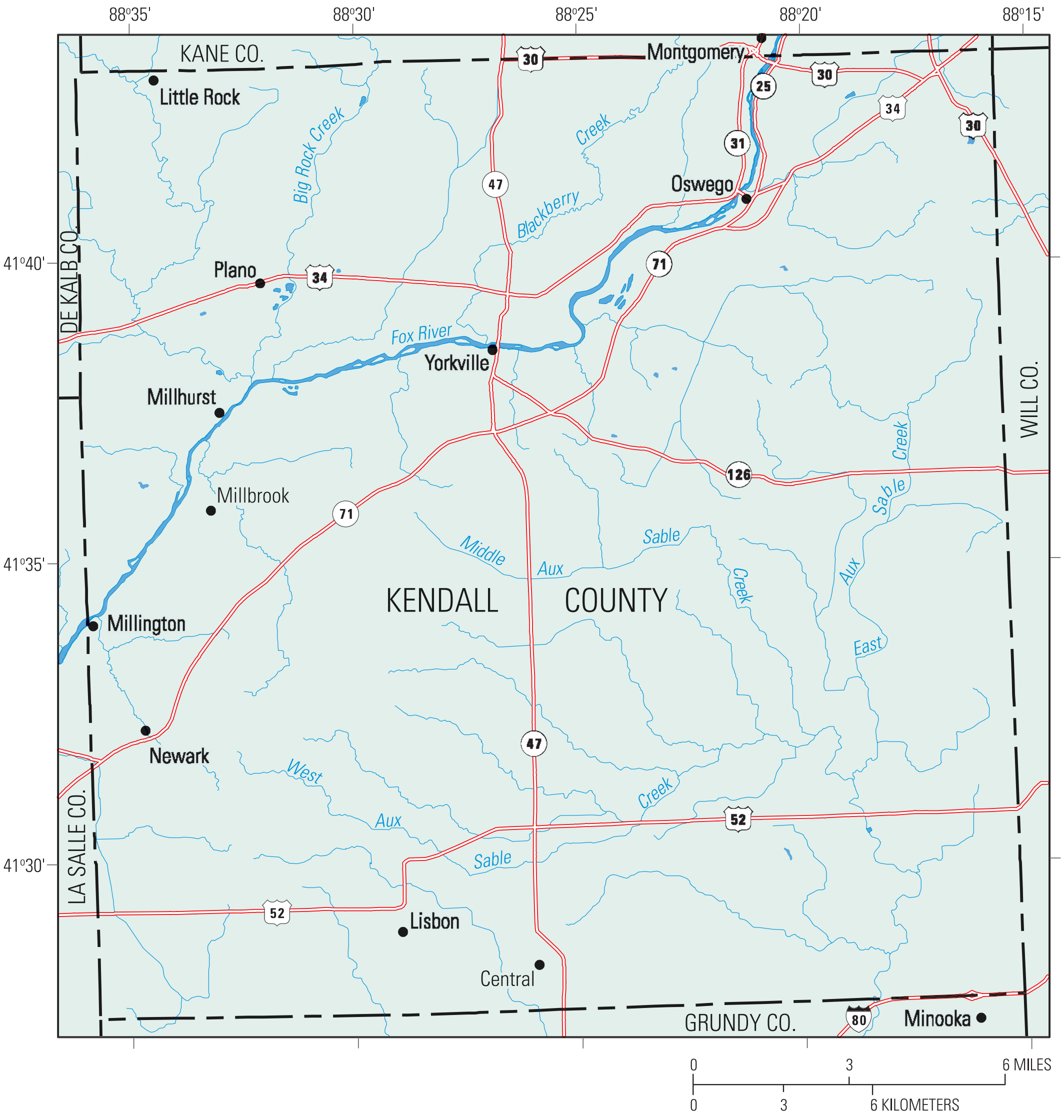
In cooperation with the Kendall County Soil and Water Conservation District

Surface-Water and Ground-Water Resources of Kendall County, Illinois



Scientific Investigations Report 2005-5122

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

Surface-Water and Ground-Water Resources of Kendall County, Illinois

By Robert T. Kay, Patrick C. Mills, Jennifer L. Hogan, and Terri L. Arnold

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Gale A. Norton, Secretary

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CONVERSION FACTORS, VERTICAL DATUM, AND ABBREVIATED WATER-QUALITY UNITS

Multiply	By	To obtain
	Length	
inch (in.)	2.54	centimeter (cm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
	Area	
square mile (mi^2)	2.590	square kilometer (km^2)
	Flow rate*	
foot per day per foot (ft/d/ft)	0.3048	meter per day per meter (m/d/m)
cubic foot per second (ft^3/s)	28.32	cubic decimeter per second (dm^3/s)
gallon per minute (gal/min)	3.785	liter per minute (L/min)
gallon per day (gal/d)	3.785	liters per day (L/d)
million gallons per day (Mgal/d)	3.785	million liters per day (ML/d)
inch per year (in/yr)	25.4	millimeter per year (mm/yr)
	Hydraulic conductivity**	
foot per day (ft/d)	0.3048	meter per day (m/d)
	Transmissivity***	
foot squared per day (ft^2/d)	0.09290	meter squared per day (m^2/d)

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

$$°F = (1.8 \times °C) + 32$$

Vertical coordinate information is referenced to the National Geodetic Vertical Datum of 1929 (NGVD29). The NGVD29 is a geodetic datum derived from a general adjustment of first-order level nets of both the United States and Canada, formerly called Sea Level Datum of 1929.

