Chapter 5. Water Quality Analyses

Water quality data collected in the Fox River watershed during 1998–2002 by various agencies were analyzed. The evaluation focused on the following constituents: nutrients (nitrogen and phosphorus), dissolved oxygen (DO), pH, suspended solids, fecal coliform, algae and biomass, and selected heavy metals (those for which the Illinois Environmental Protection Agency or IEPA specified water quality standards).

All data stored in the FoxDB were used in the following analyses. Storing the data in the FoxDB provides consistent and efficient data access. Data from different sources can be easily compared, combined, or separated, as desired. The Fox River Study Group (FRSG) requested evaluation of their monitoring data (May 2002–December 2002) while this study was in progress. Appendix 5 includes the interim report prepared for the FRSG in March 2003.

The discussion for each constituent includes: 1) a summary of available data and data limitations; 2) observations of seasonal effects or trends; 3) longitudinal changes along the Fox River; 4) flow regime effects or trends; and 5) analysis of compliance with any applicable water quality standards or guidelines. Appendix 6 provides basic statistical characteristics for each constituent.

The chapter concludes with a summary of water quality problems inferred from the data and a matrix showing the critical times and critical conditions when identified problems typically occur. These times and conditions should be the focus of modeling efforts for the given constituent. A series of maps show the spatial extent of available data and illustrate where monitoring data are not available.

5.1. Water Uses and Water Quality Standards

Water pollution control programs are designed to protect the beneficial uses of the nation's water resources. Each state is responsible for establishing water quality standards that protect the designated beneficial uses. Illinois waters are designated for various uses, including aquatic life, agricultural use, primary contact (e.g., swimming and water skiing), secondary contact (e.g., boating and fishing), industrial use, drinking water, and food processing water supply.

The Illinois Pollution Control Board (IPCB) is responsible for setting water quality standards to protect designated uses in water bodies in Illinois. The federal Clean Water Act requires the states to review and update water quality standards every three years. The IEPA, in conjunction with the U.S. Environmental Protection Agency (USEPA), identifies and prioritizes those standards to be developed or revised during this three-year period. The IEPA is responsible for developing scientifically based water quality standards and proposing them to the IPCB for adoption into state rules and regulations.

To assess the support of the designated uses and to identify potential causes of impairment, the IEPA relies on rules and regulations adopted by the IPCB. The IPCB has established four primary sets of narrative and numeric water quality standards, each set designed to help protect particular beneficial uses in particular water bodies:

- *General Use Standards*: These standards are intended to protect aquatic life, wildlife, agricultural, primary contact, secondary contact, and most industrial uses. These standards also are designed to ensure the aesthetic quality of the state's aquatic environment.
- *Public and Food Processing Water Supply Standards*: These standards apply to water bodies where water is withdrawn from surface waters of the state for human consumption or for processing of food products intended for human consumption.
- *Lake Michigan Basin Standards*: These standards protect the beneficial uses of open waters, harbors and waters within breakwaters, and the waters within Illinois jurisdiction tributary to Lake Michigan, except for the Chicago River, North Shore Channel, and Calumet River.
- *Secondary Contact and Indigenous Aquatic Life Standards*: These standards are intended to protect limited uses of those waters not suited for general use activities but are nonetheless suited for secondary contact uses and are capable of supporting indigenous aquatic life limited only by the physical configuration of the water body, its characteristics and origin, and the presence of contaminants in amounts that do not exceed these water quality standards. These standards only apply to about 80 miles of canals and streams plus Lake Calumet in northeastern Illinois.

The standards are defined in Title 35 of the Illinois Administrative Code, Subtitle C (Water Pollution), Chapter I, Section 302 Water Quality Standards (IAC, 2002). General use standards are applicable to all streams of the Fox River watershed. A limited number of reaches require compliance with public and food processing water supply standards. Water quality standards specific to constituents investigated for this report are described in relevant sections.

The USEPA developed the National Strategy for the Development of Regional Nutrient Criteria in June 1998 (USEPA, 1998). The USEPA began developing water quality criteria for nutrients because states and tribes consistently identify excessive levels of nutrients as a major reason why surface waters do not meet designated uses. Technical guidance manuals published in 2000 describe a process for assessing nutrient conditions in different water body types (USEPA, 2000a). The guidance manuals do not contain site-specific numeric nutrient criteria for any river or stream systems. While this guidance contains USEPA's scientific recommendations regarding defensible approaches for developing regional nutrient criteria, it is not regulatory. Thus it does not impose legally binding requirements. States and tribes can adopt other scientifically defensible approaches for developing regional or local nutrient criteria.

5.2. Analyses of FoxDB Water Quality Data

5.2.1. Methodology

Water quality data in the Fox DB were analyzed primarily in terms of model selection. Spatial, temporal, and seasonal trends were explored. Compliance with water quality standards were evaluated for those constituents with available standards. Patterns of concentration distribution were evaluated visually by creating scatter plots for each station. Plots from various stations are included as examples of recognizable patterns that illustrate a general trend. The probability of compliance with water quality standards was evaluated from a fitted log-normal or normal distribution. The actual distribution was used in cases where the theoretical distribution did not adequately fit the data. The probability of compliance with the standard is the probability that the standard's numerical value will not be exceeded. For a large number of samples, it corresponds to the percentage of samples satisfying the criterion.

For each water quality constituent category, the "Available Data" section gives an overview of data available for the particular constituent in question: number of stations sampled, monitoring agencies, number of samples, etc. Appendix 6 summarizes basic statistical characteristics for investigated constituents. Spatial, temporal, or constituent data gaps are identified. Data gaps also are summarized later in the "Data Gaps" section of this chapter. The "Seasonal Effects" section describes changes in constituent distribution during the year (month-to-month comparison). Seasons used in this report were: winter (December–February), spring (March–May), summer (June–August), and fall (September–November). The "Flow Regime Effects" section describes changes in concentration with flow and allows preliminary assessment of contributions from point and nonpoint sources. The "Longitudinal Changes" section describes changes in concentration as a particular constituent moves downstream along the Fox River. Analysis of Variance (ANOVA) methods was used to evaluate differences with respect to the investigated factor (location or month). Only statistically significant trends and differences are reported ($\alpha = 0.05$). The purpose of evaluations in the "Water Quality Standards" sections is to use the standard as guidance for selecting water constituents of concern for future modeling activities (Phase II), not to assess whether water quality violates the standard.

Unless specifically stated, all data described in the "Available Data" were used in analyses. Station numbers used in this chapter are unique station identifiers specific to the FoxDB. The station numbers were assigned sequentially when data were loaded to the FoxDB. They have no reference to the location of a station along the stream, station importance, or the starting of any sampling program. However, they do provide a quick access to data and an exact cross reference to the FoxDB.

5.2.2. Nitrogen

Available Data. Nitrogen in its various forms is routinely monitored by several agencies, such as the IEPA, FRSG, Fox Metro Water Reclamation District (FMWRD), and others. Ammonia nitrogen data are available for 10 sites on the Fox River and six sites on its tributaries. Nitrate or nitrate-nitrite nitrogen data are available for 12 sites on the Fox River and five sites on its tributaries (including one site with only four samples taken); total Kjeldahl nitrogen (TKN) data are available for 11 sites on the Fox River and 10 sites on its tributaries (including five sites with only five samples). There are eight sites with organic nitrogen data on the Fox River and one site on a tributary (only two samples taken). Nitrogen data exist for additional sites sampled only once or twice over the last five years. The 1999 ammonia data collected by the IEPA were identified by the IEPA as unreliable because of possible problems with laboratory contamination and were excluded from the analyses. At the time of this writing, these data remained in the IEPA database, but have been eliminated from the FoxDB. Most stations (eight for ammonia nitrogen, nitrate or nitrate-nitrite nitrogen, and TKN) have data available from all five years. However, the same is true for only two stations with respect to organic nitrogen data.

The data presented in this section include only data directly available from the FoxDB. Additional information that possibly can be calculated from existing values (e.g., organic nitrogen from TKN and ammonia nitrogen) is not included.

Seasonal Variations. Nitrate nitrogen concentrations are higher in winter and spring than in summer as illustrated by data collected at South Elgin (station 26) and shown in Figure 5.1. The winter watershedwide average reaches about 2 milligrams per liter (mg/L) and declines to about 0.65 mg/L in July and August. Both organic nitrogen (Figure 5.2) and TKN concentrations follow the opposite trend. Total nitrogen remains at approximately the same level, with spring concentrations being slightly higher (Figure 5.3). Ammonia nitrogen concentrations in winter are slightly higher than during summer. The lowest ammonia nitrogen concentrations occur during spring.

Longitudinal Changes. Average nitrate nitrogen concentrations slightly increase from upstream to downstream (Figure 5.4). The TKN concentrations remain approximately constant with a slight fluctuation among stations until a decrease in concentration at Ottawa (station 31, Route 71). Organic nitrogen concentrations do not change significantly among stations.

Flow Regime Variations. Measured average nitrate nitrogen concentrations appear to increase with measured flow (Figure 5.5). April has the highest average flow (Figure 2.3), but highest concentrations have been recorded in January and February (Figure 5.1). This apparent contradiction is attributed to sampling frequency. Samples represent a snapshot of conditions while flows plotted in Figure 2.3 are monthly averages. The TKN concentrations decrease with flow (Figure 5.6; a similar trend is observed for organic nitrogen). Total nitrogen concentrations combine these trends and result in a **U**-shaped distribution (Figure 5.7). Both low and high flows exhibit higher total nitrogen concentrations than medium flows. Unfortunately, only stations 26 (South Elgin) and 240 (I-90 Bridge north of Elgin) have a sufficient number of total nitrogen measurements to evaluate the flow relationship. Ammonia nitrogen concentrations do not correlate with flow for most stations; only three stations indicate a slight increase in ammonia concentrations for high flows (station 33: Route 34, Oswego; station 27: Montgomery; and station 34: Yorkville). However, all stations indicate an increase in ammonia loads with increased flow.

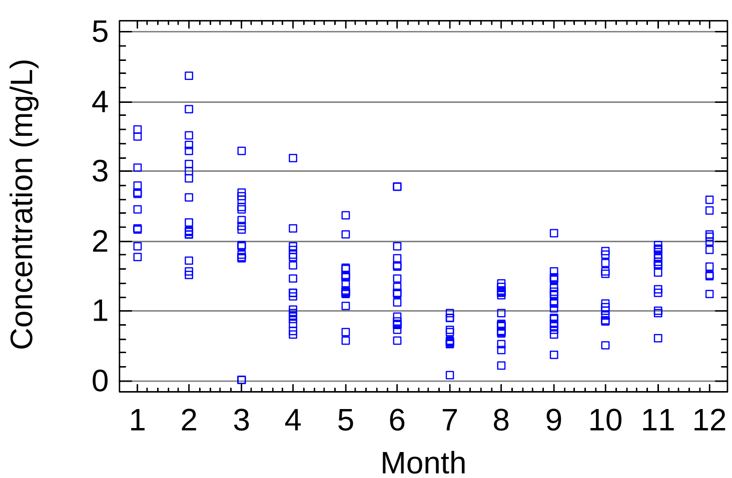

Figure 5.1. Nitrate nitrogen concentration by month, station 26 (South Elgin), 1998–2002

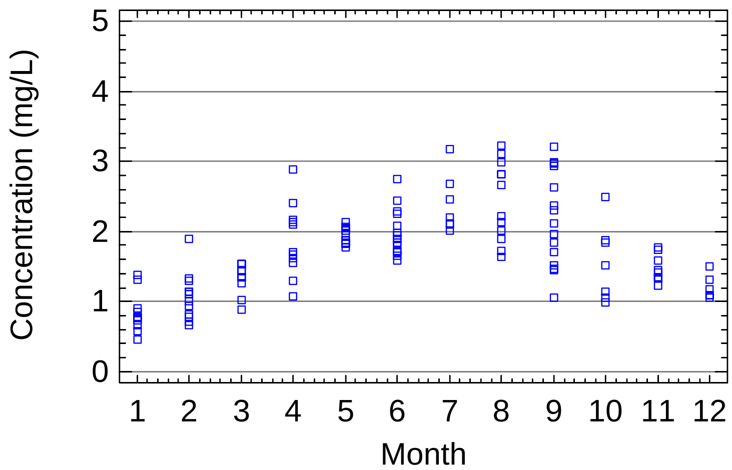

Figure 5.2. Organic nitrogen concentration by month, station 26 (South Elgin), 1998–2002

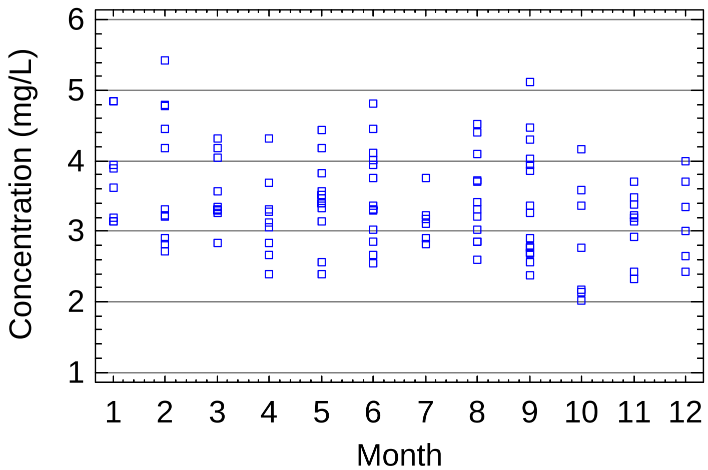

Figure 5.3. Total nitrogen concentration by month, station 26 (South Elgin), 1998–2002

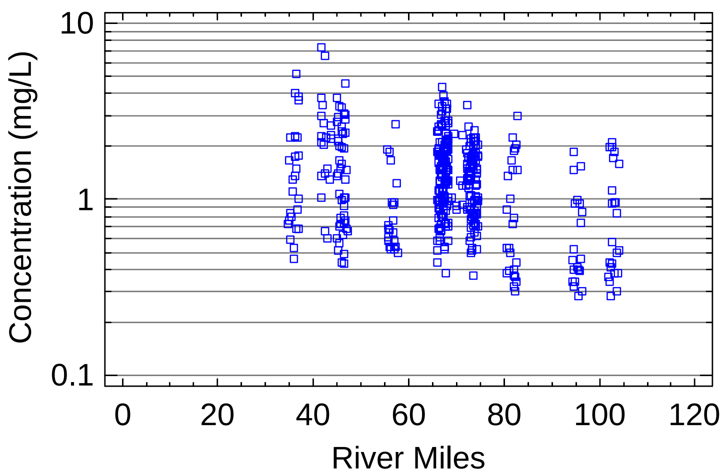

Figure 5.4. Nitrate nitrogen concentration in the Fox River by river mile, 1998–2002

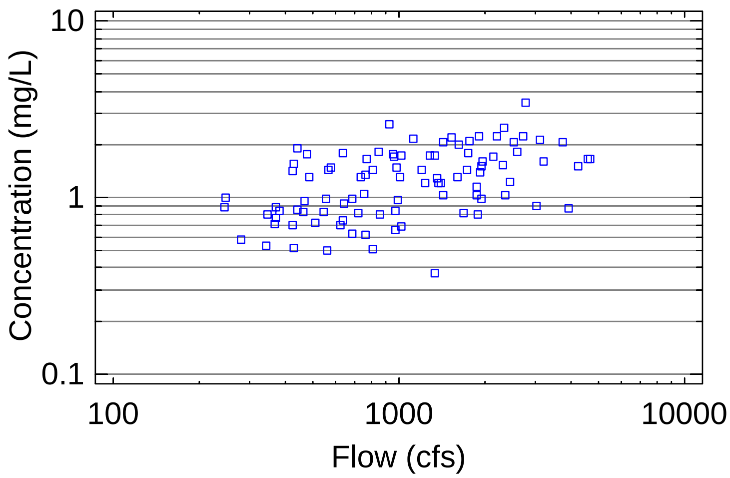

Figure 5.5. Change in nitrate-nitrogen concentration with flow (logarithmic scale), station 240 (I-90 Bridge north of Elgin), 1998–2002

