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2005 Nutrient and Sediment Monitoring Report Ballard Creek Near Arkansas/Oklahoma Line

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2005 NUTRIENT AND SEDIMENT MONITORING REPORT
BALLARD CREEK NEAR ARKANSAS/OKLAHOMA LINE

Submitted to the
Arkansas Natural Resources Commission

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SUMMARY

2005 annual loads and mean concentrations.

parameter	Loads (kg)	Mean Concentrations (mg/l)
Discharge	**37,191,500 (m3/yr)**	**1.2 (m3/s)**
Nitrate-N	**68,000**	**1.83**
Total Phosphorus	**9,700**	**0.26**
Ammonia-N	**5,490**	**0.15**
TN	**85,200**	**2.3**
Phosphate-P	**5,500**	**0.15**
TSS	**1,170,000**	**31.4**

2005 storm-flow and base-flow loads and mean concentrations.

	Storm Loads (kg)	Base Loads (kg)	Storm Concentrations (mg/l)	Base Concentrations (mg/l)
VOLUME (M3)	**6,957,000**	**30,251,000**		
NO3-N	**12,200**	**55,800**	**1.76**	**1.85**
T-P	**5,300**	**4,300**	**0.77**	**0.14**
NH4	**1,100**	**4,400**	**0.16**	**0.15**
TKN	**18,400**	**66,800**	**2.65**	**2.21**
PO4	**2,600**	**2,800**	**0.39**	**0.09**
TSS	**991,000**	**179,000**	**142.5**	**5.9**

INTRODUCTION

The Illinois River Basin has experienced water quality impairment from non-point source pollution for many years. This fact was well documented in the State of Arkansas' Water Quality Assessment report, the Soil Conservation Service River Basin Study, and several University of Arkansas studies. Thirty-seven sub-watersheds have been identified by the SCS in the Arkansas portion of the Illinois River basin. In the Arkansas portion of the Basin, the Illinois River, Evansville Creek, Baron Fork, Cincinnati Creek, Muddy Fork, Moores Creek, Clear Creek, Osage Creek and Flint Creek were all classified as not supporting their designated use as primary contact recreation streams. The identified causes of the impairment were: sediment, bacteria and nutrients.

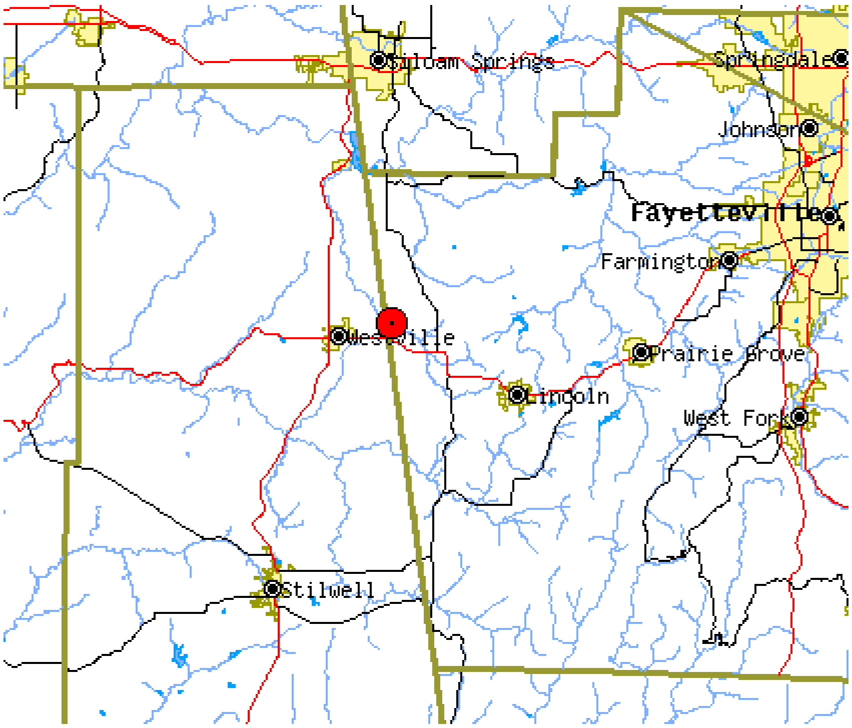
In 1997, the University of Arkansas completed a project that estimated the phosphorus loading from each of the thirty-seven sub-watersheds. This project also prioritized watersheds for implementation work based on phosphorus loads, nitrogen loads and total suspended solids loads per unit area. The thirty-seven sub-watersheds were grouped into Low (16), Medium (10) and High (11) categories based on phosphorus loadings.