Altitude, as used in this report, refers to distance above or below NGVD29.

Horizontal coordinate information used in this report is the North American Datum of 1983.

***Flow Rate:** In this report, recharge rate is presented in inch per year (in/yr). Elsewhere, recharge rate may be presented in the form gallon per day per square mile ($gal/d/mi^2$). In this report, leakage coefficient is presented in foot per day per foot (ft/d/ft). Elsewhere, leakage coefficient may be presented in the form gallon per day per square foot ($gal/d/ft^2$).

****Hydraulic conductivity:** The standard unit for hydraulic conductivity is cubic foot per day per square foot of aquifer cross-sectional area ($(ft^3/d)/ft^2$). In this report, the mathematically reduced form, foot per day (ft/d), is used for convenience. Elsewhere, hydraulic conductivity may be presented in the form gallon per day per square foot ($gal/d/ft^2$).

*****Transmissivity:** The standard unit for transmissivity is cubic foot per day per foot of head per square foot of aquifer cross-sectional area ($(ft^3/d)(ft)/ft^2$). In this report, the mathematically reduced form, square foot per day (ft^2/d), is used for convenience. Elsewhere, transmissivity may be presented in the form gallon per day per foot (gal/d/ft).

Abbreviated water-quality units used in this report: Organic- and inorganic- constituent concentrations are given in metric units. Constituent concentrations are given in milligrams per liter (mg/L) or micrograms per liter (µg/L). Milligrams per liter are considered equivalent to parts per million at the reported concentrations. Micrograms per liter are considered equivalent to parts per billion at the reported concentrations.

Fecal coliform concentrations are given in colonies per 100 milliter (colonies/100mL).

Radiometric measurements of water are given in picocuries per liter (pCi/L) or millirems per year (mrems/yr).

Turbidity is given in nephelometric turbidity units (NTU).

SURFACE-WATER AND GROUND-WATER RESOURCES OF KENDALL COUNTY, ILLINOIS

By Robert T. Kay, Patrick C. Mills, Jennifer L. Hogan, and Terri L. Arnold

Abstract

Water-supply needs in Kendall County, in northern Illinois, are met exclusively from ground water derived from glacial drift aquifers and bedrock aquifers open to Silurian, Ordovician, and Cambrian System units. As a result of population growth in Kendall County and the surrounding area, water use has increased from about 1.2 million gallons per day in 1957 to more than 5 million gallons per day in 2000. The purpose of this report is to characterize the surface-water and ground-water resources of Kendall County. The report presents a compilation of available information on geology, surface-water and ground-water hydrology, water quality, and water use.

The Fox River is the primary surface-water body in Kendall County and is used for both wastewater disposal and as a drinking-water supply upstream of the county. Water from the Fox River requires pretreatment for use as drinking water, but the river is a potentially viable additional source of water for the county.

Glacial drift aquifers capable of yielding sufficient water for municipal supply are expected to be present in northern Kendall County, along the Fox River, and in the Newark Valley and its tributaries. Glacial drift aquifers capable of yielding sufficient water for residential supply are present in most of the county, with the exception of the southeastern portion. Volatile organic compounds and select trace metals and pesticides have been detected at low concentrations in glacial drift aquifers near waste-disposal sites. Agricultural-related constituents have been detected infrequently in glacial drift aquifers near agricultural areas. However, on the basis of the available data, widespread, consistent problems with water quality are not apparent in these aquifers. These aquifers are a viable source for additional water supply, but would require further characterization prior to full development.

The shallow bedrock aquifer is composed of the sandstone units of the Ancell Group, the Prairie du Chien Group, the Galena-Platteville dolomite, the Maquoketa Group, and the Silurian dolomite where these units are at the bedrock surface. The availability of water from the shallow bedrock aquifer depends primarily on the geologic unit utilized. The Silurian dolomite, Galena-Platteville dolomite, and Ancell Group can yield sufficient water for residential and municipal supply in at least some parts of the county.

The Cambrian-Ordovician aquifer system is composed of the most widespread, productive aquifers in northern Illinois and is used for water supply by a number of municipalities and industrial facilities. Water levels in the aquifer system have declined by as much as 600 feet in Kendall County and the aquifer frequently contains concentrations of radium above established health guidelines.

INTRODUCTION

Water-supply needs in Kendall County, northern Illinois (fig. 1), are met exclusively from *ground water** derived from glacial *drift aquifers* and *bedrock* aquifers open to *Silurian*, *Ordovician*, and *Cambrian System* units. Many homes rely on water from residential-supply *wells* open to the glacial drift and bedrock aquifers less than 600 ft deep.

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*First use of words defined in the Glossary of this report is italicized.