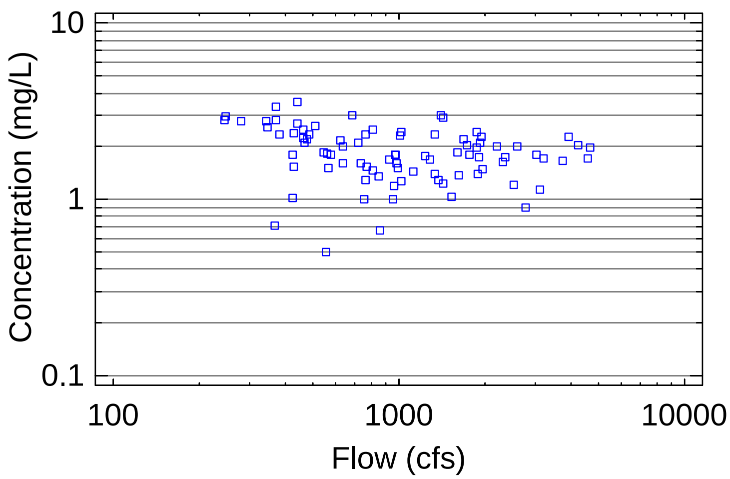

Figure 5.6. Change in TKN concentration with flow (logarithmic scale), station 240 (I-90 Bridge north of Elgin), 1998–2002

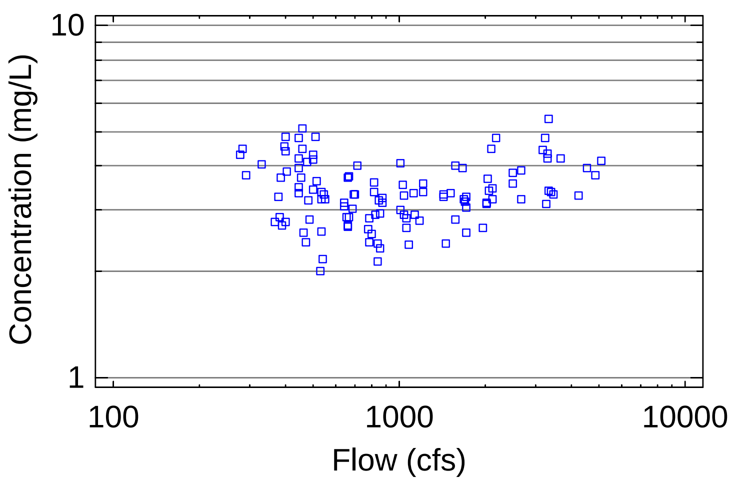

Figure 5.7. Change in total nitrogen concentration with flow (logarithmic scale), station 26 (South Elgin), 1998–2002

Water Quality Standards. General use water quality standards presently are defined only for total ammonia nitrogen (IAC, 2002). Acute, chronic, and sub-chronic standards for total ammonia nitrogen are calculated based on temperature and pH measured at the time of sample collection.

Acute standard: $$AS = \frac{0.411}{1+10^{7.204-pH}} + \frac{58.4}{1+10^{pH-7.204}}$$

Chronic standard: $$CS\ (T \le 14.51^oC) = \left\{\frac{0.0577}{1+10^{7.688-pH}} + \frac{2.487}{1+10^{pH-7.688}}\right\}(2.85)$$

$$CS\ (T > 14.51^oC) = \left\{\frac{0.0577}{1+10^{7.688-pH}} + \frac{2.487}{1+10^{pH-7.688}}\right\}\left(1.45*10^{0.028(25-T)}\right)$$

During the Early Life Stage Absent period (typically November–February):

$$CS\ (T \le 7^oC) = \left\{\frac{0.0577}{1+10^{7.688-pH}} + \frac{2.487}{1+10^{pH-7.688}}\right\}\left(1.45*10^{0.504}\right)$$

$$CS\ (T > 7^oC) = \left\{\frac{0.0577}{1+10^{7.688-pH}} + \frac{2.487}{1+10^{pH-7.688}}\right\}\left(1.45*10^{0.028(25-T)}\right)$$

The sub-chronic standard is equal to 2.5 times the chronic standard.

The toxicity quotients are determined by dividing the ammonia concentration by the calculated water quality standard. The acute toxicity standard must not be exceeded at any time. Thus, quotients less than one show compliance and greater than one, noncompliance. The chronic standard must not be exceeded by the 30-day average concentration (at least four samples taken over the 30-day period). The sub-chronic standard must not be exceeded by the 4-day average concentration of total ammonia nitrogen.

Both acute and chronic toxicity quotients were calculated for all samples for which concurrent measurements of pH and temperature were taken. Results for stations with sufficient data are summarized in Tables 5.1–5.4. Total ammonia concentrations are in compliance with the acute standards and criteria; no excursions were detected in available sampling data.

Available sampling programs do not enable direct determination of compliance with the chronic toxicity standard (i.e., calculating the 30-day average of at least four sample quotients) as a sufficient number of samples were not taken. A statistical analysis of available data is used to estimate the likelihood of compliance. Chronic toxicity standards are, in such cases, usually compared with the 99.4 percent probability of occurrence. Tables 5.3 and 5.4 show the probability of compliance with the standard. Possible noncompliance with chronic toxicity standard is indicated for stations 24 (Algonquin) and 31 (Route 71, Ottawa).

Public and food processing water supply standards specify maximum concentration for nitrate nitrogen of 10 mg/L as N (IAC, 2002). These standards apply “at any point at which

Table 5.1. Fox River: Probability of Compliance with Ammonia Acute Toxicity Standard

Station	*Location*	*Compliance (%)*	*Count*	*Max acute quotient*
23	Route 176	> 99.8	29	0.03
24	Algonquin	> 99.8	36	0.13
26	South Elgin	> 99.8	46	0.08
27	Montgomery	> 99.8	261	0.12
31	Route 71, Ottawa	> 99.8	14	0.08
33	Route 34, Oswego	> 99.8	218	0.21
34	Yorkville	> 99.8	74	0.13
40	Geneva	> 99.8	21	0.06
184	Johnsburg	> 99.8	21	0.04

Table 5.2. Fox River Tributaries: Probability of Compliance with Ammonia Acute Toxicity Standard

Station	*Location*	*Compliance (%)*	*Count*	*Max acute quotient*
25	Route 20, Poplar Creek	> 99.8	13	0.02
28	Route 47, Blackberry Creek	> 99.8	12	0.04
29	Somonauk Creek, 1 mi N Sheridan	> 99.8	13	0.06
236	Nippersink Creek, Spring Grove	> 99.8	13	0.08

Table 5.3. Fox River: Probability of Compliance with Ammonia Chronic Toxicity Standard

Station	*Location*	*Compliance (%)*	*Count*	*Max chronic quotient*
23	Route 176	> 99.8	29	0.20
24	Algonquin	99.3	36	0.34
26	South Elgin	99.6	46	0.28
27	Montgomery	> 99.8	261	0.30
31	Route 71, Ottawa	99.0	14	0.22
33	Route 34, Oswego	> 99.8	218	0.33
34	Yorkville	> 99.8	74	0.39
40	Geneva	> 99.8	21	0.35
184	Johnsburg	> 99.8	21	0.24

Table 5.4. Fox River Tributaries: Probability of Compliance with Ammonia Chronic Toxicity Standard

Station	*Location*	*Compliance (%)*	*Count*	*Max chronic quotient*
25	Route 20, Poplar Creek	> 99.8	13	0.05
28	Route 47, Blackberry Creek	> 99.8	12	0.13
29	Somonauk Creek, 1 mi N Sheridan	99.7	13	0.18
236	Nippersink Creek, Spring Grove	> 99.8	13	0.38

water is withdrawn for treatment and distribution as a potable supply or for food processing." Only two reaches are designated by the IEPA for public water supply (intakes in Aurora and Elgin). All reported measurements of nitrate nitrogen are below the public water supply standard.

National numeric criteria recommended by the USEPA (2000a) were derived as 25th percentile of concentrations within each ecoregion to reflect reference conditions. The State of Illinois has not adopted these criteria into its legislation. The total nitrogen criterion for streams in the Corn Belt Ecoregion is 2.18 (mg/L) as N. Most measurements (94% of all data) exceed the USEPA recommended nitrogen criterion. The highest level of compliance with the criterion is 16 percent for station 40 (Geneva).

5.2.3. Phosphorus

Available Data. There were 13 sites on the Fox River and 29 on its tributaries with at least five measurements of phosphorus over last five years. Total phosphorus data are available for 12 sites on the Fox River and 23 sites on its tributaries, dissolved phosphorus data for 12 sites on the Fox River and 12 sites on its tributaries. The monitoring agencies included IEPA, USGS, FRSG, FMWRD, Fox River Water Reclamation District (FRWRD), and Max McGraw Wildlife Foundation (MMGWF). Total phosphorus data were available from all five years at seven stations and from only one year at eight stations (three stations in 1998 and five stations in 2002).

Seasonal Variations. Total phosphorus reaches higher concentration levels during the summer months for the 1998–2002 data (Figure 5.8). Data from 1998–2003 is shown by year, and a comparison between years reveals the concentration for most stations on the Fox River (five out of seven stations with more than two years of data) was higher in years 2002 and 2003 than in other years. The data show phosphorus concentrations in the Fox River increase with decreasing flow. The seasonal variations noted above also are associated with low-flow conditions. Current FRSG measurements (2003) are significantly higher than previous measurements from the same season (Figure 5.9). However, flow during the FRSG sampling in 2003 was lower than during the same months in other years.

Data from station 24 (Algonquin), shown in Figure 5.10, illustrate the change in total phosphorus load in pounds per day (lb/day) with flow categorized by years. The loads during the first four months of 2002 and 2003 are comparable. However, these loads are still higher than

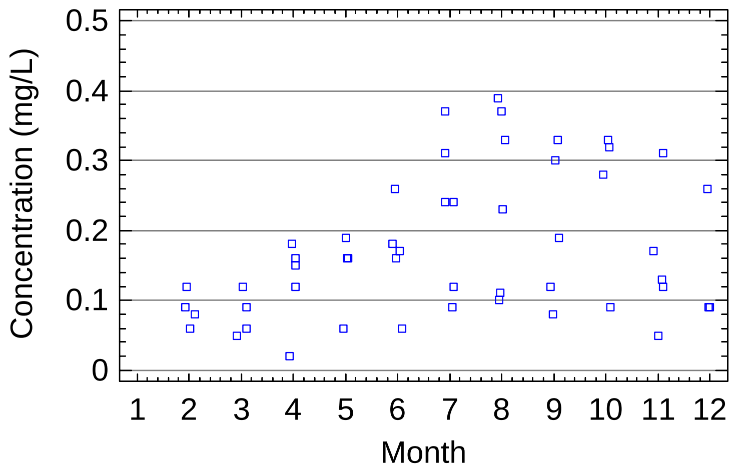

Figure 5.8. Total phosphorus concentration by month, station 24 (Algonquin), 1998–2002

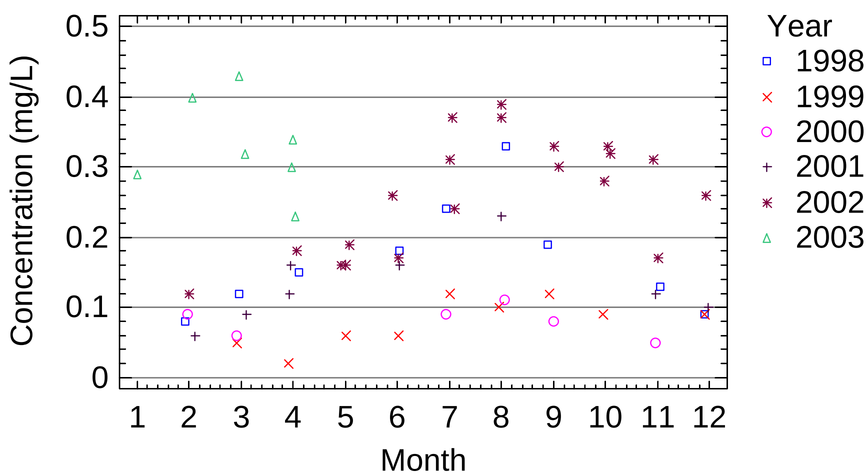

Figure 5.9. Total phosphorus concentration by month and year, station 24 (Algonquin), 1998–2003

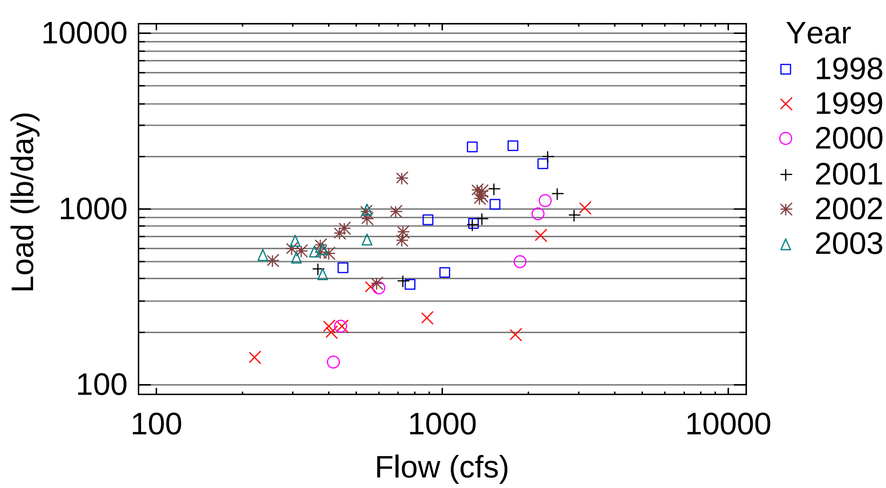

Figure 5.10. Change in total phosphorus load with flow by year, station 24 (Algonquin), 1998–2003

loads corresponding to similar flows for other years. Data presented in Figure 5.10 were collected by the IEPA (1998–2002) and by the FRSG (2002–2003). Both organizations use the same analytical method, although the analyses are performed by different laboratories.

Flow Regime Effects. Almost all stations (9 out of 12 stations on the Fox River with more than 5 measurements) exhibit a strong trend of decreasing phosphorus concentrations with increasing flow for both total and dissolved phosphorus. High concentrations of phosphorus during low flows may be attributed to point sources or other sources not related to runoff events (e.g., release from sediment). Phosphorus associated with runoff events (high flows) represents a higher total load but results in lower concentrations due to increased flow volume during runoff events. This is illustrated by the data collected at station 197 (South Elgin) in Figure 5.11.

Longitudinal Changes. Figure 5.12 shows a steady increase in average phosphorus concentrations from station 197 (Route 173, Wisconsin-Illinois border) to station 34 (Yorkville), and a decreasing trend downstream of Yorkville.

Water Quality Standards. Presently, there are no general use water quality standards for phosphorus in rivers and streams. Section 302.205 of Title 35 (IAC, 2002) defines the phosphorus standard for lakes and reservoirs as follows: "Phosphorus as P shall not exceed 0.05 mg/L in any reservoir or lake with a surface area of 8.1 hectares (20 acres) or more, or in any stream at the point where it enters any such reservoir or lake." Low-level pools constructed in free-flowing streams are excluded from this definition. Consequently, the standard does not apply to the study area.