The selection of a sub-watershed for targeted intensive voluntary BMP implementation was based on the following criteria: a) the sub-watershed had to be above the current median value for phosphorus loading, b) there would be no sewage treatment plant in the sub-watershed, and c) land user interest. The Upper Ballard Creek watershed met all these requirements. The watershed covers 6700 hectares. The creek is listed in the High category with a unit area loading of 1.75 kg. per hectare per year. The median value for the thirty-seven watersheds was 0.73 kg. per hectare per year.

HISTORY

A water quality sampling station was installed at the Washington County Road 76 Bridge over Ballard Creek just before the creek leaves the state of Arkansas and enters into Oklahoma (see Figure 1). The station was initially funded under an ASWCC 319 h grant FY99-100 to collect two storm event samples, four base flow grab samples and four periphyton growth samples per year. During the period of time from July 1, 2000 to September, 2001 the sampling station was being installed and no stage or water quality information was collected. Quarterly water quality and periphyton samples were collected in the last quarter of 2001 and during the first two quarters of 2002. However, due to datalogger failure, no stage information was collected until February 15, 2002.

Figure 1 Location of sampling site.



Beginning July 1, 2002 the funding was supplemented at this site so that all storms were sampled and grab samples and periphyton samples were collected and analyzed every two weeks. This report details the results from January 1, 2005 to December 31, 2005.

METHODS

The automatic storm water monitoring station consisted of a Sigma 900 max sampler with 24 1 liter bottles controlled by a Campbell Scientific (CSI) CR10X programmable datalogger. The sampler and data logger were enclosed in a steel gauge house located next to the Washington county road 76 Bridge over Ballard Creek. Water stage was measured using a Campbell Scientific ultrasonic distance sensor mounted underneath the bridge. A rating curve was developed by the USGS at the site to convert stage to discharge. The datalogger was programmed to trigger the sampler using either flow or time based intervals.

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. 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 two feet. It took a discrete sample after a fixed volume of water has passed. The volume of water used for the flow weighted composite samples, i.e. sampling frequency, was 1 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. Once per quarter, field blanks, sampler duplicate and bridge replicate samples were collected and used for QA/QC purposes. 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 chemical water quality sampling, periphyton sampling was done to assess the productivity of the stream. Periphyton sampling for determination of primary productivity followed method number 10300 in Standard Methods 20th edition. Standard microscope slides were used as a substrate for periphyton growth. Slides were placed in holders designed to hold eight pairs of slides vertically, perpendicular to the flow, near the surface of the stream. Slide holders were placed in the stream at two sites near the automatic water sampling station. The two sites were chosen to represent the predominate morphological features of this order stream: riffles and shallow pools. The slides were placed at the sites every two weeks during the year. Slides were left in the stream for two weeks and then retrieved and used to determine ash-free biomass weight and Chlorophyll A concentration. Primary productivity was determined from ash-free weight and Autotrophic Index was determined from ash-free weight divided by Chlorophyll A concentration. Net Primary productivity as measured by ash-free dry weight of material accumulated on the slides in the two-week period is a measurement widely used to estimate growth rate of colonizing organisms in streams. Dividing the ash-free dry weight values by the chlorophyll A values is a way to estimate the amount of accumulated organic material that is involved in photosynthesis. A high value indicates low percentages of photosynthetic organisms.

RESULTS

During 2005, 94 individual samples were collected and analyzed. They include 26 base-flow grab samples, 12 composite storm samples, 41 periphyton samples, 4 field blanks, 4 field duplicates and 5 bridge replicates. The stage for 2005 as well as the concentration results from the samples are summarized in Figure 2 and Tables 1 and 2.

Figure 2. 2005 stage, nutrients and TSS.

