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Quality of Water on the Prairie Band of Potawatomi Reservation, Northeastern Kansas, February 1999 Through February 2001

Water-Resources Investigations Report 00–4196

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

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By THOMAS J. TROMBLEY

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Lawrence, Kansas
2001

Cover photograph taken by Gregory P. Wold, Biologist, Prairie Band of Potawatomi, Mayetta, Kansas.

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U.S. Department of the Interior

Gale A. Norton, Secretary

U.S. Geological Survey

Charles G. Groat, Director

For additional information write to:

District Chief
U.S. Geological Survey
4821 Quail Crest Place
Lawrence, KS 66049–3839

Copies of this report can be purchased from:

U.S. Geological Survey
Information Services
Building 810
Box 25286, Federal Center
Denver, CO 80225–0286

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CONVERSION FACTORS AND ABBREVIATIONS

Multiply	By	To obtain
acre	4,047	square meter
cubic foot per second (ft^3/s)	0.02832	cubic meter per second
foot (ft)	0.3048	meter
gallon per minute (gal/min)	0.06309	liter per second
microgram per liter (µg/L)	1.0	part per billion
mile (mi)	1.609	kilometer
milligram per liter (mg/L)	1.0	part per million
square mile (mi^2)	2.590	square kilometer
ton	907.2	kilogram
ton	0.9072	megagram

Temperatures given in this report can be converted to degrees Celsius (^oC) or degrees Fahrenheit (^oF) by the equations:

$$^oC = 5/9\ (^oF - 32)$$
$$^oF = 9/5\ (^oC) + 32.$$

Sea level: In this report, “sea level” refers to the National Geodetic Vertical Datum of 1929—a geodetic datum derived from a general adjustment of the first-order level nets of the United States and Canada, formerly called Sea Level Datum of 1929.

Quality of Water on the Prairie Band Potawatomi Reservation, Northeastern Kansas, February 1999 Through February 2001

By Thomas J. Trombley

Abstract

Water-quality samples were collected from 20 surface-water sites and 7 ground-water sites across the Prairie Band Potawatomi Reservation in northeastern Kansas as part of a water-quality study begun in 1996. Water quality is a very important consideration for the tribe. Three creeks draining the reservation, Soldier, Little Soldier, and South Cedar Creeks, are important tribal resources used for maintaining subsistence fishing and hunting needs for tribal members. Samples were collected twice during June 1999 and June 2000 at all 20 surface-water sites after herbicide application, and nine quarterly samples were collected at 5 of the 20 sampling sites from February 1999 through February 2001. Samples were collected once at six wells and twice at one well from September through December 2000. Surface-water-quality constituents analyzed included nutrients, pesticides, and bacteria. In addition to nutrients, pesticides, and bacteria, ground-water constituents analyzed included major dissolved ions, arsenic, boron, and dissolved iron and manganese.

The median nitrite plus nitrate concentration was 0.376 mg/L (milligram per liter) for 81 surface-water samples, and the maximum concentration was 4.18 mg/L as nitrogen, which is less than one-half the U.S. Environmental Protection Agency's Maximum Contaminant Level (MCL) for drinking water of 10 mg/L as nitrogen. Fifty-one of the 81 surface-water-quality samples exceeded the U.S. Environmental Protection Agency's recommended goal for total phosphorus of 0.10 mg/L for the protection of aquatic life.

Triazine concentrations in 26 surface-water-quality samples collected during May and June 1999 and 2000 exceeded 3.0 μg/L (micrograms per liter), the Maximum Contaminant Level established for drinking water by the U.S. Environmental Protection Agency. Triazine herbicide concentrations tended to be highest during late spring runoff after herbicide application. High concentrations of fecal indicator bacteria in surface water are a concern on the reservation with fecal coliform concentrations ranging from 4 to greater than 31,000 colonies per 100 milliliters of water with a median concentration of 570 colonies per 100 milliliters. More than one-half of the surface-water-quality samples exceeded the Kansas Department of Health and Environment contact recreation criteria of 200 and 2,000 colonies per 100 milliliters of water and were collected mostly during the spring and summer.

Two wells had sodium concentrations of about 10 times the U.S. Environmental Protection Agengy health advisory level (HAL) of 20 mg/L; concentrations ranged from 241 to 336 mg/L. In water from two wells, sulfate concentrations exceeded 800 mg/L, more than three times the U.S. Environmental Protection Agency Secondary Maximum Contaminant Level (SMCL) for drinking water of 250 mg/L. All but two of the eight ground-water-quality samples had dissolved-solids concentrations exceeding the SMCL of 500 mg/L. The highest concentration of 2,010 mg/L was more than four times the SMCL.

Dissolved boron concentrations exceeded the U.S. Environmental Protection Agency 600-µg/L HAL in water from two of the seven wells sampled. Because the HAL is for a lifetime of exposure, the anticipated health risk due to dissolved boron is low. Dissolved iron concentrations in ground-water samples exceeded the 300-µg/L SMCL for treated drinking water in three of the seven wells sampled. Dissolved manganese concentrations in water from the same three wells also exceeded the established SMCL of 50 µg/L. Dissolved pesticides were not detected in any of the well samples; however, there were degradation products of the herbicides alachlor and metolachlor in several samples. Insecticides were not detected in any ground-water-quality samples.

Low concentrations of E. coli and fecal coliform bacteria were detected in water from two wells, and E. coli was detected in water from one well. Much higher concentrations of E. coli, fecal coliform, and fecal streptococcus were detected in water from one well when samples were collected shortly after the well was drilled.

Water quality on the Prairie Band Potawatomi Reservation is generally sufficient to meet the requirements of the tribe. Major concerns for surface water are related to agricultural runoff and include increased triazine herbicide concentrations during the spring and summer and high concentrations of fecal coliform bacteria. Major concerns for ground water are related to high mineral concentrations resulting from dissolution of the surrounding sedimentary rocks.

INTRODUCTION

The Prairie Band Potawatomi Reservation (fig. 1) is located in Jackson County, about 20 mi north of Topeka in northeastern Kansas. The reservation covers an area of 121 mi^2, of which 40 mi^2 is currently (2001) tribally owned (tribal trust, allotted, or recent purchases); the remainder of reservation land is designated as fee ownership and owned primarily by nontribal members.

Water quality is an important consideration for the Prairie Band Potawatomi Nation. Three of the four creeks draining the reservation, Soldier (locally referred to as Big Soldier Creek), Little Soldier, and South Cedar Creeks, are important tribal resources. These creeks are particularly important for maintaining subsistence fishing and hunting needs of tribal members. Consequently, the quality of surface water needs to be maintained at a level that poses no danger to human health and protects wildlife resources on the reservation. Ground-water quality also is a major concern to the tribe. Wells are used for domestic water supply throughout the reservation. The tribe is developing the economic base of the reservation, and a stable, usable ground-water supply is an important part of that development.

Nonpoint sources such as agricultural lands and seepage from septic systems or sewage lagoons serving a rural population are considered the primary sources of potential water-quality problems on the reservation. No documented point sources of wastewater discharge, such as a factory or waste-treatment outflow, are located on the reservation (Latane Donelin, Potawatomi Department of Planning and Environmental Protection, oral commun., 1999).

Under the Federal Clean Water Act of 1972, an Indian tribe is sovereign for the purposes of delegating the authority to regulate water within reservation boundaries. As part of efforts to develop a water plan for their reservation, which includes setting water-quality standards for surface water, the Prairie Band Potawatomi began a study in cooperation with the U.S. Geological Survey (USGS) in 1996 to define and monitor the quality of water on the reservation.

This report is the second in a series of reports resulting from this cooperative study and a previous cooperative study with four Kansas tribes and the Bureau of Indian Affairs to describe the water resources on Indian lands in northeastern Kansas and southeastern Nebraska (Trombley and others, 1996). The first report in the series describes surface-water quality on the reservation from June 1996 through November 1998 (Trombley, 1999). This report describes selected water-quality characteristics of surface and ground water on the reservation using water samples collected from February 1999 through February 2001.

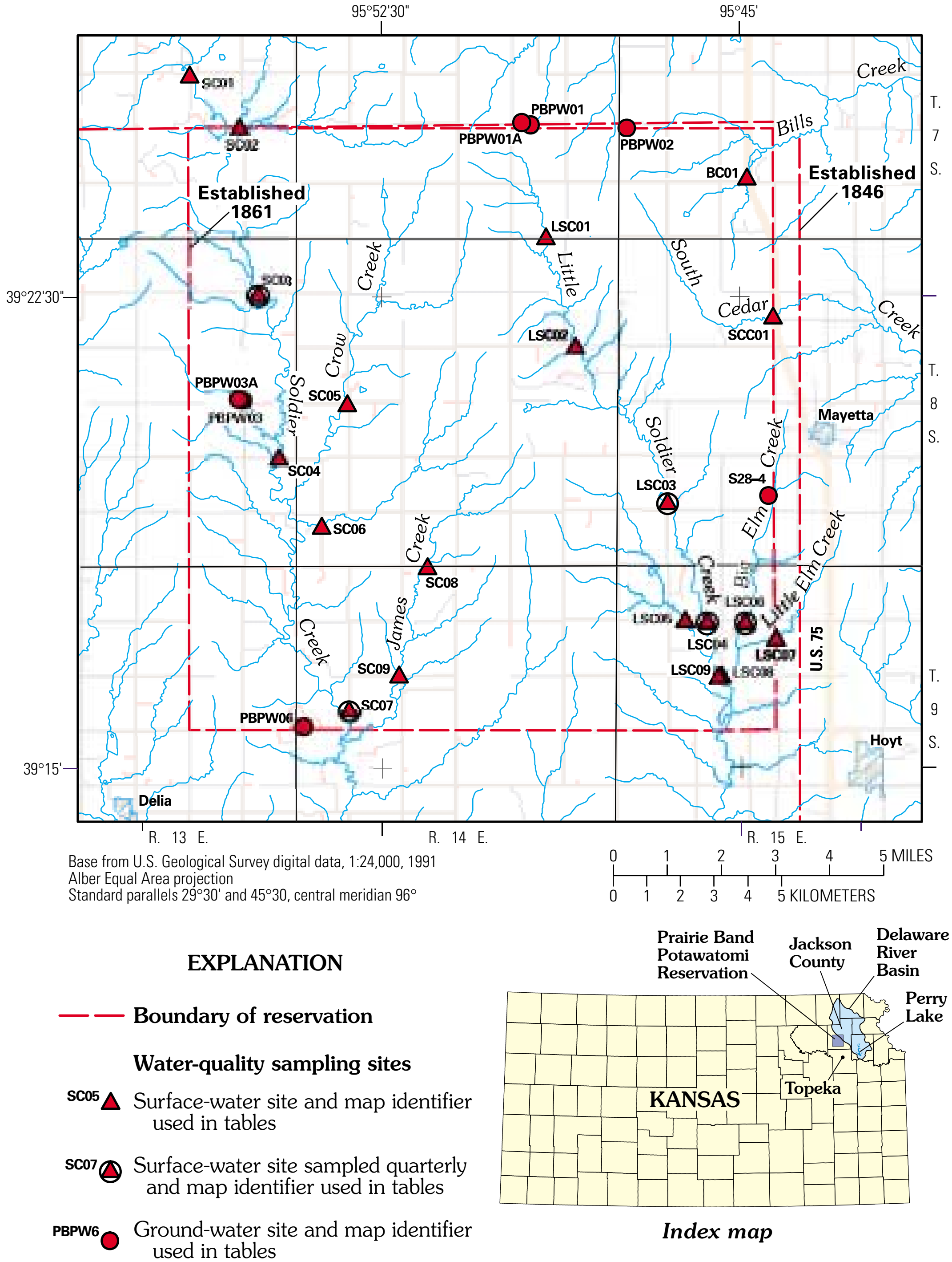

Figure 1. Location of water-quality sampling sites on and near Prairie Band Potawatomi Reservation, northeastern Kansas.

METHODS

Sample Collection

Samples were collected twice at all 20 surface-water-quality sampling sites (fig. 1, table 1) during June 1999 and June 2000, after seasonal herbicide application on fields in the area, and nine samples were collected approximately quarterly at 5 of the 20 sampling sites during February 1999 through February 2001. Surface-water-quality sampling sites were selected to represent areal distribution across the

Table 1. Location of surface-water-quality sampling sites used in this study of Prairie Band Potawatomi Reservation, northeastern Kansas

[*, asterisk indicates quarterly samples collected at site]

Map identifier (fig. 1)	Site identification number	Local number (township, range, section)[1]	Stream basin and site name	Latitude (degrees, minutes, seconds)	Longitude (degrees, minutes, seconds)
			Bills Creek Basin		
BC01	392425095445100	7S 15E 28CDD	Bills Creek, U.S. Highway 75 near Holton	39°24'25"	95°44'51"
			Little Soldier Creek Basin		
LSC01	392328095490300	7S 14E 35DCDC	Little Soldier Creek, 190 Road near Mayetta	39°23'28"	95°49'03"
LSC02	392143095482700	8S 14E 12CCDD	Little Soldier Creek, 174 Road near Mayetta	39°21'43"	95°48'27"
LSC03*	391915095463100	8S 15E 29CCBC	Little Soldier Creek, O Road near Mayetta	39°19'15"	95°46'31"
LSC04*	391720095454200	9S 15E 08ABAA	Little Soldier Creek, 134 Road near Mayetta	39°17'20"	95°45'42"
LSC05	391721095460900	9S 15E 05CDCD	Little Soldier Creek tributary, 134 Road near Hoyt	39°17’21"	95°46'09"
LSC06*	391720095445400	9S 15E 04CDDD	Big Elm Creek, 134 Road near Hoyt	39°17'20"	95°44'54"
LSC07	391704095441700	9S 15E 10BCBB	Little Elm Creek, Q Road near Hoyt	39°17'04"	95°44'17"
LSC08	391629095452400	9S 15E 09CCCC	Big Elm Creek, P Road near Hoyt	39°16'29"	95°45'24"
LSC09	391628095452800	9S 15E 17AAAA	Little Soldier Creek, 126 Road near Hoyt	39°16’28"	95°45'28"
			Soldier Creek Basin		
SC01	392603095563000	7S 13E 23BBBB	Soldier Creek, 214 Road near Circleville	39°26'03"	95°56'30"
SC02	392512095552800	7S 13E 23 DDDD	Soldier Creek tributary, G Road near Circleville	39°25'12"	95°55'28"
SC03*	06889180	8S 13E 12BABB	Soldier Creek near Saint Clere	39°22'33"	95°55'06"
SC04	391956095544000	8S 13E 25ABAB	Soldier Creek, 158 Road near Saint Clere	39°19'56"	95°54'40"
SC05	392049095531300	8S 14E 18DDDD	Crow Creek, 166 Road near Saint Clere	39°20'49"	95°53'13"
SC06	391852095534500	8S 14E 31BADD	South Branch Soldier Creek, H.5 Road near Saint Clere	39°18'52"	95°53'45"
SC07*	391557095531100	9S 14E 17CBBC	Soldier Creek, I Road near Delia	39°15'57"	95°53'11"
SC08	391813095513200	8S 14E 33CDDD	James Creek, 142 Road near Delia	39°18'13"	95°51'32"
SC09	391630095520800	9S 14E 08DDDD	James Creek, 126 Road near Delia	39°16'30"	95°52'08"
			South Cedar Creek Basin		
SCC01	392212095441800	8S 15E 09ADDA	South Cedar Creek, U.S. Highway 75 near Mayetta	39°22'12"	95°44'18"

[1]Local numbers are assigned according to a modification of the Bureau of Land Management’s system of land subdivision. In this system, the first set of digits in the number refers to the township north (N) or south (S) of the Kansas-Nebraska State line; the second set refers to the range east (E) or west (W) of the sixth principal meridian; and the third set refers to the section in which the site is located. The terminal letters refer to the 160-acre, 40-acre, 10-acre, and 2.5-acre tracts within the section. The letters A, B, C, D are assigned in a counterclockwise direction beginning in the northeast quadrant. For example, the local number 7S 14E 35DCDC indicates a site located in the southwest quarter of the southeast quarter of the southwest quarter of the southeast quarter of sec. 35, T. 7 S., R. 14 E.

reservation, surface water flowing into and out of the reservation, and surface water downstream from potential sources of contamination. Surface-water-quality samples were collected for the analysis of physical properties, nutrients, pesticides, and bacteria. Surface-water sampling methods are described in Trombley (1999).

Seven wells (fig. 1, table 2) within or directly adjacent to the reservation were sampled during September through December 2000 for ground-water-quality analysis. Six of the wells sampled were domestic supply wells for residences. One well (S28–4, fig. 1) was drilled on September 21, 2000, as part of a test for developing the tribe's water supply. Domestic wells were chosen for sampling because they (1) provide wide areal coverage of ground water on the reservation and (2) are generally, easily accessible under all weather conditions. In addition to physical properties, nutrients, pesticides, and bacteria as analyzed for surface-water-quality samples, ground-water-quality samples were analyzed for major dissolved ion concentrations, dissolved iron and manganese concentrations, and arsenic concentrations.

The water-supply test well was sampled twice. The first sample was collected on September 22, 2000, the day after it was drilled. The well had been pumped for about 4 hours at a rate of about 100 gal/min prior to sampling. The second sample was collected on September 25, 2000, at the end of an aquifer test for which the well was pumped continuously for 3 days at a rate of about 100 gal/min. Samples were collected from the six domestic wells on November 30 and December 1, 2000. These wells are in continual use and were each pumped for about 0.5 hour prior to sample collection.

Ground-water-quality samples were collected and processed in a mobile water-quality laboratory. Existing submersible pumps, permanently installed in each domestic well, were used to deliver water to the land surface, and a permanent spigot or hydrant near the wellhead was used as the water-quality sampling point. All materials in contact with the water sample downgradient from the existing plumbing consisted of either stainless steel or Teflon.

Ground-water-sampling protocols followed during this study are described in detail in Koterba and others (1995). To minimize the risk of sample contamination, all sample collection and preservation took place in dedicated environmental chambers consisting of clear polyethylene bags supported by tubular polyvinyl chloride (PVC) frames. Sampling equipment, extending from the permanent sampling point near the wellhead to the sampling chamber inside the mobile laboratory, was thoroughly decontaminated between each sample. Sampled wells were first purged of possible stagnant water. During the initial pumping period, onsite measurements of specific conductance, pH, water temperature, and dissolved oxygen were monitored every 5 minutes in a closed-cell, flow-through chamber until readings stabilized. Once stable measurements were obtained, water flow inside the laboratory was redirected to the clean sampling chamber where water was collected immediately for analysis.

Sample Analyses

Surface- and ground-water samples for determination of physical properties, nutrients, major dissolved ions, arsenic, boron, and dissolved iron and manga-

Table 2. Location and description of ground-water-quality sampling sites used in this study of Prairie Band Potawatomi Reservation, northeastern Kansas

Map identifier (fig. 1)	Site identification number	Local number (township, range, section)	Latitude (degrees, minutes, seconds)	Longitude (degrees, minutes, seconds)	Altitude of land surface (feet above sea level)
PBPW01	392514095492201	07S 14E 23CDDB01	39° 25' 14.3"	95° 49' 22.0"	1,202
PBPW01A	392517095493401	07S 14E 23CCDA01	39° 25' 16.7"	95° 49' 33.7"	1,202
PBPW02	392511095472201	07S 15E 30BBAA01	39° 25' 11.0"	95° 47' 21.7"	1,153
PBPW03	392051095552501	08S 13E 14DDDD01	39° 20' 50.7"	95° 55' 25.2"	1,049
PBPW03A	392052095552901	08S 13E 14DDDB01	39° 20' 52.0"	95° 55' 29.5"	1,054
PBPW06	391539095540801	09S 14E 18CCDC01	39° 15' 38.9"	95° 54' 08.2"	1,038
S28–4	391920095443001	08S 15E 28DACD01	39° 19' 19.4"	95° 44' 24.4"	1,100

nese concentrations were analyzed at the USGS National Water-Quality Laboratory (NWQL) in Denver, Colorado, using methods described in Ziegler and Combs (1997). Nutrient analyses included a determination of total nitrogen, nitrite plus nitrate, dissolved ammonia, total phosphorus, and orthophosphate concentrations. Dissolved pesticides, including herbicides and insecticides, were analyzed using two methods. Enzyme-linked immunosorbent assay (ELISA) was used for all samples to screen for triazine herbicides. Samples were analyzed at the USGS laboratory in Lawrence, Kansas, using procedures described in Thurman and others (1990) and used previously in a surface-water study of atrazine in northeastern Kansas (Pope and others, 1997). Selected surface-water and all ground-water samples were analyzed using both ELISA and gas chromatography/mass spectrometry (GC/MS) as verification of the ELISA method. Samples from selected surface-water sites were analyzed at the USGS National Water-Quality Laboratory for a wide range of dissolved pesticides (Trombley, 1999) using methods described in Ziegler and Combs (1997).

