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Arkansas Water Resources Center

2003 POLLUTANT LOADS KINGS RIVER NEAR BERRYVILLE, ARKANSAS

Submitted to the
Arkansas Soil and Water Conservation Commission

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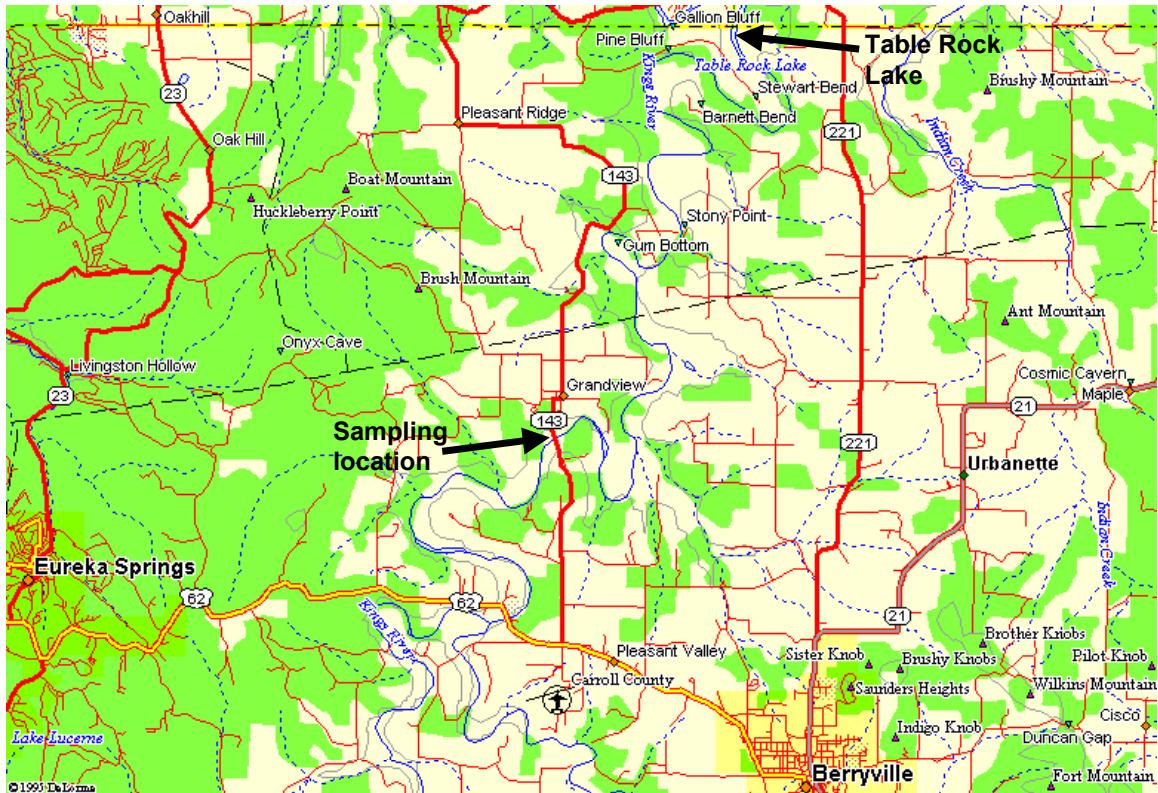
INTRODUCTION

An automatic sampler and a USGS gauging station were established in 1998 and water quality sampling was begun in 1999 on the Kings River near Berryville, Arkansas. Continuous stage and discharge measurements and frequent water quality sampling have been used to determine pollutant concentrations and loads in the river. This report presents the results from the sampling and analysis for January 1, 2003 to December 31, 2003.

BACKGROUND

In 1999, water quality sampling was begun at a new site established on the Kings River in the White River basin. The Kings River flows into Table Rock Lake at the Missouri border and the river basin contains forested and agricultural land and the wastewater from Berryville, Arkansas. USGS installed a stage gauge and developed a stage-discharge relationship for the site. The site is at "Lat 3625'36", long 9337'15", in SE1/4NE1/4 sec.3, T.20 N., R.25 W., Carroll County, Hydrologic Unit 11010001, on right bank at downstream side of bridge on State Highway 143, 1.5 mi downstream from Bee Creek, 2.5 mi upstream from Clabber Creek, 5.3 mi northwest of Berryville, and at mile 35.1" (from USGS web site). Figure 1 shows a map of the site.

