Arkansas Water Resources Center

WATER QUALITY SAMPLING, ANALYSIS AND ANNUAL LOAD DETERMINATIONS FOR NUTRIENTS AND SEDIMENT AT THE ARKANSAS HIGHWAY 45 BRIDGE ON THE WHITE RIVER JUST ABOVE BEAVER LAKE

Submitted to the
Arkansas Natural Resources Commission

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ARKANSAS WATER RESOURCES CENTER
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2006 ANNUAL REPORT

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SUMMARY

2006 loads and mean concentrations

	Annual Loads	Mean concentrations
	(kg)	(mg/l)
Discharge (m^3/year)	**385,860,012**	**12.2 M^3/s**
SO_4^+	**4,701,007**	**12.18**
Cl^-	**1,806,250**	**4.68**
NO_3-N	**244,014**	**0.63**
T-P	**117,374**	**0.30**
NH_4-N	**74,641**	**0.19**
Total Nitrogen	**356,108**	**0.92**
PO_4-P	**9,980**	**0.03**
TSS	**94,837,340**	**245**

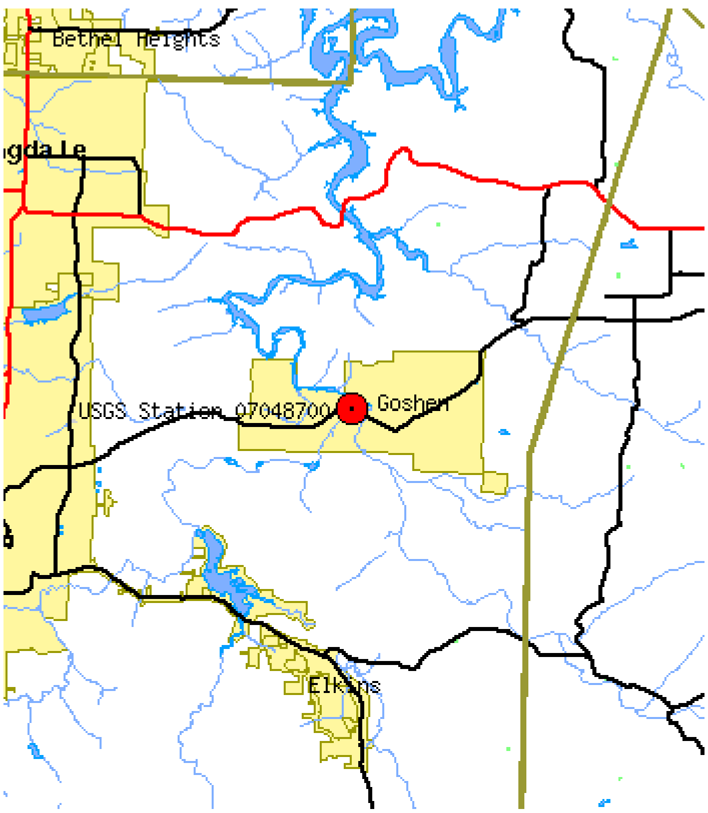
Storm flow loads, Base flow Loads and Mean Concentrations 2006.

	Storm Loads (kg)	Base Loads (kg)	Storm Concentrations (mg/l)	Base Concentrations (mg/l)
Discharge (m^3/year)	**323,028,472**	**62,831,541**		
SO_4^+	**3,265,508**	**1,435,499**	**10.11**	**22.85**
Cl^-	**1,077,609**	**728,641**	**3.34**	**11.60**
NO_3-N	**184,087**	**59,927**	**0.57**	**0.95**
T-P	**111,523**	**5,851**	**0.35**	**0.09**
NH_4-N	**69,257**	**5,384**	**0.21**	**0.09**
Total Nitrogen	**284,327**	**71,781**	**0.88**	**1.14**
PO_4-P	**8,472**	**1,508**	**0.03**	**0.02**
TSS	**93,590,086**	**1,247,254**	**289**	**19**

INTRODUCTION

A water quality sampling station was installed at the Arkansas Highway 45 Bridge on the White River just above Beaver Lake in 2002. This station is coordinated with a USGS gauging station at the same location (see figure 1). This station is 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 White River. The West Fork of the White River 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.

Figure 1 White River at Highway 45 sampling site



SCOPE

This report is for water quality sampling, water sample analysis and annual pollutant load calculations at the Arkansas Highway 45 Bridge on the White River for calendar year 2006.

