6-1-2005

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, 2004 Annual Report

Marc A. Nelson

L. Wade Cash

G. Keith Trost

Jennifer Purtle

Recommended Citation

Nelson, Marc A.; Cash, L. Wade; Trost, G. Keith; and Purtle, Jennifer. 2005. 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, 2004 Annual Report. Arkansas Water Resources Center, Fayetteville, AR. MSC322. 11

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

2004 ANNUAL REPORT

Submitted to the
Arkansas Soil and Water Conservation Commission
By

Marc A. Nelson, Ph.D., P.E.
L. Wade Cash, Research Specialist
G. Keith Trost, Research Associate
Jennifer Purtle, Research Assistant
Arkansas Water Resource Center
Water Quality Lab
University of Arkansas
Fayetteville, Arkansas

June 2005

Publication No. MSC-322

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

2004 ANNUAL REPORT

Presented to the Arkansas Soil and Water Conservation Commission
By

Marc Nelson
Wade Cash
Keith Trost
And Jennifer Purtle
University of Arkansas
AWRC- Water Quality Lab

June 2005

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 report is for 2004 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 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 rose to ten percent over the prior base flow. 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 four 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 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 auto sampler concentrations and cross-section concentrations. The USGS collected evenly weighted integrated (EWI) cross section samples at the same time AWRC collected discrete auto samples. 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. Seven samples were taken and compared during both years. All samples taken and used for analysis were 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

During 2004, 172 individual samples were collected and analyzed. They include 26 base-flow grab samples, 43 composite storm samples, 101 discrete QA samples and 1 USGS cross-section sample. The stage for 2004 as well as the concentration results from the samples is summarized in Figure 1 and Table 2.

Figure 1. 2004 Stage and Concentrations

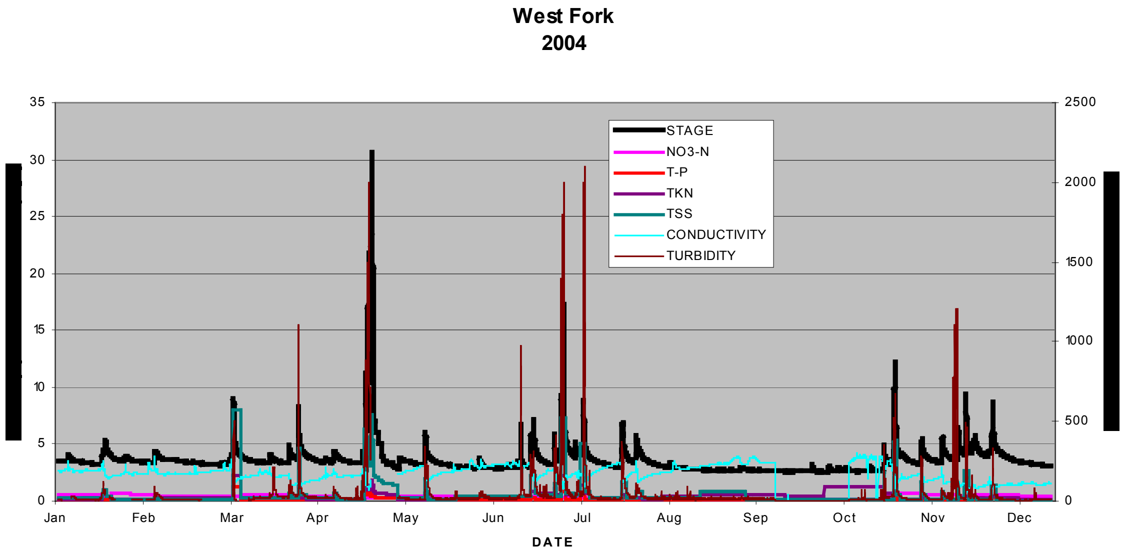


Table 2. 2004 loads and mean concentrations.

parameter	Annual Loads (kg)	Flow-weighted Mean Concentrations (mg/l)
Discharge (m3)	182,387,037	
Nitrate-N	59,705	0.33
Total Phosphorus	52,937	0.29
Ammonia-N	16,643	0.10
TKN	116,034	0.64
Phosphate-P	2,111	0.01
TSS	20,219,708	111

