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Fecal-Indicator Bacteria Concentrations in the Illinois River between Hennepin and Peoria, Illinois: 2007–08

Open File Report 2012–1075

U.S. Department of the Interior
U.S. Geological Survey

Cover photographs:
(Top) Barge on the Illinois River at Hennepin, IL., photograph by Jennifer Sharpe.

(Lower left) USGS hydrologist, David Dupre, collecting water sample from the Illinois River., photograph by Jennifer Sharpe.

(Lower right) USGS hydrologists, Paul Terrio, Erin Bertke, and Elizabeth Murphy, processing samples for fecal coliform., photograph by Jennifer Sharpe.

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By David H. Dupré, Jon E. Hortness, Paul J. Terrio, and Jennifer B. Sharpe

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KEN SALAZAR, Secretary

U.S. Geological Survey
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Conversion Factors, Vertical Datum, and Abbreviations

Inch/Pound to SI

Multiply	By	To obtain
	Length	
inch (in.)	2.54	centimeter (cm)
inch (in.)	25.4	millimeter (mm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
	Area	
square mile (mi^2)	259.0	hectare (ha)
square mile (mi^2)	2.590	square kilometer (km^2)
	Flow rate	
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)

Temperature in degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) as follows:

°F=(1.8×°C)+32

Vertical coordinate information is referenced to North American Vertical Datum of 1988 (NAVD 88).

Horizontal coordinate information is referenced to North American Datum of 1983 (NAD 83).

Altitude, as used in this report, refers to distance above the vertical datum.

Specific conductance is given in microsiemens per centimeter at 25 degrees Celsius (µS/cm at 25 °C).

Concentrations of chemical constituents in water are given either in milligrams per liter (mg/L) or micrograms per liter (µg/L).

Bacteria concentrations are given in colony-forming units per 100 milliliters (CFU/100 mL).

Water year is the 12-month period October 1 for any given year through September 30 of the following year. The water year is designated by the calendar year in which it ends and which includes 9 of the 12 months.

Abbreviations

CSO	combined sewer overflow
E. coli	*Escherichia coli*
FC	fecal coliform
FIB	fecal-indicator bacteria
IEPA	Illinois Environmental Protection Agency
TMDL	Total Maximum Daily Load
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey

Fecal-Indicator Bacteria Concentrations in the Illinois River between Hennepin and Peoria, Illinois: 2007–08

By David H. Dupré, Jon E. Hortness, Paul J. Terrio, and Jennifer B. Sharpe

Abstract

The Illinois Environmental Protection Agency has designated portions of the Illinois River in Peoria, Woodford, and Tazewell Counties, Illinois, as impaired owing to the presence of fecal coliform bacteria. The U.S. Geological Survey, in cooperation with the Tri-County Regional Planning Commission, examined the water quality in the Illinois River and major tributaries within a 47-mile reach between Peoria and Hennepin, Ill., during water year 2008 (October 2007–September 2008). Investigations included synoptic (snapshot) sampling at multiple locations in a 1-day period: once in October 2007 during lower streamflow conditions, and again in June 2008 during higher streamflow conditions. Five locations in the study area were monitored for the entire year at monthly or more frequent intervals. Two indicator bacteria were analyzed in each water sample: fecal coliform and *Escherichia coli* (*E. coli*). Streamflow information from previously established monitoring locations in the study area was used in the analysis. Correlation analyses were used to characterize the relation between the two fecal-indicator bacteria and the relation of either indicator to streamflow. Concentrations of the two measured fecal-indicator bacteria correlated well for all samples analyzed ($r = 0.94$, $p < 0.001$), indicating a strong linear correlation. Presence of one fecal-indicator bacteria generally indicates the presence of another at a similar magnitude and may support substitution of generalized data gaps for other analyses. Hydrologic conditions during the study period can be characterized as wetter than normal, with the mean annual flow in the Illinois River about 37-percent above the long-term average. However, for the Illinois River below Peoria Lake at Peoria, a statistically significant negative correlation coefficient indicates a weak inverse relation between values of streamflow and fecal-indicator bacteria (fecal coliform: rho = −0.44, p = 0.0129; *E. coli*: rho = −0.43, p = 0.0157). The correlation between fecal indicators and streamflow in tributaries or in the Illinois River at Hennepin was found to be statistically significant, yet moderate in strength with coefficient values ranging from $r = 0.4$ to 0.6. Indirect observations from the June 2008 higher flow synoptic event may indicate continued effects from combined storm and sanitary sewers in the vicinity of the Illinois River near Peoria, Ill., contributing to observed single-sample exceedance of the State criterion for fecal coliform.

Introduction

Portions of the Illinois River in Peoria, Woodford, and Tazewell Counties, Illinois, are designated as impaired by the Illinois Environmental Protection Agency (IEPA) owing to the presence of fecal coliform (FC) bacteria (Illinois Environmental Protection Agency, 2008). FC bacteria are used as an indicator of possible pathogens. Elevated concentrations of FC bacteria could cause a violation of the State water-quality standard for general-use waters primarily because of potential ingestion or physical exposure. Epidemiological research has demonstrated a relation between illness rates and the proximity to known FC bacteria point sources (Cabelli and others, 1982; Wade and others, 2006). Combined sewer overflows (CSOs) from the City of Peoria occur periodically as a result of moderate to heavy rainfall in the area (City of Peoria, 2010). CSOs result in the release of storm water, along with raw sewage, to the Illinois River, which causes elevated bacteria concentrations in the vicinity of the outfalls. However, FC bacteria data collected in the Illinois River upstream of the City of Peoria CSO discharge points indicate the Illinois River often has background concentrations of FC bacteria that exceed the water-quality standard for general-use waters. Both point sources and diffuse sources of FC bacteria may contribute to the exceedances of the water-quality standard upstream of Peoria (Sercu and others, 2009).

The Tri-County Regional Planning Commission proposed to conduct a study to better identify the likely source areas of the bacterial contamination in the river upstream from Peoria. The overall study objectives were to evaluate the impacts that point sources and diffuse sources have on the concentrations of FC bacteria in the Illinois River between Hennepin, Ill., and

the outlet of Peoria Lake at Peoria, Ill. As part of this study, the U.S. Geological Survey (USGS) evaluated bacteria concentrations in streams tributary to the Illinois River between Hennepin and Peoria, Ill., and investigated the possibility that some of these streams may be sources of elevated bacteria concentrations in the Illinois River.

After this study began, the U.S. Environmental Protection Agency (USEPA) and IEPA initiated the development of a total maximum daily load (TMDL) for FC bacteria in this reach of the Illinois River. The bacteria data collected by the USGS will be a significant resource in the development of these TMDLs. The development of a TMDL for FC bacteria assumes the bacteria, and any associated pathogens, result from direct human-controlled activities (either from point sources or diffuse sources) and that successful compliance with a water-quality standard can be achieved through managing or removing the sources of bacteria. Several limitations to this assumption for FC bacteria should be noted:

- they are not specific to human sources,
- they can persist in a more-varied manner than the associated pathogens they are meant to indicate (Anderson and others, 2005; Wade and others, 2006), and
- they can become non-culturable (Leadbetter, 1997; Statham and McMeekin, 1994).

Generally, *Escherichia coli (E. coli)* are thought to be a more accurate indicator of potential human or animal-influenced pathogenic organisms than FC bacteria because they are a subset of the FC bacteria and reside in the gut of warm-blooded creatures (U.S. Food and Drug Administration, 1998). Other FCs are not necessarily unique to warm-blooded animals.

Purpose and Scope

This report describes the results of sampling for FC and *E. coli* bacteria (collectively referred to as fecal-indicator bacteria (FIB)) along the main stem and various tributaries of the Illinois River within the study area during water year 2008. Simple linear regressions of the two FIB data types were performed against each other and against streamflow. The hydrologic conditions of the study period are compared against long-term records to describe the observed FIB concentrations in relation to historical streamflows.

Description of Study Area

The general area for this study includes the main stem of the Illinois River from Hennepin downstream to Peoria, in addition to several small basins that are tributary to this reach of the Illinois River (fig. 1). The main stem reach within the study area extends approximately 47 river miles and receives inflows from about 1,500 mi^2 of contributing drainage area. Major tributaries to the study reach include Big Bureau Creek (491 mi^2), Senachwine Creek (87 mi^2), and Farm Creek (61 mi^2). The study area also encompasses several in-channel and off-channel lakes including Senachwine Lake, Upper Peoria Lake, and Peoria Lake.

The drainage areas along the study reach generally are rural with the exception of the area in and around Peoria, which is mostly urban. Land use varies throughout the region with row-crop farming being the most common, followed by deciduous forest areas and pasture lands (fig. 2).

Combined sanitary and storm sewers are present in Peoria and CSOs are common during higher intensity rainfall events. CSO occurrences average about 28 times per year, generally when total rainfall amounts exceed about 0.15 in. for any storm event. There are 20 potential overflow points located in Peoria (City of Peoria, 2010). Several smaller towns located along the Illinois River and within the various contributing drainage basins discharge effluent from wastewater-treatment plants to the main stem or tributaries (fig. 1).

Previous Investigations

Several investigations regarding the presence of bacteria in the Illinois River were previously conducted. Greenfield (1924) studied bacteria concentrations in the approximately 80-mi reach from LaSalle to Kingston Mines. Hoskins and others (1927) studied the entire length of the Illinois River from its origin near Joliet, Ill., downstream to the confluence with the Mississippi River near Grafton, Ill. (approximately 275 mi).

Lin and Evans (1980) analyzed water samples collected from the Illinois River at Peoria on a weekly basis during June 1971–May 1976. They found that bacteria concentrations ranged widely throughout the year, with the highest concentrations generally occurring during the winter and summer months. Building upon the work by Lin and Evans (1980), Lin and Beuscher (1994) analyzed weekly water samples during June 1976–May 1986. They found that throughout the 15-year period (1971–86) only about 17 percent of the samples were in compliance with the existing water-quality standard (geometric mean of 200 colony-forming units per 100 mL CFU/100 mL), from a minimum of five samples collected in a 30-day period; or 400 CFU/100 mL in a single sample).

The IEPA has in the past and continues to collect and analyze water samples at various locations within the study area as part of their Ambient Water Quality Monitoring Network. The samples are collected approximately every 6 weeks and are analyzed for over 55 parameters including FC bacteria.

Hydrologic Perspective

The period of data collection for this study, in general, coincided with a period of relatively high precipitation across much of central and northern Illinois, including most of the