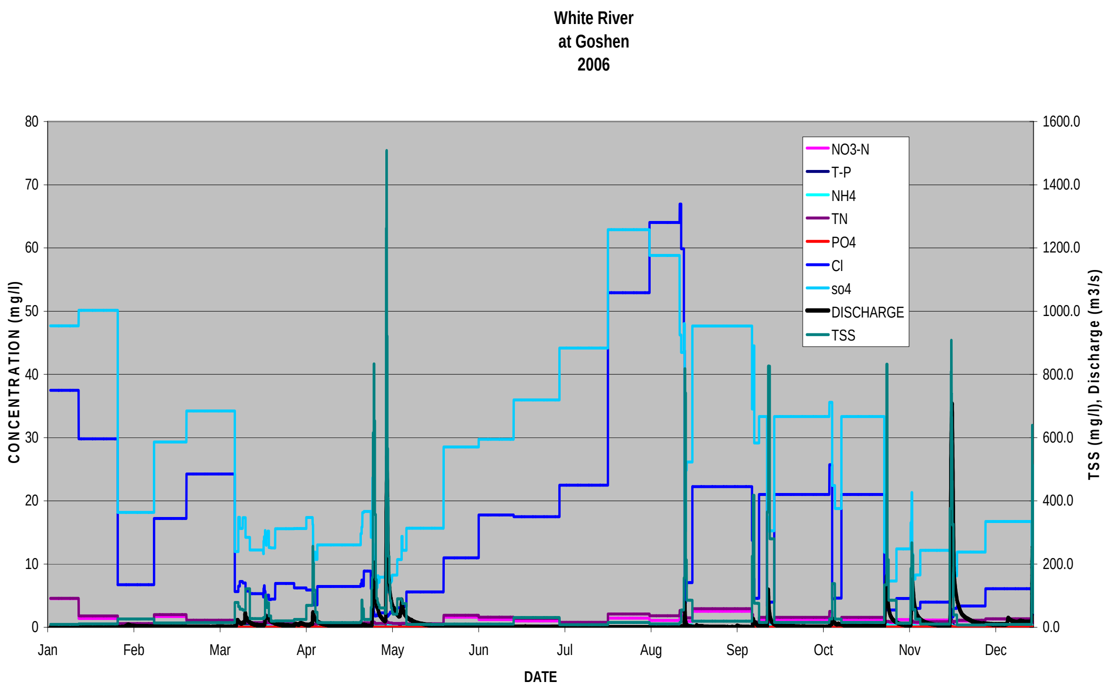
METHODS

The sampler was operated in a discrete mode taking samples at four hour intervals during each storm event. The sampler was triggered manually at the start of each storm event. The trigger level for storm sampling has not been set for this site. The site is in the upper portion of Beaver Lake when lake elevations exceed approximately 1120 feet above MSL. That means a variable trigger level must be used since the stage is not a function of runoff. In addition, discharge rating curve development by the USGS has not been possible due to variable velocities and discharges at a given elevation. That has meant that flow-weighted composite sampling has not been possible at this site to date. Storm flows have been sampled at this site by manually triggering an automatic sampler to collect samples every 4 hours when the stage makes a significant rise. In addition, grab samples were collected every two weeks. Concentrations and loads were calculated by applying the measured sample concentration to the time period from half way from the previous sample to half way to the next sample except at the start and end of storm events. All samples were collected by AWRC 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, sulfate, chloride and total suspended solids.

RESULTS

There were a total of 132 individual samples collected and analyzed for this project during the year. They include 26 grab samples, 94 discrete storm samples, 4 duplicate samples 4 bank replicate samples and 4 blank samples. The measured stage and concentrations are illustrated in figure 2.

Figure 2. 2006 Stage and measured concentrations



Quality assurance grab samples collected on November 14 indicated that the intake line was contaminated. Samples were collected through the intake line for the grab, again through the intake line for the duplicate and from the bridge with a Kemmerer sampler for the match. Samples collected through the intake line showed contamination. The line was replaced immediately. The QA samples collected in February 2007 indicated no contamination. A review of the grab sample data prior to November 14 indicated that the grab samples collected between September 15 and November 14 were suspected to have been contaminated. The concentrations from these four grab samples were replaced with the annual mean values of base-flow grabs excluding the suspect values. The following table lists the QA sampling results for 2006 and February 2007.

