Contract Report 2002-01

Watershed Monitoring for the Lake Decatur Watershed, 1999–2000

by
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Prepared for the
City of Decatur

January 2002

Illinois State Water Survey
Watershed Science Section
Champaign, Illinois

A Division of the Illinois Department of Natural Resources

Watershed Monitoring for the Lake Decatur Watershed 1999 - 2000

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Abstract

Lake Decatur is the water supply reservoir for the City of Decatur. The reservoir was created in 1922 by constructing a dam to impound the flow of the Sangamon River. The dam was modified in 1956 to increase the maximum capacity of the lake to 28,000 acre-feet. The drainage area of the Sangamon River upstream of Decatur is 925 square miles and includes portions of seven counties in east-central Illinois.

Lake Decatur has high concentrations of total dissolved solids and nitrates, and nitrate-N concentrations have been exceeding drinking water standards in recent years. This has created a serious situation for the drinking water supply of the City of Decatur, since nitrate-nitrogen (N) cannot be removed from finished drinking water through regular water purification processes. Nitrate-N concentrations in Lake Decatur have exceeded the Illinois Environmental Protection Agency (IEPA) drinking water standard of 10 milligrams per liter (mg/l) on occasions each year for the period between 1979 and 2000, except from 1993 to 1995.

Since 1993, the Illinois State Water Survey has been monitoring the Lake Decatur watershed for trends in nitrate-N concentrations and loads and to identify any significant changes in the watershed. The purpose of the monitoring is to collect reliable hydrologic and water quality data throughout the watershed for use by city planners and resource managers to develop watershed management alternatives based on scientific data. This report presents the annual data for all seven years of monitoring (May 1993-April 2000) and monthly data for Year 7 of monitoring (May 1999-April 2000). Based on the seven years of data, it can be concluded that the unit of nitrate-N loads are relatively uniform over the entire watershed but tend to be slightly higher at the tributary streams in the upper Sangamon River watershed than at the Sangamon River stations closer to the lake. Nitrate-N loads vary with concentration and streamflow and were the lowest in Year 7, because of the low streamflows during that year. Flow-weighted nitrate-N concentrations have been increasing during the study period at the Monticello station. The highest nitrate-N concentrations during the monitoring period were observed in Years 6 and 7.

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Introduction

Lake Decatur is the water supply reservoir for the City of Decatur. The reservoir was created in 1922 by constructing a dam to impound the flow of the Sangamon River. The original dam had a crest elevation of 28 feet above the river bottom and a length of one-third of a mile. The dam created a lake with a volume of 20,000 acre-feet (6,518 million gallons) and an area of 4.4 square miles. The dam was modified in 1956 to increase the maximum capacity of the lake to 28,000 acre-feet (9,125 million gallons). Water withdrawal from the lake has been averaging 37 million gallons per day (mgd). It is projected that demand will increase in the near future.

The drainage area of the Sangamon River upstream of the Decatur dam is 925 square miles. The watershed includes portions of seven counties in east-central Illinois as shown in figure 1. The predominant land use in the watershed is row crop agriculture comprising nearly 90 percent of the land area. The major urban areas within the watershed are Decatur, Monticello, and Gibson City.

Lake Decatur has high concentrations of total dissolved solids and nitrate-nitrogen (nitrate-N) concentrations have been exceeding drinking water standards in recent years. This has created a serious situation for the drinking water supply of the City of Decatur, since nitrate-N cannot be removed from finished drinking water through regular water purification processes. Nitrate-N concentrations in Lake Decatur have exceeded the Illinois Environmental Protection Agency (IEPA) drinking water standard of 10 milligrams per liter (mg/l) for the period between 1979 and 2000, except from 1993 to 1995. These exceedances generally occur on a seasonal basis (spring through mid-summer and late winter).

On June 10, 1992, a Letter of Commitment (LOC) was signed between the IEPA and the City of Decatur that requires the city to take several steps to reduce nitrate-N levels in Lake Decatur to acceptable concentrations within nine years. One of the steps required the city to conduct an initial two-year monitoring study of the Lake Decatur watershed to better understand nitrate-N yields in the watershed. The Illinois State Water Survey (ISWS) received a grant from the City of Decatur, conducted the initial two-year

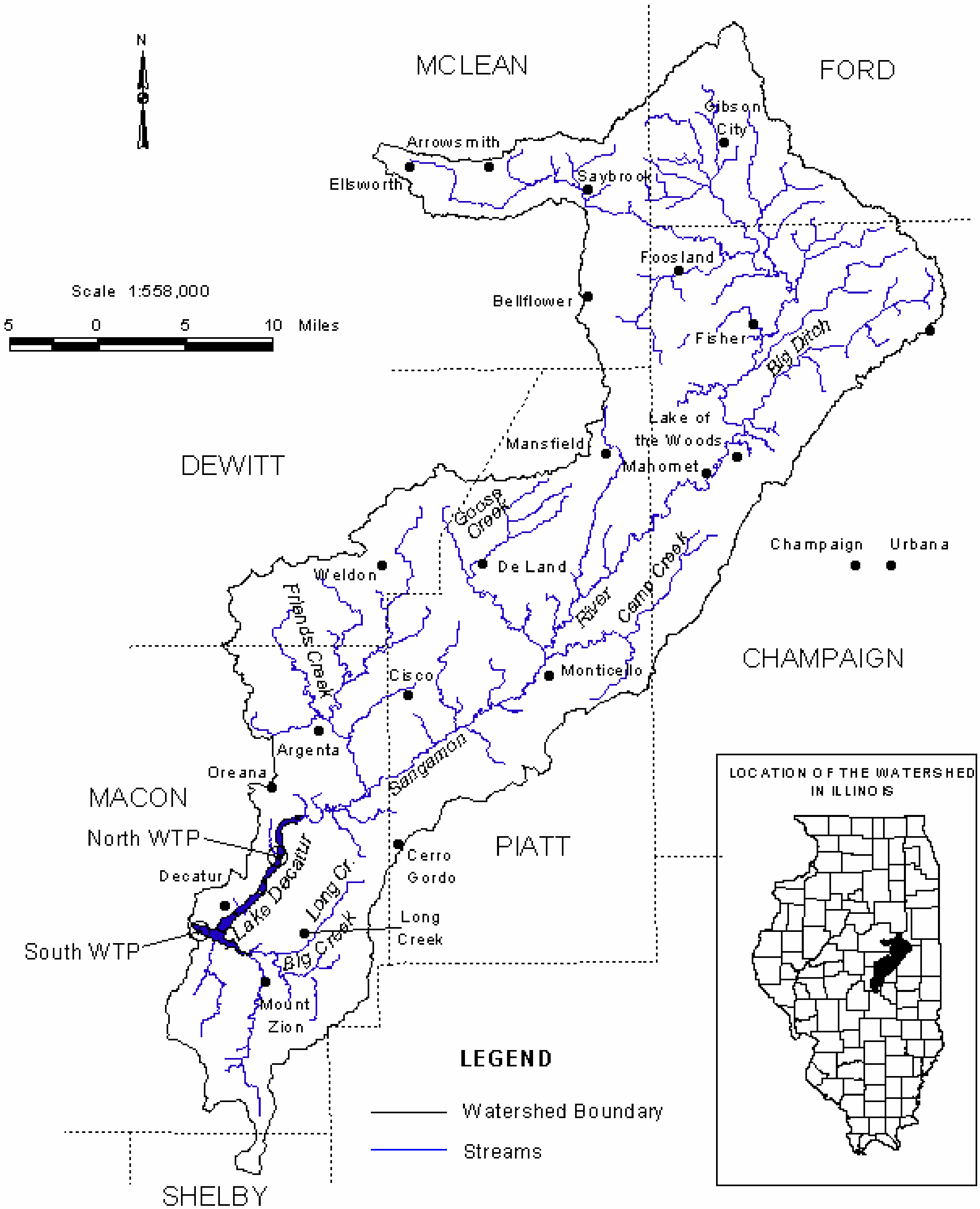

Figure 1. The Lake Decatur watershed

monitoring study, and developed land use management strategies that could assist the city in complying with the IEPA drinking water standards. Demissie et al. (1996) present the results of that two-year study. The City of Decatur has continued to fund the study past the initial two years of data collection to monitor the Lake Decatur watershed for trends in nitrate-N concentrations and loads and to identify any significant changes in the watershed. The purpose of the monitoring is to collect reliable hydrologic and water quality data throughout the watershed for use by city planners and resource managers to develop watershed management alternatives based on scientific data. Keefer and Demissie (1996) present results of Year 3 of monitoring, Keefer et al. (1997) present the results of Year 4 of monitoring, and Keefer and Demissie (1999, 2000) present the results of Years 5 and 6 of monitoring, respectively, in context of longer term records.

This technical report presents the annual data for all seven years of monitoring (May 1993-April 2000) and monthly data for Year 7 of monitoring (May 1999-April 2000). The report is organized into three main sections: Introduction, Background, and Hydrologic and Nitrate-N Monitoring. The first two sections are condensed versions of the corresponding sections in Demissie et al. (1996). The section on hydrologic and water quality monitoring discusses the monitoring results of the seven years of data collection. A Summary and Discussion and Bibliography are also included.

Acknowledgments

This work was supported by the City of Decatur. Keith Alexander, Director of Water Management, served as project manager, and his cooperation and assistance are greatly appreciated. Several other city officials and staff also have been very cooperative and supportive: Terry M. Howley, Mayor; Steve Garman, City Manager; and John Smith, Assistant City Manager for Public Services. The views expressed in this report are those of the authors and do not necessarily reflect the views of the sponsor or the Illinois State Water Survey.

The authors wish to acknowledge the significant contributions of the following project staff toward the completion of this report. Erin Bauer, field technician, was responsible for field data collection. Sandy Jones and Erin Bauer were responsible for processing and presenting data used in this report.

We gratefully acknowledge the nitrate-N analyses performed by the following chemists at the Illinois State Water Survey in Champaign: Loretta M. Skowron, Lauren F. Sievers, Ruthann Nichols, and Daniel L. Webb. William Bogner, Amy Russell, and Jim Slowikowski of the Watershed Science Section provided assistance with fieldwork, data entry, and/or analysis. Becky Howard and Patti Hill prepared the camera-ready version of the report, which was edited by Eva Kingston. Linda Hascall provided expert advice on illustration layout.

Background

Water Quality Problems in Lake Decatur

Lake Decatur has experienced water quality problems for more than 20 years. Past studies by the U.S. Environmental Protection Agency (USEPA) and the Illinois Environmental Protection Agency (IEPA) have documented water quality problems in the lake (USEPA, 1975; IEPA, 1978). Most of the problems are associated with nonpoint source pollution generated in the watershed of the Upper Sangamon River. The lake generally has high levels of total suspended solids and nitrate-N. Currently, the most pressing water quality problem in Lake Decatur is a high concentration of nitrate-N. Nitrate-N cannot be removed from finished drinking water through regular water purification processes.

The nitrate-N loads that eventually reach Lake Decatur originate in the watershed of the Upper Sangamon River that feeds into Lake Decatur (figure 1). To characterize and quantify the spatial and temporal distribution of nitrate-N yield in the Upper Sangamon, the City of Decatur has continued to support further watershed monitoring through a grant to the Illinois State Water Survey (ISWS). The purpose of the monitoring is to collect reliable hydrologic and water quality data throughout the watershed for use by city planners and resource managers to develop watershed management alternatives based on scientific data.