Fecal coliform and fecal streptococcus bacteria concentrations were analyzed by tribal or USGS personnel. All bacteria were processed within 6 hours of collection and analyzed using the membrane-filtration method presented in Wilde and others (1998, p. 3–38).

Slightly different minimum reporting and detection levels are possible from sample analysis to sample analysis at the laboratory. Determination of minimum report levels by the USGS is explained in detail by Childress and others (1999). Accordingly, concentrations are reported as less than (<) the minimum reporting level for samples in which the constituent was either not detected or could not be identified. Constituents that were detected at concentrations less than the minimum report level and that could be identified were estimated. Estimated concentrations are noted with a remark code of “E.” These data should be used with the understanding that their uncertainty is greater than that of data reported without the “E” remark code (Childress and others, 1999).

SURFACE-WATER QUALITY

Physical Properties

Specific conductance (table 3) can be used as an indicator of dissolved-solids concentration, and it generally increases as the concentrations of calcium, magnesium, sodium, chloride, bicarbonate, and sulfate increase (Hem, 1992, p. 66–69). Specific conductance values for streams on the Prairie Band Potawatomi Reservation ranged from 128 to 1,440 μS/cm (microsiemens per centimeter at 25 ^{o}C), with a median value of 509 μS/cm, during the February 1999 through February 2001 sampling period (fig. 2). At any given sampling site (SC03, for example), specific conductance values tended to be highest during low streamflow periods with no runoff and lowest during periods of high streamflow with high runoff (fig. 3). The highest specific conductance (1,440 μS/cm) was observed at sampling site LSC06 (table 3) on November 28, 2000, when streamflow was minimal at 0.10 ft^3/s. The median specific conductance value in samples from that site was 792 μS/cm. The lowest observed specific conductance value (128 μS/cm) occurred in a sample from site SC03 (table 3) on June 22, 1999, when Soldier Creek was at its highest flow during water-quality sampling of 3,050 ft^3/s.

Hydrogen activity of water is measured by pH. According to Hem (1992, p. 64), pH of stream water not affected by pollution generally ranges from 6.5 to 8.5 standard units. The lower the pH value, the more acidic the water. Values for pH greater than 7.0 standard units are indicative of alkaline water, and values less than 7.0 standard units are indicative of acidic water. Where photosynthesis by aquatic organisms takes up carbon dioxide during daylight and releases carbon dioxide at night, pH fluctuations may occur, and the maximum daytime pH value may be as high as 9.0 standard units. In contrast, other factors, such as oxidation of dissolved ferrous iron, can lower the pH. The U.S. Environmental Protection Agency (1986) recommends a pH range of 6.5 to 8.5 standard units (range of Secondary Maximum Contaminant Level, SMCL) for drinking-water supplies because, within that range, pH can be adjusted easily by treatment processes.

Onsite measurements of pH in 73 surface-water-quality samples (fig. 4) collected from the reservation between February 1999 and February 2001 ranged from a low of 6.7 to a high of 8.3 standard units

Table 3. Results of analysis of streamflow and physical properties in surface-water-quality samples from Prairie Band Potawatomi Reservation, northeastern Kansas, February 1999 through February 2001

[ft^3/s, cubic feet per second; µS/cm, microsiemens per centimeter at 25 degrees Celsius; ^oC, degrees Celsius; mg/L, milligrams per liter; mm of Hg, millimeter of mercury; --, not determined]

Map identifier (fig. 1)	Stream basin and site name	Date of sample collection (month/day/ year)	Time of sample collection (24 hour)	Streamflow (ft^3/s)	Specific con- ductance (µS/cm)	pH, onsite (standard units)	Air temper- ature (^oC)	Water temper- ature (^oC)	Dissolved oxygen (mg/L)	Barometric pressure (mm of Hg)
	Bills Creek Basin									
BC01	Bills Creek, U.S. Highway 75 near Holton	6/22/99	1010	2.0	433	6.7	--	20.2	6.3	732
		6/27/00	1025	.09	477	7.3	--	20.4	6.8	720
	Little Soldier Creek Basin									
LSC01	Little Soldier Creek, 190 Road near Mayetta	6/23/99	1445	3.1	250	7.1	26.0	21.7	7.7	726
		6/27/00	1300	.08	312	7.8	21.2	23.8	3.1	734
LSC02	Little Soldier Creek, 174 Road near Mayetta	6/23/99	1200	19	229	7.9	25.0	20.5	8.2	725
		6/27/00	1430	.26	439	7.7	20.6	21.5	7.3	730
LSC03	Little Soldier Creek, O Road near Mayetta	2/9/99	1100	6.5	582	7.7	10.0	5.6	11.6	742
		5/11/99	1055	8.6	598	7.8	15.5	16.2	8.8	735
		6/23/99	1400	35	318	7.8	26.0	20.8	8.5	726
		9/14/99	0915	--	670	7.7	12.5	13.6	6.3	738
		11/2/99	1055	0	718	7.7	11.5	9.9	4.0	744
		2/15/00	1320	.30	622	7.9	18.0	5.5	13.9	735
		5/16/00	1425	1.7	522	8.0	22.0	17.2	8.2	724
		6/27/00	1130	1.9	411	7.8	19.2	20.1	7.1	722
		11/28/00	1005	0	718	7.3	8.5	3.2	.9	738
		2/21/01	1115	1.6	269	7.5	-4.0	-.2	10.9	745
LSC04	Little Soldier Creek, 134 Road near Mayetta	2/9/99	1145	8.4	606	8.2	4.5	6.8	12.8	743
		5/11/99	1100	12	610	7.9	20.0	16.4	9.4	735
		6/23/99	1010	18	393	7.8	21.0	20.6	4.1	738
		2/15/00	0845	.38	554	7.8	4.0	.5	12.7	735
		5/16/00	0935	2.1	498	8.0	22.0	15.0	8.3	729
		6/27/00	1015	2.9	434	7.7	19.5	20.7	7.0	744
		2/21/01	1005	3.1	258	7.5	-5.5	-0.3	11.6	745

Table 3. Results of analysis of streamflow and physical properties in surface-water-quality samples from Prairie Band Potawatomi Reservation, northeastern Kansas, February 1999 through February 2001—Continued

Map identifier (fig. 1)	Stream basin and site name	Date of sample collection (month/day/year)	Time of sample collection (24 hour)	Streamflow (ft^3/s)	Specific conductance ($\mu S/cm$)	pH, onsite (standard units)	Air temperature (^oC)	Water temperature (^oC)	Dissolved oxygen (mg/L)	Barometric pressure (mm of Hg)
	Little Soldier Creek Basin—Continued									
LSC05	Little Soldier Creek tributary, 134 Road near Hoyt	6/23/99	1110	6.5	340	7.8	24.0	20.2	3.1	725
		6/27/00	1110	.53	505	7.7	21.5	19.9	7.2	745
LSC06	Big Elm Creek, 134 Road near Hoyt	2/9/99	1030	1.7	681	8.2	4.0	5.7	11.5	743
		5/11/99	0950	3.0	629	7.8	14.0	14.5	8.6	735
		6/23/99	0910	6.5	294	7.7	20.5	19.9	6.1	738
		9/14/99	0905	.06	669	7.9	17.0	13.9	8.8	738
		11/2/99	0935	.10	792	7.7	11.5	5.9	9.0	747
		2/15/00	0920	.23	909	7.7	8.0	1.5	11.4	735
		5/16/00	0835	.34	967	7.9	18.0	14.2	8.4	729
		6/27/00	0845	.57	745	7.6	18.5	19.2	7.0	735
		8/29/00	0835	.01	933	7.4	26.0	22.6	5.1	730
		11/28/00	0920	.10	1,440	7.7	6.0	2.5	10.6	737
		2/21/01	0910	--	928	7.5	-4.5	-.3	11.3	745
LSC07	Little Elm Creek, Q Road near Hoyt	6/23/99	1435	3.5	302	7.7	27.0	21.1	4.4	726
		6/27/00	1600	.23	504	7.7	25.5	21.5	7.8	743
LSC08	Big Elm Creek, P Road near Hoyt	6/23/99	1230	12	254	7.8	25.0	20.8	8.9	725
		6/27/00	1230	3.0	494	7.8	24.5	21.0	7.2	745
LSC09	Little Soldier Creek, 126 Road near Hoyt	6/23/99	1320	32	369	7.8	26.0	20.9	2.8	725
		6/27/00	1400	5.2	508	7.9	28.0	22.1	7.3	744
	Soldier Creek Basin									
SC01	Soldier Creek, 214 Road near Circleville	6/22/99	1830	--	182	7.5	--	21.2	7.2	727
		6/28/00	1445	8.8	468	7.9	28.0	24.6	9.7	740
SC02	Soldier Creek tributary, G Road near Circleville	6/22/99	1850	57	227	--	20.5	21.7	8.1	--
		6/28/00	1325	1.5	714	7.7	26.0	19.0	9.9	740
SC03	Soldier Creek near Saint Clere	2/9/99	1400	34	645	8.2	5.0	8.2	12.1	743
		5/11/99	1310	66	669	8.0	14.9	18.8	9.8	735

Table 3. Results of analysis of streamflow and physical properties in surface-water-quality samples from Prairie Band Potawatomi Reservation, northeastern Kansas, February 1999 through February 2001—Continued

Map identifier (fig. 1)	Stream basin and site name	Date of sample collection (month/day/year)	Time of sample collection (24 hour)	Streamflow (ft^3/s)	Specific conductance (μS/cm)	pH, onsite (standard units)	Air temperature (°C)	Water temperature (°C)	Dissolved oxygen (mg/L)	Barometric pressure (mm of Hg)
	Soldier Creek Basin—Continued									
SC03	Soldier Creek near Saint Clere	6/22/99	1545	3,050	128	7.4	--	20.6	7.2	728
		9/14/99	1220	3.0	697	8.0	17.0	15.1	10.3	738
		11/2/99	1115	4.1	819	8.0	11.0	8.3	9.6	747
		2/15/00	1100	4.2	689	8.1	13.0	2.0	14.1	735
		5/16/00	1100	5.9	664	8.1	23.0	16.9	9.1	729
		6/28/00	1100	17	482	7.8	32.0	21.7	8.8	741
		8/29/00	1025	.61	653	7.6	24.5	26.1	5.0	730
		11/28/00	1120	1.2	853	8.0		3.4	12.9	734
		2/21/01	1255	26	331	7.6	-5.0	-.3	11.8	745
SC04	Soldier Creek, 158 Road near Saint Clere	6/22/99	1715	--	152	--	25.5	20.7	7.3	--
		6/28/00	1330	18	478	8.0	24.0	24.6	7.1	--
SC05	Crow Creek, 166 Road near Saint Clere	6/22/99	1530	60	237	--	27.0	21.9	7.3	--
		6/28/00	0915	1.1	509	7.6	20.0	20.0	7.8	742
SC06	South Branch Soldier Creek, H.5 Road near Saint Clere	6/22/99	1415	14	219	--	24.0	21.2	7.8	--
		6/28/00	1240	.52	537	7.9	23.0	21.0	7.2	732
SC07	Soldier Creek, I Road near Delia	2/9/99	1540	54	656	8.2	5.0	7.1	11.9	743
		5/11/99	1515	100	681	8.0	18.0	18.1	9.7	735
		6/22/99	0945	57	486	--	--	21.9	7.1	--
		6/22/99	0950	57	486	--	--	21.9	7.1	--
		9/14/99	1020	4.9	655	8.1	17.0	16.8	9.2	738
		11/2/99	1300	5.1	781	8.1	12.0	12.2	9.1	747
		2/15/00	1215	7.7	644	8.2	14.0	2.8	15.0	735
		5/16/00	1240	13	556	8.0	26.5	17.7	7.9	727
		6/28/00	0830	26	432	7.7	20.0	22.1	7.6	735
		8/29/00	1250	.74	621	8.0	29.5	29.8	12.8	731
		11/28/00	1410	2.1	775	8.3	8.0	6.1	13.4	737
		2/21/01	1415	41	324	7.7	-5.0	-.3	12.4	743

Table 3. Results of analysis of streamflow and physical properties in surface-water-quality samples from Prairie Band Potawatomi Reservation, northeastern Kansas, February 1999 through February 2001—Continued

Map identifier (fig. 1)	Stream basin and site name	Date of sample collection (month/day/year)	Time of sample collection (24 hour)	Streamflow (ft^3/s)	Specific conductance ($\mu S/cm$)	pH, onsite (standard units)	Air temperature (°C)	Water temperature (°C)	Dissolved oxygen (mg/L)	Barometric pressure (mm of Hg)
	Soldier Creek Basin—Continued									
SC08	James Creek, 142 Road near Delia	6/22/99	1230	119	181	--	--	21.2	8.2	--
		6/28/00	1105	.17	315	7.7	24.0	20.5	7.0	732
SC09	James Creek, 126 Road near Delia	6/22/99	1125	73	186	--	--	20.8	7.9	--
		6/28/00	0950	.50	544	7.8	25.0	20.4	7.7	730
	South Cedar Creek Basin									
SCC01	South Cedar Creek, U.S. Highway 75 near Mayetta	6/23/99	1100	3.0	496	7.4	21.0	19.9	8.1	725
		6/27/00	0935	.57	526	7.7	19.0	20.1	6.5	721

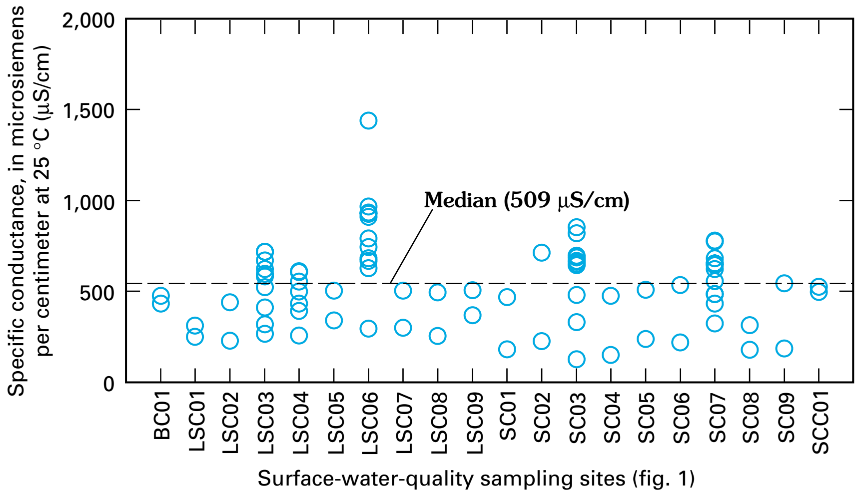

Figure 2. Distribution of specific conductance values in surface-water-quality samples, February 1999 through February 2001.

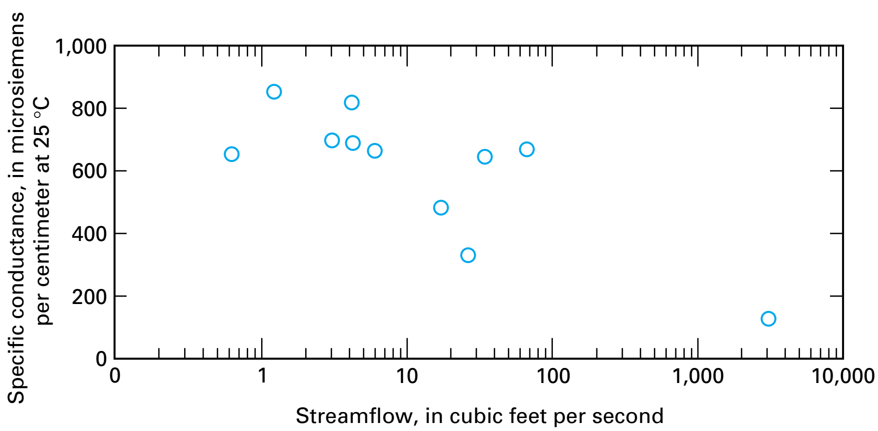

Figure 3. Comparison of specific conductance values and streamflow at surface-water-quality sampling site SC03, February 1999 through February 2001.

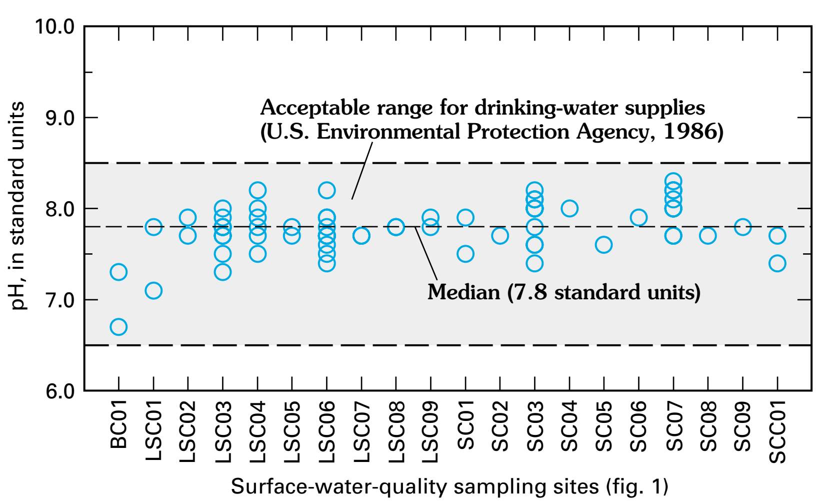

Figure 4. Distribution of pH values in surface-water-quality samples, February 1999 through February 2001.

(table 3), similar to samples collected between 1996 and 1998 (Trombley, 1999). Consequently, pH of surface water on the reservation continues to be within acceptable limits as established by the U.S. Environmental Protection Agency (1986).

Results of dissolved-oxygen measurements are shown in figure 5. Concentrations ranged from 0.9 to 15.0 mg/L in samples collected from throughout the reservation (table 3). During the first sampling period from 1996 to 1998 (Trombley, 1998), dissolved oxygen ranged from 6.3 to 18 mg/L. Higher dissolved-oxygen concentrations are generally more desirable than lower concentrations for maintaining water quality to support aquatic organisms. Several factors can affect dissolved-oxygen concentration, including water temperature and barometric pressure. A comparison of dissolved-oxygen concentrations to water temperature generally showed that dissolved oxygen decreased as water temperature increased (fig. 6). Two dissolved-oxygen concentrations less than 5.0 mg/L with water temperatures less than 10 °C that did not follow this general trend occurred in November (one in 1999 and one in 2000) in samples collected at sampling site LSC03 from a stagnant pool where there was no flowing water.

Nutrients

Nitrogen and phosphorus are essential for the growth and reproduction of plants (Hem, 1992, p. 121). Rooted aquatic plants and algae, for example, require dissolved forms of nitrogen and phosphorus as nutrients. Compounds of nitrogen, such as nitrite, nitrate, and ammonia, are the basic building blocks for pro-

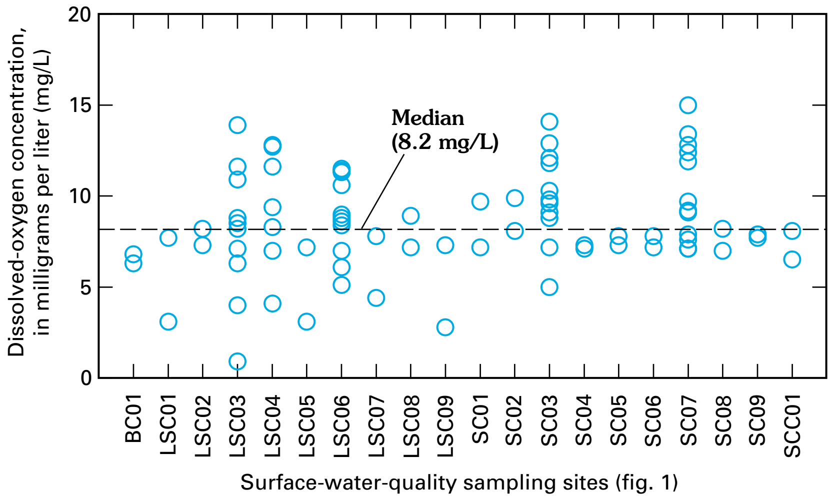

Figure 5. Distribution of dissolved-oxygen concentrations in surface-water-quality samples, February 1999 through February 2001.

