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ILLINOIS RIVER 1999 POLLUTANT LOADS At Arkansas Highway 59 Bridge

Submitted to the
Arkansas Soil and Water Conservation Commission

By

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SUMMARY

Results for Illinois River at AR59 for Calendar Year **1999**.

Pollutant	Total Discharge (m^3/yr) 635,000,000	Total Load (kg/yr)	Average Discharge (m^3/s) 20.0	Mean Concentrations (mg/l)
N03-N		1,560,000		2.45
TKN		514,000		0.81
TP		267,000		0.42
TSS		77,100,000		121

- Comparison between the loads and discharge calculated for 1997, 1998 and 1999 indicate increases in discharge and increases in pollutant loads for all measured parameters.

Comparison between 1997, 1998 and 1999 **loads**

Parameter	**1997** Loads	**1998** Loads	**1999** Loads
Discharge	458,460,000 (m^3)	588,000,000 (m^3)	635,000,000 (m^3)
N03-N	1,020,000 (kg/yr)	1,390,000 (kg/yr)	1,560,000 (kg/yr)
TKN	301,000 (kg/yr)	481,000 (kg/yr)	514,000 (kg/yr)
TP	127,000 (kg/yr)	232,000 (kg/yr)	267,000 (kg/yr)
TSS	18,400,000 (kg/yr)	72,600,000 (kg/yr)	77,100,000 (kg/yr)

- Comparison between flow-weighted mean concentrations for 1997,1998 and 1999 indicate increasing concentrations for all parameters except a slight decrease in TKN and TSS concentrations between 1998 and 1999.

Comparison between 1997, 1998 and 1999 **flow-weighted mean concentrations**

Parameter	**1997** Mean Concentrations (mg/l)	**1998** Mean Concentrations (mg/l)	**1999** Mean Concentrations (mg/l)
N03-N	2.24	2.37	2.45
TKN	0.66	0.82	0.81
TP	0.28	0.39	0.42
TSS	40	123	121

- A total of three hundred and sixty-nine water samples were collected and analyzed in 1999.

- Rating curves were used to estimate the concentrations for a nineteen-hour period during the critical portion of the largest storm of the year.

INTRODUCTION

Automatic water samplers and a U. S. Geological Survey gauging station were established in 1995 on the main stem of the Illinois River at the Arkansas Highway 59 Bridge. Since that time, continuous stage and discharge measurements and water quality sampling have been used to determine pollutant concentrations and loads in the Arkansas portion of the Illinois River. This report represents the results from the measurement and sampling for January 1, 1999 to December 31, 1999.

PREVIOUS RESULTS

In the fall of 1995, a gauge was installed at the Highway 59 bridge by the USGS and automatic sampling equipment was installed by the Arkansas Water Resource Center. In September 1995, sampling was begun on the Illinois River. Grab samples were taken every week and storms were sampled using an automatic sampler set to take samples every 4 hours. During the period from September 13, 1995 to September 15, 1996 one hundred thirty seven grab samples and discrete storm samples were collected and analyzed. Table 1. summarizes the results from that study (Parker et al, 1997).

Table 1. Results from **1996** study period (Parker et al, 1997)

Nutrients	Total Discharge (m^3/yr) 300,775,680	Total Load (kg/yr)	Average Discharge (m^3/s) 9.5	Average Flow Weighted Concentrations (mg/l)
N03-N		550,000		2.0
NH3-N		8,530		0.031
TKN		201,000		0.74
TP		89,900		0.29
TSS		27,000,000		89
TOC		1,130,000		4.2

Sampling was discontinued on September 15, 1996 and no water quality samples were taken between September 15, 1996 and November 1, 1996. Stage and discharge was still recorded for this period, however, no loads were calculated. Water quality sampling was resumed on November 1, 1996. The sampling protocol was changed to collection of grab samples every two weeks and flow-weighted storm composite samples. Between November 1, 1996 and December 31, 1996 a total of four grab samples and one storm composite sample were collected and analyzed. Stage and discharge were recorded.