Physical Characteristics of the Lake Decatur Watershed

The Lake Decatur watershed lies in a climate region classified as humid continental, which is typical for central Illinois and is located in the Till Plains section of the Central Lowland physiographic province. The Till Plains section is generally characterized by broad till plains, which are mostly in a youthful erosion stage. The Upper Sangamon watershed is located on the Bloomington Ridged Plain, a subdivision of the Till Plains section, and is characterized by low broad morainic ridges with intervening wide stretches of relatively flat or gently undulating ground moraine. Demissie et al. (1996) provide a more detailed presentation of the watershed physical characteristics.

Hydrologic and Water Quality Monitoring

A watershed monitoring network was established to provide streamflow and water quality data for the Sangamon River and its tributaries upstream of Lake Decatur for the purpose of monitoring nitrate-N yields throughout the watershed. The network is comprised of eight stations (see figure 2) at which water stage is continuously recorded. These stages are then converted to water discharges using rating curves developed by periodically measuring water discharge. Water samples were collected and analyzed for nitrate-N on a weekly basis. The network has been collecting data for seven years (May 1993-April 2000). The annual data collection period starts in May and concludes in April of the following year. For example, the Year 1 study period began in May 1993 and ended in April 1994. This report presents the monthly data collected during Year 7 (May 1999-April 2000) and annual data for all seven years of data collection.

Hydrologic Monitoring

Continuous hydrologic monitoring of water levels at each station facilitates the calculation of continuous streamflow (discharge). This is essential for establishing the nitrate-N contribution to Lake Decatur from the Sangamon River and its tributaries. Table 1 presents the names of the streams, locations of the monitoring stations, and the corresponding drainage areas for the monitoring stations.

Precipitation

Precipitation data for selected locations around the watershed have been retrieved from the Midwestern Regional Climate Center database, which is operated by the ISWS. Figure 2 shows the locations of the six precipitation stations selected from within and around the Lake Decatur watershed: Gibson City, Rantoul, Urbana, Clinton, Monticello, and Decatur.

Table 1. Streamflow and Stage Monitoring Stations in the Lake Decatur Watershed

Station number	*Location*	*Drainage area (sq mi)*
101	Long/Big Creek at Twin Bridge Road	46.2
102	Friends Creek at Rte. 48 near Argenta	111.9
103	Goose Creek near DeLand	45.1
104	Camp Creek near White Heath	47.2
105	Sangamon River at Shively Bridge near Mahomet	368.2
106	Big Ditch near Fisher	38.2
111	Sangamon River at Monticello	543.4
112	Sangamon River at Fisher	245.6

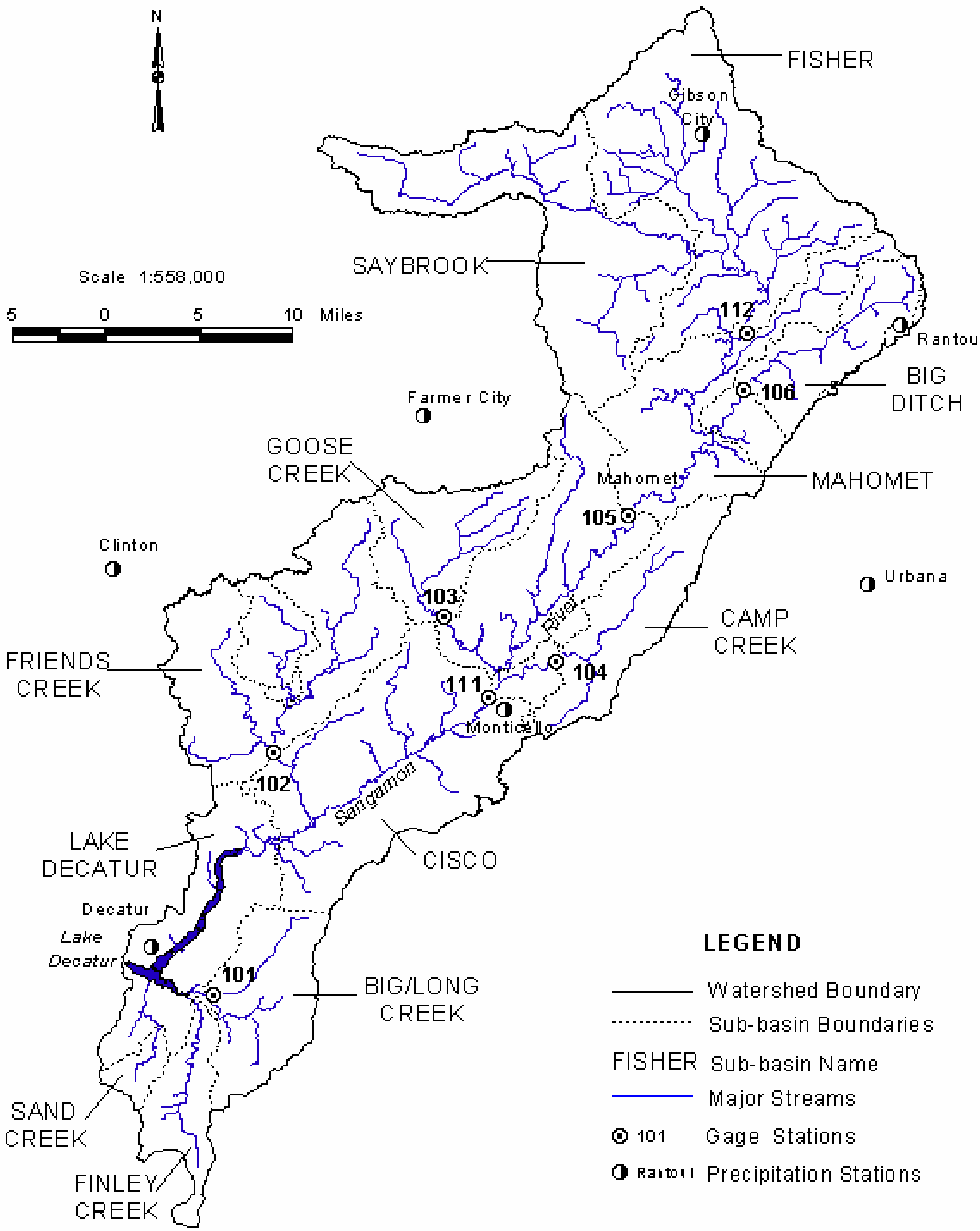

Figure 2. Stream and rain monitoring stations in the Lake Decatur watershed

The precipitation stations are listed in the approximate order in which they occur in the watershed when proceeding from headwaters to Lake Decatur. The Gibson City station is closest to the headwaters of the watershed and Decatur is the station that is nearest Lake Decatur. Table 2 presents the monthly and annual 30-year precipitation means for these stations.

Figure 3 presents the monthly precipitation in inches at all six stations for May 1999-April 2000. The highest monthly precipitation occurred at the Decatur station in June 1999 (7.6 inches). The lowest monthly rainfall was at the Gibson City station in November 1999 (0.25 inches). Precipitation at all stations in June 1999 was normal or much above the normal monthly 30-year means. The Decatur and Clinton station values were nearly twice the 30-year mean rainfall for the month of June. Values for at least three of the six stations were slightly or much above the monthly 30-year means in August 1999. Values at all stations were much below normal in November 1999. The average 30-year mean for all stations in November was 3.18 inches, while the average precipitation at all stations during November 1999 was 0.53 inches. Precipitation during May, July, September, October, November, and December 1999 and January, March, and April 2000 was below the monthly 30-year means for all stations.

Figure 4 presents the annual precipitation for the 7-year study period and the 30-year (1971-2000) long-term means at the six stations. As can be seen, precipitation during Year 1 (1993-1994) was much above the long-term mean. All stations, except Decatur, received precipitation 12-17 inches above the annual means during 1993. Years 2-5 varied between slightly below and near normal rainfall as compared to the 30-year long-term means. Year 6 was

Table 2. Monthly and Annual 30-Year (1971-2000) Mean Precipitation for Selected Stations, in inches

Month	*Gibson City*	*Rantoul*	*Urbana*	*Clinton*	*Monticello*	*Decatur*
May	4.07	3.99	4.80	4.28	4.41	4.50
June	4.04	3.97	4.21	4.06	3.97	3.79
July	3.74	3.95	4.67	4.34	4.57	4.60
August	3.91	3.50	4.37	3.93	4.15	4.10
September	2.83	3.03	3.22	2.81	2.79	2.98
October	2.66	2.89	2.81	3.16	2.77	2.76
November	3.01	2.80	3.45	3.28	3.38	3.16
December	2.54	2.38	2.76	2.85	2.86	2.86
January	1.60	1.94	1.89	1.84	1.98	2.11
February	1.59	1.76	2.01	1.93	1.93	1.94
March	2.99	2.96	3.21	3.43	3.12	3.25
April	3.30	3.84	3.65	4.03	3.75	3.63
Annual	36.28	37.01	41.05	39.94	39.66	39.68

