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WATER QUALITY MONITORING OF MOORES CREEK ABOVE LINCOLN LAKE 2003

Submitted to the
Arkansas Soil and Water Conservation Commission

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INTRODUCTION

In Northwest Arkansas, nutrients transported by surface water are a major concern. These nutrients are implicated in causing water quality impairment of lakes in Northwest Arkansas and eastern Oklahoma. The nutrients of concern are nitrogen and phosphorus. Nitrogen and phosphorus stimulate algae production in water bodies and can cause water quality degradation. Problems associated with algae growth are aesthetic impairment, objectionable taste and odor of potable water, interference with recreation activities, and fish kills in some hyper-eutrophic cases. The sources of these nutrients are primarily from land application of confined animal wastes as soil amendments to pastures.

In 1990, the University of Arkansas Cooperative Extension Service (CES) and U. S. Department of Agriculture Natural Resources Conservation Service (NRCS) initiated a program in the Muddy Fork watershed of the Illinois River. This program focused on implementing best management practices (BMP) in the watershed that would reduce nutrient losses from pastures. Education, technical assistance, and cost sharing were the approaches used by these agencies to encourage BMP implementation. The predominant BMPs implemented were nutrient management, pasture and hay-land management, waste utilization, dead poultry composting, and waste storage structures.

In 1991, the Arkansas Soil and Water Conservation Commission (ASWCC) and the U. S. Environmental Protection Agency (EPA) sponsored a monitoring project in the Lincoln Lake Basin (see Figure 1). The Lincoln Lake Basin, part of the Muddy Fork watershed, received appreciable BMP implementation by the CES and NRCS. The objective of this monitoring project was to demonstrate the effectiveness of the implemented BMPs in reducing nutrient transport from the pastures in this intensively managed area.

Nutrient and sediment transport was monitored from September 1991 until April 1994 in Moores Creek and Beatty Branch, the two streams that feed Lincoln Lake, (Edwards *et al*., 1996 and 1997). The monitoring protocol consisted of grab samples every two weeks and flow-weighted composite samples taken with autosamplers during storm events. Total nutrient and sediment loads were calculated for each site. Monitoring was discontinued in May 1994.

In January 1995, water quality monitoring stations were re-established at the same Moores Creek and Beatty Branch sites in the watershed. These sites were monitored using the same monitoring protocol as the previous study. In July 1996, a third monitoring site was added to the monitoring network on the Moores Creek basin. This site was located just above an 800-acre parcel of land surrounding the creek that was selectively logged beginning in the fall of 1995. Since the lower Moores Creek sampler was located toward the lower end of this parcel, the upper Moores Creek sampler was added to help continue trends analysis in the creek without the effects of the logging on water quality. These sites were monitored until December 1998. Total nutrient and sediment loads were calculated for all three sites (Vendrell *et al*., 1999)

Beginning in January 1999, the upper Moores Creek site was used to monitor water quality as a part of a research project investigating sampling techniques (Nelson *et al*., 2000). The other two sites were not part of this project and no monitoring occurred there. The monitoring protocol consisted of grab samples every two days and discrete storm samples taken every 30 minutes during the first twelve hours of a storm event and every 60 minutes during the next 24 hours of each storm event. Although most storm events were monitored and numerous grab samples were taken, total yearly loads were not calculated for nutrient and sediment transport in 1999.

In January 2000, automatic water sampling equipment was re-installed at the upper Moores Creek site. The site was funded for one year through the Washington County Conservation District and the Arkansas Soil and Water Conservation Commission. Water quality sampling and load calculations were performed form January 1, 2000 to February 28, 2002 using the same protocol described below.

In July 2001 funding for this site was continued as a part of an EPA 319 (h) project 1100 FY 2001 grant titled: Optimizing BMPs, Water Quality and Sustained Agriculture in the Lincoln Lake Watershed. The Quality Assurance Project Plan was approved on February 28, 2002 and water quality monitoring was continued effective March 1, 2002. This report details the results of the monitoring and the load calculations for CY 2003.