During the period from January 1, 1997 to October 15, 1997, there were twenty-six grab samples and twenty-five storm composite samples collected and analyzed using the same protocol. During the period from October 15, 1997 to December 31, 1997, the sampling protocol was changed to taking grab samples every two or three days and taking discrete storm samples every thirty or sixty minutes. In this period, there were twenty-four grab samples and one hundred and forty storm discrete samples collected and analyzed. The loads and mean concentrations for 1997 calculated using these samples are summarized in Table 2.

Table 2. Results from **1997**-study period (Nelson and Soerens, 1998).

Pollutant	Total Discharge (m^3/yr) 458,460,000	Total Load (kg/yr)	Average Discharge (m^3/s) 14.5	Mean Concentrations (mg/l)
N03-N		1,020,000		2.24
TKN		301,000		0.66
TP		127,000		0.28
TSS		18,400,000		40.2

In the periods from January 1, 1998 to May 15, 1998 and November 1, 1998 to December 31, 1998, the Illinois River sampling was supplemented by sampling from another research project. That project, sponsored by the USGS Water Resource Institute Program, was titled "Investigation of Optimum Sample Interval for Determining Storm Water Pollutant Loads" by Marc Nelson, Thomas Soerens and Jean Spooner. The sampling protocol for that project consisted of taking grab samples every two days and discrete storm water samples at thirty-minute intervals on the rising limb and sixty-minute intervals on the falling limb of storm hydrographs. Storm water sampling was begun at a variable trigger level set to the current stage plus ten percent and adjusted every two days. After the first thirty-six hours of each storm, sample times were increased to from four to twenty-four hours until the stage fell below the initial trigger. All samples were collected within twenty-four hours. All samples were analyzed for nitrate nitrogen (NO3-N), ammonia nitrogen (NH4-N), total Kjeldahl nitrogen (TKN), total phosphorus (TP), ortho phosphate (O-P) 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.

In the period from May 16, 1998 to October 31, 1998, the sampling protocol was changed back to the collection of grab samples every two weeks and flow-weighted composite samples during storms. Storms were defined as all flows above a five-foot trigger level. Once stage had risen above the trigger, a USGS programmable data logger began summing the volume of water discharged. Once a determined amount of water had been discharged, the data logger sent a signal to an automatic water sampler that filled one of twenty-four one-liter bottles. The total was then reset to zero and discharge was again summed for the next sample. In this fashion up to twenty-four samples, each representing an equal volume of storm water was collected. The volume of water represented by each individual sample was eight million cubic feet. These samples were retrieved before all twenty-four bottles were filled, or within 48 hours after being taken. The individual samples were composited into a flow-weighted composite storm sample by combining equal volumes of each. Samples were taken as long as the stage remained above the trigger level. All samples were analyzed for nitrate nitrogen (NO3-N), total Kjeldahl nitrogen (TKN), total phosphorus (TP) 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.

In the period from January 1, 1998 to December 31, 1998, there were four hundred and forty nine samples collected and analyzed. These results are summarized in Table 3.

Table 3. Results from **1998**-study period (Nelson and Soerens, 1999).

Pollutant	Total Discharge (m^3/yr) 588,000,000	Total Load (kg/yr)	Average Discharge (m^3/s) 18.6	Mean Concentrations (mg/l)
N03-N		1,390,000		2.37
TKN		481,000		0.82
TP		232,000		0.39
TSS		72,600,000		123.5

METHODS

In the periods from January 1, 1999 to May 15, 1999, the Illinois River sampling was again supplemented by sampling from another research project. That project, sponsored by the USGS Water Resource Institute Program, was titled " Continuation of An Investigation of Optimum Sample Intervals for Determining Storm Water Pollutant Loads" by Marc Nelson, Thomas Soerens and Jean Spooner. The sampling protocol for that project consisted of taking grab samples every two days and discrete storm water samples at thirty-minute intervals on the rising limb and sixty-minute intervals on the falling limb of storm hydrographs. Storm water sampling was begun at a variable trigger level set to the current stage plus ten percent and adjusted every two days. After the first thirty-six hours of each storm, sample times were increased to from four to twenty-four hours until the stage fell below the initial trigger. All samples were collected within twenty-four hours. All samples were analyzed for nitrate nitrogen (NO3-N), ammonia nitrogen (NH4-N), total Kjeldahl nitrogen (TKN), total phosphorus (TP), ortho-phosphate (O-P) 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.