Table 1 QA sampling results 2006 and February 2007

Date Sampled	Sample ID	Sample No.	Sulfate	Chloride	Nitrate	Total Phosphorus	Ammonia	Total Nitrogen	Ortho Phosphate	Total Suspended Solids
2/2/2006 11:45	White-45 blank	60265-01	0.032	0.17	0.01	0.004	0.076	0.03	0.004	0.88
2/2/2006 11:45	White-45 dup	60265-03	18.25	6.74	0.28	0.082	0.22	0.59	0.004	20
2/2/2006 11:45	White-45 grab	60265-02	18.18	6.72	0.28	0.084	0.21	0.58	0.005	26
2/2/2006 11:45	White-45 match	60265-04	18.19	6.68	0.28	0.084	0.18	0.6	0.003	15.9
5/18/2006 11:45	White-45 blank	60443-01	0.081	0.028	0	0.01	0.02	0.01	0.007	0
5/18/2006 11:45	White-45 dup	60443-03	15.71	5.53	0.44	0.11	0.07	0.59	0.047	9.4
5/18/2006 11:45	White-45 grab	60443-02	15.67	5.6	0.44	0.064	0.06	0.55	0.043	9.5
5/18/2006 11:45	White-45 match	60443-04	15.71	5.63	0.44	0.12	0.06	0.53	0.048	9.6
8/3/2006 10:45	White-45 blank	70051-01	0.027	0.0793	0	0.01	0	0.2	0.003	1.09
8/3/2006 10:45	White-45 dup	70051-03	61.58	52.77	1.45	0.61	0.057	2.08	0.007	14.17
8/3/2006 10:45	White-45 grab	70051-02	62.9	52.92	1.45	0.104	0.057	2.08	0.004	14.92
8/3/2006 10:45	White-45 match	70051-04	63.97	52.77	1.41	0.154	0.037	2.24	0.004	15.25
11/14/2006 11:45	White 45 blank	70215-01	0.03	0.186	0	0.03	0.03	0.04	0.005	0.3
11/14/2006 11:45	White 45 dup	70215-03	12.381	4.466	1.214	0.09	0.29	1.34	0.013	141.3
11/14/2006 11:45	White-45 grab	70215-02	12.341	4.451	1.209	0.15	0.14	1.33	0.007	115.1
11/14/2006 11:45	White 45 match	70215-04	12.403	4.567	1.224	0.05	0.03	0.67	0.011	12.6
2/12/2007 16:45	White 45 blank	70345-01	0	0.238	0	0.014	0.031	0.02	0.01	0.7
2/12/2007 16:45	White 45 dup	70345-02	0.05	7.137	0.966	0.008	16.44	1.2	0.03	4.7
2/12/2007 16:45	White-45 grab	70345-03	0.04	7.274	0.968	0.006	16.44	1.18	0.03	4.7
2/12/2007	match	-04	0.05	7.137	0.966	0.008	16.44	1.2	0.03	4.7

Total annual loads and flow-weighted mean concentrations were calculated for 2006 and listed in table 2. Flow-weighted mean concentrations were calculated by dividing the annual load by the annual discharge.

Table 2. 2006 loads and mean concentrations

	Annual Loads (kg)	Mean concentrations (mg/l)
Discharge ($m^{3/}year$)	**385,860,012**	**12.2 (m^3/s)**
SO_4^+	**4,701,007**	**12.18**
Cl^-	**1,806,250**	**4.68**
NO_3-N	**244,014**	**0.63**
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NH_4-N	**74,641**	**0.19**
Total Nitrogen	**356,108**	**0.92**
PO_4-P	**9,980**	**0.03**
TSS	**94,837,340**	**245**

The loads can be segregated into storm and base-flow loads by defining storm flows as anything above 20 m^3 /s at this site. The segregated loads and mean concentrations are listed in table 3.

Table 3. Storm flow loads, Base flow Loads and Mean Concentrations 2006.

	Storm Loads (kg)	Base Loads (kg)	Storm Concentrations (mg/l)	Base Concentrations (mg/l)
Discharge ($m^{3/}year$)	**323,028,472**	**62,831,541**		
SO_4^+	**3,265,508**	**1,435,499**	**10.11**	**22.85**
Cl^-	**1,077,609**	**728,641**	**3.34**	**11.60**
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Total Nitrogen	**284,327**	**71,781**	**0.88**	**1.14**
PO_4-P	**8,472**	**1,508**	**0.03**	**0.02**
TSS	**93,590,086**	**1,247,254**	**289**	**19**