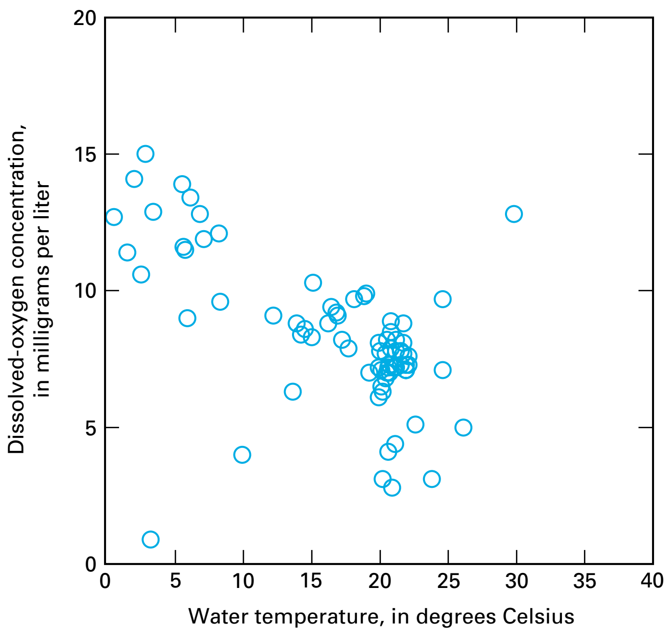

Figure 6. Comparison of dissolved-oxygen concentrations and water temperatures in surface-water-quality samples, February 1999 through February 2001.

tein synthesis. Phosphorus serves as an energy source in cellular chemical reactions. However, large inputs of nitrogen and phosphorus compounds to streams can cause excessive algal growth. This may result in taste-and-odor problems in drinking water, reduce the aesthetic and recreational value of water, and stress aquatic organisms due to decreased dissolved-oxygen concentrations when algal blooms die. Therefore, it is desirable to prevent or mitigate the introduction of excessive nutrient concentrations into surface water used as public supply or where sensitive aquatic organisms may be present.

Major sources of nutrients in and around the reservation include agricultural activities such as the application of fertilizers to enhance crop production and the pasturing and confined feeding of livestock. Common fertilizers used include, among others, anhydrous ammonia, ammonium nitrate, urea, and mono- and diammonium phosphates. The amount of fertilizer sold in Kansas has increased substantially during the last four decades. In 1950, about 180,000 tons of fertilizer (Kansas State Board of Agriculture and U.S. Department of Agriculture, 1985) were sold in Kansas, whereas by 1999, sales increased to more than 2,000,000 tons (Kansas Department of Agriculture and U.S. Department of Agriculture, 2000). It is likely that this statewide increasing trend in fertilizer use also occurred on and near the reservation. Additionally, farm livestock such as cattle and buffalo can produce considerable amounts of nitrogenous waste (urine and manure) that can concentrate in areas where large numbers of animals are pastured or confined. Decomposition of large amounts of fertilizers and manure can release nutrients to surface runoff or to shallow ground water with the potential for discharge to nearby streams.

A less significant potential source of nutrients on the reservation is bacterial decomposition of plant and animal protein and seepage from septic systems or sewage lagoons. Also, nutrients, particularly nitrate and ammonia, may be components of precipitation (Christensen and Pope, 1997); however, because of dominant agricultural land use in the area, precipitation is probably a relatively minor contributor of nutrients to reservation surface water.

Nitrite Plus Nitrate

Nitrate is formed by complete oxidation of ammonium ions by microorganisms found in soil, water, sewage, and the digestive tract (U.S. Environmental Protection Agency, 1986). In most oxygenated surface water, nitrate is by far the dominant ion due to rapid oxidation of nitrite. Nitrate nitrogen is the form of nitrogen most easily used by most rooted green plants and algae. Nitrate nitrogen generally occurs in uncontaminated surface water, with a worldwide average concentration of 0.30 mg/L (Reid and Wood, 1976, p. 235). Larger nitrate nitrogen concentrations may stimulate growth of rooted plants or accelerate algal production to an extent that may result in taste-or-odor problems in finished drinking water. Because most aquatic organisms can tolerate nitrite plus nitrate concentrations far in excess of what normally might be found even in contaminated surface water, no water-quality criteria have been established for protection of aquatic life. However, a Maximum Contaminant Level (MCL) in drinking water of 10 mg/L as nitrogen was established by the U.S. Environmental Protection Agency (1986) for nitrite plus nitrate as nitrogen because of possible toxic effects to infants.

Concentrations of dissolved nitrite plus nitrate (table 4, fig. 7) in surface-water-quality samples from the reservation were less than the minimum reporting levels of 0.050 or 0.047 mg/L as nitrogen in 14 of the 81 samples analyzed. The median concentration was 0.376 mg/L, and the maximum concentration was 4.18 mg/L. The highest concentrations of dissolved nitrite plus nitrate were found in samples from Little Soldier Creek (sampling sites LSC01, LSC02, LSC03, LSC04, fig. 7) and were collected during high-flow conditions on June 23, 1999 (table 4). These high concentrations probably are due to runoff from fields and pastures. However, these concentrations were considerably less than the MCL of 10 mg/L. In the samples collected before February 1999 (Trombley, 1999, p. 16), the maximum nitrite plus nitrate concentration was 1.46 mg/L from Soldier Creek sampling site SC03.

Ammonia

According to the U.S. Environmental Protection Agency (1986), concentrations of ammonia as nitrogen ranging from 0.44 to 19 mg/L (uncorrected for pH) are acutely toxic to 19 freshwater invertebrate species. Concentrations ranging from 0.07 to 3.8 mg/L are acutely toxic to 29 fish species. Acute toxicity of ammonia in fish causes increased respiration, oxygen uptake, and heart rate; reduction in hatching success and growth and morphologic development; and injuries to gills, liver, and kidneys. At larger concentrations, fish may experience convulsions, coma, and death. The most likely source for ammonia on the reservation is from nonpoint sources related to agricultural land use or septic systems.

Dissolved ammonia concentrations as nitrogen (table 4) for surface-water samples collected from the reservation ranged from a low of less than 0.020 mg/L to a high of 1.85 mg/L, with a median concentration of 0.030 mg/L. Thirty of the 81 samples had concentrations less than minimum reporting levels of either 0.020 or 0.041 mg/L. As with samples collected before February 1999 (Trombley, 1999, p. 21), most other concentrations were less than about 0.06 mg/L (fig. 8). The highest concentrations ranging from 0.256 to 1.85 mg/L were from samples collected during November and February quarterly sampling, when icy and low-flow conditions may have hampered evaporation of ammonia to the atmosphere. None of the dissolved ammonia as nitrogen concentrations exceeded the U.S. Environmental Protection Agency (2000) chronic water-quality criterion, which varies depending on water temperature and pH. The criterion ranged from about 1.5 to 4.5 mg/L under the temperature and pH conditions present during the sampling period from February 1999 through February 2001.

Phosphorus

Excessive concentrations of phosphorus in water may contribute to eutrophication of water bodies. Eutrophication (nutrient enrichment) is characterized by excessive nutrient concentrations, decreasing dissolved-oxygen concentrations, and dense growths of algae (Reid and Wood, 1976, p. 293). The U.S. Environmental Protection Agency (1986) established a goal for total phosphate concentration (as phosphorus) of 0.10 mg/L for aquatic life. Higher concentrations also may interfere with coagulation in water-treatment plants. To prevent excessive algal growth, the concentration should not exceed 0.050 mg/L in any stream at the point where it enters a lake or reservoir nor should it exceed 0.025 mg/L within the lake or reservoir (U.S. Environmental Protection Agency, 1986). Potential sources for high concentrations of phosphorus in streams on the Prairie Band Potawatomi Reservation are probably human or animal waste and fertilizers applied to agricultural lands.

Total phosphorus concentrations in surface-water-quality samples from the reservation (table 4, fig. 9) remain similar to those collected before February 1999 (Trombley 1999), with concentrations less than the minimum reporting level of 0.050 mg/L in 6 of 81 samples. Sixteen samples had concentrations equal to or less than 0.050 mg/L. The median concentration was 0.180 mg/L, and the maximum concentration was

Table 4. Results of analysis of nutrients in surface-water-quality samples from Prairie Band Potawatomi Reservation, northeastern Kansas, February 1999 through February 2001

[mg/L, milligrams per liter; N, nitrogen; P, phosphorus; <, less than indicated minimum report level; E, estimated; --, not determined]

Map identifier (fig. 1)	Stream basin and site name	Date of sample collection (month/day/ year)	Time of sample collection (24 hour)	Nitrite (mg/L as N)	Nitrite plus nitrate, dissolved (mg/L as N)	Ammonia as nitrogen (mg/L as N)	Ammonia as nitrogen plus organic material (mg/L as N)	Phosphorus, total (mg/L as P)	Orthophosphate (mg/L as P)
	Bills Creek Basin								
BC01	Bills Creek, U.S. Highway 75 near Holton	6/22/99	1010	0.019	0.124	0.032	1.0	0.316	0.034
		6/27/00	1025	.034	.528	.035	.62	.075	.027
	Little Soldier Creek Basin								
LSC01	Little Soldier Creek, 190 Road near Mayetta	6/23/99	1445	.033	3.48	.082	1.7	.229	.049
		6/27/00	1300	.040	.166	.024	1.3	.205	.021
LSC02	Little Soldier Creek, 174 Road near Mayetta	6/23/99	1200	.032	4.18	.075	2.7	.439	.041
		6/27/00	1430	.010	.228	<.020	.55	.076	.035
LSC03	Little Soldier Creek, O Road near Mayetta	2/9/99	1100	<.010	.224	<.020	.22	<.050	.020
		5/11/99	1055	<.010	.247	.059	.33	E.048	.047
		6/23/99	1400	.036	3.37	<.020	2.7	.571	.039
		9/14/99	0915	<.010	<.050	<.020	.31	.054	.013
		11/2/99	1055	<.010	<.050	<.020	.45	.220	.097
		2/15/00	1320	<.010	<.050	<.020	.22	<.050	.011
		5/16/00	1425	.015	.364	.038	.45	.053	.025
		6/27/00	1130	<.010	.270	.028	.57	.094	.032
		11/28/00	1005	<.006	<.047	<.041	.40	.180	.107
		2/21/01	1115	.014	.525	.256	1.0	.304	.236
LSC04	Little Soldier Creek, 134 Road near Mayetta	2/9/99	1145	<.010	.287	<.020	.25	E.037	.027
		5/11/99	1100	<.010	.332	.060	.29	.063	.056
		6/23/99	1010	.038	2.51	.028	1.5	.299	.050
		2/15/00	0845	<.010	<.050	.024	.21	<.050	<.010
		5/16/00	0935	.018	.417	.086	.65	.092	.027
		6/27/00	1015	.011	.371	.034	.68	.131	.050
		2/21/01	1005	.017	.748	.110	.97	.251	.138

Table 4. Results of analysis of nutrients in surface-water-quality samples from Prairie Band Potawatomi Reservation, northeastern Kansas, February 1999 through February 2001—Continued

Map identifier (fig. 1)	Stream basin and site name	Date of sample collection (month/day/year)	Time of sample collection (24 hour)	Nitrite (mg/L as N)	Nitrite plus nitrate, dissolved (mg/L as N)	Ammonia as nitrogen (mg/L as N)	Ammonia as nitrogen plus organic material (mg/L as N)	Phosphorus, total (mg/L as P)	Orthophosphate (mg/L as P)
	Little Soldier Creek Basin—Continued								
LSC05	Little Soldier Creek tributary, 134 Road near Hoyt	6/23/99	1110	0.016	1.02	0.022	1.3	0.211	0.029
		6/27/00	1110	<.010	.376	<.020	.29	E.039	.028
LSC06	Big Elm Creek, 134 Road near Hoyt	2/9/99	1030	.019	.595	.292	.74	.229	.194
		5/11/99	0950	.060	1.02		.75	.247	.189
		6/23/99	0910	.021	.591	<.020	1.3	.421	.132
		9/14/99	0905	<.010	.074	<.020	.17	.059	.061
		11/2/99	0935	<.010	<.050	<.020	.41	.248	.205
		2/15/00	0920	.037	1.42	1.78	3.1	1.02	.788
		5/16/00	0835	.035	.620	.092	1.7	.736	.597
		6/27/00	0845	.016	.263	.062	.95	.374	.338
		8/29/00	0835	<.010	<.050	<.020	.24	.155	.131
		11/28/00	0920	.010	.443	.347	2.0	.852	.592
		2/21/01	0910	.018	.779	1.85	2.6	.782	.676
LSC07	Little Elm Creek, Q Road near Hoyt	6/23/99	1435	.013	.222	.023	1.3	.189	.049
		6/27/00	1600	<.010	.163	<.020	.49	.068	.033
LSC08	Big Elm Creek, P Road near Hoyt	6/23/99	1230	.013	.584	<.020	.85	.258	.092
		6/27/00	1230	<.010	.443	.041	.43	.193	.147
LSC09	Little Soldier Creek, 126 Road near Hoyt	6/23/99	1320	.025	1.82	.020	1.2	.262	.060
		6/27/00	1400	<.010	.348	.029	.62	.153	.069
	Soldier Creek Basin								
SC01	Soldier Creek, 214 Road near Circleville	6/22/99	1830	.021	2.39	.057	5.2	1.57	.083
		6/28/00	1445	.123	2.50	.064	.88	.172	.080
SC02	Soldier Creek tributary, G Road near Circleville	6/22/99	1850	.012	.335	.041	2.4	.516	.034
		6/28/00	1325	<.010	.225	.031	.24	.064	.031

Table 4. Results of analysis of nutrients in surface-water-quality samples from Prairie Band Potawatomi Reservation, northeastern Kansas, February 1999 through February 2001—Continued

Map identifier (fig. 1)	Stream basin and site name	Date of sample collection (month/day/ year)	Time of sample collection (24 hour)	Nitrite (mg/L as N)	Nitrite plus nitrate, dissolved (mg/L as N)	Ammonia as nitrogen (mg/L as N)	Ammonia as nitrogen plus organic material (mg/L as N)	Phosphorus, total (mg/L as P)	Orthophosphate (mg/L as P)
	Soldier Creek Basin—Continued								
SC03	Soldier Creek near Saint Clere	2/9/99	1400	<0.010	1.08	<0.020	<0.10	<0.050	0.035
		5/11/99	1310	<.010	1.42	.057	.40	.119	.064
		6/22/99	1545	.015	.627	.089	5.0	1.69	.077
		9/14/99	1220	<.010	.323	<.020	.37	.055	.011
		11/2/99	1115	<.010	.072	<.020	.41	.055	.019
		2/15/00	1100	<.010	.093	<.020	.31	<.050	<.010
		5/16/00	1100	.010	.226	<.020	.71	.148	.022
		6/28/00	1100	.103	2.16	.107	1.0	.218	.066
		8/29/00	1025	<.010	<.050	<.020	.58	.097	.020
		11/28/00	1120	<.006	<.047	<.041	.36	E.050	E.009
		2/21/01	1255	.030	.945	.375	1.2	.266	.166
SC04	Soldier Creek, 158 Road near Saint Clere	6/22/99	1715	.016	.842	.103	5.7	1.86	.065
		6/28/00	1330	.094	2.07	.087	.93	.204	.065
SC05	Crow Creek, 166 Road near Saint Clere	6/22/99	1530	.014	.944	.051	2.5	.522	.046
		6/28/00	0915	<.010	.229	.024	.50	.094	.038
SC06	South Branch Soldier Creek, H.5 Road near Saint Clere	6/22/99	1415	.019	1.93	.037	5.4	1.32	.051
		6/28/00	1240	.012	.142	.068	.62	.148	.083
SC07	Soldier Creek, I Road near Delia	2/9/99	1540	<.010	.927	<.020	.35	.094	.042
		5/11/99	1515	<.010	1.39	.073	.52	.197	.076
		6/22/99	0945	.016	1.92	.024	.69	.245	.083
		6/22/99	0950	.018	1.94	.035	.69	.252	.084
		9/14/99	1020	<.010	<.050	<.020	.86	.107	<.010
		11/2/99	1300	<.010	<.050	<.020	.45	.064	.023
		2/15/00	1215	<.010	<.050	<.020	.25	<.050	<.010

Table 4. Results of analysis of nutrients in surface-water-quality samples from Prairie Band Potawatomi Reservation, northeastern Kansas, February 1999 through February 2001—Continued

Map identifier (fig. 1)	Stream basin and site name	Date of sample collection (month/day/year)	Time of sample collection (24 hour)	Nitrite (mg/L as N)	Nitrite plus nitrate, dissolved (mg/L as N)	Ammonia as nitrogen (mg/L as N)	Ammonia as nitrogen plus organic material (mg/L as N)	Phosphorus, total (mg/L as P)	Orthophosphate (mg/L as P)
	Soldier Creek Basin—Continued								
SC07	Soldier Creek, I Road near Delia	5/16/00	1240	.041	.578	.180	.82	.153	.048
		6/28/00	0830	0.098	2.12	0.148	1.2	0.212	0.069
		8/29/00	1250	<.010	<.050	<.020	.54	.062	.018
		11/28/00	1410	<.006	<.047	<.041	.49	.065	.022
		2/21/01	1415	.024	.839	.371	1.5	.324	.167
SC08	James Creek, 142 Road near Delia	6/22/99	1230	<.010	.135	<.020	4.3	1.18	.064
		6/28/00	1105	<.010	.061	<.020	.48	.077	.015
SC09	James Creek, 126 Road near Delia	6/22/99	1125	.011	.750	.023	2.8	.695	.092
		6/28/00	0950	<.010	.166	.024	.31	.056	.038
	South Cedar Creek Basin								
SCC01	South Cedar Creek, U.S. Highway 75 near Mayetta	6/23/99	1100	.023	.998	.028	.75	.186	.089
		6/27/00	0935	<.010	.388	.043	.58	.133	.075

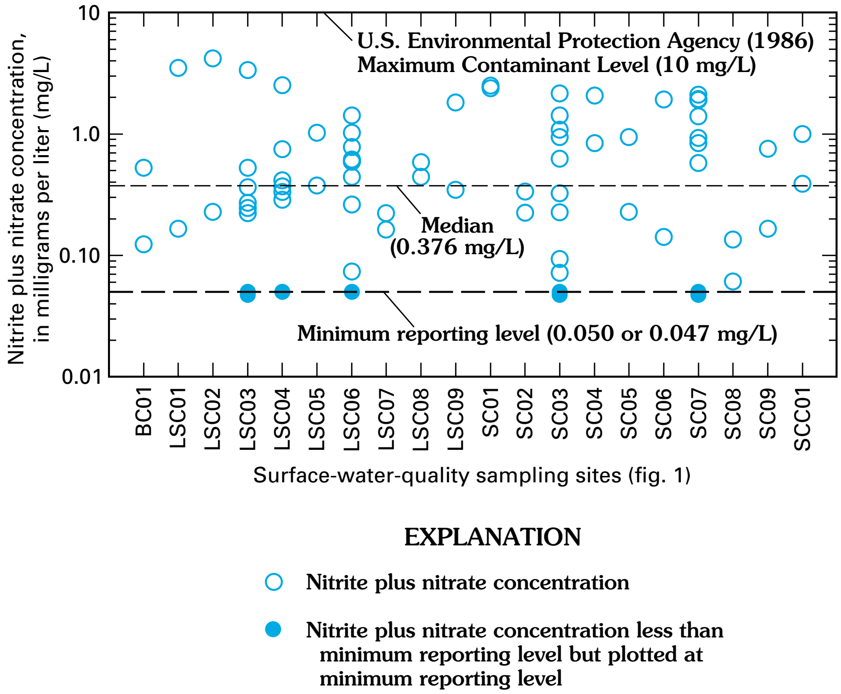

Figure 7. Distribution of nitrite plus nitrate concentrations in surface-water-quality samples, February 1999 through February 2001.

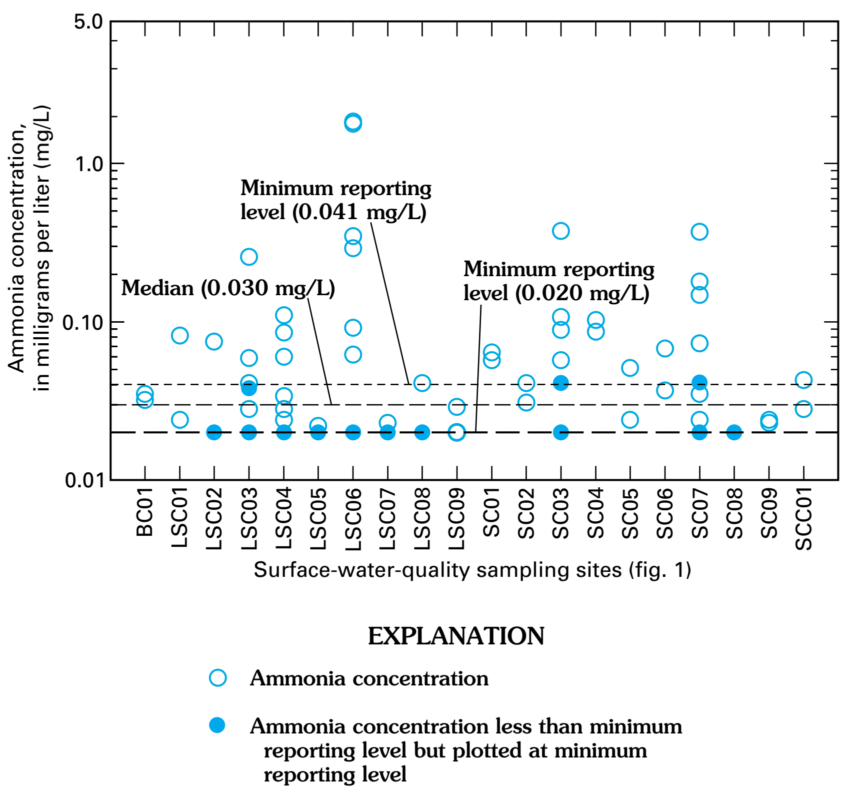

Figure 8. Distribution of ammonia concentrations in surface-water-quality samples, February 1999 through February 2001.