Figure 1. Map of Kings River Sampling site



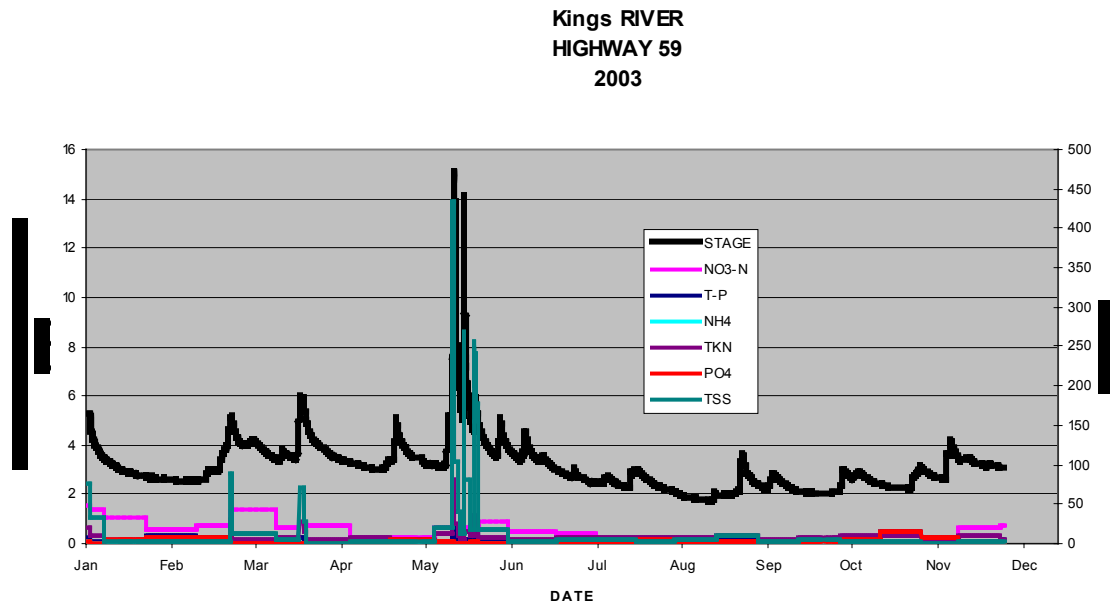
METHODS

The sampler was configured to take flow-weighted composite samples. The sampler was set to begin sampling when the stage rose above a set trigger level of five feet. It took a discrete sample after a fixed volume of water (8,000,000 cubic feet) passed. The discrete samples were composited by combining equal volumes of each into a single composite sample for analysis. The discrete samples were collected for compositing within forty-eight hours after the first sample. All storms were sampled in this manner as long as the stage was above the trigger level. Grab samples were taken every two weeks. The data collected at this site was used to calculate total pollutant loads and mean concentrations for the year. All samples were analyzed for Nitrate Nitrogen (NO₃-N), Ammonia Nitrogen (NH₄-N), Total Kjeldahl Nitrogen (TKN), Total Phosphorus (TP), Soluble Reactive Phosphate (SRP), Sulfate (SO₄), Chloride (Cl), and Total Suspended Solids (TSS). AWRC Field Services personnel collected all samples and all samples were analyzed by the AWRC Water Quality Lab using standard field and laboratory QA/QC procedures.

Pollutant loads and mean concentrations were calculated by multiplying the concentration for each 30-minute period times the discharge during that period. Pollutant concentrations were assigned to each time period by taking the measured concentration and applying it from half way to the previous sample to half way to the subsequent sample. The yearly load is the sum of all the loads for all the time periods. The yearly mean concentrations were calculated by dividing the yearly load by the yearly discharge.

A total of 26 grab samples and 7 storm composite samples were collected, analyzed and used for load determination at this site in calendar year 2003. In addition, 4 field blanks, 4 field duplicates and 3 USGS/AWRC paired samples were collected, analyzed and used for QA/QC. The stage and determined concentrations are illustrated in figure 2.

Figure 2. 2003 Stage and Concentrations.



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. Five storm-flow paired samples were taken and compared during the year.