Figure 3 Trends in storm-flow and base-flow concentrations

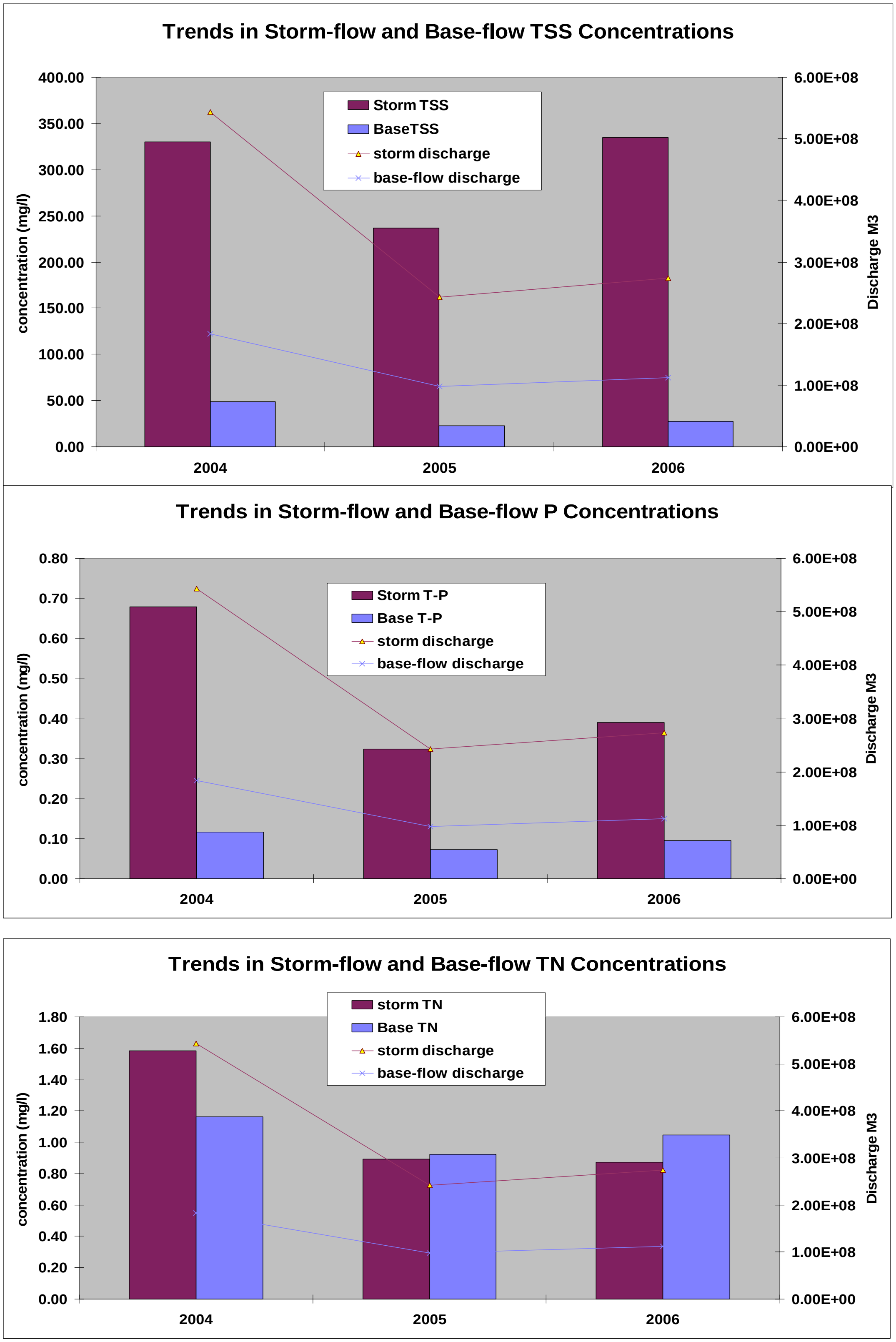
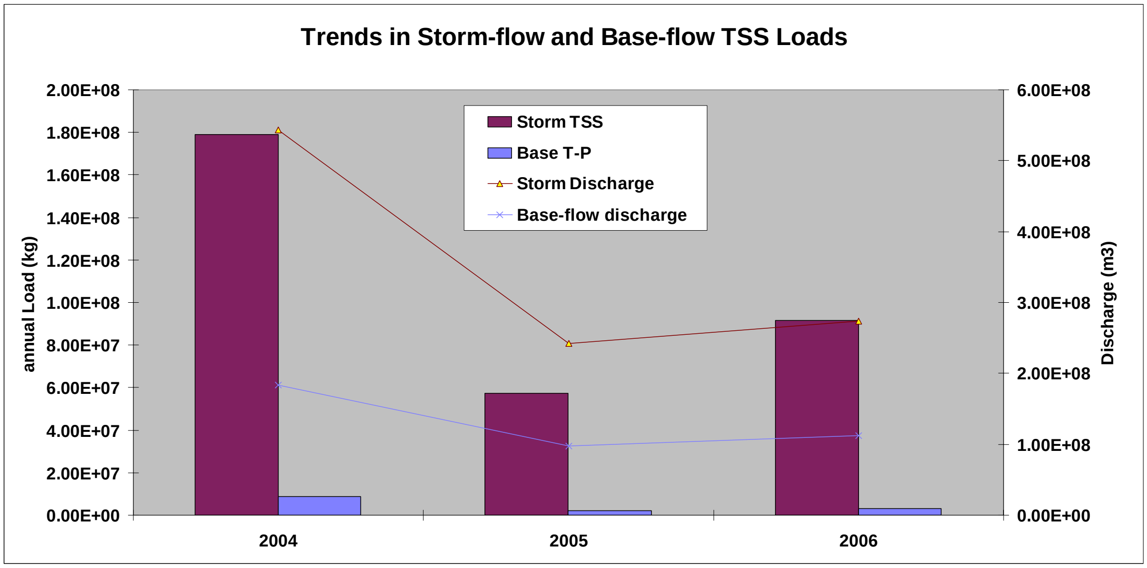
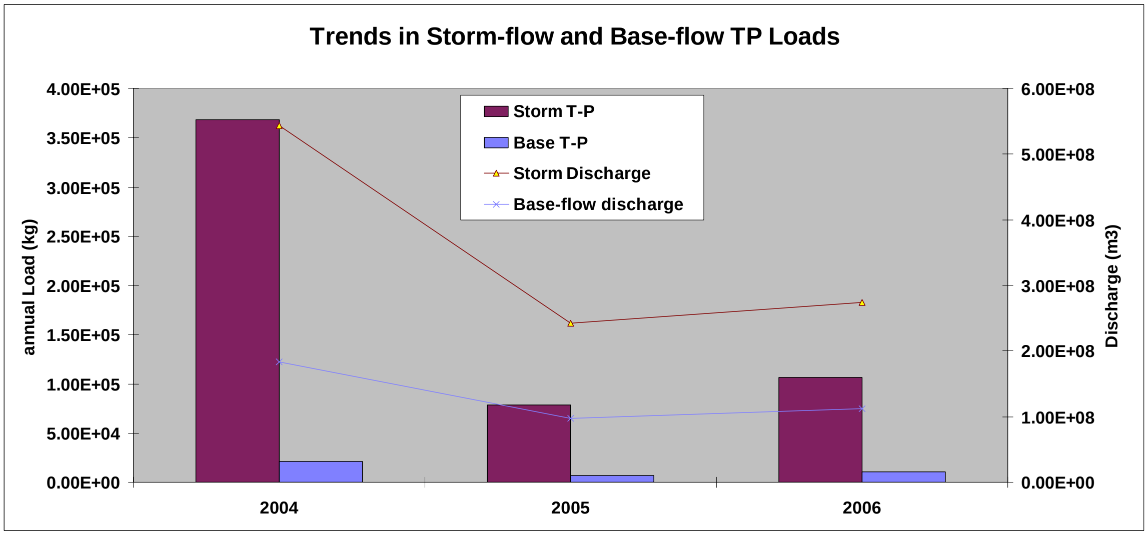
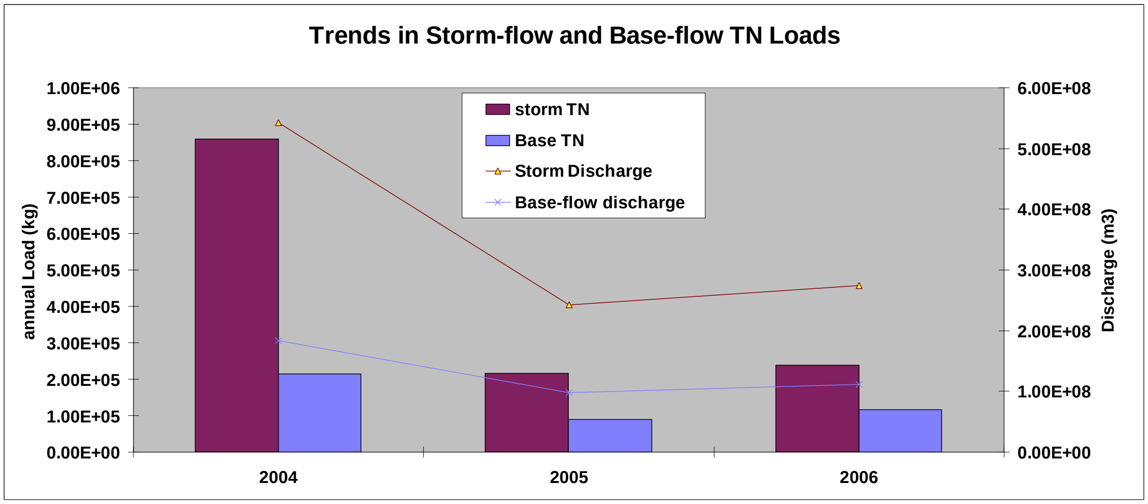