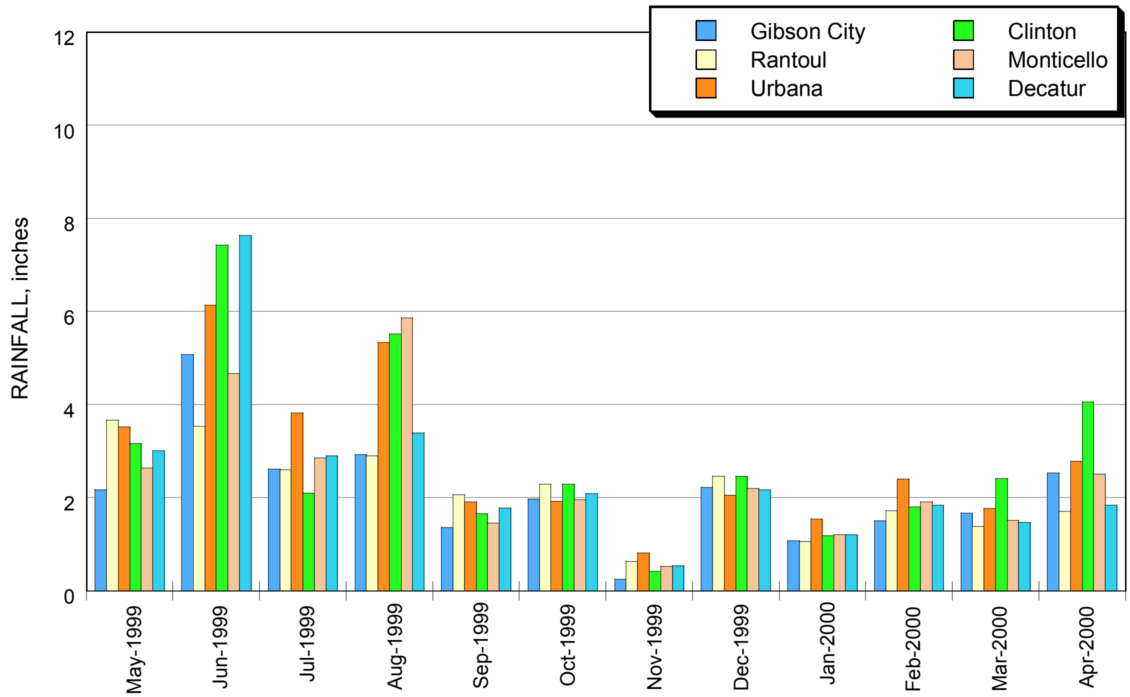

Figure 3. Monthly precipitation, May 1999 – April 2000

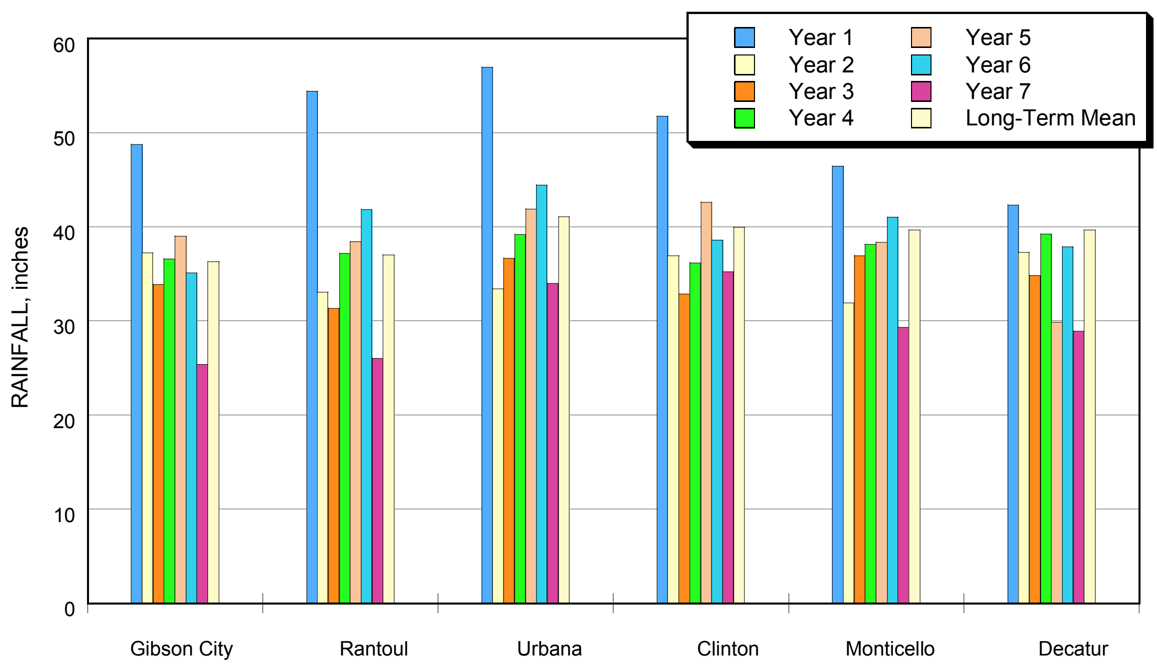

Figure 4. Annual precipitation during study period, May 1993 - April 2000

slightly above normal to near normal. All stations were below much below normal during Year 7 of monitoring, ranging from 4.7 inches (Clinton) to 10.9 inches (Rantoul and Gibson City) below the annual 30-year mean.

Streamflow

Streamflow data are derived from the stream stage record for each monitoring station. Stage data are converted to mean daily streamflow data by applying a stage-to-discharge rating curve. For each station, detailed field measurements of the stream discharge at a wide range of known stages are taken throughout the monitoring period. The discharge measurements and the corresponding stages are plotted or regressed to produce a stage-to-discharge rating curve or an equation, respectively. Ratings were developed for Long Creek at Twin Bridge Road (station 101), Friends Creek at Route 48 near Argenta (station 102), Goose Creek near DeLand (station 103), Camp Creek near White Heath (station 104), the Sangamon River at Shively Bridge near Mahomet (station 105), and Big Ditch near Fisher (station 106). During the monitoring period the rating curve may need to be recalibrated due to changes in the channel cross-section caused by extreme streamflow events or man-made modifications. In these cases, shifts are created in the curve and applied only to that portion of the stage record affected by the disturbance. Discharge data from the streamgaging stations on the Sangamon River at Route 136 near Fisher (station 112) and at Monticello (station 111) are obtained from from the U.S. Geological Survey (USGS).

Streamflow Data. Monthly streamflow data presented in this report are for the period May 1999-April 2000, and annual streamflow data are presented for the seven-year monitoring period.

Figures 5 and 6 show the monthly discharge data results for Year 7 of monitoring. Figure 5 shows the monthly discharge for the stations located on tributaries of the Sangamon River (stations 101, 102, 103, 104, and 106), and figure 6 shows the stations located on the Sangamon River (stations 111, 105, and 112). Discharges for the tributary streams were below 3,250 cubic feet per second (cfs) for most of the year except during June 1999. Friends Creek had the two highest discharges, 3,250 and 7,310 cfs in May and June 1999, respectively, and Goose Creek had the third highest monthly discharge of 2,700 cfs in June 1999. All stations had low flows below 1,000 cfs from July 1999 to April 2000, except Friends Creek for which the low flow duration was shorter (August 1999-January 2000).

Figure 6 shows the main Sangamon River stations with the same trends as the tributary stations for Year 7 of monitoring. Discharges were highest in May and June 1999. Monticello, which has the largest drainage area of the three river stations, had the highest flows for the year, 11,250 and 20,600 cfs during May and June 1999, respectively. All three stations had their highest monthly discharge of the study period during Year 7 in June 1999. The lowest discharges at all river stations ranged from near zero to less than 2,500 cfs (August 1999-January 2000).

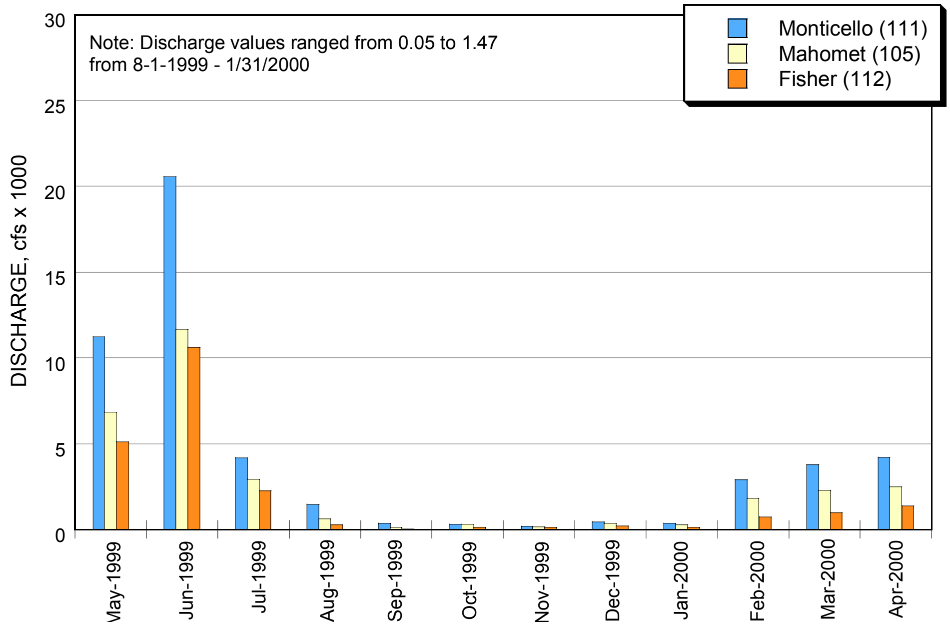

Figure 5. Monthly discharge for tributary stations, May 1999 – April 2000

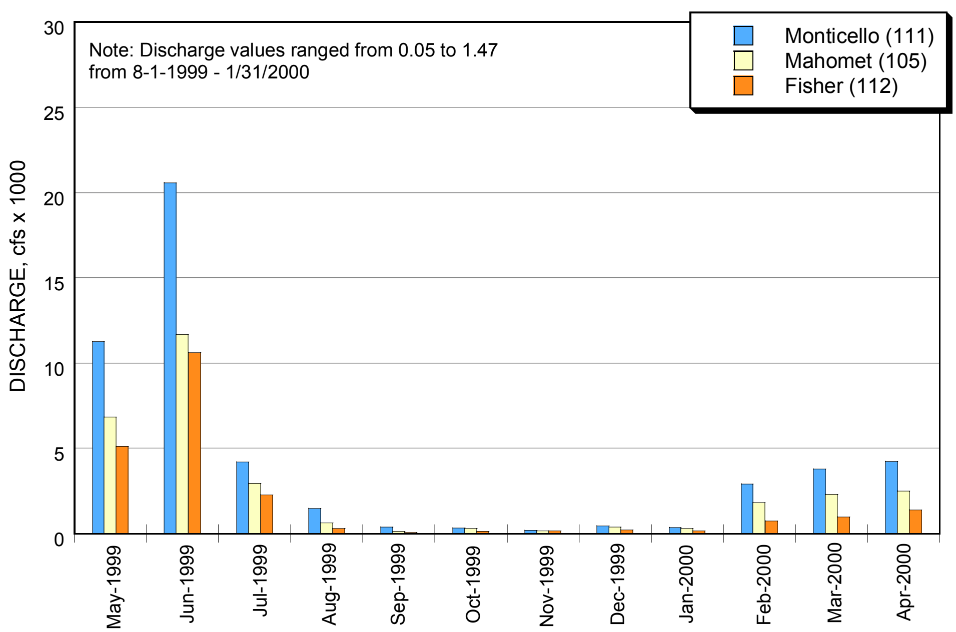

Figure 6. Monthly discharge for Sangamon River stations, May 2000 – April 2001

Discharge is converted to inches over the contributing watershed to compare streamflow to rainfall and to compare streamflow between basins. The monthly discharge is divided by the drainage area upstream of the streamgaging station to determine the streamflow in inches, which is termed "runoff." Figures 7 and 8 show the Year 7 monthly runoff in inches for the tributary and Sangamon River stations, respectively. The variation of runoff between stations is due to several factors, such as the spatial variability of rainfall events land cover, soil moisture, and pre-event flow conditions throughout the entire watershed.

Figure 7 shows that the highest monthly tributary runoff during Year 7 was from Friends Creek (2.4 inches) in June 1999. The next highest runoffs for the entire year also occurred in June 1999 at Goose Creek (2.2 inches) and Long Creek (2.1 inches). All tributary stations had greater than 0.5 inches of runoff during May and June 1999. The lowest runoff during the year (near zero) occurred from August 1999-January 2000 at all stations except Long Creek. Runoff at all tributary stations was at or less than 1 inch during the last 10 months of the period (July 1999-April 2000). Runoff exceeded 1 inch during June 1999 at four of the five stations.

Figure 8 shows the monthly runoff for the three main Sangamon River stations. All three stations had runoffs greater than 1 inch during June 1999, ranging from approximately 1.2 to 1.6 inches. Two months of the year (May and June 1999) had runoffs greater than 0.5 inch. Runoff was nearly zero during August 1999-January 2000 and below 0.25 inch during August 1999-April 2000.