Regressions of log USGS vs. log AWRC concentrations for total P and TSS from the beginning of the project are shown in figures 3 and 4.

Figure 3. log USGS vs. log AWRC TSS

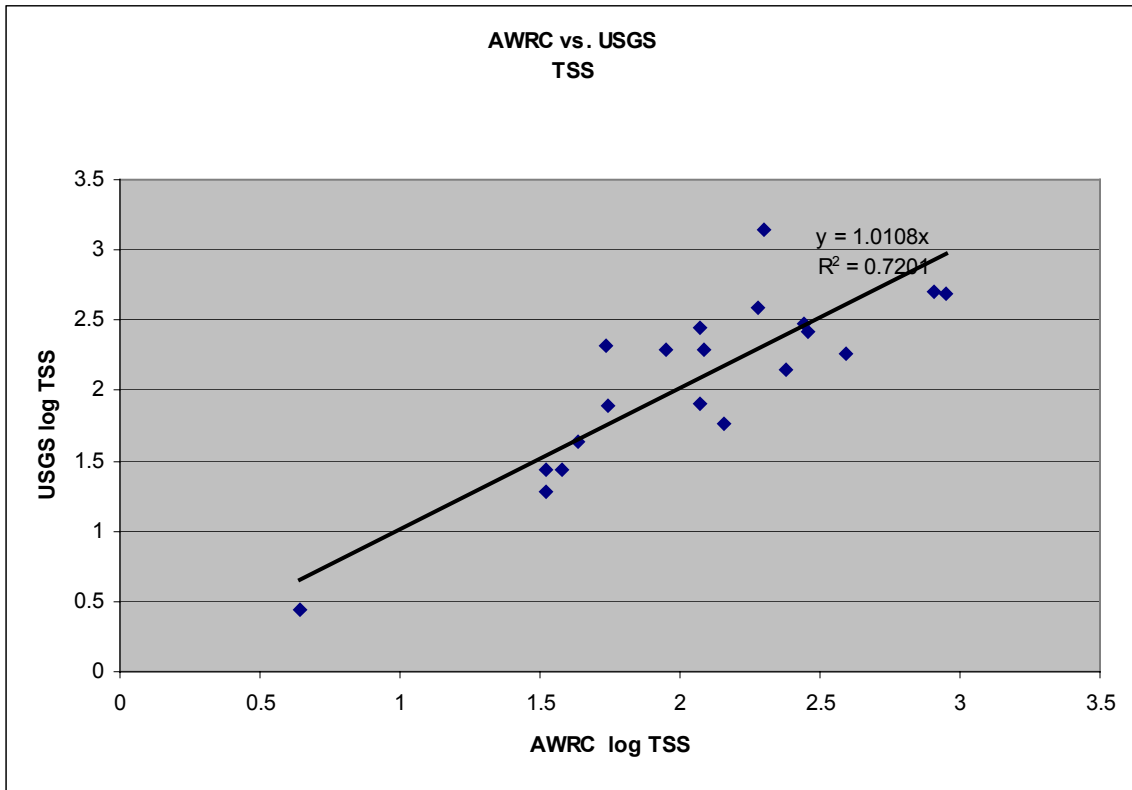
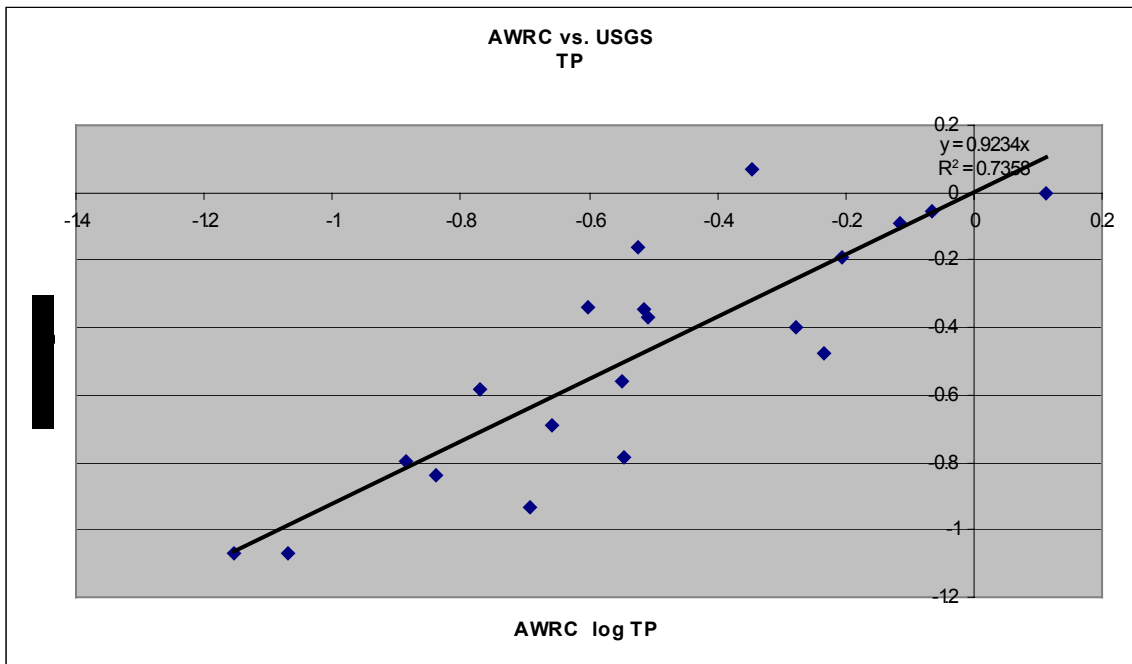