National numeric criteria recommended by the USEPA (2000a) were derived as 25th percentile concentrations within each ecoregion to reflect reference conditions. The State of Illinois has not adopted these criteria into its legislation. The total phosphorus criterion for streams in the Corn Belt Ecoregion is 0.076 mg/L as P. To control eutrophication, the USEPA recommends that total phosphate concentrations should not exceed 0.1 mg/L as P in streams (USEPA, 1986).

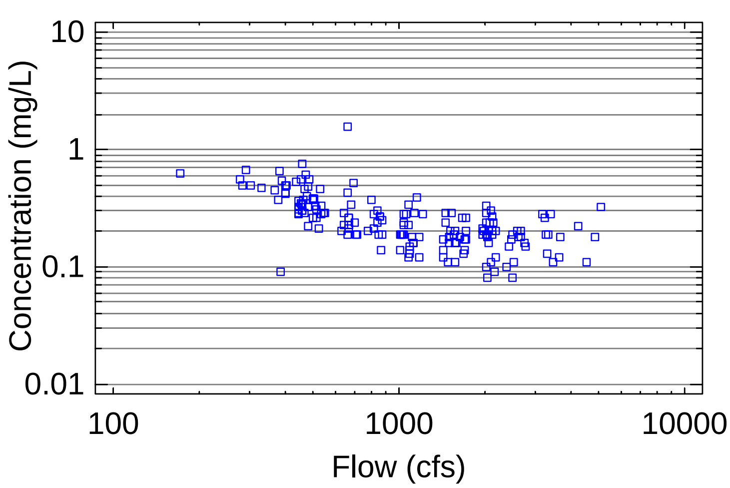

Figure 5.11. Change in total phosphorus concentration with flow (logarithmic scale), station 26 (South Elgin), 1998–2002

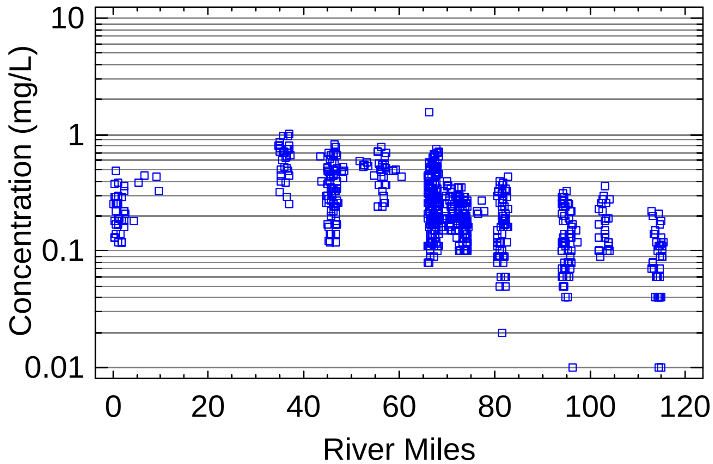

Figure 5.12. Total phosphorus concentration in the Fox River by river mile, 1998–2002

Table 5.5. Fox River: Percent Compliance with 0.076-mg/L Total Phosphorus Criterion, 1998–2002

Station	*Location*	*Compliance (%)*	*Count*	*Max TP*
23	Route 176	25.4	58	0.33
24	Algonquin	13.2	60	0.43
26	South Elgin	1.0	181	1.56
27	Montgomery	< 1.0	60	0.82
31	Route 71, Ottawa	< 1.0	33	0.49
34	Yorkville	< 1.0	26	0.65
35	National St., Elgin	< 1.0	19	0.36
40	Geneva	< 1.0	24	0.78
184	Johnsburg	3.3	24	0.36
240	I-90 Bridge N of Elgin	< 1.0	97	0.35
273	Kimball-Lawrence St., Elgin	< 1.0	19	0.37

Tables 5.5 and 5.6 show a compliance with the 0.076-mg/L criterion for the Fox River and its tributaries, respectively. Most measurements (95% of all data) exceed the USEPA recommended total phosphorus criterion of 0.076 mg/L as P (see also Figure 5.12). Phosphorus concentrations among Fox River stations are the lowest overall at station 197 (Route 173, Wisconsin-Illinois border), which complied with the recommended criterion in 55 percent of all cases. Phosphorus concentrations are the second lowest at station 23 (Fox River by Route 176), which complied with the recommended criterion in 25 percent of all cases. Phosphorus concentrations in the Fox River are higher than concentrations in its tributaries.

Table 5.6. Fox River Tributaries: Percent Compliance with 0.076-mg/L Phosphorus Criterion, 1998-2002

Station	*Location*	*Compliance (%)*	*Count*	*Max TP*
1	Nippersink Creek ,Thompson Road by Wonder Lake	35.5	39	1.16
25	Poplar Creek, Route 20, Elgin	72.3	38	0.24
28	Blackberry Creek, Route 47	41.1	36	0.33
29	Somonauk Creek, 1 mi N Sheridan	61.1	35	0.62
236	Nippersink Creek, Spring Grove	27.4	36	0.26
268	Tyler Creek, Route 31	6.4	19	0.54
615	Poplar Creek, Raymond Street	< 1.0	19	0.38

5.2.4. Dissolved Oxygen

Available Data. Dissolved oxygen (DO) has been monitored by several agencies, including: IEPA (22 sites, of which 12 are on tributaries), FRWRD (6 sites), FMWRD (3 sites), FRSG (7 sites), MMGWF (22 sites), and USGS (20 sites on tributaries, of which 5 sites are in Wisconsin). Measurements of DO conducted by MMGWF included two grab samples and continuous monitoring during 16-, 40-, and 96-hour sampling periods (Santucci and Gephard, 2003). There are a total of 62 sites, of which 36 sites are located on the Fox River mainstem, and 26 sites are on tributaries. Thirty-nine sites are a part of regular monitoring programs (13 sites on the Fox River, and 26 sites on its tributaries), and the remaining 23 sites are a part of completed, limited sampling programs.

Due to the diurnal fluctuation of DO, time of sampling plays an important role in interpreting the results. However, time of sampling was not provided for all samples. Those DO samples with available sampling time (other than MMGWF continuous data) were collected during morning to early afternoon hours, which is typical for regular sampling programs. Thus, the data presented in this section reflect the morning to early afternoon conditions unless specifically stated otherwise.

Seasonal Variations. The saturation concentration of DO is a function of temperature. As a result, seasonal variation in temperature has profound effects on DO level in surface waters. Lower DO is expected during summer months when temperatures are typically higher. Figure 5.13 shows a seasonal DO profile for station 273 (Kimball-Lawrence St., Elgin), a typical profile for DO concentrations. Data from 1998–2002 were grouped by month for each station and average values compared. August concentrations average 7 mg/L lower than February concentrations. Similar behavior was observed at all stations.

Figure 5.14 shows percent oxygen saturation for the same station and period as Figure 5.13. The fluctuation of percent oxygen saturation is much wider during the summer months than for the rest of the year. Saturation level fluctuates between 50 percent and 140 percent during the summer.

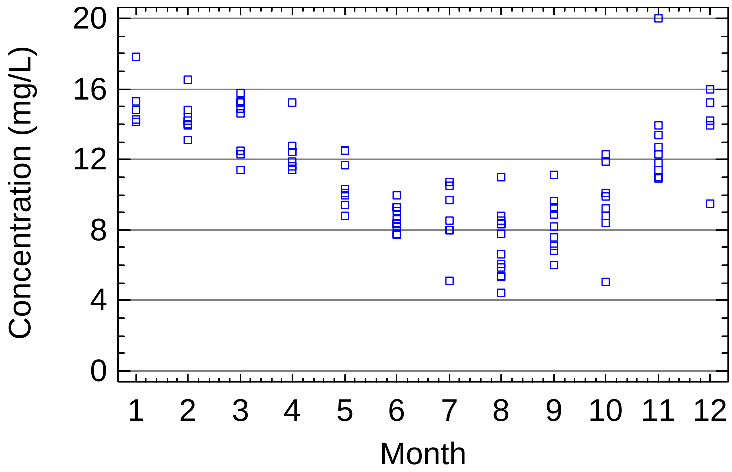

Figure 5.13. Dissolved oxygen concentration by month, station 273 (Kimball-Lawrence St., Elgin), 1998–2002

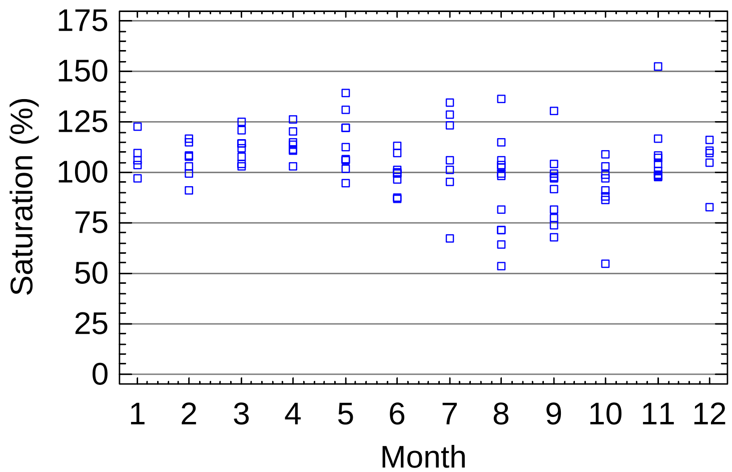

Figure 5.14. Percent oxygen saturation by month, station 273 (Kimball-Lawrence St., Elgin), 1998–2002

Longitudinal Changes. Figures 5.15 and 5.16 show percent oxygen saturation at stations on the Fox River for summer and the combined data for the other months, respectively. Stations are ordered from downstream to upstream. The figures allow comparisons of DO saturation fluctuation among individual stations. Stations 33 (Route 34, Oswego) and 31 (Route 71 near Ottawa) show the widest fluctuation and the largest oxygen saturation during the summer months. Although the DO concentration and degree of saturation fluctuates among stations, there is no clear indication of a pattern or trend upstream to downstream along the river.

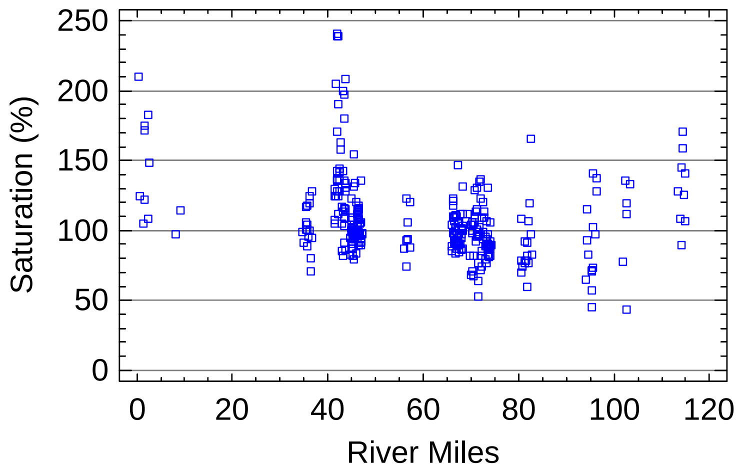

Figure 5.15. Percent oxygen saturation in the Fox River by river mile, 1998–2002 (July–September)

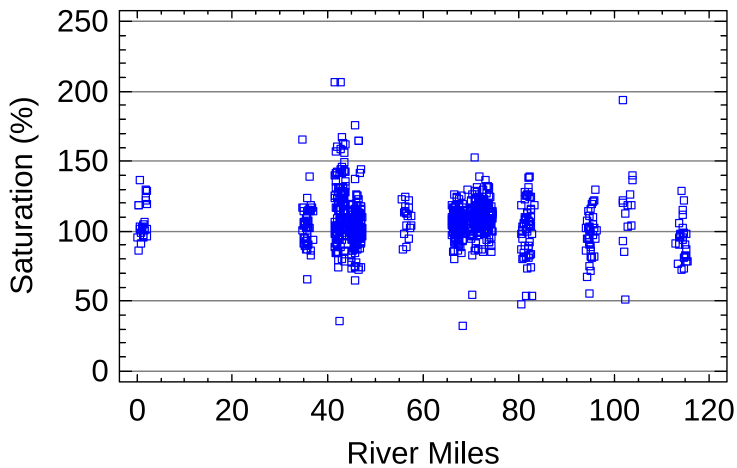

Figure 5.16. Percent oxygen saturation in the Fox River by river mile, 1998–2002 (October–June)

Water Quality Standard. According to Title 35 (IAC, 2002), dissolved oxygen "shall not be less than 6.0 mg/L during at least 16 hours of any 24-hour period, nor less than 5.0 mg/L at any time." Diurnal measurements are necessary to evaluate compliance with the DO standard of 6 mg/L. Evaluation of grab samples reveals that measured DO fell below 5 mg/L in several instances (Tables 5.7 and 5.8). Note that only grab samples were included in this evaluation. Diurnal monitoring data (MMGWF) were excluded and are discussed separately in the section below.

Most of the low DO values occurred in summer or fall. However, substandard concentrations also were found on two occasions in winter. Unfortunately, very little additional information is available for the January 2000 sample at station 33 (Route 34, Oswego), making it impossible either to identify a possible cause or to classify this value as an outlier.

Table 5.7. Fox River: Substandard Dissolved Oxygen Levels, 1998–2002 (Excluding MMGWF Monitoring)

Station	*Location*	*Stream*	*Date*	*DO (mg/L)*	*Agency*
23	Route 176	Fox River	Jul 9, 2002	4.4	FRSG
			Sep 3, 2002	3.8	FRSG
24	Algonquin	Fox River	Jul 16, 2002	4.8	IEPA
			Oct 3, 2002	4.3	IEPA
26	South Elgin	Fox River	Feb 15, 2000	4.5	IEPA
33	Route 34, Oswego	Fox River	Jan 26, 2000	4.9	FMWRD
184	Johnsburg	Fox River	Sep 3, 2002	3.6	FRSG
			Oct 1, 2002	4.6	FRSG
273	Kimball St., Elgin	Fox River	Aug 30, 2000	4.4	FRWRD

Table 5.8. Fox River Tributaries: Substandard Dissolved Oxygen levels, 1998–2002

Station	*Location*	*Stream*	*Date*	*DO (mg/L)*	*Agency*
22	County Road 1900	Buck Creek	Aug 27, 2002	4.5	IEPA

Analyses of additional constituents give insight into the overall state of water quality at station 26 (South Elgin) during the February 2000 sampling event. The results show high countsof fecal coliform (2600 per 100 mL, the general use water quality standard is 400 per 100 mL) and high concentrations of nutrients. The phosphorus value reached 0.3 mg/L as P for total phosphorus and 0.24 mg/L as P for dissolved phosphorus (25 percent exceedance), and the nitrate-nitrite nitrogen concentration was 3.1 mg/L as nitrogen (maximum value reported for this station). The high concentrations of other constituents support the low DO value and indicate an overall water quality problem on the particular day, although its direct causes only can be speculated. Flow during the sampling event corresponded to about 75 percent annual exceedance. Meteorological data from the Elgin station (COOPID112736) indicate possible influence of snowmelt. Accumulated snow depth reached about 9 inches at the beginning of February, when above freezing temperature initiated snowmelt. An additional inch of snow fell on February 14, 2000, and the total 3-inch snow cover completely melted the following day. Salt-laden runoff may have an impact on oxygen levels because salinity affects the saturation values for DO. Loading from a point source during this event is another possible cause of low oxygen. Atypical events are sometimes due to flawed data but, when supported by other evidence, provide insight to the potential range of conditions that can occur.

Table 5.9 and Table 5.10 show the probability of compliance with the 5-mg/L standard. A lognormal distribution was fitted to DO values for stations with a sufficient number of measurements. Substandard DO values are in bold.