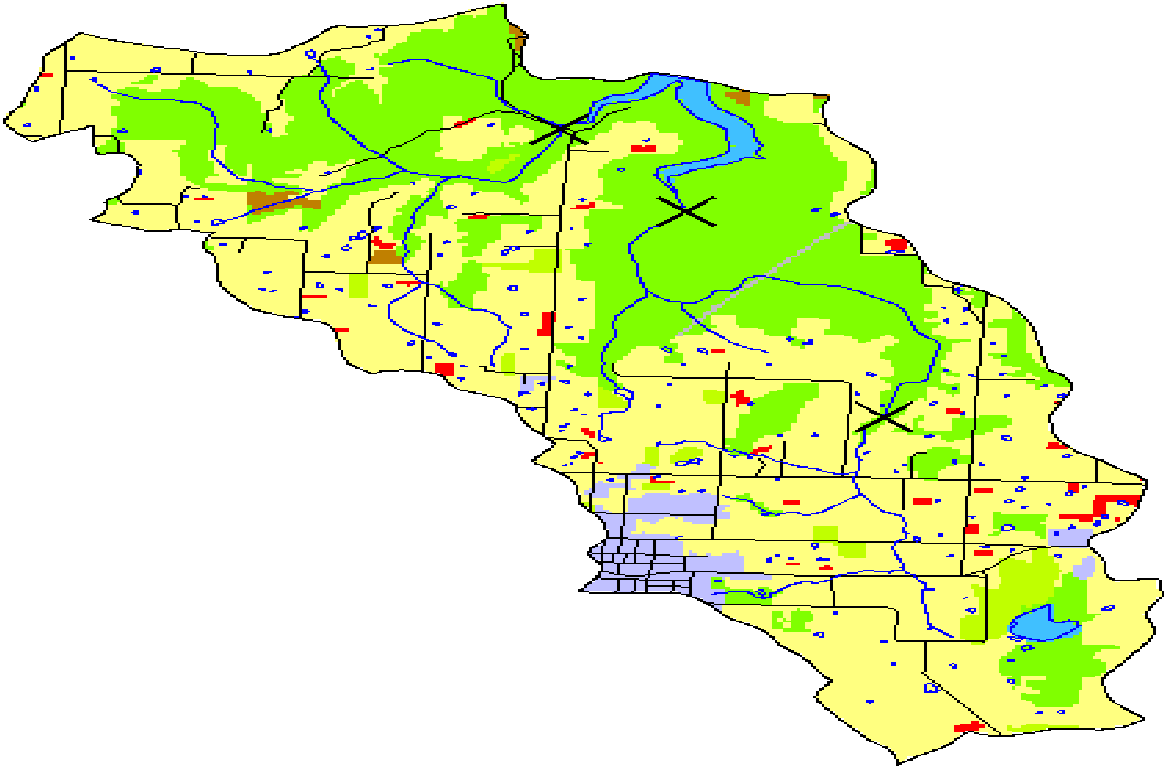


Figure 1. Location of sampling sites..

METHODS

A programmable datalogger was used in conjunction with a pressure transducer to measure and record water depth (stage). It converted the stage to discharge using a stage/discharge-rating curve developed in previous years. The datalogger initiated sampling by triggering the autosampler as soon as the stage had reached a depth of 26 inches. This trigger level was chosen initially in previous years to cause the upper sampler to begin taking samples at the same point in a storm hydrograph as the lower sampler. Once sampling had been initiated, the datalogger began calculating discharge and summing the total volume passing the sampler. Each time ten thousand cubic meters had passed, the sampler took a discrete sample, until it had taken 24 samples, or samples were retrieved. Once per day during storm events samples were retrieved from the sampler and it was reset to continue sampling until the stage had fallen below the trigger level. Each time samples were collected, equal volumes from each discrete sample were combined into one sample for analysis. These flow-weighted composite samples gave an accurate picture of the average concentrations for the entire storm event. In addition to sampling all storm events where the stage exceeds the trigger level for more than six hours, grab samplers were taken manually every two weeks during the year.