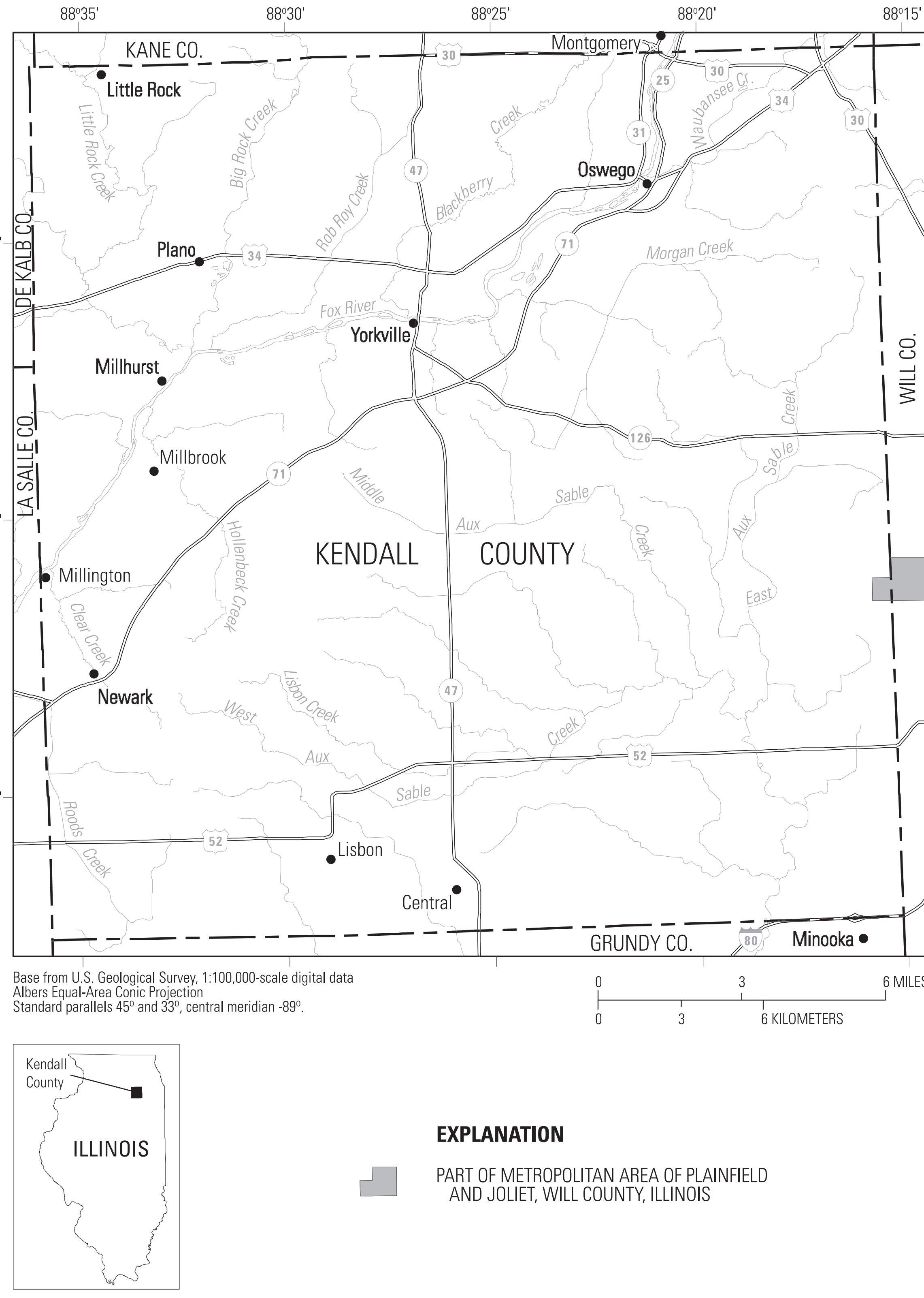


Figure 1. Location of Kendall County, Illinois.

Most municipal water-supply wells in the county are open either to the glacial drift aquifer or to one or more aquifers of the Cambrian-Ordovician aquifer system, with one municipal-supply well open to the Silurian *dolomite* (table 1).

Large decreases in ground-water levels because of drought or pumpage from residential wells have resulted in water-supply interruptions in the glacial drift aquifer and shallow bedrock aquifers in parts of northern Illinois (Kay and Krakse, 1996). Problems with water quality and large decreases in water levels resulting from excessive pumping of the Cambrian-Ordovician aquifer system in much of northeastern Illinois have forced many municipalities to switch from ground water to Lake Michigan or, in part, the Fox River for water supply. Population growth in Kendall County and nearby areas increases the potential for depletion of ground-water resources in the county.

Table 1. Summary of information from municipal-supply wells in Kendall County, Illinois.

[GD, glacial drift; AN, Ancell; CO, Cambrian-Ordovician; IG, Ironton-Galesville; PDC, Prairie du Chien; SB, shallow bedrock; SI, Silurian dolomite; GP, Galena-Platteville; MG, Maquoketa Group; gal/d, gallons per day; Bold denotes data averaged for entire system; unk, unknown; -, no remarks]