1.86 mg/L, with 51 surface-water-quality samples from throughout the reservation exceeding the 0.10-mg/L goal for aquatic life established by the U.S. Environmental Protection Agency (1986). The large number of total phosphorus concentrations near and exceeding 0.10 mg/L probably reflects nonpoint-source contributions from agricultural activities or septic systems on and upstream from the reservation.

Pesticides

Several studies relating to herbicide use have been conducted in Kansas during the past few years. Atrazine, one of the triazine herbicides, is the major herbicide of interest in and around the reservation because it has been used since the 1950s in the production of corn and grain sorghum in the area. Another potential source of atrazine may be its use in controlling weeds along railroad rights-of-way and along roads and highways. It is the most frequently detected herbicide in Kansas surface water (Stamer and Zelt, 1994).

Atrazine, where used extensively, may pose a potential threat to surface water on the reservation because of possible adverse effects on human health and potential toxicity to aquatic life. Currently (2001), the Kansas Department of Health and Environment (1994) and the U.S. Environmental Protection Agency (2000) have established an annual mean MCL of 3.0 µg/L in finished drinking-water supplies.

On the basis of a study of atrazine concentrations in the Delaware River Basin (fig. 1) in northeastern Kansas, Pope and others (1997) showed that daily mean triazine concentrations exceeded 3.0 µg/L at times during the months of May, June, and July. Daily mean triazine concentrations equal to or greater than 30 µg/L were not uncommon. However, daily mean concentrations greater than 3.0 µg/L were rare at other times of the year and generally were less than 1.0 µg/L between August and April; consequently, the annual mean triazine concentration for the Delaware River Basin during July 1992 through September 1995 was less than the MCL (Pope and others, 1997).

In a study of the distribution, transport, and relative age of atrazine in Perry Lake (southeast of the reservation; see index map in fig. 1), Fallon (1994) described the effects of precipitation, reservoir residence time, and herbicide application. Runoff occurring immediately after atrazine application increased atrazine concentrations in the lake. Results of the study by Pope and others (1997) of the Delaware River Basin and the study by Fallon (1994) of Perry Lake suggest that runoff resulting from precipitation in late spring and early summer after atrazine application increases atrazine concentrations in the streams.

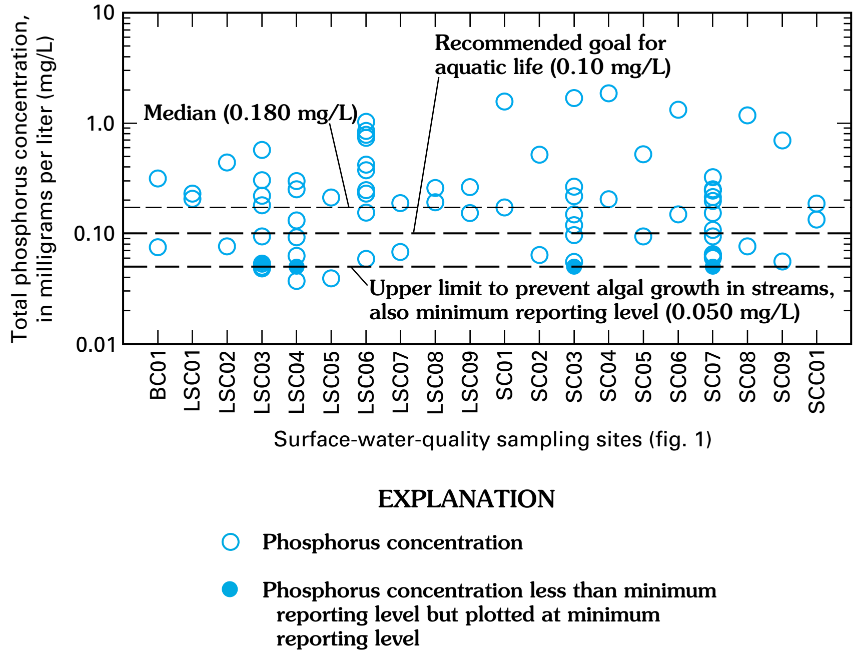

Figure 9. Distribution of total phosphorus concentrations in surface-water-quality samples, February 1999 through February 2001. Water-quality criteria from U.S. Environmental Protection Agency (1986).

Figure 10 shows the concentrations of dissolved triazine herbicides as analyzed using the ELISA method (triazine screen in table 5). Of the 81 triazine analyses, 24 contained triazine concentrations less than the minimum reporting level of 0.1 µg/L. The median concentration was 0.5 µg/L, and the maximum concentration was 10 µg/L. Triazine concentrations in 26 samples equaled or exceeded 3.0 µg/L. Ten samples that equaled or exceeded 3.0 µg/L were from the Little Soldier Creek Basin, and 14 were from the Soldier Creek Basin. Eleven of the 14 Soldier Creek Basin samples were from sampling sites on Soldier Creek. With one exception, all samples with detected concentrations equal to or greater than the median value of 0.5 µg/L were collected in either May or June of 1999 or 2000 as illustrated in figure 11, which shows triazine herbicide concentrations by date. In surface-water-quality samples collected before February 1999, triazine concentrations exceeded the 3.0-µg/L MCL in four samples collected on June 26, 1996 (Trombley, 1999, p. 23).

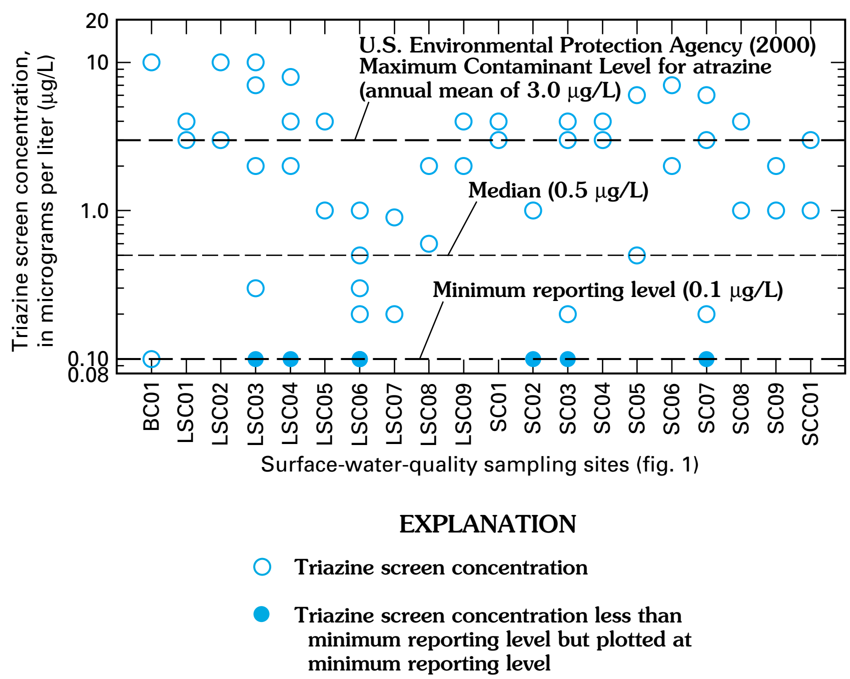

Figure 10. Distribution of triazine screen concentrations in surface-water-quality samples, February 1999 through February 2001.

Dissolved atrazine concentrations (table 5) using the GC/MS method ranged from a low of 0.01 µg/L to a maximum of 7.87 µg/L. Of the 23 surface-water samples analyzed using this method, four had concentrations of dissolved atrazine that were less than a min-

Table 5. Results of analysis of pesticides and pesticide metabolites in surface-water-quality samples from Prairie Band Potawatomi Reservation, northeastern Kansas, February 1999 through February 2001

[ELISA, enzyme-linked immunosorbent assay; GC/MS, gas chromatography/mass spectrometry; µg/L, micrograms per liter; --, not analyzed or not determined; <, less than indicated minimum reporting level; E, estimated]

Map identifier (fig. 1)	Stream basin and site name	Date of sample collection (month/day/ year)	Time of sample collection (24 hour)	Triazine pesticides or metabolites: Triazine screen using ELISA (µg/L)	Atrazine, dissolved, using GC/MS (µg/L)	Deethyl-atrazine (µg/L)	Deisopropyl-atrazine (µg/L)	Cyanazine, dissolved (µg/L)	Cyanazine amide (µg/L)	Propazine, dissolved (µg/L)
	Bills Creek Basin									
BC01	Bills Creek, U.S. Highway 75 near Holton	6/22/99	1010	0.1	--	--	--	--	--	--
		6/27/00	1025	10	--	--	--	--	--	--
	Little Soldier Creek Basin									
LSC01	Little Soldier Creek, 190 Road near Mayetta	6/23/99	1445	3.0	--	--	--	--	--	--
		6/27/00	1300	4.0	--	--	--	--	--	--
LSC02	Little Soldier Creek, 174 Road near Mayetta	6/23/99	1200	10	7.87	1.9	0.75	<0.05	--	0.11
		6/27/00	1430	3.0	--	--	--	--	--	--
LSC03	Little Soldier Creek, O Road near Mayetta	2/9/99	1100	<.1	--	--	--	--	--	--
		5/11/99	1055	.1	--	--	--	--	--	--
		6/23/99	1400	10	6.92	2.1	.75	<.05	--	.11
		9/14/99	0915	<.1	--	--	--	--	--	--
		11/2/99	1055	.1	--	--	--	--	--	--
		2/15/00	1320	<.1	--	--	--	--	--	--
		5/16/00	1425	7.0	--	--	--	--	--	--
		6/27/00	1130	2.0	--	--	--	--	--	--
		11/28/00	1005	.3	.15	<.05	<.05	<.05	<0.05	<.05
		2/21/01	1115	<.1	--	--	--	--	--	--
LSC04	Little Soldier Creek, 134 Road near Mayetta	2/9/99	1145	<.1	--	--	--	--	--	--
		5/11/99	1100	<.1	--	--	--	--	--	--
		6/23/99	1010	4.0	--	--	--	--	--	--
		2/15/00	0845	<.1	--	--	--	--	--	--
		5/16/00	0935	8.0	--	--	--	--	--	--

Table 5. Results of analysis of pesticides and pesticide metabolites in surface-water-quality samples from Prairie Band Potawatomi Reservation, northeastern Kansas, February 1999 through February 2001—Continued

Map identifier (fig. 1)	Stream basin and site name	Date of sample collection (month/day/year)	Time of sample collection (24 hour)	Triazine pesticides or metabolites: Triazine screen using ELISA (µg/L)	Atrazine, dissolved, using GC/MS (µg/L)	Deethyl-atrazine (µg/L)	Deisopropyl-atrazine (µg/L)	Cyanazine, dissolved (µg/L)	Cyanazine amide (µg/L)	Propazine, dissolved (µg/L)
	Little Soldier Creek Basin—Continued									
LSC04	Little Soldier Creek, 134 Road near Mayetta	6/27/00	1015	2.0	--	--	--	--	--	--
		2/21/01	1005	.1	--	--	--	--	--	--
LSC05	Little Soldier Creek tributary, 134 Road near Hoyt	6/23/99	1110	4.0	--	--	--	--	--	--
		6/27/00	1110	1.0	--	--	--	--	--	--
LSC06	Big Elm Creek, 134 Road near Hoyt	2/9/99	1030	<.1	--	--	--	--	--	--
		5/11/99	0950	<.1	--	--	--	--	--	--
		6/23/99	0910	1.0	--	--	--	--	--	--
		9/14/99	0905	.5	--	--	--	--	--	--
		11/2/99	0935	<.1	--	--	--	--	--	--
		2/15/00	0920	<.1	--	--	--	--	--	--
		5/16/00	0835	.2	--	--	--	--	--	--
		6/27/00	0845	.3	--	--	--	--	--	--
		8/29/00	0835	<.1	--	--	--	--	--	--
		11/28/00	0920	.1	0.133	E0.048	--	<0.018	--	--
		2/21/01	0910	.2	--	--	--	--	--	--
LSC07	Little Elm Creek, Q Road near Hoyt	6/23/99	1435	.2	--	--	--	--	--	--
		6/27/00	1600	.9	--	--	--	--	--	--
LSC08	Big Elm Creek, P Road near Hoyt	6/23/99	1230	2.0	1.20	E.20	--	<.004	--	--
		6/27/00	1230	.6	.295	E.061	--	<.004	--	--
LSC09	Little Soldier Creek, 126 Road near Hoyt	6/23/99	1320	4.0	6.29	E.68	--	<.004	--	--
		6/27/00	1400	2.0	--	--	--	--	--	--

Table 5. Results of analysis of pesticides and pesticide metabolites in surface-water-quality samples from Prairie Band Potawatomi Reservation, northeastern Kansas, February 1999 through February 2001—Continued

Map identifier (fig. 1)	Stream basin and site name	Date of sample collection (month/day/year)	Time of sample collection (24 hour)	Triazine pesticides or metabolites						
				Triazine screen using ELISA (µg/L)	Atrazine, dissolved, using GC/MS (µg/L)	Deethyl-atrazine (µg/L)	Deisopropyl-atrazine (µg/L)	Cyanazine, dissolved (µg/L)	Cyanazine amide (µg/L)	Propazine, dissolved (µg/L)
	Soldier Creek Basin									
SC01	Soldier Creek, 214 Road near Circleville	6/22/99	1830	4.0	4.04	E0.42	--	<0.004	--	--
		6/28/00	1445	3.0	2.89	E.40	--	<.004	--	--
SC02	Soldier Creek tributary, G Road near Circleville	6/22/99	1850	1.0	--	--	--	--	--	--
		6/28/00	1325	<.1	--	--	--	--	--	--
SC03	Soldier Creek near Saint Clere	2/9/99	1400	<.1	--	--	--	--	--	--
		5/11/99	1310	<.1	.089	E.014	--	<.004	--	--
		6/22/99	1545	4.0	--	--	--	--	--	--
		9/14/99	1220	.1	--	--	--	--	--	--
		11/2/99	1115	<.1	--	--	--	--	--	--
		2/15/00	1100	<.1	.030	E.016	--	<.004	--	--
		5/16/00	1100	3.0	--	--	--	--	--	--
		6/28/00	1100	3.0	--	--	--	--	--	--
		8/29/00	1025	<.1	--	--	--	--	--	--
		11/28/00	1120	<.1	<.05	<.05	<0.05	<.05	<0.05	<0.05
		2/21/01	1255	.2	--	--	--	--	--	--
SC04	Soldier Creek, 158 Road near Saint Clere	6/22/99	1715	4.0	--	--	--	--	--	--
		6/28/00	1330	3.0	--	--	--	--	--	--
SC05	Crow Creek, 166 Road near Saint Clere	6/22/99	1530	6.0	7.25	.74	.30	<.05		.08
		6/28/00	0915	.5	--	--	--	--	--	--
SC06	South Branch Soldier Creek, H.5 Road near Saint Clere	6/22/99	1415	7.0	--	--	--	--	--	--
		6/28/00	1240	2.0	--	--	--	--	--	--

Table 5. Results of analysis of pesticides and pesticide metabolites in surface-water-quality samples from Prairie Band Potawatomi Reservation, northeastern Kansas, February 1999 through February 2001—Continued

Map identifier (fig. 1)	Stream basin and site name	Date of sample collection (month/day/year)	Time of sample collection (24 hour)	Triazine pesticides or metabolites: Triazine screen using ELISA (µg/L)	Atrazine, dissolved, using GC/MS (µg/L)	Deethyl-atrazine (µg/L)	Deisopropyl-atrazine (µg/L)	Cyanazine, dissolved (µg/L)	Cyanazine amide (µg/L)	Propazine, dissolved (µg/L)
	Soldier Creek Basin—Continued									
SC07	Soldier Creek, I Road near Delia	2/9/99	1540	<0.1	0.012	E0.006	--	<0.004	--	--
		5/11/99	1515	.1	--	--	--	--	--	--
		6/22/99	0945	6.0	5.85	E.23	--	<.004	--	--
		6/22/99	0950	6.0	2.57	E.16	--	<.004	--	--
		9/14/99	1020	<.1	.121	E.019	--	<.004	--	--
		11/2/99	1300	<.1	.056	E.019	--	<.004	--	--
		2/15/00	1215	<.1	--	--	--	--	--	--
		5/16/00	1240	3.0	3.60	E.14	--	<.004	--	--
		6/28/00	0830	3.0	3.37	E.36	--	<.004	--	--
		8/29/00	1250	.2	.137	E.042	--	<.004	--	--
		11/28/00	1410	<.1	<.05	<.05	<0.05	<.050	<0.05	<0.05
		2/21/01	1415	.2	--	--	--	--	--	--
SC08	James Creek, 142 Road near Delia	6/22/99	1230	4.0	--	--	--	--	--	--
		6/28/00	1105	1.0	--	--	--	--	--	--
SC09	James Creek, 126 Road near Delia	6/22/99	1125	2.0	1.64	E.32	--	<.004	--	--
		6/28/00	0950	1.0	--	--	--	--	--	--
	South Cedar Creek Basin									
SCC01	South Cedar Creek, U.S. Highway 75 near Mayetta	6/23/99	1100	3.0	--	--	--	--	--	--
		6/27/00	0935	1.0	--	--	--	--	--	--

Table 5. Results of analysis of pesticides and pesticide metabolites in surface-water-quality samples from Prairie Band Potawatomi Reservation, northeastern Kansas, February 1999 through February 2001—Continued

				Triazine pesticides or metabolites						
Map identifier (fig. 1)	Stream basin and site name	Date of sample collection (month/day/year)	Time of sample collection (24 hour)	Simazine, dissolved (µg/L)	Acetochlor, filtered (µg/L)	Acetochlor ethane sulfonic acid, filtered (µg/L)	Acetochlor oxanilic acid (µg/L)	Alachlor, dissolved (µg/L)	Alachlor ethane sulfonic acid (µg/L)	Alachlor oxanilic acid (µg/L)
	Bills Creek Basin									
BC01	Bills Creek, U.S. Highway 75 near Holton	6/22/99	1010	--	--	--	--	--	--	--
		6/27/00	1025	--	--	--	--	--	--	--
	Little Soldier Creek Basin									
LSC01	Little Soldier Creek, 190 Road near Mayetta	6/23/99	1445	--	--	--	--	--	--	--
		6/27/00	1300	--	--	--	--	--	--	--
LSC02	Little Soldier Creek, 174 Road near Mayetta	6/23/99	1200	<0.05	<0.05	--	--	3.67	--	--
		6/27/00	1430	--	--	--	--	--	--	--
LSC03	Little Soldier Creek, 0 Road near Mayetta	2/9/99	1100	--	--	--	--	--	--	--
		5/11/99	1055	--	--	--	--	--	--	--
		6/23/99	1400	<.05	<.05	--	--	1.52	--	--
		9/14/99	0915	--	--	--	--	--	--	--
		11/2/99	1055	--	--	--	--	--	--	--
		2/15/00	1320	--	--	--	--	--	--	--
		5/16/00	1425	--	--	--	--	--	--	--
		6/27/00	1130	--	--	--	--	--	--	--
		11/28/00	1005	<.05	<.05	<0.05	<0.05	<.05	0.29	0.15
		2/21/01	1115	--	--	--	--	--	--	--
LSC04	Little Soldier Creek, 134 Road near Mayetta	2/9/99	1145	--	--	--	--	--	--	--
		5/11/99	1100	--	--	--	--	--	--	--
		6/23/99	1010	--	--	--	--	--	--	--
		2/15/00	0845	--	--	--	--	--	--	--
		5/16/00	0935	--	--	--	--	--	--	--

Table 5. Results of analysis of pesticides and pesticide metabolites in surface-water-quality samples from Prairie Band Potawatomi Reservation, northeastern Kansas, February 1999 through February 2001—Continued