Continuous monitoring of DO was carried out by MMGWF in August 2001 (Santucci and Gephard, 2003). Although mean oxygen concentrations were similar between free-flowing and impounded reaches, daily extremes varied between these habitat types. Standard violations for DO and pH were widespread and of long duration in impounded reaches throughout the study

Table 5.9. Fox River: Probability of Compliance with the 5-mg/L DO Standard, 1998–2002

Station	*Location*	*Compliance (%)*	*Count*	*Minimal DO*
31	Route 71, Ottawa	> 99.8	33	7.7
34	Yorkville	> 99.8	59	5.6
33	Route 34, Oswego	> 99.8	166	**4.9**
27	Montgomery	> 99.8	231	6.6
40	Geneva	99.5	25	6.0
26	South Elgin	99.5	201	**4.5**
35	National St., Elgin	> 99.8	21	8.6
273	Kimball-Lawrence St., Elgin	99.2	95	**4.4**
240	I-90 Bridge N of Elgin	> 99.8	113	6.4
24	Algonquin	98.5	69	**4.3**
23	Route 176	95.7	49	**3.8**
184	Johnsburg	92.3	21	**3.6**

Notes: Substandard DO values are in bold.

Table 5.10. Fox River Tributaries: Probability of Compliance with the 5-mg/L DO Standard, 1998–2002

Station	*Location*	*Stream*	*Compliance (%)*	*Count*	*Minimal DO*
1	Thompson Road by Wonder Lake	Nippersink Creek	> 99.8	35	6.3
3	Bull Valley Road	Boone Creek	N/A	3	8.7
14	Leroy Oaks	Ferson Creek	N/A	3	9.0
22	County Road 1900	Buck Creek	N/A	3	**4.5**
25	Route 20, Elgin	Poplar Creek	> 99.8	41	7.2
28	Route 47	Blackberry Creek	98.7	39	5.2
29	1 mi N Sheridan	Somonauk Creek	99.8	38	6.3
236	Wind Road, Spring Grove	Nippersink Creek	99.5	39	5.7
268	Route 31	Tyler Creek	> 99.8	21	8.8

Notes: NA indicates not applicable, insufficient data. Substandard DO values are in bold.

area, but they occurred infrequently and for shorter time periods in free-flowing habitats. Minimum DO concentrations were below the 5-mg/L standard at eight of 11 impounded stations during the first sampling event and all four impoundments monitored during the second event. The water quality standard allows DO to drop below 6 mg/L, provided it lasts less than eight hours in a 24-hour period. When substandard conditions existed in impounded areas, they typically lasted for more than 8 hours in a 24-hour period (>15 hours at two stations). In contrast, DO fell below 6 mg/L at only two of 11 stations in the free-flowing river, and these conditions lasted for only a short time (<2 hours). Substandard oxygen and pH conditions in Fox River impounded areas occurred during periods of low flows in combination with warm water temperatures (Santucci and Gephard, 2003).

5.2.5. pH

Available Data. There are 13 sites on the Fox River and 13 on its tributaries with at least five measurements over the last five years. There are 39 additional sites with from one to four measurements available. The monitoring agencies include IEPA, FRSG, FRWRD, and MMGWF. Eight stations have data from all years, two stations have data only from 1998, and two stations have data only from 2002.

Seasonal Variations. The pattern varies from station to station.

Flow Regime Variations. A relationship between flow and pH is observed only at stations downstream of Montgomery: 27 (Montgomery), 31 (Route 71, Ottawa), 33 (Route 34, Oswego), and 34 (Yorkville). The value of pH for these stations decreases with increasing flow (Figure 5.17). Santucci and Gephard (2003) reported that high pH values during continuous monitoring often were associated with oxygen levels above saturation. Grab samples confirm this for stations 31 (Route 71, Ottawa), 197 (Route 173, Wisconsin-Illinois border), and 240 (I-90 Bridge north of Elgin).

Stream pH is affected by consumption of carbon dioxide during photosynthesis. High photosynthesis during low-flow periods can contribute to an increase of stream pH value above the standard.

Longitudinal Changes. There are differences among stations but no clear pattern from upstream to downstream.

Water Quality Standards. Illinois water quality standards state "pH shall be within the range of 6.5 to 9.0 except for natural causes" (IAC, 2002). There were no cases of pH being less than 6.5 over the last five years and only four cases when pH dropped below 7. Only one value less than 7 was reported at tributaries (station 28 – Route 47, Blackberry Creek). The minimum value measured during the investigated period along the Fox River was 6.6 (two cases). However, pH values above 9 often were reported (Tables 5.11 and 5.12). Most of them were measured by the FMWRD at station 33 (Route 34, Oswego). This station is not monitored by other agencies (only two samples were analyzed by the IEPA for this location).

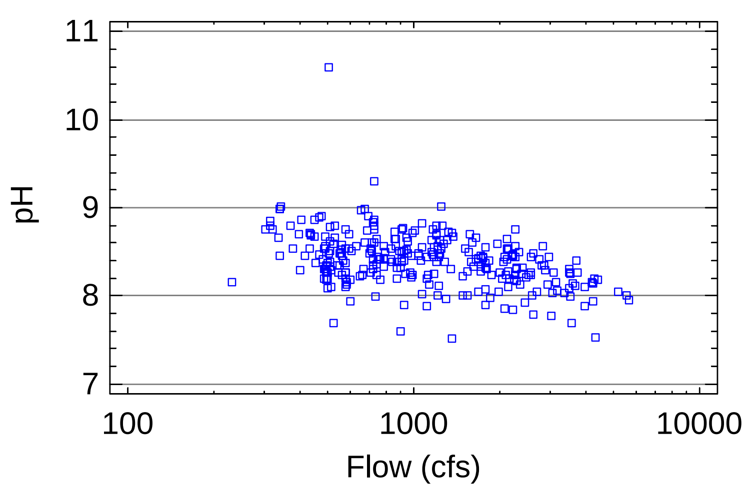

Figure 5.17. Change in pH with flow (semi-logarithmic scale), station 27 (Montgomery), 1998–2002

Table 5.11. Fox River: Probability of Compliance with Upper Limit of pH Standard (9), 1998–2002

Station	*Location*	*Compliance (%)*	*Count*	*Maximum value*	*Minimum value*
23	Route 176	99.2	58	8.9	7.0
24	Algonquin	95.4	70	9.0	6.7
26	South Elgin	98.7	159	9.0	7.3
27	Montgomery	97.6 (98.6*)	306 (305*)	10.6 (9.3*)	7.5
31	Route 71, Ottawa	94.7	33	9.1	7.3
33	Route 34, Oswego	93.4	242	9.4	7.6
34	Yorkville	99.5	76	9.2	7.8
35	National St., Elgin	99.0	20	8.9	8.0
40	Geneva	99.1	25	8.8	7.6
184	Johnsburg	> 99.9	24	8.8	8.0
197	Route 173, Wisconsin-Illinois border	> 99.9	41	8.7	7.5
240	I-90 Bridge north of Elgin	> 99.9	81	8.9	7.4
273	Kimball-Lawrence St., Elgin	99.1	27	9.0	7.9

Note: *Statistics calculated after excluding the value of 10.6 as an outlier.

Table 5.12. Fox River Tributaries: Probability of Compliance with Upper Limit of pH Standard (9), 1998–2002

Station	*Location*	*Compliance (%)*	*Count*	*Maximum value*	*Minimum value*
1	Nippersink Creek, Thompson Road by Wonder Lake,	> 99.9	44	8.5	7.5
14	Ferson Creek, Leroy Oaks	> 99.9	5	8.4	8.1
22	Buck Creek, County Road 1900	> 99.9	5	8.2	7.6
25	Elgin, Poplar Creek Route 20,	> 99.9	41	8.3	7.1
28	Blackberry Creek, Route 47	> 99.9	40	8.5	6.8
29	Somonauk Creek, 1 mi N of Sheridan	> 99.9	38	8.6	7.3
236	Nippersink Creek, Spring Grove	> 99.9	39	8.7	7.3
268	Tyler Creek, Route 31	98.9	20	9.0	7.8
615	Poplar Creek, Raymond Street	> 99.9	20	8.4	7.2

5.2.6. Suspended Solids

Available Data. Information on suspended solids is available for 14 sites on the Fox River (of which one site has only two samples) and 14 sites on its tributaries (of which eight sites have only one or two samples). Most stations on the Fox River have data for all five years, two stations have data for 2002 only, and two stations for 1998 only. Only four stations on tributaries have data for all five years, eight stations have data for 2002 only, and two stations have data for 1998 only.

Data on suspended solids in the Fox River were collected by the IEPA at nine sites. Most samples on tributaries were taken and analyzed by the IEPA. The FRWRD sampled two tributaries in 1998 in addition to four stations on the mainstem sampled throughout the investigated period. The FMWRD analyzed suspended solids for two stations on the Fox River as part of their quarterly sampling.

Seasonal Variations. All stations exhibit a similar pattern that is illustrated by the data collected at station 27 (Montgomery) in Figure 5.18. Late fall and winter concentrations are low followed by an increase in spring (April–May). Concentrations stay high until September or October. The peak concentrations usually occur in July.

Suspended solids are a mixture of inorganic (silt and clay) and organic (decomposed plant material, soil humus, and algae) material. High summer concentrations are influenced by increased algal populations.

Flow Regime Variations. The relationship between concentration of suspended solids and flow is ambiguous. It is commonly assumed that high flow rates are associated with high suspended solid concentrations as runoff erodes soil or organic particles. However, this typical trend is not apparent, as illustrated by the data from station 27 (Montgomery) shown in Figure 5.19.

The expected flow-suspended solids relationship possibly is perturbed by the contribution of algae during the summer. Figure 5.20 shows the relationship with flow broken down by quarters. The data show a positive correlation between suspended solids concentration and flow for all quarters with January–March data showing the steepest increase. Suspended algae, limited erosion during the winter months, and contribution from point sources are likely causes for these relationships.

Interference with algae concentration complicates determination of soil erosion. Planktonic algal concentrations theoretically are lower at high flows. Therefore, high suspended

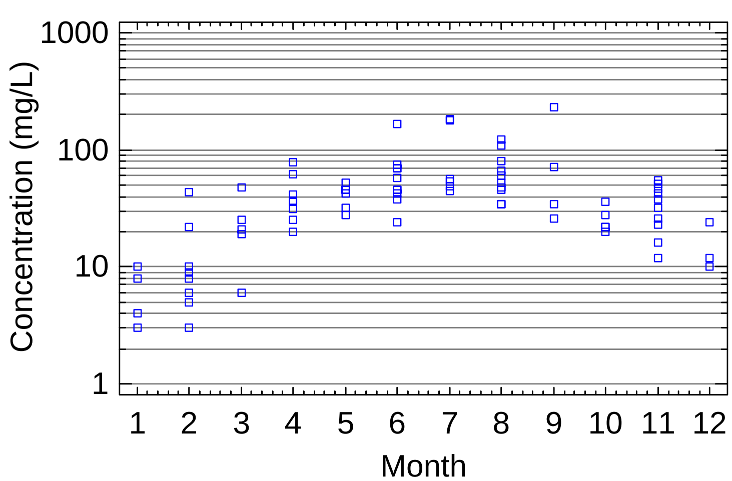

Figure 5.18. Suspended solids by months, station 27 (Montgomery), 1998–2002

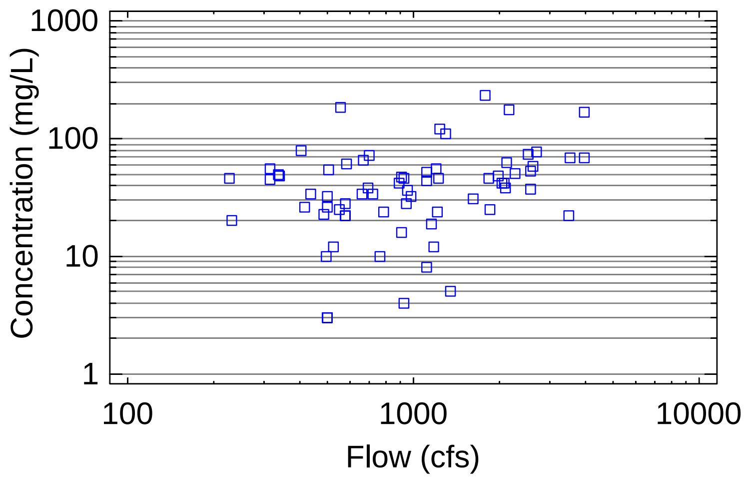

Figure 5.19. Change in suspended solids with flow (logarithmic scale), station 27 (Montgomery), 1998–2002

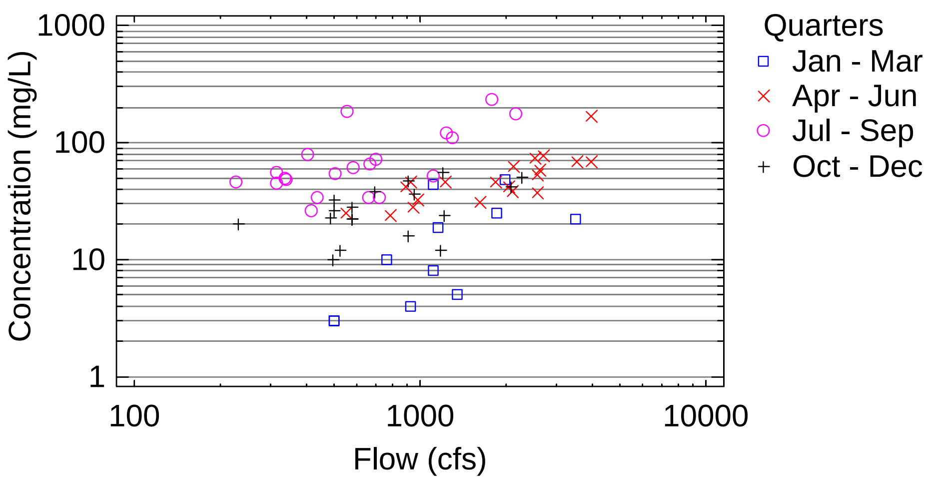

Figure 5.20. Change in suspended solids with flow (logarithmic scale), categorized by quarters, station 27 (Montgomery), 1998–2002

solids loads during high flows mostly can be attributed to surface runoff and streambank erosion. The inorganic and organic portions of suspended solids can be determined to quantify the possible influence of algae. Only the IEPA samples contain information on volatile suspended solids (VSS), the organic portion of suspended solids. The organic material represents between 20 and 60 percent of suspended solids with average values between 30 and 40 percent. The organic portion decreases with increasing flow. Detailed analyses and the watershed loading model can help to fully clarify the issue.

Longitudinal Changes. Average suspended solids concentrations remain approximately constant along the Fox River (Figure 5.21). Only the first and the last stations, stations 197 (Route 173, Wisconsin-Illinois border) and 31 (Route 71, Ottawa) have statistically significant higher average concentrations than the stations between them.