Discrete storm samples were collected on 5 storms in 2002 using 190 individual samples. 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 3. These relationships were used to predict storm event concentrations for one storm event during the year. That storm event began on April 23, 2004. The storm submerged the USGS sampling station and automatic sampler, so that neither stage data was recorded or samples were collected. The station was inoperable until May 5. USGS has provided daily discharge estimates for all of this time period except the first day. At the time of this report, the USGS has not finished its internal review of the indirect measurements of the daily discharge for April 23. For the purposes of this report, stage and discharge have been estimated to peak at the last available measured value and decline uniformly to the next estimated value. Since automatic sampling was not feasible during the 12 days of station outage, the concentrations of all constituents was estimated using the regression coefficients listed in table 3.

Table 3. Corrected Regression equations determined from discrete storm samples 2002

parameter	Regression equation	Regression coefficient
Nitrate-N	$y = -0.054x + 0.416$	$R^2 = 0.0379$
Total Phosphorus	$y = 0.0299x + 0.1626$	$R^2 = 0.377$
Ammonia-N	$y = 0.003x + 0.0361$	$R^2 = 0.1248$
TKN	$y = 0.0424x + 0.4855$	$R^2 = 0.224$
Phosphate-P	$y = 0.002x + 0.0035$	$R^2= 0.2611$
TSS	$y = 16.008x + 53.214$	$R^2 = 0.443$

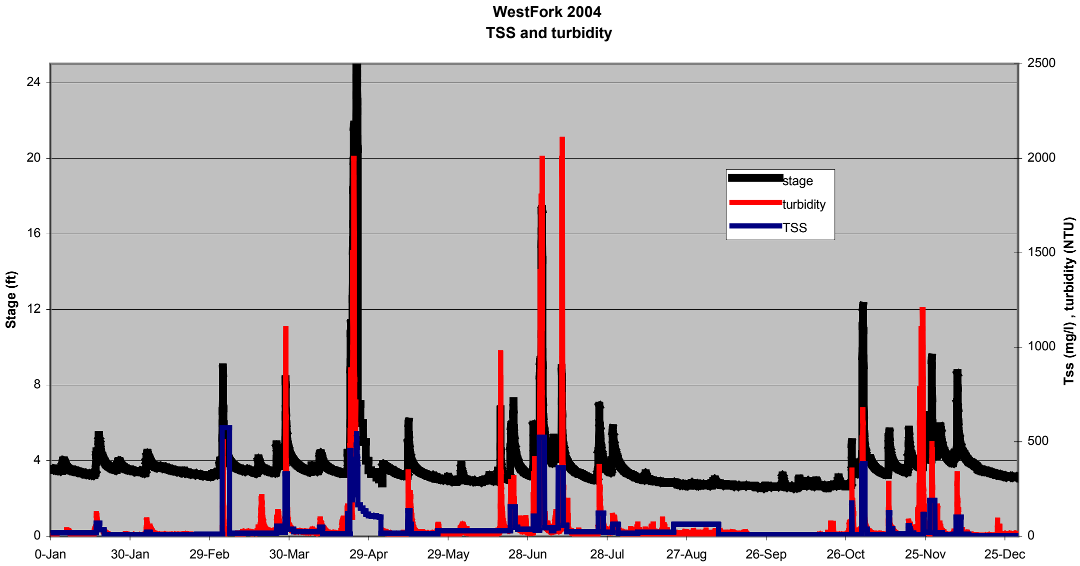
The loads and mean concentrations can be segregated into storm-flow and base-flow using the trigger level as an arbitrary distinction between flow regimes. Using the trigger level value of 4 feet, the segregated loads and mean concentrations for 2004 are shown in Table 4.

Table 4. Storm flow and Base flow Loads and Mean Concentrations 2004.