Figure 9 presents annual runoff during Years 1-7 of monitoring at the tributary and Sangamon River stations. The long-term average annual runoff (1908-2000) over the Lake Decatur watershed, as measured at the Monticello station, is 10.3 inches (USGS, 2001). Figure 9a shows annual runoff at the tributary stations. All five tributary station annual runoff values were averaged together for Years 1-7 of monitoring and are as follows: 20.3, 6.0, 8.5, 11.4, 10.5, 15.3 and 4.2 inches, respectively. Runoffs during Year 1 were extremely high, while they were quite low during Year 2. Runoffs increased from Years 2-6, while Year 7 was the lowest of the study period. The figure shows some variability in runoffs between tributary stations, as well as between monitoring years. Five of the six tributary stations had their highest runoffs in Year 1, and the second highest runoffs occurred during Year 6. Long Creek is the only station at which the highest annual runoff for the study period occurred during Year 6. Runoff during Year 7 was the lowest recorded during the study period for three of the five stations. The lowest runoffs for the other two stations, Long Creek and Friends Creek, occurred in Year 2. It should be noted that Friends Creek received water from the DeWitt County well-fields from November 1999-February 2000 to augment the drinking water supply in Lake Decatur due to below average rainfall during the summer and fall of 1999. This additional flow volume accounted for less than 5 percent of the annual runoff at Friends Creek.

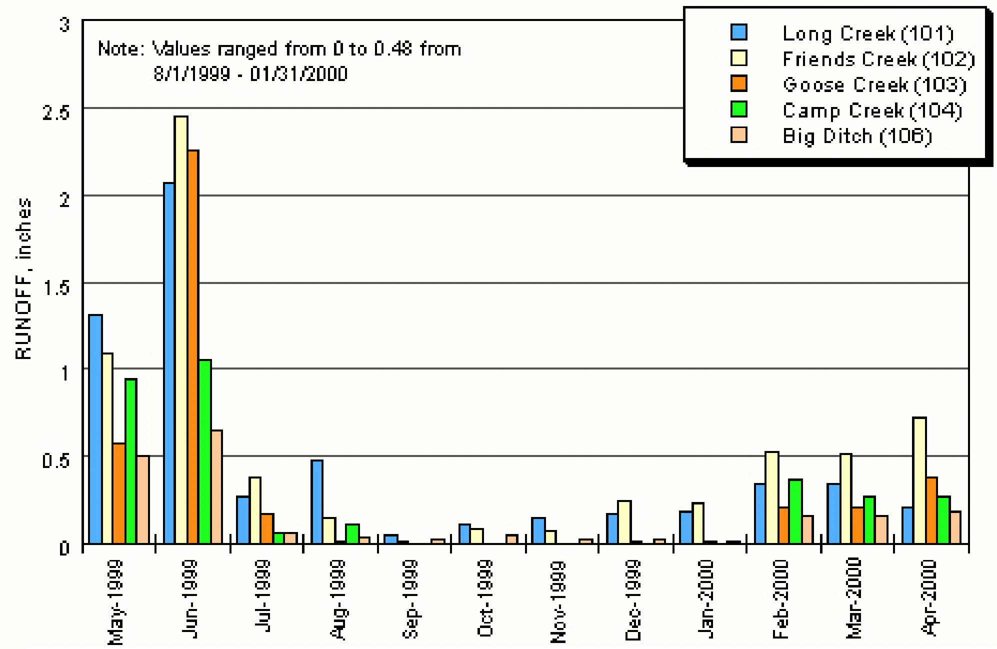

Figure 7. Monthly runoff for tributary stations, May 1999 - April 2000

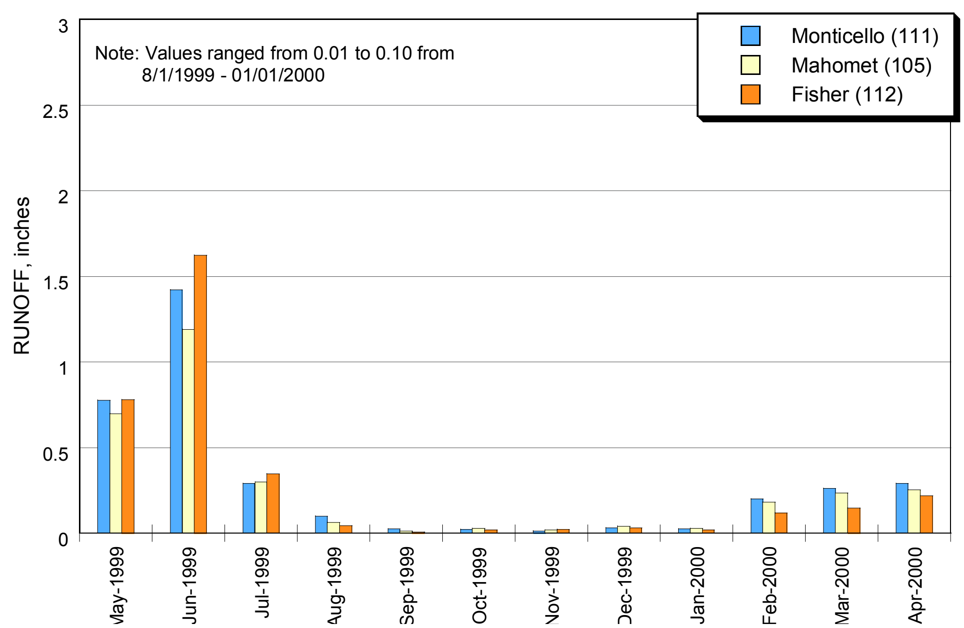

Figure 8. Monthly runoff for Sangamon River stations, May 2000 – April 2001

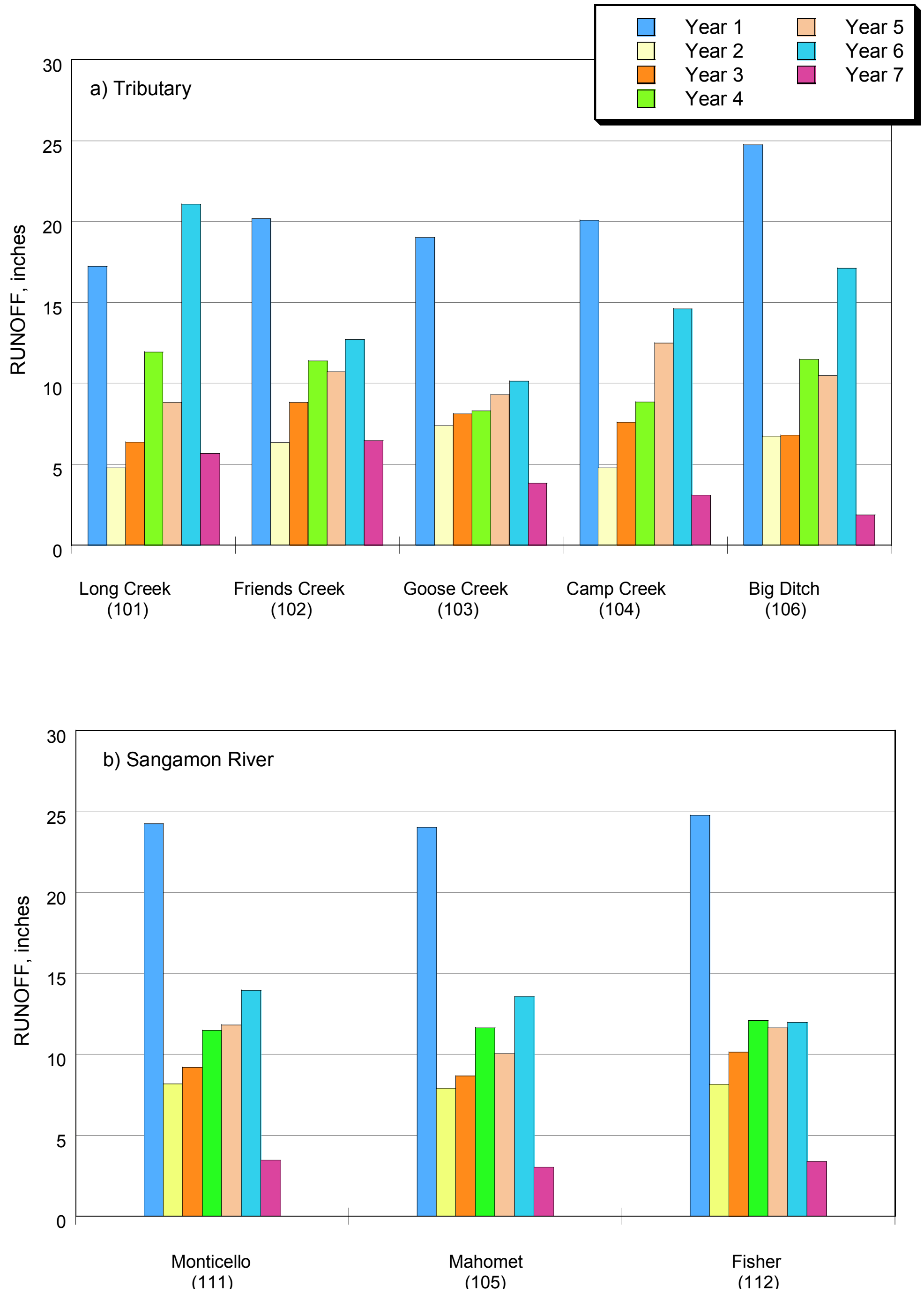

Figure 9. Annual runoff for tributary and Sangamon River stations during study period, May 1993 – April 2000

Year 7 runoffs from river stations at Monticello, Mahomet, and Fisher were 3.5, 3.3, and 3.4 inches, respectively (figure 9b). It should be noted that the annual runoff values for Fisher and Monticello during Year 6 of monitoring (see figure 9b) are slightly different in this report than in Keefer and Demissie (2000). The USGS operates these stations, and the data retrieved for the earlier publication were available only on a provisional basis. However, those data have been finalized by the USGS and adjusted accordingly in this report. These three stations reflect the same pattern as the tributary runoffs. Year 1 had the highest recorded annual runoff for all three river stations. The average of the three river station runoffs in Year 1 is 24.4 inches. The annual runoffs decreased during Year 2 but gradually increased through Year 6. Year 7 was the lowest recorded in the study period with a station average of 3.4 inches.

Nitrate-N Monitoring

Nitrate-N was sampled at each of the eight monitoring stations for all seven years. During Years 1 and 2 (May 1993-April 1995), two additional nitrogen parameters were collected: ammonium-nitrogen (ammonium-N) and total Kjeldahl nitrogen (TKN). Demissie et al. (1996) reported ammonium-N and TKN concentrations for the eight monitoring stations during Years 1 and 2.

Nitrate-N Concentrations

Figures 10-11 present Year 7 monthly nitrate-N concentration data at the five tributary and three Sangamon River monitoring stations. Keefer and Demissie (2000) present annual nitrate-N concentration data for Years 1-6 of the monitoring study.

Figure 10 shows the seasonal variation of nitrate-N concentrations observed in the previous years (Demissie et al., 1996; Keefer et al., 1997; Keefer and Demissie, 1999, 2000). Concentrations in May and June 1999 predominantly ranged from 11 to 18 mg/l. Nitrate-N concentrations for all tributary stations decreased through the month of July 1999, to below 3 mg/l. Concentrations ranged from 0.1 to 5 mg/l through November 1999. Concentrations at most stations slowly increased from December 1999 through March 2000 with some variability due to locally concentrated rainfall. Long Creek and Big Ditch concentrations did not increase until February 2000. Concentrations during the latter half of April 2000 ranged from approximately 7 to 12 mg/l. The highest nitrate-N concentration, 17.97 mg/l, occurred at the Goose Creek station in June 1999. The next highest concentrations were also in June 1999 at Camp Creek, 17.50 mg/l, and Big Ditch, 16.88 mg/l. The lowest concentration, 0.11 mg/l, occurred at all stations except Friends Creek in September 1999.