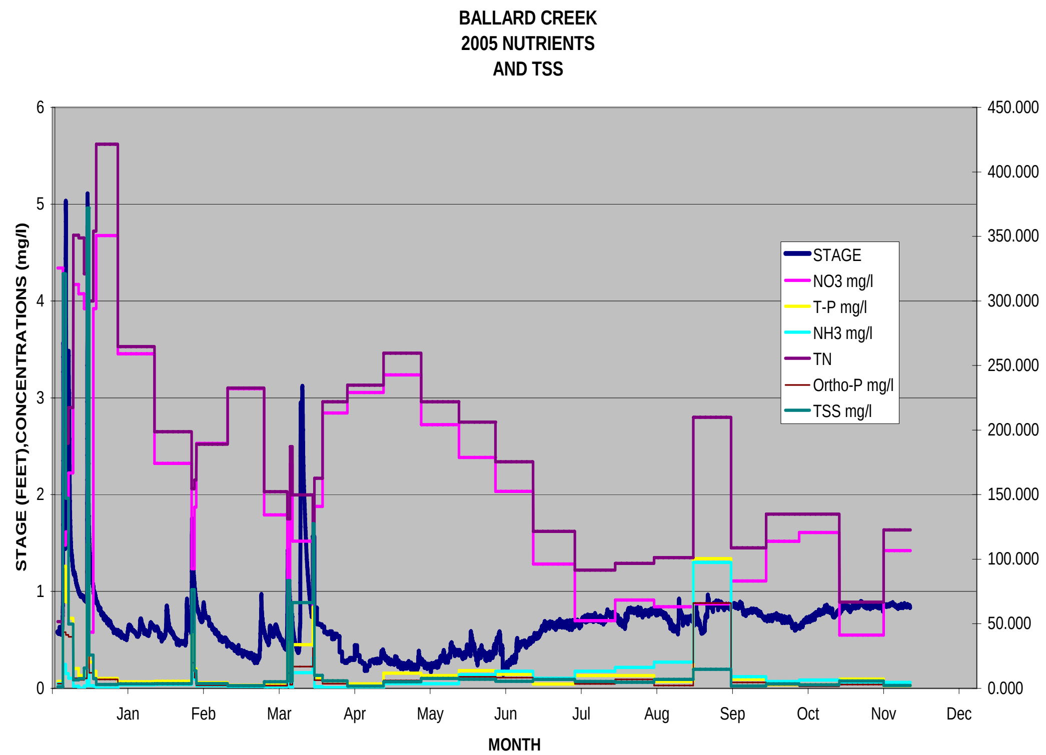


Table 1. 2005 annual loads and mean concentrations.

parameter	Loads (kg)	Mean Concentrations (mg/l)
Discharge	**37,191,500 (m3/yr)**	**1.2 (m3/s)**
Nitrate-N	**68,000**	**1.83**
Total Phosphorus	**9,700**	**0.26**
Ammonia-N	**5,490**	**0.15**
TN	**85,200**	**2.3**
Phosphate-P	**5,500**	**0.15**
TSS	**1,170,000**	**31.4**

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 1 foot, the segregated loads and mean concentrations for 2005 are shown in Table 2.

Table 2. 2005 storm-flow and base-flow loads and mean concentrations.

	Storm Loads (kg)	Base Loads (kg)	Storm Concentrations (mg/l)	Base Concentrations (mg/l)
VOLUME (M3)	**6,957,000**	**30,251,000**		
NO3-N	**12,200**	**55,800**	**1.76**	**1.85**
T-P	**5,300**	**4,300**	**0.77**	**0.14**
NH4	**1,100**	**4,400**	**0.16**	**0.15**
TKN	**18,400**	**66,800**	**2.65**	**2.21**
PO4	**2,600**	**2,800**	**0.39**	**0.09**
TSS	**991,000**	**179,000**	**142.5**	**5.9**

Table 3 Previous nutrient and sediment annual results.