Owner	Local name	Aquifer	Depth (feet)	2000 withdrawal (gal/d)	Remarks
Plano	1	GD	18	0	Abandoned
Plano	2	GD	40	207,651	-
Plano	3	GD	40	207,651	-
Plano	4	GD	37	207,651	-
Plano	5	GD	41	207,651	-
Yorkville	1	AN	590	205,667	-
Yorkville	2	GD	42	0	Abandoned
Yorkville	3	CO	1,335	205,667	-
Yorkville	4	CO	1,393	205,667	-
Yorkville	7	IG	1,510	0	Not yet on line in 2004
Yorkville	8	PDC/IG	1,390	0	Not yet on line in 2004
Yorkville	9	IG	1,310	0	Not yet on line in 2004
Oswego	1	AN	680	0	Abandoned
Oswego	3	CO	1,378	70,000	-
Oswego	4	CO	1,396	70,000	-
Oswego	5	SB (SI)	207	70,000	-
Oswego	6	CO	1,392	70,000	-
Oswego	7	IG	1,483	70,000	-
Oswego	8	IG	1,450	70,000	-
Newark	2	AN	287	36,000	-
Newark	3	AN	336	36,000	-
Fox Lawn Utility Company	1	AN	715	14,430	-
Bonnie Lane Water Supply	1	CO	unk	36,000	-
Bonnie Lane Water Supply	2	CO	unk	43,200	-
Hollis Park Subdivision	1	SB (GP)	200	10,836	-
Silver Springs State Park	1	SB (GP)	120	unk	-
Storybrook Highlands	1	SB (SI)	344	unk	-
Metro Utility-Valley Division	1	SB (MG)	187	unk	-
Metro Utility-Valley Division	2	AN	700	unk	-
Morgan Creek	1	AN	642	5,000	-

The Illinois Department of Natural Resources (IDNR), in developing a program for the equitable allocation of water from Lake Michigan, must consider the water needs of the six-county Chicago metropolitan area (Cook, Lake, DuPage, Kane, McHenry, and Will), which does not include Kendall County. Although the IDNR is not prohibited from making water allocations to water systems in Kendall County, they must first take into account the present and future water needs of the six-county area. That, combined with the IDNR criteria that new applicants for Lake Michigan water must demonstrate that Lake Michigan water will be the most cost-effective, long-term, water-supply source indicates that ground water will continue to be critical to meeting the water-supply needs of Kendall County (Daniel Injerd, Illinois Department of Natural Resources, written commun., 2004). Water diverted from the Fox River for water supply would require pre-treatment to be potable and available supplies likely would be insufficient to meet the entire water needs of the county. It is therefore important that the water resources of Kendall County be fully characterized so that the long-term sustainability of the resource can be determined. The information gathered by this study will be useful to water-resources managers and will aid in characterization of flow in shallow and regional aquifers. In addition, it will lead to increased understanding of ground-water interaction with surface water, and of the hydrogeologic framework of regional aquifers and *confining units*. Therefore, the U.S. Geological Survey (USGS), in cooperation with the Kendall County Soil and Water Conservation District and the Kendall County municipalities, began an investigation of the water resources of Kendall County in 2003.

Purpose and Scope

This report provides an assessment of the surface-water and ground-water resources of Kendall County, Illinois. The report presents a compilation of available information on population, land use, physiography, climate, geology, surface-water and ground-water hydrology, surface-water and ground-water quality, and water use in the county. Results are presented of analyses of previously collected water-quality and streamflow data from stations in northeastern Illinois, in addition to analyses of water-quality data collected from more than 100 residential supply wells and more than 20 municipal supply wells. Results are also presented from analyses of *lithologic logs* from more than 2,000 residential- and municipal-supply wells, and of *geophysical logging* from 3 municipal-supply wells. In addition, results are presented from *aquifer tests* that were performed as part of this investigation on one well open to the glacial drift and three wells open to the lower part of the Cambrian-Ordovician aquifer system.

Methods of Investigation

Much of the information on geology, hydrology, water quality, and water use given in this report was compiled from previous investigations of northern and northeastern Illinois performed by Federal and State scientific and regulatory agencies (Bergstrom and others, 1955; Suter and others, 1959; Buschbach, 1964; Emrich, 1966; Willman, 1971; Visocky and others, 1985). Additional data were obtained from reports of investigations at four hazardous-waste-disposal sites in the county investigated by the Illinois Environmental Protection Agency (IEPA) or U.S. Environmental Protection Agency (USEPA) (Illinois Environmental Protection Agency, 1989, 1990a, 1990b, 1992, 1993, 1995, 1997; Metcalf and Eddy, Inc., 1995, 1996; Ecology and Environment, Inc., 1986, 1987, 1988).

Hydrogeologic and water-use data also were obtained from analysis of construction records of approximately 2,000 water-supply wells on file with the Illinois State Water Survey (ISWS) and the Kendall County Health Department. Data on these records include location, lithologic descriptions, static and pumping ground-water levels, and *hydrogeologic unit* supplying water to the well. This information was compiled and manipulated by use of geographic information system (GIS) software to supplement the analyses of previous investigations.

Additional hydrogeologic and water-quality interpretations were made based on the results of geophysical logging, aquifer testing, and *isotope* sampling performed as part of this investigation at two new municipal-supply wells drilled by the City of Yorkville and by analysis of production-test data at selected municipal-supply wells in the county. Details of these activities are presented in appendix A.

Description of Kendall County

Kendall County is located on the fringe of the Chicago Metropolitan area in northeastern Illinois. Environmental conditions in the county are typical of other areas in northeastern Illinois, where increases in population have created concern about the long-term availability of high-quality water.