Figure 11 shows the nitrate-N concentration data for the three stations on the Sangamon River during Year 7 of monitoring. The seasonal variation in concentration throughout the year also follows the pattern seen in past data and similar to the pattern for tributary stations

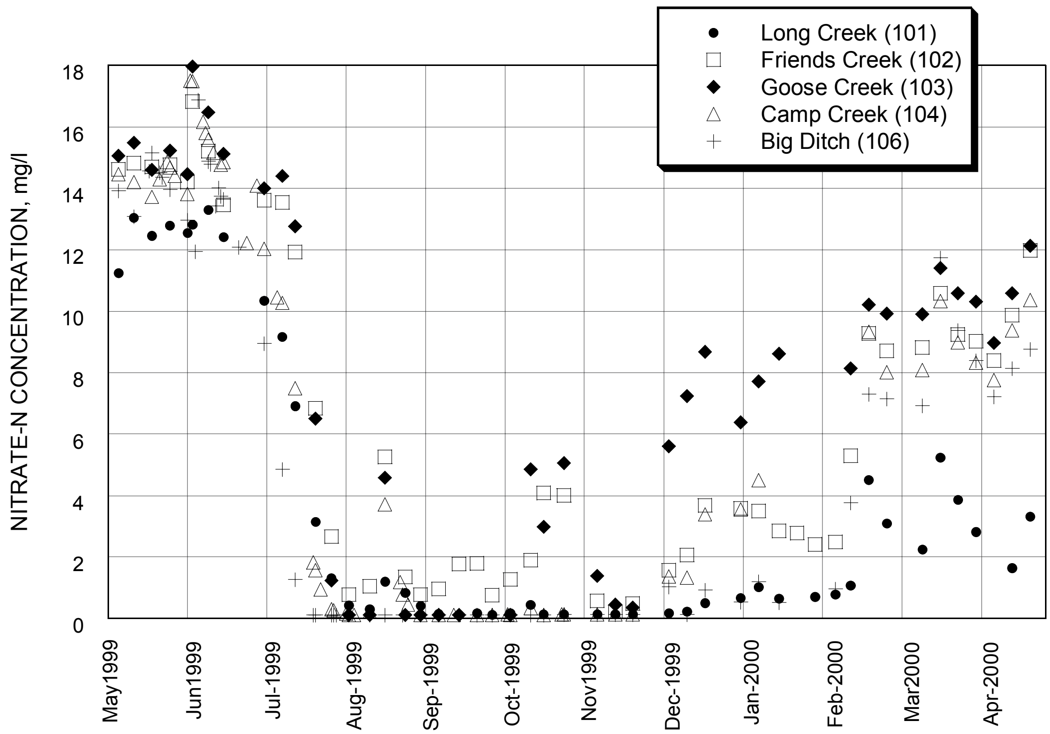

Figure 10. Nitrate-N concentrations for tributary stations, May 1998 – April 2000

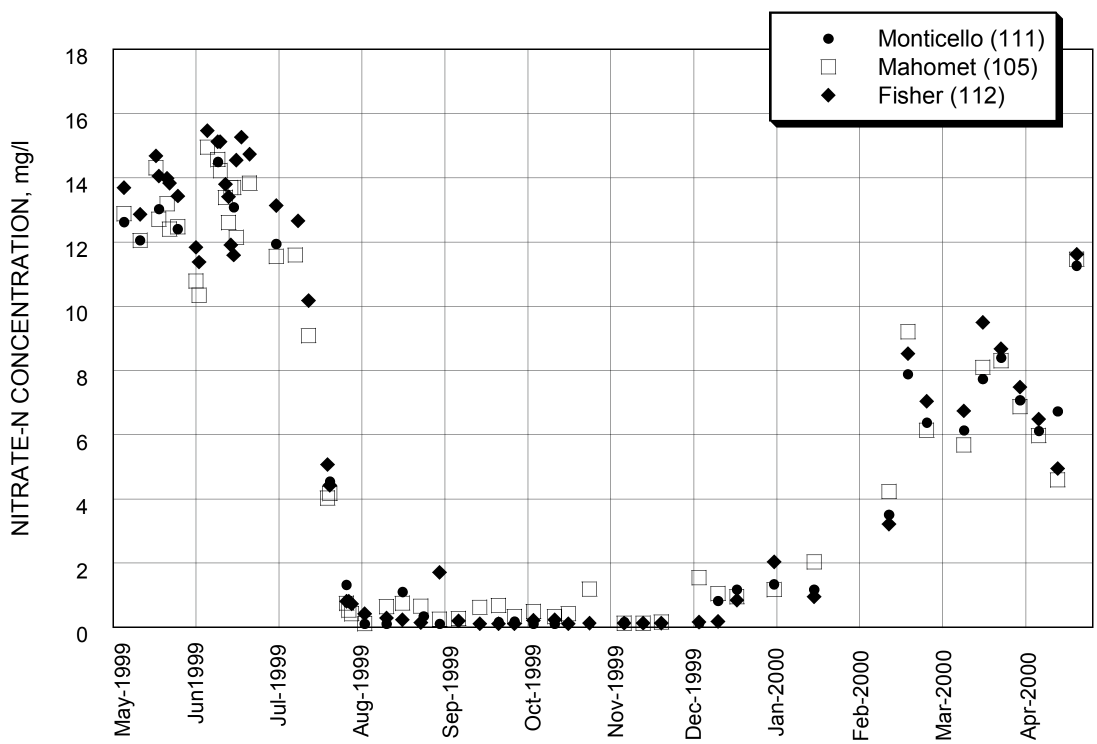

Figure 11. Nitrate-N concentrations for Sangamon River stations, May 1999 - April 2000

discussed above. Nitrate-N concentrations ranged from approximately 10 to 15.5 mg/l during May 1999 and decreased to less than 1 mg/l by August 1999. Concentrations remained low (2 mg/l or less) through January 2000. Concentrations rebounded from mid-February through mid-March 2000, ranging from approximately 6 to 10 mg/l. Concentrations decreased to below 7 mg/l in mid-April 2000 and then increased to approximately 11.5 mg/l. All three stations had their highest concentrations of the year in June 1999. Fisher had the highest nitrate-N concentration of 15.47 mg/l; Mahomet and Monticello had 14.96 and 14.51 mg/l, respectively. Overall, peak nitrate-N concentrations were 1-2 mg/l less than concentrations reported for the tributary stations, as shown in figure 10.

Figure 12 shows nitrate-N concentration data for Lake Decatur, provided by the City of Decatur for use in this study. Figure 12a shows the nitrate-N concentrations for the north and south water treatment plant (WTP) intakes in Lake Decatur during Year 7 of watershed monitoring. The lake water shows the same patterns in nitrate-N concentrations exhibited in the tributary and river stations. Concentrations in the lake are lower than those at the river stations, just as concentrations at the river stations are lower than those at the tributary stations. In the lake, nitrate-N concentrations ranged from approximately 8 to 12 mg/l during May and June 1999. Concentrations decreased through August 1999 to below 2.0 mg/l. Concentrations from September 1999 through late January 2000 ranged from 0.3 to slightly greater than 2 mg/l. Nitrate-N concentrations increased steeply at the north WTP in late February to 7.6 mg/l, then oscillated between 3.5 and 7.8 mg/l through April 2000. The nitrate-N concentrations at the south WTP began increasing in March 2000, slowly and with some variability, through April 2000. Concentrations stayed below 2.7 mg/l during this period. The highest observed concentrations, 11.7 and 11.5 mg/l, occurred in May and June 1999 at the south WTP and north WTP, respectively. The lowest concentrations for both treatment plants occurred during October and November 1999.

Figure 12b shows the variability of the annual nitrate-N concentrations in Lake Decatur. The minimum contamination limit (MCL) for nitrate-N in drinking water is 10 mg/l and is indicated on the figure. Data retrieved from the City of Decatur at the south WTP from 1967-2000 show that the annual maximum nitrate-N concentrations ranged from 7.6 to 16 mg/l, with the 16 mg/l readings occurring in 1981 and 1989. The next highest concentration, 13.0 mg/l, occurred in 1982, 1984, 1985, and 1990. The average of the annual maximum nitrate-N concentration was 10.7 mg/l. The annual mean nitrate-N concentrations ranged from 2.2 to 8.8 mg/l in 1994 and 1981, respectively. The average of the annual mean concentrations was 5.1 mg/l. The annual minimum nitrate-N concentrations ranged from 0.1 to 2.4 mg/l. The 2.4 mg/l reading occurred in 1993, and the 0.1 mg/l reading occurred many times throughout this period, with the average of the annual minimum concentration being 0.5 mg/l.

Figures 13-15 show the maximum, mean, and minimum concentrations of nitrate-N sampled at the five tributary and three river stations in the watershed and the north and south WTPs during the seven-year study period. As seen in figure 13a, Goose Creek had the highest

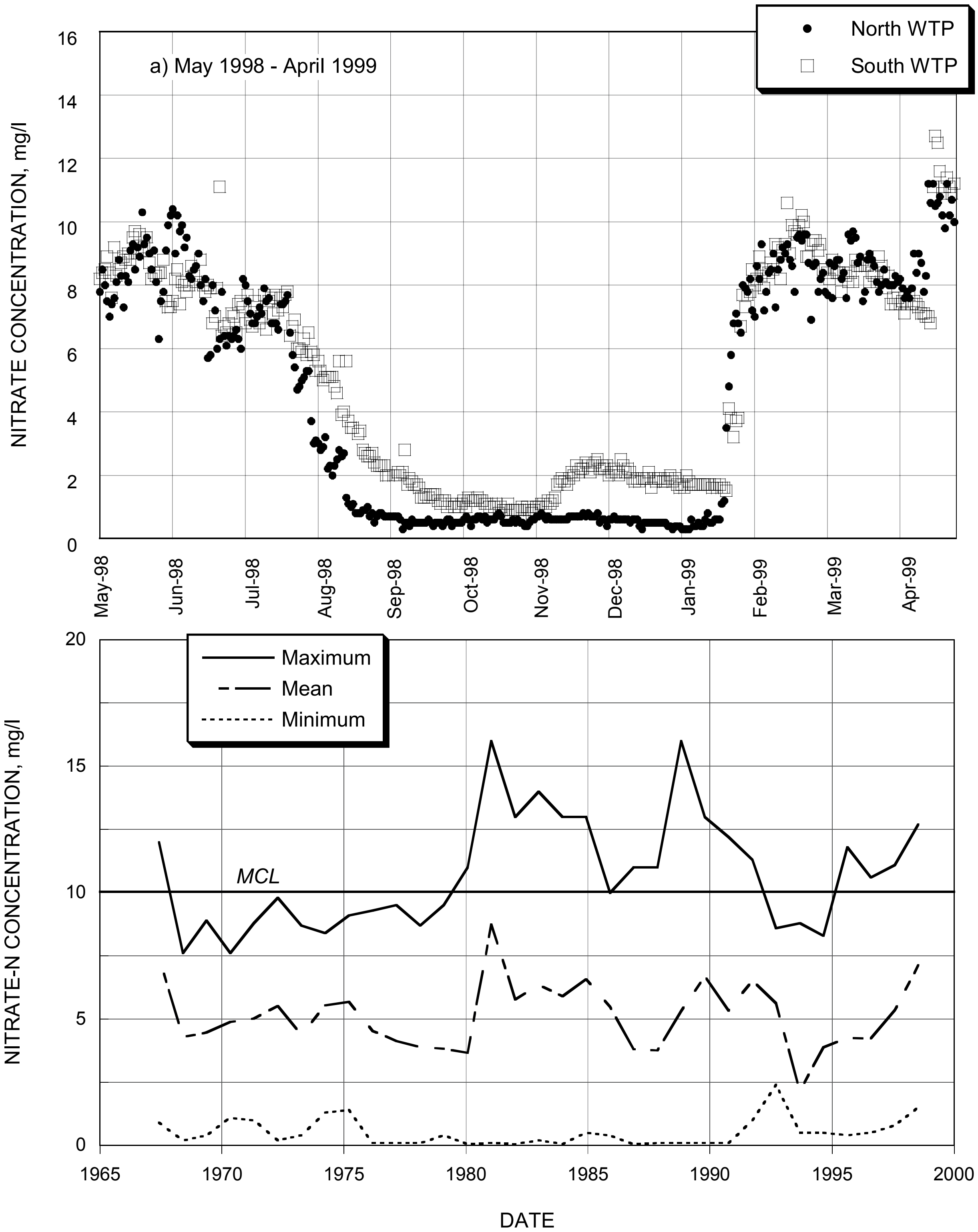

Figure 12. Nitrate-N concentrations for Lake Decatur: a) daily values from May 1998 to April 1999 for the north and south water treatment plants, and b) annual maximum, mean, and minimum concentrations from 1967-1999 for the south water treatment plant