Map identifier (fig. 1)	Stream basin and site name	Date of sample collection (month/day/year)	Time of sample collection (24 hour)	Triazine pesticides or metabolites: Simazine, dissolved (µg/L)	Acetochlor, filtered (µg/L)	Acetochlor ethane sulfonic acid, filtered (µg/L)	Acetochlor oxanilic acid (µg/L)	Alachlor, dissolved (µg/L)	Alachlor ethane sulfonic acid (µg/L)	Alachlor oxanilic acid (µg/L)
	Little Soldier Creek Basin—Continued									
LSC04	Little Soldier Creek, 134 Road near Mayetta	6/27/00	1015	--	--	--	--	--	--	--
		2/21/01	1005	--	--	--	--	--	--	--
LSC05	Little Soldier Creek tributary, 134 Road near Hoyt	6/23/99	1110	--	--	--	--	--	--	--
		6/27/00	1110	--	--	--	--	--	--	--
LSC06	Big Elm Creek, 134 Road near Hoyt	2/9/99	1030	--	--	--	--	--	--	--
		5/11/99	0950	--	--	--	--	--	--	--
		6/23/99	0910	--	--	--	--	--	--	--
		9/14/99	0905	--	--	--	--	--	--	--
		11/2/99	0935	--	--	--	--	--	--	--
		2/15/00	0920	--	--	--	--	--	--	--
		5/16/00	0835	--	--	--	--	--	--	--
		6/27/00	0845	--	--	--	--	--	--	--
		8/29/00	0835	--	--	--	--	--	--	--
		11/28/00	0920	<0.011	<0.004	--	--	<0.002	--	--
		2/21/01	0910	--	--	--	--	--	--	--
LSC07	Little Elm Creek, Q Road near Hoyt	6/23/99	1435	--	--	--	--	--	--	--
		6/27/00	1600	--	--	--	--	--	--	--
LSC08	Big Elm Creek, P Road near Hoyt	6/23/99	1230	<.005	.182	--	--	.037	--	--
		6/27/00	1230	<.005	.005	--	--	.010	--	--
LSC09	Little Soldier Creek, 126 Road near Hoyt	6/23/99	1320	<.005	.033	--	--	1.63	--	--
		6/27/00	1400	--	--	--	--	--	--	--

Table 5. Results of analysis of pesticides and pesticide metabolites in surface-water-quality samples from Prairie Band Potawatomi Reservation, northeastern Kansas, February 1999 through February 2001—Continued

Map identifier (fig. 1)	Stream basin and site name	Date of sample collection (month/day/year)	Time of sample collection (24 hour)	Triazine pesticides or metabolites	Acetochlor, filtered (µg/L)	Acetochlor ethane sulfonic acid, filtered (µg/L)	Acetochlor oxanilic acid (µg/L)	Alachlor, dissolved (µg/L)	Alachlor ethane sulfonic acid (µg/L)	Alachlor oxanilic acid (µg/L)
				Simazine, dissolved (µg/L)						
	Soldier Creek Basin									
SC01	Soldier Creek, 214 Road near Circleville	6/22/99	1830	0.127	<0.002	--	--	0.687	--	--
		6/28/00	1445	.009	.069	--	--	.740	--	--
		6/22/99	1850	--	--	--	--	--	--	--
SC02	Soldier Creek tributary, G Road near Circleville	6/28/00	1325	--	--	--	--	--	--	--
SC03	Soldier Creek near Saint Clere	2/9/99	1400	--	--	--	--	--	--	--
		5/11/99	1310	E.003	.004	--	--	.013	--	--
		6/22/99	1545	--	--	--	--	--	--	--
		9/14/99	1220	--	--	--	--	--	--	--
		11/2/99	1115	--	--	--	--	--	--	--
		2/15/00	1100	E.003	<.002	--	--	<.002	--	--
		5/16/00	1100	--	--	--	--	--	--	--
		6/28/00	1100	--	--	--	--	--	--	--
		8/29/00	1025	--	--	--	--	--	--	--
		11/28/00	1120	<.05	<.05	<0.05	<0.05	<.05	0.10	0.09
		2/21/01	1255	--	--	--	--	--	--	--
SC04	Soldier Creek, 158 Road near Saint Clere	6/22/99	1715	--	--	--	--	--	--	--
		6/28/00	1330	--	--	--	--	--	--	--
SC05	Crow Creek, 166 Road near Saint Clere	6/22/99	1530	<.05	<.05	--	--	3.04	--	--
		6/28/00	0915							
SC06	South Branch Soldier Creek, H.5 Road near Saint Clere	6/22/99	1415	--	--	--	--	--	--	--
		6/28/00	1240	--	--	--	--	--	--	--

Table 5. Results of analysis of pesticides and pesticide metabolites in surface-water-quality samples from Prairie Band Potawatomi Reservation, northeastern Kansas, February 1999 through February 2001—Continued

Map identifier (fig. 1)	Stream basin and site name	Date of sample collection (month/day/year)	Time of sample collection (24 hour)	Triazine pesticides or metabolites: Simazine, dissolved (µg/L)	Acetochlor, filtered (µg/L)	Acetochlor ethane sulfonic acid, filtered (µg/L)	Acetochlor oxanilic acid (µg/L)	Alachlor, dissolved (µg/L)	Alachlor ethane sulfonic acid (µg/L)	Alachlor oxanilic acid (µg/L)
	Soldier Creek Basin—Continued									
SC07	Soldier Creek, I Road near Delia	2/9/99	1540	E0.004	<0.002	--	--	<0.002	--	--
		5/11/99	1515							
		6/22/99	0945	.051	<.002	--	--	.305	--	--
		6/22/99	0950	.026	<.002	--	--	.144	--	--
		9/14/99	1020	<.005	<.002	--	--	<.002	--	--
		11/2/99	1300	<.005	<.002	--	--	<.002	--	--
		2/15/00	1215							
		5/16/00	1240	.013	.010	--	--	.338	--	--
SC07	Soldier Creek, I Road near Delia	6/28/00	0830	.016	.062	--	--	.776	--	--
		8/29/00	1250	E.005	<.002	--	--	<.010	--	--
		11/28/00	1410	<.05	<.05	<0.05	<0.05	<.05	0.13	0.12
		2/21/01	1415	--	--	--	--	--	--	--
SC08	James Creek, 142 Road near Delia	6/22/99	1230	--	--	--	--	--	--	--
		6/28/00	1105	--	--	--	--	--	--	--
SC09	James Creek, 126 Road near Delia	6/22/99	1125	.006	<.002	--	--	.036	--	--
		6/28/00	0950	--	--	--	--	--	--	--
	South Cedar Creek Basin									
SCC01	South Cedar Creek, U.S. Highway 75 near Mayetta	6/23/99	1100	--	--	--	--	--	--	--
		6/27/00	0935	--	--	--	--	--	--	--

Table 5. Results of analysis of pesticides and pesticide metabolites in surface-water-quality samples from Prairie Band Potawatomi Reservation, northeastern Kansas, Feburary 1999 through February 2001—Continued

Map identifier (fig. 1)	Stream basin and site name	Date of sample collection (month/day/year)	Time of sample collection (24 hour)	Metol-achlor ethane sulfonic acid (μg/L)	Metol-achlor oxanilic acid (μg/L)	Metol-achlor oxanilic acid (μg/L)	2,6-diethyl-aniline (μg/L)	Carbaryl, filtered (μg/L)	Diazinon, dissolved (μg/L)	Metribuzin, dissolved (μg/L)	Prometon, dissolved (μg/L)
	Bills Creek Basin										
BC01	Bills Creek, U.S. Highway 75 near Holton	6/22/99	1010	--	--	--	--	--	--	--	--
		6/27/00	1025	--	--	--	--	--	--	--	--
	Little Soldier Creek Basin										
LSC01	Little Soldier Creek, 190 Road near Mayetta	6/23/99	1445	--	--	--	--	--	--	--	--
		6/27/00	1300	--	--	--	--	--	--	--	--
LSC02	Little Soldier Creek, 174 Road near Mayetta	6/23/99	1200	<0.05	--	--	--	--	--	<0.05	<0.05
		6/27/00	1430	--	--	--	--	--	--	--	--
LSC03	Little Soldier Creek, O Road near Mayetta	2/9/99	1100	--	--	--	--	--	--	--	--
		5/11/99	1055	--	--	--	--	--	--	--	--
		6/23/99	1400	<.05	--	--	--	--	--	<.05	<.05
		9/14/99	0915	--	--	--	--	--	--	--	--
		11/2/99	1055	--	--	--	--	--	--	--	--
		2/15/00	1320	--	--	--	--	--	--	--	--
		5/16/00	1425	--	--	--	--	--	--	--	--
		6/27/00	1130	--	--	--	--	--	--	--	--
		11/28/00	1005	<.05	<0.05	<0.05	--	--	--	<.05	<.05
		2/21/01	1115	--	--	--	--	--	--	--	--
LSC04	Little Soldier Creek, 134 Road near Mayetta	2/9/99	1145	--	--	--	--	--	--	--	--
		5/11/99	1100	--	--	--	--	--	--	--	--
		6/23/99	1010	--	--	--	--	--	--	--	--
		2/15/00	0845	--	--	--	--	--	--	--	--
		5/16/00	0935	--	--	--	--	--	--	--	--

Table 5. Results of analysis of pesticides and pesticide metabolites in surface-water-quality samples from Prairie Band Potawatomi Reservation, northeastern Kansas, Feburary 1999 through February 2001—Continued

Map identifier (fig. 1)	Stream basin and site name	Date of sample collection (month/day/ year)	Time of sample collection (24 hour)	Metol-achlor ethane sulfonic acid (µg/L)	Metol-achlor oxanilic acid (µg/L)	Metol-achlor oxanilic acid (µg/L)	2,6-diethyl-aniline (µg/L)	Carbaryl, filtered (µg/L)	Diazinon, dissolved (µg/L)	Metribuzin, dissolved (µg/L)	Prometon, dissolved (µg/L)
	Little Soldier Creek Basin—Continued										
LSC04	Little Soldier Creek, 134 Road near Mayetta	6/27/00	1015	--	--	--	--	--	--	--	--
		2/21/01	1005	--	--	--	--	--	--	--	--
LSC05	Little Soldier Creek tributary, 134 Road near Hoyt	6/23/99	1110	--	--	--	--	--	--	--	--
		6/27/00	1110	--	--	--	--	--	--	--	--
LSC06	Big Elm Creek, 134 Road near Hoyt	2/9/99	1030	--	--	--	--	--	--	--	--
		5/11/99	0950	--	--	--	--	--	--	--	--
		6/23/99	0910	--	--	--	--	--	--	--	--
		9/14/99	0905	--	--	--	--	--	--	--	--
		11/2/99	0935	--	--	--	--	--	--	--	--
		2/15/00	0920	--	--	--	--	--	--	--	--
		5/16/00	0835	--	--	--	--	--	--	--	--
		6/27/00	0845	--	--	--	--	--	--	--	--
		8/29/00	0835	--	--	--	--	--	--	--	--
		11/28/00	0920	E0.003	--	--	<0.002	<0.041	<0.005	<0.006	E0.011
		2/21/01	0910	--	--	--	--	--	--	--	--
LSC07	Little Elm Creek, Q Road near Hoyt	6/23/99	1435	--	--	--	--	--	--	--	--
		6/27/00	1600	--	--	--	--	--	--	--	--
LSC08	Big Elm Creek, P Road near Hoyt	6/23/99	1230	.021	--	--	<.003	<.003	<.002	<.004	.044
		6/27/00	1230	E.004	--	--	<.003	<.003	<.002	<.004	E.016
LSC09	Little Soldier Creek, 126 Road near Hoyt	6/23/99	1320	.088	--	--	<.003	<.003	<.002	<.004	E.008
		6/27/00	1400	--	--	--	--	--	--	--	--

Table 5. Results of analysis of pesticides and pesticide metabolites in surface-water-quality samples from Prairie Band Potawatomi Reservation, northeastern Kansas, Feburary 1999 through February 2001—Continued

Map identifier (fig. 1)	Stream basin and site name	Date of sample collection (month/day/year)	Time of sample collection (24 hour)	Metol-achlor ethane sulfonic acid (µg/L)	Metol-achlor oxanilic acid (µg/L)	Metol-achlor oxanilic acid (µg/L)	2,6-diethyl-aniline (µg/L)	Carbaryl, filtered (µg/L)	Diazinon, dissolved (µg/L)	Metribuzin, dissolved (µg/L)	Prometon, dissolved (µg/L)
	Soldier Creek Basin										
SC01	Soldier Creek, 214 Road near Circleville	6/22/99	1830	0.378	--	--	<0.003	<0.003	<0.002	<0.004	<0.018
		6/28/00	1445	1.32	--	--	E.003	E.013	<.002	.036	E.001
SC02	Soldier Creek tributary, G Road near Circleville	6/22/00	1850	--	--	--	--	--	--	--	--
		6/228/00	1325	--	--	--	--	--	--	--	--
SC03	Soldier Creek near Saint Clere	2/9/99	1400	--	--	--	--	--	--	--	--
		5/11/99	1310	.033	--	--	<.003	<.003	<.002	<.004	<.018
		6/22/99	1545	--	--	--	--	--	--	--	--
		9/14/99	1220	--	--	--	--	--	--	--	--
		11/2/99	1115	--	--	--	--	--	--	--	--
		2/15/00	1100	.008	--	--	<.003	<.003	<.002	<.004	<.018
		5/16/00	1100	--	--	--	--	--	--	--	--
		6/28/00	1100	--	--	--	--	--	--	--	--
		8/29/00	1025	--	--	--	--	--	--	--	--
		11/28/00	1120	<.05	0.07	<0.05	--	--	--	<.05	<.05
		2/21/01	1255	--	--	--	--	--	--	--	--
SC04	Soldier Creek, 158 Road near Saint Clere	6/22/99	1715	--	--	--	--	--	--	--	--
		6/28/00	1330	--	--	--	--	--	--	--	--
SC05	Crow Creek, 166 Road near Saint Clere	6/22/99	1530	.37	--	--	--	--	--	<.05	<.05
		6/28/00	0915	--	--	--	--	--	--	--	--
SC06	South Branch Soldier Creek, H.5 Road near Saint Clere	6/22/99	1415	--	--	--	--	--	--	--	--
		6/28/00	1240	--	--	--	--	--	--	--	--

Table 5. Results of analysis of pesticides and pesticide metabolites in surface-water-quality samples from Prairie Band Potawatomi Reservation, northeastern Kansas, Feburary 1999 through February 2001—Continued

Map identifier (fig. 1)	Stream basin and site name	Date of sample collection (month/day/year)	Time of sample collection (24 hour)	Metolachlor ethane sulfonic acid (µg/L)	Metolachlor oxanilic acid (µg/L)	Metolachlor oxanilic acid (µg/L)	2,6-diethylaniline (µg/L)	Carbaryl, filtered (µg/L)	Diazinon, dissolved (µg/L)	Metribuzin, dissolved (µg/L)	Prometon, dissolved (µg/L)
	Soldier Creek Basin—Continued										
SC07	Soldier Creek, I Road near Delia	2/9/99	1540	0.007	--	--	<0.003	<0.003	<0.002	<0.004	<0.018
		5/11/99	1515	--	--	--	--	--	--	--	--
		6/22/99	0945	1.42	--	--	<.003	<.003	<.002	.114	<.018
		6/22/99	0950	.664	--	--	<.003	<.003	<.002	<.004	<.018
		9/14/99	1020	.020	--	--	<.003	<.003	<.002	<.004	<.018
		11/2/99	1300	.013	--	--	<.003	<.003	<.002	<.004	<.018
		2/15/00	1215	--	--	--	--	--	--	--	--
		5/16/00	1240	1.93	--	--	<.003	<.003	E.003	<.004	<.018
		6/28/00	0830	1.28	--	--	E.003	<.003	<.002	.016	<.018
		8/29/00	1250	.022	--	--	<.003	<.003	<.002	<.004	<.018
		11/28/00	1410	<.05	0.08	0.07	--	--	--	<.05	<.05
		2/21/01	1415	--	--	--	--	--	--	--	--
SC08	James Creek, 142 Road near Delia	6/22/99	1230	--	--	--	--	--	--	--	--
		6/28/00	1105	--	--	--	--	--	--	--	--
SC09	James Creek, 126 Road near Delia	6/22/99	1125	.744	--	--	<.003	<.003	<.002	.007	<.018
		6/28/00	0950	--	--	--	--	--	--	--	--
	South Cedar Creek Basin										
SCC01	South Cedar Creek, U.S. Highway 75 near Mayetta	6/23/99	1100	--	--	--	--	--	--	--	--
		6/27/00	0935	--	--	--	--	--	--	--	--

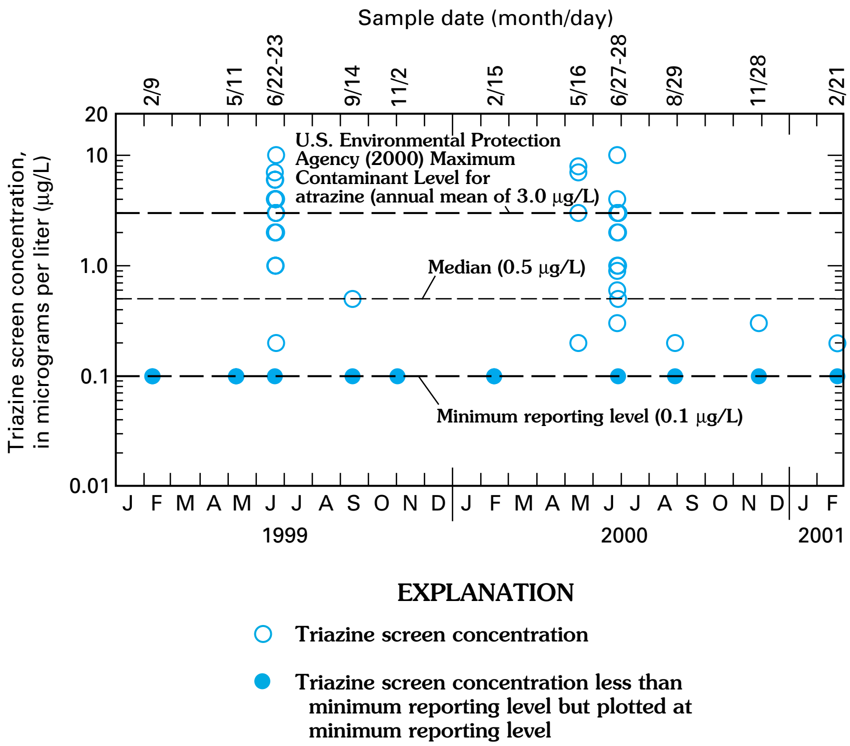

Figure 11. Distribution by date of triazine screen concentrations in surface-water-quality samples, February 1999 through February 2001.

imum reporting level of 0.05 µg/L. The median concentration was 1.20 µg/L. Eight samples collected during May and June of 1999 and 2000 exceeded 3.0 µg/L.

At concentrations greater than the triazine minimum reporting level (0.1 µg/L), a direct relation exists between triazine and atrazine concentrations whereby the triazine concentration slightly overestimates the atrazine concentration (Trombley, 1999, p. 23). This is due, in part, to the presence of other triazine herbicides in the water samples such as the atrazine metabolite (degradation product) deethylatrazine and the triazine herbicide cyanazine. Of 23 samples analyzed for deethylatrazine, 10 samples contained concentrations less than the minimum reporting level for deethylatrazine of 0.05 µg/L. Seventeen samples had estimated deethylatrazine concentrations ranging from 0.006 to 0.68 µg/L. Three samples collected during high flow in June 1999 at sampling sites SC05, LSC02, and LSC03 had detections of 0.74, 1.9, and 2.1 µg/L, respectively. These three samples also had detectable levels of deisopropylatrazine, another degradation product of atrazine. The median deethylatrazine concentration was an estimated value of 0.14 µg/L. As with samples collected before February 1999 (Trombley, 1999, p. 23), none of the 23 samples analyzed for cyanazine contained concentrations that were higher than the minimum reporting levels (minimum reporting levels varied from 0.004 to 0.05 µg/L.

Other detected herbicides included alachlor and metolachlor. Alachlor concentrations were detected in 14 of 23 surface-water-quality samples, with a median concentration of less than 0.05 µg/L. Two samples collected at sampling sites SC05 and LSC02 during high flow in June 1999 had detected alachlor concentrations of 3.04 and 3.67 µg/L, which exceed the 2.0-µg/L MCL for drinking water (U.S. Environmental Protection Agency, 2000). Twenty-three samples were analyzed for metolachlor using the GC/MS method. Fourteen of those samples contained concentrations less than a minimum reporting level of 0.05 µg/L. Measured concentrations of metolachlor, however, ranged from an estimated 0.003 to 1.9 µg/L. The median concentration of metolachlor was less than 0.05 µg/L. No detections of insecticides were observed in any of the samples as was the case for the June 1996 through November 1998 sampling (Trombley, 1999).