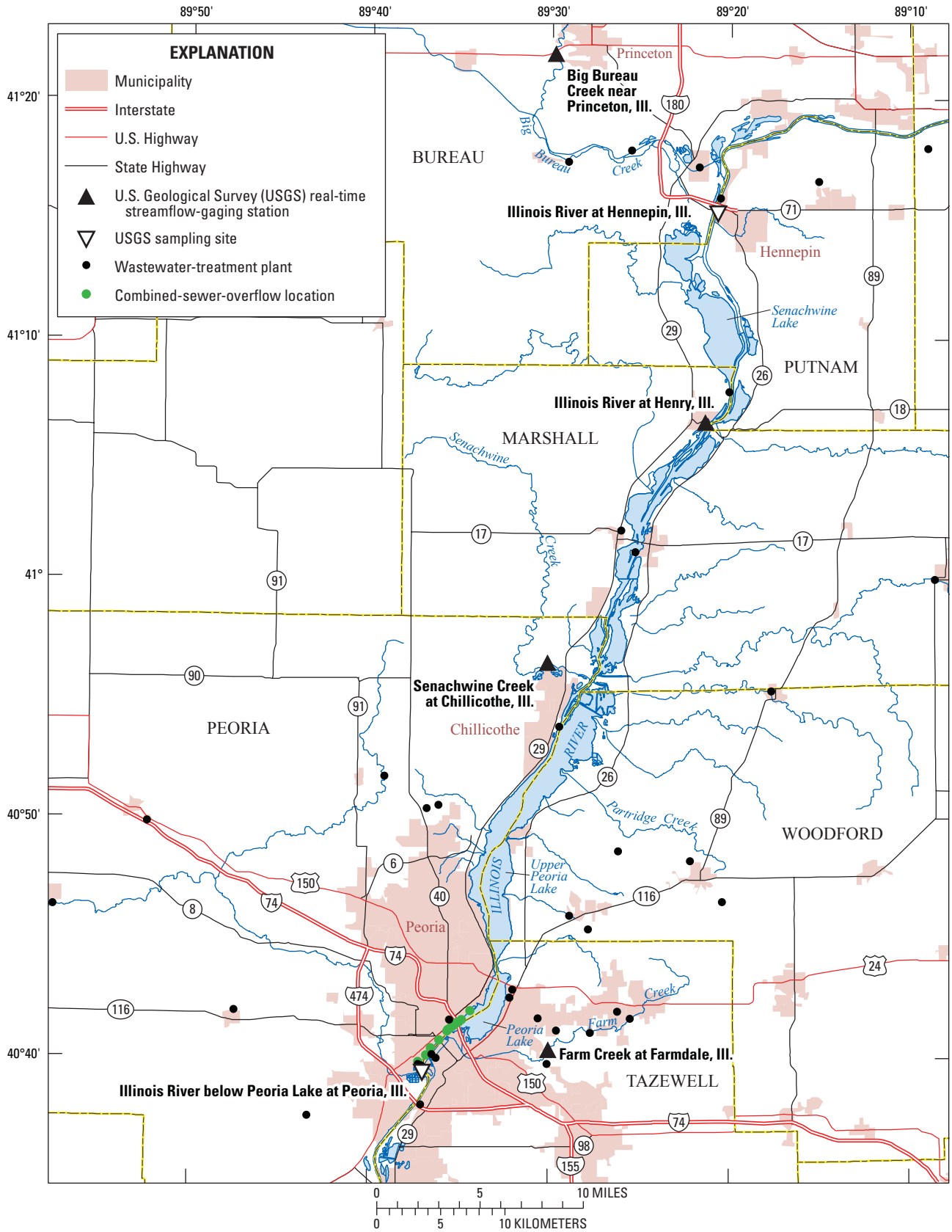

Figure 1. General study area, locations of combined-sewer-overflow points, and wastewater-treatment plant discharge points between Hennepin and Peoria, Illinois.

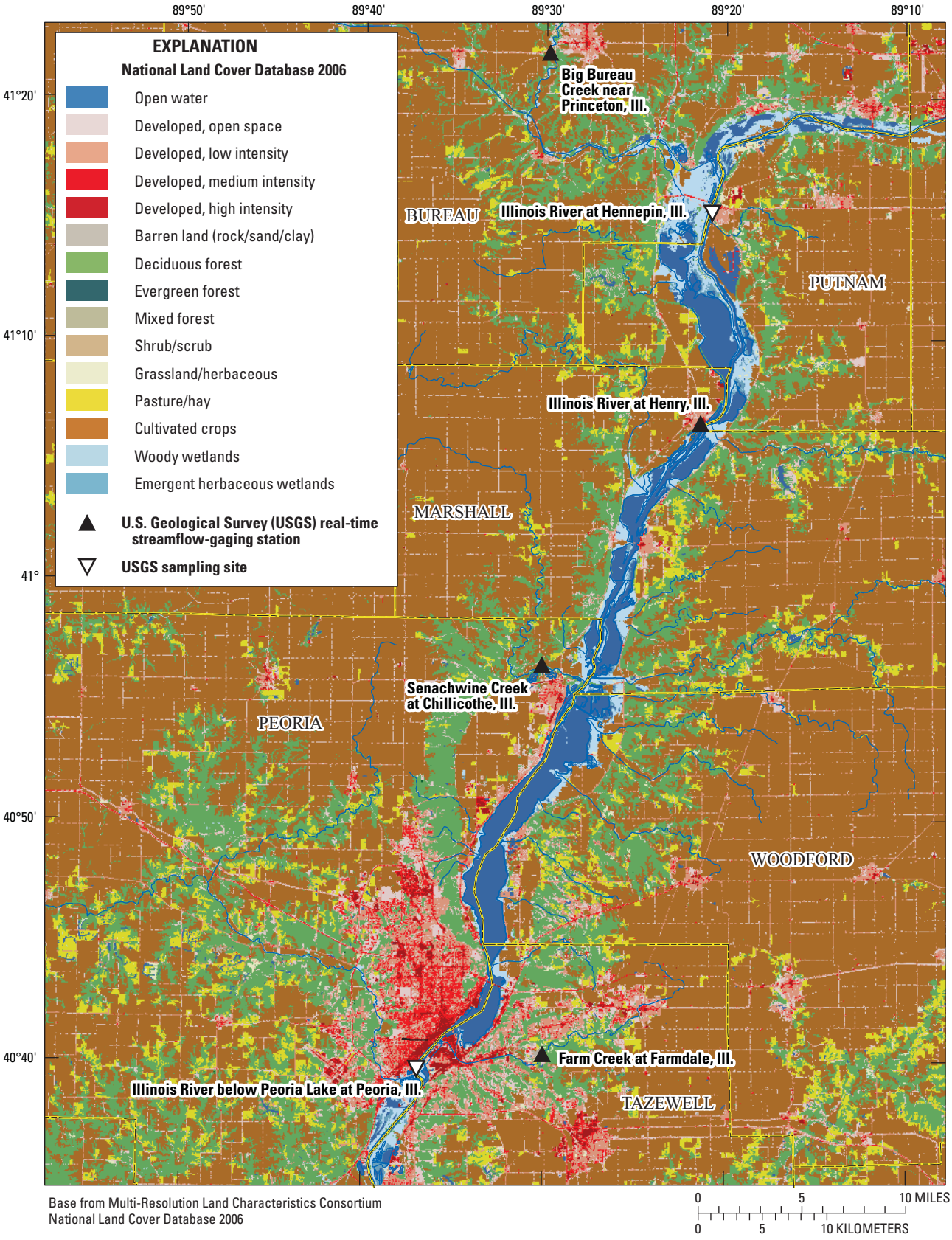

Figure 2. Land cover in the general study area between Hennepin and Peoria, Illinois.

Illinois River Basin. Average precipitation levels across the State for October–December 2007 were near normal to just slightly below normal (30-year average; 1971–2000). However, January–June 2008 was the wettest first 6 months of the year on record (since 1895), with a statewide average of 27.7 in., which was 8.3 in. above normal. The statewide average precipitation for the entire year (2008) was 50.7 in.—11.4 in. above normal—resulting in the second wettest year on record (Illinois State Water Survey, 2010). Specific locations within the Illinois River Basin showed similar precipitation results:

Chicago O'Hare International Airport: October–December 2007, 1.7 in. below normal; 2008, 14.6 in. above normal

Ottawa, Ill.: October–December 2007, 2.4 in. below normal; 2008, 6.6 in. above normal

Peoria Regional Airport: October–December 2007, 0.8 in. below normal; 2008, 10.5 in. above normal (National Oceanic and Atmospheric Administration, 2007, 2008).

As a result of the above-normal precipitation, streamflows in the Illinois River and in the tributaries within the study area were well above the long-term average. The annual mean streamflow for the Illinois River at Henry, Ill., (USGS streamflow-gaging station number 05558300, which is located north-central in the study area), was 20,600 ft^3/s for water year 2008. This was about 37-percent higher than the long-term (1982–2008) annual mean streamflow of 15,000 ft^3/s. Similarly, the annual mean streamflow for Big Bureau Creek at Princeton, Ill., (USGS streamflow-gaging station number 05556500, a tributary to the Illinois River near the upstream end of the study area), was 282 ft^3/s for water year 2008. This was about 97-percent higher than the long-term (1936–2008) annual mean streamflow of 143 ft^3/s. Hydrographs showing comparisons between water year 2008 and long-term daily mean streamflows for the Illinois River at Henry and Big Bureau Creek at Princeton are presented in figures 3 and 4, respectively.

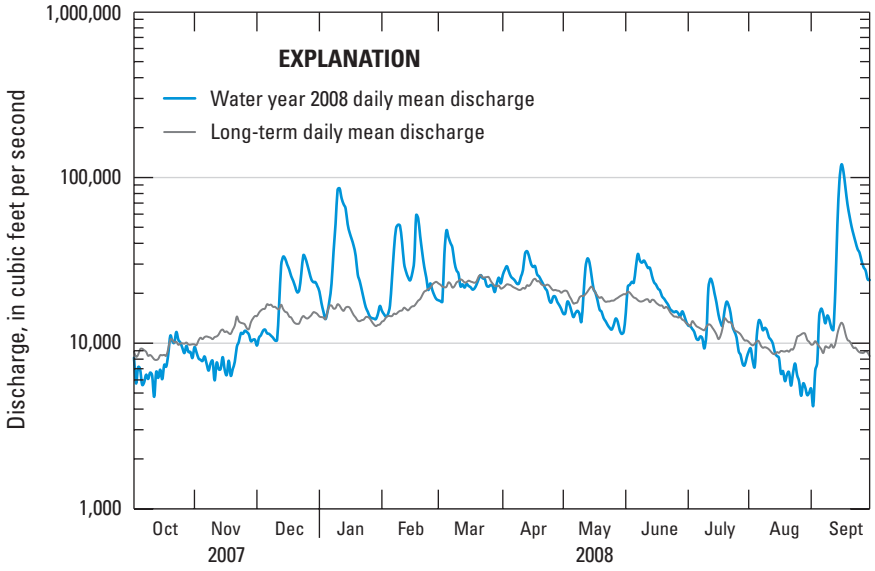

Figure 3. Comparison between water year 2008 and long-term daily mean streamflows for the Illinois River at Henry, Illinois (U.S. Geological Survey streamflow-gaging station number 05558300).

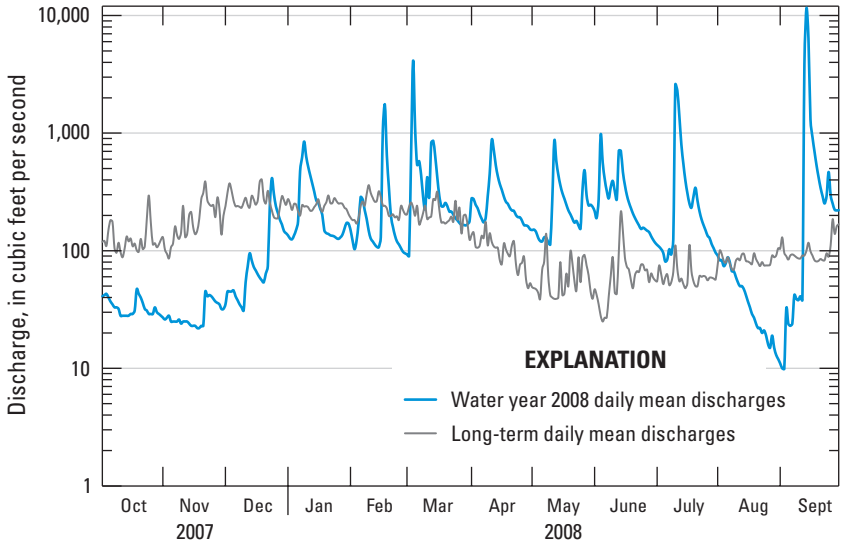

Figure 4. Comparison between water year 2008 and long-term daily mean streamflows for Big Bureau Creek at Princeton, Illinois (U.S. Geological Survey streamflow-gaging station number 05556500).

Data Collection

Samples were collected from the main stem of the Illinois River at Hennepin and Peoria, Ill., and near the outlets of three major tributaries to the Illinois River (Big Bureau Creek, Senachwine Creek, and Farm Creek) during the same time period. In addition, four sets of samples were collected at two locations in the upper portion of the Partridge Creek Watershed.

Two intensive synoptic sampling efforts also were completed under different environmental conditions. During these efforts, samples were collected at multiple locations along the main stem of the Illinois River and in several tributaries within the study area (fig. 5).

Two types of FIB were assessed: FC and *Escherichia coli* (*E. coli*). All samples were collected and processed following USGS standard protocols and methods documented in the USGS National Field Manual (U.S. Geological Survey, variously dated); specific details on FIB sampling are found in chapter A7 (Myers and others, 2007).