Population and Land Use

Census data (U.S. Census Bureau, 2004) indicate that from 1850 through 1950, the population of Kendall County was stable at less than 15,000 residents (fig. 2). Population has increased steadily since about 1950, reaching an estimated value of 66,565 in 2003. Although the 2003 population of Kendall County is low in comparison to the rest of the Chicago metropolitan area, population increased by more than 38 percent from 1990 to 2000 and increased nearly 7 percent from 2000 to 2001. This population growth is expected to continue as suburban Chicago expands and by the year 2030 it is estimated that the population of Kendall County will be about 170,000 (John Kos, Illinois Department of Transportation, written commun., 2004), nearly 10 times the population in 1960.

Kendall County has an area of about 320 mi^2. Land use primarily is agricultural (about 75 percent of the total) (fig. 3). Wetland (about 1 percent of the total land use in Kendall County), and forest and grassland (about 17 percent) areas are along the Fox River, the lower part of Aux Sable Creek, and near some of the urban areas in the north-central part of the county.

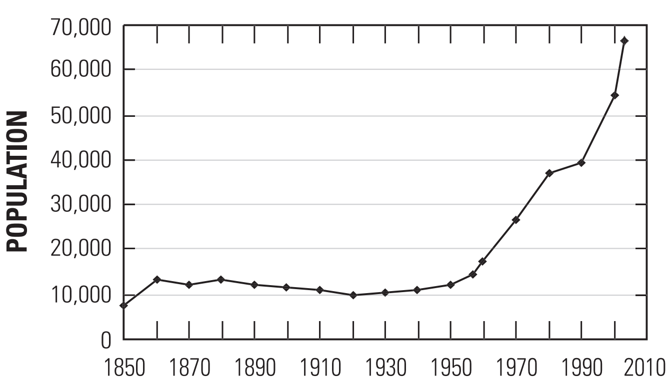


Figure 2. Population of Kendall County, Illinois, 1850 through 2003 (from U.S. Census Bureau, 2004.

Urban land use (about 4 percent of the total) is focused in the northern part of the county along the Fox River at Montgomery (which extends south from Kane County), Oswego, and Yorkville, and north of the river at Plano (fig. 3). The communities of Newark, Millington, Lisbon, and Minooka (which extends north from Grundy County) are located in the southern part of the county. Parts of the communities of Joliet and Plainfield, which are located primarily in Will County, extend to the extreme eastern part of Kendall County (figs. 1, 3). Analysis of census bureau population data indicates that, in 2000, population density was less than 56 people per mi^2 in most of Kendall County, with population densities in excess of 2,340 people per mi^2 in parts of the northeastern corner of the county. By 2030, urban expansion is expected from the current population centers, with the communities of Plainfield, Joliet, and Minooka expanding substantially to occupy most of the eastern third of the county (Jeffrey Wilkins, Kendall County Administrator, oral commun., 2004). Expansion around Montgomery, Oswego, Yorkville, and Plano is expected to increase the amount of urban land in the northern third of the county.

Physiography

The northern two-thirds of Kendall County is part of the Bloomington Ridged Plain subsection of the *Till* Plains section of the Central Lowland *Physiographic* Province (Leighton and others, 1948) (fig. 4). The southern one-third of the county is part of the Kankakee Till Plain subsection of the Till Plains section of the Central Lowland Physiographic Province.

The Till Plains are characterized by an undulating surface of low relief composed of *ground moraine*. The Bloomington Ridged Plain is characterized by low, broad morainic ridges with intervening wide stretches of flat or gently undulatory ground moraine. Moraines from the St. Charles