All samples were taken immediately upon collection to the Arkansas Water Resources Center- Water Quality Lab and analyzed for nitrate-nitrogen (NO_3-N), ammonia-nitrogen (NH_3-N), total Kjeldahl nitrogen (TKN), total phosphorus TP, ortho-phosphate (PO4-P), and total suspended solids (TSS). All samples were analyzed using approved and certified methods, and all laboratory and field sampling procedures adhered to the laboratory quality management plan. In addition, field blanks and duplicates were used as field sampling quality control.

Stage, time and discharge data was downloaded from the dataloggers once per month. These data were combined with the analytical results for the samples in a spreadsheet and used to calculate total nutrient and solids loads for the year. Loads were calculated by assigning a concentration to every thirty-minute time interval, multiplying the concentration by the volume passing during the time interval, and summing each thirty-minute load over the year. Flow-weighted mean concentrations were calculated by dividing the year's total load for each parameter by the year's total discharge.

RESULTS

There were a total of 18 grab samples taken at approximate two-week intervals during the year. Grab samples were not taken during a three month period in the summer and early fall when the creek dried up completely. There were seven storm events during the year. Three storm events were sampled using flow-weighted composite samples. The other storm events were not adequately sampled and concentrations were estimated using stage/ concentration relationships developed using discrete storm samples in 1998 and 1999. The regression relationships developed are summarized in Table 1 as regression equations and R^2 values. The load and concentration results are summarized in Figure 2, Figure 3, Table 2 and Table 3.

Table 1. Regression equations determined from discrete storm samples

Parameter	Regression equation	Regression coefficient
Nitrate-N	$y = -0.0447x + 2.9617$	$R^2 = 0.0741$
Total Phosphorus	$y = 0.0529x – 0.6994$	$R^2 = 0.7546$
Ammonia-N	$y = -0.0028x + 0.0072$	$R^2 = 0.0242$
TKN	$y = 0.1337x – 1.62$	$R^2 = 0.7359$
Phosphate-P	$y = 0.0108x + 0.1771$	$R^2= 0.4431$
TSS	$y = 28.029x – 492.69$	$R^2 = 0.5451$

Table 2. 2003 discharge and flow-weighted mean concentrations.

Volume (M^3)	NO3-N (mg/l)	TP (mg/l)	NH3-N (mg/l)	TKN (mg/l)	PO4-P (mg/l)	TSS (mg/l)
4,609,255	1.18	0.23	0.05	0.72	0.11	41.25

Table 3. 2003 total nutrient and sediment loads.

NO3-N (kg)	TP (kg)	NH3-N (kg)	TKN (kg)	PO4-P (kg)	TSS (kg)
5,450	1,080	217	3,336	499	190,141