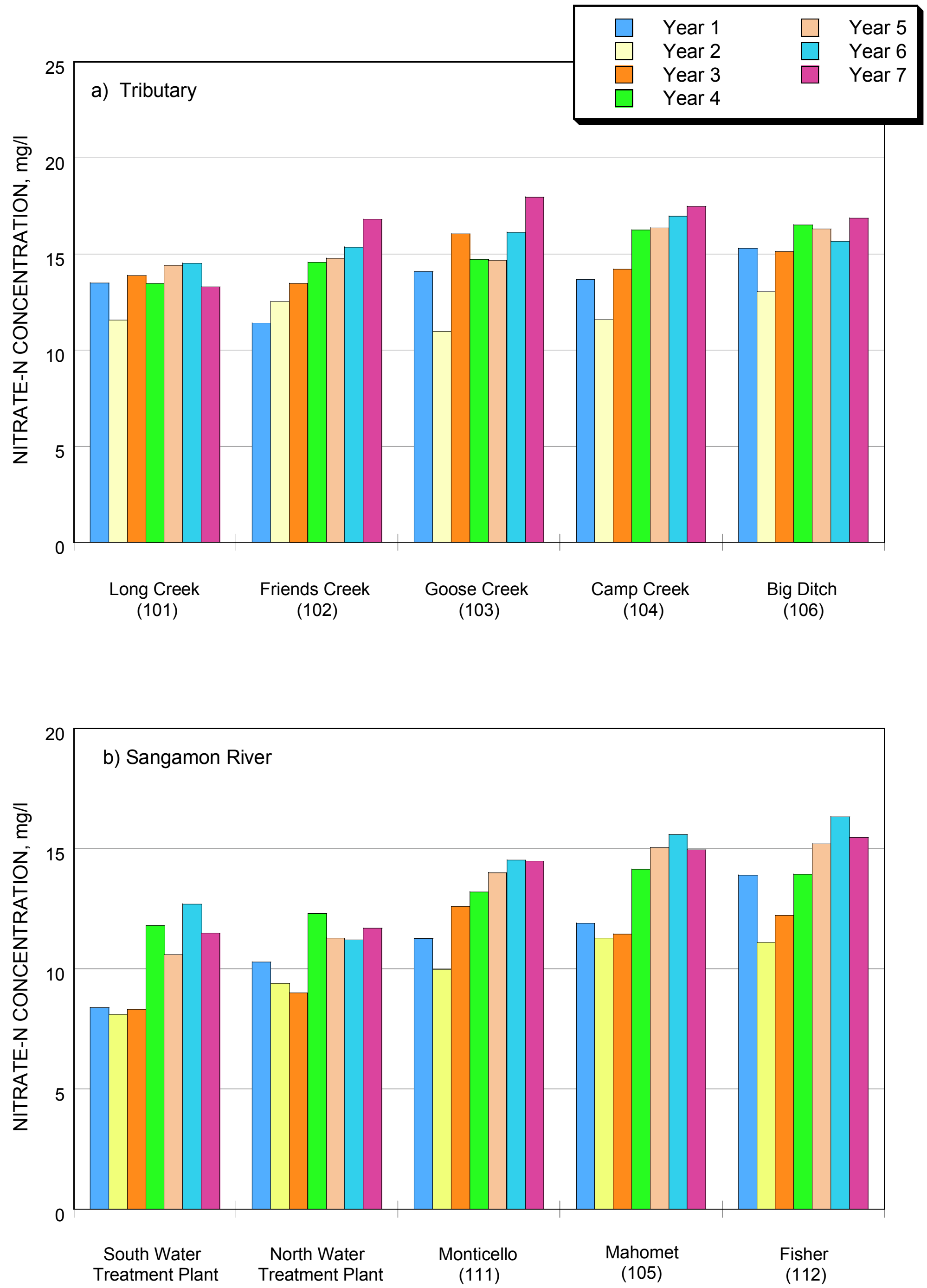

Figure 13. Maximum nitrate-N concentrations during study period, May 1993 - April 2000

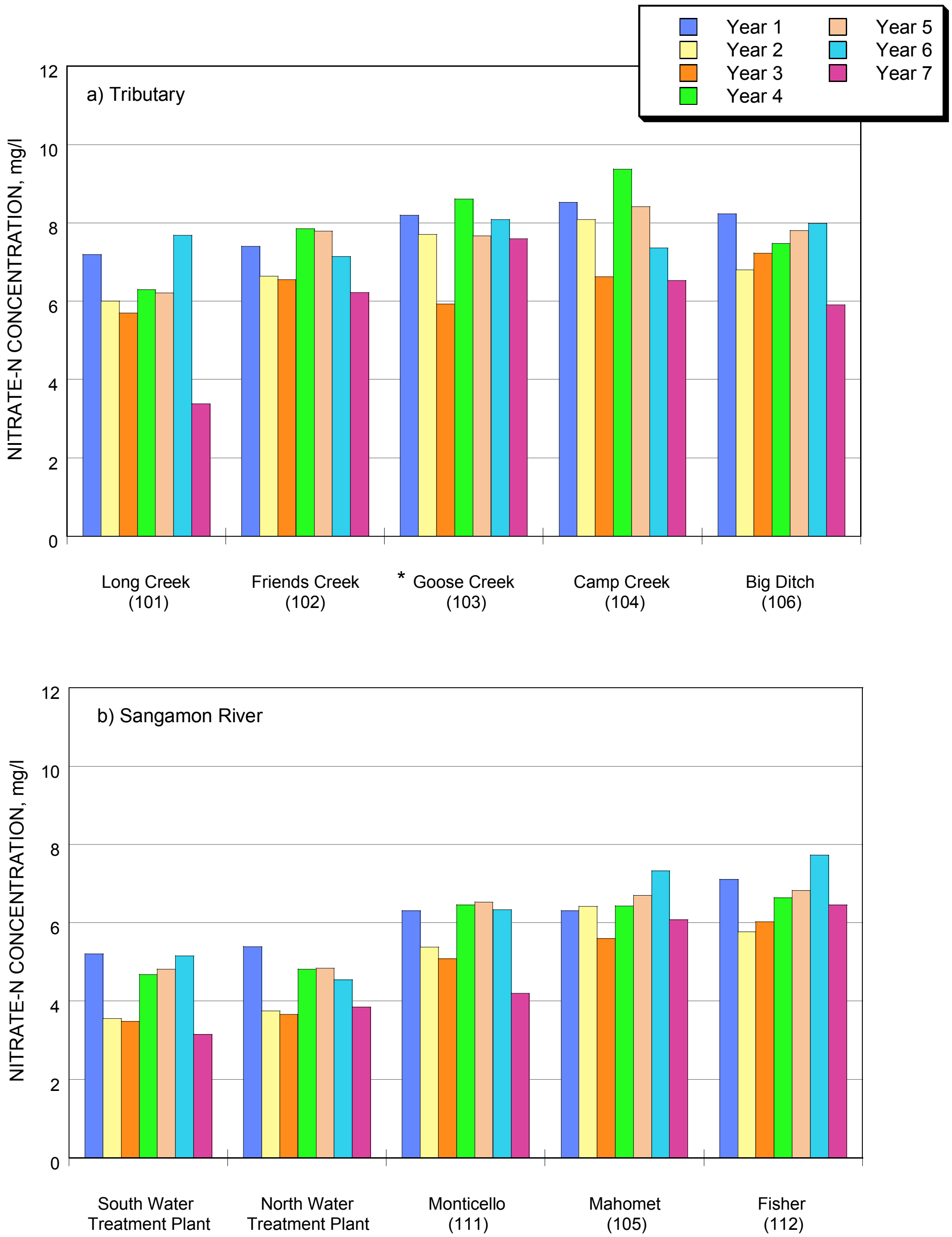

Figure 14. Mean nitrate-N concentrations during study period, May 1993 – April 2000

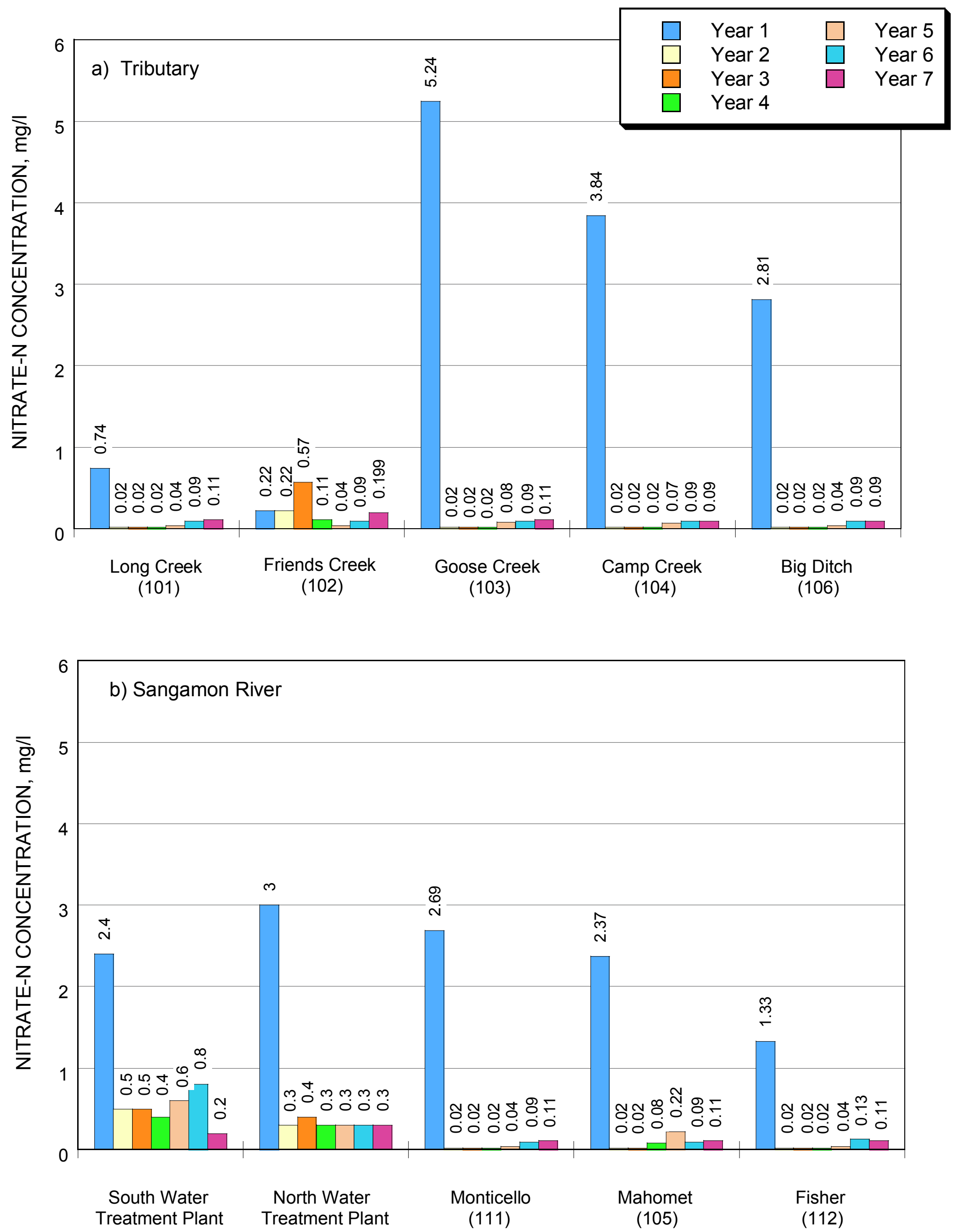

Figure 15. Minimum nitrate-N concentrations during study period, May 1993 - April 2000