Periodic Sampling

Samples were collected approximately weekly at the Illinois River at Hennepin, Ill. (USGS streamflow-gaging station number 05556200) (table 1), and at the Illinois River below Peoria Lake at Peoria, Ill. (USGS streamflow-gaging station number 05562200) (table 2), for a total of 31 times during water year 2008. All of the samples were analyzed for both FC and *E. coli.* In addition, the following water-quality parameters were measured on-site during the sample collection: air temperature, water temperature, barometric pressure, dissolved oxygen, pH, and specific conductance. Streamflow is estimated at sites without continuous monitoring.

Samples were collected on a monthly basis near the outlets of three major tributaries to the Illinois River within the study area. A total of 11 samples were collected at Big Bureau Creek near Princeton, Ill. (USGS streamflow-gaging station number 05556500) (table 3); a total of 10 samples were collected at Farm Creek at Farmdale, Ill. (USGS streamflow-gaging station number 05560500) (table 4); and a total of 9 samples were collected at Senachwine Creek at Chillicothe, Ill. (USGS streamflow-gaging station number 05559700) (table 5).

Finally, four sets of samples (table 6) were collected at two locations in the upper portion of the Partridge Creek Watershed in an attempt to identify potential sources of bacteria within a specified stream reach. Again, all samples were analyzed for both FC and *E. coli*, and observations of air temperature, water temperature, barometric pressure, dissolved oxygen, pH, and specific conductance were measured on-site during sampling.

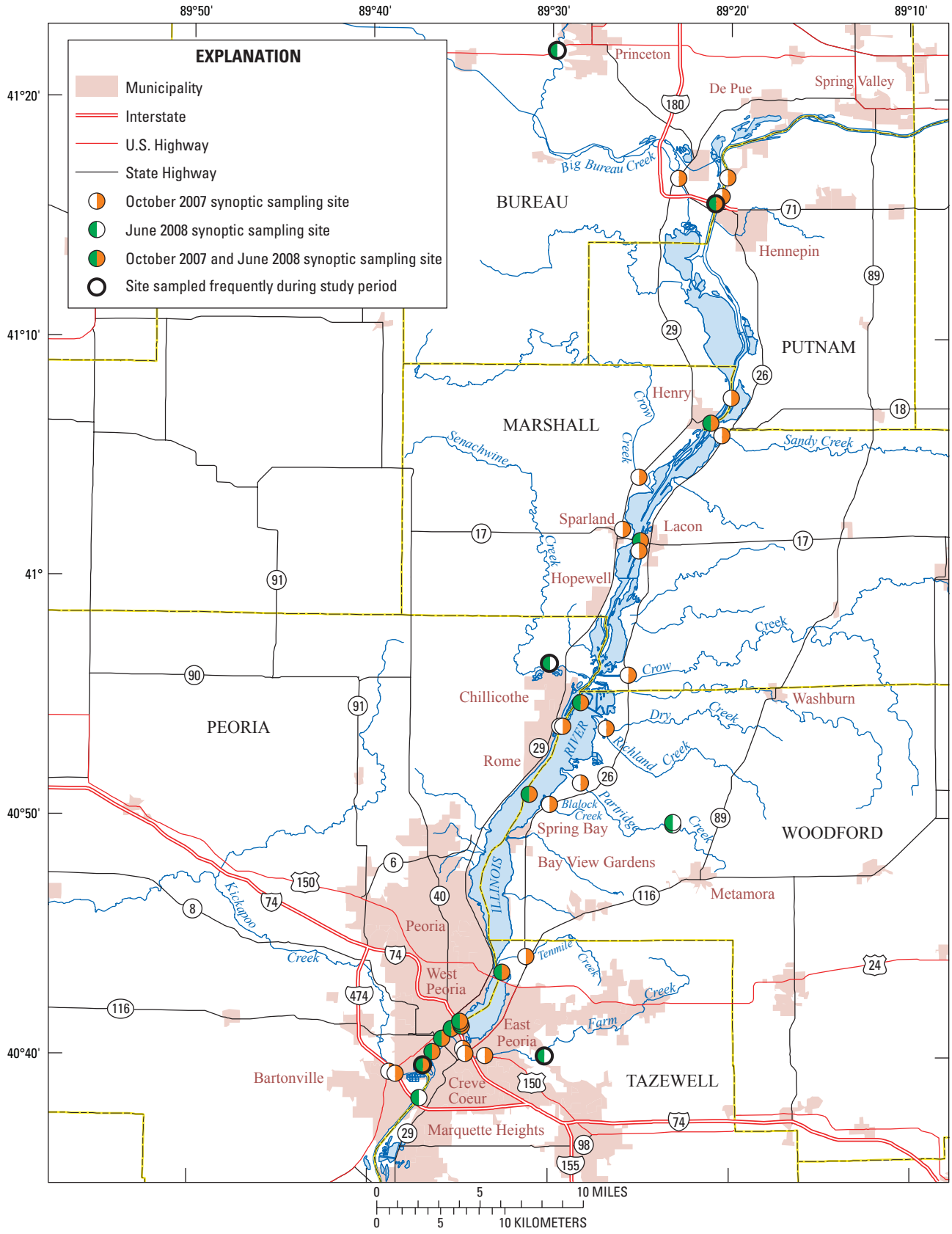

Figure 5. Locations sampled during October 2007 and June 2008 synoptic samplings and frequently during the study period between Princeton and Peoria, Illinois.

Table 1. Physical, chemical, and bacterial data for the Illinois River at Hennepin, Illinois (U.S. Geological Survey streamflow-gaging station number 05556200), during water year 2008 (October 2007–September 2008).

[hhmm, hour minute; Hg, mercury; MF, membrane filter; col/100 mL, colonies per 100 milliliters; ft, foot; ft³/s, cubic foot per second; micron, micrometer; mg/L, milligrams per liter; mm, millimeter; °C, degrees Celsius; µS/cm, microsiemens per centimeter; —, no data; E, estimated; k, counts outside acceptable range; CDT, central daylight time; CST, central standard time]

Sample notes	Date	Time (24-hour clock, hhmm)	Barometric pressure, (mm Hg) (00025)	Temperature, air, (°C) (00020)	Discharge, (ft³/s) (00060)	Dissolved oxygen, water, unfiltered, (mg/L) (00300)	pH, water, unfiltered, field, (standard units) (00400)	Specific conductance, water, unfiltered, (µS/cm at 25 °C) (00095)	Temperature, water, (°C) (00010)	Gage height, (ft) (00065)	Number of sampling points, (count) (00063)	*Escherichia coli*, modified m-TEC MF method, water (col/100 mL) (90902)	Fecal coliform, M-FC MF (0.45 micron) method, water, (col/100 mL) (31616)
Median values from synoptic cross-section	Oct 10 2007	1442 CDT	748	E12.0	E6350	9.3	8.5	850	21.8	—	4	E14.5 k	E28 k
Cross-section part 1 of 2; mid-channel	Oct 18 2007	1410 CST	725	—	E8560	9.4	8.2	860	18.5	—	1	140	93
Cross-section part 2 of 2; left-channel	Oct 18 2007	1445 CST	725	—	E8560	9.4	8.3	872	18.5	—	1	81	170
Mid-channel grab	Oct 25 2007	1100 CST	754	7.2	E9340	9.4	8.2	863	14.9	—	1	48	50
Mid-channel grab	Nov 1 2007	1145 CST	757	10.0	E8790	10.9	8.3	831	12.9	—	1	48	89
Mid-channel grab	Nov 7 2007	0930 CST	756	-3.8	E6820	13.2	8.8	816	9.6	—	1	E17 k	60
Cross-section composite	Nov 15 2007	0855 CST	750	1.7	E6900	12.2	8.2	856	9.4	—	3	76	38
Cross-section composite	Nov 21 2007	0850 CST	745	—	E9460	13.2	8.8	888	9.5	—	3	38	51
Cross-section composite	Nov 28 2007	1135 CST	746	4.4	E10300	12.7	8.4	833	5.0	—	3	110	E44 k
Cross-section composite	Dec 5 2007	1045 CST	747	-1.1	E12100	14.3	8.5	792	1.7	—	3	140	E54 k
Cross-section composite	Dec 12 2007	1025 CST	756	-1.1	E17000	13.5	8.3	984	2.2	—	3	550	300
Cross-section composite	Dec 19 2007	1010 CST	750	-5.0	E23700	13.9	8.0	976	1.6	—	3	170	130
Cross-section composite	Jan 3 2008	0955 CST	763	-15.0	E15400	14.7	8.3	1010	0.0	—	3	73	48
Cross-section composite	Jan 9 2008	1105 CST	751	2.0	E51800	10.5	7.9	882	7.9	—	3	1600	670
Cross-section composite	Jan 16 2008	0945 CST	748	0.2	E46200	12.8	7.9	564	2.4	—	3	230	E200 k
Mid-channel grab, iced conditions	Jan 24 2008	0945 CST	758	-20.0	E16400	13.2	8.0	790	0.1	—	1	110	150
Cross-section composite	Feb 6 2008	1000 CST	729	0.0	E24300	13.3	8.0	1090	1.6	—	3	E450 k	E330 k
Cross-section composite	Mar 12 2008	1235 CST	—	3.9	E21900	12.8	8.1	901	3.3	—	3	120	73
Cross-section composite	Mar 26 2008	1015 CST	752	5.2	E22300	12.0	8.1	819	6.8	—	3	110	E55 k
Cross-section composite	Apr 2 2008	0940 CST	759	5.7	E27500	12.0	8.1	977	8.2	—	3	200	130
Cross-section composite	Apr 9 2008	1050 CST	752	5.7	E22700	11.1	8.1	874	11.0	—	3	150	120

Table 1. Physical, chemical, and bacterial data for the Illinois River at Hennepin, Illinois (U.S. Geological Survey streamflow-gaging station number 05556200), during water year 2008 (October 2007–September 2008).—Continued

[hhmm, hour minute; Hg, mercury; MF, membrane filter; col/100 mL, colonies per 100 milliliters; ft, foot; ft³/s, cubic foot per second; micron, micrometer; mg/L, milligrams per liter; mm, millimeter; °C, degrees Celsius; µS/cm, microsiemens per centimeter; —, no data; E, estimated; k, counts outside acceptable range; CDT, central daylight time; CST, central standard time]

Sample notes	Date	Time (24-hour clock, hhmm)	Barometric pressure, (mm Hg) (00025)	Temperature, air, (°C) (00020)	Discharge, (ft³/s) (00060)	Dissolved oxygen, water, unfiltered, (mg/L) (00300)	pH, water, unfiltered, field, (standard units) (00400)	Specific conductance, water, unfiltered, (µS/cm at 25 °C) (00095)	Temperature, water, (°C) (00010)	Gage height, (ft) (00065)	Number of sampling points, (count) (00063)	*Escherichia coli*, modified m-TEC MF method, water, (col/100 mL) (90902)	Fecal coliform, M-FC MF (0.45 micron) method, water, (col/100 mL) (31616)
Cross-section composite	Apr 16 2008	0955 CST	745	10.9	E28600	11.3	8.1	838	10.0	—	3	150	E54 k
Cross-section composite	Apr 23 2008	0940 CST	754	17.1	E20400	10.2	8.2	827	17.1	—	3	E31 k	E18 k
Cross-section composite	May 1 2008	0945 CST	740	14.5	E15000	11.6	8.2	873	13.6	—	3	92	E18 k
Cross-section composite	May 7 2008	0940 CST	739	15.8	E15100	10.6	8.2	933	17.4	—	3	E26 k	E8 k
Cross-section composite	May 21 2008	0930 CST	743	11.0	E14000	10.0	8.1	820	16.6	—	3	E14 k	E10 k
Cross-section composite	May 28 2008	1015 CST	758	13.0	E13200	11.6	8.5	874	18.1	—	3	E23 k	E23 k
Cross-section composite	June 12 2008	0805 CDT	747	24.0	E28200	—	7.9	—	23.9	—	3	90	E100 k
Cross-section composite	July 2 2008	0915 CST	745	22.4	E12700	9.6	8.3	765	24.9	—	3	E17 k	E24 k
Cross-section composite	July 16 2008	1000 CST	753	22.7	E17200	9.0	8.3	786	—	—	3	E120 k	E100 k
Cross-section composite	Aug 20 2008	1110 CST	756	25.8	E6460	9.2	8.4	726	27.6	—	3	E10 k	E13 k
Cross-section composite	Sept 22 2008	1235 CST	761	27.3	E45100	6.2	8.0	503	20.8	—	3	83	80

Table 2. Physical, chemical, and bacterial data for the Illinois River below Peoria Lake at Peoria, Illinois (U.S. Geological Survey streamflow-gaging station number 05562200), during water year 2008 (October 2007–September 2008).