Figure 4 Trends in Storm-flow and Base-flow Loads.







DISCUSSION

The White River at the 45 Bridge sampling does not use stage to trigger the sampler or differentiate between storm and base-flows. The stage levels are strongly influenced by the lake levels. Instead, discharge is used to divide the flows into storm and base-flows. Velocities are measured by USGS using a doppler area-velocity meter and converted to discharge. The discharge used in the past reports as the dividing line has been 50 m^3/s. This appears to be unreasonably high for this year's data. Therefore, 20 m^3/s was used for this year's data as shown in table 3. The two prior year's values were recalculated with a 20 m^3/s division and the trends illustrated in figures 3 and 4 use this value for comparison.

It is premature to identify trends of watershed improvement or decline from three years of water quality data. The data does suggest the typical response to hydrological variation. That is, the higher the discharge, the higher the concentrations, and since loads are concentration multiplied by discharge, the higher the loads. The hydrological variation and the short period of data available make it difficult to determine if the changes are a result of improvements or declines in the watershed or not. Storm -flow TSS appears to be increasing at a greater rate than increased discharge would predict, but this could be a result of increased storm intensity or other factors. Total phosphorus and total nitrogen storm-flow concentrations and loads do not show an increase above what increased discharge would predict. Base-flow total phosphorus and total nitrogen concentrations appear to be increasing slightly above what increased discharge would predict.