nitrate-N reading (17.97 mg/l) during Year 7 of monitoring, with the next highest reading at Camp Creek (17.5 mg/l) also during Year 7. The lowest maximum concentration was in Year 2 at Goose Creek (10.97 mg/l). Figure 13b shows that, for the three river stations, Fisher had the highest maximum nitrate-N concentration (16.32 mg/l), during Year 6 and Monticello had the lowest maximum concentration (10 mg/l) during Year 2. During Year 7 all stations, except Long Creek, established new maximum nitrate-N concentrations for the entire study period. However, the study period maximum concentrations were not as high as those measured by the City of Decatur for the period of 1967-2000. A comparison of Figures 12b and 13b shows that for the south WTP, the maximum nitrate-N values in the 1980s were much higher than in Year 7 of monitoring.

Figure 14 shows the mean nitrate-N concentrations during the seven years of monitoring. The average annual nitrate-N concentrations for all tributary stations during Years 1-7 monitoring are 7.9, 7.0, 6.4, 7.9, 7.6, 7.6, and 5.9 mg/l, respectively. The average annual concentrations for all the river stations are 6.6, 5.8, 5.6, 6.5, 6.7, 7.1 and 5.6 mg/l, respectively. The average annual nitrate-N concentrations from the north and south WTPs in Lake Decatur during Years 1-7 are 5.3, 3.6, 3.6, 4.8, 4.8, 4.8 and 3.5, respectively. Thus the average nitrate-N concentrations decrease as water proceeds from the tributaries to the Sangamon River and finally to Lake Decatur. Figure 15 shows the minimum nitrate-N concentrations measured. During Year 7 of monitoring, no station exceeded 0.20 mg/l of nitrate-N concentration. The highest minimum concentrations occurred during Year 1 of monitoring (May 1993-April 1994) for all stations except Friends Creek.

Nitrate-N Loads

The calculation of nitrate-N loads is necessary to determine the contribution of different areas over time to the total nitrate-N input into the lake. Nitrate-N concentrations are used for regulatory purposes but are not sufficient to determine the relative contribution of nitrate-N from different areas over time. Using discharge and concentration data collected from each station, nitrate-N loads are calculated as the product of nitrate-N concentration and discharge, converted to the desired units (pounds or tons) by using the appropriate conversion factors, over a certain period of time. The total loads are then normalized per unit area to determine the relative contribution of different areas in the Lake Decatur watershed. For example, a tributary may have some of the highest nitrate-N concentrations, but if it is one of the smallest sub-watersheds, its total contribution of nitrate-N could be small as compared to other larger sub-watersheds. Figures 16 and 17 present monthly nitrate-N loads (lb/acre/month) during the Year 7 for all eight stations.

Figure 16 shows the monthly nitrate-N loads in pounds per acre (lb/acre) for the tributary stations during Year 7 of monitoring: the mean of the monthly loads for all five stations for the year was one lb/acre. Monthly nitrate-N loads were highest at Friends Creek and Goose Creek in June 1999 (8.2 and 8.1 lb/acre respectively) and at Goose Creek in May 1999 (8.1 lb/acre). All

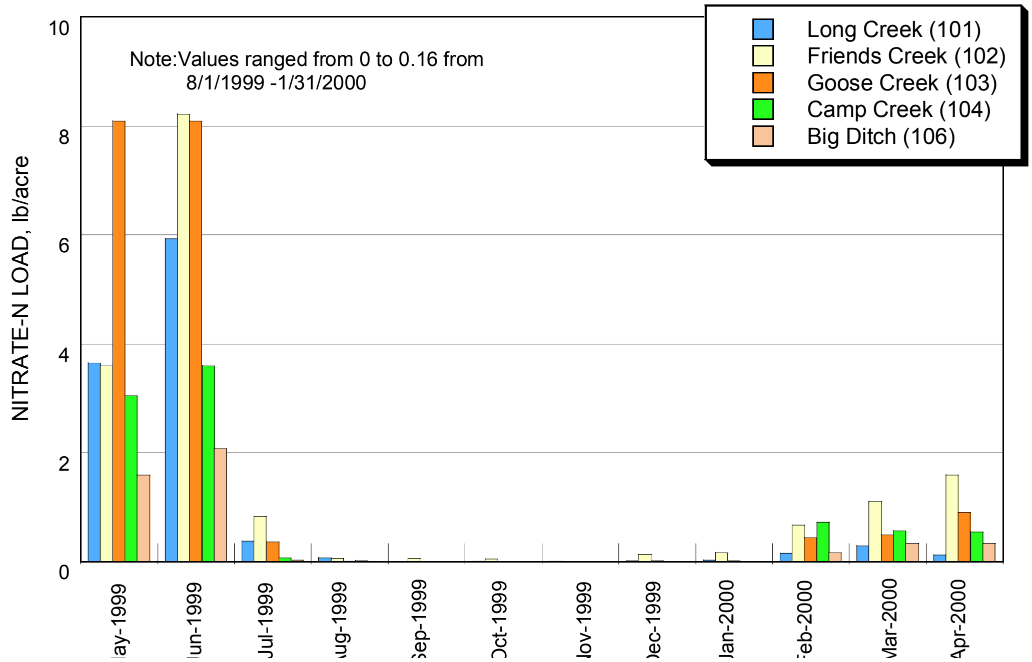

Figure 16. Monthly nitrate-N load for tributary stations, May 1998 – April 1999

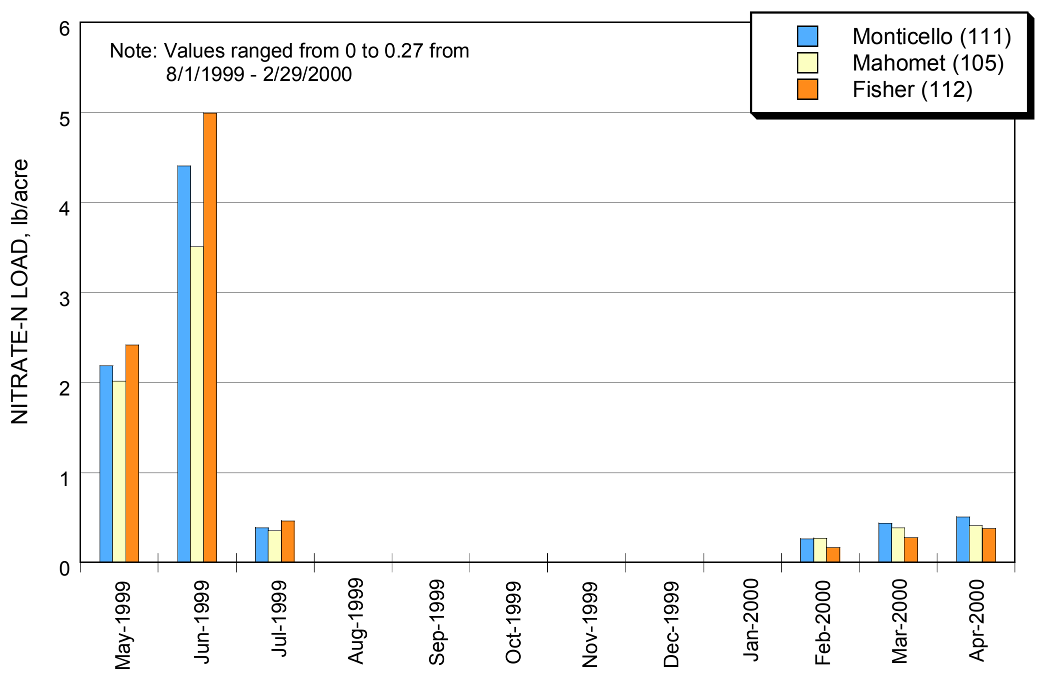

Figure 17. Monthly nitrate-N load for Sangamon River stations, May 1998 – April 1999

tributary stations had nearly zero nitrate-N loads from August 1999 to January 2000. Nitrate-N loads were highest in June 1999 for all tributary stations.

Figure 17 presents the monthly nitrate-N loads for the three Sangamon River stations, where the mean of the monthly loads for all three stations for Year 7 was 0.7 lb/acre. The highest monthly load occurred at the Fisher station in June 1999 (5.0 lb/acre). Nitrate-N loads were near zero at all river stations (August 1999-January 2000).

Annual Nitrate-N Loads. Table 3 and figure 18 summarize the annual nitrate-N loads during the seven-year study period at all stations monitored. The tributary and main river results are presented separately for comparison purposes.

For the tributary stations, the annual nitrate-N load for Year 7 (Figure 18a) ranges from a low of 5 lb/acre for Big Ditch to a high of 16 lb/acre for Friends Creek. The other tributary stations (Long Creek, Goose Creek, and Camp Creek) generated loads ranging from 9 to 12 lb/acre/yr during Year 7. The seven-year mean annual load for all the tributary stations was 24 lb/acre. It was observed that, on the average over the entire seven-year study period, Big Creek had slightly higher nitrate-N load per unit area, and Long Creek and Goose Creek had slightly lower nitrate-N load per unit area. Figure 18b presents the annual nitrate-N loads for the three Sangamon River stations. During Year 7 of monitoring, the mean annual load for the main river stations was 8 lb/acre, and annual loads ranged from a low of 7 lb/acre at the Mahomet station to a high of 9 lb/acre at the Monticello station.

Table 3. Annual Nitrate-N Loads in the Sangamon River Basin

Station	*Drainage Area (acres)*	*Annual nitrate-N load (lb/acre)*							
		Year 1	*Year 2*	*Year 3*	*Year 4*	*Year 5*	*Year 6*	*Year 7*	*Mean*
Tributary stations									
Long Creek (101)	29,539	28	9	13	25	18	50	11	22
Friends Creek (102)	71,647	35	12	20	28	25	35	16	24
Goose Creek (103)	28,892	36	16	18	20	21	29	12	22
Camp Creek (104)	30,242	39	11	18	24	28	36	9	24
Big Ditch (106)	24,421	49	15	17	26	27	47	5	27
Sangamon River stations									
Fisher (112)	157,177	40	15	21	26	27	33	8	24
Mahomet (105)	235,653	37	14	17	25	22	32	7	22
Monticello (111)	347,747	34	14	16	24	25	33	8	22
Annual yield into Lake Decatur*	586,868	32	12	16	25	23	38	10	22

*Area-weighted using Long Creek, Friends Creek, and Monticello.

