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Continuation of Illinois River Water Quality Monitoring of Moores Creek

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CONTINUATION OF ILLINOIS RIVER WATER QUALITY MONITORING OF MOORES CREEK

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PROJECT DESCRIPTION

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 objectionable water quality. 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 was the approach 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. 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 transport by Moores Creek and Beatty Branch, the two streams that feed Lincoln Lake, was monitored from September 1991 until April 1994 (Edwards *et al.*, 1996 and 1997). During storm flow conditions, significant decreases in mean concentrations and mass transport of nitrate-nitrogen (NO_3-N), ammonia-nitrogen (NH_3-N), total Kjeldahl nitrogen (TKN), and chemical oxygen demand (COD) were observed in this watershed and attributed to BMP implementation. There were no decreases in total phosphorus (TP) or total suspended solids (TSS). Likewise, during base flow conditions, significant decreases of NH_3-N, TKN, and COD were observed. After the end of this initial monitoring project, the stream monitoring continued on a limited basis in the Lincoln Lake basin. This report will compare the results of continued monitoring to the findings of the first project. This supplemental monitoring was conducted from 1 January 1995 until 30 September 1997.

PROJECT OBJECTIVES

The objectives of the continued water quality monitoring of Moores Creek and Beatty Branch are to 1) determine if the reductions in mean concentration and mass transport of nitrogen have been sustained, 2) determine if transport of nitrogen continues to decline, and 3) search for changes in phosphorus transport.

MATERIALS AND METHODS

Watershed Description

The Lincoln Lake basin is a sub-basin of the Illinois River watershed that is located in Northwest Arkansas and eastern Oklahoma (Figures 1 and 2). Moores Creek and Beatty Branch Creek are the two streams that flow into Lincoln Lake (Figure 3). The drainage area of the Lincoln Lake basin is approximately 3240-ha with Moores Creek and Beatty Branch draining 2120 and 1120-ha, respectively.

The 1990 land use in the overall Lincoln Lake basin is 56% pasture, 34% forest, and 10% other uses. Land use distribution in the monitored portion of the Moores Creek watershed is 62% pasture, 26% forest, 7% urban, and 5% other uses. Whereas, the monitored portion of the Beatty Branch basin has 57% pasture, 40% forest and 3% other uses.

Nutrient management, pasture and hay-land management, waste utilization, dead poultry composting, and waste storage structures were the predominant BMPs implemented. The distribution of all the BMPs implemented within the Lincoln Lake watershed is mapped in Figure 4.

In the fall of 1995 a timber harvest began in the Moores Creek watershed. Select hardwoods were removed from approximately 200-ha. The timber harvest continued until the spring of 1996. Following the tree removal the cleared areas were sub-divided into residential tracts. Therefore, the land use distribution of forest in the Moores Creek watershed declined in favor of residential development. In response to this change in land use, a new monitoring site (Figure 3) was installed above the harvested area.

Water Quality Monitoring

Two water quality monitoring sites from the first study were maintained for the collection of base flow and storm flow samples. These two sites are referred to as Beatty Branch (BB) and lower Moores Creek (LMC). Another monitoring site was installed upstream of the timber harvest activity and is referred to as the upper Moores Creek (UMC) site. The locations of these monitoring sites are displayed in Figure 3. Automated samplers and data-loggers were used at all sites to measure and record stream stage and collect flow-weighted composite or discrete water samples during storm flow events. Flow-weighted composite storm samples were collected at the BB and LMC sites while discrete storm samples were collected at the UMC site. Base flow water samples were collected as grab samples on two week intervals at all sites.

The LMC monitoring site was located upstream from the lake at a point that represented about 85% of the total drainage area or 1800-ha. Whereas, the BB site accounted for 71% of that total drainage or approximately 800-ha.

Water samples collected at base flow or from a storm were analyzed for concentrations of NO_3-N, NH_3-N, TKN, TP, total organic carbon (TOC), and TSS. Stream stage was monitored continuously and converted to discharge using a rating-curve. Mass transport of nutrients, carbon, and sediment were calculated by integrating, with respect to time, the product of the mean event concentration and stream discharge. The methods used to apply the analytical concentrations across the discharge hydrographs are described in Table 1.

Discharge at the LMC site was calculated by first converting pressure transducer response to stage using factory provided calibration values, then converting stage to discharge using a rating curve developed in the original Moores Creek project. The stage to discharge conversion was calculated as follows:

Discharge (cfs) = 0	when	$0 < x < 1.85$ in
$= 5.37(x/12)^{3.3}$	when	1.85 in $< x < 35.525$ in
$= 8.41(x/12)^{2.91}$	when	$35.525 < x < \propto$.

where x = stage in inches - 1.8

This stage to discharge conversion was originally done by the Campbell Scientific data logger and discharge was downloaded to the spreadsheet for load calculation. However, it was determined in July 1997, during a no flow period, that the stages recorded were negative as a result of drift in the pressure transducer reading. The largest negative value recorded was 2.04-in. In order to correct for this transducer drift, the stage was downloaded to the spreadsheets where the discharge was calculated according to the above relationships after adding 2.04-in. back to the stage. This correction was applied to the entire data set beginning in January 1996.

Discharge at the BB site was calculated by first converting pressure transducer response to stage using factory provided calibration values, then converting stage to discharge using a rating curve developed in the original Moores Creek project. The stage to discharge conversion was calculated as follows:

Discharge (cfs)

$= -5.7743x^5 + 23.137x^4 - 30.922x^3 + 19.961x^2 - 3.4722x + 0.7357$ when $0 < x < 0.63$

$= 76.865x^4 - 224.7x^3 + 246.19x^2 - 116.38x + 20.829$ when $0.63 < x < 0.88$

$= -493.7x^5 + 3165.1x^4 - 8027x^3 + 101.09x^2 - 629.7x + 1547.9$ when $0.88 < x < 1.68$

$= -0.1212x^5 - 1.9356x^4 + 10.815x^3 + 0.3038x^2 + 47.208x - 68.795$ when $1.68 < x < 1.83$

$= 7.599\, x^{3.4312}$ when $1.83 < x < 2.58$

$= -1.8582x^5 + 42.333x^4 - 335.91x^3 + 1417.8x^2 - 2803.3x + 2108.5$ when $2.58 < x < 10$.

where x in feet = (stage in inches - 2.4) / 12

This stage to discharge conversion was done by the Campbell Scientific data logger and discharge was downloaded to the spreadsheet for load calculation

Discharge at the UMC site was calculated by first converting pressure transducer response to stage using factory provided calibration values, then converting stage to discharge using a rating curve developed during this project. The stage discharge relationship developed was as follows:

Discharge (cfs)		
$= 0.595x$	when	$0 < x < 0.975$ ft
$= 20.335\, x^2 - 34.656x + 15$	when	$0.975 < x < 5$ ft.

where x in feet = stage in feet
The stage was downloaded to spreadsheets where the above relationships were used to calculate discharge to be used in the load calculations.

Monthly mean concentrations were calculated for each of the sites and for each measured parameter by dividing the monthly mass transport determined for a given measured parameter by the total discharge for the month. These calculations were done for combined flow (total), base flow and storm flow. The base flow and storm flow loads were differentiated by defining storm flow as all discharges above the sampling trigger level. The trigger levels were as follows:

UMC trigger = 27 in
LMC trigger = 22 in
BB trigger = 19 in.

The trigger levels for LMC and BB were the same levels used in the original project. The trigger level for UMC were chosen so that the upper and lower sites would trigger at approximately the same relative point on a hydrograph.

Statistical Trend Analysis

In previous monitoring of these basins by Edwards *et al.*, statistical trend analysis was performed over a three year period form 1991 to 1994. The trend analyses for this period are published by the authors (Edwards *et al.* 1996 and 1997). Trend analysis requires that there is consistency throughout the monitoring period in the methods used to produce the mean concentration and mass transport. The methods used by Edwards et al. could not precisely be reproduced for calculation of mean concentrations and mass transport. Therefore, to prevent the possibility of creating a significant trend as a result of differing calculation methods, the judgment was to conduct trend analyses over the period from 1995 to 1997.

The objective of the statistical analysis was to determine if the response variables exhibited a significant increasing or decreasing trend across time. We chose to carry out an analysis consistent with that of Edwards *et al.* for data collected during prior years. Each of the response variables was transformed by the natural logarithm for use as the dependent variable in the statistical analysis. The trend analysis was achieved by a linear regression on time, where time was represented by the number of months of the sample collection and January 1995 was designated as the first month. The regression model included the sine and cosine functions of time in order to remove potential seasonal effects that would be consistent across years. A significant ($p<0.10$) regression coefficient, determined by a t test, indicated the presence of a trend with time, and the sign of the coefficient indicates whether the trend is increasing (positive) or decreasing (negative). The regression model is as follows:

$$\ln(y) = B0 + B1(time) + B2 \sin(2\pi\ time/12) + B3 \cos(2\pi\ time/12).$$

RESULTS AND DISCUSSION

Stream Discharge

Monthly stream discharges past the LMC, UMC, and BB monitoring sites under storm, base and combined flow (base flow and storm flow combined) conditions are described by Figure 5. The usual occurrences of high stream flows in this region of the country are in the spring and fall of the year. The exception to this general concept was the fall of 1995 when the usual fall rainfall lacked the intensity of produce the runoff.

Trend analyses of stream discharge at base flow, storm flow and combined flow conditions at the BB, LMC, and UMC sites are presented in Table 2. Only at the BB site was there a significantly increasing trend in stream discharge. Base flow and combined flow discharge both significantly increased, however, there was no change in storm flow discharge overall. Therefore, the increase in base flow accounted for the increase in combined flow. The lack of change in discharge at the LMC site could have been due to the timber harvesting activities that occurred early in the project. During active harvesting periods in the fall and early winter of 1995, runoff could have been enhanced. Whereas, the capability of the harvesting to enhance runoff became less following the under-story re-growth in the spring and summer of 1996. No changes at the UMC site can be explained by the monitoring period. Discharge monitoring at the UMC site did not include the dry fall of 1995 and was insufficient in length (15 months) to determine yearly trends.

Mean Concentrations

Flow-weighted mean concentration of NO_3-N, TP, NH_4-N, TKN, TOC, and TSS under combined flow, base flow, and storm flow conditions were calculated for the LMC, UMC, and BB sites on a monthly basis. The LMC and BB sites have monthly concentrations from January 1995 until September 1997. Whereas, the UMC site has monthly concentrations from July 1996 until September 1997. These mean concentrations are plotted by month in Figures 6 through 14. Overlain onto each graph of mean concentrations are the predicted lines that represent the regression models used to determine trends within time. The coefficients in the regression equation defined previously to produce these lines are listed in Tables 4, 5, and 6. Two rules are used to determine if there is a significant trend within time for a parameter. The first rule is that the model must be significant ($p<0.10$) and the second rule is that the regression coefficient that represents the slope with time (trend slope) must be significant ($p<0.10$). All cases where these two rules were met are summarized in Table 3.

Significant downward trends (Table 3) for mean concentrations of NH_4-N, TKN, and TOC were observed at the LMC site. Ammonia-N and TOC concentrations decrease over the course of the monitoring period at this site only during storm flow conditions. Whereas, TKN only decreased during base and combined flow conditions. The previous monitoring effort by Edwards *et al.* (1996 and 1997) showed decreasing NH_4-N, TKN, and COD during base flow and NO_3-N, NH_4-N, TKN, and COD during storm flow at the

LMC site. It is reasonable to believe that decreases in TOC and COD represent a similar decrease in carbon. These results are consistent with the previous monitoring at the LMC site except there were no decreases of NO_3-N or TKN during storms and no decreases of NH_4-N or TOC during base flow. Inconsistencies with the previous monitoring are probably due to the timber harvest above this site.

The new UMC site showed increasing trends of TP, NH_4-N, TOC and TSS. There is no previous monitoring results for comparison. The brief period of monitoring at this site does not provide enough data for the statistical approach to account for seasonal variations between years. Therefore, there is good reason to be skeptical that these trends relate to BMP implementation in this watershed. Another reason for doubting these trends is that the LMC site is below this site on the same stream and it did not show increasing trends. Monitoring is planned to continue at this site for at least another year and trend analysis will be performed again over a longer period.

At the BB site significant decreases in mean concentrations of NO_3-N, TP, NH_4-N, TKN, TOC and TSS was observed during storm flow. Ammonia-N and TKN decreased during base and combined flow conditions. The reduction of TP and TSS concentrations during storm flow is a new response that was not observed in the previous monitoring. A possible explanation for this difference is that the BMPs were not able to reduce phosphorus and solid concentrations within the three years of the first monitoring effort but as the BMPs matured they were able to produce an effect.

Mass Transport

Mass transport of NO_3-N, TP, NH_4-N, TKN, TOC, and TSS under combined flow, base flow, and storm flow conditions were calculated for the LMC, UMC, and BB sites on a monthly basis. The LMC and BB sites have monthly mass loads from January 1995 until September 1997. Whereas, the UMC site has monthly mass from July 1996 until September 1997. These masses are plotted by month in Figures 15 through 23. Overlain onto each graph of mass transport are the predicted lines that represent the regression models used to determine trends within time. The coefficients in the regression equation defined previously to produce these lines are listed in Tables 7, 8, and 9. Two rules are used to determine if there is a significant trend with time for a parameter. The first rule is that the model must be significant ($p<0.10$) and the second rule is that the regression coefficient that represents the slope with time (trend slope) must be significant ($p<0.10$). All cases where these two rules were met are summarized in Table 3.

There were no significant trends for mass transport at the LMC site. This is in contrast to the first three years of monitoring the showed downward trends of NO_3-N, NH_4-N, TKN, and TOC. Since there were no significant changes in stream discharge (Table 2) it is reasonable to believe that again the timber harvest was responsible.

Similar to the results for the flow-weighted mean concentrations at the UMC site, mass transport of solids increased. There is good reason to be skeptical of this trend for the same reasons described for mean concentration trends at this site.

Decreasing NH_4-N and TSS occurred during storm flow at the BB site. Nitrate-N, TKN, and carbon did not decline as they did in the first three years of monitoring. However, it is important to note that they did not significantly increase. Therefore, the BMPs that were implemented within the Beatty Branch Creek basin have expressed their ability to reduce mass transport of NO_3-N, TKN, and carbon and have been able to sustain the reduced loads. Significant reduction of solid transport was not experienced in the earlier study. It is likely that there is a time delay longer than three years for BMPs to express their full effect.

CONCLUSIONS

The objectives of the continued water quality monitoring of Moores Creek and Beatty Branch were to 1) determine if the reductions in mean concentration and mass transport of nitrogen have been sustained following the initial three years of monitoring, 2) determine if transport of nitrogen continues to decline, and 3) search for changes in phosphorus transport.

1) No increasing trends were observed for either mean concentration or mass transport of nitrogen; therefore, the decreases observed in the 1991 through 1994 monitoring have been sustained. This shows that the implemented BMPs were able to retard nitrogen transport early in their application and these early declines were effectively maintained through the following years.

2) Mean concentrations of NO_3-N, NH_4-N, and TKN in Beatty Branch Creek and NH_4-N and TKN in Moores Creek continue to decline. Mass transport of NH_3-N in Beatty Branch Creek continued to decline. This indicates that the maximum ability of the BMPs to abate nitrogen loading to surface water has not been reached. Knowing the maximum ability this group of BMPs to reduce nitrogen loading will be valuable for predicting larger scale improvements to this region's water quality as a result of BMP implementation throughout the Illinois River Watershed. Therefore, it is important to continue monitoring this watershed for the purpose of identifying when the nitrogen loading stops declining.

3) Downward total phosphorus concentrations were observed at the Beatty Branch site during storm flow. This is the first time that significant phosphorus reductions have been observed during storm flow conditions in this watershed. A longer period of time may be required for phosphorus reductions to be realized following BMP implementation. A conceptual model that may explain this delayed response is that the nutrient management may lead to improved pasture quality, more complete ground cover and reduced erosion potential. Phosphorus from manure that is applied to less erodible areas would be less likely to be lost in runoff water. Best management practices that express their effect through pasture development probably require a period to mature.

In 1990 through 1996 the two the predominant BMPs used in this watershed, nutrient management and waste utilization, were based on meeting the nitrogen needs of forage crops with manure applications. This approach to nutrient management commonly leads to excess additions of phosphorus to pastures. Resent changes in nutrient management and waste utilization are to base the manure applications on phosphorus needs rather than nitrogen, whereby, limiting excessive phosphorus applications. It is expected these changes will create consistent declines in phosphorus transport and reiterate the need to continue the monitoring in this basin.

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Edwards, D. R., T. C. Daniel, H. D. Scott, P. A. Moore, Jr., J. F. Murdock, and P. F. Vendrell, Effect of BMP implementation on storm flow quality of two Northwest Arkansas streams, ASAE, 40(5):1311-1319, 1997.

Edwards, D. R., T. C. Daniel, H. D. Scott, J. F. Murdock, M. J. Habiger, and H. M. Burks, Stream quality impacts of best management practices in a Northwest Arkansas basin, Water Resources Bulletin, 32(3), 499-509, 1996.

Figure 1 Location of the Illinois River watershed in Arkansas.