[hhmm, hour minute; Hg, mercury; MF, membrane filter; col/100 mL, colonies per 100 milliliters; ft, foot; ft³/s, cubic foot per second; micron, micrometer; mg/L, milligrams per liter; mm, millimeter; °C, degrees Celsius; µS/cm, microsiemens per centimeter; —, no data; E, estimated; k, counts outside acceptable range; CDT, central daylight time; CST, central standard time]

Sample notes	Date	Time (24-hour clock, hhmm)	Barometric pressure (mm Hg)	Temperature, air (°C)	Discharge (ft³/s)	Dissolved oxygen, water, unfiltered (mg/L)	pH, water, unfiltered, field (standard units)	Specific conductance, water, unfiltered (µS/cm at 25 °C)	Temperature, water (°C)	Gage height (ft)	Number of sampling points (count)	*Escherichia coli*, modified m-TEC MF method, water (col/100 mL)	Fecal coliform, M-FC MF (0.45 micron) method, water (col/100 mL)
			(00025)	(00020)	(00060)	(00300)	(00400)	(00095)	(00010)	(00065)	(00063)	(90902)	(31616)
Synoptic sample, mid-channel	Oct 10 2007	1210 CDT	—	E10.8	E6760	—	—	—	—	—	1	130	300
	Oct 18 2007	1220 CST	725	—	E6000	8.2	8.1	838	18.2	—	1	750	1100
	Oct 25 2007	0915 CST	752	4.4	E10200	9.8	8.3	868	12.3	—	1	53	88
	Nov 1 2007	0945 CST	757	7.2	E8970	9.9	8.0	865	12.2	—	1	43	120
	Nov 7 2007	1110 CST	756	2.8	E7370	11.3	8.1	805	7.9	—	1	110	200
	Nov 15 2007	1030 CST	751	4.4	E7070	12.0	8.4	805	9.4	—	1	450	340
	Nov 21 2007	1020 CST	744	—	E7550	12.5	8.9	833	10.0	—	1	E9700 k	E6800 k
	Nov 28 2007	0845 CST	748	4.4	E12000	13.1	8.5	871	3.7	—	1	200	E250 k
	Dec 5 2007	0800 CST	743	0.0	E15500	13.6	8.4	818	1.1	—	1	77	76
	Dec 12 2007	0800 CST	754	-1.1	E13600	14.0	8.3	826	0.8	—	1	88	40
	Dec 19 2007	0755 CST	749	-4.4	E26200	14.1	8.0	855	1.2	—	1	140	210
	Jan 3 2008	0815 CST	764	-10.0	E22100	13.9	7.5	888	0.0	—	1	220	200
	Jan 9 2008	0800 CST	750	1.3	E28900	12.7	8.1	982	4.7	—	1	79	130

Table 2. Physical, chemical, and bacterial data for the Illinois River below Peoria Lake at Peoria, Illinois (U.S. Geological Survey streamflow-gaging station number 05562200), during water year 2008 (October 2007–September 2008).—Continued

[hhmm, hour minute; Hg, mercury; MF, membrane filter; col/100 mL, colonies per 100 milliliters; ft, foot; ft³/s, cubic foot per second; micron, micrometer; mg/L, milligrams per liter; mm, millimeter; °C, degrees Celsius; µS/cm, microsiemens per centimeter; —, no data; E, estimated; k, counts outside acceptable range; CDT, central daylight time; CST, central standard time]

Sample notes	Date	Time (24-hour clock, hhmm)	Barometric pressure (mm Hg)	Temperature, air (°C)	Discharge (ft³/s)	Dissolved oxygen, water, unfiltered (mg/L)	pH, water, unfiltered, field (standard units)	Specific conductance, water, unfiltered (µS/cm at 25 °C)	Temperature, water (°C)	Gage height (ft)	Number of sampling points (count)	*Escherichia coli*, modified m-TEC MF method, water (col/100 mL)	Fecal coliform, M-FC MF (0.45 micron) method, water (col/100 mL)
			(00025)	(00020)	(00060)	(00300)	(00400)	(00095)	(00010)	(00065)	(00063)	(90902)	(31616)
	Jan 16 2008	0750 CST	748	-2.0	E59400	10.9	7.9	591	2.9	—	1	190	130
	Jan 24 2008	0820 CST	757	-20.5	E33800	11.7	7.8	519	0.0	—	1	110	93
Runoff/snowmelt event	Feb 6 2008	0715 CST	734	0.0	E27900	11.8	8.0	734	0.1	—	1	1900	E2250 k
	Mar 12 2008	0805 CST	744	0.0	E35100	12.3	8.4	843	2.7	—	1	E26 k	E18 k
	Mar 26 2008	0740 CST	751	2.0	E30600	12.9	8.3	813	6.5	—	1	E31 k	E24 k
	Apr 2 2008	0740 CST	758	2.0	E33400	11.8	8.4	938	7.6	—	1	E15 k	E4 k
	Apr 9 2008	0740 CST	751	4.7	E32100	11.0	8.3	903	10.3	—	1	E7 k	E5 k
	Apr 16 2008	0740 CST	747	8.5	E35300	11.3	8.2	867	9.7	—	1	E10 k	E10 k
	Apr 23 2008	0735 CST	753	14.8	E30600	10.5	8.2	809	16.7	—	1	E2 k	E3 k
	May 1 2008	0735 CST	740	14.5	E26300	10.8	8.2	828	14.7	—	1	E7 k	E3 k
	May 7 2008	0740 CST	740	16.0	E21400	11.9	8.6	865	17.5	—	1	E14 k	E5 k
	May 21 2008	0730 CST	741	10.4	E24400	11.6	8.6	781	16.3	—	1	E4 k	E1 k
	May 28 2008	0725 CST	757	9.4	E19800	9.3	8.9	812	16.1	—	1	E9 k	E9 k

Table 2. Physical, chemical, and bacterial data for the Illinois River below Peoria Lake at Peoria, Illinois (U.S. Geological Survey streamflow-gaging station number 05562200), during water year 2008 (October 2007–September 2008).—Continued

[hhmm, hour minute; Hg, mercury; MF, membrane filter; col/100 mL, colonies per 100 milliliters; ft, foot; ft³/s, cubic foot per second; micron, micrometer; mg/L, milligrams per liter; mm, millimeter; °C, degrees Celsius; µS/cm, microsiemens per centimeter; —, no data; E, estimated; k, counts outside acceptable range; CDT, central daylight time; CST, central standard time]

Sample notes	Date	Time (24-hour clock, hhmm)	Barometric pressure (mm Hg)	Temperature, air (°C)	Discharge (ft³/s)	Dissolved oxygen, water, unfiltered (mg/L)	pH, water, unfiltered, field (standard units)	Specific conductance, water, unfiltered (µS/cm at 25 °C)	Temperature, water (°C)	Gage height (ft)	Number of sampling points (count)	*Escherichia coli*, modified m-TEC MF method, water (col/100 mL)	Fecal coliform, M-FC MF (0.45 micron) method, water (col/100 mL)
			(00025)	(00020)	(00060)	(00300)	(00400)	(00095)	(00010)	(00065)	(00063)	(90902)	(31616)
Synoptic sample, mid-channel	June 12 2008	1115 CDT	752	E29.2	E20400	7.0	8.0	620	24.1	—	3	120	410
	July 2 2008	0750 CST	746	21.0	E15900	7.8	8.2	728	25.1	—	1	E19 k	E4 k
	July 16 2008	0720 CST	753	23.0	E18600	7.2	8.4	658	26.7	—	1	63	E100 k
	Aug 20 2008	0830 CST	752	20.8	E7240	7.3	8.4	703	26.2	—	1	80	110
	Sept 22 2008	0945 CST	758	22.8	E67100	4.4	8.1	380	20.5	—	1	38	110

Table 3. Physical, chemical, and bacterial data for Big Bureau Creek near Princeton, Illinois (U.S. Geological Survey streamflow-gaging station number 05556500), during water year 2008 (October 2007–September 2008).

[hhmm, hour minute; Hg, mercury; MF, membrane filter; col/100 mL, colonies per 100 milliliters; ft, foot; ft³/s, cubic foot per second; micron, micrometer; mg/L, milligrams per liter; mm, millimeter; °C, degrees Celsius; µS/cm, microsiemens per centimeter; —, no data; E, estimated; k, counts outside acceptable range; CDT, central daylight time; CST, central standard time]

Sample notes	Date	Time (24-hour clock, hhmm)	Barometric pressure (mm Hg) (00025)	Temperature, air (°C) (00020)	Discharge instantaneous (ft³/s) (00061)	Dissolved oxygen, water, unfiltered (mg/L) (00300)	pH, water, unfiltered, field (standard units) (00400)	Specific conductance, water, unfiltered (µS/cm at 25 °C) (00095)	Temperature, water (°C) (00010)	Gage height (ft) (00065)	Number of sampling points (count) (00063)	*Escherichia coli*, modified m-TEC MF method, water (col/100 mL) (90902)	Fecal coliform, M-FC MF (0.45 micron) method, water (col/100 mL) (31616)
Sampled near mouth, no sample at this location	Oct 10 2007	—	—	—	—	—	—	—	—	—	—	—	—
	Nov 1 2007	1250 CST	753	12.8	26	13.1	8.4	781	9.5	1.55	1	65	220
	Dec 5 2007	1200 CST	743	-1.1	46	14.4	8.4	770	0.2	1.75	1	100	33
	Jan 9 2008	1020 CST	747	1.0	885	11.6	8.0	682	5.1	4.71	1	1200	E900 k
Runoff/snowmelt event	Feb 6 2008	0920 CST	730	0.0	273	12.9	8.1	667	0.2	3.06	1	1700	1920
	Mar 12 2008	1030 CST	742	3.4	939	11.8	8.2	350	1.9	4.83	1	280	E280 k
	Apr 9 2008	1000 CST	748	3.8	258	11.4	8.2	667	7.3	2.98	1	870	900
	May 21 2008	1005 CST	741	10.9	187	11.3	8.1	683	13.5	2.66	1	120	110
Synoptic sample	June 12 2008	0835 CDT	744	19.0	282	8.8	8.2	696	18.5	3.07	1	440	450
	July 16 2008	0915 CST	749	23.1	405	8.4	8.1	663	21.2	3.49	1	1100	1170
	Aug 20 2008	1035 CST	751	21.1	25	8.9	8.1	647	23.5	1.56	1	740	580
	Sept 22 2008	1155 CST	755	25.3	291	9.0	8.1	672	18.6	3.10	1	610	510

Table 4. Physical, chemical, and bacterial data for Farm Creek at Farmdale, Illinois (U.S. Geological Survey streamflow-gaging station number 05560500), during water year 2008 (October 2007–September 2008)

[hhmm, hour minute; Hg, mercury; MF, membrane filter; col/100 mL, colonies per 100 milliliters; ft, foot; ft³/s, cubic foot per second; micron, micrometer; mg/L, milligrams per liter; mm, millimeter; °C, degrees Celsius; µS/cm, microsiemens per centimeter; —, no data; E, estimated; k, counts outside acceptable range; CDT, central daylight time; CST, central standard time