Figure 4. log USGS vs. log AWRC T-P



RESULTS

The 2003 calculated loads and flow-weighted mean concentrations are shown in Table 1.

Table 1. Kings River near Berryville 2003 Loads and Mean Concentrations

| Parameter | Total Load (kg/yr) | Mean concentration (mg/L) |
|----------------------------------|--------------------|---------------------------|
| Discharge (m ³ /yr) | 213,724,326 | 239 (cfs) |
| SO ₄ ⁴⁻ | 1,307,889 | 6.12 |
| Cl ⁻ | 1,025,241 | 4.80 |
| NO ₃ -N | 154,168 | 0.72 |
| TP | 40,230 | 0.19 |
| NH ₄ ⁺ -N | 3,927 | 0.02 |
| TKN | 106,926 | 0.50 |
| PO ₄ ²⁻ -P | 13,383 | 0.06 |
| TSS | 13,840,392 | 64.76 |

Table 2. Loads for all parameters

| Parameter | 1999 Loads | 2000 Loads | 2001 Loads | 2002 Loads | 2003 Loads |
|---|-------------|-------------|-------------|-------------|-------------|
| Discharge (m ³) | 477,590,619 | 285,535,630 | 332,293,424 | 582,849,012 | 213,724,326 |
| NO ₃ -N (kg/yr) | 401,729 | 250,132 | 479,272 | 432,143 | 154,168 |
| TP (kg/yr) | 153,786 | 102,332 | 108,473 | 180,203 | 40,230 |
| NH ₄ ⁺ -N (kg/yr) | 12,997 | 10,968 | 17,316 | 20,936 | 3,927 |
| TKN (kg/yr) | 348,376 | 210,601 | 226,891 | 401,495 | 106,926 |
| PO ₄ P (kg/yr) | 47,914 | 47,106 | 34,984 | 44,767 | 13,383 |
| TSS (kg/yr) | 79,598,491 | 35,645,367 | 36,818,561 | 63,146,716 | 13,840,392 |
| SO ₄ (kg/yr) | 1,804,599 | 1,737,722 | 2,100,924 | 4,960,436 | 1,307,889 |
| Cl ⁻ (kg/yr) | 2,608,416 | 1,464,226 | 1,791,831 | 2,383,729 | 1,025,241 |

Table 3 Flow-weighted Mean concentrations.