Calendar year pollutants loads and mean concentrations were calculated from the collected data. USGS stage and discharge data in thirty-minute intervals was used to calculate thirty-minute total volumes. Each volume was assigned a pollutant concentration. The pollutant concentrations were assigned by applying the results of grab samples between storm trigger levels and the results of storm water samples above trigger levels. All concentration data were assigned to the time periods from half way to the previous sample to half way to the subsequent sample except the first and last of a storm or base flow period which were assigned to the start or end of the period. Thirty-minute loads were calculated by multiplying thirty-minute volumes by their assigned concentrations. The yearly loads were calculated by summing the thirty-minute loads during the calendar year. Yearly mean concentrations were calculated by dividing the yearly load by the yearly volume.

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 will be used to determine correction factors for the auto-sample concentrations. Six storm-flow and two base flow samples were taken and compared during the year.

RESULTS

In the period from January 1, 1999 to December 31, 1999, there were two hundred and ninety-three discrete storm samples, eleven composite storm samples and sixty-five base-flow grab samples collected, analyzed and used to calculate loads. These results are summarized in Table 4 and Figure 1.

Table 4. Results for Illinois River at AR59 for Calendar Year **1999**.

Pollutant	Total Discharge (m^3/yr) 635,000,000	Total Load (kg/yr)	Average Discharge (m^3/s) 20.0	Mean Concentrations (mg/l)
N03-N		1,560,000		2.45
TKN		514,000		0.81
TP		267,000		0.42
TSS		77,100,000		121

Figure 1. Recorded stage and measured concentration for 1999.