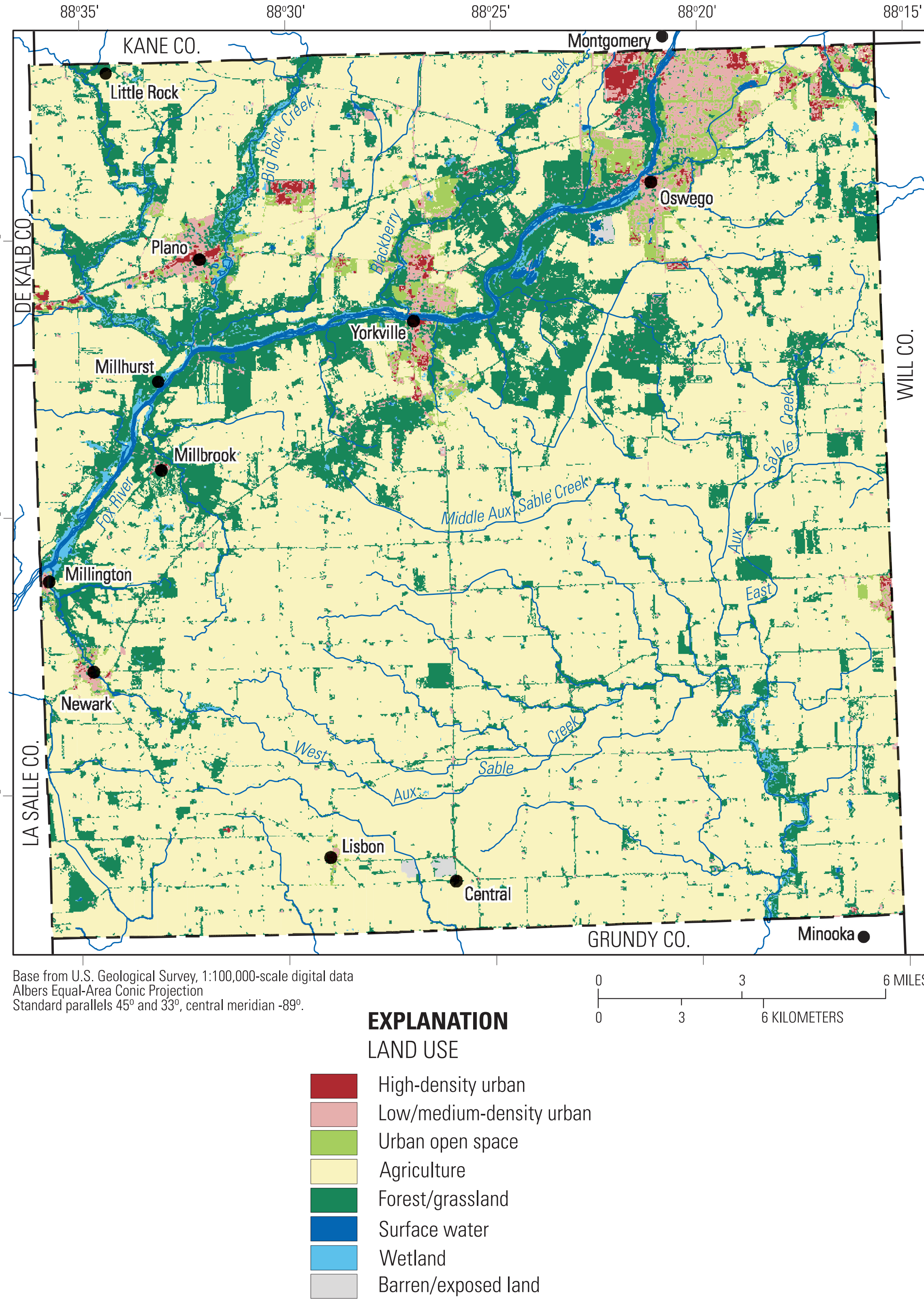


Figure 3. Land use in Kendall County, Illinois, 2000 (modified from National Land Cover Data, Multi-Resolution Land Characterization Consortium, 2000).