	Storm Loads (kg)	Base Loads (kg)	Storm Concentrations (mg/l)	Base Concentrations (mg/l)
Discharge (M3)	136,076,416	46,310,621		
NO3-N	43,524	16,161	0.32	0.35
T-P	52,263	669	0.38	0.01
NH4	17,013	1,329	0.13	0.03
TKN	103,719	12,316	0.76	0.27
PO4	1,866	246	0.01	0.005
TSS	19,298,049	921,660	142	20

In addition to measuring TSS, turbidity was measured and recorded every fifteen minutes during the project. Figure 5 shows the stage TSS and turbidity measured during the year. The Maximum value recorded during 2004 was 2100 NTUs. This value was above the calibration range for the meter (1 to 1000 NTUs) and may not be an accurate value. The average turbidity value for 2004 was 40 NTUs. The average turbidity measured during storm-flows was 177 NTU and the average measured during base-flows was22 NTU.

Figure 2 2004 Stage, TSS and Turbidity measurements



DISCUSSION

West Fork @ 195 Bridge site during 2004 can be compared to loads and concentrations developed in other watersheds in Northwest Arkansas. Six other watersheds in Northwest Arkansas 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 7 and Figure 8. 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. The West Fork watershed has high levels of total TSS compared to the others and most of the TSS is transported during storm events.

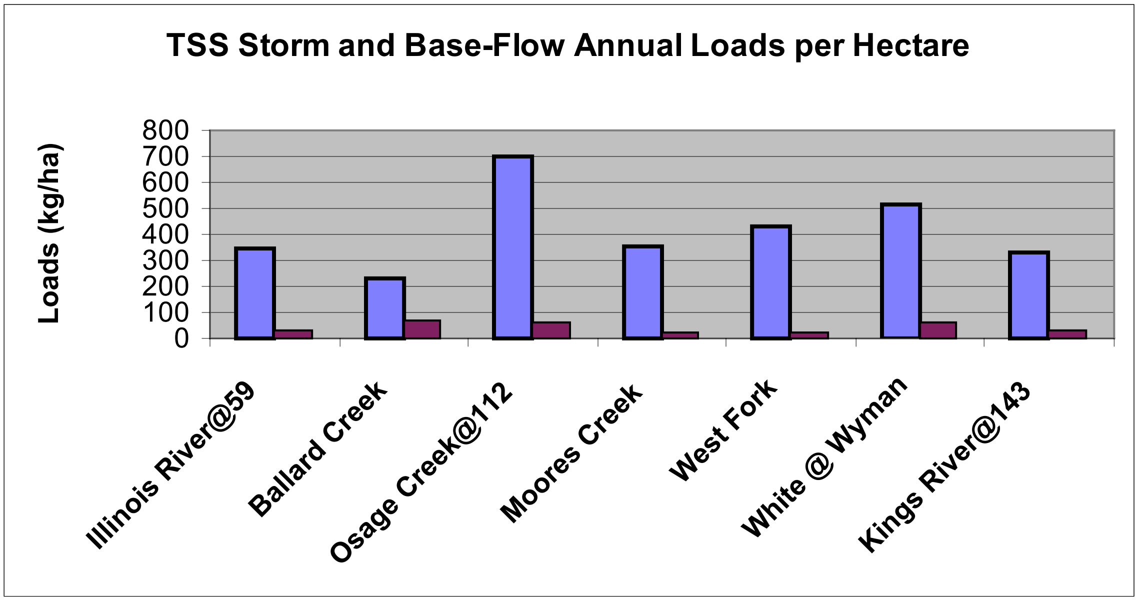
The P load for the West Fork is similar to the other watersheds with the primary transport occurring during storm events. Base Flow P concentrations are far lower than the other watersheds studied.

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 low compared to the other watersheds. The base-flow concentration of T-P is very low compared to the other watersheds. Likewise, Total Nitrogen loads and mean concentrations are the lowest of the watersheds studied.