The White River @ 45 Bridge during 2006 can be compared to loads and concentrations developed in other watersheds in Northwest Arkansas for 2006. 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 5. The table and figure 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. Normalizing storm and base-flow loads to a per hectare basis (yield) 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 (yields) may be used to represent relative impacts from non-point sources. The White River watershed had very high TSS yields compared to the other watersheds during base-flows and particularly storm-flows. Most of the TSS was transported during storm events. The P yield for the White River was higher than the other watersheds in the White River basin with values comparable to the Illinois River basin. The storm-flow P yield was greater than the Illinois River but the base-flow P yield was less. Total nitrogen yield was similar to other White River sub-basin watersheds which are lower than the Illinois River sub-basin watersheds in general.

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 very high, much higher than the values measured at the upstream tributary the West Fork. The T-P concentration was highest in the White basin, but lower than the Illinois Basin. The nitrate concentration was low considering there are point source discharges into the river (Fayetteville and West Fork WWTPs).

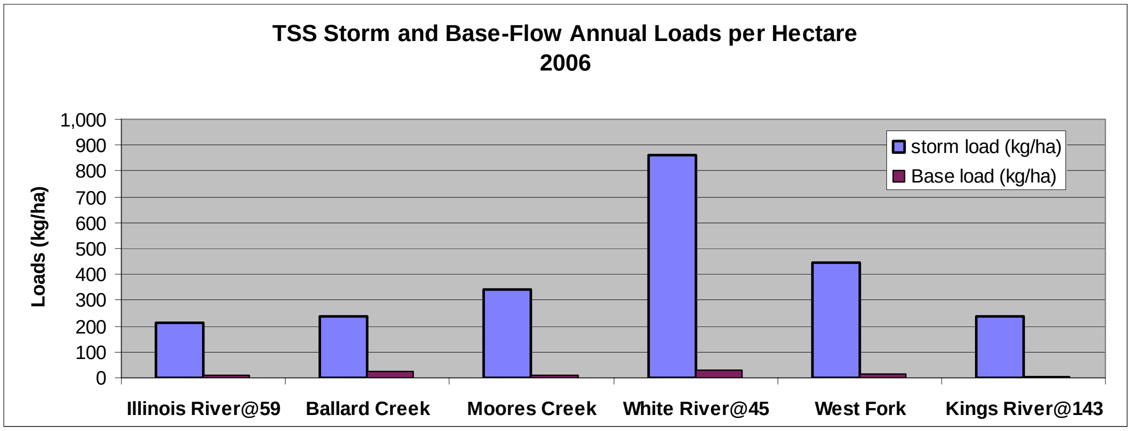
Figure 2 shows that there are significant levels of sulfate and chloride in the White River. These concentrations peak in late summer when the flow is at its lowest. This indicates a relatively constant source that is diluted at higher flows. Chlorides and sulfate are often associated with wastewater from WWTPs or septic tanks. Data obtained from the Fayetteville WWTP shows that in August 2006 their average discharge was 6.3 cfs and contained an average of 81 mg/l sulfate and 68 mg/l sulfate. The river averaged 4.2 cfs and contained 63 mg/l sulfate and 53 mg/l chloride during the first two weeks of August. This suggests the impact the WWTP discharge may be having on the river, particularly at low base-flows.

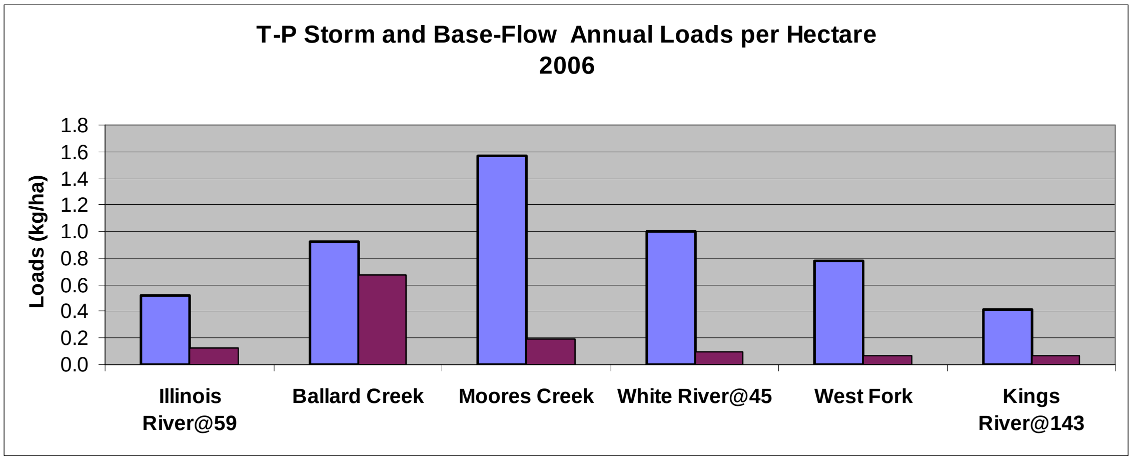
The TP discharge from the Fayetteville WWTP discharge averaged 0.42 mg/l at 6.2 MGD or 3,187 kg TP in 2006. That was about 3% of the P measured at the bridge.