	2003 loads	2003 concentrations	2004 loads	2004 concentrations
VOLUME (M3)	**36,251,000**		**43,096,000**	
NO3-N	**75,200**	**2.07**	**110,203**	**2.56**
T-P	**10,100**	**0.28**	**13,946**	**0.32**
NH4	**2,600**	**0.07**	**2,540**	**0.06**
TKN	**30,300**	**0.84**	**33,495**	**0.78**
PO4	**4,100**	**0.11**	**6,394**	**0.15**
TSS	**1,787,000**	**49.3**	**2,524,000**	**58.6**

Periphyton samples were collected 22 separate times in 2004. Samples were collected by retrieving glass slides that had been placed two weeks previously at a pool and a riffle just upstream from the sampling station. The slides were analyzed for Chlorophyll A and ash-free dry weight. Primary Productivity was determined from the average accumulated mass on each set of eight slides as measured by ash-free dry weight. Autotrophic Index was determined by dividing ash-free dry weight by the average Chlorophyll A determined from each set of eight slides. The results are summarized in figures 3 and 4.

Figure 3 Primary productivity 2005.

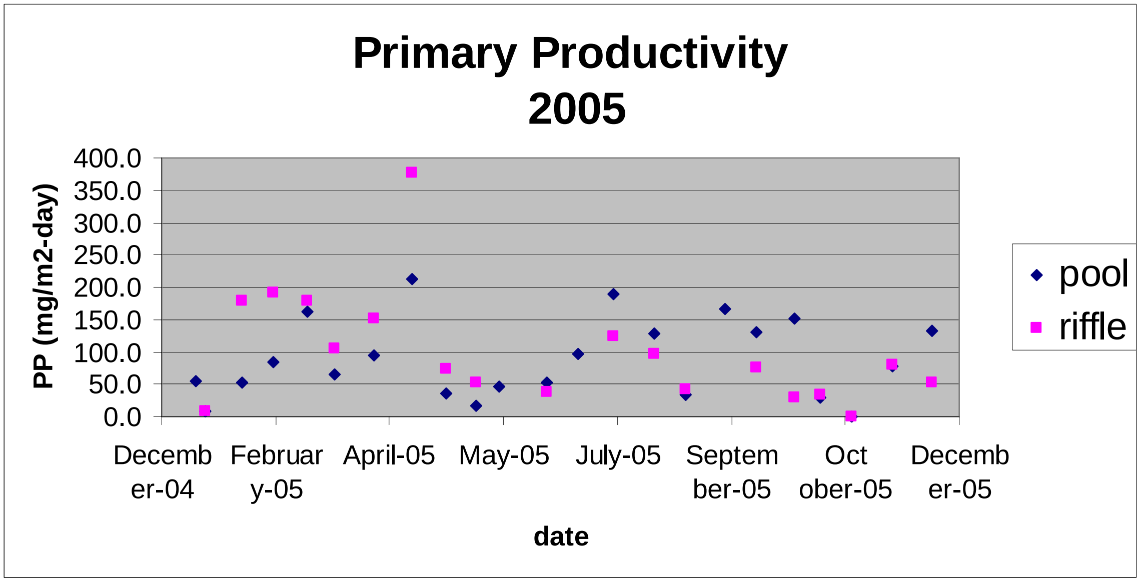
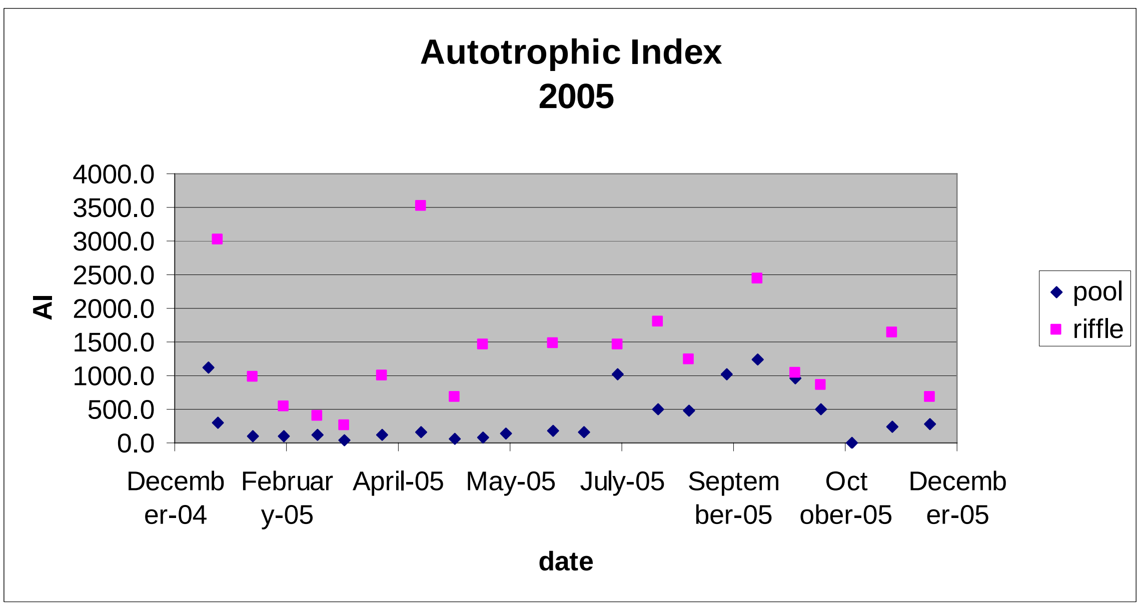