Table 5. Comparison of seven northwest Arkansas watersheds

	Illinois River@ 59	Ballard Creek	Osage Creek@ 112	Moores Creek	West Fork	White @ Wyman	Kings River@ 143
Hectares	148,930	7,106	8,988	1,000	30,563	103,603	136,497
YEARS of data	8	2	3	4	3	2	6
tss load (kg/ha)	374	303	764	838	454	576	360
tss load storm (kg/ha)	345	232	702	781	433	514	333
tss load base (kg/ha)	29	72	62	57	22	62	27
tss conc. base (mg/l)	18	17	40	18	19	39	20
p load (kg/ha)	1.45	1.69	1.54	2.80	1.06	1.69	0.88
p storm load (kg/ha)	1.06	1.04	1.23	2.22	1.04	1.26	0.63
p load base (kg/ha)	0.39	0.66	0.30	0.58	0.02	0.44	0.24
p base conc. (mg/l)	0.23	0.16	0.19	0.17	0.02	0.24	0.20
Total Nitrogen load (kg/ha)	10.80	17.54	19.54	7.72	3.89	4.62	4.54
NO3-N base conc. (mg/l)	2.43	2.62	3.59	2.20	0.34	0.55	0.85
DISCHARGE (m^3/ha)	3,465	5,583	5,130	3,011	4,303	4,009	2,964

Figure 3. Comparison of seven watersheds



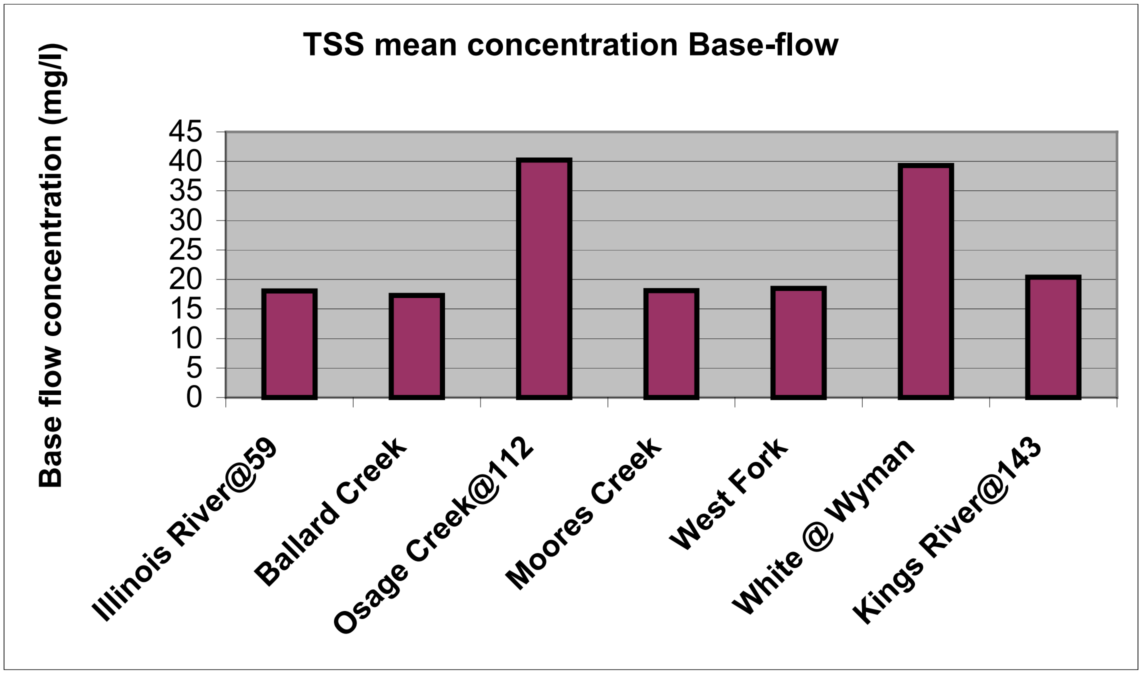
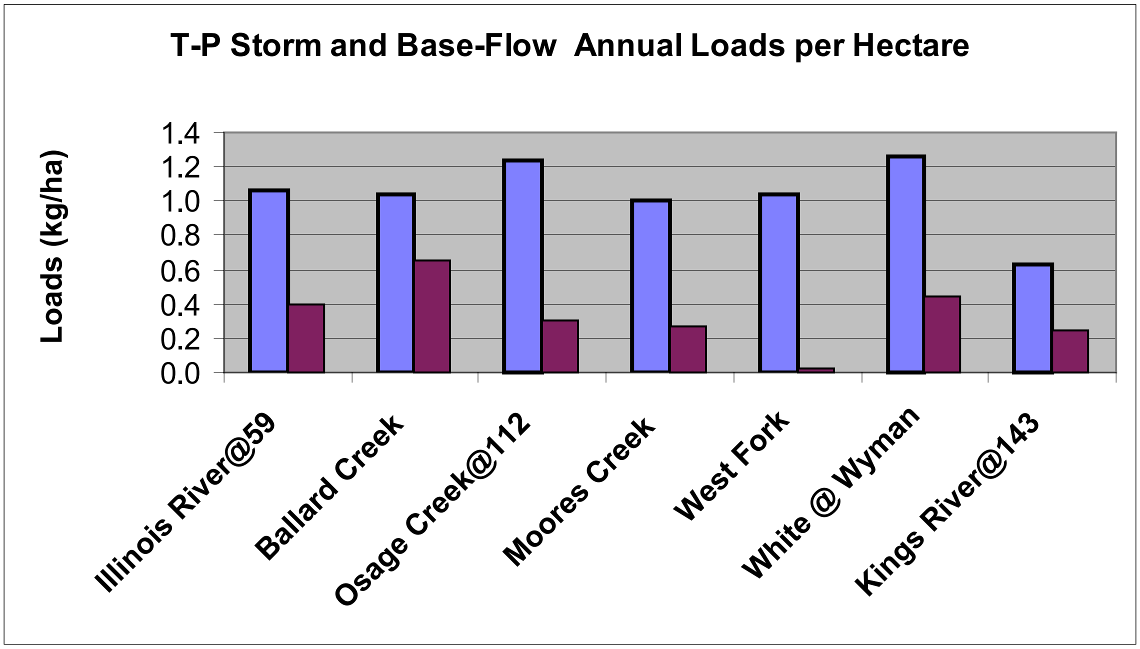