| Parameter | 1999 mean concentrations | 2000 mean concentrations | 2001 mean concentrations | 2002 mean concentrations | 2003 mean concentrations |
|--|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| Discharge (cfs) | 535 | 320 | 372 | 653 | 239 |
| NO ₃ -N (mg/l) | 0.84 | 0.88 | 1.44 | 0.74 | 0.72 |
| TP (mg/l) | 0.32 | 0.36 | 0.33 | 0.31 | 0.19 |
| NH ₄ ⁺ -N (mg/l) | 0.03 | 0.04 | 0.05 | 0.04 | 0.02 |
| TKN (mg/l) | 0.73 | 0.74 | 0.68 | 0.69 | 0.50 |

| | | | | | |
|-----------------------------|------|------|------|------|-------|
| PO ₄ P (mg/l) | 0.10 | 0.16 | 0.11 | 0.08 | 0.06 |
| TSS (mg/l) | 167 | 125 | 111 | 108 | 64.76 |
| SO ₄ (mg/l) | 3.78 | 6.09 | 6.32 | 8.51 | 6.12 |
| Cl ⁻ (mg/l) | 5.46 | 5.13 | 5.39 | 4.09 | 4.80 |

During the year, there was 1 portions of a storm event that was not sampled due to equipment malfunctions. The concentrations during this period were estimated using the stage / concentration regression relationships. These relationships were determined from intensive discrete storm sampling in 1999 and 2000. The equations used are listed in table 4.

Table 4. Regression equations determined from discrete storm samples

| Parameter | Regression equation | Regression coefficient |
|------------------|-------------------------|------------------------|
| Nitrate-N | $y = -0.0139x + 0.9438$ | $R^2 = 0.0109$ |
| Total Phosphorus | $y = 0.0965x - 0.1158$ | $R^2 = 0.2415$ |
| Ammonia-N | $y = -0.0004x + 0.0275$ | $R^2 = 0.0011$ |
| TKN | $y = 0.26x - 0.4359$ | $R^2 = 0.2962$ |
| Phosphate-P | $y = 0.0116x + 0.1771$ | $R^2 = 0.1433$ |
| TSS | $y = 97.54x - 333.16$ | $R^2 = 0.4361$ |
| SO ₄ | $y = -0.2865 + 4.9888$ | $R^2 = 0.4551$ |
| Cl ⁻ | $y = -0.1864 + 6.8752$ | $R^2 = 0.3082$ |

DISCUSSION

The loads and concentrations developed for the Kings River 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.

