	368,000	256,000	65920	22,208	2,200
YEARS of data	4	6	1	1	2	3
tss load (#/acre)	351	340	644	839	501	401
tss load storm (#/acre)	320	312	475	570	442	377
tss conc. base (mg/l)	21	20	93	170	39	20
p load (#/acre)	0.89	1.38	1.38	1.30	1.16	1.38
p storm load (#/acre)	0.62	0.98	1.00	0.91	0.70	1.13
p base conc. (mg/l)	0.19	0.26	0.21	0.25	0.21	0.19
DISCHARGE (ft3)	1.0E+10	1.9E+10	1.5E+10	3.5E+09	1.4E+09	9.6E+07
DISCHARGE/AC (ft3/acre)	29,528	52,625	57,847	53,419	62,066	43,804

Figure 4. Comparisons between 6 watersheds.






T-P Total and Storm Loads per acre
Storm Loads (lbs per acre)
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
Kings River@143
Illinois River@59
White River@wyman
West Fork
Osage Creek@112
Moores Creek


T-P mean concentration Base flow
Base flow concentration (mg/l)
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Kings River@143
Illinois River@59
White River@wyman
West Fork
Osage Creek@112
Moores Creek

REFERENCES

Nelson, M.A., T.S. Soerens, J. Spooner "Results of Investigation of Optimum Sample Interval for Determining Storm Water Pollutant Loads", Proceedings of the Water Environment Federation WEFTEK Conference, New Orleans, LA, 1999.

Nelson, M.A., T.S. Soerens "1997 Pollutant Loads At. Arkansas Highway 59 Bridge" Presented at Arkansas-Oklahoma Arkansas River Compact Commission Meeting, September 1998.

Nelson, M.A., T.S. Soerens "1998 Pollutant Loads At. Arkansas Highway 59 Bridge" Arkansas Water resources Center Publication, 1999.

Nelson, M.A., T.S. Soerens "1999 Pollutant Loads At. Arkansas Highway 59 Bridge" Arkansas Water resources Center Publication, 2000.

Nelson, M.A., T.S. Soerens "2000 Pollutant Loads At. Arkansas Highway 59 Bridge" Arkansas Water resources Center Publication, 2001.

Nelson, M.A., T.S. Soerens "2001 Pollutant Loads At. Arkansas Highway 59 Bridge" Arkansas Water resources Center Publication, 2002.

Nelson, M.A., T.S. Soerens, J. Spooner " Preliminary Results of Investigation of Optimum Sample Interval for Determining Storm Water Pollutant Loads", Presented at ASCE Watershed Management Conference, Memphis, TN, 1998.

Nelson, M.A., T.S. Soerens and D.G. Parker "Phosphorus Transport in the Illinois River: Preliminary Results of Intensive Sampling" Proceedings of the Arkansas Water Resource Center Annual Conference, 1998.

Parker, D.G., R. Williams and E. Teague "Illinois River Water Quality Automatic Sampler Installation" Arkansas Water Resource Center Miscellaneous Publication 0227, 1997.

Nelson, M.A., T.S. Soerens, J. Spooner "Investigation of Optimum Sample Number and Timing for Determining Storm Water Pollutant Loads Year [1998 and 1999}", Arkansas Water Resources Center Annual Report 1999-2000, August 2001.

Nelson, M.A., L.W. Cash "Water Quality Sampling, Analysis And Annual Load Determinations For TSS, Nitrogen And Phosphorus At The Wyman Road Bridge On The White River, Final Report" Arkansas Water Resources Center Publication, 2003.

Nelson, M.A., L.W. Cash "Illinois River2002 Pollutant Loads at the Arkansas Highway 59 Bridge" Arkansas Water Resources Center Publication, 2003.

Nelson, M.A., L.W. Cash "Water Quality Sampling, Analysis And Annual Load Determinations For TSS, Nitrogen And Phosphorus At The 143 Bridge On The Kings River, 2002 Annual Report" Arkansas Water Resources Center Publication, 2003.

Nelson, M.A., S. L. Diffin "Water Quality Sampling, Analysis And Annual Load Determinations For TSS, Nitrogen And Phosphorus At The 112 Bridge On The Osage Creek, Final Report" Arkansas Water Resources Center Publication, 2003.

Nelson, M.A., L.W. Cash “Water Quality Sampling, Analysis And Annual Load Determinations For TSS, Nitrogen And Phosphorus On Moores Creek, 2002 Annual Report” Arkansas Water Resources Center Publication, 2003.