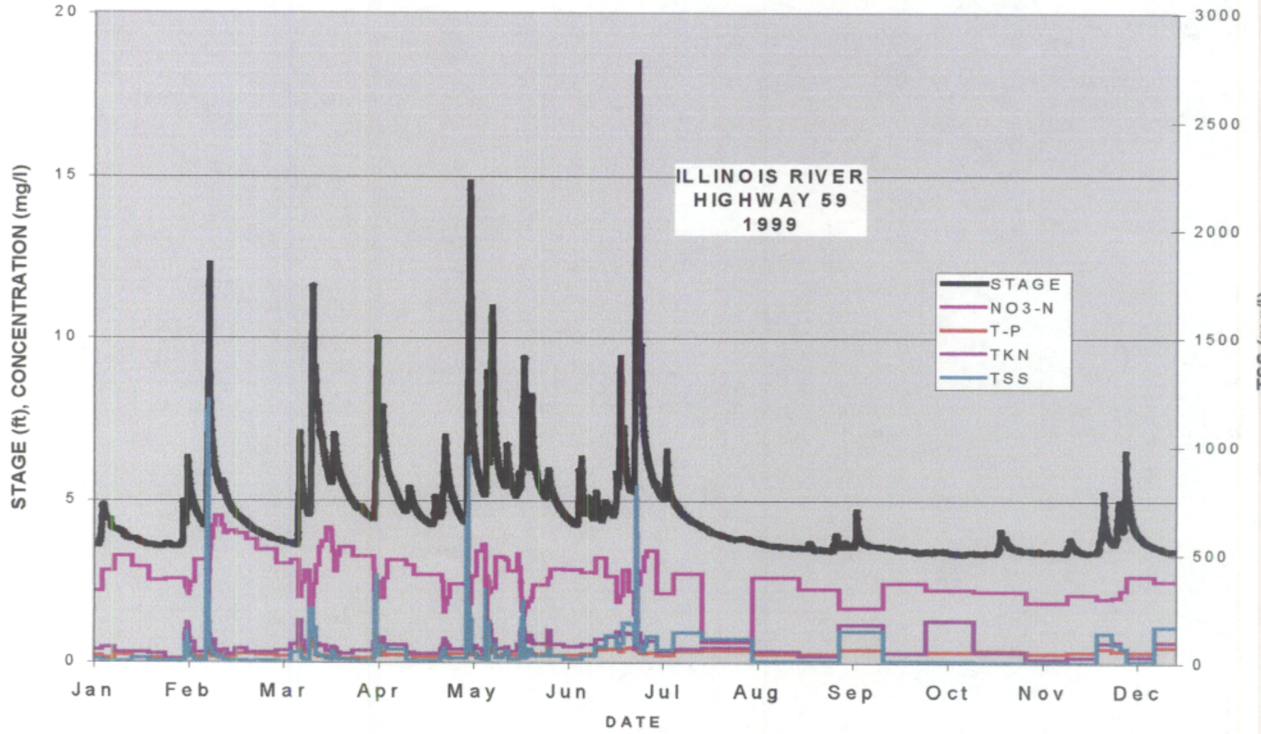


Figure 2. Trends in mean discharge and mean concentrations