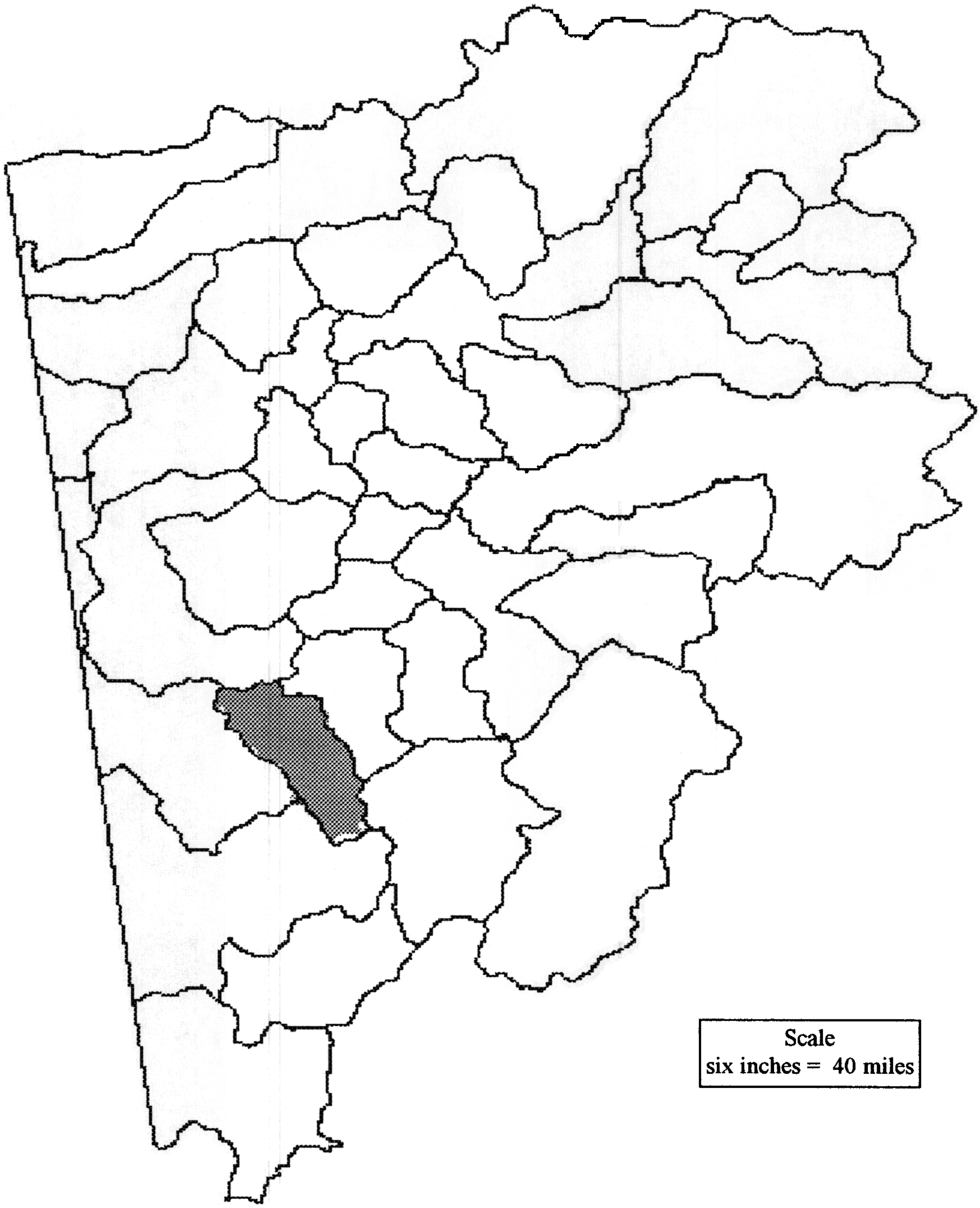

Figure 2. Location of the Lincoln Lake subasin in the Illinois River watershed.

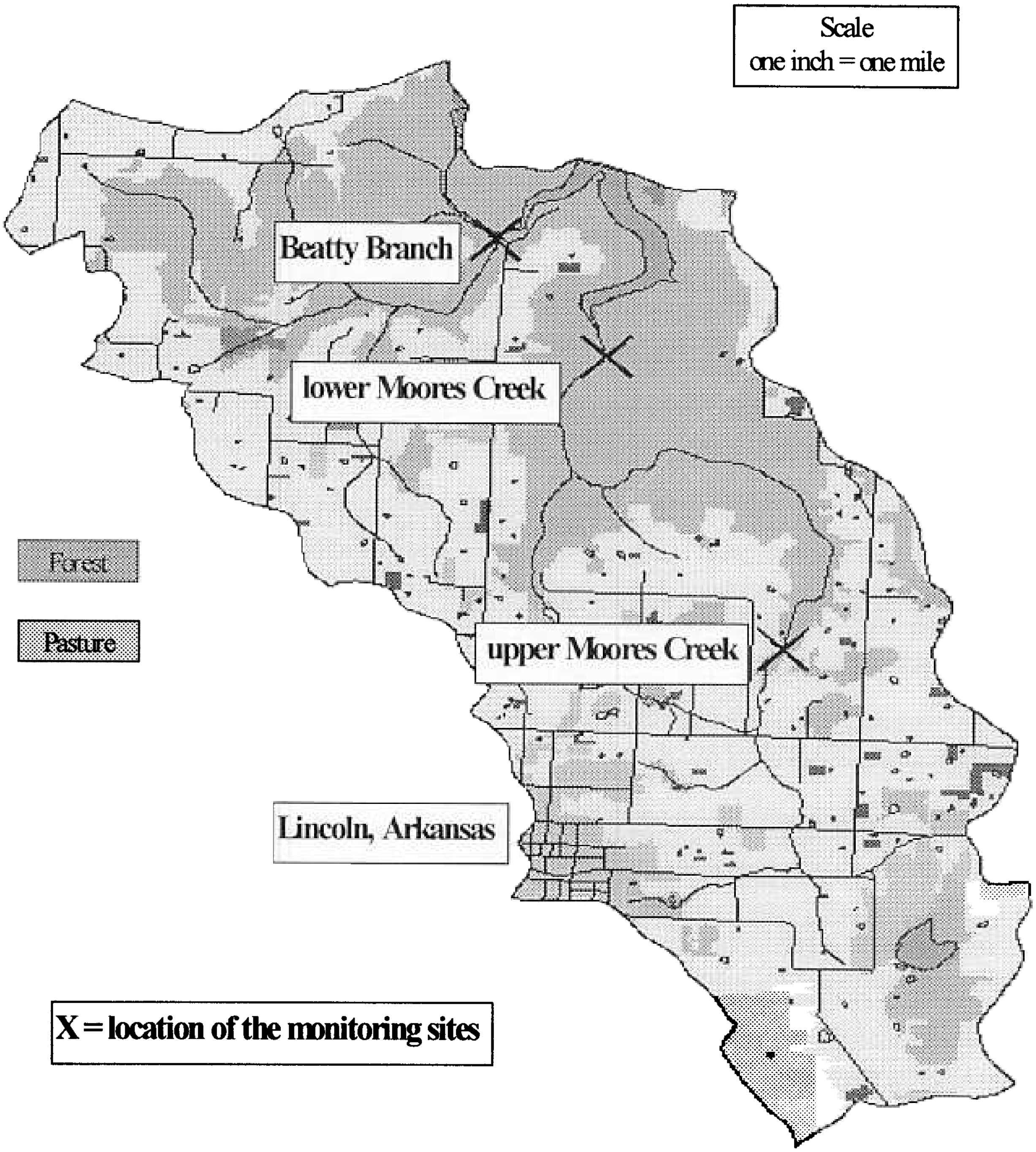

Figure 3 Location of the monitoring sites in the Lincoln Lake subasin.

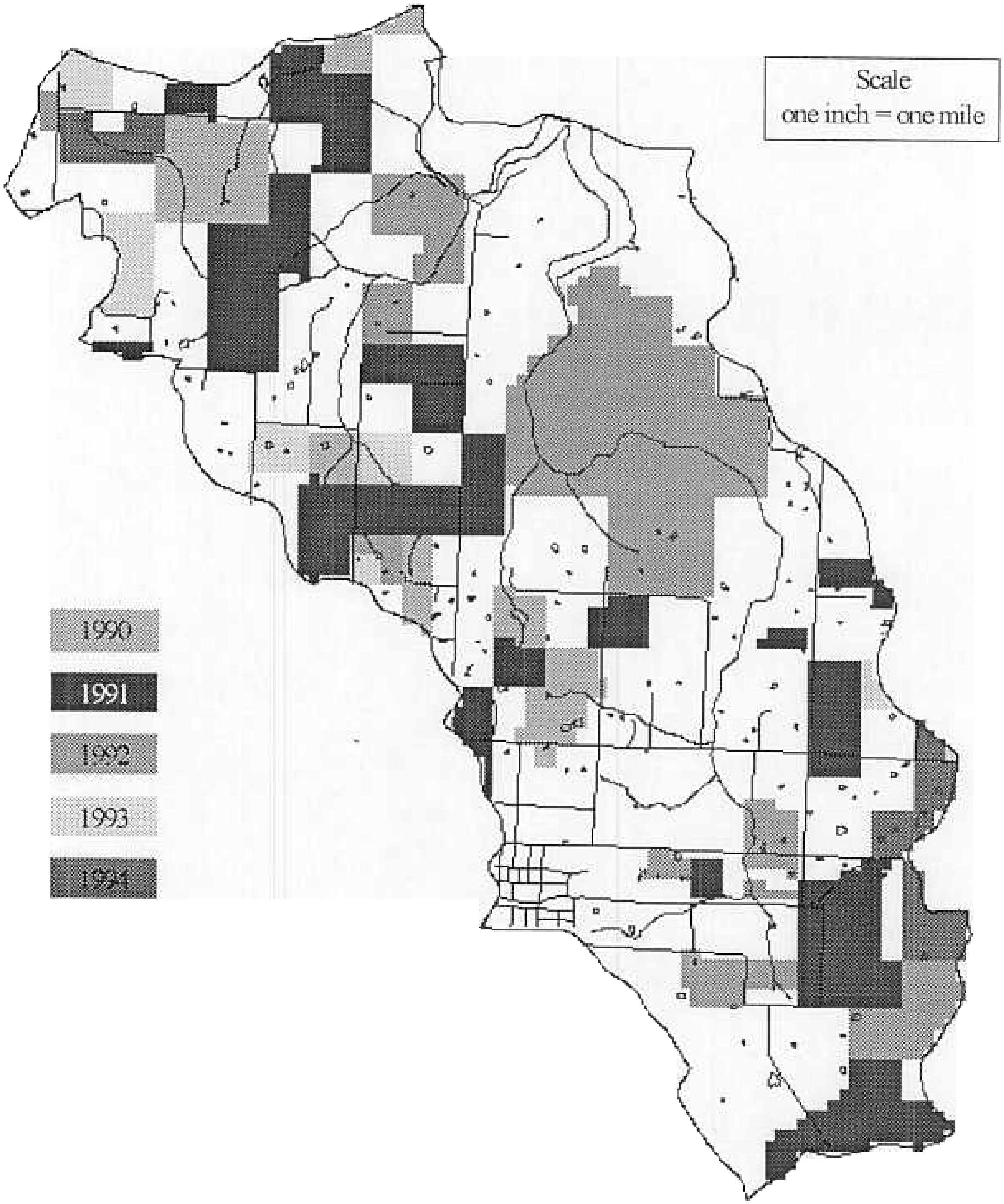

Figure 4. Distribution of the best management practices implemented in 1990, 1991, 1992, 1993, and 1994 within the Lincoln Lake subasin.

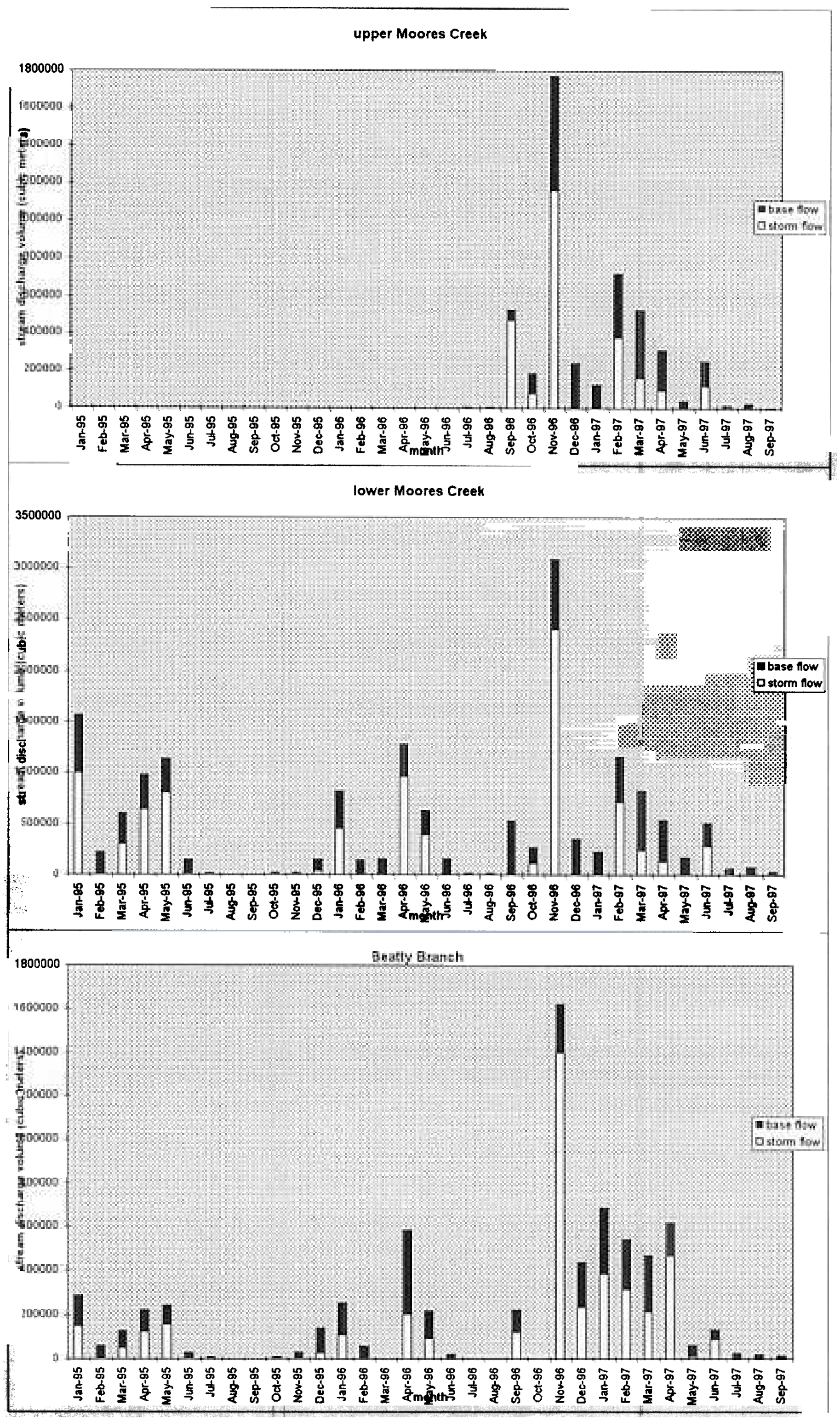

Figure 5. Monthly stream discharge under storm, base, and combined flow conditions at the LMC, UMC, and BB sites.

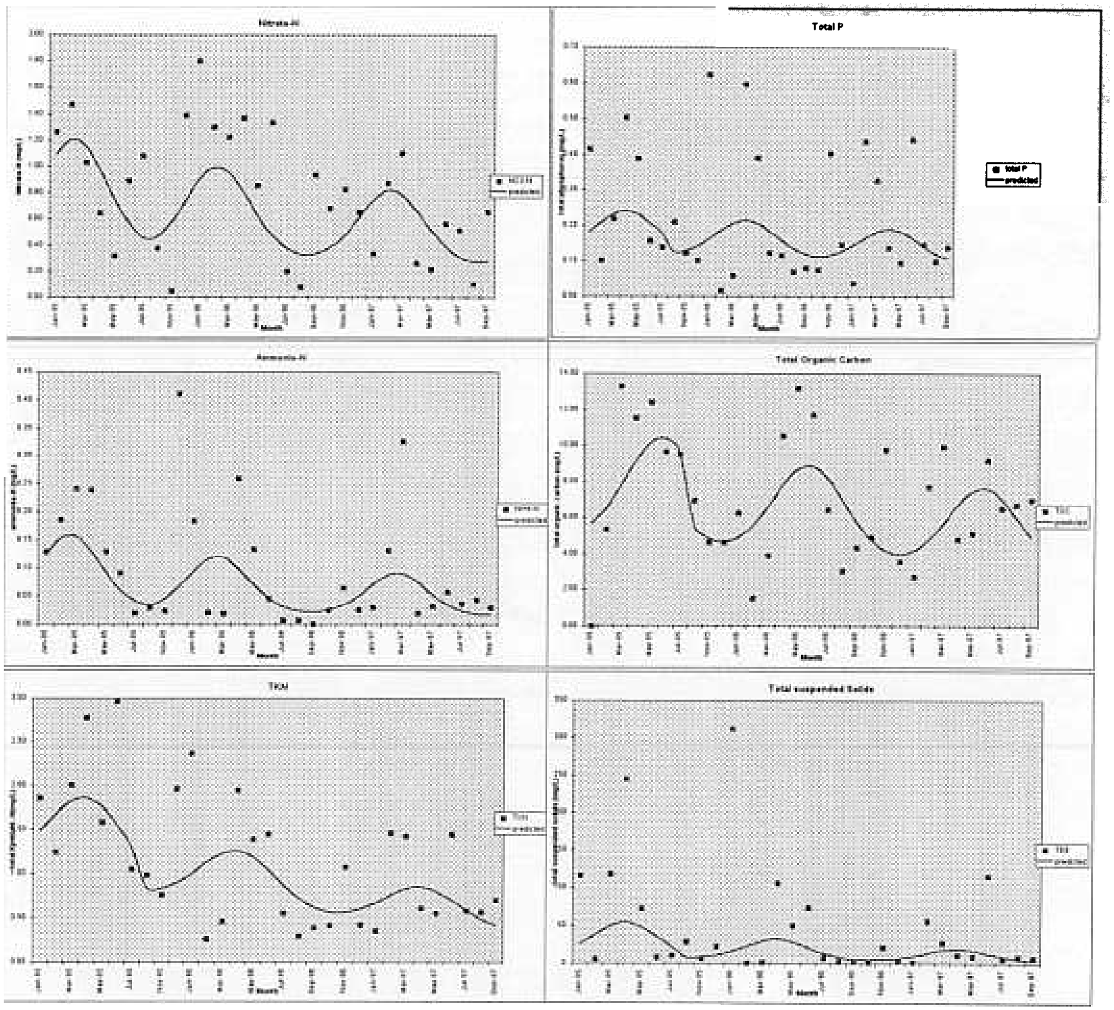

Figure 6. Monthly mean concentrations of NO3-N, TP, NH4-N, TKN, TOC and TSS under combined flow (baseand storm) at the LMC site.