Figure 2. Stage and nutrient concentrations 2003

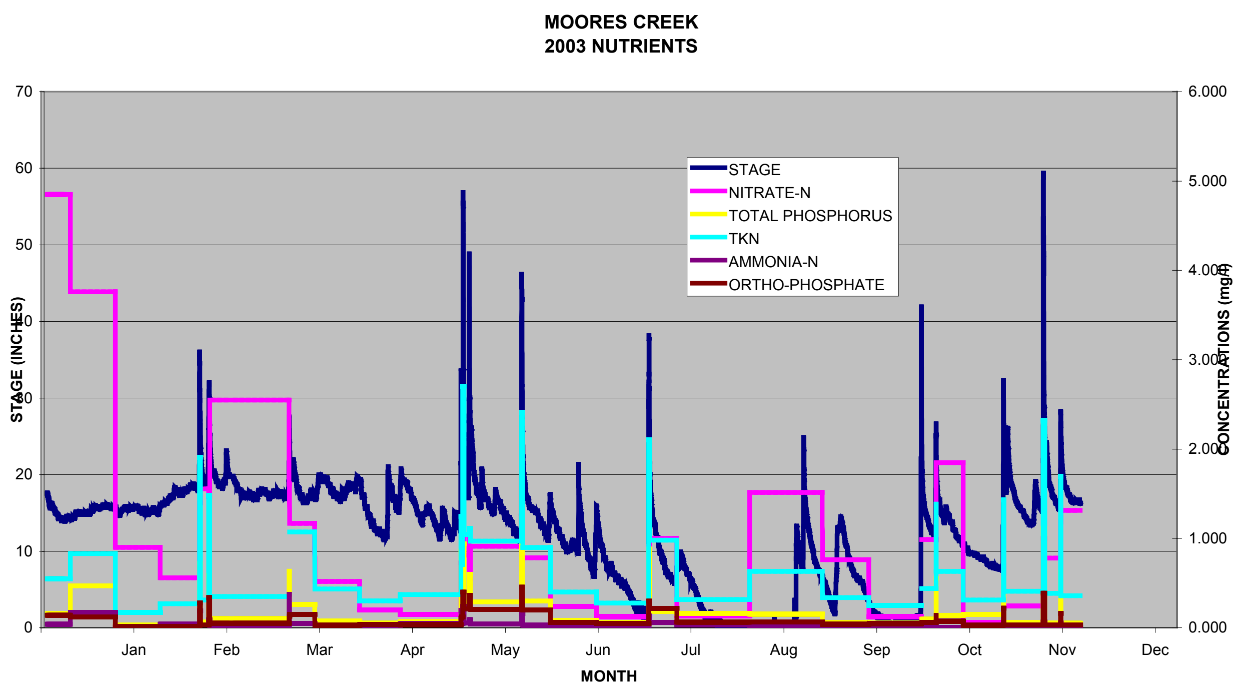
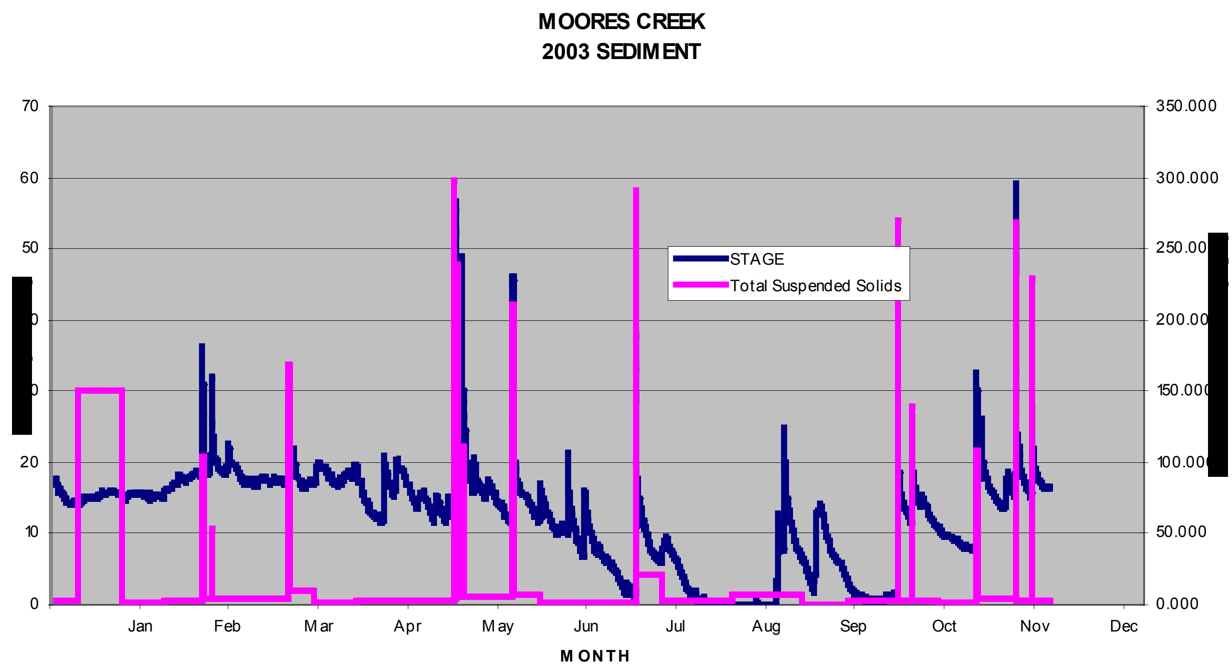