Table 3 presents the nitrate-N loads from the entire watershed into Lake Decatur during the seven-year study period. The seven-year mean annual nitrate-N loads from the tributary and river stations are 24 and 23 lb/acre, respectively. Year 6 had the highest load (37 lb/acre), and Year 7 had the lowest load (10 lb/acre). The total nitrate-N delivered into Lake Decatur was determined by using the Long Creek, Friends Creek, and Monticello station data to calculate area-weighted mean annual yields. The stations of Goose Creek, Camp Creek, Big Ditch, Fisher, and Mahomet were not considered in the calculation because they are all within the Monticello station watershed. Consequently, the mean annual nitrate-N delivered to Lake Decatur for the seven-year study period is 22 lb/acre, which is equal to approximately 6,500 tons per year.

Based on the data, it can be concluded that the unit nitrate-N loads are relatively uniform over the entire watershed but tend to be slightly higher at the tributary streams in the upper Sangamon River watershed than at the main stem stations closer to the lake. On the Sangamon River, the nitrate-N load is generally highest at Fisher and lowest at Monticello. Based on the load data calculated for the last seven years, it can be concluded that the nitrate-N loads vary from monitoring station to station and can change significantly from year to year.

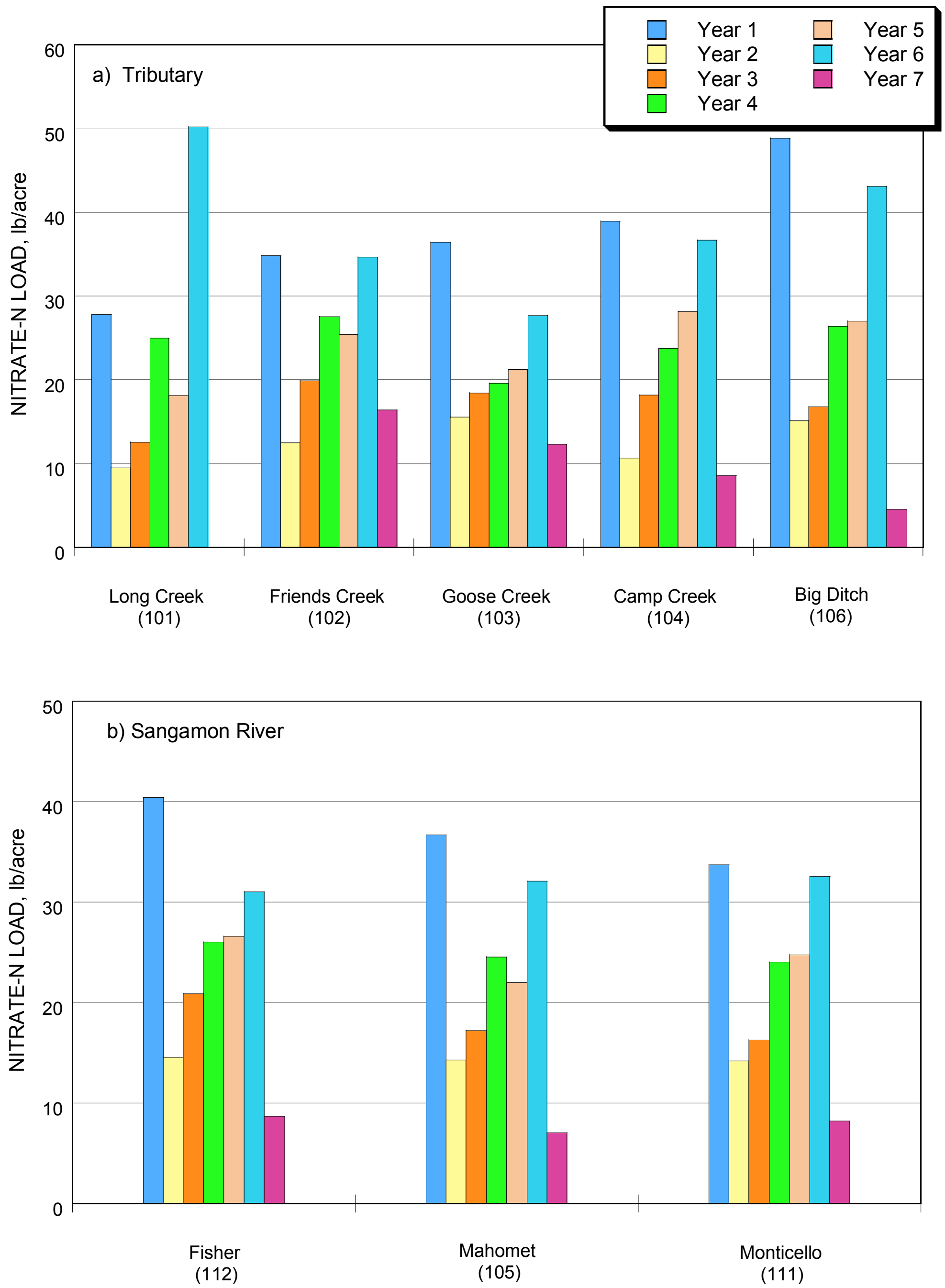

Figure 18. Annual nitrate-N load for tributary and Sangamon River stations during study period, May 1993 – April 2000

Summary and Discussion

Some important observations can be made from the data collected over the seven-year monitoring period (May 1993-April 2000).

- Streamflow and nitrate-N concentrations decreased significantly from Year 1 (May 1993-April 1994) to Year 2 (May 1994-April 1995), rebounded for most stations through Year 6, and decreased again in Year 7 (May 1999-April 2000). Year 2, which followed the wettest monitoring year (May 1993-April 1994), had the second lowest flow and lowest concentrations during the entire study period. Year 7, which followed the second wettest monitoring year (May 1998-April 1999), had the lowest flows and some of the highest concentrations during the study period.

  Table 4 presents the average rainfall, average annual streamflow, flow-weighted nitrate-N concentrations, and annual nitrate-N loads for the Sangamon River at Monticello (543.4-square-mile drainage area, representing approximately 60 percent of the Lake Decatur watershed) for the monitoring period. The flow-weighted nitrate-N concentration was determined by summing the product of the monthly average nitrate-N concentrations and the monthly total streamflow then dividing that summation by the total annual streamflow.

  As can be seen from table 4 and figure 19 for the Monticello station, the first monitoring year was an extremely wet hydrologic period with the highest annual mean streamflow. The 961 cfs streamflow rate was surpassed only twice in the nearly 90-year period of record for this station (Demissie et al., 1996). Year 2 was significantly drier than Year 1. During the next four monitoring years, the streamflow gradually increased from 323 cfs, well below the long-term mean of 417 cfs, to 556 cfs, well above the long-term mean. Year 7 (May 1999-April 2000) was the driest year observed for the entire study period. The streamflow, 138 cfs, was a significant decrease from the 556 cfs during Year 6. Year 7 (May 1999-April 2000) was the 9th lowest annual mean streamflow in the period of record (1909-2000). Figure 11 shows the monthly nitrate-N concentrations at the Monticello station for Year 7. Data for the entire monitoring period are summarized by the flow-weighted annual concentrations in table 4 and figure 19 and show an increase in flow-weighted nitrate-N concentrations during the study period at the Monticello station from 6.17 to 10.57 mg/l.
- As a result of the decrease in streamflow, nitrate-N loads significantly dropped from Year 1 to Year 2. Due to the increases in both streamflow and nitrate-N concentrations, nitrate-N loads have increased from Year 2 through Year 6. Because of a significant decrease in streamflow in Year 7, nitrate-N loads have dropped significantly in Year 7 (as seen in table 3 and figure 18).
- The highest nitrate-N concentrations during the seven-year monitoring period were observed in Year 6 and Year 7. Concentrations were highest at all three river stations and one tributary station (Long Creek) in Year 6. Concentrations were highest at the remaining tributary stations in Year 7.

Table 4. Summary of Rainfall, Flow, Flow-Weighted Nitrate-N Concentration and Load for the Sangamon River at Monticello for the Duration of the Monitoring Period

Monitoring Year (May – April)	*Average Rainfall (inches)*	*Average streamflow (cfs)*	*Flow-weighted Nitrate-N concentration (mg/l)*	*Nitrate-N load (lb/acre/yr)*
1993-1994	51.7	961	6.17	34
1994-1995	34.5	323	7.72	14
1995-1996	34.3	362	7.88	16
1996-1997	37.4	460	9.29	24
1997-1998	40.0	469	9.32	25
1998-1999	40.3	556	10.39	33
1999-2000	30.0	138	10.57	8
Long-term mean*	-	417	-	-

*Water Year 1908-2000

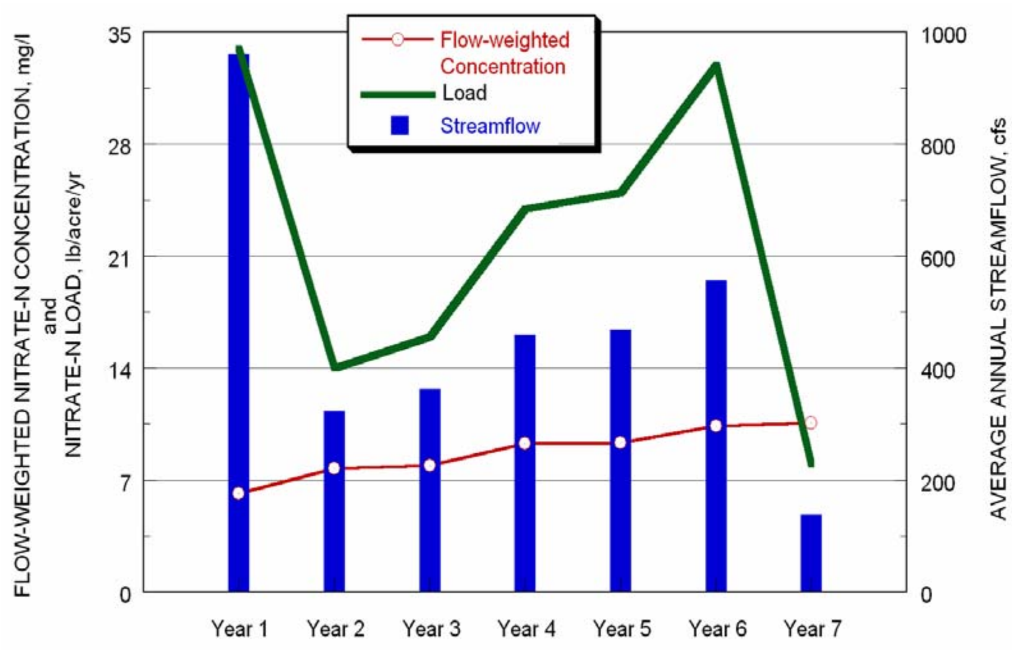

Figure 19. Mean annual streamflows, load and flow-weighted mean nitrate-N concentrations on the Sangamon River at Monticello during study period, May 1993 – April 2000

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