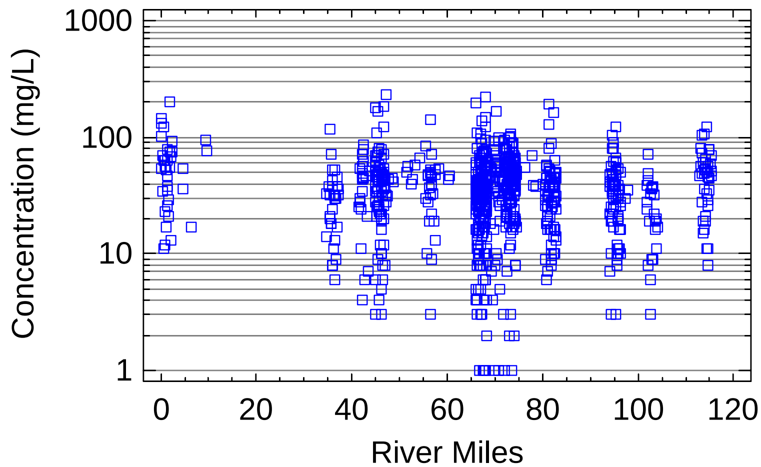

Figure 5.21. Suspended solids concentration in the Fox River by river mile, 1998–2002

Table 5.13. Fox River: Suspended Solids Concentration (mg/L), Basic Statistics Derived Using Log-Normal Distribution, 1998–2002

Station	*Location*	*Count*	*Minimum*	*Average*	*Maximum*
23	Route 176	70	3	35	122
24	Algonquin	72	6	37	194
26	South Elgin	211	1	36	224
27	Montgomery	79	3	45	234
31	Route 71, Ottawa	30	11	63	202
33	Route 34, Oswego	22	4	40	86
34	Yorkville	26	6	31	118
35	National St., Elgin	22	1	41	100
40	Geneva	22	3	40	141
184	Johnsburg	23	3	26	71
240	I-90 Bridge N of Elgin	123	1	43	107
273	Kimball-Lawrence St., Elgin	23	1	46	168

		Percentiles				
Station	*Location*	*25*	*50*	*75*	*90*	*99*
23	Route 176	19	31	47	62	122
24	Algonquin	16	28	45	56	194
26	South Elgin	18	31	43	61	148
27	Montgomery	22	37	53	78	234
31	Route 71, Ottawa	29	56	75	127	202
33	Route 34, Oswego	24	44	54	72	86
34	Yorkville	14	27	38	52	118
35	National St., Elgin	16	41	55	78	100
40	Geneva	19	35	49	71	141
184	Johnsburg	11	22	37	42	71
240	I-90 Bridge N of Elgin	26	40	57	73	102
273	Kimball-Lawrence St., Elgin	19	41	59	93	168

Water Quality Standards. There are no Federal or Illinois water quality standards for suspended solids. Table 5.13 shows basic statistical characteristics such as the average, median, etc. for stations with measured suspended solids concentration.

5.2.7. Fecal Coliform

Available Data. Fecal coliform was monitored at 12 sites on the Fox River and six sites on its tributaries over the last five years by the IEPA, FRSG, and FRWRD. Only two stations have data from all years, three stations have no data from 2001, two additional stations have no 2001–2002 data, three stations have data only from 2002, and three stations have data only from 1998.

Seasonal Variations. Only two stations have sufficient data for evaluating seasonal trends: 26 (South Elgin) and 240 (I-90 Bridge north of Elgin). Both stations show a similar pattern: fecal coliform counts in summer months are generally lower than during the rest of the year (Figure 5.22). This pattern possibly can be attributed to more stringent water quality standards during summer that may lead to more stringent National Pollutant Discharge Elimination System (NPDES) permits that require lower fecal coliform levels during the summer than other seasons.

Flow Regime Variations. There were no significant flow regime effects.

Longitudinal Changes. Three stations between the Fox Chain of Lakes and Algonquin have lower fecal coliform counts than stations downstream of Algonquin. There is a slight decrease in fecal coliform counts downstream of Montgomery.

Water Quality Standards. The Illinois water quality standard is defined in two different steps: the summer standard is defined for May–October and is based on a minimum of five samples taken over no more than a 30-day period. Summer fecal coliform counts “shall not exceed a geometric mean of 200 per 100 mL.” Also, less than 10 percent of the samples can

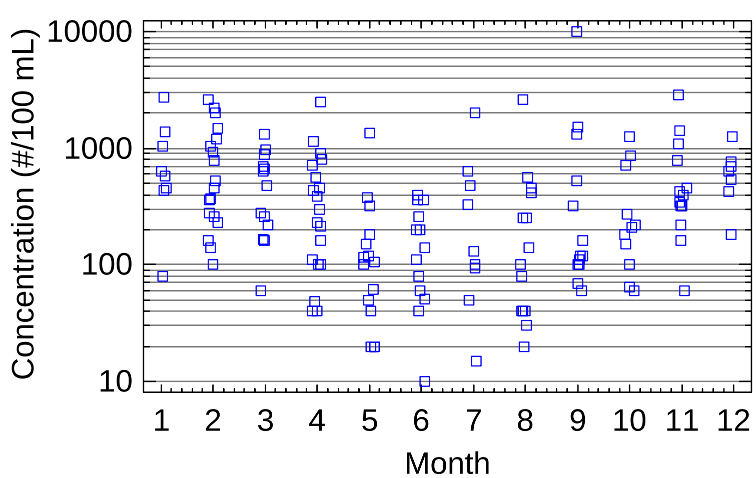

Figure 5.22. Fecal coliform by months, station 26 (South Elgin), 1998-2002

exceed 400 per 100 mL during any 30-day period (IAC, 2002). None of the monitoring programs carried out in the Fox River watershed over the last five years is adequate for determining compliance with the standard.

The probability limit of compliance (i.e., the percentage of samples that should meet the standard) is not clear from the formulation of the summer standard. Based on the formulation of the standard, the 400/100 mL limit can be exceeded by no more than 10 percent of the total number of samples, or the compliance must be greater than 90 percent for any 30-day period. Tables 5.14 and 5.15 show overall percent compliance with the standard for last five years (i.e., without incorporating the 30-day averaging period). Although the proper evaluation of achieving the standard is not possible with currently available data, the high fecal coliform counts exhibited at almost all stations (all stations downstream of Algonquin) indicate a probable noncompliance with the water quality standard.

Table 5.14. Fox River: Probability of Compliance with Fecal Coliform Standard (400/100 mL), 1998–2002

Station	*Location*	*Compliance (%)*	*Count*	*Maximum value (#/100 mL)*
23	Route 176	>90	29	1160
24	Algonquin	>90	34	4000
26	South Elgin	62	162	TNTC
27	Montgomery	65	31	TNTC
31	Route 71, Ottawa	80	13	1517
34	Yorkville	76	21	4000
35	National St, Elgin	55	22	2720
40	Geneva	81	17	2000
184	Johnsburg	>90	18	100
240	I-90 Bridge N of Elgin	73	107	2960
273	Kimball-Lawrence St., Elgin	60	21	1000

Note: TNTC = too numerous to count.

Table 5.15. Fox River Tributaries: Probability of Compliance with Fecal Coliform Standard (400/100 mL), 1998–2002

Station	*Location*	*Stream*	*Compliance (%)*	*Count*	*Maximum value (#/100mL)*
25	Route 20, Elgin	Poplar Creek	52	14	TNTC
28	Route 47	Blackberry Creek	54	13	7340
29	1 mi N of Sheridan	Somonauk Creek	68	13	3800
236	Wind Road	Nippersink Creek	60	15	5900
268	Route 31	Tyler Creek	73	22	1340
615	Raymond St.	Poplar Creek	58	22	2340

Note: TNTC = too numerous to count.

5.2.8. Algae and Biomass – Chlorophyll a

Available Data. There are 31 stations with information on chlorophyll on the Fox River, including 10 stations with more than five observations, and 31 stations on 19 lakes within the study watershed. Tributaries were not sampled for chlorophyll. Monitoring agencies include FRSG (seven stations), IEPA (two stations), FRWRD (two stations), and MMGWF (22 stations). Only the two stations sampled by FRWRD have data from all five years: station 26 (South Elgin) and station 240 (I-90 Bridge north of Elgin). All the agencies monitor mostly at independent locations. The FRSG and FRWRD share one sampling station (26 – South Elgin).

Seasonal Variations. The limited number of samples does not allow for statistical comparison. Generally, chlorophyll concentrations are higher during summer and early fall.

Flow Regime Variations. Analyses indicate a decrease in chlorophyll *a* concentration with increasing flow. However, more data would be required to confirm this relationship.

Longitudinal Changes. The apparent slight increase in chlorophyll *a* concentration from upstream to downstream is not statistically significant.

Water Quality Standards. A standard for chlorophyll is not specifically defined in the State of Illinois. Title 35 (IAC, 2002) states: "waters of the State shall be free from sludge or bottom deposits, floating debris, visible oil, odor, plant or algal growth, color or turbidity of other than natural origin," but does not give any specific numerical guidelines. There is generally a good agreement between planktonic primary production and algal biomass, and algal biomass is an excellent trophic state indicator. Chlorophyll *a* is the dominant type of chlorophyll in the algae most commonly found in surface waters, and it is a commonly used variable for algal biomass. Pheophytin is a breakdown product of chlorophyll, and the ratio of chlorophyll to pheophytin provides information about the health of the algal population. The proportion of pheophytin is low during periods of algae growth and high during periods of algae population decline, such as follows prolonged cloudy weather or exposure of algae to toxic substances. Only values corrected for pheophytin have been considered in the analyses below.

The USEPA Nutrient Guidance (USEPA, 2000a) defines chlorophyll criteria for Corn Belt Region (VI) as follows: 2.7 micrograms per liter or µg/L (chlorophyll *a* measured by the fluorometric method with acid correction), 7.33 µg/L (chlorophyll *a* measured by the spectrophotometric method with acid correction), or 6.83 µg/L (chlorophyll *a b c* measured by the trichromatic method). Eutrophic conditions are often associated with chlorophyll *a* concentrations exceeding 10 µg/L (USEPA, 1974).

Table 5.16 shows basic statistical characteristics such as the average, median, etc. for stations with measured chlorophyll *a*. Even the minimum values exceed the recommended criteria for all stations. The minimum values are also at least two times higher than the USEPA indicator of eutrophic condition.

Table 5.16. Fox River: Chlorophyll *a* Concentration (µg/L): Basic Statistics Derived Using Log-Normal Distribution, 1998–2002

Station	*Location*	*Count*	*Minimum*	*Average*	*Maximum*
23	Route 176	20	42	101	246
24	Algonquin	25	32	97	259
26	South Elgin	27	21	101	246
27	Montgomery	24	54	108	273
34	Yorkville	25	46	109	328
40	Geneva	21	40	112	270
184	Johnsburg	23	24	89	251

		Percentiles				
Station	*Location*	*25*	*50*	*75*	*90*	*99*
23	Route 176	72	108	123	182	294
24	Algonquin	67	97	147	192	337
26	South Elgin	79	101	157	193	328
27	Montgomery	60	97	176	224	404
34	Yorkville	69	96	206	240	456
40	Geneva	84	99	168	222	388
184	Johnsburg	62	83	117	173	300

5.2.9. Priority Pollutants

Priority pollutants refer to a list of about 130 specific pollutants. The priority pollutants are a subset of “toxic pollutants” as defined in the Clean Water Act. These 130 pollutants were assigned a high priority for development of water quality criteria and effluent limitation guidelines because they are frequently found in wastewater. Heavy metals, pesticides, and other chemicals are among those included on the priority pollutant list:

- *Heavy Metals (Total and Dissolved)*: “Heavy Metal” refers to heavy, dense, metallic elements that usually occur at only trace levels in water. However, certain forms of these metals are very toxic and tend to accumulate in the suspended and bed sediments of water bodies (arsenic, cadmium, chromium, lead, mercury, zinc, etc.).
- *Pesticides*: Pesticides comprise a large class of compounds of concern. Typical pesticides and herbicides include DDT, aldrin, chlordane, endosulfan, endrin, heptachlor, and diazinon. Concentrations of pesticides in urban runoff may be equal or even greater than the pesticides in agricultural runoff.
- *Polycyclic Aromatic Hydrocarbons (PAHs)*: Polycyclic Aromatic Hydrocarbons include a family of semi-volatile organic pollutants such as naphthalene, anthracene, pyrene, and benzo(a)pyrene. There are typically two main sources of PAHs: spilled or released petroleum products (from oil spills or the discharge of oil production brines) and combustion products that are found in urban runoff.

- *Polychlorinated biphenyls (PCBs)*: Polychlorinated biphenyls are organic chemicals that formerly had widespread use in electrical transformers and hydraulic equipment. This class of chemicals is extremely persistent in the environment and has been proven to bioconcentrate in the food chain, thereby leading to environmental and human health concerns in areas such as the Great Lakes.

This section focuses on evaluating ambient water quality with respect to trace metals. Due to the accumulation of metals in sediment or in biota, a comprehensive assessment of toxic effects caused by trace metals would have to include evaluation of sediment concentrations (Chapter 6) as well as concentrations in tissues and biotic indices.

Available Data. Metals were measured at 10 sites on the Fox River and 12 sites on its tributaries over the last five years. Most sampling was carried out by the IEPA (21 stations). Data also were provided by the FRWRD (two stations) and FMWRD (two stations). Most stations have data from all five years; there are two stations with data only from 2002.

Most sampling results by the IEPA were reported as below detection limits (95% of data for regulated constituent). The FMWRD sampled two stations on a quarterly basis for 26 metals: station 27 (Montgomery) and station 33 (Route 34, Oswego). Samples were analyzed for both total and dissolved forms since 2000. Only total concentrations were reported for prior samples. The FRWRD sampled two stations: station 26 (South Elgin) and station 240 (I-90 Bridge north of Elgin). Five samples were collected in September–October 1998, with an additional sample collected in May 1999.

Seasonal Variations. Only the FMWRD sampling provides enough data for analyses of seasonal effects. Samples were usually collected in February, June, August, and November. August average concentrations of total copper are higher than average concentrations in February or November (Figure 5.23). A similar trend was observed for other metals, such as zinc (Figure 5.24), iron, etc.

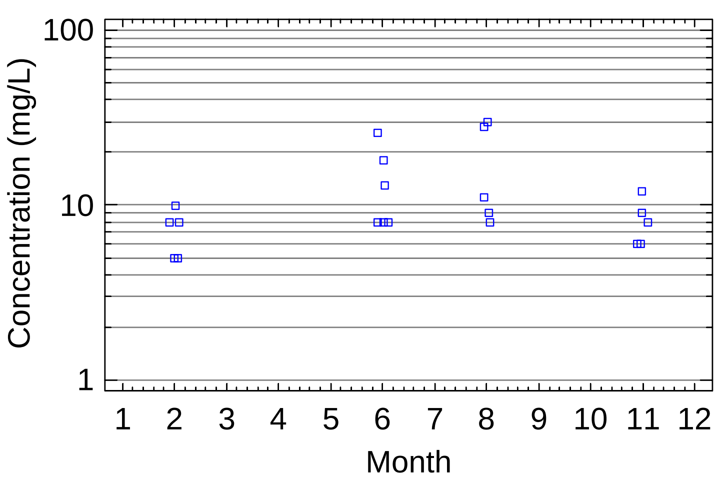

Figure 5.23. Total copper concentration by month, station 27 (Montgomery), 1998–2002 FMWRD

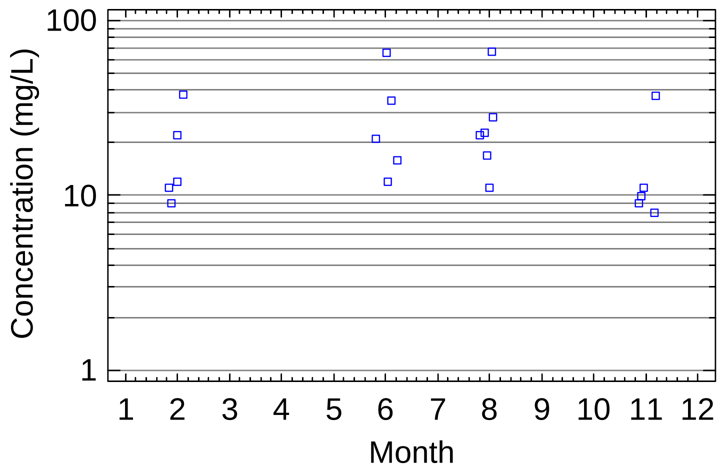

Figure 5.24. Total zinc concentration by month, station 27 (Montgomery), 1998–2002 FMWRD

Flow Regime Variations. No significant flow regime effects were noted.