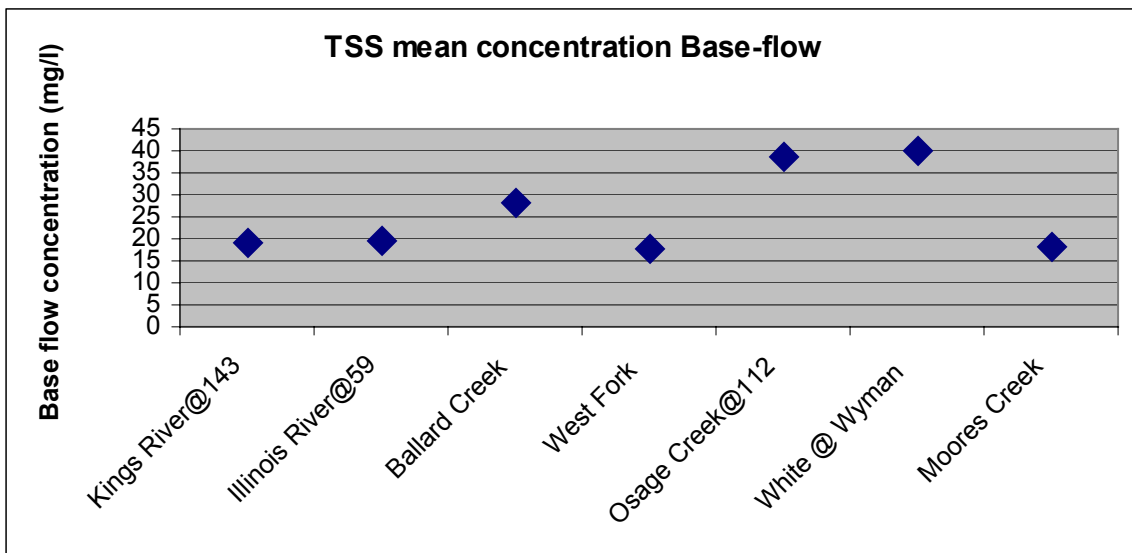
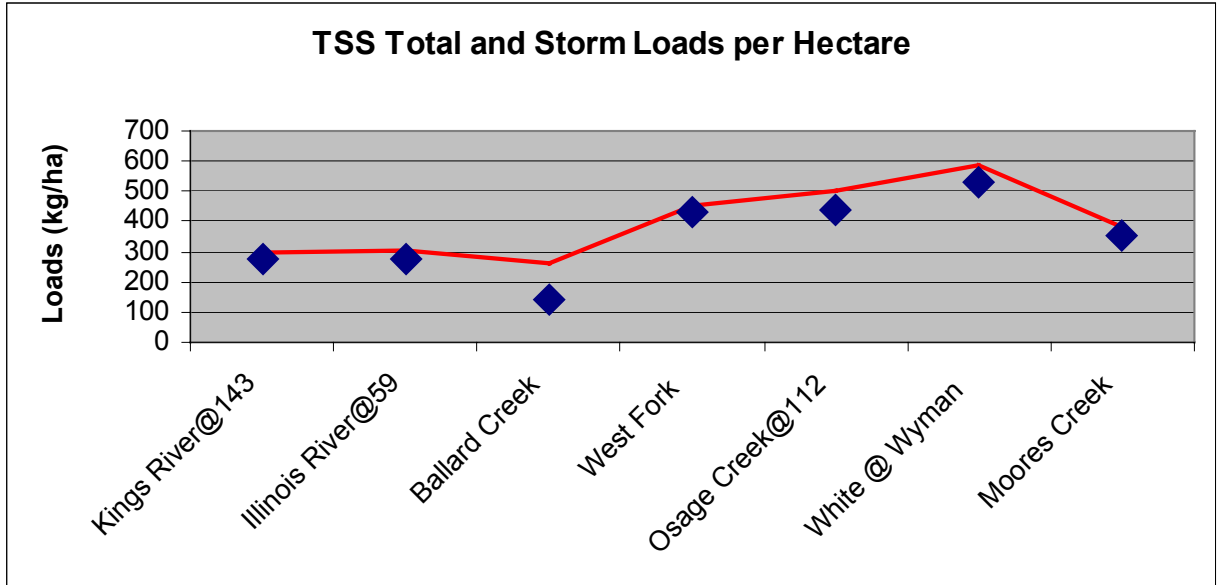
The results for the six watersheds are summarized in Table 5 and Figure 5. The table and figure show TSS and phosphorus as total annual loads per watershed acre, as storm loads per watershed acre and as base-flow concentrations. Normalizing total and storm loads to a per acre basis allows comparison 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 8, a red line represents the total loads and blue diamonds represents the storm loads. The Kings River watershed has relatively low total TSS compared to the others and most of the TSS is transported during storm events. The P load for the Kings is significantly lower than the other watersheds with the primary difference during storm events.