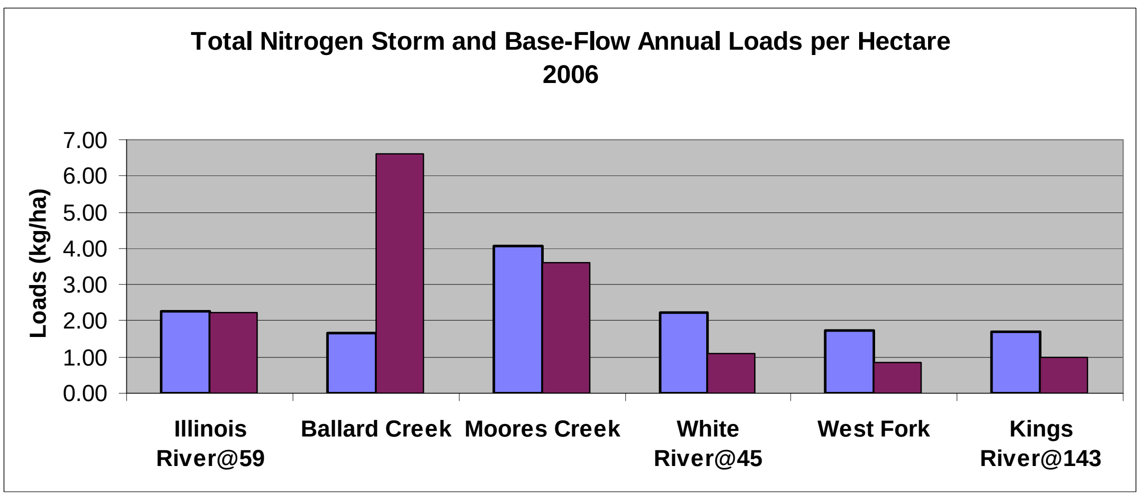
Table 4 Comparison of six Northwest Arkansas watersheds **2006**

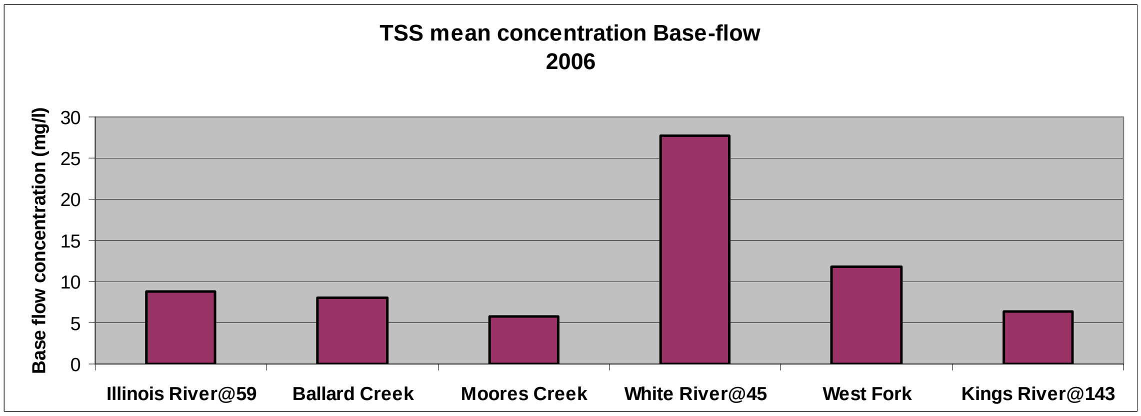
2006	Illinois River@59	Ballard Creek	Moores Creek	White River@45	West Fork	Kings River@143
Hectares	148,930	7,106	1,000	106,711	30,563	136,497
Year of data	2006	2006	2006	2006	2006	2006
TSS yield (kg/ha)	222	261	352	889	460	245
TSS storm yield (kg/ha)	213	235	341	860	444	237
TSS base yield (kg/ha)	9	26	11	29	16	7
TSS conc. base (mg/l)	9	8	6	28	12	6
P yield (kg/ha)	0.65	1.60	1.77	1.10	0.85	0.48
P storm yield (kg/ha)	0.52	0.93	1.57	1.00	0.78	0.41
P base yield (kg/ha)	0.13	0.67	0.20	0.10	0.06	0.07
P base conc. (mg/l)	0.13	0.21	0.10	0.10	0.05	0.06
Total Nitrogen yield (kg/ha)	3.86	8.27	5.73	3.34	2.58	2.69
Total Nitrogen storm yield (kg/ha)	2.27	1.66	4.08	2.24	1.74	1.71
Total Nitrogen base yield (kg/ha)	2.22	6.62	3.61	1.10	0.84	0.98
NO3-N base conc. (mg/l)	2.14	1.68	1.58	0.90	0.43	0.73
Discharge (m^3)	256,585,770	28,532,395	3,845,410	385,860,012	103,028,696	310,839,767
Discharge/area (m^3/ha)	1,722	4,015	3,845	3,616	3,371	2,047