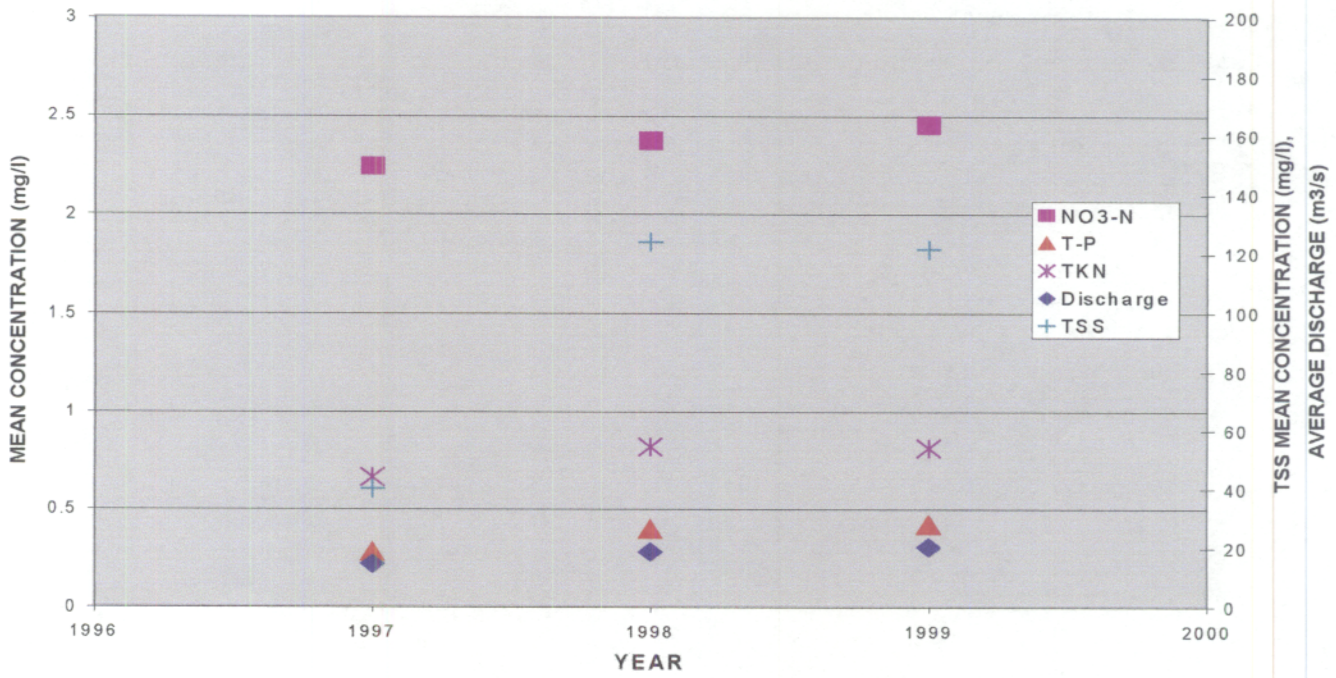


Figure 3. Comparison of auto-sampler concentrations to EWI cross-section concentrations of TSS.