Longitudinal Changes. Data were insufficient for evaluation.

Water Quality Standards. Water quality standards for priority pollutants are defined based on toxicity of the compound. According to Title 35 (IAC, 2002), acute standard (AS) for the aquatic life protection "shall not be exceeded at any time." The chronic standard (CS) "shall not be exceeded by the arithmetic average of at least four consecutive samples collected over any period of at least four days." The human health standard (HHS) "shall not be exceeded when the stream flow is at or above the harmonic mean flow…nor shall an annual average, based on at least eight samples, collected in a manner representative of the sampling period, exceed the HHS."

For the metals that have water quality-based standards dependent upon hardness, the water quality standard is calculated using the hardness of the water body at the time the metals sample was collected. To calculate attainment status of chronic metals standards, the concentration of the metal in each sample is divided by the calculated water quality standard for the sample. This ratio, called a quotient, indicates how many times the measured value exceeds the standard. The water quality standard is attained if the mean of the sample quotients is less than or equal to one for the duration of the averaging period.

The acute standard was exceeded on three occasions (Table 5.17) for various constituents. The IEPA sampling on May 26, 1999 in Algonquin showed unusually high concentrations for most analyzed metals. For example, the acute standard for copper was exceeded by 10 times and the chronic standard by about 20 times.

Table 5.17. Acute Toxicity of Metals: Measurements Exceeding Acute Standard, 1998–2002

Station	*Stream*	*Date*	*Constituent*	*Conc. (µg/L)*	*Acute quotient*	*Agency*
24	Fox River, Algonquin	May 26, 1999	Ni, total	389	1.99	IEPA
			Cu, total	485	10.48	IEPA
26	Fox River, South Elgin	May 17, 2002	Zn, total	500	1.62	IEPA
25	Poplar Creek	Apr 13, 1999	Fe, dissolved	1300	1.30	IPEA

Table 5.18. Fox River: Chronic Toxicity of Metals: Measurements Exceeding Chronic Standard, 1998–2002

Station	*Location*	*Date*	*Constituent*	*Conc. (µg/L)*	*Chronic quotient*	*Agency*
24	Algonquin	17 Mar 1998	Zn, total	130	1.97	IEPA
		26 May 1999	Zn, total	203	3.91	IEPA
			Ni, total	389	32.84	IEPA
			Cu, total	485	17.17	IEPA
		13 Feb 2001	Ni, total	30	2.32	IEPA
26	South Elgin	16 Sep 1998	Ni, total	13	1.33	FRWRD
		17 May 2002	Zn, total	500	9.04	IEPA
27	Montgomery	2 Feb 1998	Ni, total	39	2.71	FMWRD
		3 Aug 1998	Ni, total	33	2.62	FMWRD
		2 Nov 1998	Ni, total	16	1.18	FMWRD
		1 Feb 1999	Ni, total	28	2.30	FMWRD
		1 Jun 1999	Ni, total	29	2.27	FMWRD
		1 Aug 2000	Ni, total	16	1.38	FMWRD
			Cu, total	30	1.08	FMWRD
			Zn, total	67	1.32	FMWRD
		28 Nov 2000	Ni, total	33	2.25	IEPA
		4 Jun 2002	Zn, total	65	1.30	FMWRD
33	Route 34, Oswego	2 Feb 1998	Ni, total	45	3.33	FMWRD
		2 Jun 1998	Ni, total	16	1.27	FMWRD
		3 Aug 1998	Ni, total	33	2.83	FMWRD
		2 Nov 1998	Ni, total	19	1.42	FMWRD
		1 Feb 1999	Ni, total	30	2.48	FMWRD
		1 Jun 1999	Ni, total	27	2.02	FMWRD
		1 Jun 2000	Ni, total	13	1.1	FMWRD
			Cu, total	43	1.54	FMWRD
240	I-90 Bridge north of Elgin	16 Sep 1998	Ni, total	12	1.16	FRWRD

Table 5.19. Fox River Tributaries: Chronic Toxicity of Metals: Measurements Exceeding Chronic Standard, 1998–2002

Station	*Location*	*Date*	*Constituent*	*Conc. [μg/L]*	*Chronic quotient*	*Agency*
25	Poplar Creek, Route 20	May 6, 2002	Cd, total	4	1.36	IEPA
28	Blackberry Creek, Route 47	Dec 21, 1999	Ni, total	29	1.88	IEPA
			Cu, total	49	1.33	IEPA
94	Little Indian Creek at Syndam Road	Aug 27, 2002	Cd, total	4	1.36	IEPA
236	Nippersink Creek, Spring Grove,	Jul 17, 2000	Ni, dissolved	25	1.96	IEPA

Statistical evaluation of chronic toxicity is limited by the prevalence of reported concentrations below the detection limit. Only 5 percent of reported concentrations for constituents with Illinois water quality standards are actual values, not the detection limit, which does not allow calculating the probability of compliance with a standard. However, this does not mean heavy metals are not a problem in the Fox River watershed. For example, the IEPA detection limit for cadmium or nickel exceeds the chronic standard. The evaluation of compliance with acute and chronic standards is impossible with existing data. Tables 5.18 and 5.19, respectively, display actual measurements exceeding chronic standards in the Fox River mainstem and its tributaries.

5.3. Data Gaps

The following sections describe available data and its limitations (data gaps) in terms of geographic coverage in the watershed, period of record, constituents monitored, and monitoring type and frequency.

5.3.1. Geographic Coverage and Period of Record

The FoxDB includes water quality data collected at 190 different sites in the Fox River watershed; 88 sites are located directly on the Fox River and 102 sites are on the tributaries. However, only 60 sites were sampled at least once during the last five years (1998-2002): 38 sites on the Fox River and 22 sites on its tributaries (Figure 5.25). The middle part of the watershed (mostly in Kane County) was monitored extensively contrary to a sporadic coverage of the lower part of the watershed. The middle part has been a focus of water quality studies due to its urbanization level and numerous impoundments in this region.

The dams and associated impoundments introduce discontinuity and limit whether the sample accurately reflects water quality above and below the monitoring site. Water quality, as

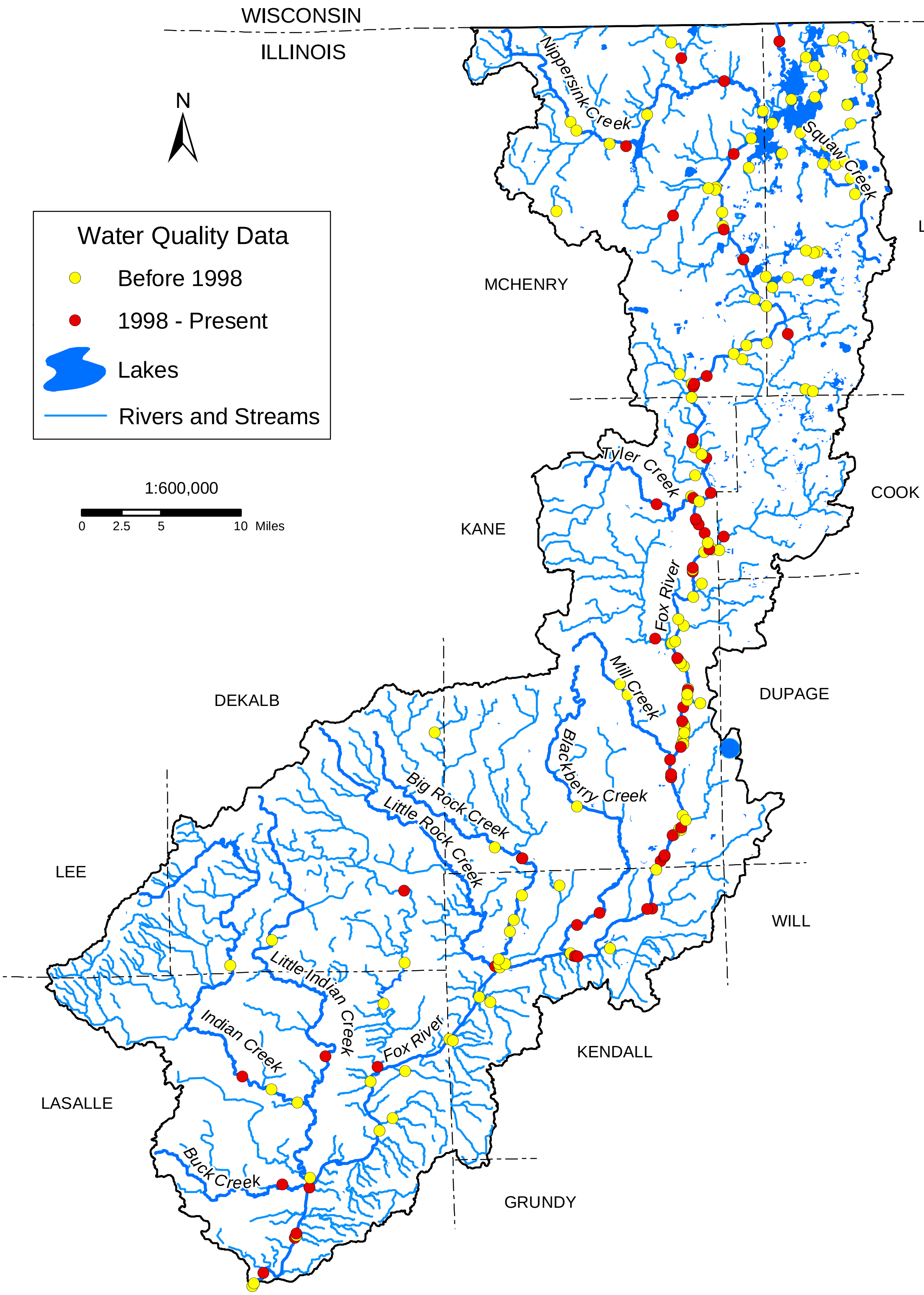

Figure 5.25. Stations for which water quality data are available

well as chemical and biological processes, differ between free-flowing and impounded reaches. Data from individual impoundments and free-flow areas would be required to fully understand and evaluate water quality in the Fox River.

The next series of maps shows the availability of recent measurements for individual constituents: DO, ammonia nitrogen, nitrate nitrogen, phosphorus, fecal coliform, suspended solids, and trace metals (Figures 5.26–5.32). Only stations with recent data (1998–2002) are displayed, categorized by number of data points available. These figures include grab samples as well as continuous water quality measurements. Generally, water quality data are very limited for the lower part of the watershed and for the Fox River tributaries.

A standard constituent included in most monitoring programs is DO, a primary indicator of enrichment by organic matter. Most stations with DO measurements are located in the middle part of the watershed (Figure 5.26), which is typical for all constituents. Most tributaries have either no data or limited data available.

Sites with available nutrient data (ammonia, nitrate, and phosphorus, Figures 5.27–5.29) and associated constituents (suspended solids, Figure 5.31) exhibit a similar spatial pattern. Sufficient data were gathered at sites evenly located along the mainstem with a cluster of sites around Elgin. Other sites have no data or limited data.

Fecal coliform was sampled at several sites along the mainstem, again with a cluster of sites around Elgin (Figure 5.30). Limited trace metals data (Figure 5.32) are available for some tributaries and for the Fox River. Symbols indicate a total number of samples analyzed over the last five years, including those many concentrations below detection limit.

The sampling of tributaries mostly is limited to locations near their confluence with the Fox River. Table 5.20 summarizes data available for Fox River tributaries. Stations nearest to the confluence are included because of their importance in modeling water quality in the Fox River. Only three tributaries are a part of regular monitoring programs (Poplar Creek, Blackberry Creek, and Somonauk Creek).

Three tributaries represent a top priority in bridging the data gap: Crystal Creek has no current data, but there are several point sources in its watershed (Lake in the Hills Sanitary Treatment Plant or STP, and Crystal Lake STP). Recent data available for both Tyler Creek and Ferson Creek are insufficient (sampled once or twice). However, these creeks represent significant tributaries in the area of interest.

High priority can be assigned to Flint Creek, There are three point sources upstream in the Flint Creek watershed: Barrington STP, Cary STP, and Quaker Oats. Current data are insufficient (all sampled once in July 2000).

Poplar Creek has data available from the IEPA's regular monitoring at 6-week sampling intervals. These data would be desirable to refine. There are no data for Waubansee Creek draining an area that is experiencing high growth. No current data exist for Indian Creek, Little Rock Creek, Big Rock Creek, or Buck Creek, significant tributaries in the area downstream of Yorkville. Gathering of the data for these tributaries should receive medium priority.