Sample notes	Date	Time (24-hour clock, hhmm)	Barometric pressure (mm Hg) (00025)	Temperature, air (°C) (00020)	Discharge, instantaneous (ft³/s) (00061)	Discharge, (ft³/s) (00060)	Dissolved oxygen, water, unfiltered (mg/L) (00300)	pH, water, unfiltered, field (standard units) (00400)	Specific conductance, water, unfiltered (µS/cm at 25 °C) (00095)	Temperature, water (°C) (00010)	Gage height (ft) (00065)	Number of sampling points (count) (00063)	*Escherichia coli*, modified m-TEC MF method, water (col/100 mL) (90902)	Fecal coliform, M-FC MF (0.45 micron) method, water (col/100 mL) (31616)
Sampled near mouth, no sample at this location	Oct 10 2007	—	—	—	—	—	—	—	—	—	—	—	—	—
	Nov 1 2007	1430 CST	753	12.8	2.7	—	12.9	8.4	1480	10.7	1.90	1	E26 k	52
	Dec 5 2007	1205 CST	746	0.0	3.7	—	15.8	8.7	1440	2.7	1.93	1	360	250
	Jan 9 2008	1230 CST	748	4.1	402	—	11.8	7.9	535	6.1	4.00	1	3400	—
Runoff/ snowmelt event	Feb 6 2008	1145 CST	729	0.0	679	—	13.6	8.0	336	0.5	4.61	1	E20000 k	E10300 k
	Mar 12 2008	1235 CST	744	7.4	22	—	12.0	8.2	913	5.6	2.24	1	210	88
	Apr 9 2008	1205 CST	750	7.5	38	—	12.7	8.2	722	9.5	2.44	1	1400	2300
	May 21 2008	1200 CST	741	13.9	—	8.8	13.3	8.4	890	15.2	2.01	1	E28 k	E26 k
Synoptic sample	June 12 2008	0640 CDT	745	18.0	19	—	8.7	8.0	895	18.5	2.19	1	7300	1030
	July 16 2008	1140 CDT	752	24.6	22	—	8.5	8.2	977	23.3	2.17	1	1200	833
	Aug 20 2008	1320 CST	750	24.9	2.8	—	11.1	8.3	1940	23.5	1.74	1	110	120
	Sept 22 2008	0820 CST	754	18.6	33	—	9.3	8.7	815	16.7	2.38	1	1700	1130

Table 5. Physical, chemical, and bacterial data for Senachwine Creek at Chillicothe, Illinois (U.S. Geological Survey streamflow-gaging station number 05559700), during water year 2008 (October 2007–September 2008).

[hhmm, hour minute; Hg, mercury; MF, membrane filter; col/100 mL, colonies per 100 milliliters; ft, foot; ft³/s, cubic foot per second; micron, micrometer; mg/L, milligrams per liter; mm, millimeter; °C, degrees Celsius; µS/cm, microsiemens per centimeter; —, no data; E, estimated; k, counts outside acceptable range; CDT, central daylight time; CST, central standard time]

Sample notes	Date	Time (24-hour clock, hhmm)	Baro-metric pressure (mm Hg)	Tempera ture, air (°C)	Discharge, instanta-neous (ft³/s)	Discharge (ft³/s)	Dissolved oxygen, water, unfiltered (mg/L)	pH, water, unfiltered, field (standard units)	Specific conductance, water, unfiltered (µS/cm at 25 °C)	Tem-perature, water (°C)	Gage height (ft)	Number of sampling points (count)	*Escherichia coli*, modified m-TEC MF method, water (col/100 mL)	Fecal coliform, M-FC MF (0.45 micron) method, water (col/100 mL)
			(00025)	(00020)	(00061)	(00060)	(00300)	(00400)	(00095)	(00010)	(00065)	(00063)	(90902)	(31616)
No sample, dry	Oct 10 2007	—	—	—	—	—	—	—	—	—	—	—	—	—
No sample, dry	Nov 1 2007	—	—	—	—	—	—	—	—	—	—	—	—	—
	Dec 12 2007	0925 CST	754	-1.1	—	E1.7	13.1	8.2	680	0.8	5.81	1	63	E19 k
	Jan 9 2008	0920 CST	750	0.0	182	—	12.4	8.2	603	4.2	7.95	1	340	E180 k
Runoff/ snowmelt event	Feb 6 2008	0820 CST	732	0.0	—	E190	13.4	8.1	287	0.0	9.42	1	1300	2000
	Mar 12 2008	0935 CST	745	3.8	45	—	12.7	8.3	691	2.4	6.74	1	E11 k	E9 k
	Apr 9 2008	0910 CST	750	3.7	90	—	11.1	8.3	619	7.3	7.32	1	600	380
	May 21 2008	1110 CST	743	12.2	44	—	11.6	8.2	673	15.4	6.73	1	120	65
Synoptic sample	Jun 12 2008	1010 CDT	748	22.5	40	—	9.4	8.2	706	21.3	6.68	1	260	430
	Jul 16 2008	0820 CST	752	22.3	16	—	7.9	8.1	680	23.4	6.42	1	300	370
No sample, dry	Aug 20 2008		—	—	—	—	—	—	—	—	—	—	—	—
	Sep 22 2008	1105 CST	758	25.0	26	—	9.3	8.0	732	18.8	6.65	1	520	440

Table 6. Physical, chemical, and bacterial data for Partridge Creek near Metamora, Illinois (U.S. Geological Survey (USGS) streamflow-gaging station number 05559800), and Partridge Creek Tributary near Metamora, Illinois (USGS streamflow-gaging station number 05559820), from May to August 2008.

[hhmm, hour minute; Hg, mercury; MF, membrane filter; col/100 mL, colonies per 100 milliliters; ft³/s, cubic foot per second; micron, micrometer; mg/L, milligrams per liter; mm, millimeter; °C, degrees Celsius; µS/cm, microsiemens per centimeter; —, no data; <, less than; CDT, central daylight time; CST, central standard time]

Sample notes	Date	Time (24-hour clock, hhmm)	Barometric pressure (mm Hg) (00025)	Temperature, air (°C) (00020)	Discharge, instantaneous (ft³/s) (00061)	Dissolved oxygen, water, unfiltered (mg/L) (00300)	pH, water, unfiltered, field (standard units) (00400)	Specific conductance, water, unfiltered (µS/cm at 25 °C) (00095)	Temperature, water (°C) (00010)	Number of sampling points (count) (00063)	*Escherichia coli*, modified m-TEC MF method, water (col/100 mL) (90902)	Fecal coliform, M-FC MF (0.45 micron) method, water, (col/100 mL) (31616)
Partridge Creek near Metamora (05559800)												
	May 28 2008	0915 CST	752	9.5	—	11.4	8.3	815	11.2	1	220	200
Synoptic sample	June 12 2008	0720 CDT	743	18.2	—	8.6	8.1	831	18.7	1	800	930
	July 16 2008	1105 CST	750	25.1	—	8.8	8.3	766	23.1	1	1900	1200
	Aug 20 2008	1240 CST	749	25.6	—	9.5	8.3	783	22.5	1	580	480
Partridge Creek Tributary near Metamora (05559820)												
	May 28 2008	0900 CST	752	9.5	—	11.1	8.4	770	9.9	1	210	150
Synoptic sample	June 12 2008	0730 CDT	743	18.2	—	8.8	8.1	774	16.9	1	220	1630
	July 16 2008	1100 CST	749	25.1	—	8.6	8.2	761	21.3	1	1100	900
Near zero flow, no sample possible	Aug 20 2008	1230 CDT	749	25.6	<0.1	4.1	7.8	911	16.1	—	—	—

Synoptic Sampling

Intensive synoptic sampling was completed on October 10, 2007, and June 12, 2008. These dates were chosen based on hydrologic conditions in the area at that time. The October 10, 2007, sampling took place during a relatively dry period with streamflows in the Illinois River and tributaries generally at or below the long-term means. In contrast, the June 12, 2008, sampling took place during a relatively wet period with streamflows in the Illinois River and tributaries generally at or above the long-term means (figs. 3 and 4).

During October 2007, samples were collected at 16 sites on the Illinois River and at 14 sites on various tributaries within the study area. The sample sites on the main stem of the Illinois River were selected based mainly on the following factors: the location of major tributary inflows, the location of sewage-treatment plant discharge points, and the location of in-channel lakes where changes in hydraulic characteristics may affect the transport and (or) lifespan of bacteria. Tributary sample sites were selected to best represent possible bacteria loading from a wide range of land-use areas, ranging from rural to urban. As was the case with the periodic sampling, all samples were analyzed for both FC and *E. coli*, and observations of air temperature, water temperature, barometric pressure, dissolved oxygen, pH, and specific conductance were measured at each sampling location. Streamflow is estimated at sites without continuous monitoring. Results of the October 10, 2007, sampling are presented in table 7.

During June 2008, samples were collected at 12 sites on the Illinois River and at 5 sites on tributaries within the study area. These sites were a subset of the sites that were sampled in October 2007; the results of the October 2007 sampling indicated that a similar amount of information could be obtained while sampling fewer sites throughout the study area. The results of the June 12, 2008, sampling are presented in table 8.

Table 7. Results of synoptic sampling on the Illinois River and selected tributaries between Hennepin and Peoria, Illinois, October 10, 2007.

[hhmm, hour minute; Hg, mercury; MF, membrane filter; col/100 mL, colonies per 100 milliliters; ft, foot; ft³/s, cubic foot per second; micron, micrometer; mg/L, milligrams per liter; mm, millimeter; °C, degrees Celsius; µS/cm, microsiemens per centimeter; —, no data; <, less than; E, estimated; k, counts outside acceptable range; CDT, central daylight time; CST, central standard time; DS, downstream; US, upstream]

Site name	U.S. Geological Survey station number	Sample notes	Time (24-hour clock, hhmm)	Barometric pressure (mm Hg) (00025)	Temperature, air (°C) (00020)	Discharge, instantaneous (ft³/s) (00061)	Dissolved oxygen, water, unfiltered (mg/L) (00300)
Illinois River Upstream of Hennepin near Mile 209.3		Mid-channel grab	1420 CDT	749	E13.0	—	9.8
Illinois River Upstream of Hennepin near Mile 208.4		Mid-channel grab	1430 CDT	749	E12.5	—	9.6
Illinois River at Hennepin	05556200	Cross-section part 1 of 4; Collected near right-channel	1435 CDT	749	E12.5	—	10.0
		Cross-section part 2 of 4; Collected near mid-channel	1440 CDT	750	E12.0	—	9.1
		Cross-section part 3 of 4; Collected near island, navigation-channel side	1445 CDT	748	E12.0	—	8.9
		Cross-section part 4 of 4; Collected sample near left-channel	1450 CDT	748	E12.0	—	9.4
Illinois River Upstream of Henry near Mile 198.2		Mid-channel grab	1310 CDT	—	E13.0	—	—
Illinois River at Henry	05558300	Mid-channel grab	1255 CDT	—	E13.0	7510	—
Illinois River at Lacon	05558995	Mid-channel grab	1230 CDT	—	E13.0	—	—
Illinois River Downstream of Lacon near Mile 188.7		Collected sample near left-bank	1225 CDT	—	E12.5	—	—
Illinois River at Chillicothe	05559600	Mid-channel grab, at public boat ramp	1631 CDT	748	E12.1	—	8.4
Illinois River downstream of Chillicothe near Mile 179		Collected sample near right-bank	1555 CDT	—	E12.1	—	—
		Mid-channel grab	1600 CDT	—	E12.1	—	—
Illinois River at South Rome	05559850	Mid-channel grab	1545 CDT	E748	E53.8	—	

pH, water, unfiltered, field (standard units) (00400)	Specific conductance, water, unfiltered (µS/cm at 25 °C) (00095)	Temperature, water (°C) (00010)	Gage height (ft) (00065)	Sampling depth (ft) (00003)	Number of sampling points (count) (00063)	*Escherichia coli*, modified m-TEC MF method, water (col/100 mL) (90902)	Fecal coliform, M-FC MF (0.45 micron) method, water (col/100 mL) (31616)
8.5	852	21.9	—	3.00	1	E17 k	50
8.5	974	22.4	—	3.00	1	E13 k	E30 k
8.6	849	21.8	—	3.00	1	E10 k	52
8.5	850	21.9	—	3.00	1	E16 k	E20 k
8.5	850	21.8	—	3.00	1	E13 k	E18 k
8.5	894	21.8	—	2.00	1	770	E36 k
—	—	—	—	3.00	1	38	45
—	—	—	14.73	3.00	1	E13 k	40
—	—	—	—	3.00	1	E8 k	E6 k
—	—	—	—	2.00	1	73	98
8.5	836	20.8	—	3.00	1	E2 k	E12 k
—	—	20.6	—	2.00	1	45	430
—	—	20.6	—	3.00	1	E2 k	E9 k
8.5	832	20.6		3.00	1	E12 k	E24 k