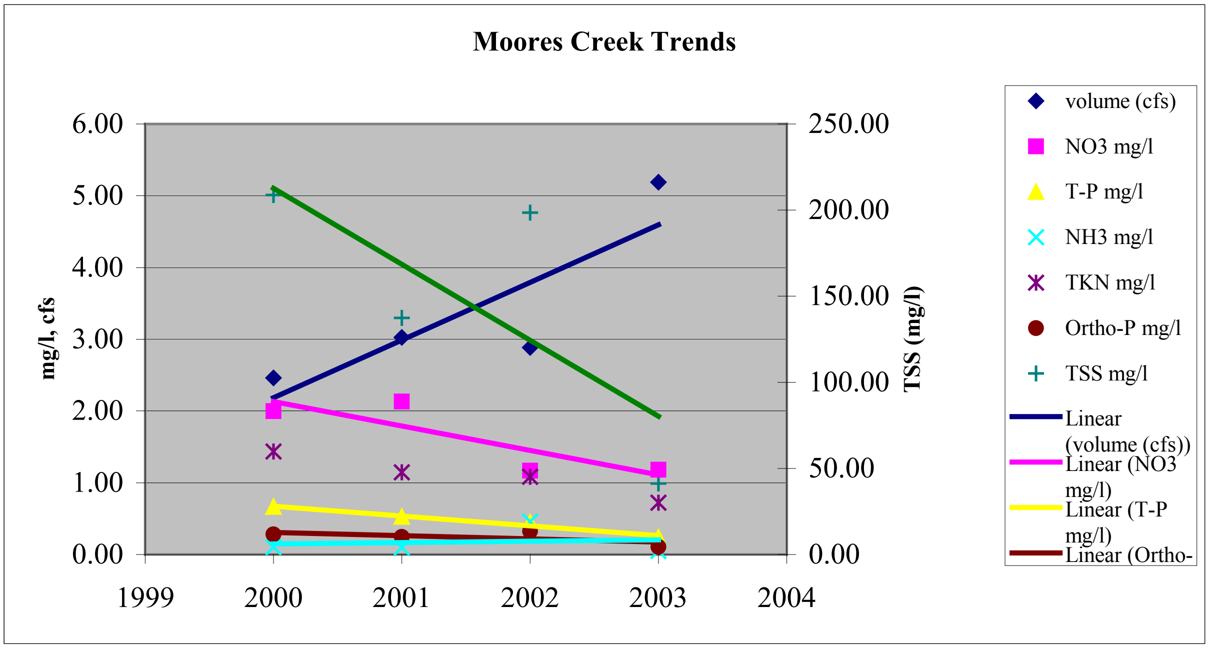
Figure 3 2003 stage and sediment



DISCUSSION

The results from the last four years of monitoring at this site using the same protocol are shown in figure 4. The figure shows the declining concentrations for all parameters except discharge, which shows an increasing trend. This implies that management practices may have had the desired effect since typically concentrations increase as discharge increases.

Figure4 Trends in mean concentrations.



The loads and concentrations developed for Moores Creek 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 seven watersheds are summarized in Table 6 and figure 7. The table shows 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 Moores Creek watershed has relatively average total TSS compared to the others and most of the TSS is transported during storm events. The P load for Moores Creek is similar to the other watersheds with most of the phosphorus 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 P concentration is the lowest of any of the other watersheds. It is the only one of the six watersheds without a point-source discharge (WWTP).