Bacteria

Fecal coliform and fecal streptococcus bacteria are indigenous to the intestinal tract of warmblooded animals. The presence of high concentrations of these organisms in surface water indicates fecal contamination and also may indicate the presence of disease-causing organisms. Potential sources of these bacteria on the reservation include seepage from domestic septic systems and sewage lagoons, runoff and seepage from livestock areas, such as pastures and confined feedlots, and from wildlife populations.

Because of public-health concerns associated with fecal contamination, the Kansas Department of Health and Environment (Michael Tate, written commun., May 2001) established a criterion for fecal coliform of 200 col/100 mL (colonies per 100 milliliters of water) for streams used for primary contact recreation and 2,000 col/100 mL for those streams used for secondary contact recreation. The primary contact recreation criterion is based on the geometric mean of at least five consecutive samples collected during separate 24-hour periods within a 30-day period. The criterion is in effect from April 1 through October 31 of each year. Primary contact recreation, during which the body is immersed to the extent that some inadvertent ingestion is probable, includes boating, mussel harvesting, swimming, skin diving, waterskiing, and wind surfing. Secondary contact recreation, during which ingestion of surface water is unlikely, includes, but is not limited to, wading, fishing, trapping, and hunting. The secondary contact recreation criterion is in effect all year.

High concentrations of fecal indicator bacteria are a concern on the reservation. As reported by Trombley (1999), fecal coliform concentrations ranged from 7 to 7,700 col/100 mL with a median concentration of 290 col/100 mL for June 1996 through November 1998. During February 1999 through February 2001, fecal coliform concentrations ranged from 4 to 31,000 col/100 mL (table 6) with a median concentration of 570 col/100 mL. Figure 12 shows fecal coliform concentrations for all surface-water-quality samples collected from June 1996 through February 2001. The figure shows an apparent seasonal relationship of fecal coliform concentration in streams on the reservation, with higher concentrations occurring during the spring and summer and lower concentrations during fall and winter. The highest fecal coliform concentrations were observed during high-flow conditions during June 1999. More than one-half of the observed fecal coliform concentrations exceeded the Kansas Department of Health and Environment (Michael Tate, written commun., May 2001) 200-col/100 mL fecal coliform criterion for primary contact recreation and were mostly from samples collected either in May or June. All of the concentrations exceeding the Kansas Department of Health and Environment (Michael Tate, written commun., May 2001) criterion of 2,000 col/100 mL for secondary contact recreation also occurred in samples collected during either May or June. The lowest concentrations tended to be from samples collected either in November or February.

GROUND-WATER QUALITY

The Prairie Band Potawatomi Reservation lies within the stable interior of the North American continent. Since Precambrian time (about 600 million years ago), most of this part of the continent has undergone gentle upwarp and downwarp of the Earth's crust over large areas. Structurally, this part of the continent is characterized by broad basins and arches, with subtle folding of sedimentary rocks and few major fault zones (Jorgensen and others, 1993, p. B12 and fig. 15). The reservation lies on the western part of what is termed the Forest City Basin. Uppermost bedrock within the reservation consists mostly of limestone and shale (Walters, 1953, fig. 13) of Permian and Pennsylvanian age (about 245 to 320 million years

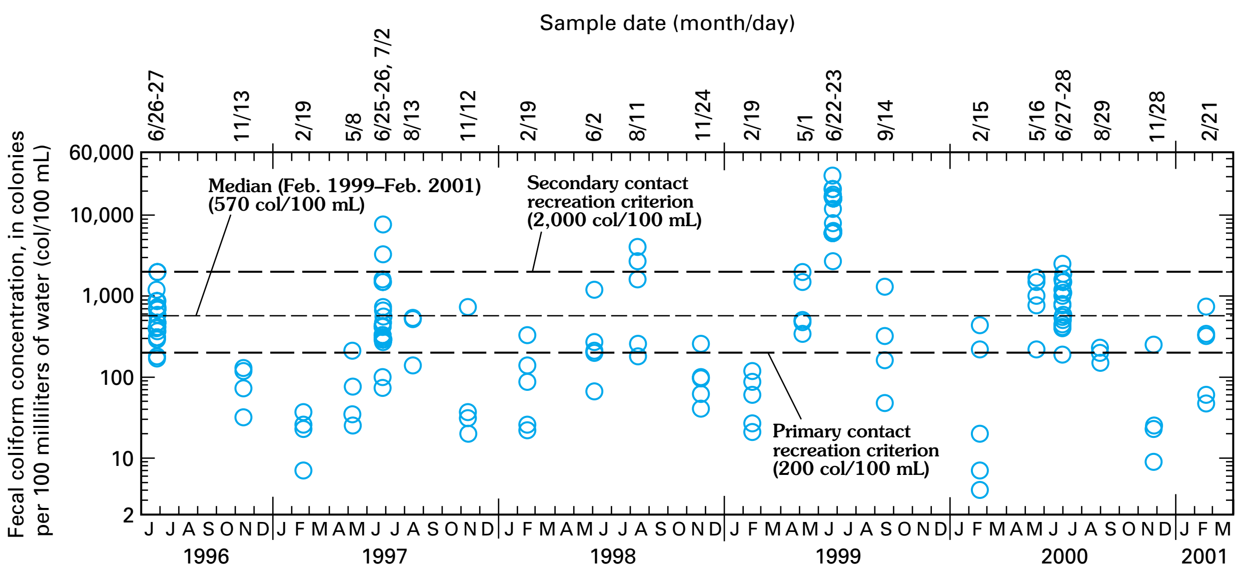

Figure 12. Distribution of fecal coliform concentrations in surface-water-quality samples, June 1996 through February 2001. Recreation water-quality criteria from Kansas Department of Health and Environment (Michael Tate, written commun., May 2001).

Table 6. Results of analysis of bacteria in surface-water-quality samples from Prairie Band Potawatomi Reservation, northeastern Kansas, February 1999 through February 2001

[E. coli, *Escherichia* coli; col/100 mL, colonies per 100 milliliters of water; --, not detected; K, nonideal count, estimated value; >, greater than]

Map identifier (fig. 1)	Stream basin and site name	Date of sample collection (month/day/year)	Time of sample collection (24 hour)	E. coli (col/100 mL)	Fecal coliform (col/100 mL)	Fecal strepto-coccus (col/100 mL)
	Bills Creek Basin					
BC01	Bills Creek, U.S. Highway 75 near Holton	6/22/99	1010	--	K17,000	6,700
		6/27/00	1025	148	190	950
	Little Soldier Creek Basin					
LSC01	Little Soldier Creek, 190 Road near Mayetta	6/23/99	1445	--	K16,000	K27,000
		6/27/00	1300	K140	550	160
LSC02	Little Soldier Creek, 174 Road near Mayetta	6/23/99	1200	--	K18,000	>8,000
		6/27/00	1430	320	K450	670
LSC03	Little Soldier Creek, O Road near Mayetta	2/9/99	1100	--	27	150
		5/11/99	1055	--	1,500	2,000
		6/23/99	1400	--	K16,000	K22,000
		9/14/99	0915	--	1,300	420
		11/2/99	1055	--	--	51
		2/15/00	1320	K2	K7	32
		5/16/00	1425	140	220	320
		6/27/00	1130	967	770	760
		11/28/00	1005	63	K9	56
		2/21/01	1115	330	340	1,000
LSC04	Little Soldier Creek, 134 Road near Mayetta	2/9/99	1145	--	60	95
		5/11/99	1100	--	480	1,200
		6/23/99	1010	--	K8,000	K27,000
		2/15/00	0845	310	440	55
		5/16/00	0935	450	770	1,000
		6/27/00	1015	790	1,000	950
		2/21/01	1005	155	60	850
LSC05	Little Soldier Creek tributary, 134 Road near Hoyt	6/23/99	1110	--	6,000	K12,000
		6/27/00	1110	490	800	440
LSC06	Big Elm Creek, 134 Road near Hoyt	2/9/99	1030	--	120	240
		5/11/99	0950	--	2,000	2,900
		6/23/99	0910	--	K21,000	>1,600
		9/14/99	0905	--	320	280
		11/2/99	0935	--	--	66
		2/15/00	0920	200	220	130
		5/16/00	0835	785	1,000	4,700

Table 6. Results of analysis of bacteria in surface-water-quality samples from Prairie Band Potawatomi Reservation, northeastern Kansas, February 1999 through February 2001—Continued

Map identifier (fig. 1)	Stream basin and site name	Date of sample collection (month/day/year)	Time of sample collection (24 hour)	E. coli (col/100 mL)	Fecal coliform (col/100 mL)	Fecal strepto-coccus (col/100 mL)
	Little Soldier Creek Basin—Continued					
LSC06	Big Elm Creek, 134 Road near Hoyt	6/27/00	0845	500	2,500	800
		8/29/00	0835	K108	230	540
		11/28/00	0920	226	250	760
		2/21/01	0910	30	47	110
LSC07	Little Elm Creek, Q Road near Hoyt	6/23/99	1435	--	K6,400	K17,000
		6/27/00	1600	769	1,600	400
LSC08	Big Elm Creek, P Road near Hoyt	6/23/99	1230	--	K12,000	>8,000
		6/27/00	1230	415	400	440
LSC09	Little Soldier Creek, 126 Road near Hoyt	6/23/99	1320	--	K6,100	K17,000
		6/27/00	1400	833	1,200	2,800
	Soldier Creek Basin					
SC01	Soldier Creek tributary, G Road near Circleville	6/22/99	1830	--	K31,000	>8,000
		6/28/00	1445	580	1,100	820
SC02	Soldier Creek, 214 Road near Circleville	6/22/99	1850	--	K21,000	>8,000
		6/28/00	1325	353	590	990
SC03	Soldier Creek near Saint Clere	2/9/99	1400	--	K21	170
		5/11/99	1310	--	340	1,400
		6/22/99	1545	--	>6,000	>8,000
		9/14/99	1220	--	160	300
		11/2/99	1115	--	--	86
		2/15/00	1100	K4	20	45
		5/16/00	1100	861	1,700	1,100
		6/28/00	1100	667	1,900	1,300
		8/29/00	1025	164	200	340
		11/28/00	1120	35	23	300
		2/21/01	1255	K150	320	1,100
SC04	Soldier Creek, 158 Road near Saint Clere	6/22/99	1715	--	>6,000	>8,000
		6/28/00	1330	667	1,500	930
SC05	Crow Creek, 166 Road near Saint Clere	6/22/99	1530	--	--	>8,000
		6/28/00	0915	550	510	770
SC06	South Branch Soldier Creek, H.5 Road near Saint Clere	6/22/99	1415	--	--	>8,000
		6/28/00	1240	3,500	--	490

Table 6. Results of analysis of bacteria in surface-water-quality samples from Prairie Band Potawatomi Reservation, northeastern Kansas, February 1999 through February 2001—Continued

Map identifier (fig. 1)	Stream basin and site name	Date of sample collection (month/day/year)	Time of sample collection (24 hour)	E. coli (col/100 mL)	Fecal coliform (col/100 mL)	Fecal strepto-coccus (col/100 mL)
	Soldier Creek Basin—Continued					
SC07	Soldier Creek, I Road near Delia	2/9/99	1540	--	K88	270
		5/11/99	1515	--	510	1,800
		6/22/99	0945	--	--	K8,300
		6/22/99	0950		--	7,100
		9/14/99	1020	--	48	70
		11/2/99	1300	--	--	K12
		2/15/00	1215	K2	K4	K13
		5/16/00	1240	1,166	1,500	570
		6/28/00	0830	933	1,500	910
		8/29/00	1250	144	150	380
		11/28/00	1410	38	25	80
		2/21/01	1415	500	750	2,900
SC08	James Creek, 142 Road near Delia	6/22/99	1230	--	--	>8,000
		6/28/00	1105	243	--	930
SC09	James Creek, 126 Road near Delia	6/22/99	1125	--	--	>8,000
		6/28/00	0950	--	--	700
	South Cedar Creek Basin					
SCC01	South Cedar Creek, U.S. Highway 75 near Mayetta	6/23/99	1100	--	K2,700	K16,000
		6/27/00	0935	K180	420	710

ago). Unconsolidated glacial and stream (alluvial) deposits overlie the erosional surface of the sedimentary rocks. The composition of these unconsolidated deposits varies vertically and horizontally and ranges from fine-grained sediment consisting of till, silt, and clay to coarse-grained sediment consisting of sand, gravel, pebbles, cobbles, and boulders (Trombley and others, 1996, p. 9–14).

The unconsolidated glacial and alluvial deposits are the primary source of ground water on the reservation. Well yields from these deposits are highly variable and generally are less than 300 gal/min (Trombley and others, 1996, p. 16 and 38). Results of an aquifer test at well S28–4 conducted in September 2000 indicated a yield of as much as 280 gal/min for the glacial aquifer at that well (W. Robert Talbot, Bureau of Reclamation, written commun., May 2001).

Wells sampled are indicated in figures 1 and 13, and listed in table 2. No information on depth or aquifer characteristics is available for the wells sampled except for the aquifer test well (S28–4). That well is 120 ft deep and obtains water from a 36-ft-thick layer of cherty gravel.

Physical Properties

Specific conductance and pH were the primary physical properties measured in ground-water-quality samples collected from wells during September through December 2000. Specific conductance values measured onsite in samples from four of the seven wells (PBPW01, PBPW02, PBPW03, PBPW03A) ranged from 648 to 751 µS/cm (fig. 14), slightly higher than values generally found in surface water on the reservation. In water from well PBPW01A (table 7) specific conductance measured onsite was 1,760 µS/cm and in water from well PBPW06,

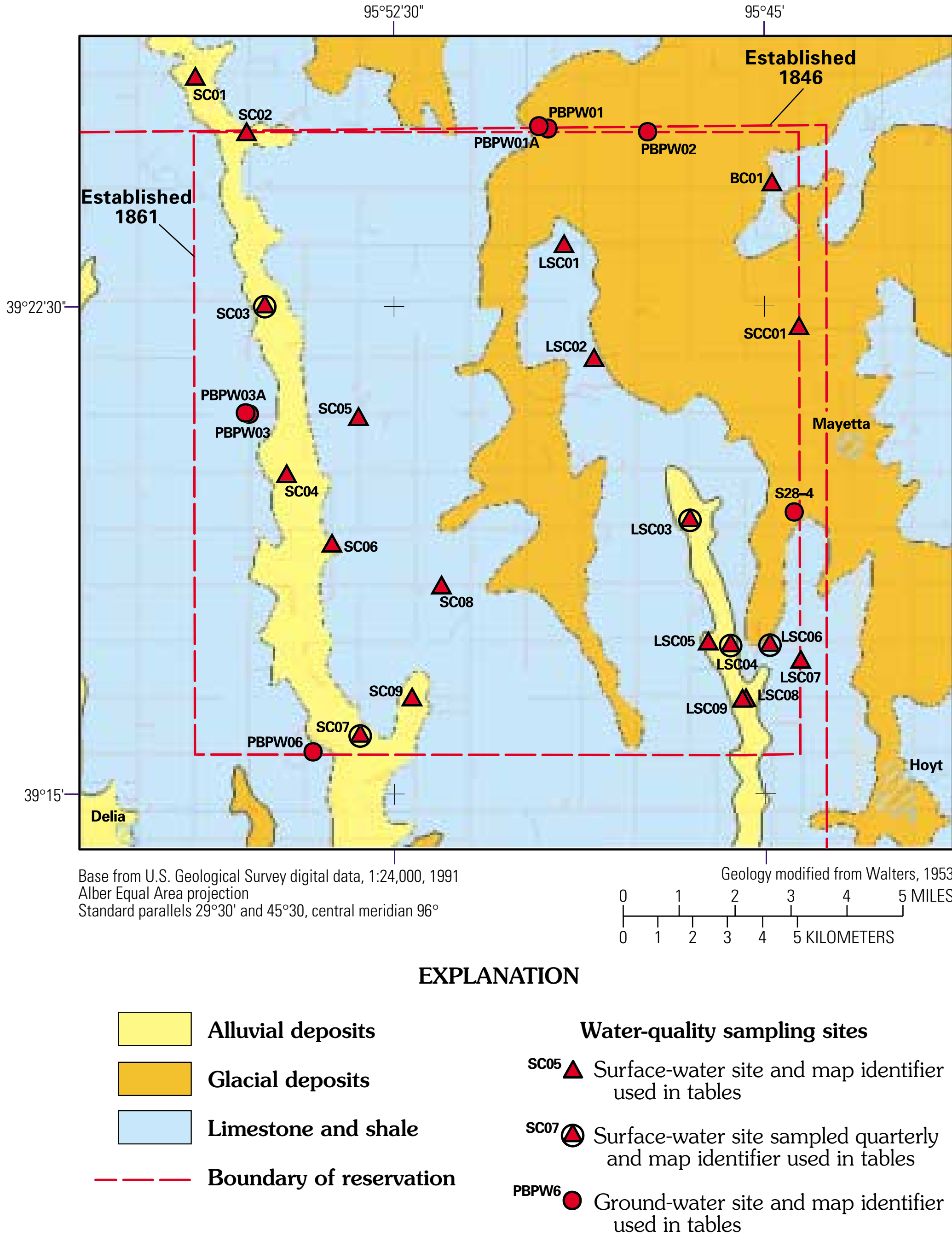

Figure 13. Generalized geology underlying Prairie Band Potawatomi Reservation.

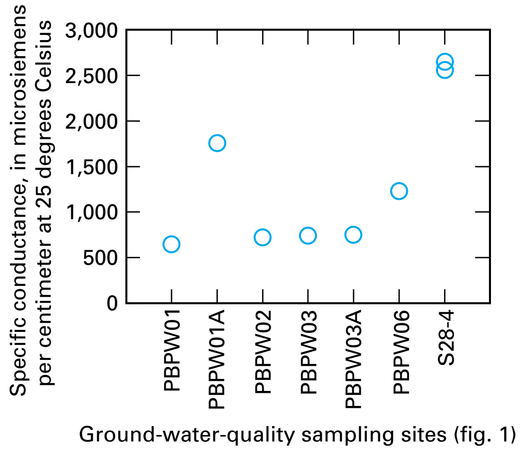

Figure 14. Distribution of specific conductance values measured onsite in ground-water-quality samples, September through December 2000.

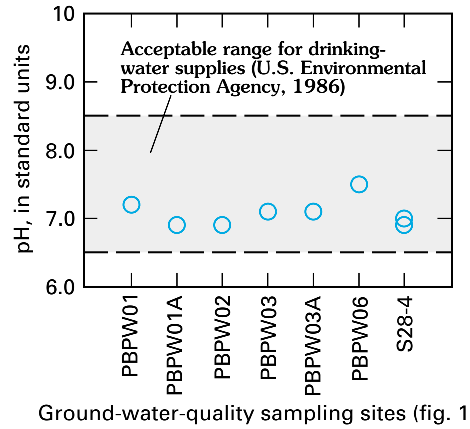

Figure 15. Distribution of pH measured onsite in ground-water-quality samples, September through December 2000.

1,230 µS/cm. In water from the aquifer test well (S28–4), specific conductance values (2,650 and 2,560 µS/cm) were more than twice the value measured onsite in water from well PBPW06 (table 7).

The range in pH values measured onsite for all well samples was 6.9 to 7.5 standard units, well within the U.S. Environmental Protection Agency (1986) SMCL range of 6.5 to 8.5 (fig. 15).

Major Ions

Calcium

Calcium is a major constituent of carbonate rocks (Hem, 1992, p. 85), such as limestone and dolomite, and it dissolves readily in water; therefore, the calcium concentration in water from areas with carbonate rocks and associated unconsolidated deposits tends to be higher than in other areas. Calcium contributes to the total hardness of water. High concentrations of calcium are objectionable in domestic water supplies because it tends to cause encrustations on cooking utensils and in water heaters and it increases soap consumption in water used for cleaning.

Calcium concentrations in ground water on the reservation result primarily from the dissolution of carbonate rocks and ranged from 36.6 to 111 mg/L (fig. 16*A*, table 8). The lowest calcium concentration was in water from well PBPW06. Most concentrations were similar to those found in surface water in northeastern Kansas (Trombley and others, 1996, p. 43); however, calcium concentrations in water from two wells (S28–4 and PBPW01A) were higher, ranging from 241 to 336 mg/L.

Magnesium

Magnesium is a common alkaline-earth metal and is essential in plant and animal nutrition (Hem, 1992, p. 96–97). The principal sources for magnesium on the reservation are carbonate rocks such as dolomite and limestone. Magnesium also contributes to the total hardness of water and may cause encrustation and increase soap or detergent consumption in water used for cleaning.