Figure 4 Autotrophic Index 2005



DISCUSSION

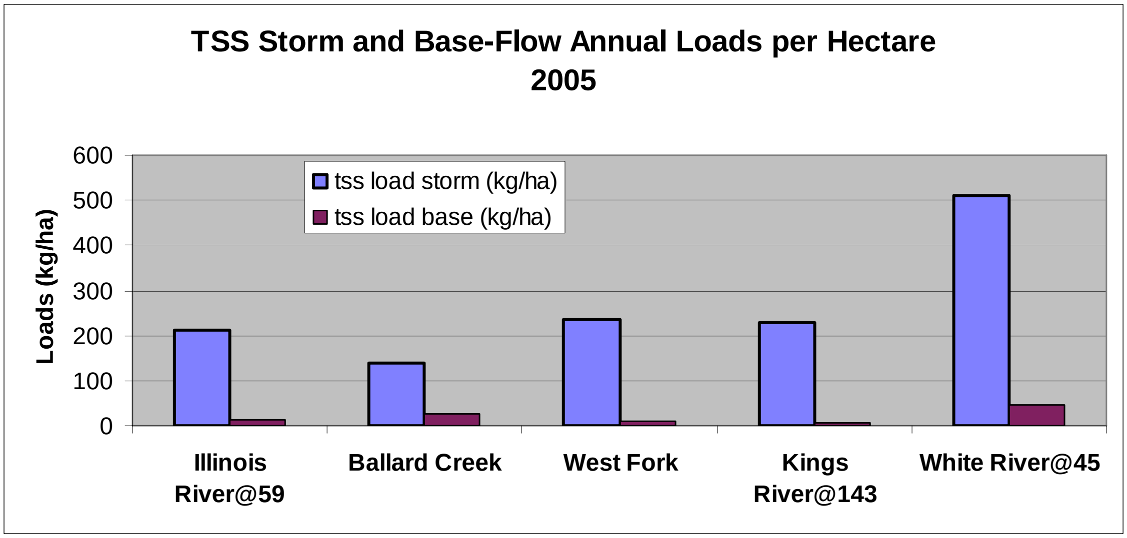
The loads and concentrations developed for Ballard Creek can be compared to loads and concentrations developed in other watersheds in Northwest Arkansas for 2005. Four other watersheds have been monitored using the same monitoring and load calculation protocols. The only differences between the protocols 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.