Table 4. Total load and discharge trends

Parameter	**2000**	**2001**	**2002**	**2003**
Discharge (m3)	2,184,249	2,689,187	3,339,859	4,609,255
No3-N kg	4,364	5,724	5,094	5,450
T-P kg	1,452	1,419	1,257	1,080
NH3 kg	227	267	306	217
TKN kg	3,136	3,086	3,204	3,336
Ortho-P kg	613	660	609	499
TSS kg	455,827	369,532	377,356	190,141

Table 5 Mean concentration trends

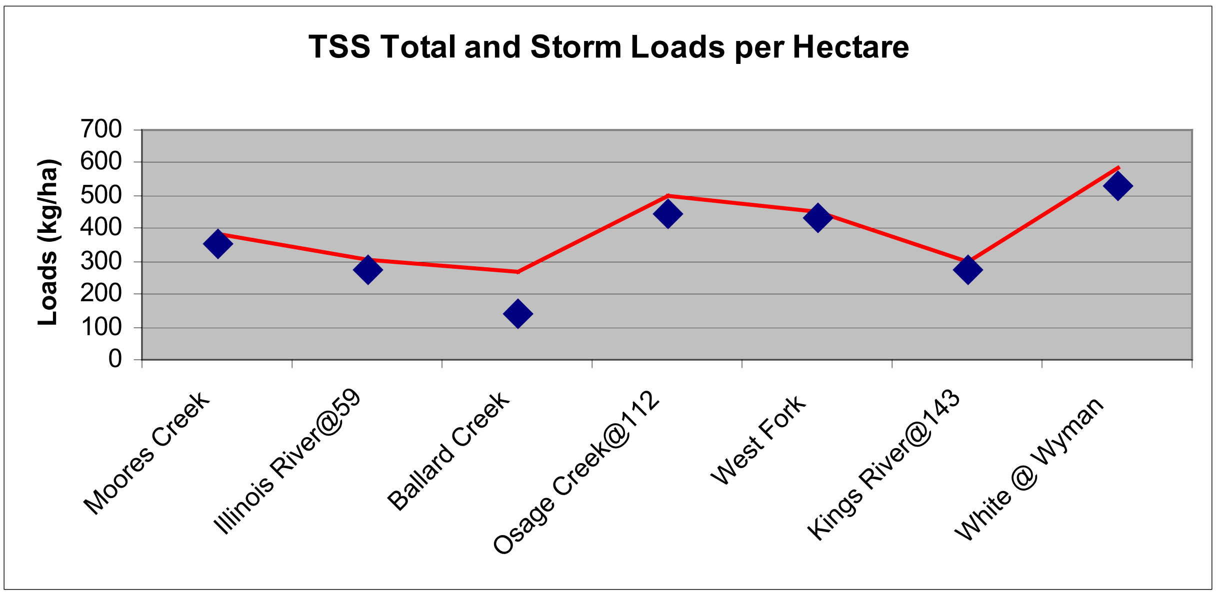
Parameter	**2000**	**2001**	**2002**	**2003**
NO3-N mg/l	2.00	2.13	1.53	1.18
T-P mg/l	0.66	0.53	0.38	0.23
NH3 mg/l	0.10	0.10	0.09	0.05
TKN mg/l	1.44	1.15	0.96	0.72
Ortho-P mg/l	0.28	0.25	0.18	0.11
TSS mg/l	208.69	137.41	112.99	41.25