Magnesium concentrations in ground-water-quality samples from reservation wells (fig. 16*B*, table 8) exhibit a pattern similar to that for calcium but with lower values (generally about 20 to 30 percent of the calcium concentrations), consistent with the dissolution of carbonate rocks. Magnesium concentrations in water from five wells were less than 30 mg/L (table 8). In water from well PBPW01A, the magnesium concentration was higher, with a value of 48.3 mg/L, and in water from the aquifer test well (S28–4), the magnesium concentrations were about doubled, with measured values of 87.0 and 89.5 mg/L.

Sodium

Sodium is the most abundant member of the alkali-metal group of elements, and when dissolved, it tends to remain in solution (Hem, 1992, p. 100). Natural sources include the weathering of plagioclase feldspar and the dissolution of sodium salts from sedimentary rocks. Human-related sources include

Table 7. Results of analysis of physical properties in ground-water-quality samples from Prairie Band Potawatomi Reservation, northeastern Kansas, September through December 2000

[µS/cm, microsiemens per centimeter at 25 °C; °C, degrees Celsius; mg/L, milligrams per liter; --, not determined]

Map identifier (fig. 1)	Local number (township, range, section)	Date of sample collection (month/day/year)	Time of sample collection (24 hour)	Specific conductance, onsite (µS/cm)	Specific conductance, laboratory (µS/cm)	pH, onsite (standard units)	pH, laboratory (standard units)	Water temperature (°C)	Dissolved oxygen (mg/L)	Barometric pressure (mm of Hg)
PBPW01	07S 14E 23CDDB01	11/29/00	1530	648	674	7.2	7.3	14.3	1.8	--
PBPW01A	07S 14E 23CCDA01	12/1/00	1230	1,760	1,810	6.9	7.0	13.2	.1	--
PBPW02	07S 15E 30BBAA01	11/29/00	1215	722	743	6.9	7.1	13.5	.2	742
PBPW03	08S 13E 14DDDD01	11/30/00	1250	745	843	7.1	7.2	14.9	3.5	--
PBPW03A	08S 13E 14DDDB01	11/30/00	1130	751	851	7.1	7.3	14.1	4.0	--
PBPW06	09S 14E 18CCDC01	12/1/00	1000	1,230	1,250	7.5	7.6	13.6	1.8	--
S28–4	08S 15E 28DACD01	9/22/00	1400	2,650	2,690	6.9	7.2	13.8	--	734
		9/25/00	1215	2,560	2,590	7.0	7.2	13.2	--	747

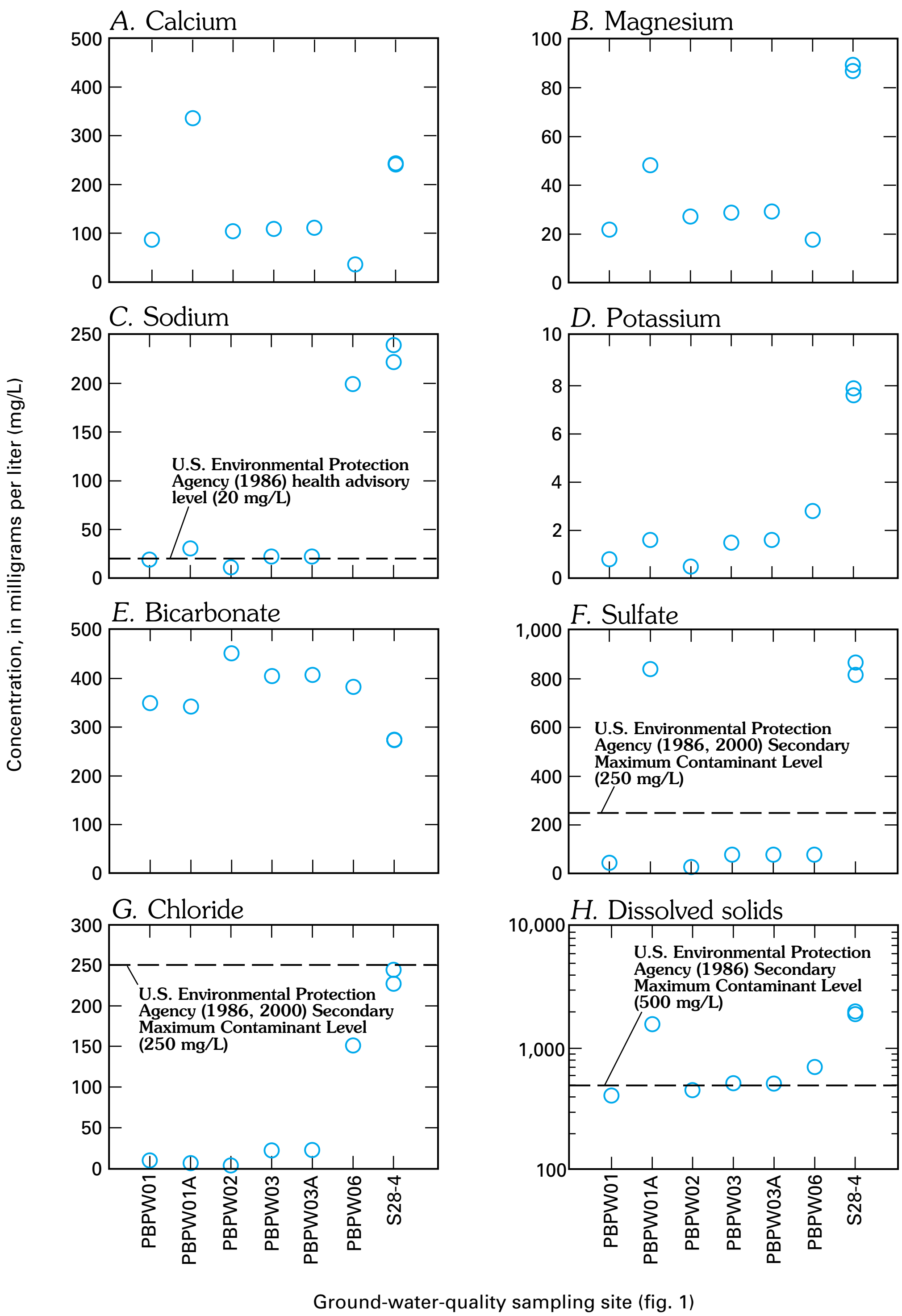

Figure 16. Distribution of selected major ion and dissolved-solids concentrations in ground-water-quality samples, September through December 2000.

seepage from septic systems and a by-product of water treatment (it is discharged by water softeners and reverse-osmosis units). Sodium in drinking water may impart a salty taste and may be harmful to persons suffering from heart, kidney, and circulatory diseases and women with toxemias of pregnancy. Therefore, the U.S. Environmental Protection Agency (1986) established a health advisory level (HAL) of 20 mg/L for people who are on restricted sodium diets.

Sodium concentrations in ground-water-quality samples from the reservation (fig. 16*C*) ranged from 11.4 to 239 mg/L (table 8). The source of sodium in ground water is probably the result of the dissolution of sodium salts in the rocks and deposits. The median concentration was 21.9 mg/L, which is slightly higher than the 20-mg/L HAL. Only two wells had water with sodium concentrations less than the HAL (wells PBPW01 and PBPW02 located along the northern boundary of the reservation). Water from wells PBPW03 and PBPW03A had concentrations of sodium of 22.2 and 22.4 mg/L, and water from well PBPW01A had a slightly higher concentration of 30.5 mg/L. Water from well PBPW06 and the aquifer test well (S28–4) had sodium concentrations of about 10 times the HAL, ranging from about 199 to 239 mg/L (table 8).

Potassium

Potassium is an essential element for both plants and animals. Maintenance of optimal soil fertility depends on a supply of available potassium. The ele-

Table 8. Results of analysis of major ions and dissolved solids in ground-water-quality samples from Prairie Band Potawatomi Reservation, northeastern Kansas, September through December 2000

[mg/L, milligrams per liter; $CaCO_3$, calcium bicarbonate; ^{o}C, degrees Celsius]

Map identifier (fig. 1)	Local number (township, range, section)	Date of sample collection (month/day/year)	Time of sample collection (24 hour)	Alkalinity, onsite (mg/L)	Alkalinity, laboratory (mg/L)	Calcium, dissolved (mg/L)	Magnesium, dissolved (mg/L)	Sodium, dissolved (mg/L)	Potassium, dissolved (mg/L)	Bicarbonate, onsite (mg/L)	Carbonate, onsite (mg/L)
PBPW01	07S 14E 23CDDB01	11/29/00	1530	286	304	87.5	21.9	19.3	0.8	349	0
PBPW01A	07S 14E 23CCDA01	12/1/00	1230	280	300	336	48.3	30.5	1.6	342	0
PBPW02	07S 15E 30BBAA01	11/29/00	1215	370	397	104	27.2	11.4	.5	451	0
PBPW03	08S 13E 14DDDD01	11/30/00	1250	332	348	109	28.8	22.2	1.5	405	0
PBPW03A	08S 13E 14DDDB01	11/30/00	1130	334	352	111	29.3	22.4	1.6	407	0
PBPW06	09S 14E 18CCDC0	12/1/00	1000	313	337	36.6	17.8	199	2.8	382	0
S28–4	08S 15E 28DACD011	9/22/00	1400	225	308	241	89.5	239	7.9	274	0
		9/25/00	1215	224	309	244	87.0	222	7.6	273	0

Map identifier (fig. 1)	Local number (township, range, section)	Date of sample collection (month/day/year)	Time of sample collection (24 hour)	Sulfate, dissolved (mg/L)	Chloride, dissolved (mg/L)	Fluoride, dissolved (mg/L)	Silica, dissolved (mg/L)	Dissolved solids residue at 180 ^{o}C (mg/L)
PBPW01	07S 14E 23CDDB01	11/29/00	1530	45.7	9.7	0.6	26.4	410
PBPW01A	07S 14E 23CCDA01	12/1/00	1230	839	6.6	.6	27.0	1,590
PBPW02	07S 15E 30BBAA01	11/29/00	1215	27.2	3.3	.5	22.7	454
PBPW03	08S 13E 14DDDD01	11/30/00	1250	79.2	22.5	.4	14.4	517
PBPW03A	08S 13E 14DDDB01	11/30/00	1130	78.6	22.9	.4	14.3	515
PBPW06	09S 14E 18CCDC01	12/1/00	1000	79.1	151	.8	13.8	706
S28–4	08S 15E 28DACD01	9/22/00	1400	867	244	.3	33.0	2,010
		9/25/00	1215	816	227	.4	34.7	1,920

ment is present in plant material and is lost from agricultural soil by crop harvesting and by leaching and runoff acting on organic residues. Potassium concentrations generally are much lower than sodium concentrations in most natural water (Hem, 1992, p. 104–105). Concentrations of potassium more than a few tens of milligrams per liter are unusual except in water having high dissolved-solids concentrations or in water from hot springs. Where the sodium concentration substantially exceeds 10 mg/L, the potassium concentration commonly is one-half to a one-tenth that of sodium.

Potassium concentrations in ground-water-quality samples from the reservation ranged from 0.5 to 7.9 mg/L (fig. 16*D*), at levels expected in relation to sodium concentrations. The median concentration was 1.6 mg/L. Potassium concentrations in the water from the aquifer test well (S28–4, table 8) were more than four times the median concentration, with values of 7.6 and 7.9 mg/L.

Bicarbonate

Bicarbonate concentrations in water are calculated by dividing alkalinity by 0.8202 (Hem, 1992, p. 55, 57). Alkalinity is defined as the capacity of a solute to neutralize acid (Hem, 1992, p. 106–109) and is expressed in milligrams per liter of calcium carbonate ($CaCO_3$). The bicarbonate concentration in natural water generally is held within a moderate range. In most surface streams, bicarbonate concentrations are much less than 200 mg/L, but in ground water somewhat higher concentrations are not uncommon. The primary source for bicarbonate on the Prairie Band Potawatomi Reservation is the dissolution of carbonate rocks and deposits.

Bicarbonate concentrations in ground-water-quality samples from the reservation ranged from 273 to 451 mg/L (fig. 16*E*, table 8). Bicarbonate concentrations generally increased as the concentrations of calcium and magnesium increased. However, the lowest bicarbonate concentrations (273 and 274 mg/L) were in water from the aquifer test well (S28–4) where both calcium and sodium concentrations were highest.

Sulfate

Natural sources of sulfate (Hem, 1992, p. 112–117) in water include the weathering of sulfur-bearing minerals, such as pyrite and gypsum, volcanic discharges to the atmosphere, and biologic and biochemical processes. Human-related sources include industrial discharges to both streams and the atmosphere and the combustion of fossil fuels, such as coal and gasoline. The U.S. Environmental Protection Agency (1986, 2000) established an SMCL of 250 mg/L in drinking water to help avoid laxative effects.

Sulfate concentrations in ground-water-quality samples from five wells on the reservation (fig. 16*F*, table 8) were generally low, with values less than 80 mg/L. In water from two wells, PBPW01A and the aquifer test well (S28–4), sulfate concentrations exceeded 800 mg/L, more than three times the SMCL. Consequently, water from these wells may create laxative effects in people unaccustomed to drinking the water.

Chloride

Chloride is present in all natural water, but the concentrations generally are low (Hem, 1992, p. 118–119). The most important natural source on the reservation is dissolution of halite from sedimentary rocks. The discharge of human, animal, or industrial wastes also may add substantial quantities of chloride to surface and ground water. Chloride can impart a salty taste to drinking water and may accelerate the corrosion of metals used in water-supply systems. On the basis of taste, an SMCL of 250 mg/L in drinking-water supplies was established for chloride by the U.S. Environmental Protection Agency (1986, 2000).

Chloride concentrations in ground-water samples from five wells on the reservation were substantially less than the SMCL, with concentrations less than 25 mg/L (fig. 16*G*, table 8). In water from two wells (PBPW06 and S28–4), chloride concentrations were higher (151 to 244 mg/L) but did not exceed the SMCL.

Dissolved Solids

Dissolved solids in natural water consist primarily of the cations calcium, magnesium, sodium, and potassium and the anions bicarbonate, sulfate, and chloride. Dissolved-solids values are used widely in evaluating water quality and in comparing water. Freshwater has dissolved-solids concentrations less than 1,000 mg/L, whereas slightly saline water ranges from 1,000 to 3,000 mg/L (Winslow and Kister, 1956). According to the U.S. Environmental Protection

Agency (1986), excess dissolved solids are objectionable in drinking water because of possible physiological effects, unpalatable mineral tastes, and higher costs because of corrosion or the necessity for additional treatment. Consequently, an SMCL for dissolved solids of 500 mg/L has been established (U.S. Environmental Protection Agency, 1986).

All but two of the ground-water-quality samples from the reservation had dissolved-solids concentrations exceeding the SMCL. Water from well PBPW01 had the lowest measured dissolved-solids concentration at 410 mg/L, and water from well PBPW02 had the second lowest concentration at 454 mg/L (fig. 16*H*, table 8). Water from two wells, PBPW03 and PBPW03A, had dissolved-solids concentrations at or near the median value of 517 mg/L, slightly higher than the SMCL. Water from three wells had dissolved-solids concentrations substantially higher than the SMCL. Water from well PBPW06 had a dissolved-solids concentration of 706 mg/L. The sample from well PBPW01A had a dissolved-solids concentration of 1,590 mg/L, more than three times the SMCL, whereas the dissolved-solids concentrations in water from the aquifer test well (S28–4) were four times the SMCL at 1,920 and 2,010 mg/L.

The principle constituents in water from four wells (PBPW01, PBPW02, PBPW03, and PBPW03A) were calcium, magnesium, and bicarbonate. Water of this type generally is formed from the dissolution of limestone. Water from two wells had elevated sodium and chloride concentrations consistent with dissolution of halite (wells PBPW06 and S28–4). In addition, water from two wells (PBPW01A and S28–4) had elevated sulfate concentrations consistent with dissolution of gypsum or anhydrite (Hem, 1992, p. 90).

Nutrients

Nutrients generally occur in ground water leaching from the surface down to the water table. Spruill (1983) described a relation between the distance of well-screen openings below casing water levels in water-table aquifers (unconfined, unconsolidated) in Kansas. In that study, nitrate concentrations were highest close to the land surface and decreased with depth. Spruill (1983) observed no concentrations of nitrate greater than 10 mg/L as nitrogen in wells where screens were deeper than 60 ft below the casing water level.

Nutrient levels in sampled ground water on the reservation were not high enough to be of concern. Nitrite plus nitrate concentrations in all of the well samples were considerably less than the MCL of 10 mg/L as nitrogen (table 9). The minimum concentration was less than 0.047 mg/L, and the maximum concentration was 1.92 mg/L, which is less than 20 percent of the MCL. Dissolved ammonia concentrations were also low, ranging from less than the minimum reporting level of 0.041 to 1.58 mg/L. Total phosphorus concentrations were less than the minimum reporting level of 0.060 mg/L in all but one sample from well PBPW02, which had a concentration of 0.068 mg/L.

Trace Constituents

Arsenic

Arsenic has been used as a component of pesticides and thus may enter streams or ground water through waste disposal or agricultural drainage (Hem, 1992, p. 144–145). It also occurs naturally as a minor impurity in rocks and deposits. Because small amounts of arsenic can be toxic to humans, the U.S. Environmental Protection Agency (2000) proposed an MCL for arsenic of 10.0 µg/L. The current MCL for arsenic in drinking water is 50 µg/L (U.S. Environmental Protection Agency, 2000). Implementation of the proposed MCL is currently (2001) under review.

Water from five of the wells sampled had dissolved arsenic concentrations (fig. 17*A*, table 10) less than the minimum reporting level of 2.0 µg/L (wells PBPW01, PBPW03, PBPW03A, and PBPW06). Water from the aquifer test well (S28–4) had dissolved arsenic concentration estimated at 1.5 and 1.8 µg/L. In water from well PBPW02, the dissolved arsenic concentration was 2.5 µg/L, one-quarter of the proposed MCL. In water from well PBPW01A, the dissolved arsenic concentration was 4.0 µg/L, slightly less than one-half the proposed MCL.

Boron

Boron is a minor constituent in ground water and is usually found as a sodium or calcium borate salt. Boron is an essential element for the growth of plants, but there is no evidence that it is required by animals. The U.S. Environmental Protection Agency (2000) established a lifetime HAL of 600 µg/L (concentration

Table 9. Results of analysis of nutrients in ground-water-quality samples from Prairie Band Potawatomi Reservation, northeastern Kansas, September through December 2000

[mg/L, milligrams per liter; N, nitrogen; P, phosphorus; <, less than indicated minimum reporting level; E, estimated]

Map identifier (fig. 1)	Local number (township, range, section)	Date of sample collection (month/day/year)	Time of sample collection (24 hour)	Nitrite, dissolved (mg/L as N)	Nitrite plus nitrate, dissolved (mg/L as N)	Ammonia as nitrogen (mg/L as N)	Ammonia as nitrogen plus organic material (mg/L as N)	Phosphorus, total (mg/L as P)	Phosphorus, dissolved (mg/L as P)	Orthophosphate (mg/L as P)
PBPW01	07S 14E 23CDDB01	11/29/00	1530	<0.006	1.92	<0.041	0.10	<0.060	<0.060	<0.018
PBPW01A	07S 14E 23CCDA01	12/1/00	1230	<.006	E.032	.097	.10	<.060	<.060	<.018
PBPW02	07S 15E 30BBAA01	11/29/00	1215	<.006	<.047	<.041	.12	.068	<.060	E.012
PBPW03	08S 13E 14DDDD01	11/30/00	1250	<.006	1.41	<.041	.12	<.060	E.036	.040
PBPW03A	08S 13E 14DDDB01	11/30/00	1130	<.006	1.39	<.041	.18	<.060	E.038	.041
PBPW06	09S 14E 18CCDC01	12/1/00	1000	<.006	.894	<.041	.12	<.060	<.060	<.018
S28–4	08S 15E 28DACD01	9/22/00	1400	<.010	<.050	1.58	1.7	E.034	.135	<.010
		9/25/00	1215	<.010	<.050	1.50	1.6	E.032	<.050	<.010

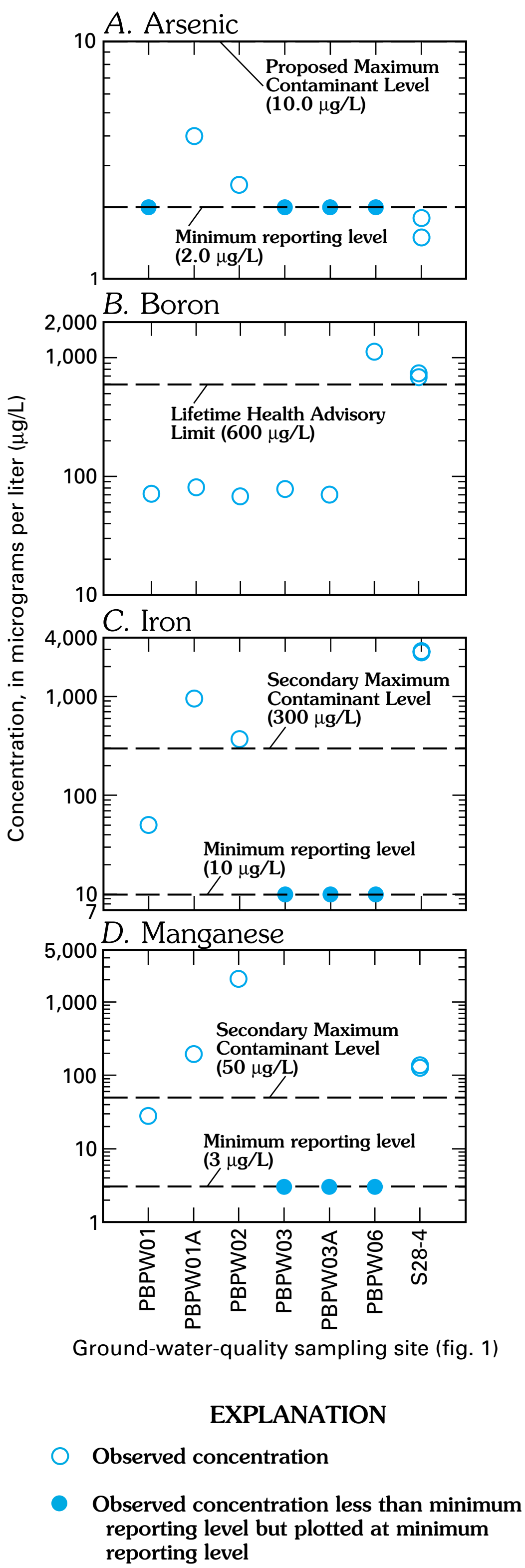

Figure 17. Distribution of selected trace constituent concentrations in ground-water-quality samples, September through December 2000. Water-quality criteria from U.S. Environmental Protection Agency (1986, 2000).

in drinking water that is not expected to cause any adverse effects for a lifetime of exposure).