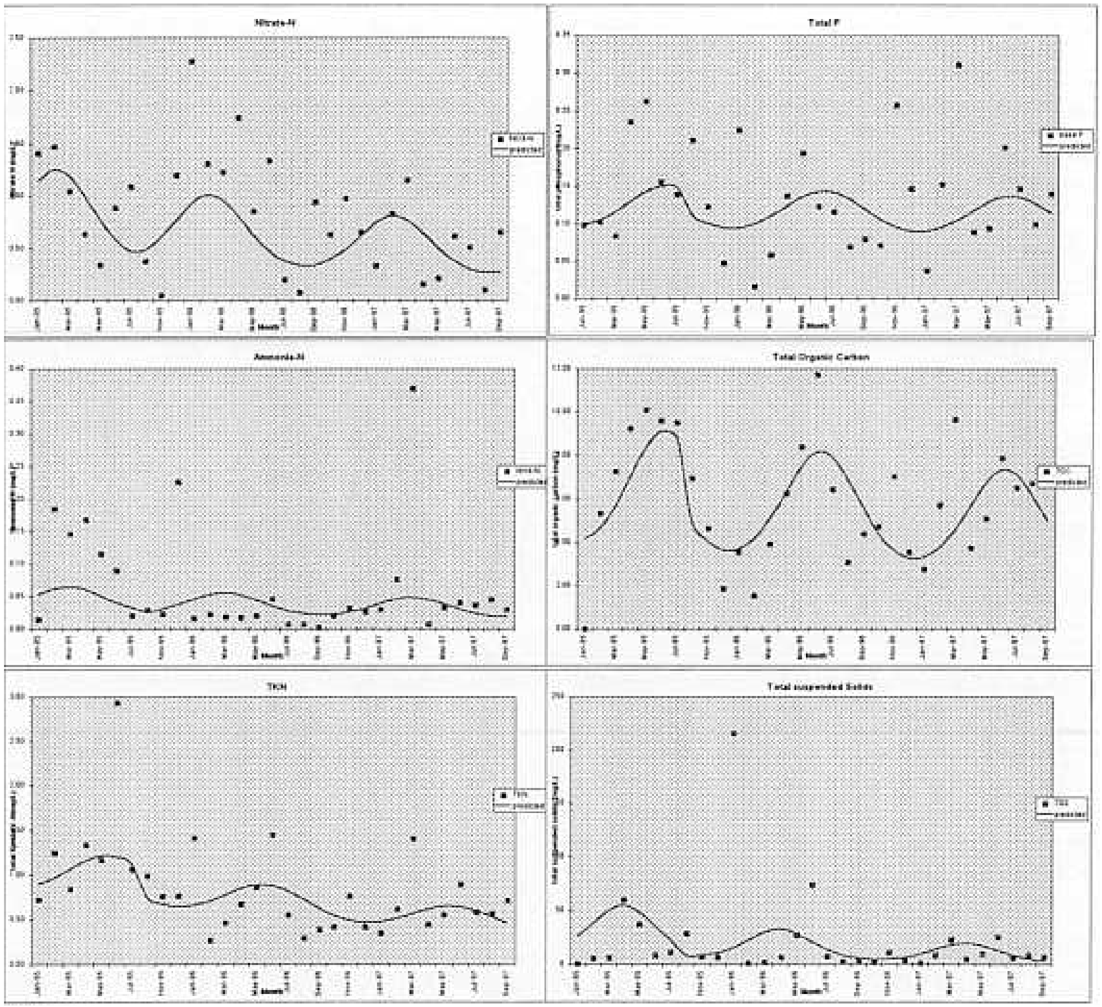

Figure 7. Monthly mean concentrations of NO_3-N, TP, NH4-N, TKN, TOC and TSS under base flow at the LMC site.

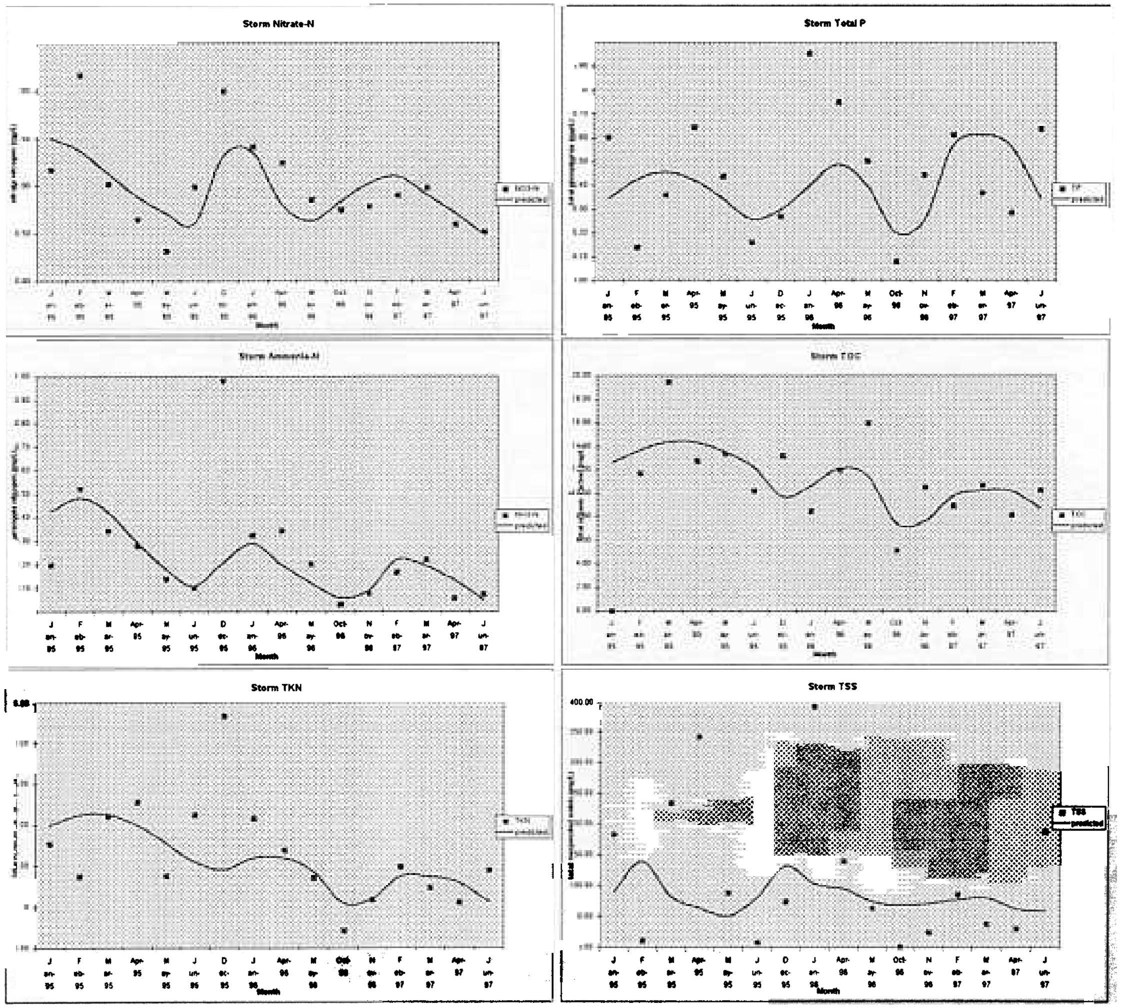

Figure 8. Monthly mean concentrations of NO_3-N, TP, NH4-N, TKN, TOC and TSS under storm flow at the LMC site.

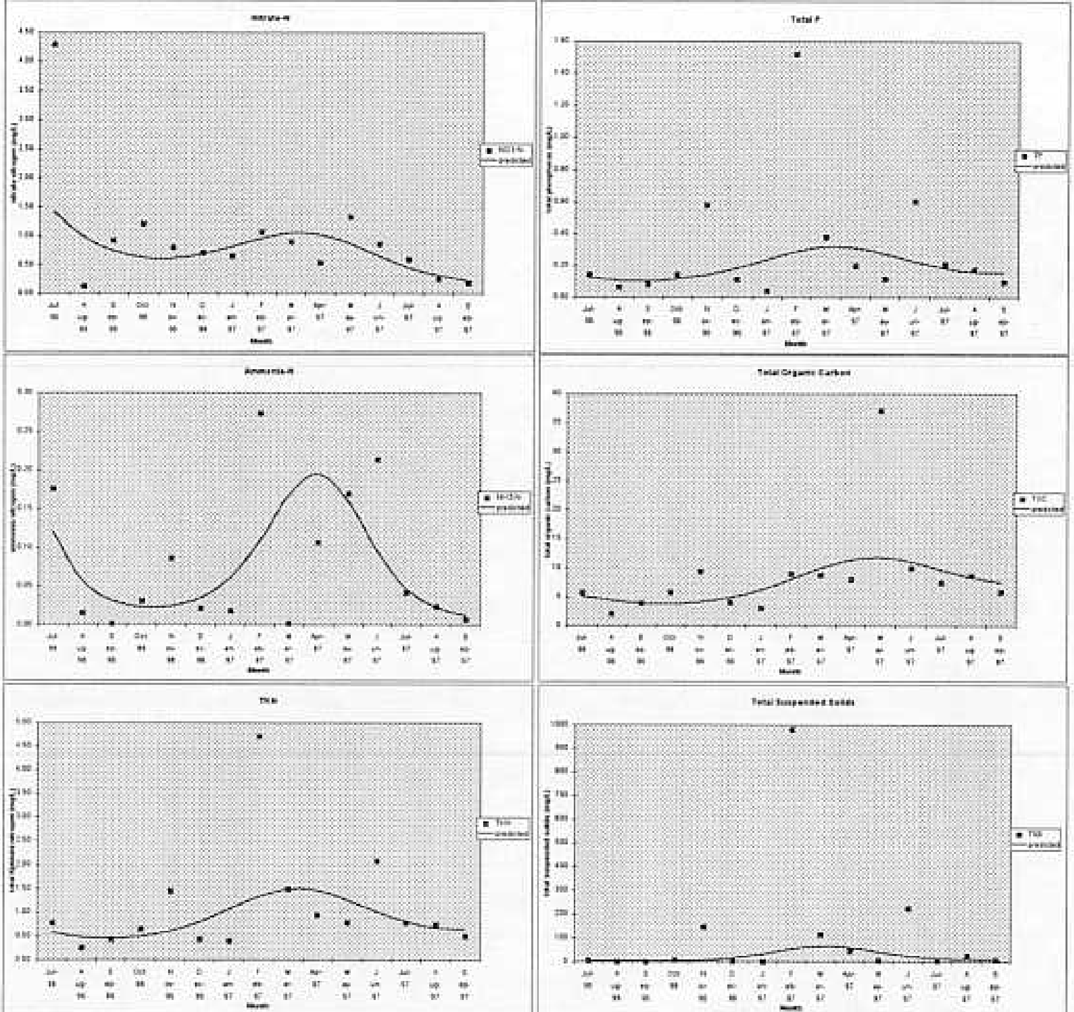

Figure 9. Monthly mean concentrations of NO_3-N, TP, NH_4-N, TKN, TOC and TSS under combined flow . (baseand storm) at the UMC site

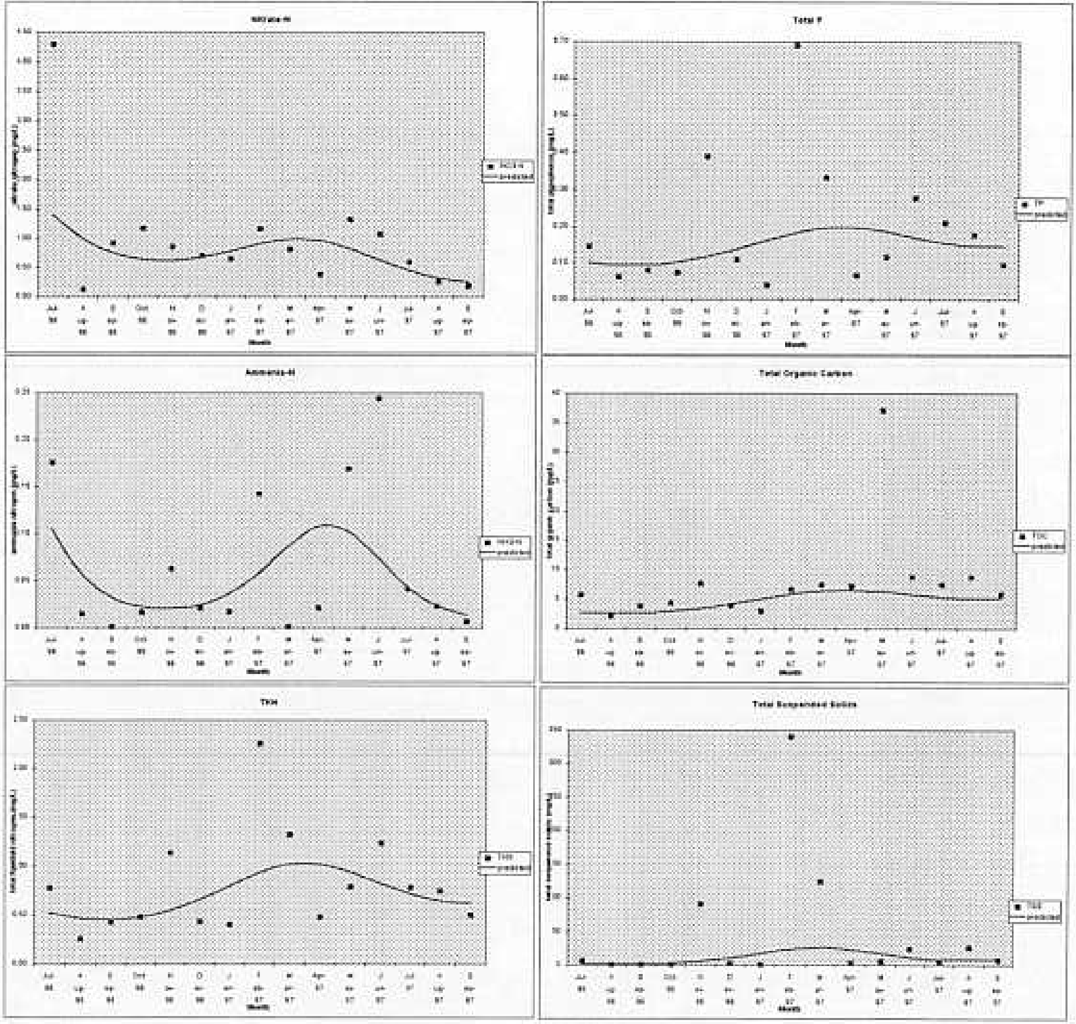

Figure 10. Monthly mean concentrations of NO_3-N, TP, NH4-N, TKN, TOC and TSS under base flow the UMC site.

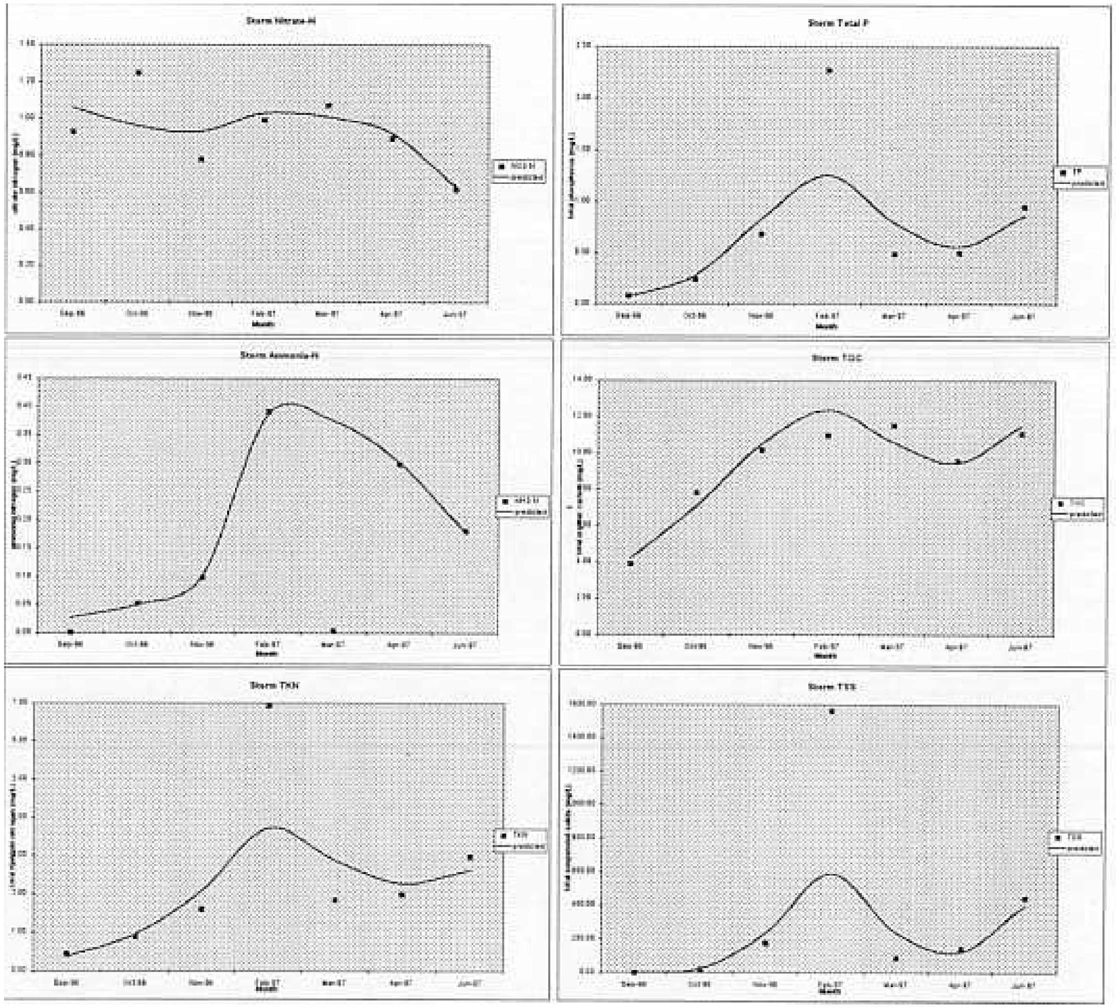

Figure 11. Monthly mean concentrations of NO_3-N, TP, NH4-N, TKN, TOC and TSS under storm flow at the UMC site.