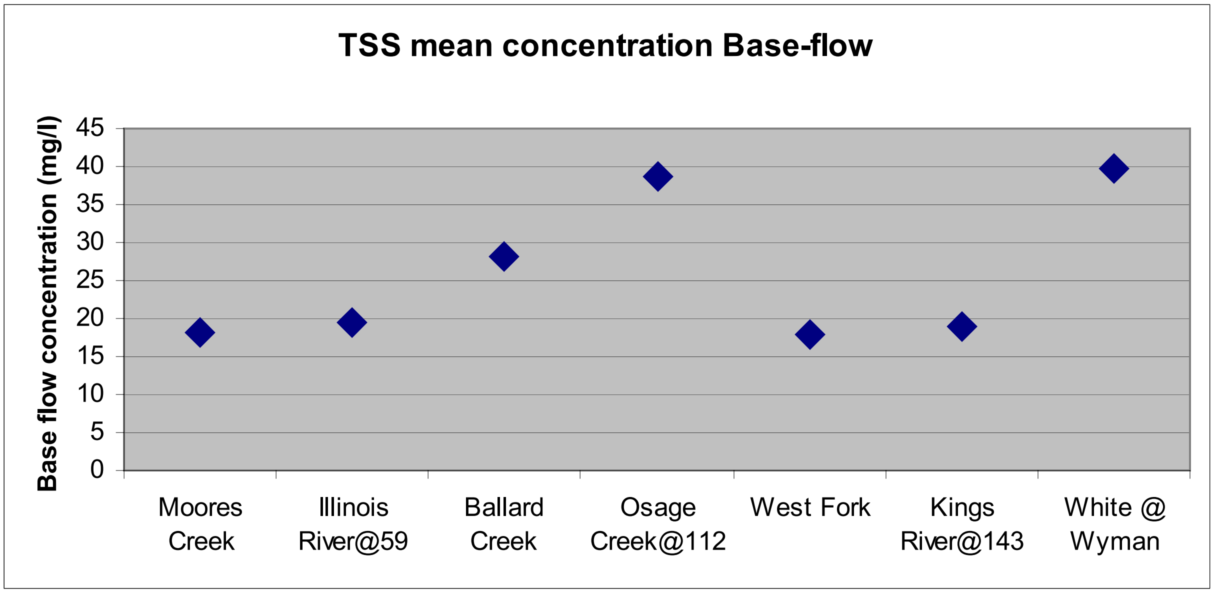
Table 6 Comparison of six watersheds

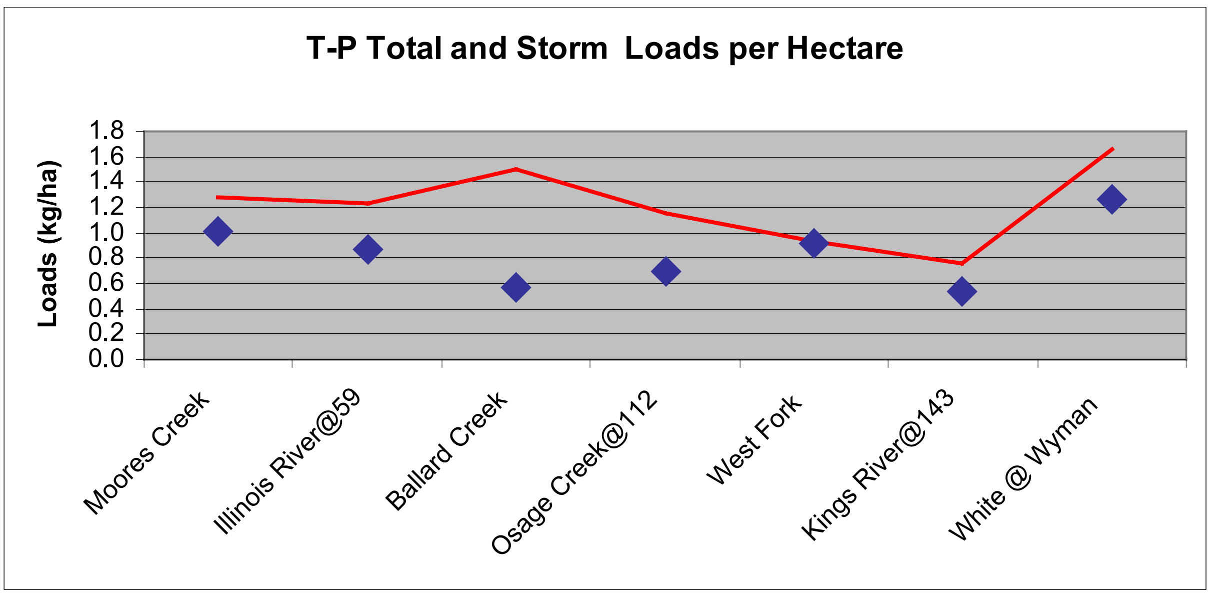
	Moores Creek	Illinois River@59	Ballard Creek	Osage Creek@ 112	West Fork	Kings River@1 43	White @ Wyman
Hectares	1,000	167,273	6,742	10,095	29,964	153,309	116,364
YEARS of data	4	7	1	2	2	5	2
tss load (kg/ha)	381	302	265	501	450	299	586
tss load storm (kg/ha)	355	274	141	442	430	273	528
tss conc. base (mg/l)	18	20	28	39	18	19	40