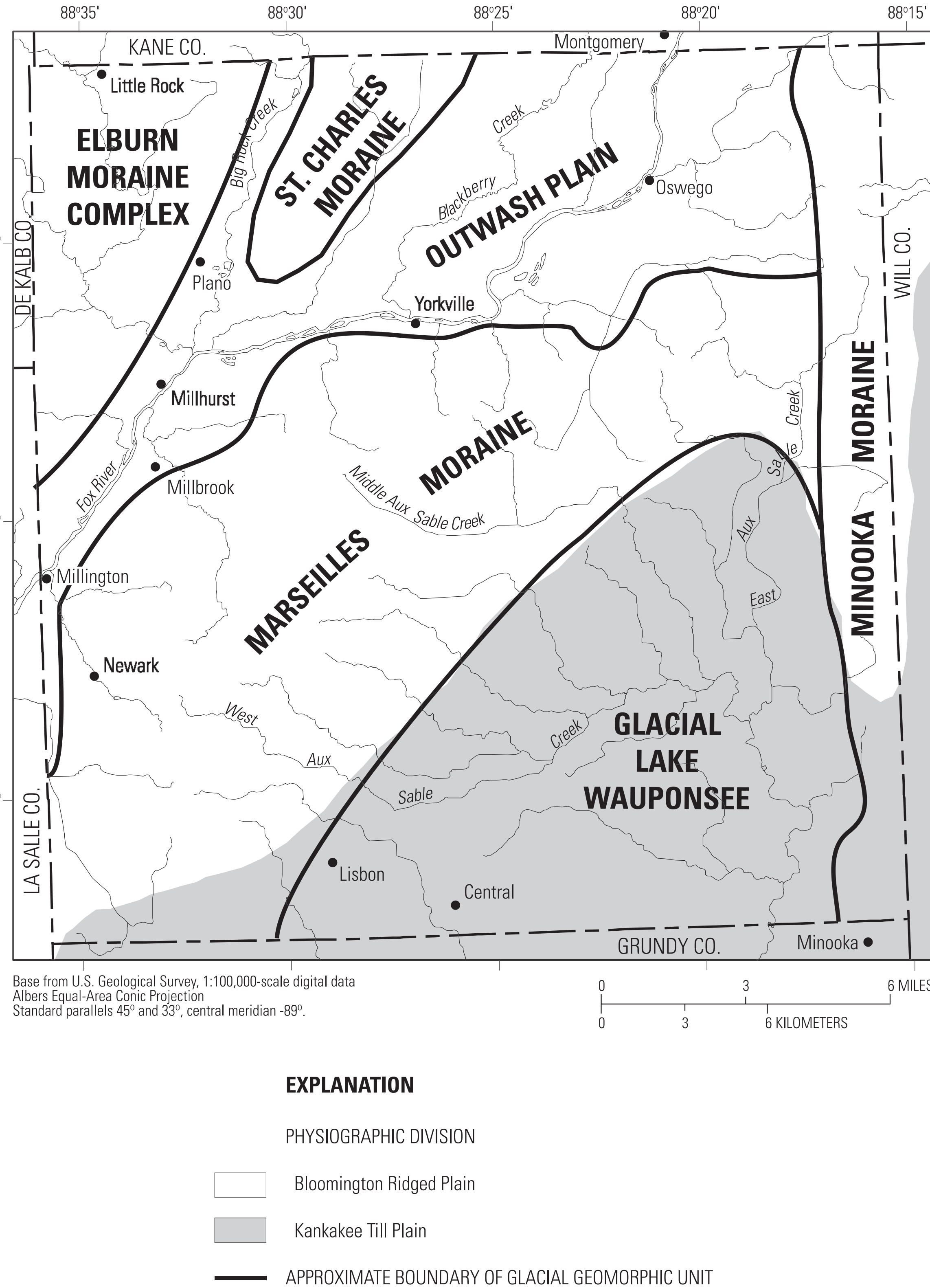


Figure 4. Physiography of Kendall County, Illinois (modified from Leighton and others, 1948; Wilman and Lineback, 1970; and Hansel and Johnson, 1996).

and Elburn complexes compose part of the ridged plain in the northwestern part of the county. Part of the Marseilles Morainic System defines the southern boundary of the Bloomington Ridged Plain in southeastern to central Kendall County and part of the Minooka Moraine defines the boundary of the Bloomington Ridged Plain in eastern Kendall County. The Kankakee Till Plain is characterized by a flat to gently undulatory surface, with low morainic islands, glacial terraces, torrent bars, and *sand* dunes. In Kendall County, much of the area that makes up the Kankakee Till Plain was the location of Glacial Lake Wauponsee (fig. 4).

Land-surface altitude exceeds 700 ft above the National Geodetic Vertical Datum of 1929 (NGVD 29) in the northwestern corner of the county, and is between 600 and 700 ft in most of the area north of the Fox River (fig. 5). A topographic ridge is present about 6 mi south of the Fox River. The altitude of the land surface along this ridge varies from about 650 to 750 ft. This ridge roughly parallels the Fox River and defines the location of the Marseilles Morainic System in the county. South of the ridge, surface-water drainage is to Aux Sable Creek. North of the ridge, drainage is to the Fox River. Land-surface altitude is between 550 and 600 ft in most of the southeastern part of the county. Much of this area corresponds to the location of the former Glacial Lake Wauponsee (compare figures 4 and 5).

Climate

The climate in Kendall County is classified as temperate continental, with a mean annual temperature of 47.9 °F and a mean annual precipitation of 38.4 in. (National Oceanic and Atmospheric Administration, 2003). Precipitation varies seasonally, with monthly averages about 1.5 in. in January and February, increasing to more than 4.0 in. from June through August, and decreasing to 2.4 in. in December (table 2). More than half of all precipitation typically falls in the period from April 1 through August 31.

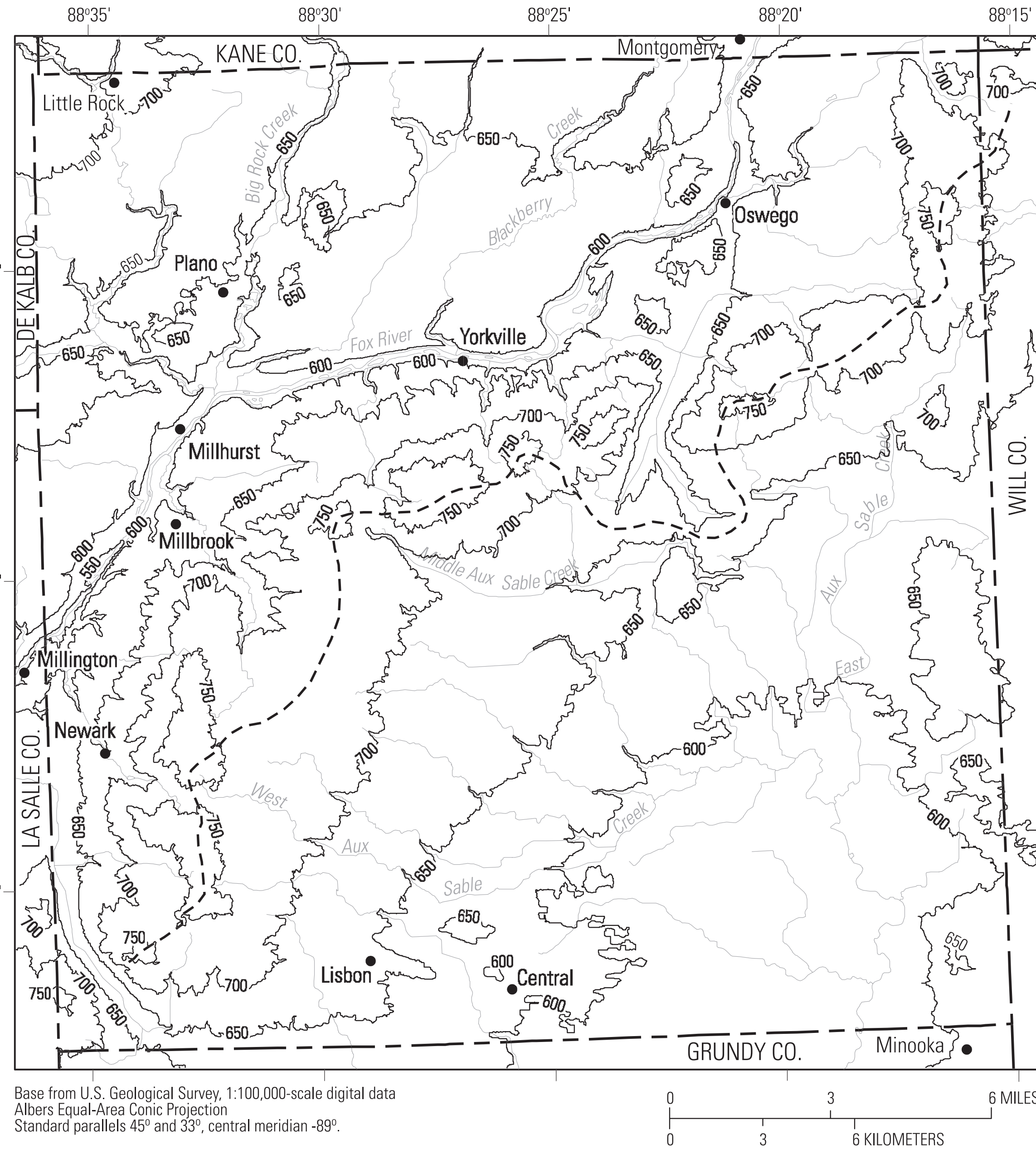
An estimated 70 percent of the average annual precipitation that falls on Kendall County is returned to the atmosphere by *evapotranspiration* (Mades, 1987). Based on this percentage, average annual precipitation available to ground water is no greater than 11.5 in. More than three-quarters of all evapotranspiration occurs during the growing season, which is approximately from April through September (U.S. Geological Survey, 1970). During the growing season, evapotranspiration normally exceeds precipitation by about 1 to 2 in., depleting the available soil moisture, and reducing the potential for *recharge* to ground water. During the nongrowing season, precipitation generally exceeds evapotranspiration by about 11 in., replenishing soil moisture and recharging shallow ground water.