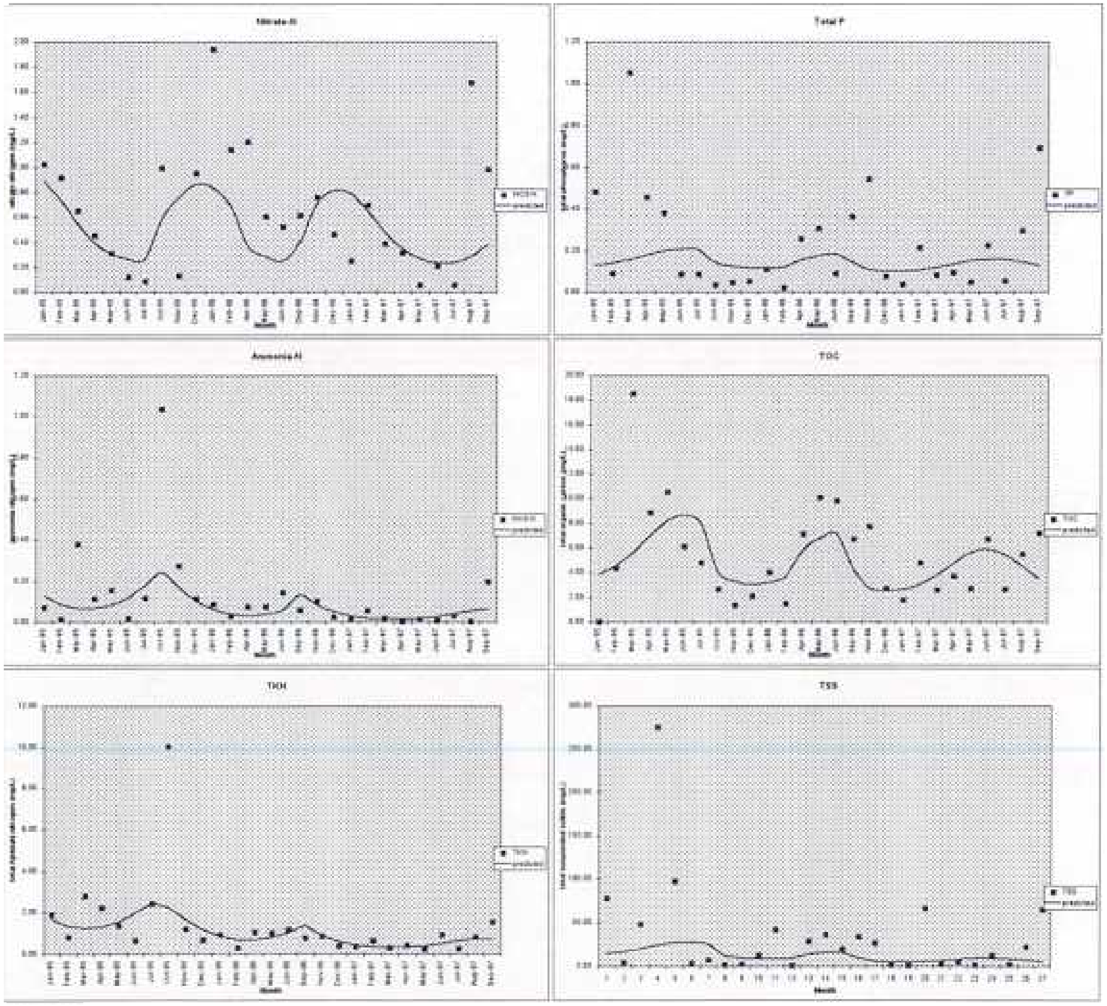

Figure 12. Monthly mean concentrations of NO_3-N, TP, NH_4-N, TKN, TOC and TSS under combined flow (baseand storm) at the BB site

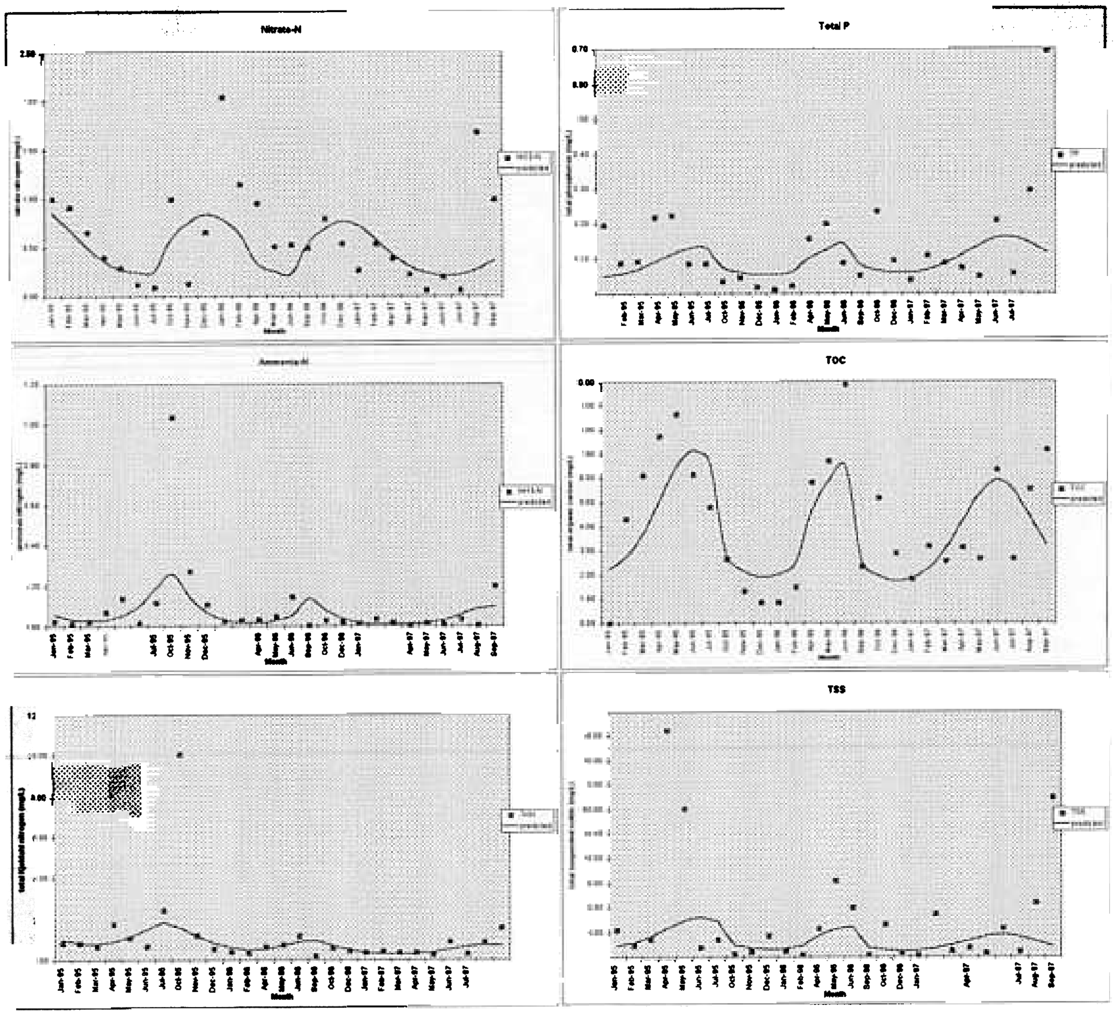

Figure 13. Monthly mean concentrations of NO_3-N, TP, NH4-N, TKN, TOC and TSS under base flow at the BB site.

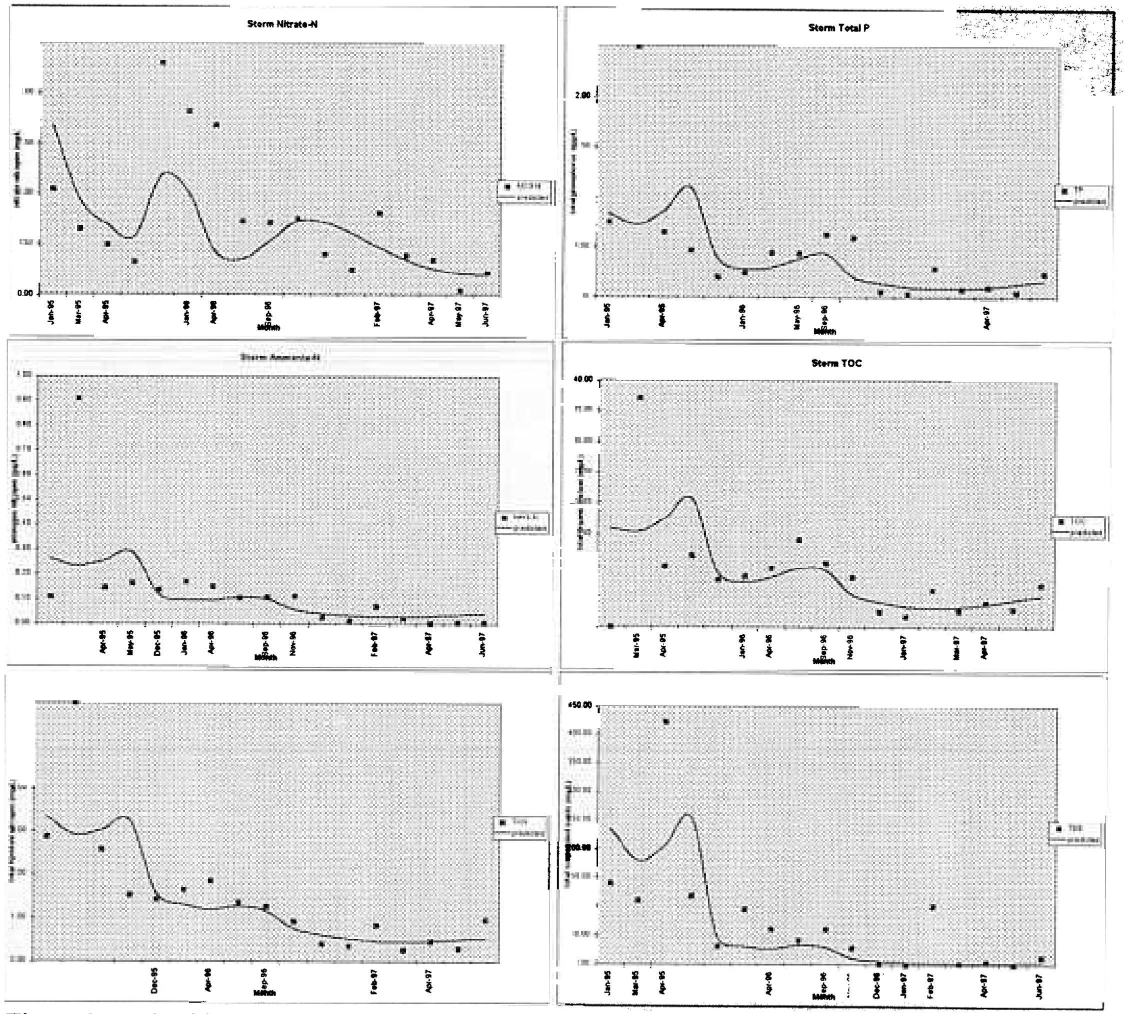

Figure 14. Monthly mean concentrations of NO_3-N, TP, NH4-N, TKN, TOC and TSS under storm flow at the BB site.

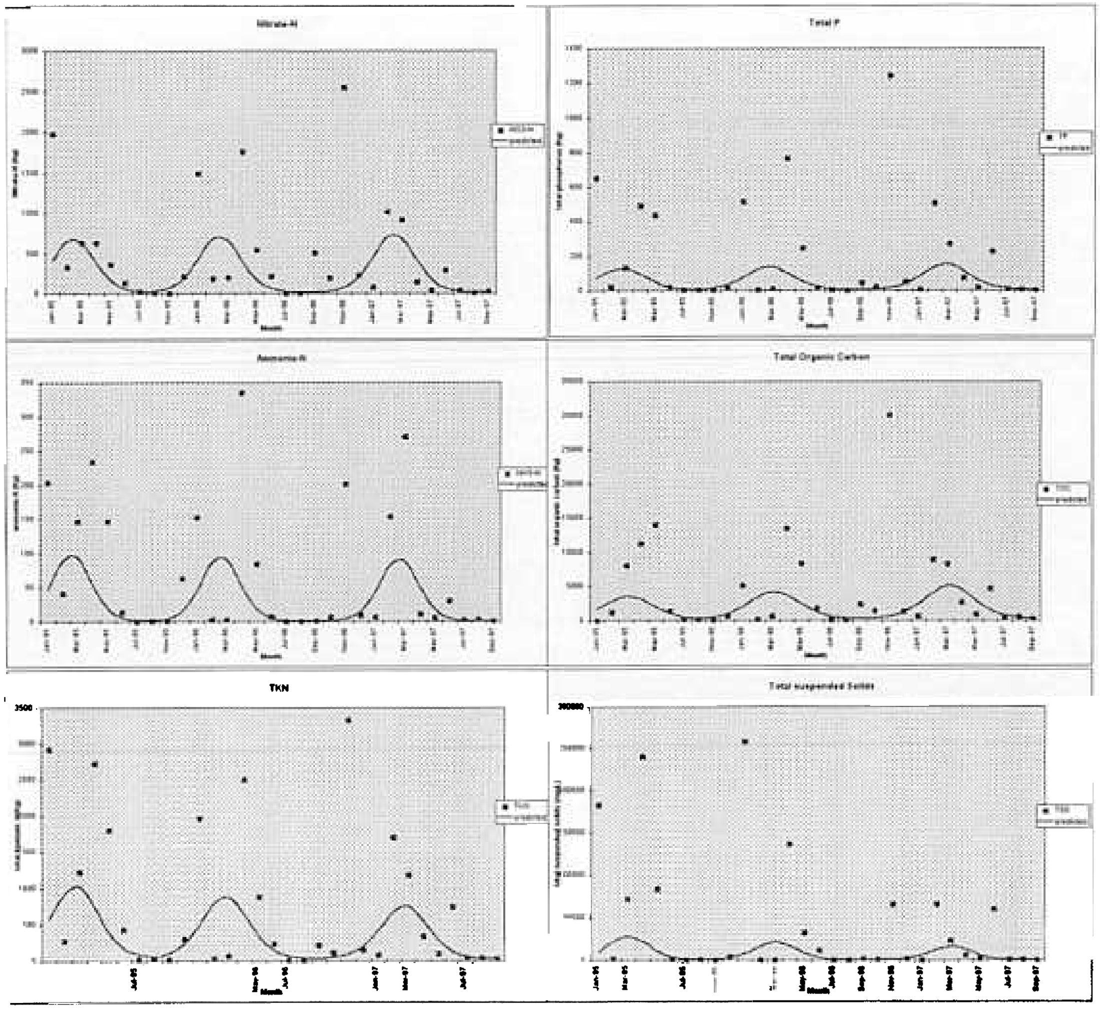

Figure 15. Monthly mass transport of NO_3-N, TP, NH_4-N, TKN, TOC and TSS under combined flow (baseand storm) at the LMC site

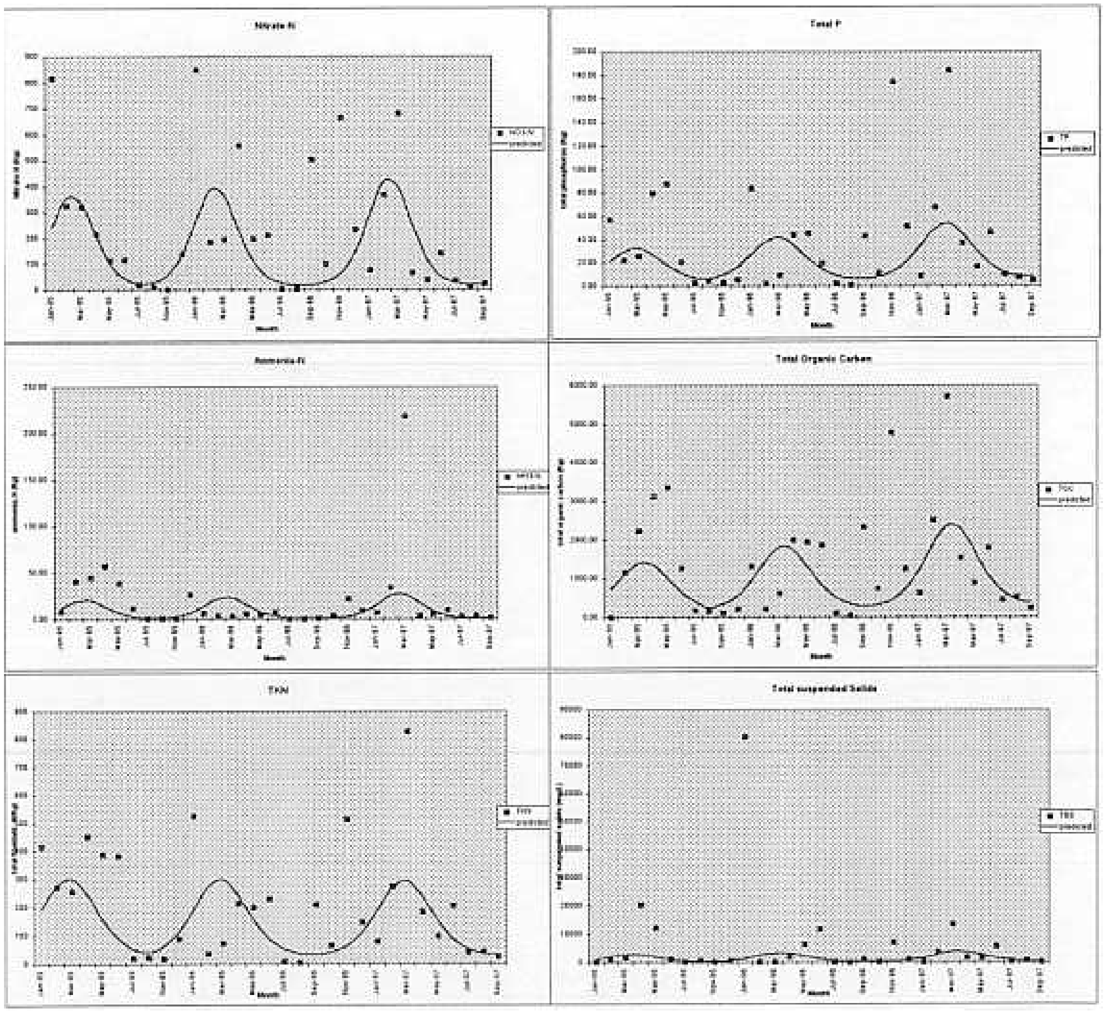

Figure 16. Monthly mass transport of NO_3-N, TP, NH4-N, TKN, TOC and TSS under base flow at the LMC site.