Table 7. Results of synoptic sampling on the Illinois River and selected tributaries between Hennepin and Peoria, Illinois, October 10, 2007.—Continued

[hhmm, hour minute; Hg, mercury; MF, membrane filter; col/100 mL, colonies per 100 milliliters; ft, foot; ft³/s, cubic foot per second; micron, micrometer; mg/L, milligrams per liter; mm, millimeter; °C, degrees Celsius; µS/cm, microsiemens per centimeter; —, no data; <, less than; E, estimated; k, counts outside acceptable range; CDT, central daylight time; CST, central standard time; DS, downstream; US, upstream]

Site name	U.S. Geological Survey station number	Sample notes	Time (24-hour clock, hhmm)	Barometric pressure (mm Hg) (00025)	Temperature, air (°C) (00020)	Discharge, instantaneous (ft³/s) (00061)	Dissolved oxygen, water, unfiltered (mg/L) (00300)
Illinois River at Water Company at Peoria	05559900	Mid-channel grab	0845 CDT	—	E8.8	—	—
		Collected sample near right-bank	0850 CDT	—	E8.8	—	—
Illinois River at Peoria	05560000	Cross-section part 1 of 3; near Mile 163, left-channel	1245 CDT	—	E11.7	—	—
		Cross-section part 2 of 3; near Mile 163, mid-channel	1250 CDT	—	E11.7	—	—
		Cross-section part 3 of 3; near Mile 163, right-channel	1255 CDT	—	E11.7	—	—
Illinois River at William Kumpf Blvd at Peoria	05562100	Mid-channel grab	1240 CDT	—	E11.2	—	—
Illinois River upstream of Highway 8/29/116 Bridge at Peoria		Mid-channel grab	1235 CDT	—	E11.2	—	—
Illinois River near railroad bridge at Peoria near Mile 160.8		Collected sample near right-bank	1225 CDT	—	E11.2	—	—
Illinois River below Peoria Lake at Peoria	05562200	Mid-channel grab	1210 CDT	—	E10.8	—	—
		Collected sample near right-bank	1215 CDT	—	E10.9	—	—
Big Bureau Creek at Bureau	05558000	Mid-channel grab	0900 CDT	749	13.0	115	8.4
Sandy Creek at Henry	05558295	Mid-channel grab	0945 CDT	748	E10.0	16	9.1
Crow Creek (West) at Highway 29 near Sparland		Mid-channel grab	0950 CDT	749	E10.0	<.10	2.9
Thenius Creek at Sparland	05558990	Mid-channel grab	1115 CDT	749	E10.5	.10	7.6
Crow Creek near Chillicothe	05559590	Mid-channel grab	0840 CDT	747	E9.0	10	7.1

pH, water, unfiltered, field (standard units) (00400)	Specific conductance, water, unfiltered (µS/cm at 25 °C) (00095)	Temperature, water (°C) (00010)	Gage height (ft) (00065)	Sampling depth (ft) (00003)	Number of sampling points (count) (00063)	*Escherichia coli*, modified m-TEC MF method, water (col/100 mL) (90902)	Fecal coliform, M-FC MF (0.45 micron) method, water (col/100 mL) (31616)
—	—	18.3	—	3.00	1	E15 k	E5 k
—	—	18.3	—	2.00	1	E5 k	E4 k
—	—	18.3	—	3.00	1	E8 k	43
—	—	18.3	—	3.00	1	E24 k	180
—	—	18.9	—	3.00	1	30	160
—	—	18.9	—	3.00	1	370	94
—	—	19.4	—	3.00	1	93	190
—	—	20.0	—	3.00	1	570	870
—	—	—	—	3.00	1	130	300
—	—	20.0	—	3.00	1	130	240
7.8	719	13.8	—	.50	1	200	200
—	726	14.2	—	1.50	1	260	410
7.7	811	14.7	—	.50	1	E5 k	E6 k
7.8	903	14.3	—	—	1	90	220
—	704	11.6	—	1.50	1	160	150

Table 7. Results of synoptic sampling on the Illinois River and selected tributaries between Hennepin and Peoria, Illinois, October 10, 2007.—Continued

[hhmm, hour minute; Hg, mercury; MF, membrane filter; col/100 mL, colonies per 100 milliliters; ft, foot; ft³/s, cubic foot per second; micron, micrometer; mg/L, milligrams per liter; mm, millimeter; °C, degrees Celsius; µS/cm, microsiemens per centimeter; —, no data; <, less than; E, estimated; k, counts outside acceptable range; CDT, central daylight time; CST, central standard time; DS, downstream; US, upstream]

Site name	U.S. Geological Survey station number	Sample notes	Time (24-hour clock, hhmm)	Barometric pressure (mm Hg) (00025)	Temperature, air (°C) (00020)	Discharge, instantaneous (ft³/s) (00061)	Dissolved oxygen, water, unfiltered (mg/L) (00300)
Senachwine Creek at Chillicothe	05559700	No sample, dry		—	—	—	—
Richland Creek below Dry Creek Mouth near Chillicothe	05559770	Mid-channel grab	0745 CDT	745	E7.3	.71	6.2
Partridge Creek near Spring Bay	05559830	Mid-channel grab	1420 CDT	749	E12.6	.46	9.8
Blalock Creek near Spring Bay	05559840	Mid-channel grab	1355 CDT	749	E12.8	.02	7.8
Tenmile Creek at Trail-park Gardens	05559890	Mid-channel grab	1320 CDT	749	E12.1	1.3	10.1
Farm Creek at U.S. Highway 150 at East Peoria	05561800	Mid-channel grab	1215 CDT	749	12.5	.43	18.4
Farm Creek at East Peoria	05562000	Mid-channel grab	1120 CDT	750	E10.9	<1.0	19.3
Farm Creek at Camp Street Bridge at East Peoria	05562010	Mid-channel grab	1045 CDT	749	E10.8	<1.0	16.6
Kickapoo Creek at Bartonville	05563525	Mid-channel grab about 150ft US of HWY24	0825 CDT	748	E8.3	4.1	7.7
		Mid-channel grab about 1500ft DS of HWY24	0805 CDT	749	E7.8	4.1	10.0

	pH, water, unfiltered, field (standard units) (00400)	Specific conductance, water, unfiltered (µS/cm at 25 °C) (00095)	Temperature, water (°C) (00010)	Gage height (ft) (00065)	Sampling depth (ft) (00003)	Number of sampling points (count) (00063)	*Escherichia coli*, modified m-TEC MF method, water (col/100 mL) (90902)	Fecal coliform, M-FC MF (0.45 micron) method, water (col/100 mL) (31616)
	—	—	—	—	—	—	—	—
	—	743	14.4	—	.20	1	770	970
	—	658	17.1	—	1.00	1	E21 k	E34 k
	—	774	14.5	—	.30	1	740	610
	—	781	14.6	—	.70	1	410	6
	—	1410	15.5	—	.40	1	270	800
	—	1230	14.4	—	.20	1	73	83
	—	1290	13.3	—	E.60	1	110	140
	—	962	15.0	—	E.60	1	110	290
	—	991	14.9	—	E.80	1	E740 k	390

Table 8. Results of synoptic sampling on the Illinois River and selected tributaries between Hennepin and Peoria, Illinois, June 12, 2008.

[hhmm, hour minute; Hg, mercury; MF, membrane filter; col/100 mL, colonies per 100 milliliters; ft, foot; ft³/s, cubic foot per second; micron, micrometer; mg/L, milligrams per liter; mm, millimeter; °C, degrees Celsius; µS/cm, microsiemens per centimeter; —, no data; <, less than; E, estimated; k, counts outside acceptable range; CDT, central daylight time; CST, central standard time]

Site name	U.S. Geological Survey station number	Sample notes	Time (24-hour clock, hhmm)	Barometric pressure (mm Hg) (00025)	Tem perature, air (°C) (00020)	Discharge, instantaneous (ft³/s) (00061)
Illinois River at Hennepin	05556200	Cross-section composite	0805 CDT	747	24.0	—
Illinois River at Henry	05558300	Mid-channel grab	0910 CDT	747	25.0	28500
Illinois River at Lacon	05558995	Mid-channel grab	1000 CDT	747	25.0	—
Illinois River at Chillicothe	05559600	Mid-channel grab, at public boat ramp	1055 CDT	748	26.5	—
Illinois River at South Rome	05559850	Mid-channel grab	1215 CDT	748	24.5	—
Illinois River at Water Company at Peoria	05559900	Mid-channel grab	0950 CDT	751	E26.9	—
Illinois River at Peoria	05560000	Cross-section part 3 of 3; near Mile 163, right-channel	1025 CDT	750	E28.0	—
		Cross-section part 2 of 3; near Mile 163, mid-channel	1030 CDT	752	E28.1	—
		Cross-section part 1 of 3; near Mile 163, left-channel	1040 CDT	753	E28.3	—
Illinois River at William Kumpf Blvd at Peoria	05562100	Mid-channel grab	1045 CDT	751	E28.5	—
Illinois River upstream of Highway 8/29/116 Bridge at Peoria		Mid-channel grab	1100 CDT	751	E28.9	—
Illinois River near railroad bridge at Peoria near Mile 160.8		Mid-channel grab	1110 CDT	752	E29.1	—
Illinois River below Peoria Lake at Peoria	05562200	Cross-section composite	1115 CDT	752	E29.2	—
Illinois River above Peoria Lock and Dam near Creve Coeur	05563590	Cross-section composite, near Mile 159	1135 CDT	751	E29.5	—
Big Bureau Creek at Princeton	05556500	Mid-channel grab	0835 CDT	744	19.0	282
Senachwine Creek at Chillicothe	05559700	Mid-channel grab	1010 CDT	748	22.5	40
Partridge Creek near Metamora	05559800	Mid-channel grab	0720 CDT	743	18.2	—
Partridge Creek Tributary near Metamora	05559820	Mid-channel grab	0730 CDT	743	18.2	—
Farm Creek at Farmdale	05560500	Mid-channel grab	0640 CDT	745	18.0	19

Dissolved oxygen, water, unfiltered (mg/L) (00300)	pH, water, unfiltered, field (standard units) (00400)	Specific conductance, water, unfiltered (µS/cm at 25 °C) (00095)	Tem perature, water (°C) (00010)	Gage height (ft) (00065)	Sampling depth (ft) (00003)	Number of sampling points (count) (00063)	*Escherichia coli*, modified m-TEC MF method, water (col/100 mL) (90902)	Fecal coliform, M-FC MF (0.45 micron) method, water (col/100 mL) (31616)
—	7.9	—	23.9	—	3.00	3	90	E100 k
—	7.8	—	23.5	20.64	3.00	1	73	110
—	7.8	—	23.7	—	3.00	1	77	E88 k
—	7.8	—	24.1	—	3.00	1	110	110
—	7.9	—	24.4	—	3.00	1	78	70
7.1	7.9	624	23.9	—	3.00	1	E26 k	35
7.0	8.0	619	24.1	—	3.00	1	55	35
7.3	8.1	620	23.9	—	3.00	1	E28 k	45
7.1	8.0	619	24.1	—	3.00	1	E20 k	71
7.0	8.0	618	24.1	—	3.00	1	E26 k	E44 k
7.0	8.0	619	24.2	—	3.00	1	E38 k	E48 k
7.0	8.0	623	24.1	—	3.00	1	190	510
7.0	8.0	620	24.1	—	3.00	3	120	410
6.9	8.0	623	24.2	—	3.00	3	250	520
8.8	8.2	696	18.5	3.07	—	1	440	450
9.4	8.2	706	21.3	6.68	—	1	260	430
8.6	8.1	831	18.7	—	—	1	800	930
8.8	8.1	774	16.9	—	—	1	220	1630
8.7	8.0	895	18.5	2.19	—	1	7300	1030

Data Analysis

Correlation analyses were performed to investigate the strength of the relation between FC and *E. coli* counts, as well as correlation between each FIB and streamflow. Linear correlation was calculated with Pearson's r coefficient and non-linear correlation with Spearman's rho coefficient, using methods as described in Helsel and Hirsch (1992). Both of these coefficients have the characteristic of ranging in value from −1 to 1. When there is no correlation, the coefficient equals zero. Values closer to 1 indicate both variables increase simultaneously. Values closer to −1 indicate as one variable decreases, the other increases. Statistical significance was chosen for a 90-percent confidence with these tests. This is demonstrated when the p-value is less than 0.1, or 10 percent.