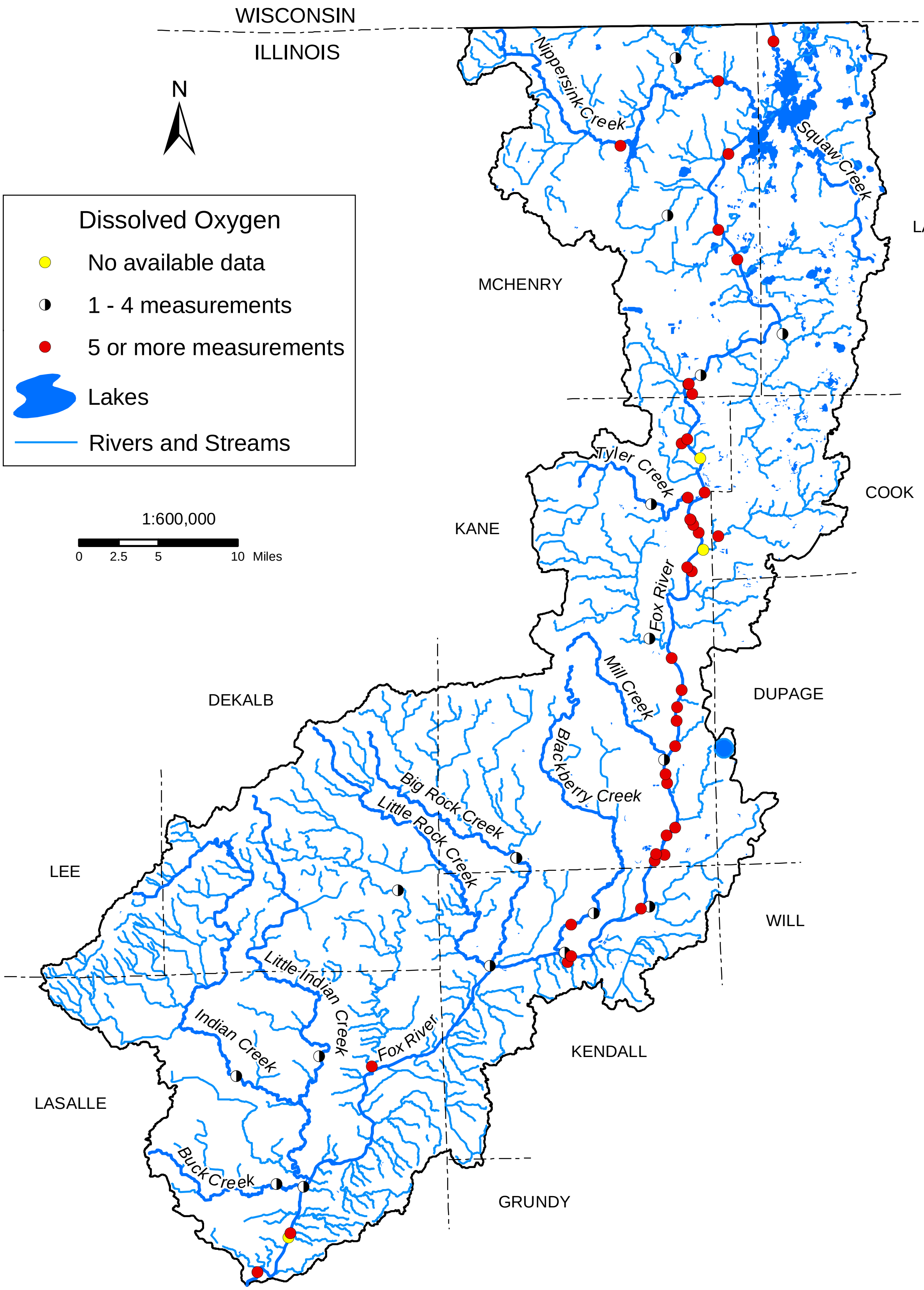

Figure 5.26. Stations for which dissolved oxygen data are available, 1998–2002

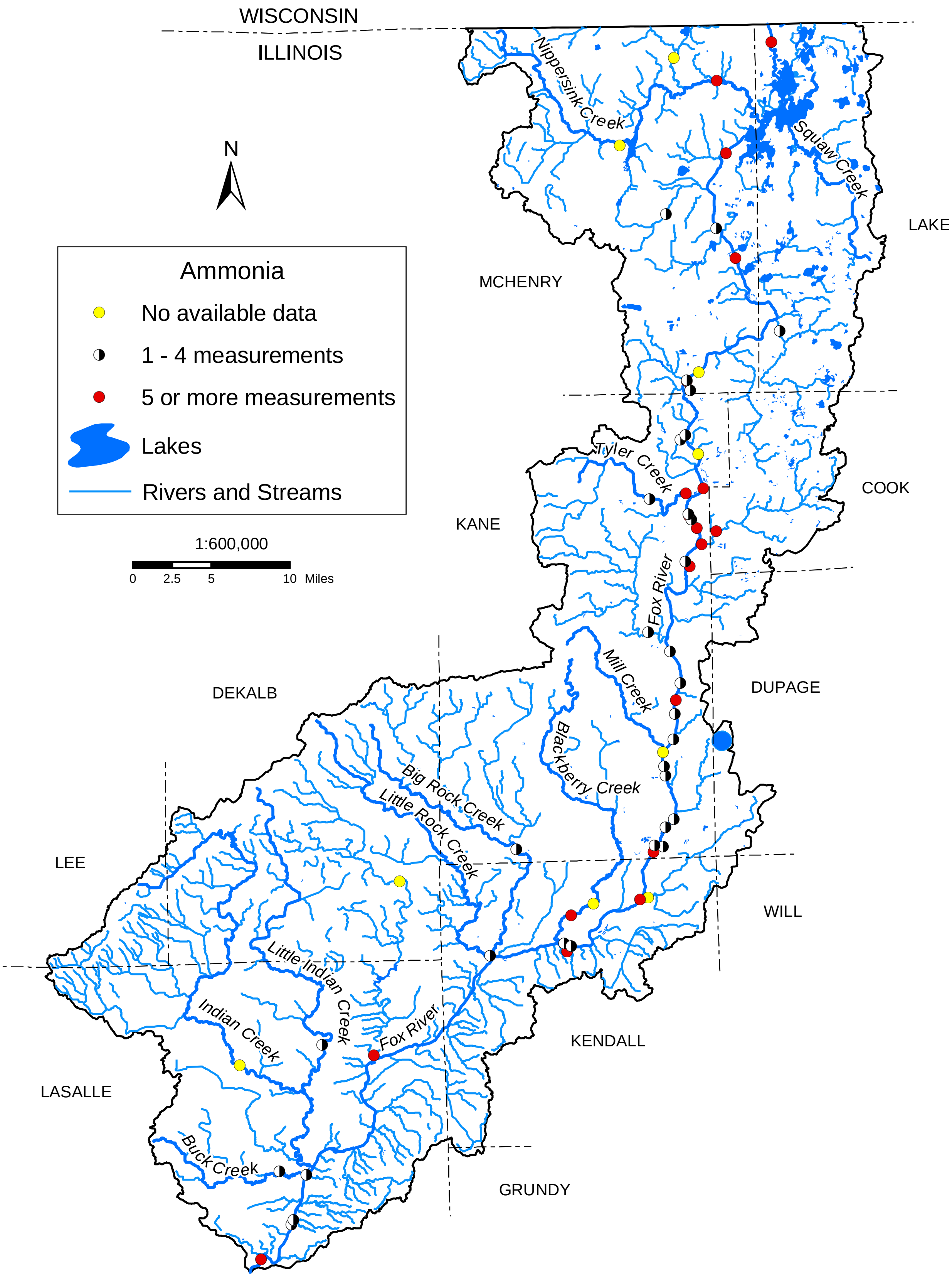

Figure 5.27. Stations for which ammonia data are available, 1998–2002

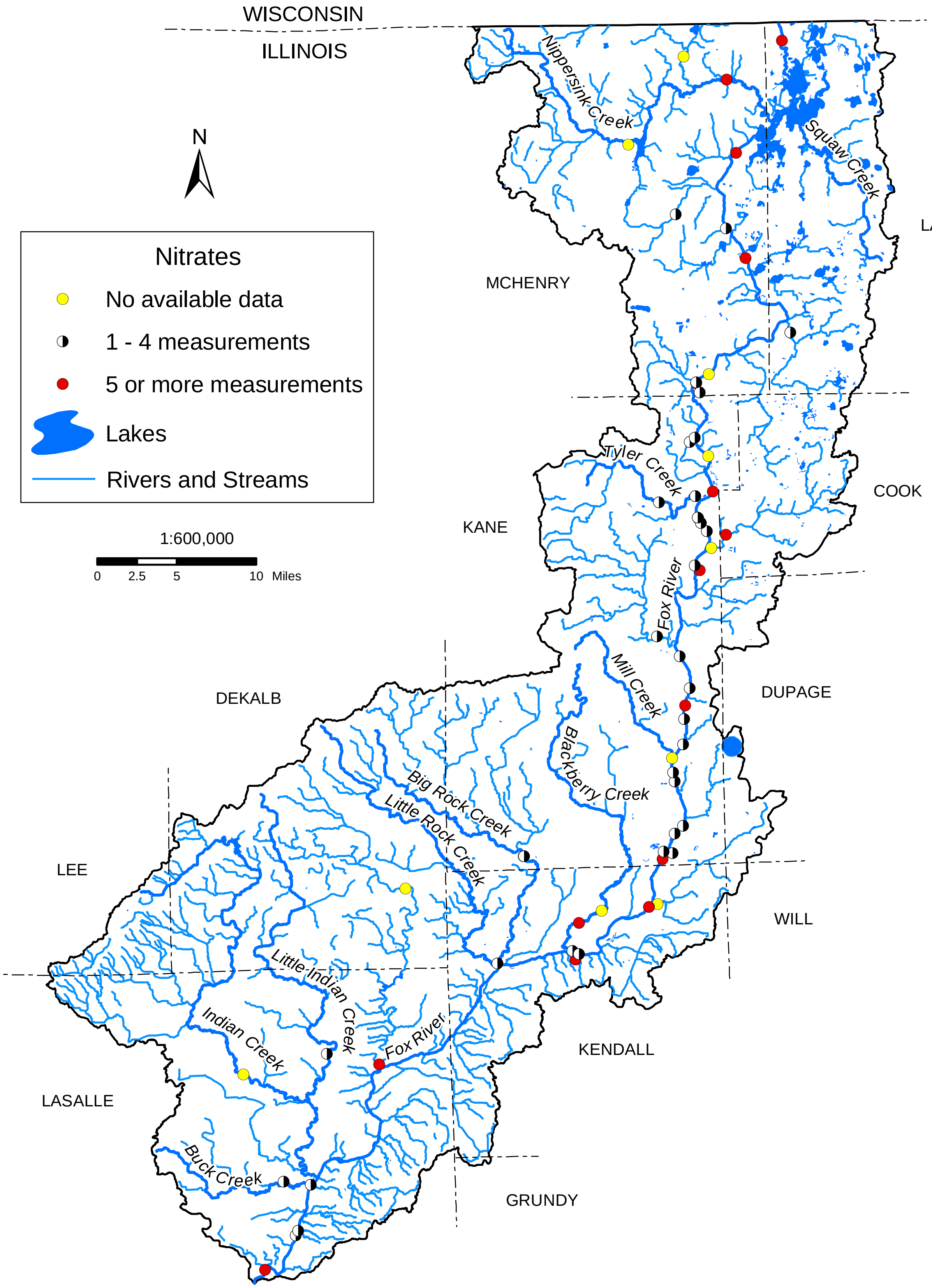

Figure 5.28. Stations for which nitrate data are available, 1998–2002

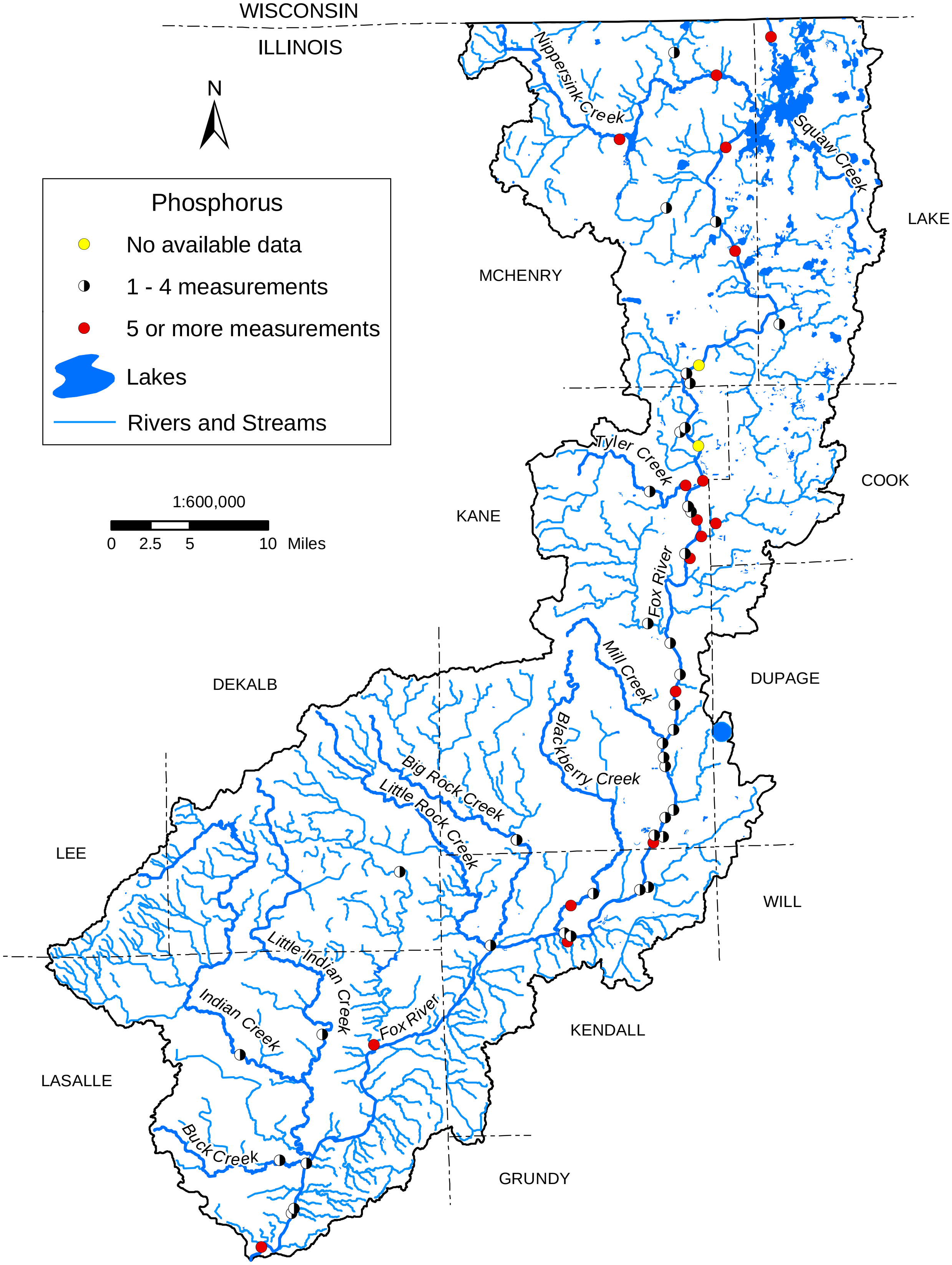

Figure 5.29. Stations for which phosphorus data are available, 1998–2002

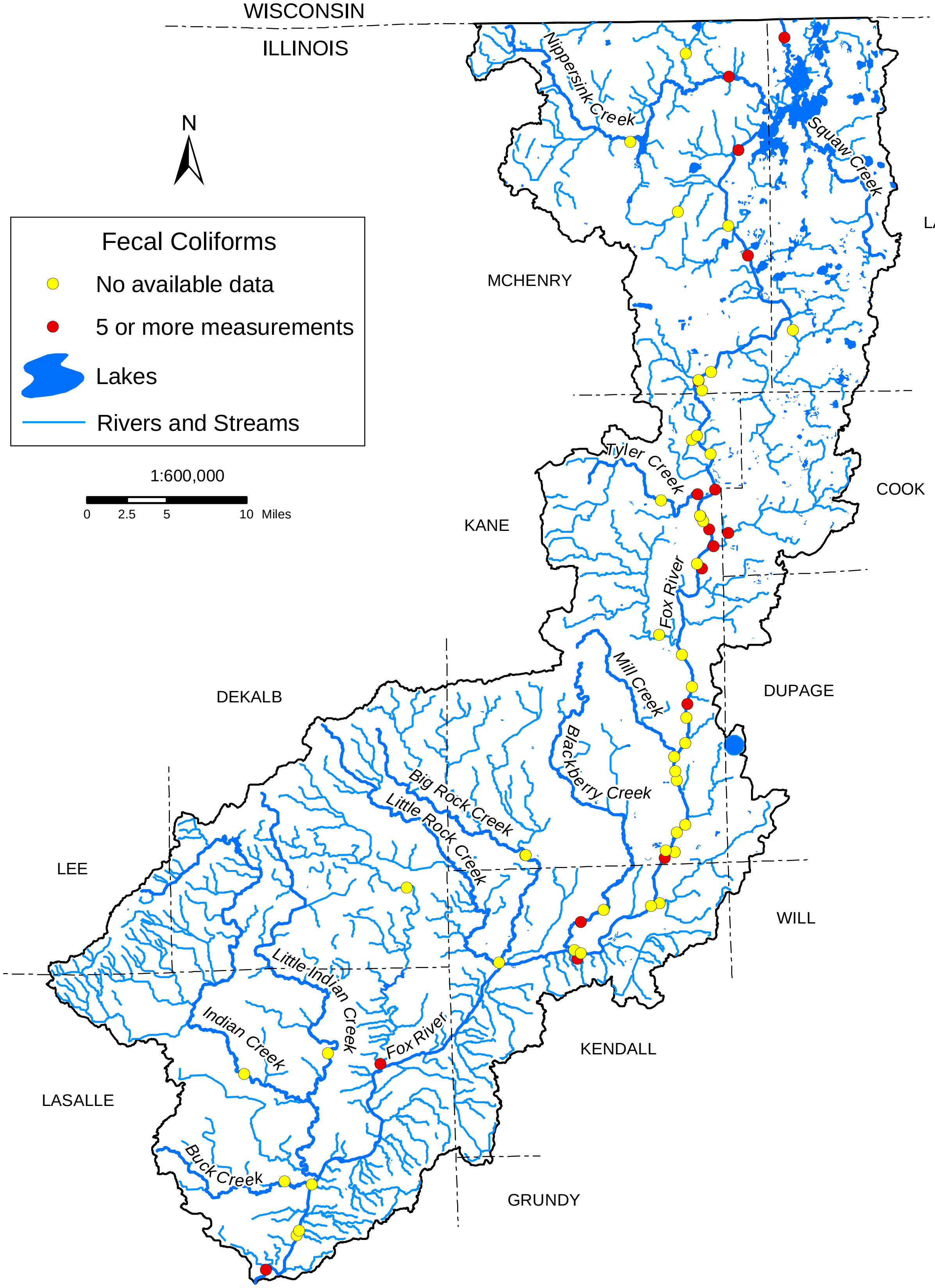

Figure 5.30. Stations for which fecal coliform data are available, 1998–2002

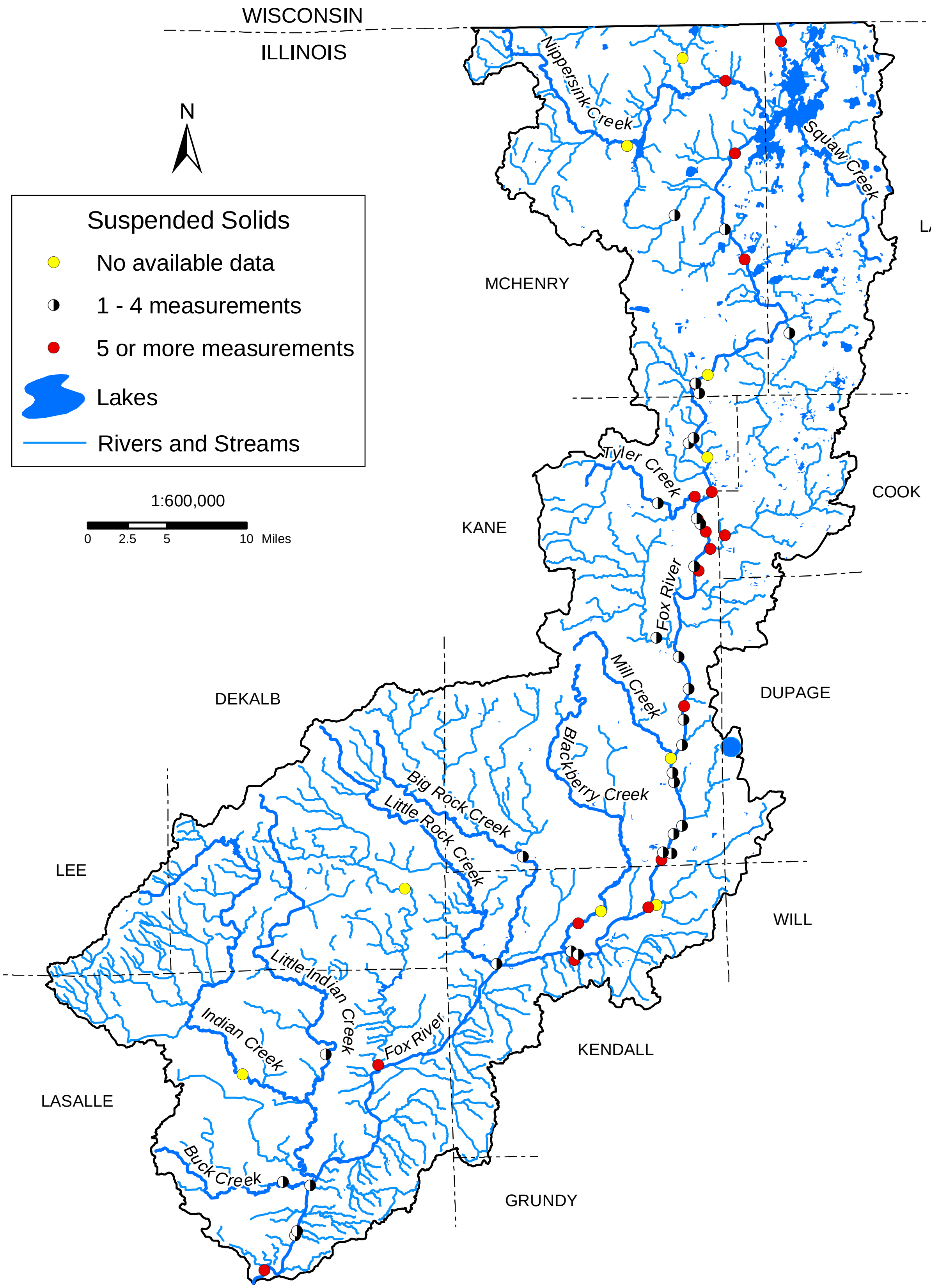

Figure 5.31. Stations for which suspended solids data are available, 1998–2002

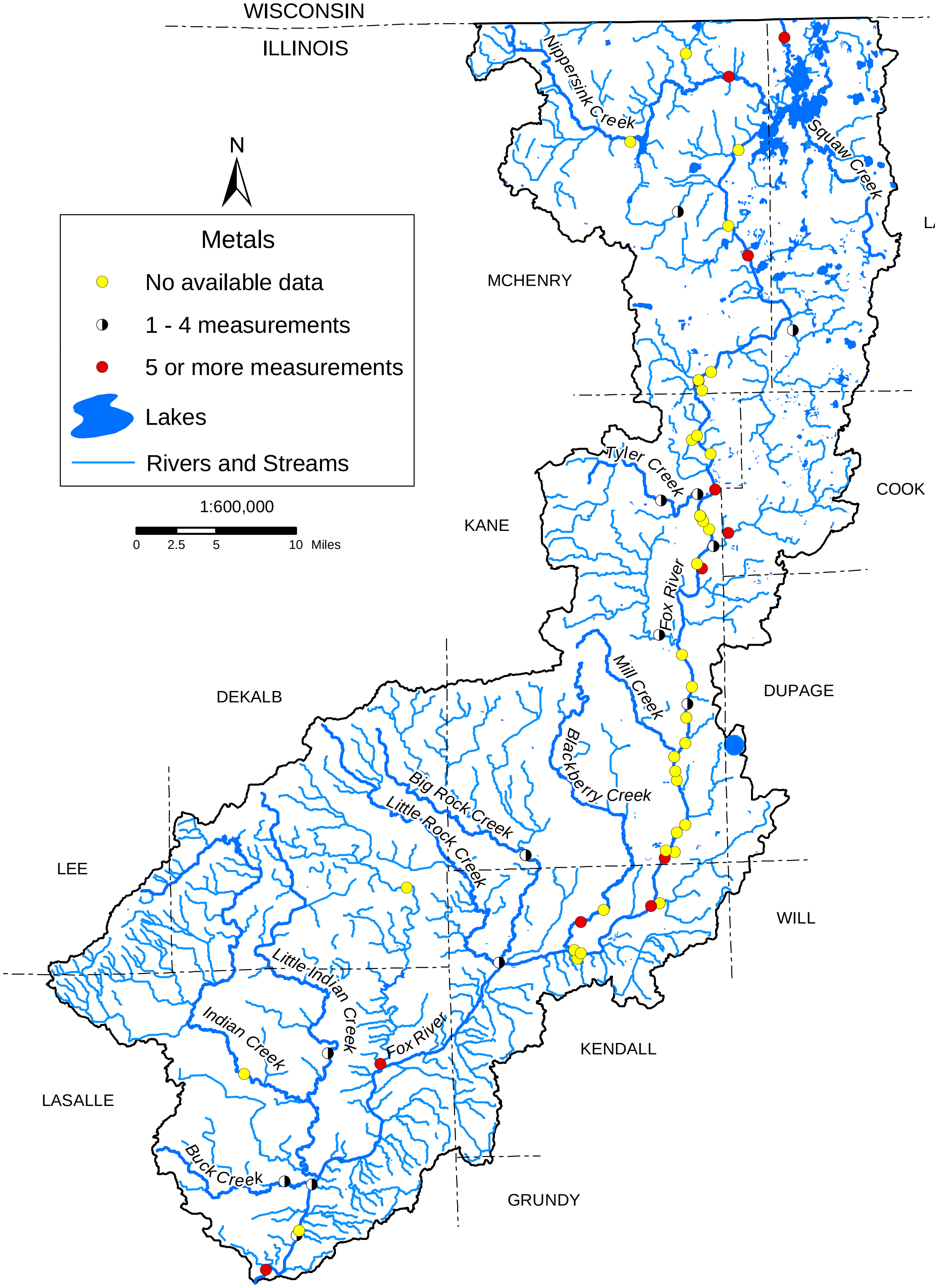

Figure 5.32. Stations for which metals data are available, 1998–2002

Table 5.20. List of Fox River Tributaries and Available Water Quality Data Ordered from Upstream to Downstream

Tributary name	*Station ID*	*Agency*	*Year*	*Sampling frequency*
Boone Creek	3	NAWQA	2000	(1 sample)
		IEPA	2002	(2 samples)
Flint Creek	4	NAWQA	2000	(1 sample)
Spring Creek	275*	*	(1970s, 1980s)	*
Crystal Creek	271*	*	(1970s)	*
Tyler Creek	5	NAWQA	2000	(1 sample)
	268	FRWRD	1998	1 week
Poplar Creek	25	IEPA	1998–2002	6 weeks
		NAWQA	2000	(1 sample)
	615	FRWRD	1998	1 week
Ferson Creek	14	NAWQA	2000	(1 sample)
		IEPA	2002	(2 samples)
Mill Creek	15	NAWQA	2000	(1 sample)
Waubansee Creek	16	NAWQA	2000	(1 sample)
Blackberry Creek	28	IEPA	1998–2002	6 weeks
	17	NAWQA	2000	(1 sample)
Little Rock Creek	19	NAWQA	2000	(1 sample)
		IEPA	2002	(1 sample)
Big Rock Creek	75*	*	(1970s, 1980s)	*
	18	NAWQA	2000	(1 sample)
	99	IEPA	2002	(1 sample)
Somonauk Creek	29	IEPA	1998–2002	6 weeks
	20	NAWQA	2000	(1 sample)
Indian Creek	74*	*	(1970s, 1980s)	*
	564*	*	(1980s)	*
	21	NAWQA	2000	(1 sample)
Little Indian Creek	94	IEPA	2002	(2 samples)
Buck Creek	22	NAWQA	2000	(1 sample)
		IEPA	2002	(2 samples)

Note: *Stations with no recent data available.

5.3.2. Chemical Data Gaps

There are pollution issues typically associated with urbanizing area for which little or no data are available in the study area. The insufficiency of data precludes determining if these are problematic in the Fox River watershed.

Priority Pollutants. A lack of accurate values for trace metals and especially their dissolved form is a serious limitation. State-of-the-art "clean" techniques minimizing sample contamination are not presently used in collecting and analyzing priority pollutants. In addition, analytical methods with relatively high detection limits hinder data usability. For example, the IEPA detection limit for cadmium or nickel is higher than the respective chronic standards, which precludes evaluating compliance with the standards.

Winter Runoff. Potential pollutants associated with melting snow are a concern to watershed managers in northern climates, especially in areas applying chemicals for road deicing. Snowmelt and associated early spring runoff can carry substantial portions of the annual load of pollutants such as hydrocarbons, metals, solids, nutrients, and chlorides. Snowmelt runoff originates from short duration chemically driven events due to application of deicers and from longer duration end-of-season events due to warmer temperatures. Snowmelt runoff carries pollutants that have accumulated in the snowpack for prolonged periods, as well as street and soil surface material that washes off these surfaces. In addition, high concentrations of chlorides can increase toxicity of heavy metals by increasing the dissolved fraction of heavy metals (Warren and Zimmerman, 1994).

Emerging Water Quality Issues. During the last three decades, monitoring and evaluation of the impact of chemical pollution has focused almost exclusively on the "conventional" priority pollutants. Another diverse group of chemicals has received comparatively little attention as potential environmental pollutants. This includes pharmaceuticals, active ingredients in personal care products, nutraceuticals, fragrances, sun-screen agents, and many others (e.g., Kolpin et al., 2002). These compounds and their metabolites are introduced to the aquatic environment primarily by untreated and treated sewage, although there are a number of exposure routes. Immediate effects could escape detection if they are subtle, while long-term effects could be insidious (Daughton and Ternes, 1999).