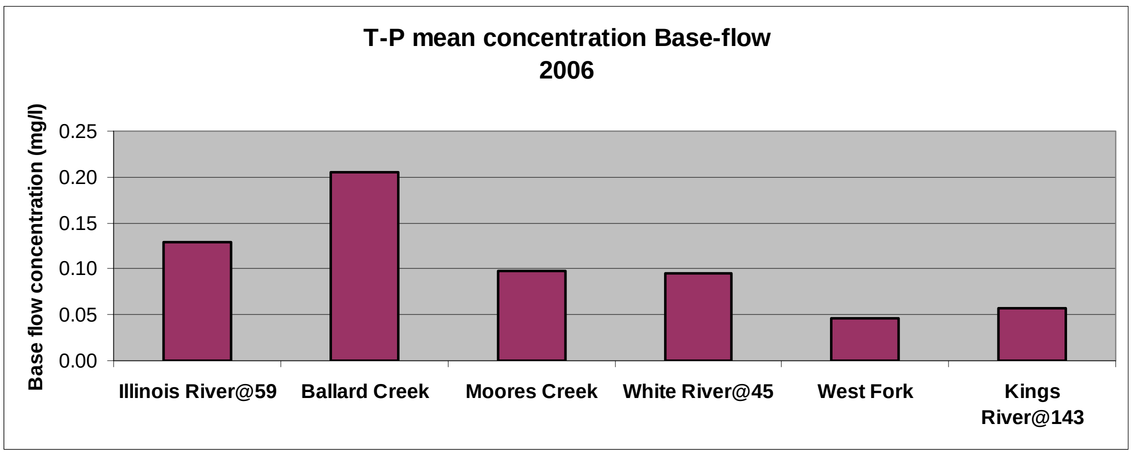
Figure 5 Comparison of six watersheds

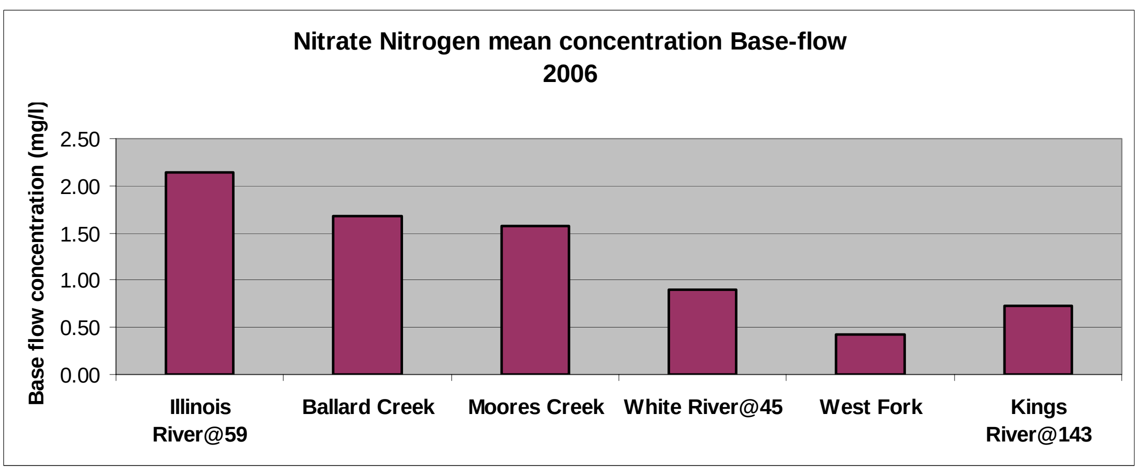







TSS mean concentration Base-flow
2006
Base flow concentration (mg/l)
30
25
20
15
10
5
0
Illinois River@59
Ballard Creek
Moores Creek
White River@45
West Fork
Kings River@143


T-P mean concentration Base-flow
2006
Base flow concentration (mg/l)
0.25
0.20
0.15
0.10
0.05
0.00
Illinois River@59
Ballard Creek
Moores Creek
White River@45
West Fork
Kings River@143


Nitrate Nitrogen mean concentration Base-flow
2006
Base flow concentration (mg/l)
2.50
2.00
1.50
1.00
0.50
0.00
Illinois River@59
Ballard Creek
Moores Creek
White River@45
West Fork
Kings River@143

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