Concentrations of FC and *E. coli* bacteria correlated well with each other for samples from all locations ($r = 0.94$, $p < 0.001$; fig. 6), for the Illinois River at Hennepin, Ill. ($r = 0.95$, $p < 0.001$; fig. 7), and for the Illinois River below Peoria Lake at Peoria, Ill. ($r = 0.99$, $p < 0.001$; fig. 8). Each of these results indicates a strong linear correlation between the concentrations of FC and *E. coli* bacteria. Spearman's rho coefficient was not calculated because of these findings.

Counts of FC bacteria can encompass more types of coliforms than *E. coli* alone; therefore, the possibility exists for an upward counting bias when relying on FC data to indicate potential FIB sources. However, the statistically significant correlation observations may indicate incorporation or substitution of *E. coli* concentrations with those of FC (for non-regulatory purposes) and could be supported for other instances depending on the type of investigation.

Correlation between streamflow and bacteria concentrations also was determined. Weaker relations were found for either FIB to streamflow than were observed between the FIB; however, the correlation coefficients were found to be statistically significant. For both the tributaries and the Illinois River at Hennepin, Ill., a positive coefficient value was found. Interestingly, a negative coefficient was found for both FC and *E. coli* in relation to streamflow for the Illinois River below Peoria Lake at Peoria, Ill.

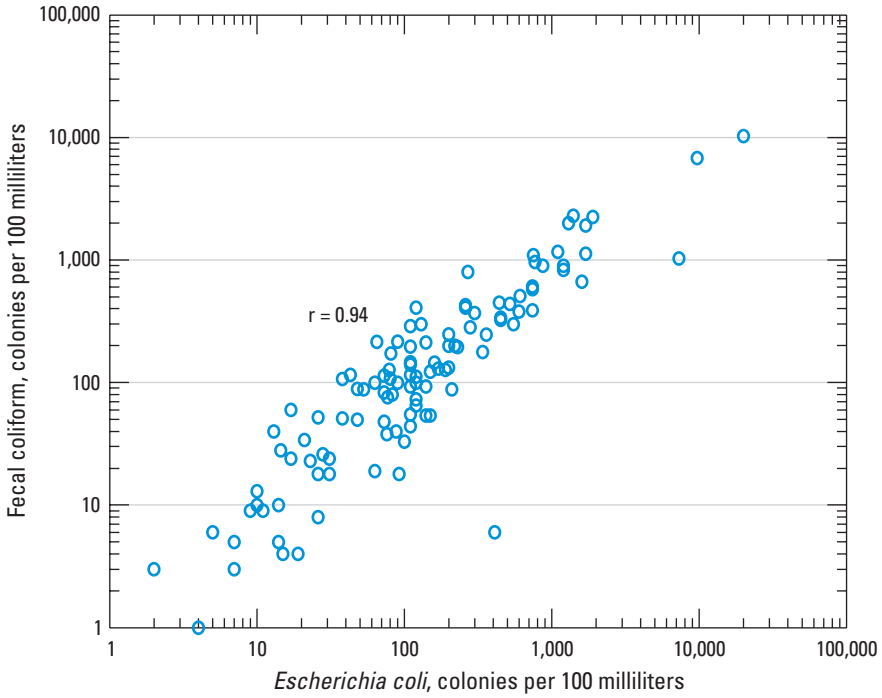

Figure 6. Correlation of fecal coliform to *Escherichia coli* concentrations for all stations and all samples.

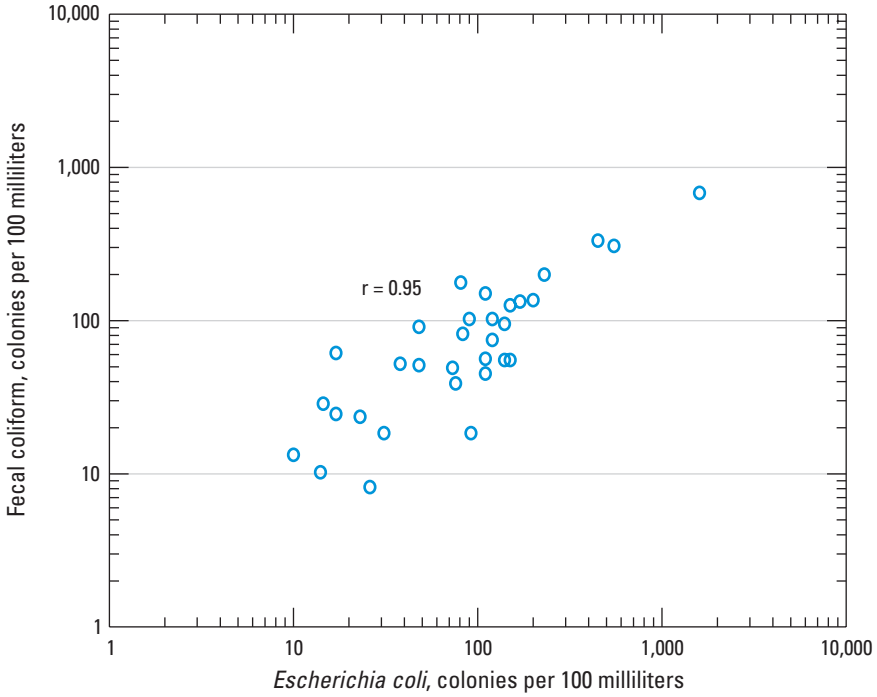

Figure 7. Correlation of fecal coliform to *Escherichia coli* concentrations for Illinois River at Hennepin, Illinois.

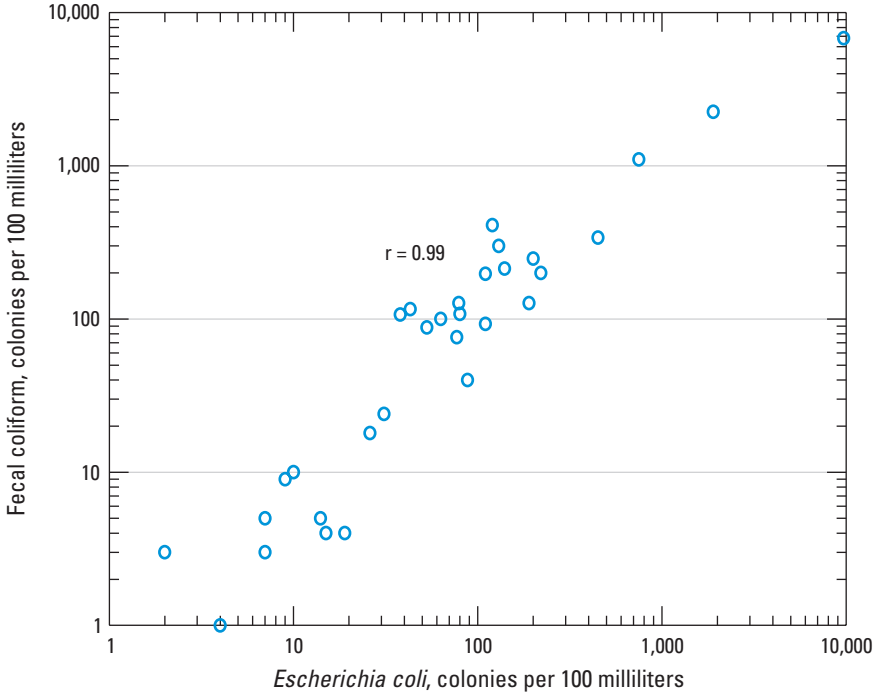

Figure 8. Correlation of fecal coliform to *Escherichia coli* concentrations for Illinois River below Peoria Lake at Peoria, Illinois.

The tributaries to the Illinois River had a weak correlation for streamflow to either FC (rho = 0.40, p = 0.0071; r = 0.44, p = 0.0032) or *E. coli* (rho = 0.48, p = 0.0008; r = 0.40, p = 0.0046), see figure 9. The Illinois River at Hennepin, Ill., had a moderate correlation for streamflow to either FC (rho = 0.49, p = 0.004; r = 0.60, p <0.001) or *E. coli* (rho = 0.66, p <0.001; r = 0.60, p <0.001), see figure 10. The Illinois River below Peoria Lake at Peoria, Ill., had a negative correlation coefficient for streamflow to either FC (rho = −0.44, p = 0.0129) or *E. coli* (rho = −0.43, p = 0.0157), see figure 11. This last relation did not have a statistically significant Pearson r coefficient.

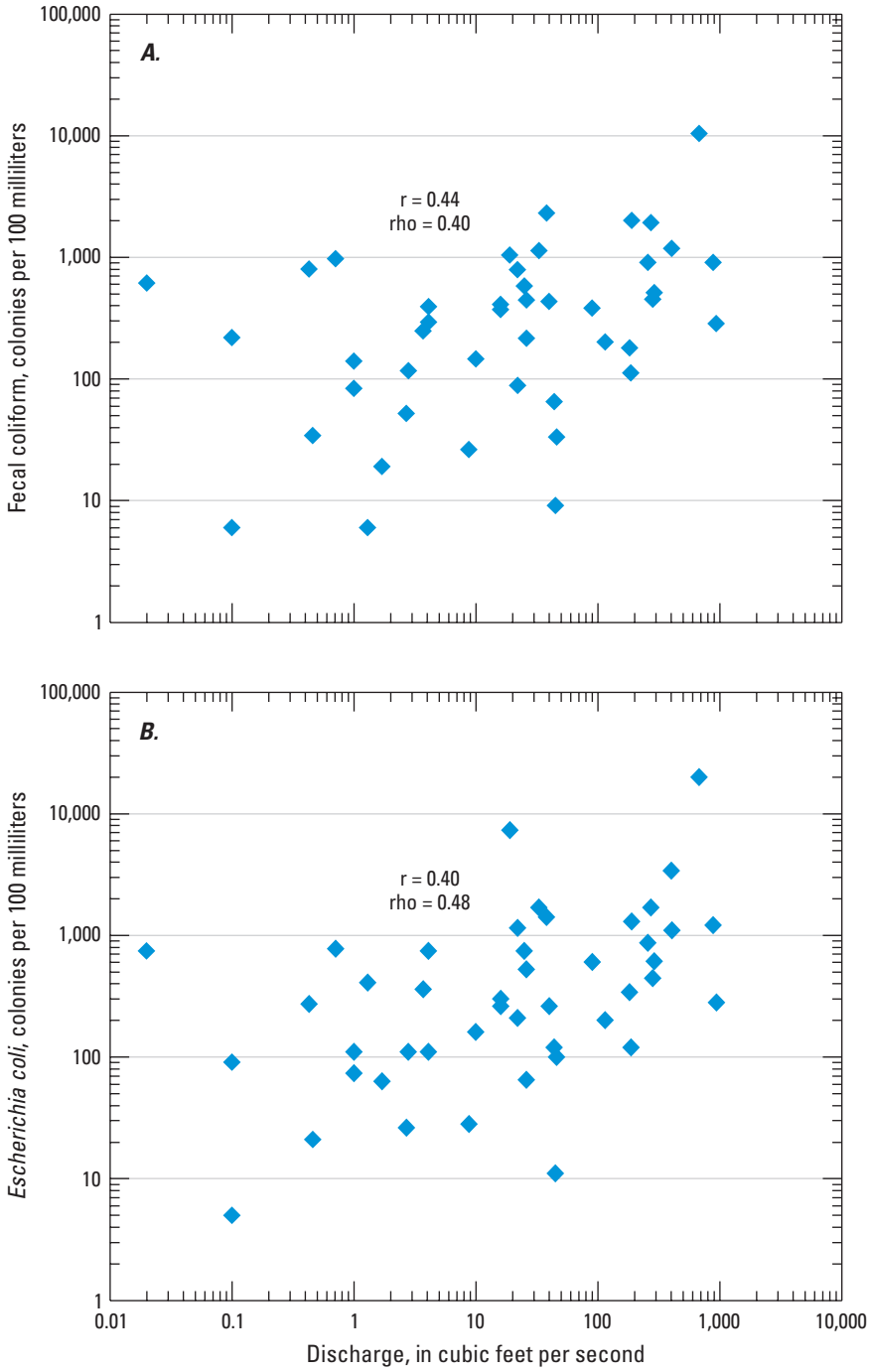

Figure 9. Correlation of *A*, fecal coliform colonies and *B*, *Escherichia coli* colonies to discharge from tributaries to the Illinois River.