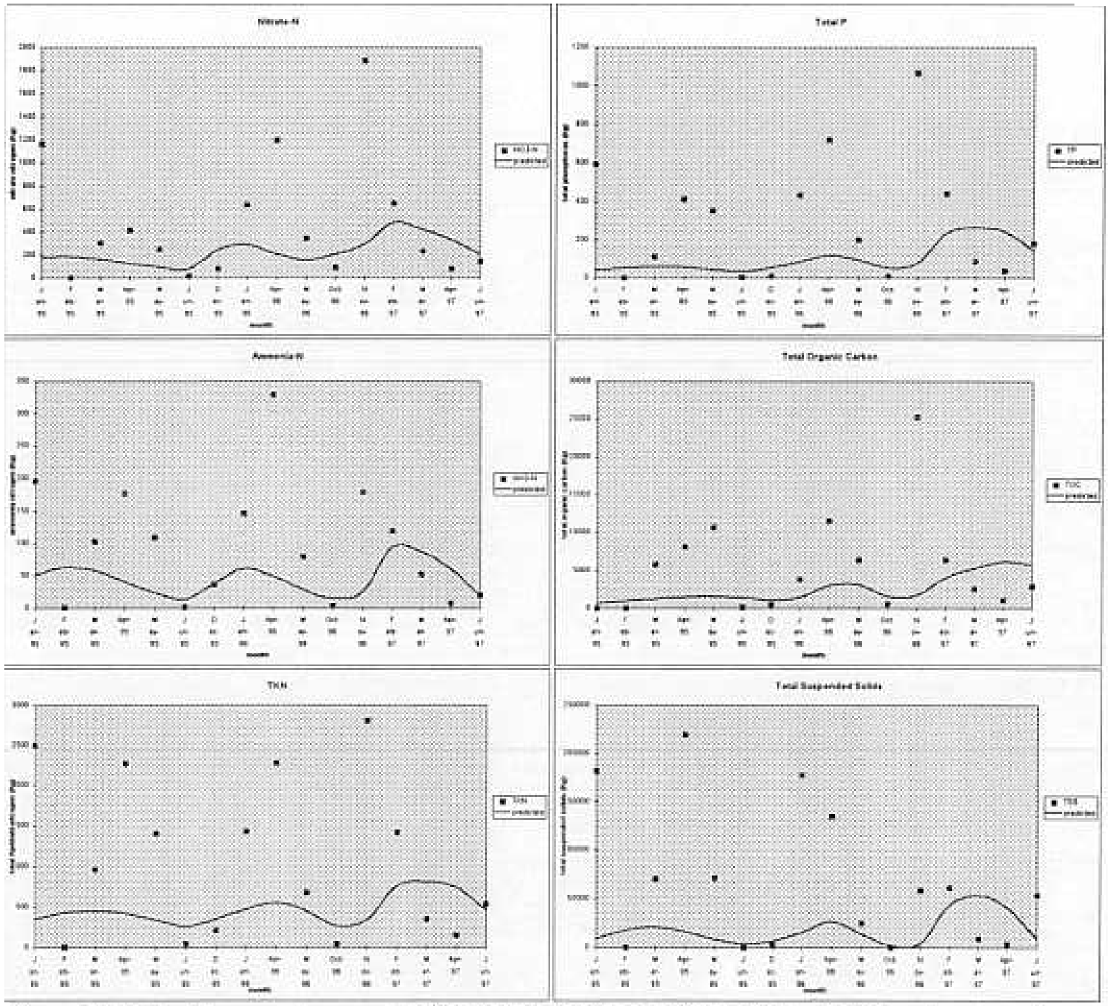

Figure 17. Monthly mass transport of NO_3-N, TP, NH4-N, TKN, TOC and TSS under storm flow at the LMC site.

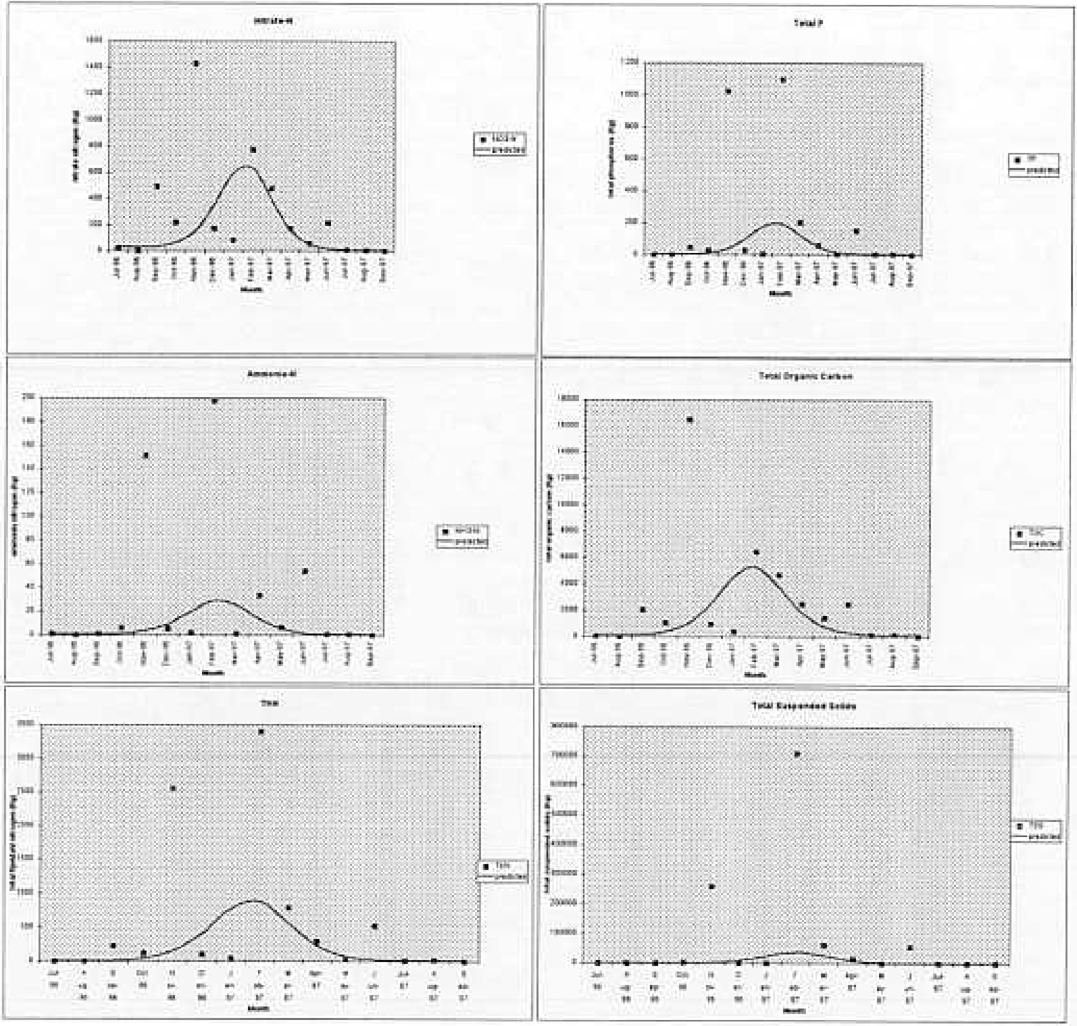

Figure 18. Monthly mass transport of NO_3-N, TP, NH_4-N, TKN, TOC and TSS under combined flow (baseand storm) at the UMC site

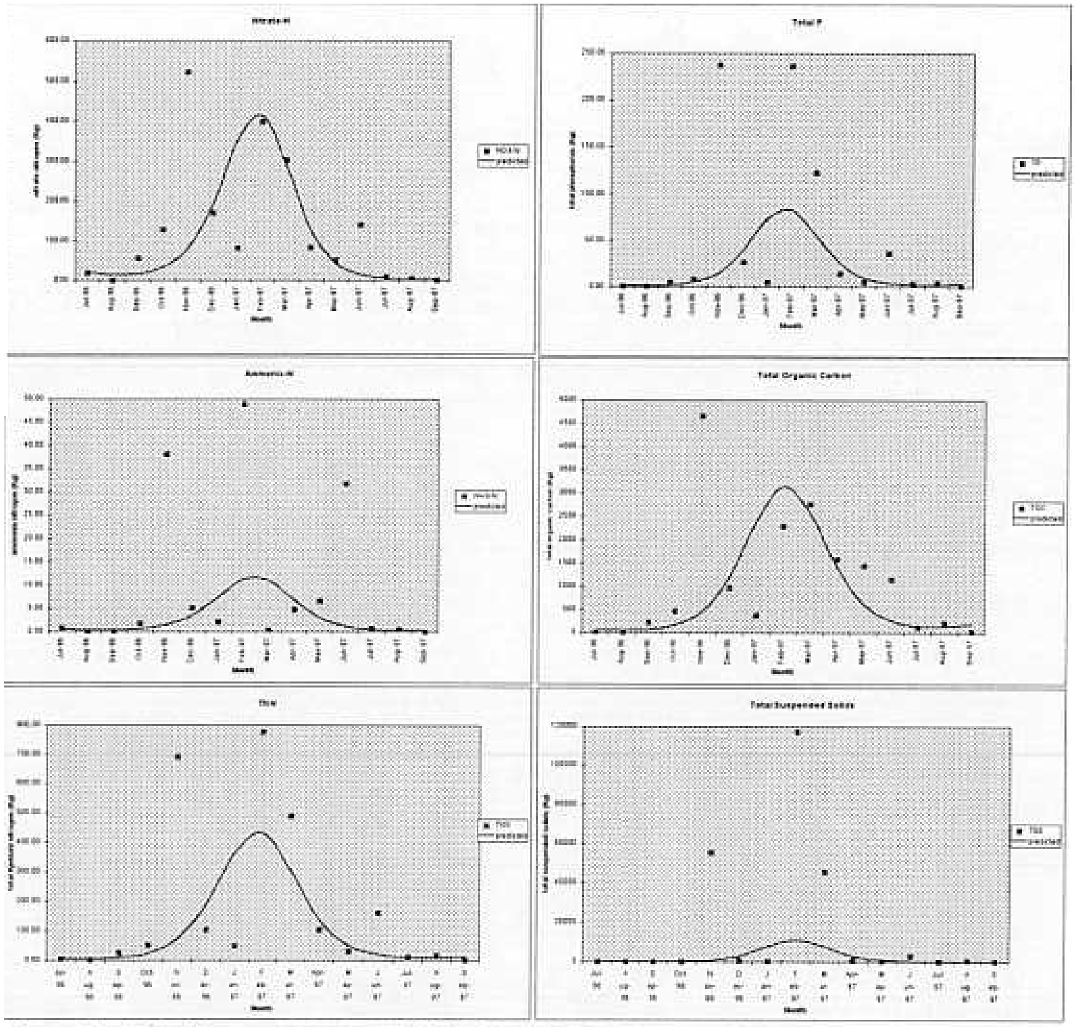

Figure 19. Monthly mass transport of NO_3-N, TP, NH4-N, TKN, TOC and TSS under base flow at the UMC site.

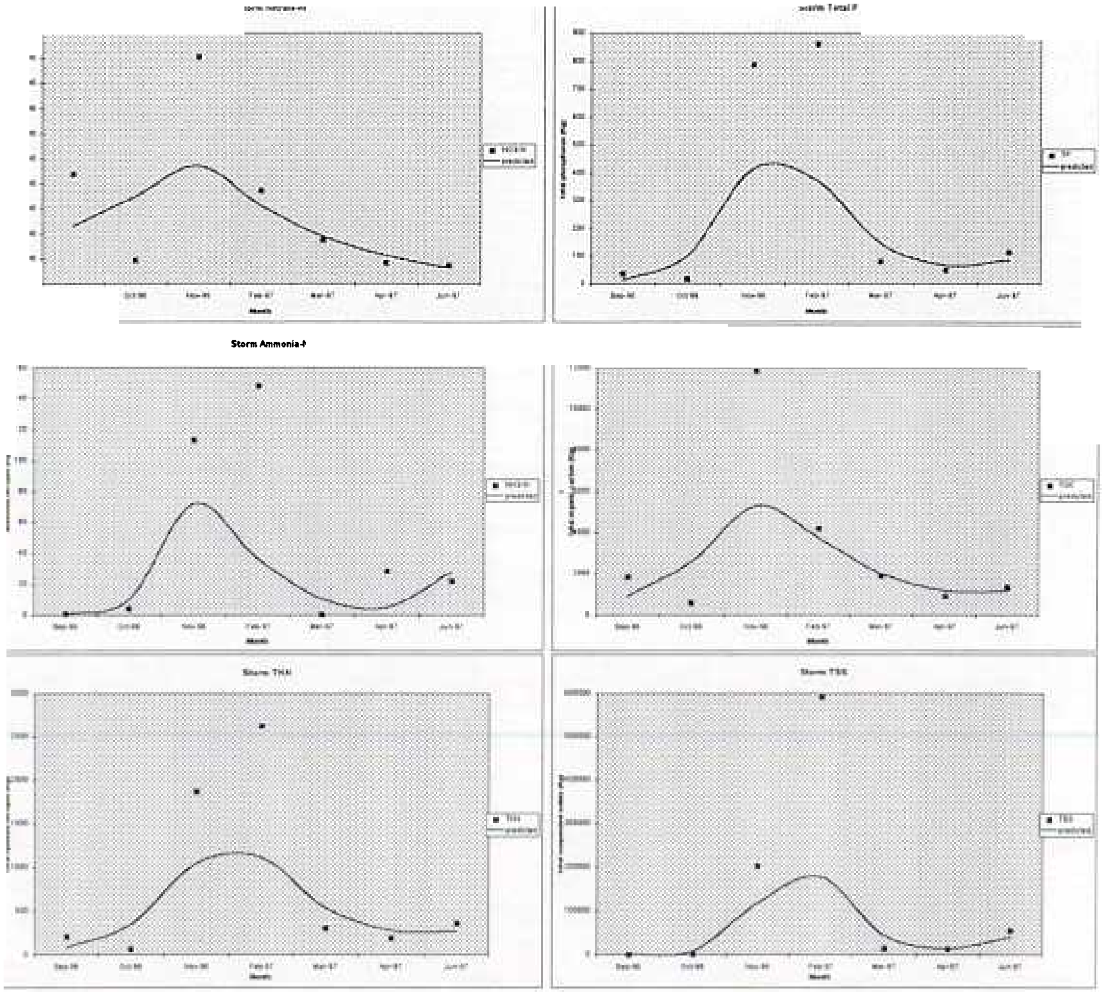

Figure 20. Monthly mass transport of NO_3-N, TP, NH4-N, TKN, TOC and TSS under storm flow at the UMC site.

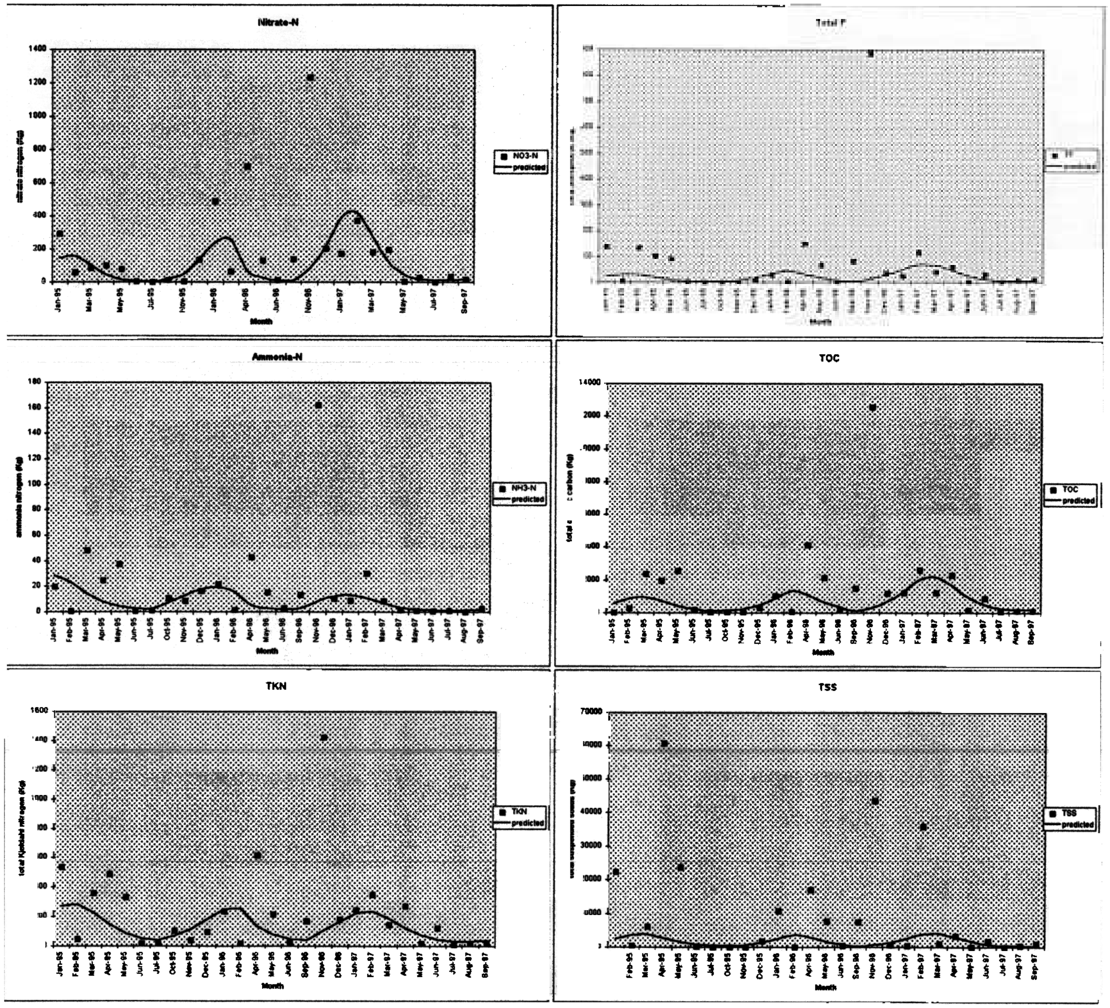

Figure 21. Monthly mass transport of NO_3-N, TP, NH_4-N, TKN, TOC and TSS under combined flow (baseand storm) at the BB site

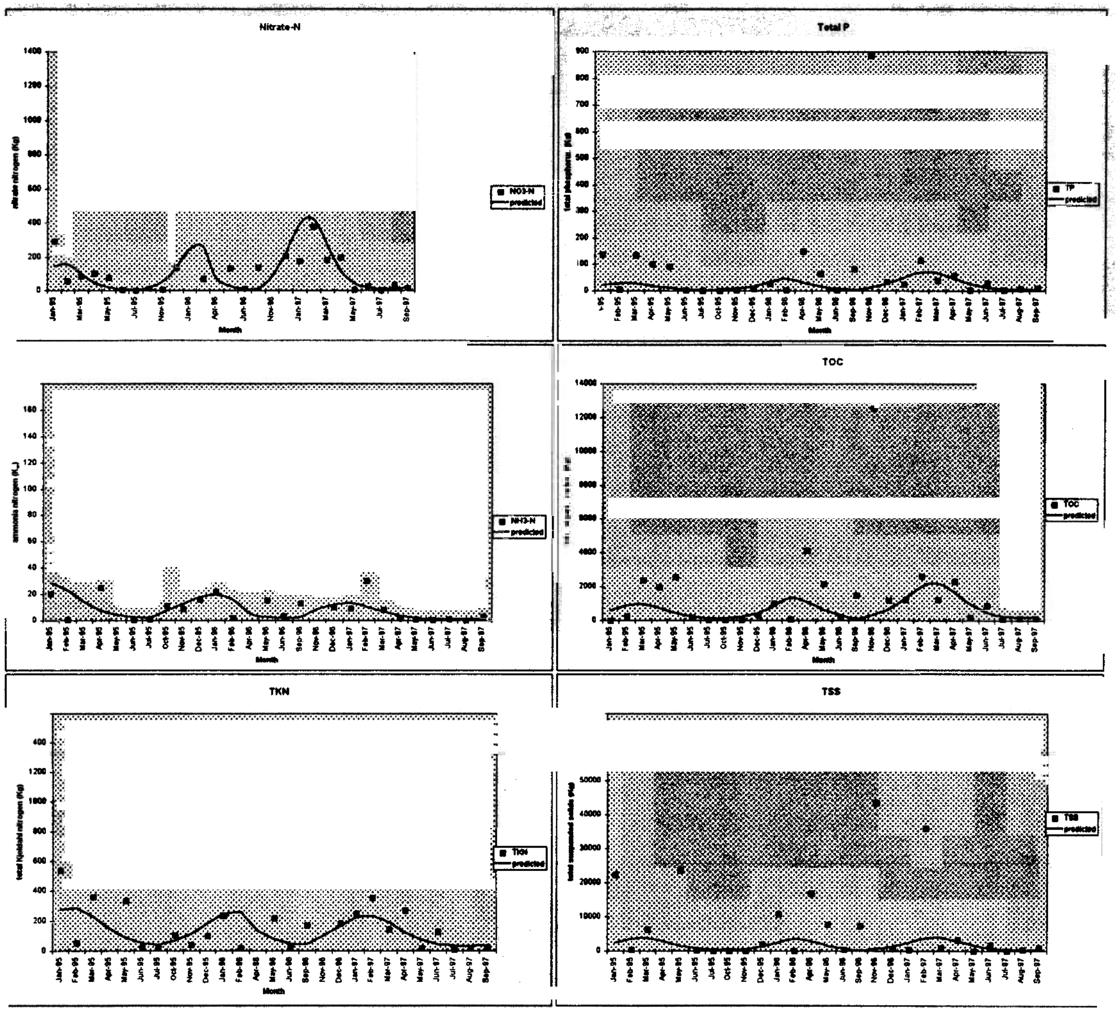

Figure 22. Monthly mass transport of NO_3-N, TP, NH4-N, TKN, TOC and TSS under base flow at the BB site.