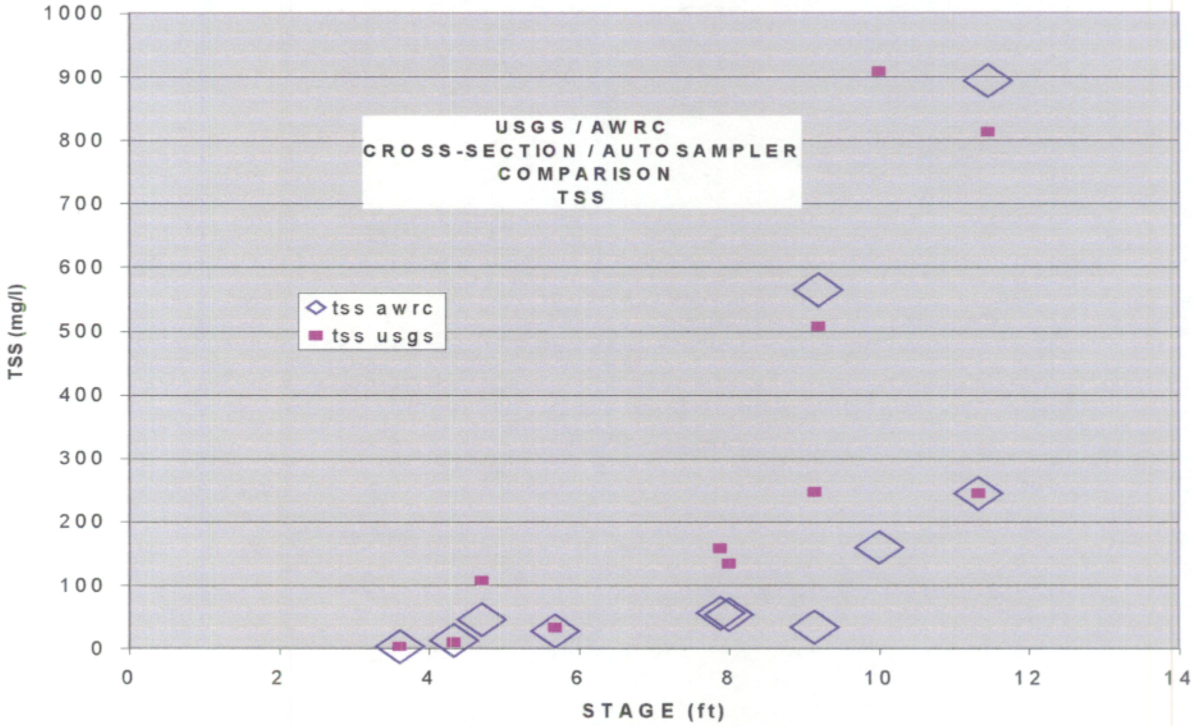
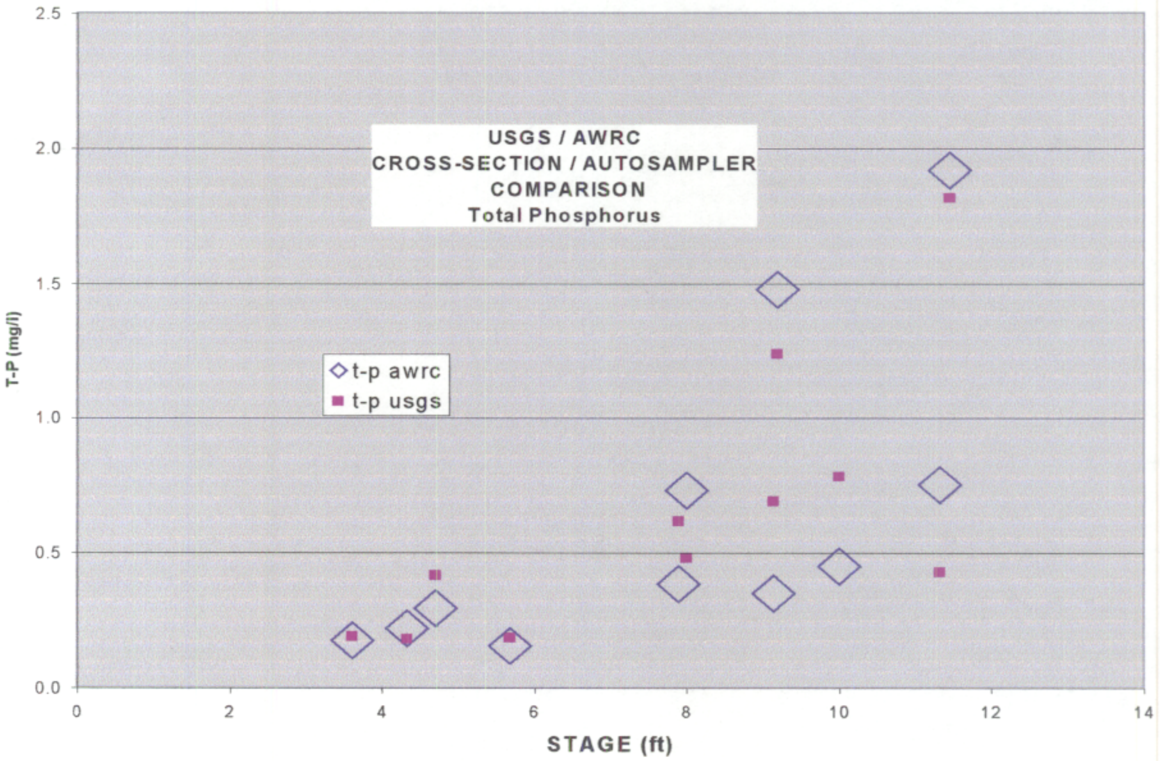