Figure 3. (continued)



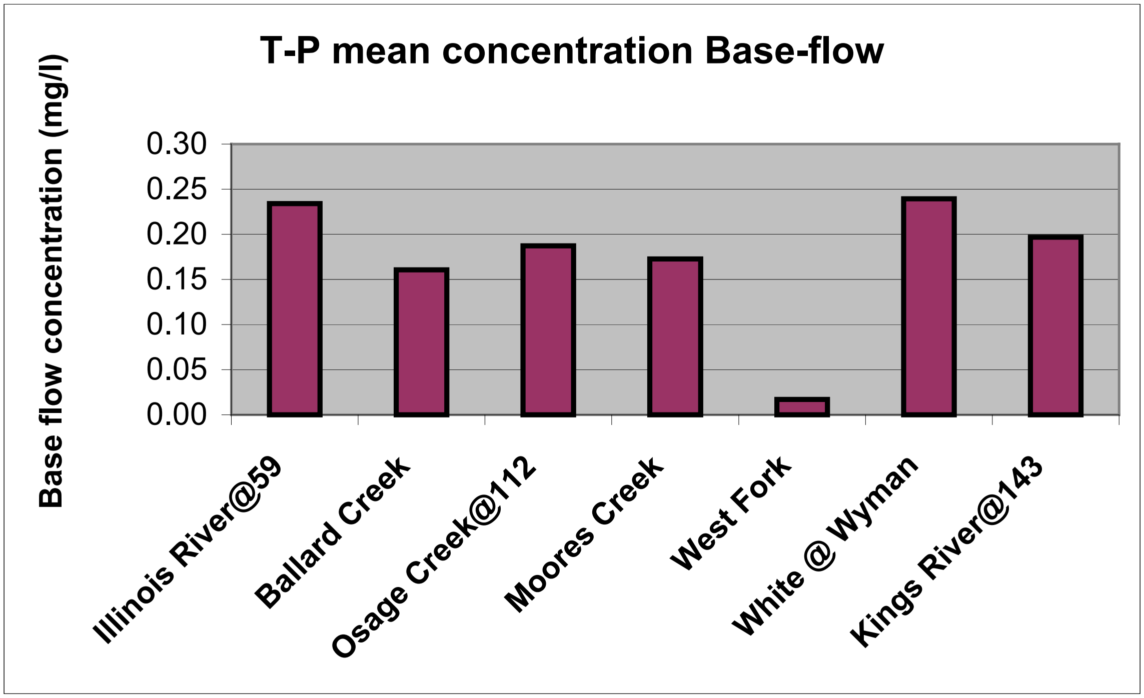