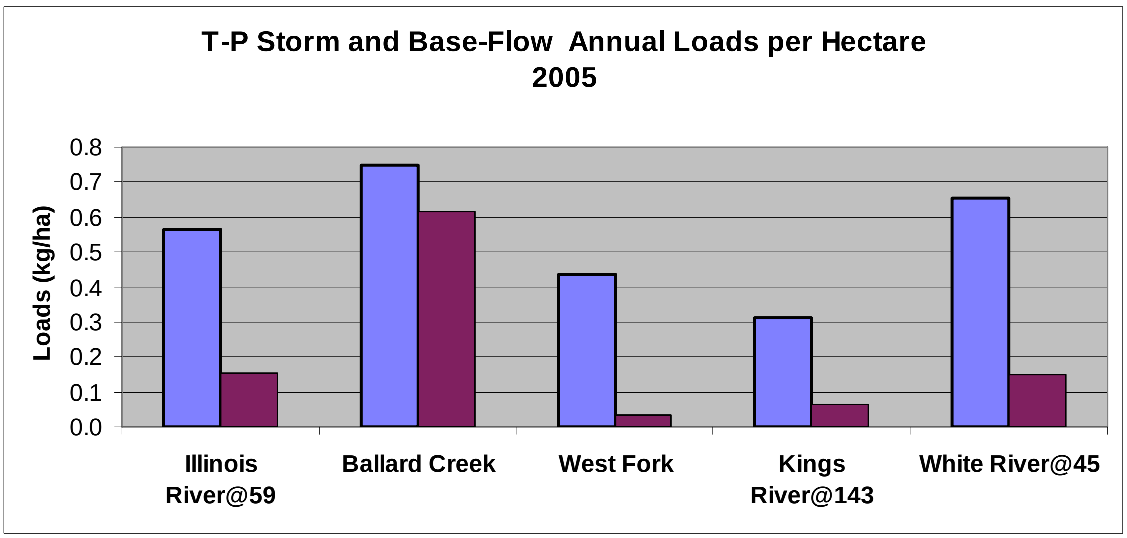
The results for the five watersheds show TSS, total phosphorus and total nitrogen as total annual storm-flow loads per watershed hectare, as base-flow loads per watershed hectare and as base-flow concentrations (Table 3, Figure 5). Normalizing storm and base-flow loads to a per hectare basis allows comparison 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 hectare may be used to represent relative impacts from non-point sources. The Ballard Creek watershed has below average TSS loads compared to the others. Like the others, most of the TSS is transported during storm events. However, it has a larger percentage transported during base-flow than the average. The P load for Ballard creek is significantly higher than the other watersheds. Both Storm-flow transport, and especially base-flow transport was higher than the others. Total nitrogen loads per hectare were also greater than the average. Base-flow nitrogen transport was much higher than any of the other watersheds studied. The high base-flow transports may be the result of significantly higher discharge. The annual discharge per watershed hectare was 5,234 m^3/ha versus 2,625 m^3/ha for the Illinois River.
The base-flow concentrations show relative levels of TSS, T-P and TN 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 biological habitat and nuisance algae production. The base-flow concentration of TSS was low compared to the other sites. The T-P concentration was very high considering there was no point-source discharge. The nitrate concentration was high compared to the White River sites, but average for Illinois River sites where groundwater levels are high.

Table 3. Results from five Northwest Arkansas Watersheds.

2005	Illinois River@59	Ballard Creek	West Fork	Kings River@143	White River@45
Hectares	148,930	7,106	30,563	136,497	106,711
YEARS of data	2005	2005	2005	2005	2005
tss load (kg/ha)	225	165	245	235	559
tss load storm (kg/ha)	212	140	235	228	511
tss load base (kg/ha)	13	25	11	7	47
tss conc. base (mg/l)	8	6	10	5	25
p load (kg/ha)	0.72	1.36	0.47	0.38	0.80
p load storm (kg/ha)	0.56	0.75	0.44	0.31	0.65
p load base (kg/ha)	0.15	0.62	0.03	0.07	0.15
p base conc. (mg/l)	0.10	0.14	0.03	0.05	0.08
Total Nitrogen load (kg/ha)	7.86	12.00	2.12	2.13	2.87
Total Nitrogen load storm (kg/ha)	3.48	2.60	1.60	1.15	1.33
Total Nitrogen load base (kg/ha)	2.69	9.40	0.52	0.98	1.54
NO3-N base conc. (mg/l)	2.57	1.85	0.36	0.20	0.56
DISCHARGE (m^3)	390,894,159	37,191,537	84,315,555	279,456,255	340,264,093
DISCHARGE/AC (m^3/ha)	2,625	5,234	2,759	2,047	3,189