5.3.3. Limitations Imposed by Frequency and Type of Monitoring

Frequency. Current regular monitoring programs are not conducted with a frequency needed for evaluating compliance with IEPA water quality standards. Many standards require at least four samples within a 30-day period. Sampling once every six weeks or even biweekly does not satisfy this requirement. In this report, a probabilistic evaluation was substituted for direct assessment of compliance. This has been possible because the purpose of the previous analyses was to identify problematic areas and constituents. However, no firm conclusion can be made on compliance with water quality standards. This includes standards for fecal coliform and chronic standards for ammonia nitrogen.

Diurnal Measurements. Evaluation of nutrient enrichment and the effect of algae on the oxygen regime is possible only with diurnal measurements. Algae produce oxygen during the day and consume it during the night, causing a wide fluctuation in oxygen concentration. A daytime grab sample cannot always indicate possible problems. Diurnal measurements are critical for evaluating compliance with the IEPA standards for DO. Continuous monitoring of DO and other constituents (e.g., temperature, pH, and conductivity) is now possible with available instrumentation. Only the MMGWF conducted continuous monitoring in the Fox River during the last five years. Critical night conditions are not reflected in available grab samples that were mostly collected in the morning or early afternoon.

Event-Driven Sampling. Current sampling programs do not address all problems related to urban, and agricultural runoff or combined sewer overflows. Water quality can change rapidly during runoff events with receding and rising portions of the hydrograph yielding different concentrations for the same flow. Thus, a single sample is not representative of the mean concentration during the event. Flow proportional sampling or multiple sampling of the event would be required to evaluate average event concentrations or loads associated with the event.

5.4. Summary

Water quality data compiled in the FoxDB were analyzed for major constituents. Table 5.21 summarizes results of analyses described in this chapter for key locations on the Fox River. Problems are identified either by presence of values exceeding the standards (DO, P, and pH) or by probabilistic evaluation (ammonia nitrogen and fecal coliform). Water quality data for two locations, Algonquin and South Elgin, indicate possible problems for all investigated constituents.

Table 5.22 reviews critical time and critical conditions for investigated constituents. The constituents can be categorized into two groups: problems associated with summer and low-flow period, or with high-flow periods (usually spring runoff events). Steady-state water quality models are appropriate to describe summer fairly constant low-flow conditions. Pollutants associated with runoff events should be modeled using dynamic models.

Table 5.21. Water Quality Problems Identified at Selected Locations

	Probabilistic non-compliance			*Presence of samples with substandard values*	
Location	*Ammonia nitrogen (Chronic quotient >1)*	*Fecal Coliform (>400/100mL)*	*Phosphorus (>0.076 mg/L+)*	*DO (<5 mg/L)*	*pH (>9)*
Johnsburg			X	X	
Route 176			X	X	
Algonquin	X	X	X	X	X
South Elgin		X	X	X	X
Geneva		X	X	X	
Montgomery		X	X		X
Oswego			X	X	X
Yorkville		X	X		X
Ottawa	X	X	X		X

Note:
+ Not a water quality standard

Table 5.22. Critical Times and Conditions Identified for Selected Constituents in the Fox River Watershed

Constituent	*Critical time*	*Critical conditions*
DO	Summer (seasonal variation) Prior to sunrise (diurnal variation)	High temperature, low flow Impoundment, algae
Total nitrogen	Concentration fairly constant	Both high and low flows
Ammonia	Varies, typically summer (lower standard)	Low flow, high temperature and high pH (effects standard)
Nitrate/nitrite	Spring	Precipitation events
Total phosphorus	Summer	Low flow (concentration) High flow (load)
Fecal coliform	Summer (lower standard)	No clear pattern
pH	Varies	Low flow, algae
Suspended solids	Summer (concentration) Spring to early summer (load)	High flow
Algae	Summer	Low flow, nutrient enrichment
Trace metals	Summer	Insufficient data available