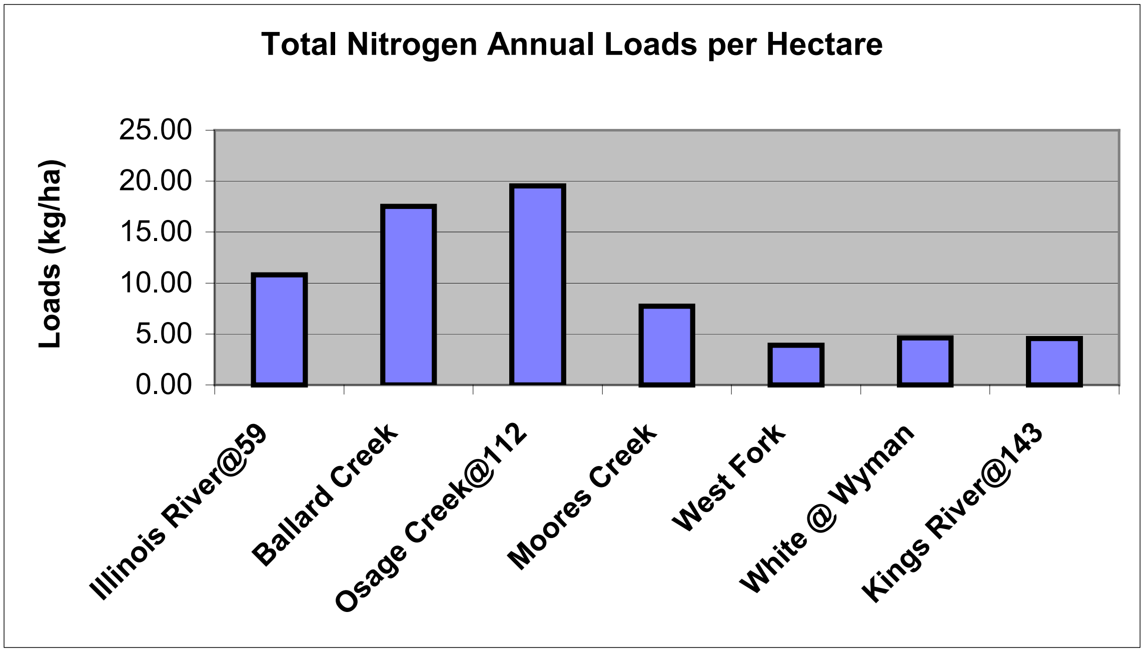
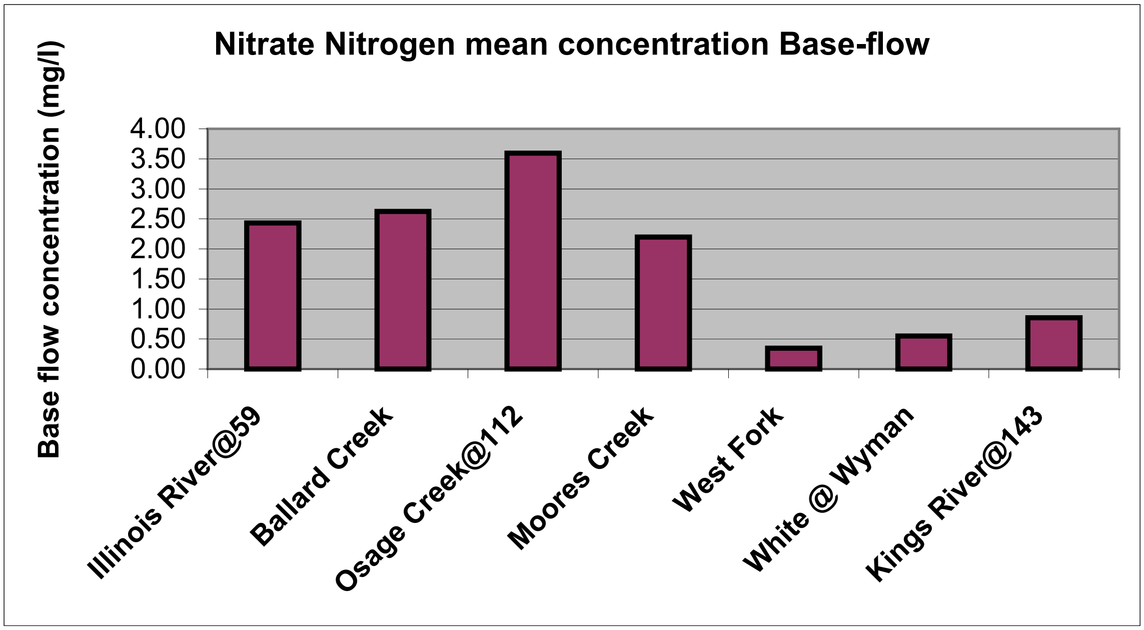