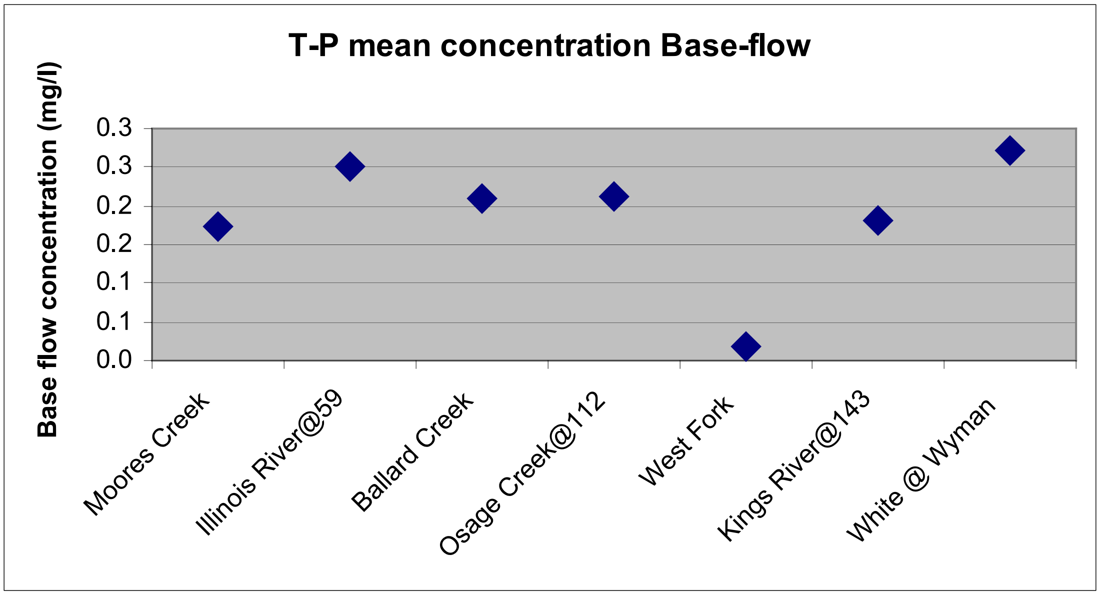
p load (kg/ha)	1.27	1.24	1.50	1.16	0.94	0.76	1.66
p storm load (kg/ha)	1.01	0.86	0.58	0.70	0.92	0.53	1.26
p base conc. (mg/l)	0.17	0.25	0.21	0.21	0.02	0.18	0.27
DISCHARGE (m^3)	3,011,285	545,516,682	36,251,012	38,827,312	106,081,072	378,398,602	243,428,688
DISCHARGE/AC (m^3/ha)	3,011	3,261	5,377	3,846	3,540	2,468	3,540

Figure 5 Comparison of 7 Northwest Arkansas Watersheds




TSS mean concentration Base-flow
Base flow concentration (mg/l)
45
40
35
30
25
20
15
10
5
0
Moores Creek
Illinois River@59
Ballard Creek
Osage Creek@112
West Fork
Kings River@143
White @ Wyman


T-P Total and Storm Loads per Hectare
Loads (kg/ha)
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
Moores Creek
Illinois River@59
Ballard Creek
Osage Creek@112
West Fork
Kings River@143
White @ Wyman


T-P mean concentration Base-flow
Base flow concentration (mg/l)
0.3
0.3
0.2
0.2
0.1
0.1
0.0
Moores Creek
Illinois River@59
Ballard Creek
Osage Creek@112
West Fork
Kings River@143
White @ Wyman

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