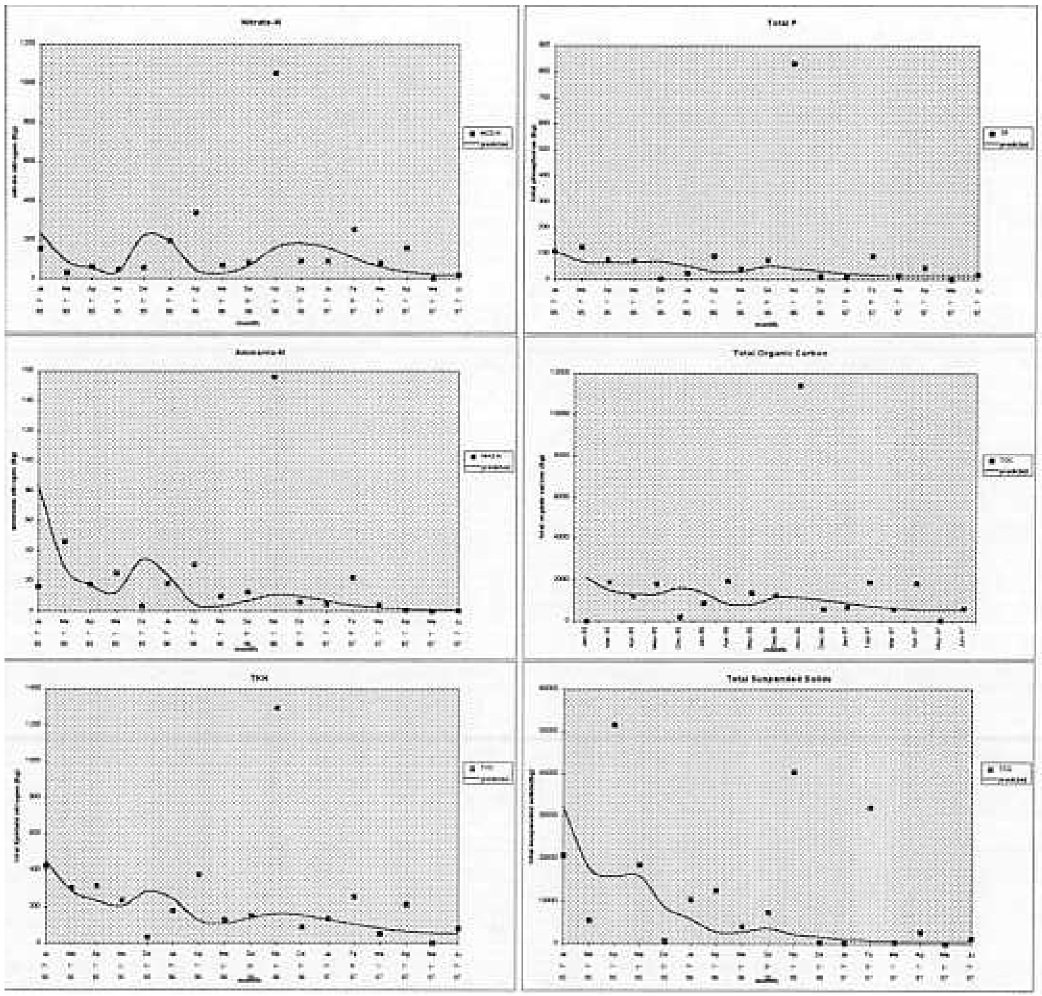

Figure 23. Monthly mass transport of NO_3-N, TP, NH4-N, TKN, TOC and TSS under storm flow at the BB site.

Table 1: Methods for applying analytical concentrations during various base and storm flow scenarios.

Sample Type	Stream Condition	Scenario	Method
Grab	Base flow	Two consecutive grab samples taken with no storm sample between the two.	Grab sample concentration is extended to the midpoint between the two samples.
Grab	Base flow	Grab sample followed by a storm sample.	Grab sample concentration is extended forward to the trigger level of the storm.
Grab	Base flow	Storm sample followed by a grab sample.	Grab sample concentration is applied back to where stage falls below trigger level.
Flow-Weighted Composite	Storm flow	Storm sample with a grab sample collected before and after the storm.	Storm sample concentration is applied for the duration of the storm (i.e. stage remains above trigger level).
Flow-Weighted Composite	Storm flow	Two consecutive storm samples collected with no grab sample taken between the two storms.	Individual storm samples are applied for the duration of the separate storms. An average concentration of the two storms is calculated and this concentration is applied between the two storms.
Time-Incremented Discrete	Storm flow	Discrete storm samples collected with a grab sample taken before and after the storm.	Each individual sample concentration is extended to the midpoint between each discrete sample for duration of the storm. The first discrete sample is applied from the trigger level forward and the last discrete sample is applied forward to where the stage falls below the trigger level.
Time-Incremented Discrete	Storm flow	Two consecutive storms collected with no grab sample taken between the two storms.	An average of the last discrete sample from the first storm and the first discrete sample of the second storm is calculated. This concentration is applied between the two storms.

Table 2. Trend analysis of stream discharge at base, storm, and combined flow conditions at the BB, LMC, and UMC sites.

Monitoring Site	**Flow Conditions**	**Trend Slope****	**Trend Probability***
BB	base	**0.033**	**0.027**
	storm	0.027	0.386
	combined	**0.047**	**0.046**
	base	0.025	0.169
	storm	0.050	0.364
	combined	0.019	0.440
	base	0.007	0.924
	storm	0.050	0.900
	combined	-0.029	0.785

* Progability values less than 0.10 indicate regression coeficients significantly different from zero (bold values).

** Positive regression coefficients indicate increasing trends.

Table 3. Significant trends for mean concentrations and mass transport of NO_3-N, NH3-N,TP, TKN, TOC, and TSS during base, storm, and combined flow conditions at the LMC, UMC, and BB sites.

Concentrations

Site	Parameter	Flow	Model Prob.*	Trend Slope**	Trend Prob.*
LMC	NH_3-N	storm	0.013	-0.033	0.072
	TKN	base	0.024	-0.026	0.011
		combined	0.010	-0.033	0.011
		storm	0.075	-0.014	0.083
UMC	NH_3-N	storm	0.013	0.209	0.029
	TOC	storm	0.016	0.202	0.011
	TP	storm	0.055	0.533	0.040
	TSS	storm	0.029	1.201	0.020
BB	NH_3-N	base	0.001	-0.052	0.013
		storm	0.038	-0.084	0.009
		combined	0.024	-0.061	0.012
	NO_3-N	storm	0.058	-0.042	0.059
	TKN	base	0.009	-0.044	0.004
		storm	0.000	-0.078	0.000
		combined	0.001	-0.055	0.000
	TOC	storm	0.006	-0.065	0.001
	TP	storm	0.008	-0.088	0.001
	TSS	storm	0.012	-0.168	0.001

Mass Transport

Site	Parameter	Flow	Model Prob.*	Trend Slope**	Trend Prob.*
UMC	TSS	storm	0.130	1.250	0.080
BB	NH_3-N	storm	0.063	-0.103	0.032
	TSS	storm	0.184	-0.142	0.037

* Probability values less than 0.10 indicate that the slope is significantly different from zero.

** Negative slopes represent decreasing trends as mg/month or Kg/month.

Table 4. Significant trends for mean concentrations of NO_3-N, NH_3-N, TP, TKN, TOC, and TSS during base, storm, and combined flow conditions at the LMC site.

Parameter	Flow	Model Probability	Intercept	Trend Slope**	Trend Probability*	sin Function	cos Function
ammonia nitrogen	base	0.318	-3.136	-0.012	0.547	0.432	-0.012
	storm	**0.013**	**-1.608**	**-0.033**	**0.072**	**0.843**	**0.427**
	combined	0.010	-2.540	-0.023	0.215	0.756	0.107
nitrate nitrogen	base	0.073	-0.234	-0.018	0.301	0.462	0.185
	storm	0.055	-0.030	-0.009	0.401	0.181	0.414
	combined	0.064	-0.283	-0.016	0.344	0.476	0.173
total Kjeldahl nitrogen	base	**0.024**	**0.107**	**-0.026**	**0.011**	**0.030**	**-0.233**
	storm	**0.141**	**0.927**	**-0.026**	**0.086**	**0.329**	**0.031**
	combined	**0.010**	**0.460**	**-0.033**	**0.011**	**0.241**	**-0.177**
total organic carbon	base	0.004	1.833	-0.009	0.310	-0.073	-0.429
	storm	**0.075**	**2.512**	**-0.014**	**0.083**	**0.193**	**-0.073**
	combined	0.028	2.054	-0.013	0.195	0.031	-0.363
total phosphorus	base	0.570	-2.089	-0.004	0.770	-0.052	-0.218
	storm	0.385	-1.387	0.012	0.506	0.571	0.030
	combined	0.513	-1.668	-0.010	0.552	0.240	-0.160
total suspended solids	base	0.318	2.230	-0.013	0.626	0.112	-0.616
	storm	0.199	3.604	-0.011	0.759	1.461	0.090
	combined	0.086	3.370	-0.043	0.170	0.670	-0.451

* Probability values less than 0.10 indicate that the regression coefficient (slope) is significantly different from zero (bold values).

** Negative regression coefficients indicate decreasing trends.

Table 5. Significant trends for mean concentrations of NO_3-N, NH_3-N, TP, TKN, TOC, and TSS during base, storm, and combined flow conditions at the UMC site.

Parameter	Flow	Model Probability*	Intercept	Trend Slope**	Trend Probability*	sin Function	cos Function
ammonia nitrogen	base	0.175	-1.200	-0.072	0.286	0.700	-0.765
	storm	**0.013**	**-7.327**	**0.209**	**0.029**	**0.702**	**0.664**
	combined	0.044	-0.746	-0.078	0.198	1.066	-0.739
nitrate nitrogen	base	0.298	2.114	-0.094	0.105	0.417	-0.249
	storm	0.383	2.289	-0.094	0.238	0.257	-0.078
	combined	**0.223**	**2.183**	**-0.096**	**0.083**	**0.462**	**-0.259**
total Kjeldahl nitrogen	base	0.338	-1.040	0.027	0.464	0.326	-0.034
	storm	0.100	-8.568	0.358	0.104	-0.040	1.207
	combined	0.234	-0.866	0.028	0.540	0.504	-0.034
total organic carbon	base	0.073	0.419	0.055	0.139	0.268	-0.315
	storm	**0.016**	**-2.949**	**0.202**	**0.011**	**-0.144**	**0.670**
	combined	0.108	0.560	0.053	0.176	0.306	-0.264
total phosphorus	base	0.716	-2.831	0.035	0.529	0.255	0.000
	storm	**0.055**	**-14.259**	**0.533**	**0.040**	**-0.362**	**1.884**
	combined	0.551	-2.522	0.034	0.599	0.458	0.000
total suspended solids	base	0.350	-0.955	0.124	0.306	0.880	0.301
	storm	**0.029**	**-26.063**	**1.201**	**0.020**	**-0.894**	**3.979**
	combined	0.289	-0.329	0.123	0.360	1.191	0.160

* Probability values less than 0.10 indicate that the regression coefficient (slope) is significantly different from zero (bold values).

** Negative regression coefficients indicate decreasing trends.

Table 6. Significant trends for mean concentrations of NO_3-N, NH_3-N, TP, TKN, TOC, and TSS during base, storm, and combined flow conditions at the BB site.

Parameter	Flow	Model Probability*	Intercept	Trend Slope**	Trend Probability*	sin Function	cos Function
ammonia nitrogen	base	**0.001**	**-2.038**	**-0.052**	**0.013**	**-1.410**	**-0.042**
	storm	**0.038**	**-0.875**	**-0.084**	**0.009**	**-0.319**	**-0.247**
	combined	**0.024**	**-1.641**	**-0.061**	**0.012**	**-0.885**	**0.117**
nitrate nitrogen	base	0.075	-0.719	-0.007	0.711	0.059	0.629
	storm	**0.058**	**0.156**	**-0.042**	**0.059**	**-0.096**	**0.521**
	combined	0.097	-0.692	-0.005	0.777	0.107	0.609
total Kjeldahl nitrogen	base	**0.009**	**0.474**	**-0.044**	**0.004**	**-0.581**	**-0.170**
	storm	**0.000**	**1.544**	**-0.078**	**0.000**	**-0.235**	**-0.164**
	combined	**0.001**	**0.921**	**-0.055**	**0.000**	**-0.555**	**-0.087**
total organic carbon	base	0.003	1.378	-0.008	0.459	-0.044	-0.636
	storm	**0.006**	**3.259**	**-0.065**	**0.001**	**-0.327**	**-0.303**
	combined	0.040	1.781	-0.016	0.196	-0.007	-0.471
total phosphorus	base	0.238	-2.546	0.008	0.672	-0.138	-0.459
	storm	**0.008**	**0.484**	**-0.088**	**0.001**	**-0.542**	**-0.360**
	combined	0.809	-1.761	-0.011	0.610	-0.066	-0.262
total suspended solids	base	0.241	2.199	-0.024	0.379	-0.020	-0.732
	storm	**0.012**	**6.311**	**-0.168**	**0.001**	**-0.617**	**-0.434**
	combined	0.476	3.149	-0.045	0.196	-0.021	-0.460

Probability values less than 0.10 indicate that the regression coefficient (slope) is significantly different from zero (bold values).

* Negative regression coefficients indicate decreasing trends.

Table 7. Significant trends for mass transport of NO_3-N, NH_3-N, TP, TKN, TOC, and TSS during base, storm, and combined flow conditions at the LMC site.

Parameter	Flow	Model Probability*	Intercept	Trend Slope**	Trend Probability*	sin Function	cos Function
ammonia nitrogen	base	0.001	1.289	0.011	0.691	1.678	0.359
	storm	0.726	2.965	0.017	0.748	1.044	0.470
	combined	0.001	2.301	-0.003	0.937	2.254	0.484
nitrate nitrogen	base	0.004	4.278	0.007	0.826	1.519	0.529
	storm	0.771	4.538	0.041	0.403	0.404	0.456
	combined	0.004	4.691	0.003	0.921	1.762	0.524
total Kjeldahl nitroge	base	0.007	4.626	-0.001	0.963	1.085	0.116
	storm	0.942	5.495	0.024	0.675	0.552	0.072
	combined	0.007	5.445	-0.013	0.675	1.523	0.179
total organic carbon	base	0.024	6.201	0.022	0.331	0.977	-0.139
	storm	0.734	6.570	0.059	0.325	0.393	-0.319
	combined	0.033	6.823	0.015	0.632	1.308	-0.089
total phosphorus	base	0.053	2.426	0.021	0.406	0.995	0.118
	storm	0.794	3.182	0.062	0.377	0.790	0.071
	combined	0.043	3.317	0.008	0.823	1.505	0.192
total suspended solids	base	0.087	6.750	0.012	0.715	1.165	-0.267
	storm	0.736	8.173	0.038	0.645	1.684	0.130
	combined	0.023	8.354	-0.023	0.624	1.951	-0.095

* Probability values less than 0.10 indicate that the regression coefficient (slope) is significantly different from zero (bold values).

** Negative regression coefficients indicate decreasing trends.

Table 8 Significant trends for mass transport of NO_3-N, NH_3-N, TP, TKN, TOC, and TSS during base, storm, and combined flow conditions at the UMC site.

Parameter	Flow	Model Probability*	Intercept	Trend Slope**	Trend Probability*	sin Function	cos Function
ammonia nitrogen	base	0.219	1.157	-0.015	0.914	1.645	0.470
	storm	0.473	-26.163	1.124	0.208	-1.837	4.238
	combined	0.195	2.980	-0.059	0.704	1.856	0.632
nitrate nitrogen	base	0.029	6.382	-0.088	0.400	1.664	0.985
	storm	0.481	6.453	-0.046	0.887	0.041	0.907
	combined	0.074	7.782	-0.126	0.339	1.617	1.097
total Kjeldahl nitroge	base	0.020	3.225	0.034	0.724	1.573	1.200
	storm	0.514	-4.438	0.407	0.400	-0.261	2.193
	combined	0.091	4.734	-0.002	0.991	1.657	1.322
total organic carbon	base	0.027	4.672	0.062	0.502	1.513	0.919
	storm	0.584	1.187	0.251	0.508	-0.364	1.656
	combined	0.120	6.144	0.024	0.850	1.459	1.091
total phosphorus	base	0.050	1.490	0.039	0.720	1.488	1.245
	storm	0.390	-10.137	0.582	0.265	-0.588	2.872
	combined	0.148	3.124	0.003	0.986	1.608	1.358
total suspended solids	base	0.059	3.297	0.131	0.415	2.125	1.534
	storm	**0.130**	**-21.930**	**1.250**	**0.080**	**-1.114**	**4.965**
	combined	0.159	5.257	0.094	0.656	2.343	1.515

Probability values less than 0.10 indicate that the regression coefficient (slope) is significantly different from zero (bold values).