Figure 3. (continued)





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. Soreness “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.

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, 2004.

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.

Parker, D. G, R. D. Williams, and H. D. Scott. 1996. Watershed Prioritization Publication No MSC-204 Arkansas Water Resources Center. University of Arkansas. Fayetteville, Arkansas.

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., L.W. Cash “Illinois River 2003 Pollutant Loads at the Arkansas Highway 59 Bridge” Arkansas Water Resources Center Publication, 2004.

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, 2003 Annual Report” Arkansas Water Resources Center Publication, 2004.

Nelson, M.A., L.W. Cash “Water Quality Sampling, Analysis And Annual Load Determinations For TSS, Nitrogen And Phosphorus On Moores Creek, 2003 Annual Report” Arkansas Water Resources Center Publication, 2004.

Nelson, M.A., L.W. Cash “Water Quality Sampling, Analysis And Annual Load Determinations For TSS, Nitrogen And Phosphorus on Ballard Creek, 2003 Annual Report” Arkansas Water Resources Center Publication, 2004.

Nelson, M.A., L.W. Cash “Water Quality Sampling, Analysis And Annual Load Determinations For TSS, Nitrogen And Phosphorus on the West Fork, 2003 Annual Report” Arkansas Water Resources Center Publication, 2004.

Nelson, M.A., L.W. Cash “Water Quality Sampling, Analysis And Annual Load Determinations For TSS, Nitrogen And Phosphorus on the White River at the 45 Bridge, 2003 Annual Report” Arkansas Water Resources Center Publication, 2004.

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, 2004 Annual Report” Arkansas Water Resources Center Publication, 2005.

Nelson, M.A., L.W. Cash “Water Quality Sampling, Analysis And Annual Load Determinations For TSS, Nitrogen And Phosphorus On Moores Creek, 2004 Annual Report” Arkansas Water Resources Center Publication, 2005.

Nelson, M.A., L.W. Cash “Water Quality Sampling, Analysis And Annual Load Determinations For TSS, Nitrogen And Phosphorus on Ballard Creek, 2004 Annual Report” Arkansas Water Resources Center Publication, 2005.

Nelson, M.A., L.W. Cash “Water Quality Sampling, Analysis And Annual Load Determinations For TSS, Nitrogen And Phosphorus on the West Fork, 2004 Annual Report” Arkansas Water Resources Center Publication, 2005.

Nelson, M.A., L.W. Cash “Water Quality Sampling, Analysis And Annual Load Determinations For TSS, Nitrogen And Phosphorus on the White River at the 45 Bridge, 2004 Annual Report” Arkansas Water Resources Center Publication, 2005.