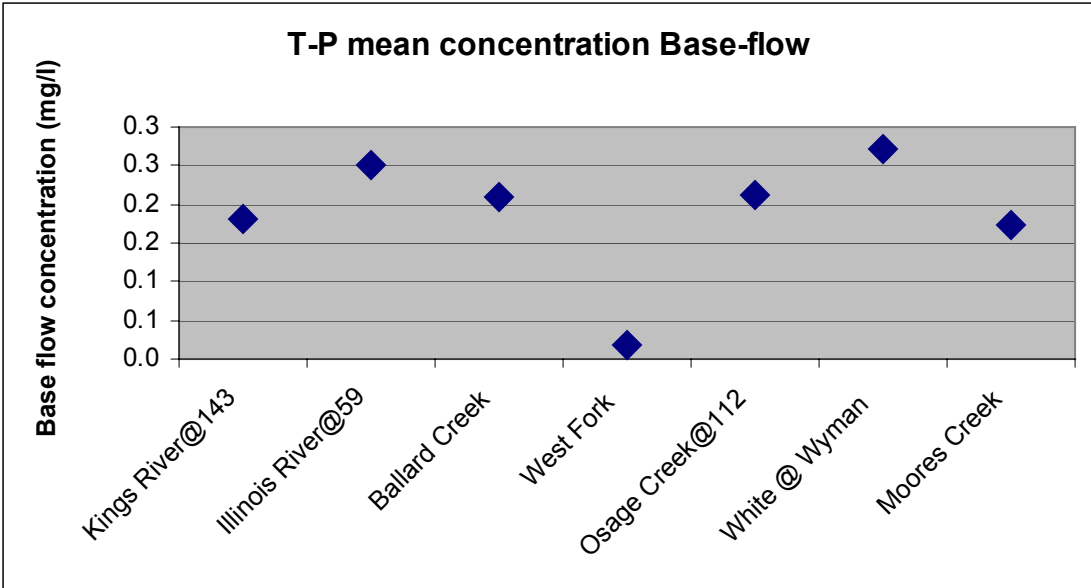
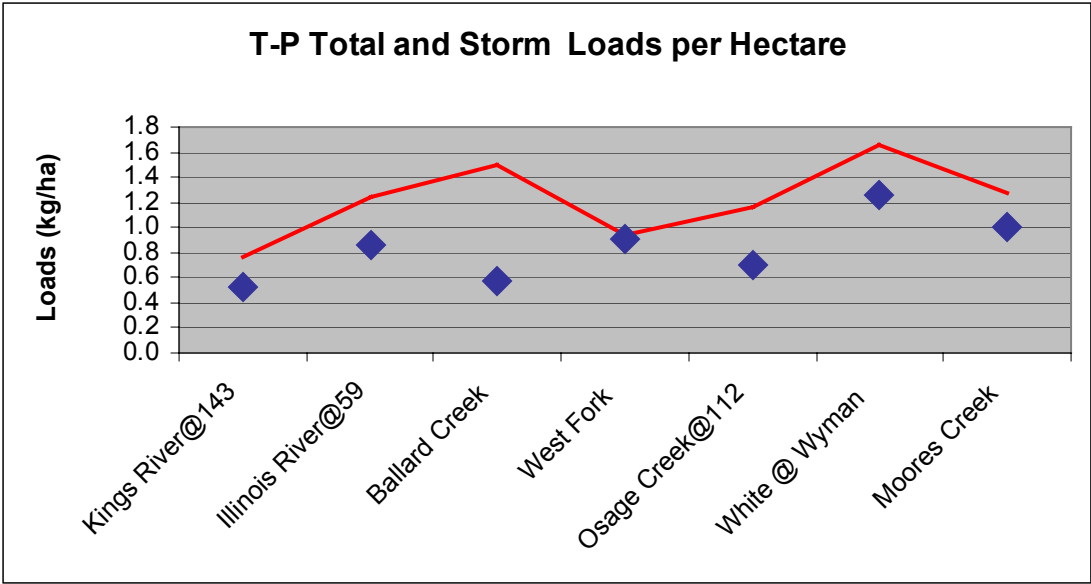
The base-flow concentrations show relative levels of TSS and P that are impacting in-stream biological activity during most of the year. These are the values that are of greatest interest for determining impacts to in-stream macro invertebrate habitat and nuisance algae production. The base-flow concentration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

Table 5 Comparison of six watersheds

| | Kings River@143 | Illinois River@59 | Ballard Creek | West Fork | Osage Creek@11 2 | White @ Wyman | Moore's Creek |
|--------------------------------------|--------------------|----------------------|------------------|-------------|------------------------|------------------|------------------|
| Hectares | 153,309 | 167,273 | 6,742 | 29,964 | 10,095 | 116,364 | 1,000 |
| YEARS of data | 5 | 7 | 1 | 2 | 2 | 2 | 4 |
| tss load (kg/ha) | 299 | 302 | 265 | 450 | 501 | 586 | 381 |
| tss load storm (kg/ha) | 273 | 274 | 141 | 430 | 442 | 528 | 355 |
| tss conc. base (mg/l) | 19 | 20 | 28 | 18 | 39 | 40 | 18 |
| p load (kg/ha) | 0.76 | 1.24 | 1.50 | 0.94 | 1.16 | 1.66 | 1.27 |
| p storm load (kg/ha) | 0.53 | 0.86 | 0.58 | 0.92 | 0.70 | 1.26 | 1.01 |
| p base conc. (mg/l) | 0.18 | 0.25 | 0.21 | 0.02 | 0.21 | 0.27 | 0.17 |
| DISCHARGE (m ³) | 378,398,602 | 545,516,682 | 36,251,012 | 106,081,072 | 38,827,312 | 243,428,688 | 63,011,285 |
| DISCHARGE/AC (m ³ /ha) | 2,468 | 3,261 | 5,377 | 3,540 | 3,846 | 3,540 | 3,011 |

Figure 5. Comparisons between 6 watersheds.





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