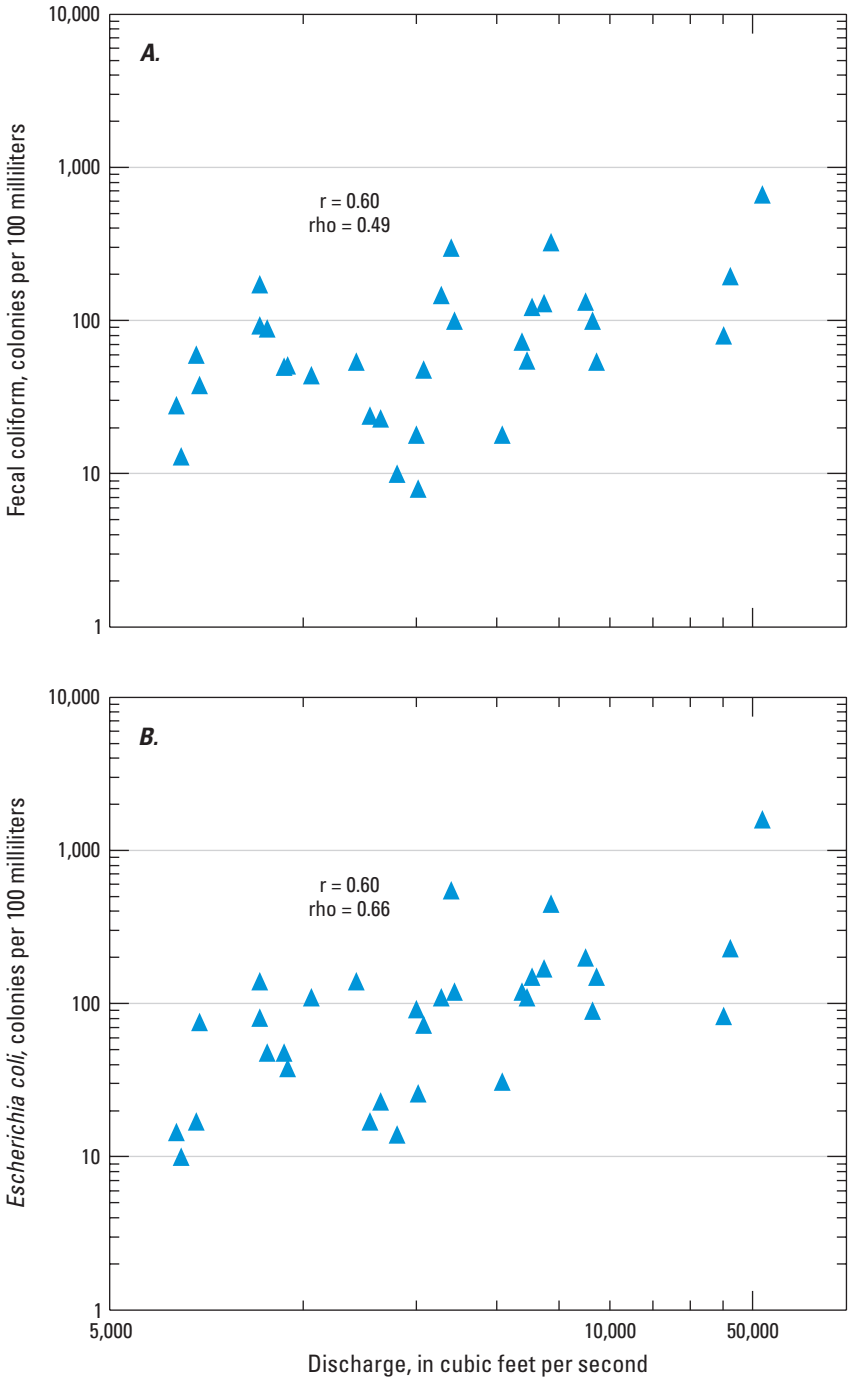

Figure 10. Correlation of *A*, fecal coliform colonies and *B*, *Escherichia coli* colonies to discharge for the Illinois River at Hennepin, Illinois.

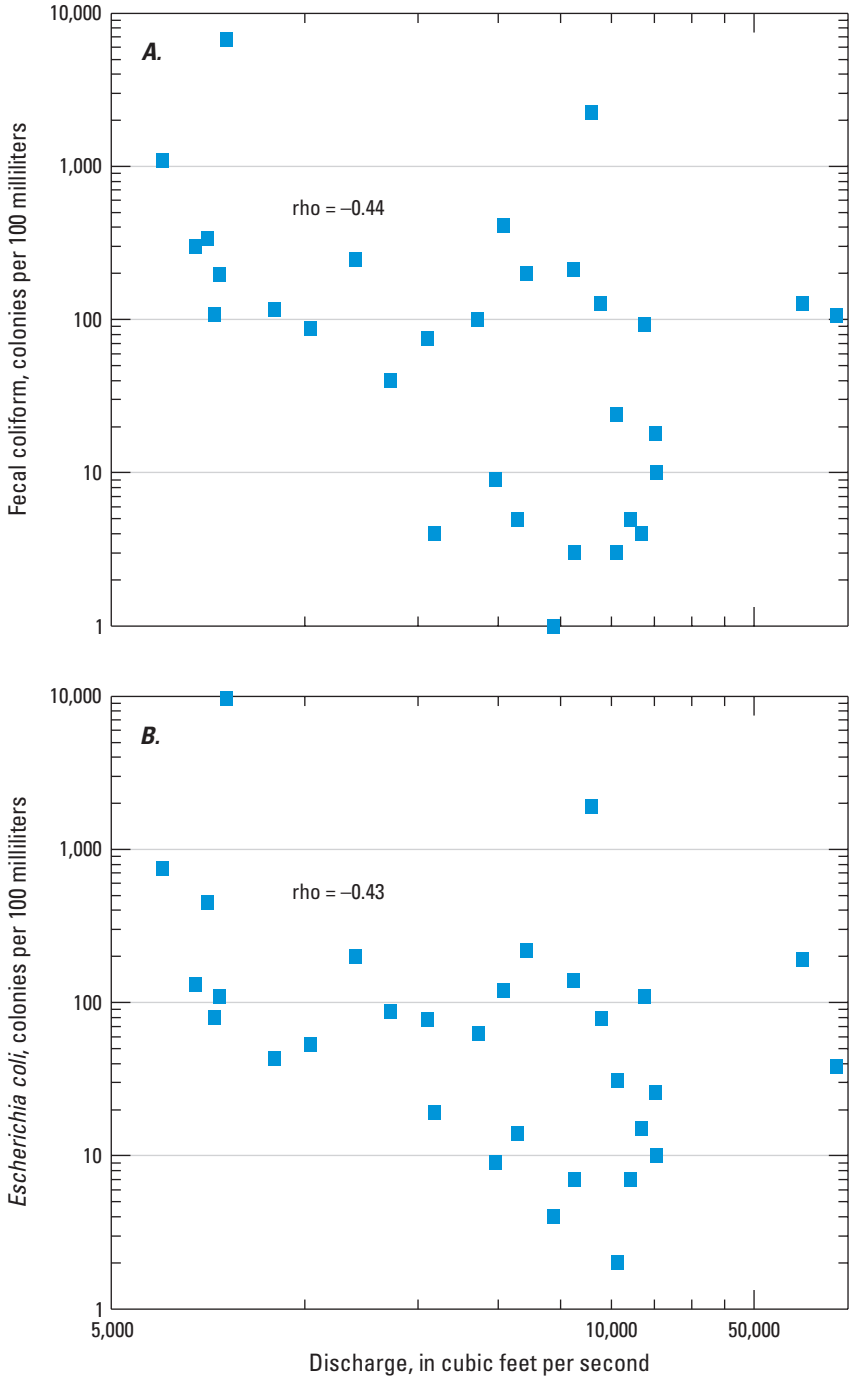

Figure 11. Correlation of *A*, fecal coliform colonies and *B*, *Escherichia coli* colonies to discharge for the Illinois River below Peoria Lake at Peoria, Illinois.

The data from June 2008 indicate a possible influence of CSOs on FC concentrations following rainfall-runoff events in the reach of the Illinois River immediately near Peoria, Ill. The June 2008 synoptic survey of FIB in the Illinois River indicated FC concentrations greater than the water-quality standard only below the known CSO outfalls in Peoria, Ill. Each tributary sampled during June 2008 also had FC concentrations above the standard; however, concentrations in the main stem of the Illinois River below the mouths of these tributaries and still upstream of Peoria, Ill., did not exceed the State of Illinois single-sample water-quality standard of 400 CFU/100 mL. These data are presented in table 8.

The influences of high FIB concentrations in the tributary streams on concentrations in the Illinois River are not clear from the data collected in this investigation. For example, during the June 2008 synoptic sampling, FIB concentrations in Partridge and Farm Creeks exceeded the water-quality standard. These tributaries enter the Illinois River well upstream of the Highway 8/29/116 bridge (figs. 1 and 5); however, FIB concentrations in the Illinois River did not exceed the water-quality standard at any location upstream of the bridge.

Conclusions

Portions of the Illinois River in Peoria, Woodford, and Tazewell Counties, Illinois, are designated as impaired for primary-contact recreation by the Illinois Environmental Protection Agency, and fecal coliform bacteria are listed as a potential cause of impairment. Combined sanitary and storm sewers around the City of Peoria might contribute to elevated bacteria concentrations during overflow events. The U.S. Geological Survey, in cooperation with the Tri-County Regional Planning Commission, investigated fecal-indicator bacteria (FIB) concentrations in this reach of the Illinois River and many of the tributary waterways during water year 2008 (October 2007–September 2008). Information regarding both diffuse- and point-source contributions of FIB will aid in any possible future resource-management efforts of these water resources at the Federal, State, or local level.

Hydrologic conditions during the study period are characterized as wetter than normal, with the mean annual flow in the Illinois River about 37-percent above the long-term average. Rainfall was normal to slightly below normal during the first three months of the study period; however, the observed rainfall across the State of Illinois for 2008 was the second wettest since 1895. Precipitation-recording stations within the study area had similar results as did the aggregated State-level records.

Two synoptic sampling efforts were conducted to determine FIB concentrations during low- and high-flow conditions in the waterways of the study area. The low-flow period was characterized during October 2007 sampling, and the high-flow period was characterized during June 2008 sampling. The Illinois River and 12 tributaries were sampled at 30 different locations during October 2007. The Illinois River and 5 tributaries were sampled at 17 different locations during June 2008. The Illinois River also was sampled routinely during the study period at the upstream and downstream boundaries of the study area, at Hennepin and Peoria, Ill., respectively. Additionally, fixed-interval samples were collected from three tributaries where streamflow was continuously monitored.

Concentrations of the two measured FIB—fecal coliform and *Escherichia coli*—demonstrated a statistically significant correlation to each other for all samples ($r = 0.94$, $p < 0.001$), regardless of the specific sampling location. Correlation of FIB concentrations to streamflow also was investigated. A weaker statistical relation was found for streamflow to concentrations at any location. For the Illinois River water samples from the Hennepin, Ill., location or from any of the tributaries, positive correlation coefficients indicate that both streamflow and FIB values increase and decrease simultaneously in magnitude. At the downstream study boundary for the Illinois River below Peoria Lake at Peoria, Ill., however, a statistically significant negative correlation coefficient indicates a weaker inverse relation between values of streamflow and FIB.

Possible linkage may be evident between combined storm- and sanitary-sewer overflows with assumed elevated fecal coliform concentrations, based on previous investigative research by the City of Peoria, Ill., and measured concentrations in the Illinois River during June 2008. The data presented in this report indicate both diffuse and point sources of fecal indicators in the water column throughout the study area. The presence of one of the studied FIB typically indicates the presence of the other.

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