* Negative regression coefficients indicate decreasing trends.

Table 9. Significant trends for mass transport of NO_3-N, NH_3-N, TP, TKN, TOC, and TSS during base, storm, and combined flow conditions at the BB site.

Parameter	Flow	Model Probability*	Intercept	Trend Slope**	Trend Probability*	sin Function	cos Function
ammonia nitrogen	base	0.065	1.258	-0.028	0.267	0.355	0.682
	storm	**0.063**	**3.913**	**-0.103**	**0.032**	**-0.235**	**0.854**
	combined	0.043	2.261	-0.032	0.316	0.497	1.006
nitrate nitrogen	base	0.001	2.808	0.027	0.264	1.164	1.224
	storm	0.269	4.551	-0.016	0.699	0.030	1.047
	combined	0.002	3.065	0.041	0.179	1.445	1.334
total Kjeldahl nitroge	base	0.016	4.001	-0.011	0.459	0.517	0.422
	storm	0.373	5.932	-0.052	0.150	-0.108	0.350
	combined	0.052	4.669	-0.008	0.762	0.787	0.634
total organic carbon	base	0.014	4.858	0.027	0.191	1.054	-0.060
	storm	0.768	7.626	-0.037	0.363	-0.202	0.204
	combined	0.057	5.444	0.034	0.286	1.330	0.215
total phosphorus	base	0.093	0.982	0.041	0.120	0.963	0.140
	storm	0.501	4.881	-0.063	0.166	-0.423	0.144
	combined	0.163	1.985	0.035	0.363	1.280	0.465
total suspended solids	base	0.195	5.724	0.009	0.782	1.083	-0.137
	storm	**0.184**	**10.701**	**-0.142**	**0.037**	**-0.492**	**0.081**
	combined	0.324	6.899	0.002	0.973	1.320	0.261

Probability values less than 0.10 indicate that the regression coefficient (slope) is significantly different from zero (bold values).

* Negative regression coefficients indicate decreasing trends.

Table 10. Monthly mean concentrations of NO3-N, TP, NH3-N, TKN, TOC, and TSS during combined flow conditions (base and storm) for the LMC, UMC, and BB sites.

Lower Moores Creek

Date month-year	Discharge M^3	NO3-N mg/L	TP mg/L	NH3-N mg/L	TKN mg/L	TOC mg/L	TSS mg/L
Jan-95	1570759	1.26	0.42	0.13	1.86	0.00	116.31
Feb-95	222158	1.47	0.10	0.19	1.24	5.35	5.56
Mar-95	607347	1.03	0.22	0.24	2.01	13.28	118.84
Apr-95	979624	0.65	0.50	0.24	2.78	11.52	245.01
May-95	1134548	0.32	0.39	0.13	1.58	12.39	73.36
Jun-95	146047	0.89	0.16	0.09	2.96	9.67	8.12
Jul-95	18643	1.08	0.14	0.02	1.05	9.51	10.70
Aug-95	*	*	*	*	*	*	*
Sep-95	*	*	*	*	*	*	*
Oct-95	23028	0.38	0.21	0.03	0.98	6.93	28.66
Nov-95	24624	0.05	0.12	0.02	0.75	4.63	7.02
Dec-95	153619	1.39	0.10	0.41	1.96	4.63	23.28
Jan-96	825281	1.80	0.62	0.18	2.37	6.24	312.14
Feb-96	141606	1.30	0.02	0.02	0.26	1.52	1.07
Mar-96	159690	1.22	0.06	0.02	0.46	3.90	1.80
Apr-96	1283491	1.37	0.60	0.26	1.94	10.52	106.42
May-96	631345	0.86	0.39	0.13	1.39	13.18	50.06
Jun-96	159040	1.33	0.12	0.05	1.44	11.70	73.52
Jul-96	17795	0.20	0.12	0.01	0.55	6.42	7.83
Aug-96	16553	0.08	0.07	0.01	0.29	3.06	2.30
Sep-96	536641	0.94	0.08	0.00	0.39	4.36	2.20
Oct-96	273235	0.68	0.07	0.02	0.42	4.90	1.48
Nov-96	3084779	0.83	0.40	0.06	1.08	9.75	21.23
Dec-96	351349	0.66	0.15	0.03	0.42	3.53	3.33
Jan-97	227320	0.34	0.04	0.03	0.35	2.75	1.35
Feb-97	1160513	0.87	0.44	0.13	1.46	7.68	55.96
Mar-97	829009	1.10	0.33	0.33	1.42	9.94	27.04
Apr-97	546691	0.26	0.14	0.02	0.61	4.81	10.70
May-97	176026	0.21	0.09	0.03	0.55	5.10	9.47
Jun-97	513994	0.56	0.44	0.06	1.45	9.18	115.91
Jul-97	69391	0.51	0.15	0.04	0.58	6.51	5.81
Aug-97	76842	0.10	0.10	0.04	0.57	6.70	8.40
Sep-97	35706	0.65	0.14	0.03	0.71	6.97	6.[illegible]2

Upper Moores Creek

Date month-year	Discharge M^3	NO3-N mg/L	TP mg/L	NH3-N mg/L	TKN mg/L	TOC mg/L	TSS mg/L
Jul-96	4654	4.29	0.15	0.18	0.78	5.78	6.32
Aug-96	5686	0.13	0.06	0.02	0.25	2.10	0.93
Sep-96	531000	0.93	0.08	0.00	0.43	3.89	1.30
Oct-96	183915	1.21	0.14	0.03	0.64	5.78	8.93
Nov-96	1770023	0.81	0.58	0.09	1.45	9.31	146.02
Dec-96	242129	0.70	0.11	0.02	0.43	3.99	2.70
Jan-97	125422	0.65	0.04	0.02	0.40	3.03	1.33
Feb-97	722180	1.07	1.52	0.27	4.71	8.93	980.71
Mar-97	533094	0.90	0.38	0.00	1.48	8.73	112.51
Apr-97	311616	0.54	0.20	0.11	0.94	7.97	45.91
May-97	38778	1.33	0.12	0.17	0.79	37.08	5.55
Jun-97	251668	0.86	0.60	0.21	2.07	9.89	225.62
Jul-97	16107	0.60	0.21	0.04	0.78	7.48	5.57
Aug-97	24192	0.26	0.18	0.02	0.75	8.70	26.48
Sep-97	4457	0.19	0.10	0.01	0.50	5.88	7.19

Beatty Branch

Date month-year	Discharge M^3	NO3-N mg/L	TP mg/L	NH3-N mg/L	TKN mg/L	TOC mg/L	TSS mg/L
Jan-95	285369	1.03	0.48	0.07	1.89	0.00	78.79
Feb-95	60860	0.92	0.09	0.01	0.82	4.31	4.76
Mar-95	127663	0.66	1.05	0.38	2.80	18.51	48.28
Apr-95	220470	0.46	0.46	0.11	2.22	8.88	274.77
May-95	242360	0.31	0.38	0.16	1.36	10.53	97.64
Jun-95	29213	0.12	0.09	0.02	0.65	6.13	3.98
Jul-95	7759	0.09	0.09	0.12	2.41	4.79	7.14
Aug-95	*	*	*	*	*	*	*
Sep-95	*	*	*	*	*	*	*
Oct-95	10436	0.99	0.03	1.04	10.02	2.64	1.42
Nov-95	31120	0.13	0.05	0.27	1.20	1.32	2.03
Dec-95	141283	0.96	0.05	0.11	0.69	2.10	12.79
Jan-96	252111	1.94	0.11	0.09	0.93	4.03	42.33
Feb-96	58092	1.14	0.02	0.03	0.31	1.47	0.82
Mar-96	*	*	*	*	*	*	*
Apr-96	581810	1.20	0.26	0.07	1.05	7.10	29.02
May-96	213986	0.61	0.31	0.07	1.01	10.06	36.02
Jun-96	21830	0.52	0.09	0.14	1.17	9.83	19.75
Jul-96	0	0.00	0.00	0.00	0.00	0.00	0.00
Aug-96	0	0.00	0.00	0.00	0.00	0.00	0.00
Sep-96	221112	0.62	0.37	0.06	0.77	6.70	33.57
Oct-96	*	*	*	*	*	*	*
Nov-96	1624215	0.76	0.55	0.10	0.88	7.72	26.72
Dec-96	436373	0.46	0.08	0.02	0.41	2.68	1.29
Jan-97	686524	0.25	0.04	0.01	0.36	1.78	0.53
Feb-97	538114	0.70	0.22	0.06	0.65	4.80	66.54
Mar-97	468623	0.39	0.08	0.02	0.30	2.59	2.04
Apr-97	616659	0.32	0.09	0.00	0.44	3.72	5.18
May-97	63916	0.06	0.05	0.01	0.26	2.68	1.39
Jun-97	132229	0.21	0.23	0.01	0.93	6.73	12.64
Jul-97	27154	0.06	0.06	0.03	0.27	2.63	2.02
Aug-97	21180	1.67	0.30	0.00	0.84	5.51	22.00
Sep-97	15263	0.99	0.69	0.19	1.53	7.16	64.51

* missing data

NH3-N, TKN, TOC, and TSS during combined flow conditions
r the LMC, UMC, and BB sites.

Lower Moores Creek

Date month-year	Discharge M^3	NO3-N Kg	TP Kg	NH3-N Kg	TKN Kg	TOC Kg	TSS Kg
Jan-95	1570759	1978.91	652.52	203.48	2918.22	0.00	182688.11
Feb-95	222158	326.97	22.74	41.33	276.44	1187.50	1235.10
Mar-95	607347	626.49	133.77	146.67	1218.37	8063.75	72174.56
Apr-95	979624	631.92	492.18	233.97	2720.24	11288.03	240015.59
May-95	1134548	362.21	439.91	147.01	1795.43	14061.50	83231.76
Jun-95	146047	130.63	22.88	13.31	432.45	1412.09	1186.23
Jul-95	18643	20.22	2.59	0.37	19.65	177.20	199.42
Aug-95	*	*	*	*			
Sep-95	*	*	*	*			
Oct-95	23028	8.70	4.87	0.66	22.58	159.61	660.04
Nov-95	24624	1.15	3.03	0.58	18.57	114.05	172.91
Dec-95	153619	213.63	15.64	63.14	301.65	710.83	3576.06
Jan-96	825281	1487.08	514.84	152.22	1956.97	5150.85	257603.85
Feb-96	141606	184.44	2.33	3.08	37.29	215.93	151.72
Mar-96	159690	195.47	9.40	2.95	73.14	623.55	286.66
Apr-96	1283491	1757.25	765.50	334.61	2494.47	13507.81	136592.93
May-96	631345	540.79	245.94	84.41	876.90	8320.54	31604.74
Jun-96	159040	212.19	19.59	7.36	229.52	1861.51	11692.95
Jul-96	17795	3.52	2.06	0.14	9.84	114.32	139.35
Aug-96	16553	1.31	1.15	0.12	4.82	50.72	38.13
Sep-96	536641	503.80	42.92	0.80	209.22	2338.56	1180.61
Oct-96	273235	185.97	20.49	6.70	113.97	1338.44	403.54
Nov-96	3084779	2545.02	1241.14	200.39	3326.14	30063.91	65485.81
Dec-96	351349	230.59	51.39	9.09	147.05	1241.98	1169.97
Jan-97	227320	76.41	8.49	6.85	80.53	625.83	306.37
Feb-97	1160513	1015.41	507.77	152.81	1693.75	8914.30	64947.65
Mar-97	829009	914.37	271.47	270.68	1178.29	8243.61	22420.00
Apr-97	546691	143.53	74.93	10.79	332.81	2629.85	5847.99
May-97	176026	37.46	16.62	5.71	97.67	897.09	1667.52
Jun-97	513994	288.30	227.04	30.07	744.29	4716.30	59575.49
Jul-97	69391	35.55	10.17	2.54	40.31	451.82	403.14
Aug-97	76842	7.76	7.61	3.46	43.80	514.84	645.47
Sep-97	35706	23.33	4.98	1.06	25.25	249.02	236.27

Upper Moores Creek

Date month-year	Discharge M^3	NO3-N Kg	TP Kg	NH3-N Kg	TKN Kg	TOC Kg	TSS Kg
Jul-96	4654	19.96	0.68	0.82	3.61	26.92	29.43
Aug-96	5686	0.74	0.36	0.09	1.45	11.96	5.31
Sep-96	531000	493.37	42.47	0.80	228.23	2064.44	690.01
Oct-96	183915	221.79	26.57	5.70	118.45	1062.97	1643.12
Nov-96	1770023	1427.40	1024.17	151.58	2558.67	16472.71	258451.18
Dec-96	242129	170.34	26.62	5.17	104.39	965.88	653.44
Jan-97	125422	81.28	5.00	2.20	50.44	379.99	166.21
Feb-97	722180	773.94	1097.67	197.18	3398.92	6450.94	708248.12
Mar-97	533094	478.60	203.09	0.97	789.19	4655.41	59979.06
Apr-97	311616	168.45	61.86	33.16	293.55	2483.71	14306.05
May-97	38778	51.44	4.50	6.58	30.52	1438.07	215.11
Jun-97	251668	215.43	151.44	53.76	520.97	2489.55	56780.58
Jul-97	16107	9.61	3.36	0.67	12.55	120.42	89.70
Aug-97	24192	6.20	4.27	0.56	18.04	210.39	640.66
Sep-97	4457	0.84	0.43	0.03	2.22	26.21	32.04

Beatty Branch

Date month-year	Discharge M^3	NO3-N Kg	TP Kg	NH3-N Kg	TKN Kg	TOC Kg	TSS Kg
Jan-95	285369	293.25	138.17	19.84	538.00	0.00	22284.55
Feb-95	60860	55.86	5.37	0.68	49.70	262.46	289.66
Mar-95	127663	83.65	134.42	48.29	356.96	2362.79	6163.12
Apr-95	220470	100.60	100.50	24.77	489.07	1957.27	60579.43
May-95	242360	75.74	92.25	37.57	330.71	2553.26	23662.84
Jun-95	29213	3.63	2.49	0.49	18.85	179.03	116.19
Jul-95	7759	0.69	0.67	0.90	18.70	37.13	55.37
Aug-95	*	*	*	*			
Sep-95	*	*	*	*			
Oct-95	10436	10.36	0.36	10.81	104.59	27.55	14.84
Nov-95	31120	4.09	1.42	8.45	37.31	41.19	63.05
Dec-95	141283	134.97	7.30	15.99	97.86	297.30	1806.45
Jan-96	252111	488.81	27.53	21.81	234.17	1016.51	10671.99
Feb-96	58092	66.43	1.24	1.68	18.28	85.13	47.47
Mar-96	*	*	*	*	*	*	*
Apr-96	581810	700.22	149.20	42.77	613.33	4133.46	16882.03
May-96	213986	130.36	65.71	15.48	215.44	2152.98	7708.58
Jun-96	21830	11.45	1.91	3.13	25.49	214.66	431.14
Jul-96	0	0.00	0.00	0.00	0.00	0.00	0.00
Aug-96	0	0.00	0.00	0.00	0.00	0.00	0.00
Sep-96	221112	136.61	80.81	13.05	169.91	1482.03	7421.80
Oct-96	*	*	*	*	*	*	*
Nov-96	1624215	1232.91	885.29	162.26	1422.29	12542.46	43399.23
Dec-96	436373	202.91	33.45	10.22	179.18	1171.28	564.15
Jan-97	686524	171.82	25.09	8.84	244.26	1221.41	362.47
Feb-97	538114	374.79	115.98	30.16	350.40	2582.94	35805.93
Mar-97	468623	180.62	39.14	8.33	142.43	1215.09	954.76
Apr-97	616659	194.49	58.15	1.49	268.44	2295.40	3195.89
May-97	63916	3.72	3.18	0.79	16.49	171.38	88.54
Jun-97	132229	27.62	29.99	0.71	123.49	889.41	1671.91
Jul-97	27154	1.52	1.53	0.81	7.42	71.50	54.75
Aug-97	21180	35.46	6.27	0.10	17.79	116.70	465.97
Sep-97	15263	15.06	10.57	2.98	23.42	109.29	984.62

missing data

, TP, NH3-N, TKN, TOC, and TSS during base flow conditions
r the LMC, UMC, and BB sites.