Figure 5 Comparison of seven watersheds





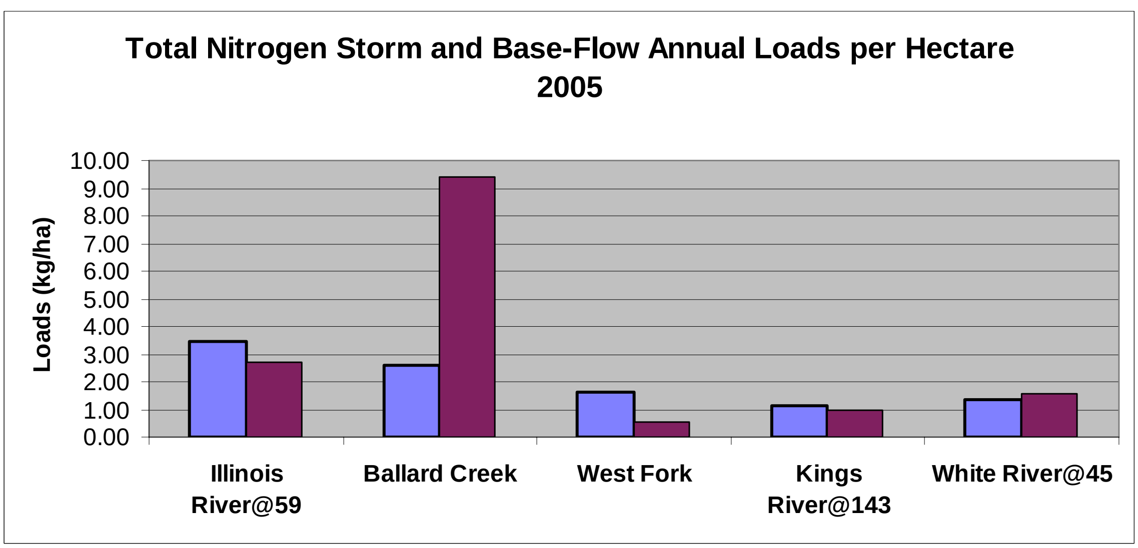
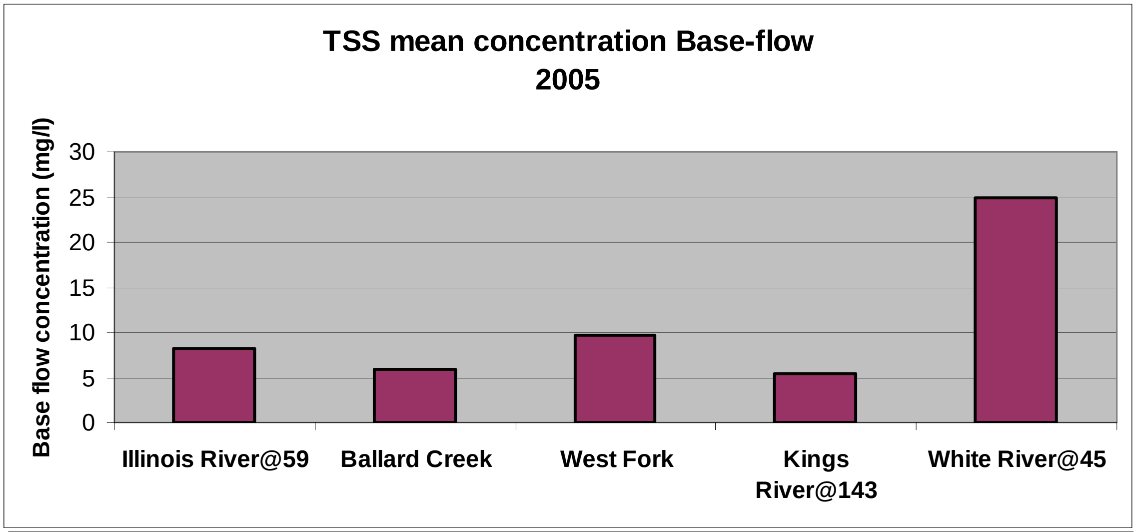