Figure 4. Comparison of auto-sampler concentrations to EWI cross-section concentrations of T-P.



All storm events during the year were sampled either with discrete samples spaced thirty or sixty minutes apart, or with composite samples. The largest storm of the year (based on peak stage) began on June 30, and lasted until July 5. Most of the storm was sampled using composite samples. However, a nineteen-hour period straddling the peak of the storm was not sampled due to sampler malfunction. This period covered the most critical portion of the storm when concentrations are typically at the highest level. Usually missed concentrations are estimated for missed time periods by averaging values before and after the missing portion. In this case, since it was a critical portion of a critical storm, concentrations were estimated using rating curves. The rating curves were developed using linear regression techniques between concentrations and stage. All discrete samples taken this year (258) were used in the regression. Figure 5. Shows the concentrations of T-P with the regression line, equation and the R^2 value, which is an estimate of how well the regression line fits the points. Table 5 lists the regression equations and the R^2 values found for all parameters.

Figure 5. Linear regression of total phosphorus and stage

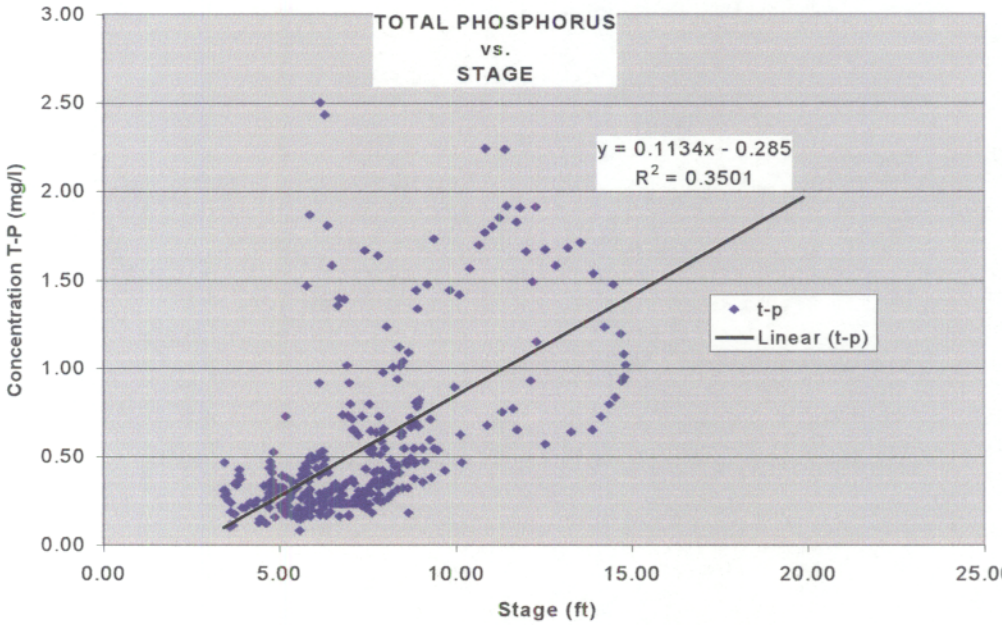


Table 5. Regression equations and residuals (R^2)

Parameter	Regression equation	Residual
Nitrate	Y=-0.1703 x + 3.6893	0.2548
Ammonia	Y=-0.0013 x + 0.0598	0.0066
Total phosphorus	Y=0.1134 x - 0.2850	0.3501
Kjeldahl nitrogen	Y=0.2038 x - 0.4022	0.3338
Phosphate	Y=0.0211 x + 0.0525	0.2287
Total suspended solids	Y=57.567 x - 247.25	0.3517

DISCUSSION

The loads calculated for the year 1999 should be considered a very reliable estimate of the actual loads in the Illinois River in Arkansas. There were no gaps in the discharge data and all storm events were sampled except for the missing portion of one storm. Most of the storm events were sampled using discrete samples taken at thirty-minute intervals during rising flow and sixty-minute intervals during falling flow. The results of the research conducted during 1997,1998 and 1999 at this site to determine an optimum sample interval indicate that on average, the loads calculated from storms that were sampled at sixty-minute intervals or less are within five percent of the actual value.

A potential source of error is the missing portion of the storm on June 30. The regression equations used to estimate concentrations were not particularly good fits with the residuals ranging in value from 0.0066 to 0.3517. This spread in the data results from different relationships between concentration and stage on the rising limb and the falling limb of storms. However, since the missing period straddled the peak of the storm, the errors should balance. The regression equation should underestimate the concentrations on the rising limb and overestimate the concentrations on the falling limb for TSS, T-P and TKN (the opposite effect should occur for NH_4, PO_4 and NO_3). Using the regression equations instead of averaging before and after concentrations had a large effect on the loads calculated, since the storm was large and the missing portion was critical. The T-P load for the year was 42,000 kg greater using the regression approach, nearly 20%. The effect on the other parameters was similar. These results reinforce the importance of adequately sampled storm events for accurate determination of pollutant loads. In addition, there must be a method to reasonably predict individual storm loads for "missed" storms.

A source of error in the use of automatic samplers to collect samples is that the sampler may take samples that are not representative of the cross-section. In an effort to determine the possible error, beginning in 1998, the USGS began taking samples that represent the entire cross-section at the same time the autosampler was taking samples. Results from those samples indicate that the auto samples may be underestimating concentrations during low to medium flow range and overestimating concentrations during high flow (see Figures 3 and 4). More measurements particularly at high flows need to be made to accurately characterize this relationship.