Dissolved boron concentrations in ground-water-quality samples collected on the reservation ranged from 68 to 1,130 µg/L (fig. 17*D*). Water from two wells exceeded the 600-µg/L HAL, the aquifer test well (S28–4, table 10) with concentrations of 686 and 739 µg/L and water from well PBPW06 with a concentration of 1,130 µg/L. Because the HAL is for a lifetime of exposure, the anticipated health risk due to dissolved boron is low.

Iron

Although iron is the secondmost abundant element in the Earth's outer crust, concentrations present in water generally are small. Iron is an essential element in the metabolism of animals and plants. If iron is present in water in excessive amounts, it forms a red iron-oxide precipitate that stains laundry and plumbing fixtures and, therefore, is an objectionable constituent in domestic and industrial water supplies (Hem, 1992, p. 77). The U.S. Environmental Protection Agency (1986, 2000) has established an SMCL of 300 µg/L for iron. This limit is for drinking water that has been treated. If source water contains iron concentrations that are higher than 300 µg/L, the iron generally can be removed through treatment processes.

Total iron concentrations in ground water in northeastern Kansas typically are from about 45 to 5,000 µg/L (Trombley and others, 1996, p. 55). Dissolved iron concentrations in ground-water samples collected on the reservation ranged from less than 10 to 2,890 µg/L (fig. 17*C*, table 10). Water from four wells had iron concentrations less than the SMCL of 300 µg/L. In water from well PBPW01, the iron concentration was 50 µg/L. In water from wells PBPW03, PBPW03A, and PBPW06, concentrations were less than 10 µg/L. The dissolved iron concentration in water from three wells, however, exceeded the SMCL (well PBPW02, 370 µg/L, slightly higher than the SMCL; well PBPW01A, 950 µg/L, three times the SMCL; aquifer test well (S28–4), 2,800 and 2,890 µg/L, almost 10 times the SMCL).

Manganese

As with iron, manganese forms a staining precipitate (black). The SMCL for manganese is 50 µg/L (U.S. Environmental Protection Agency, 1986, 2000).

Table 10. Results of analysis of trace constituents in ground-water-quality samples from Prairie Band Potawatomi Reservation, northeastern Kansas, September through December 2000

[µg/L, micrograms per liter; <, less than indicated minimum reporting level; E, estimated]

Map identifier (fig. 1)	Local number (township, range, section)	Date of sample collection (month/day/year)	Time of sample collection (24 hour)	Arsenic, dissolved (µg/L)	Boron, dissolved (µg/L)	Iron, dissolved (µg/L)	Manganese, dissolved (µg/L)	Selenium, dissolved (µg/L)
PBPW01	07S 14E 23CDDB01	11/29/00	1530	<2.0	71	50	28	3.3
PBPW01A	07S 14E 23CCDA01	12/1/00	1230	4.0	81	950	195	<2.4
PBPW02	07S 15E 30BBAA01	11/29/00	1215	2.5	68	370	2,050	<2.4
PBPW03	08S 13E 14DDDD01	11/30/00	1250	<2.0	78	<10	<3	E2.2
PBPW03A	08S 13E 14DDDB01	11/30/00	1130	<2.0	70	<10	<3	<2.4
PBPW06	09S 14E 18CCDC01	12/1/00	1000	<2.0	1,130	<10	<3	<2.4
S28–4	08S 15E 28DACD01	9/22/00	1400	E1.8	739	2,800	128	E1.2
		9/25/00	1215	E1.5	686	2,890	137	E1.2

Dissolved manganese concentrations in water from four of the sampled wells were less than the SMCL of 50 µg/L (fig. 17*D*, table 10). In water from well PBPW01, the dissolved manganese concentration was 28 µg/L. In water from wells PBPW03, PBPW03A, and PBPW06, dissolved manganese concentrations were less than the minimum reporting level of 3 µg/L. In water from well PBPW01A, the dissolved manganese concentration was 195 µg/L, almost four times the SMCL. In water from well PBPW02, the dissolved manganese was 2,050 µg/L, 41 times the SMCL. Water from the aquifer test well (S28–4) had dissolved manganese concentrations of 128 and 137 µg/L, almost three times the SMCL.

Pesticides

Dissolved pesticides were not detected in any of the well samples; however, degradation products of the herbicides alachlor and metolachlor were detected in several samples (table 11). Alachlor ethane sulfonic acid (0.39 µg/L) and oxanilic acid (0.96 µg/L) were detected in water from well PBPW02. Metolachlor ethane sulfonic acid was detected in water from wells PBPW03 (0.09 µg/L) and PBPW03A (0.07 µg/L). Detections were close to the minimum reporting level, which is 0.05 µg/L. The U.S. Environmental Protection Agency currently (2001) has not established water-quality criteria for these herbicide degradation products; however, their presence suggests the occurrence of alachlor and metolachlor at some point in the past in the vicinity of these wells. No insecticides were detected in any of the ground-water-quality samples.

Bacteria

As a general rule, fecal indicator bacteria are not detected in uncontaminated well water. Low densities of E. coli and fecal coliform were detected in water from wells PBPW03 and PBPW03A (table 12), both of which are located near a small feedlot. Low densities of E. coli were detected in water from well PBPW01A (estimated 1 col/100 mL). Bacteria densities were very low in water from each of these wells and, therefore, are not a major concern. Much higher concentrations of E. coli, fecal coliform, and fecal streptococcus were detected in water from the aquifer test well (S28–4, table 12). Water samples were collected shortly after the well was drilled, and the higher bacteria concentrations may be related to the drilling process even though the well was treated with sodium hypochlorite after the casing was set.

Table 11. Results of analysis of pesticides and pesticide metabolites in ground-water-quality samples from Prairie Band Potawatomi Reservation, northeastern Kansas, September through December 2000

[ELISA, enzyme-linked immunosorbent assay; GC/MS, gas chromatography/mass spectrometry; µg/L, micrograms per liter; <, less than indicated minimum reporting level; --, not analyzed, not determined]

Map identifier (fig. 1)	Local number (township, range, section)	Date of sample collection (month/day/year)	Time of sample collection (24 hour)	Triazine herbicides and metabolites: Triazine screen using ELISA (µg/L)	Atrazine, dissolved using GC/MS (µg/L)	Deethylatrazine (µg/L)	Deisopropylatrazine (µg/L)	Cyanazine, dissolved (µg/L)	Cyanazine amide (µg/L)	Propazine, dissolved (µg/L)	Simazine, dissolved (µg/L)	Acetochlor, dissolved (µg/L)	Acetochlor ethane sulfonic acid, filtered (µg/L)
PBPW01	07S 14E 23CDDB01	11/29/00	1530	<0.1	<0.050	<0.050	<0.05	<0.050	<0.050	<0.05	<0.050	<0.050	<0.05
PBPW01A	07S 14E 23CCDA01	12/1/00	1230	<.1	<.050	<.050	<.05	<.050	<.050	<.05	<.050	<.050	--
PBPW02	07S 15E 30BBAA01	11/29/00	1215	<.1	<.050	<.050	<.05	<.050	<.050	<.05	<.050	<.050	<.05
PBPW03	08S 13E 14DDDD01	11/30/00	1250	<.1	<.050	<.050	<.05	<.050	<.050	<.05	<.050	<.050	<.05
PBPW03A	08S 13E 14DDDB01	11/30/00	1130	<.1	<.050	<.050	<.05	<.050	<.050	<.05	<.050	<.050	<.05
PBPW06	09S 14E 18CCDC01	12/1/00	1000	<.1	<.050	<.050	<.05	<.050	<.050	<.05	<.050	<.050	--
S28–4	08S 15E 28DACD01	9/22/00	1400	<.1	<.050	<.050	<.05	<.050	<.050	<.05	<.050	<.050	<.05
		9/25/00	1215	<.1	<.050	<.050	<.05	<.050	<.050	<.05	<.050	<.050	<.05

Map identifier (fig. 1)	Local number (township, range, section)	Date of sample collection (month/day/year)	Time of sample collection (24 hour)	Acetochlor oxanilic acid, filtered (µg/L)	Alachlor, dissolved (µg/L)	Alachlor ethane sulfonic acid (µg/L)	Alachlor oxanilic acid (µg/L)	Metolachlor (µg/L)	Metolachlor ethane sulfonic acid (µg/L)	Metolachlor oxanilic acid (µg/L)	Propachlor, dissolved (µg/L)	Prometryn, dissolved (µg/L)	Prometon, dissolved (µg/L)
PBPW01	07S 14E 23CDDB01	11/29/00	1530	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
PBPW01A	07S 14E 23CCDA01	12/1/00	1230	--	<.05	--	--	<.05	--	--	<.05	<.05	<.05
PBPW02	07S 15E 30BBAA01	11/29/00	1215	<.05	<.05	.39	.96	<.05	<.05	<.05	<.05	<.05	<.05
PBPW03	08S 13E 14DDDD01	11/30/00	1250	<.05	<.05	<.05	<.05	<.05	.09	<.05	<.05	<.05	<.05
PBPW03A	08S 13E 14DDDB01	11/30/00	1130	<.05	<.05	<.05	<.05	<.05	.07	<.05	<.05	<.05	<.05
PBPW06	09S 14E 18CCDC01	12/1/00	1000	--	<.05	--	--	<.05	--	--	<.05	<.05	<.05
S28–4	08S 15E 28DACD01	9/22/00	1400	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05
		9/25/00	1215	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05

Table 12. Results of analysis of bacteria in ground-water-quality samples from Prairie Band Potawatomi Reservation, northeastern Kansas, September through December 2000

[E. coli, *Escherchia* coli; col/100 mL, colonies per 100 milliliters of water; K, nonideal count, estimated value; <, less than; >, greater than]

Map identifier (fig. 1)	Local number (township, range, section)	Date of sammple collection (month/ day/year)	Time of sample collection (24 hour)	E. coli (col/100 mL)	Fecal coliform (col/100 mL)	Fecal streptococcus (col/100 mL)
PBPW01	07S 14E 23CDDB01	11/29/00	1530	<1	<1	<1
PBPW01A	07S 14E 23CCDA01	12/1/00	1230	K1	<1	<1
PBPW02	07S 15E 30BBAA01	11/29/00	1215	<1	<1	<1
PBPW03	08S 13E 14DDDD01	11/30/00	1250	K3	K1	<1
PBPW03A	08S 13E 14DDDB01	11/30/00	1130	K1	K1	<1
PBPW06	09S 14E 18CCDC01	12/1/00	1000	<1	<1	<1
S28–4	08S 15E 28DACD01	9/22/00	1400	K300	19	K13
		9/25/00	1215	>600	100	190

SUMMARY

Water-quality samples were collected from February 1999 through February 2001 at 20 surface-water-quality sampling sites across the Prairie Band Potawatomi Reservation in northeastern Kansas as part of a study which began in 1996. Water quality is a very important consideration for the tribe. Three creeks draining the reservation, Soldier, Little Soldier, and South Cedar Creeks, are important tribal resources used for maintaining subsistence fishing and hunting needs for tribal members. Samples were collected twice at all 20 sites in June 1999 and June 2000 after herbicide application, and nine quarterly samples were collected at five surface-water-quality sampling sites from February 1999 through February 2001. Surface-water-quality sampling sites were selected to represent areal distribution across the reservation, surface water flowing into and out of the reservation, and surface water downgradient from potential sources of contamination. Surface-water-quality constituents of primary interest included nutrients, pesticides, and bacteria.

Single ground-water-quality samples were collected from six domestic supply wells, and two samples were collected from an aquifer test well. Ground-water constituents of primary interest included major dissolved ions, nutrients, arsenic, boron, dissolved iron and manganese, pesticides, and bacteria.

The median nitrite plus nitrate concentration in 81 surface-water-quality samples was 0.376 mg/L, and the maximum concentration was 4.18 mg/L as nitrogen, which is less than one-half the U.S. Environmental Protection Agency Maximum Contaminant Level (MCL) for drinking water of 10 mg/L as nitrogen. Ammonia concentrations in surface water ranged from a low of less than 0.020 to 1.85 mg/L, with a median concentration of 0.030 mg/L. The median concentration for total phosphorus in 81 surface-water-quality samples was 0.180 mg/L, and the maximum concentration was 1.86 mg/L. Fifty-one samples from throughout the reservation exceeded the U.S. Environmental Protection Agency recommended goal of 0.10 mg/L for the protection of aquatic life. The large number of surface-water-quality samples with total phosphorus concentrations near and exceeding 0.10 mg/L probably reflects nonpoint-source contributions from agricultural activities or septic systems on and upstream from the reservation.

Of 81 surface-water-quality samples analyzed for triazine herbicides, primarily atrazine, 24 contained triazine concentrations less than the minimum reporting level of 0.1 µg/L. Triazine concentrations in 26 samples collected in May and June 1999 and 2000 equalled or exceeded the 3.0-µg/L MCL. The maximum concentration was 10 µg/L. The U.S. Environmental Protection Agency MCL of 3.0 µg/L refers to an annual mean concentration, not a one-time sample concentration; consequently, triazine herbicide concentrations detected in surface-water-quality samples from the reservation during this study met the drinking-water criterion. However, triazine concentrations are likely to be highest during late spring. High triazine herbicide concentrations in the May and June samples resulted directly from late spring runoff after herbicide application.

High concentrations of fecal indicator bacteria in surface water are a concern on the reservation. Fecal coliform bacteria ranged from 4 to greater than 31,000 col/100 mL with a median concentration of 570 col/100 mL. There appears to be a relationship to fecal coliform concentration in streams on the reservation with higher concentrations occurring during the spring and summer and decreasing during the fall and winter. More than one-half of the observed fecal coliform concentrations in surface-water-quality samples exceeded the Kansas Department of Health and Environment criterion for primary contact recreation (200 col/100 mL), and occurred mostly in May or June. All fecal coliform bacteria concentrations exceeding the Kansas Department of Health and Environment criterion for secondary contact recreation (2,000 col/100 mL) also occurred in samples collected during either May or June.

Calcium is a major constituent of the carbonate rocks underlying the reservation and contributes to the total hardness of water. Concentrations in water from seven ground-water-quality sampling sites generally ranged from 87.5 to 111 mg/L. The lowest concentration of 36.6 mg/L occurred in a sample from a well located in the southwest part of the reservation. Calcium concentrations in ground water of about 100 mg/L are similar to those found in surface water in northeastern Kansas; however, calcium concentrations in water from two wells were higher, with values ranging from 241 to 336 mg/L. The median sodium concentration in water from the ground-water-quality sampling sites was 21.9 mg/L, which is slightly higher than the 20-mg/L U.S. Environmental Protection Agency health advisory level (HAL) that was established in consideration of those people who must restrict their sodium intake for health reasons. Only two wells had samples with sodium concentrations less than the HAL. Water samples from two wells had sodium concentrations of about 10 times the HAL, ranging from 199 to 239 mg/L.

Bicarbonate concentrations in ground-water samples ranged from 273 to 451 mg/L and generally followed the concentrations of calcium and manganese. The lowest bicarbonate concentrations, however, were found in water from an aquifer test well, in which both calcium and sodium concentrations were highest. Sulfate concentrations in water from five wells were generally low, with values less than 80 mg/L. In water from two wells, however, sulfate concentrations exceeded 800 mg/L, which is more than three times the U.S. Environmental Protection Agency Secondary Maximum Contaminant Level (SMCL) of 250 mg/L established to alleviate the laxative effects of sulfate in drinking water. Chloride can import a salty taste to drinking water and may accelerate corrosion of metals used in water-supply systems. Chloride concentrations approached the U.S. Environmental Protection Agency SMCL of 250 mg/L in water from two wells.

All but two of the eight ground-water-quality samples had dissolved-solids concentrations exceeding the U.S. Environmental Protection Agency SMCL of 500 mg/L. The highest concentration of 2,010 mg/L was more than four times the SMCL. Dissolved solids in excess of 500 mg/L are objectionable in drinking water because of possible physiological effects, unpotable mineral tastes, and higher treatment costs.

The principal constituents in water from four wells were calcium, magnesium, and bicarbonate. Water of this type generally is formed from the dissolution of limestone. Water from two wells also showed evidence of saltwater intrusion. In addition, water from two wells had elevated sulfate concentrations consistent with dissolution of gypsum or anhydrite.

Nutrient concentrations in ground water are not at levels high enough to cause concern. The maximum nitrite plus nitrate concentration was 1.92 mg/L, which is less than 20 percent of the 10-mg/L MCL. The maximum ammonia concentration was also low, at 1.9 mg/L. Only one well sample had a total phosphorus concentration (0.068 mg/L) exceeding the 0.060 mg/L minimum reporting level.

Dissolved boron concentrations exceeded the U.S. Environmental Protection Agency 600-μg/L HAL in water from two of the seven wells sampled. Because the HAL is for a lifetime of exposure, the anticipated health risk due to dissolved boron is low.

Dissolved iron concentrations in ground-water samples ranged from less than 10 to 2,890 μg/L. Water from four wells had iron concentrations less than the 300-μg/L SMCL. Iron concentrations in excess of 300 μg/L stain laundry and plumbing fixtures. Dissolved manganese concentrations in water from three wells exceeded the established SMCL of 50 μg/L by 2, 3, and 41 times, respectively. As with iron, manganese can form a precipitate that stains laundry and plumbing fixtures. Dissolved manganese concentrations in water from the remaining four wells were less than the SMCL.

Dissolved pesticides were not detected in any of the well samples; however, there were degradation products of the herbicides alachlor and metolachlor in several samples. Low levels of alachlor ethane sulfonic acid (0.39 μg/L) and alachlor oxanilic acid (0.96 μg/L), degradation products of alachlor, were detected in water from one well. A degradation product of metolachlor (metolachlor ethane sulfonic acid) was detected in water from two wells at 0.07 and 0.09 μg/L. No insecticides were detected in any of the ground-water-quality samples.

Fecal indicator bacteria E. coli and fecal coliform were detected in water from two wells, and E. coli was detected in water from one well. Bacteria levels in the three wells were very low (1 to 3 col/100mL) and, therefore, are not a major concern. Much higher concentrations of E. coli, fecal coliform, and fecal streptococcus were detected in an aquifer test well where samples were collected shortly after the well was drilled. Even though the well was treated with sodium hypochlorite, the well may have been contaminated during the drilling process. As a general rule, fecal indicator bacteria are not found in uncontaminated well water.

Water quality on the Prairie Band Potawatomi Reservation is generally sufficient to meet the requirements of the tribe. Major concerns for surface water are related to agricultural runoff and include increased triazine herbicide concentrations during the spring and summer and high concentrations of fecal indicator bacteria. Major concerns for ground water are related to high mineral concentrations resulting from dissolution of the surrounding sedimentary rocks.

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