Lower Moores Creek

Date month-year	Discharge M^3	NO3-N mg/L	TP mg/L	NH3-N mg/L	TKN mg/L	TOC mg/L	TSS mg/L
Jan-95	578792	1.41	0.10	0.01	0.72	0.00	0.57
Feb-95	220989	1.47	0.10	0.18	1.24	5.31	5.53
Mar-95	307103	1.04	0.08	0.15	0.84	7.26	5.85
Apr-95	338748	0.64	0.24	0.17	1.33	9.24	60.08
May-95	333220	0.34	0.26	0.11	1.16	10.08	36.94
Jun-95	131043	0.88	0.16	0.09	2.93	9.61	8.11
Jul-95	18643	1.08	0.14	0.02	1.05	9.51	10.70
Aug-95	*	*	*	*	*		*
Sep-95	*	*	*	*	*		*
Oct-95	23028	0.38	0.21	0.03	0.98	6.93	28.66
Nov-95	24624	0.05	0.12	0.02	0.75	4.63	7.02
Dec-95	115892	1.20	0.05	0.23	0.76	1.85	6.65
Jan-96	372407	2.28	0.22	0.02	1.41	3.52	215.08
Feb-96	141606	1.30	0.02	0.02	0.26	1.52	1.07
Mar-96	159690	1.22	0.06	0.02	0.46	3.90	1.80
Apr-96	320906	1.74	0.14	0.02	0.66	6.24	6.46
May-96	232254	0.85	0.19	0.02	0.86	8.38	27.09
Jun-96	159040	1.33	0.12	0.05	1.44	11.70	73.52
Jul-96	17795	0.20	0.12	0.01	0.55	6.42	7.83
Aug-96	16553	0.08	0.07	0.01	0.29	3.06	2.30
Sep-96	536641	0.94	0.08	0.00	0.39	4.36	2.20
Oct-96	158269	0.63	0.07	0.02	0.42	4.72	1.53
Nov-96	677020	0.98	0.26	0.03	0.76	7.03	10.50
Dec-96	351349	0.66	0.15	0.03	0.42	3.53	3.33
Jan-97	227320	0.34	0.04	0.03	0.35	2.75	1.35
Feb-97	442142	0.83	0.15	0.08	0.62	5.69	8.25
Mar-97	591152	1.15	0.31	0.37	1.40	9.65	22.79
Apr-97	413779	0.16	0.09	0.01	0.45	3.73	4.58
May-97	176026	0.21	0.09	0.03	0.55	5.10	9.47
Jun-97	229574	0.62	0.20	0.04	0.89	7.86	24.97
Jul-97	69391	0.51	0.15	0.04	0.58	6.51	5.81
Aug-97	76842	0.10	0.10	0.04	0.57	6.70	8.40
Sep-97	35706	0.65	0.14	0.03	0.71	6.97	6.62

Upper Moores Creek

Date month-year	Discharge M^3	NO3-N mg/L	TP mg/L	NH3-N mg/L	TKN mg/L	TOC mg/L	TSS mg/L
Jul-96	4654	4.29	0.15	0.18	0.78	5.78	6.32
Aug-96	5686	0.13	0.06	0.02	0.25	2.10	0.93
Sep-96	60189	0.92	0.08	0.00	0.43	3.87	1.30
Oct-96	108216	1.18	0.07	0.02	0.48	4.34	1.02
Nov-96	610364	0.86	0.39	0.06	1.13	7.63	90.60
Dec-96	242129	0.70	0.11	0.02	0.43	3.99	2.70
Jan-97	125422	0.65	0.04	0.02	0.40	3.03	1.33
Feb-97	343320	1.16	0.69	0.14	2.26	6.68	340.72
Mar-97	369208	0.82	0.33	0.00	1.32	7.50	123.80
Apr-97	216110	0.39	0.07	0.02	0.48	7.28	3.45
May-97	38778	1.33	0.12	0.17	0.79	37.08	5.55
Jun-97	130446	1.08	0.28	0.24	1.23	8.79	23.66
Jul-97	16107	0.60	0.21	0.04	0.78	7.48	5.57
Aug-97	24192	0.26	0.18	0.02	0.75	8.70	26.48
Sep-97	4457	0.19	0.10	0.01	0.50	5.88	7.19

Beatty Branch

Date month-year	Discharge M^3	NO3-N mg/L	TP mg/L	NH3-N mg/L	TKN mg/L	TOC mg/L	TSS mg/L
Jan-95	137279	1.00	0.20	0.03	0.81	0.00	10.87
Feb-95	60860	0.92	0.09	0.01	0.82	4.31	4.76
Mar-95	76535	0.66	0.09	0.02	0.66	6.11	7.04
Apr-95	97981	0.41	0.22	0.07	1.75	7.71	92.19
May-95	86484	0.30	0.22	0.14	1.07	8.63	60.05
Jun-95	29213	0.12	0.09	0.02	0.65	6.13	3.98
Jul-95	7759	0.09	0.09	0.12	2.41	4.79	7.14
Aug-95	*	*	*	*		*	*
Sep-95	*	*	*	*		*	*
Oct-95	10436	0.99	0.03	1.04	10.02	2.64	1.42
Nov-95	31120	0.13	0.05	0.27	1.20	1.32	2.03
Dec-95	115518	0.66	0.02	0.11	0.53	0.85	8.68
Jan-96	143762	2.03	0.01	0.02	0.39	0.85	2.26
Feb-96	58092	1.14	0.02	0.03	0.31	1.47	0.82
Mar-96	*	*	*	*	*	*	*
Apr-96	379005	0.95	0.16	0.03	0.63	5.80	11.49
May-96	118718	0.51	0.20	0.05	0.72	6.69	30.69
Jun-96	21830	0.52	0.09	0.14	1.17	9.83	19.75
Jul-96	0	0.00	0.00	0.00	0.00	0.00	0.00
Aug-96	0	0.00	0.00	0.00	0.00	0.00	0.00
Sep-96	101040	0.50	0.05	0.00	0.18	2.34	0.85
Oct-96	*	*	*	*	*	*	*
Nov-96	225209	0.80	0.23	0.03	0.56	5.15	13.06
Dec-96	204757	0.54	0.10	0.02	0.43	2.87	1.47
Jan-97	300935	0.26	0.04	0.01	0.36	1.82	0.60
Feb-97	224595	0.53	0.11	0.03	0.41	3.16	17.16
Mar-97	255233	0.39	0.09	0.01	0.34	2.53	2.30
Apr-97	149776	0.22	0.07	0.00	0.35	3.11	3.54
May-97	54598	0.06	0.05	0.01	0.25	2.64	1.57
Jun-97	44849	0.19	0.21	0.01	0.86	6.33	11.56
Jul-97	27154	0.06	0.06	0.03	0.27	2.63	2.02
Aug-97	21180	1.67	0.30	0.00	0.84	5.51	22.00
Sep-97	15263	0.99	0.69	0.19	1.53	7.16	64.51

missing data

P, NH3-N, TKN, TOC, and TSS during base flow condition
r the LMC, UMC, and BB sites.

Lower Moores Creek

Date month-year	Discharge M^3	NO3-N Kg	TP Kg	NH3-N Kg	TKN Kg	TOC Kg	TSS Kg
Jan-95	578792	816.39	57.02	8.27	413.94	0.00	332.12
Feb-95	220989	324.45	22.57	40.72	274.42	1173.86	1221.37
Mar-95	307103	320.24	25.69	44.59	257.59	2230.02	1797.53
Apr-95	338748	216.69	79.77	56.96	451.44	3128.84	20351.57
May-95	333220	112.47	87.53	38.19	387.06	3358.04	12308.54
Jun-95	131043	115.77	20.48	11.81	383.84	1259.50	1063.19
Jul-95	18643	20.22	2.59	0.37	19.65	177.20	199.42
Aug-95	*	*	*	*		*	*
Sep-95	*	*	*	*			
Oct-95	23028	8.70	4.87	0.66	22.58	159.61	660.04
Nov-95	24624	1.15	3.03	0.58	18.57	114.05	172.91
Dec-95	115892	138.56	5.46	26.17	88.49	213.96	771.07
Jan-96	372407	847.69	83.73	5.95	524.33	1309.13	80096.63
Feb-96	141606	184.44	2.33	3.08	37.29	215.93	151.72
Mar-96	159690	195.47	9.40	2.95	73.14	623.55	286.66
Apr-96	320906	558.48	44.08	5.59	213.25	2002.47	2074.51
May-96	232254	198.42	45.14	4.65	199.52	1946.80	6291.37
Jun-96	159040	212.19	19.59	7.36	229.52	1861.51	11692.95
Jul-96	17795	3.52	2.06	0.14	9.84	114.32	139.35
Aug-96	16553	1.31	1.15	0.12	4.82	50.72	38.13
Sep-96	536641	503.80	42.92	0.80	209.22	2338.56	1180.61
Oct-96	158269	99.74	11.29	3.25	65.69	747.52	242.58
Nov-96	677020	662.20	174.56	21.75	513.25	4762.58	7107.95
Dec-96	351349	230.59	51.39	9.09	147.05	1241.98	1169.97
Jan-97	227320	76.41	8.49	6.85	80.53	625.83	306.37
Feb-97	442142	367.59	67.45	33.52	274.47	2516.09	3648.20
Mar-97	591152	681.30	183.94	218.51	828.07	5703.42	13471.29
Apr-97	413779	64.64	36.85	3.18	185.55	1543.14	1894.96
May-97	176026	37.46	16.62	5.71	97.67	897.09	1667.52
Jun-97	229574	141.63	46.31	9.33	204.55	1803.92	5732.91
Jul-97	69391	35.55	10.17	2.54	40.31	451.82	403.14
Aug-97	76842	7.76	7.61	3.46	43.80	514.84	645.47
Sep-97	35706	23.33	4.98	1.06	25.25	249.02	236.27

Upper Moores Creek

Date month-year	Discharge M^3	NO3-N Kg	TP Kg	NH3-N Kg	TKN Kg	TOC Kg	TSS Kg
Jul-96	4654	19.96	0.68	0.82	3.61	26.92	29.43
Aug-96	5686	0.74	0.36	0.09	1.45	11.96	5.31
Sep-96	60189	55.51	4.80	0.09	25.78	232.98	77.96
Oct-96	108216	127.37	8.11	1.78	51.88	470.09	110.21
Nov-96	610364	522.09	237.72	38.08	691.10	4657.90	55299.82
Dec-96	242129	170.34	26.62	5.17	104.39	965.88	653.44
Jan-97	125422	81.28	5.00	2.20	50.44	379.99	166.21
Feb-97	343320	398.26	236.52	48.87	775.32	2292.79	116977.54
Mar-97	369208	302.90	122.92	0.41	488.10	2767.31	45706.23
Apr-97	216110	83.21	14.24	4.66	104.13	1572.59	746.21
May-97	38778	51.44	4.50	6.58	30.52	1438.07	215.11
Jun-97	130446	140.68	36.08	31.83	160.62	1147.00	3086.69
Jul-97	16107	9.61	3.36	0.67	12.55	120.42	89.70
Aug-97	24192	6.20	4.27	0.56	18.04	210.39	640.66
Sep-97	4457	0.84	0.43	0.03	2.22	26.21	32.04

Beatty Branch

Date month-year	Discharge M^3	NO3-N Kg	TP Kg	NH3-N Kg	TKN Kg	TOC Kg	TSS Kg
Jan-95	137279	137.75	27.10	3.55	111.50	0.00	1492.74
Feb-95	60860	55.86	5.37	0.68	49.70	262.46	289.66
Mar-95	76535	50.42	7.11	1.76	50.19	467.99	539.04
Apr-95	97981	39.80	21.47	6.81	171.88	755.31	9033.01
May-95	86484	25.56	19.33	11.95	92.86	746.02	5193.13
Jun-95	29213	3.63	2.49	0.49	18.85	179.03	116.19
Jul-95	7759	0.69	0.67	0.90	18.70	37.13	55.37
Aug-95	*	*	*	*			
Sep-95	*	*	*	*			
Oct-95	10436	10.36	0.36	10.81	104.59	27.55	14.84
Nov-95	31120	4.09	1.42	8.45	37.31	41.19	63.05
Dec-95	115518	75.71	2.15	12.38	61.27	98.40	1002.59
Jan-96	143762	291.61	1.53	3.39	55.39	121.55	324.67
Feb-96	58092	66.43	1.24	1.68	18.28	85.13	47.47
Mar-96	*	*	*	*	*	*	*
Apr-96	379005	359.64	59.17	11.66	237.62	2197.50	4353.44
May-96	118718	60.56	23.84	5.55	85.17	794.63	3643.52
Jun-96	21830	11.45	1.91	3.13	25.49	214.66	431.14
Jul-96	0	0.00	0.00	0.00	0.00	0.00	0.00
Aug-96	0	0.00	0.00	0.00	0.00	0.00	0.00
Sep-96	101040	50.15	5.16	0.21	18.62	236.88	85.39
Oct-96	*	*	*	*	*	*	*
Nov-96	225209	179.39	52.91	6.29	126.50	1159.53	2940.77
Dec-96	204757	110.14	19.54	4.06	87.23	587.65	301.33
Jan-97	300935	79.46	11.55	3.83	106.92	548.07	182.03
Feb-97	224595	119.21	24.37	7.63	91.95	709.10	3853.71
Mar-97	255233	98.71	22.12	3.68	86.81	644.94	587.09
Apr-97	149776	33.56	10.84	0.47	52.58	465.78	529.83
May-97	54598	3.30	2.71	0.74	13.69	144.26	85.75
Jun-97	44849	8.74	9.37	0.32	38.73	283.86	518.49
Jul-97	27154	1.52	1.53	0.81	7.42	71.50	54.75
Aug-97	21180	35.46	6.27	0.10	17.79	116.70	465.97
Sep-97	15263	15.06	10.57	2.98	23.42	109.29	984.62

missing data

TP, NH3-N, TKN, TOC, and TSS during storm flow conditions
r the LMC, UMC, and BB sites.

Lower Moores Creek

Date month-year	Discharge M^3	NO3-N mg/L	TP mg/L	NH3-N mg/L	TKN mg/L	TOC mg/L	TSS mg/L
Jan-95	991967	1.17	0.60	0.20	2.52	0.00	183.83
Feb-95	1168	2.16	0.14	0.52	1.73	11.67	11.75
Mar-95	300243	1.02	0.36	0.34	3.20	19.43	234.40
Apr-95	640875	0.65	0.64	0.28	3.54	12.73	342.76
May-95	801328	0.31	0.44	0.14	1.76	13.36	88.51
Jun-95	15004	0.99	0.16	0.10	3.24	10.17	8.20
Jul-95	0	0.00	0.00	0.00	0.00	0.00	0.00
Aug-95	*	*	*	*	*	*	*
Sep-95	*	*	*	*	*	*	*
Oct-95	0	0.00	0.00	0.00	0.00	0.00	0.00
Nov-95	0	0.00	0.00	0.00	0.00	0.00	0.00
Dec-95	37727	1.99	0.27	0.98	5.65	13.17	74.35
Jan-96	452874	1.41	0.95	0.32	3.16	8.48	391.96
Feb-96	0	0.00	0.00	0.00	0.00	0.00	0.00
Mar-96	0	0.00	0.00	0.00	0.00	0.00	0.00
Apr-96	962585	1.25	0.75	0.34	2.37	11.95	139.75
May-96	399091	0.86	0.50	0.20	1.70	15.97	63.43
Jun-96	0	0.00	0.00	0.00	0.00	0.00	0.00
Jul-96	0	0.00	0.00	0.00	0.00	0.00	0.00
Aug-96	0	0.00	0.00	0.00	0.00	0.00	0.00
Sep-96	0	0.00	0.00	0.00	0.00	0.00	0.00
Oct-96	114966	0.75	0.08	0.03	0.42	5.14	1.40
Nov-96	2407759	0.78	0.44	0.07	1.17	10.51	24.25
Dec-96	0	0.00	0.00	0.00	0.00	0.00	0.00
Jan-97	0	0.00	0.00	0.00	0.00	0.00	0.00
Feb-97	718370	0.90	0.61	0.17	1.98	8.91	85.33
Mar-97	237858	0.98	0.37	0.22	1.47	10.68	37.62
Apr-97	132912	0.59	0.29	0.06	1.11	8.18	29.74
May-97	0	0.00	0.00	0.00	0.00	0.00	0.00
Jun-97	284420	0.52	0.64	0.07	1.90	10.24	189.31
Jul-97	0	0.00	0.00	0.00	0.00	0.00	0.00
Aug-97	0	0.00	0.00	0.00	0.00	0.00	0.00
Sep-97	0	0.00	0.00	0.00	0.00	0.00	0.00

Upper Moores Creek

Jul-96	0	0.00	0.00	0.00	0.00	0.00	0.00
Aug-96	0	0.00	0.00	0.00	0.00	0.00	0.00
Sep-96	470811	0.93	0.08	0.00	0.43	3.89	1.30
Oct-96	75700	1.25	0.24	0.05	0.88	7.83	20.25
Nov-96	1159659	0.78	0.68	0.10	1.61	10.19	175.18
Dec-96	0	0.00	0.00	0.00	0.00	0.00	0.00
Jan-97	0	0.00	0.00	0.00	0.00	0.00	0.00
Feb-97	378860	0.99	2.27	0.39	6.92	10.98	1560.66
Mar-97	163885	1.07	0.49	0.00	1.84	11.52	87.09
Apr-97	95507	0.89	0.50	0.30	1.98	9.54	141.98
May-97	0	0.00	0.00	0.00	0.00	0.00	0.00
Jun-97	121222	0.62	0.95	0.18	2.97	11.08	442.94
Jul-97	0	0.00	0.00	0.00	0.00	0.00	0.00
Aug-97	0	0.00	0.00	0.00	0.00	0.00	0.00
Sep-97	0	0.00	0.00	0.00	0.00	0.00	0.00

Beatty Branch

Jan-95	148090	1.05	0.75	0.11	2.88	0.00	140.40
Feb-95	0	0.00	0.00	0.00	0.00	0.00	0.00
Mar-95	51128	0.65	2.49	0.91	6.00	37.06	110.00
Apr-95	122488	0.50	0.65	0.15	2.59	9.81	420.83
May-95	155876	0.32	0.47	0.16	1.53	11.59	118.49
Jun-95	0	0.00	0.00	0.00	0.00	0.00	0.00
Jul-95	0	0.00	0.00	0.00	0.00	0.00	0.00
Aug-95	*	*	*	*	*	*	*
Sep-95	*	*	*	*	*	*	*
Oct-95	0	0.00	0.00	0.00	0.00	0.00	0.00
Nov-95	0	0.00	0.00	0.00	0.00	0.00	0.00
Dec-95	25765	2.30	0.20	0.14	1.42	7.72	31.20
Jan-96	108349	1.82	0.24	0.17	1.65	8.26	95.50
Feb-96	0	0.00	0.00	0.00	0.00	0.00	0.00
Mar-96	*	*	*	*	*	*	*
Apr-96	202805	1.68	0.44	0.15	1.85	9.55	61.78
May-96	95268	0.73	0.44	0.10	1.37	14.26	42.67
Jun-96	0	0.00	0.00	0.00	0.00	0.00	0.00
Jul-96	0	0.00	0.00	0.00	0.00	0.00	0.00
Aug-96	0	0.00	0.00	0.00	0.00	0.00	0.00
Sep-96	120072	0.72	0.63	0.11	1.26	10.37	61.10
Oct-96	*	*	*	*	*	*	*
Nov-96	1399006	0.75	0.59	0.11	0.93	8.14	28.92
Dec-96	231616	0.40	0.06	0.03	0.40	2.52	1.13
Jan-97	385590	0.24	0.04	0.01	0.36	1.75	0.47
Feb-97	313519	0.82	0.29	0.07	0.82	5.98	101.91
Mar-97	213390	0.38	0.08	0.02	0.26	2.67	1.72
Apr-97	466883	0.34	0.10	0.00	0.46	3.92	5.71
May-97	9318	0.05	0.05	0.00	0.30	2.91	0.30
Jun-97	87381	0.22	0.24	0.00	0.97	6.93	13.20
Jul-97	0	0.00	0.00	0.00	0.00	0.00	0.00
Aug-97	0	0.00	0.00	0.00	0.00	0.00	0.00
Sep-97	0	0.00	0.00	0.00	0.00	0.00	0.00

missing data