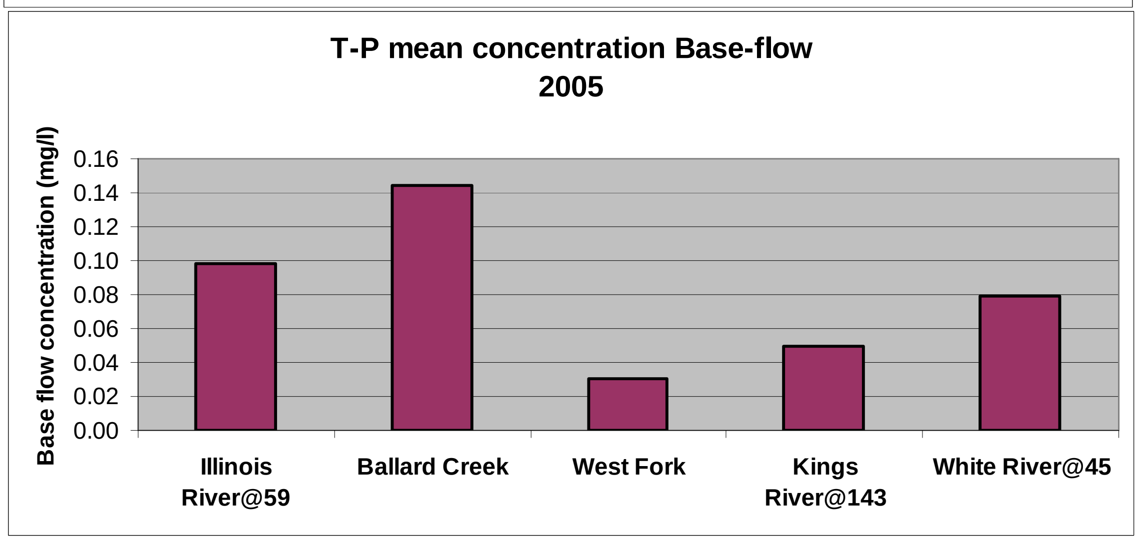
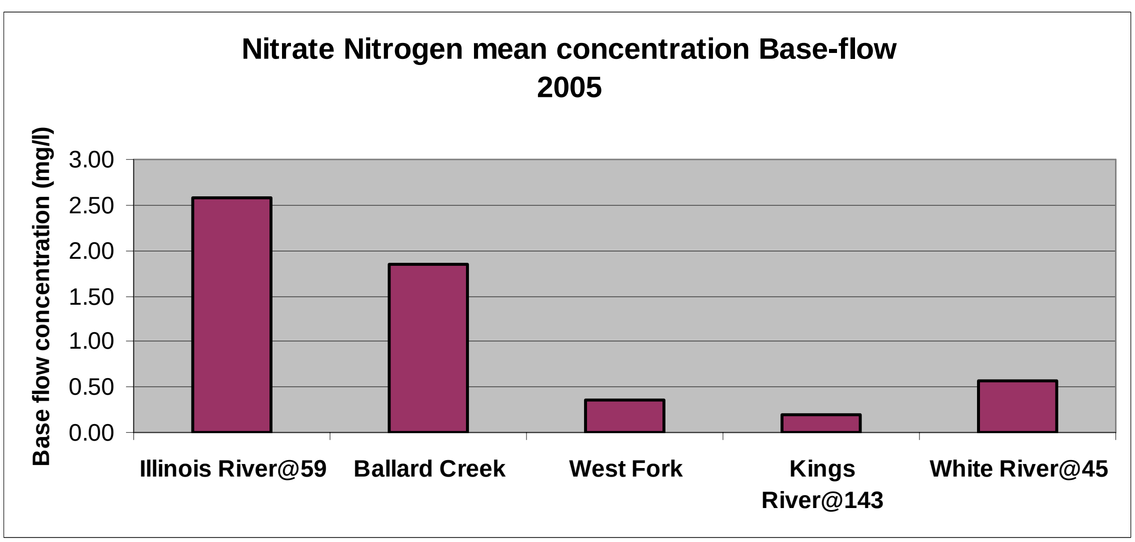


Figure 5 (continued).







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