GEOLOGY

The geology of Kendall County can be divided into the *unconsolidated units* of the *Quaternary* System and the underlying bedrock units of the Cambrian through Silurian Systems. The *stratigraphic* framework for these units is shown in figure 6. Stratigraphic nomenclature used in this report is that of the Illinois State Geological Survey (Willman and others, 1975; Hansel and Johnson, 1996) and does not necessarily follow the usage of the USGS.

Table 2. Average monthly precipitation and temperature data, Kendall County, Illinois (National Oceanic and Atmospheric Administration, 2003).

	January	February	March	April	May	June	July	August	September	October	November	December	Total precipitation and average temperature
Precipitation (inches)	1.62	1.52	2.57	3.88	3.91	4.34	4.39	4.38	3.50	2.71	3.17	2.40	38.39
Temperature (degrees Farenheit)	20.0	25.3	36.3	47.8	59.0	68.2	72.4	70.3	62.6	50.7	37.5	25.3	44.1



EXPLANATION

650 — LINE OF EQUAL LAND-SURFACE ALTITUDE-- Contour interval 50 feet. Datum is NGVD 29.

- - - - APPROXIMATE TOPOGRAPHIC RIDGE

Figure 5. Topography of Kendall County, Illinois.

SYSTEM	GROUP	FORMATION	REGIONAL AQUIFER OR CONFINING UNIT	LOCAL HYDROGEOLOGIC DESIGNATION		THICKNESS (feet)	DESCRIPTION
Quaternary		Cahokia	Sand and gravel aquifers and till, silt, and clay confining units	Glacial drift aquifers and confining units		0-400	Alluvial silt, sand, gravel
	Mason	Equality					Lacustrine silt, clay, sand
		Peoria and Roxanna Silt					Eolian silt
		Henry					Glacial alluvial silt, sand, gravel
	Wedron	Lemont					Glacial till
Silurian		Kankakee	Silurian aquifer	Shallow bedrock aquifer	Units of Maquoketa Group less than 160 feet below bedrock surface part of shallow bedrock aquifer. Units more than about 160 feet below bedrock surface part of upper confining unit. Galena-Platteville part of shallow bedrock aquifer where unit is at bedrock surface, part of upper confining unit where overlain by Maquoketa Group.	0-100	Dolomite
		Edgewood					
Ordovician	Maquoketa	Neda	Upper confining unit			0-150	Shale, locally argillaceous dolomite or limestone
		Brainard					
		Fort Atkinson					
		Scales					
	Galena					0-350	Dolomite and limestone
	Platteville						
	Ancell	Glenwood	Cambrian-Ordovician aquifer system		Ancell aquifer. Part of shallow bedrock aquifer where at bedrock surface. Part of Cambrian-Ordovician aquifer system where overlain by Galena-Platteville unit	200-300	Sandstone, shale at top.
		St. Peter					Sandstone. Basal shale (Kress Member)
	Prairie du Chien	Shakopee			Upper part of Prairie du Chien part of shallow bedrock aquifer where at bedrock surface. Parts of Prairie du Chien Group and sandstones are aquifers locally where not at bedrock surface.	0-200	Dolomite
		New Richmond		Middle confining unit		0-65	Sandstone
		Oneota				0-250	Dolomite
		Gunter				0-15	Sandstone
Cambrian		Eminence				100	Dolomite and sandstone
		Potosi				100-150	Dolomite
		Franconia				100	Dolomite, sandstone, and shale
		Ironton		Ironton-Galesville aquifer		175-200	Sandstone, fine-to-medium grained, well sorted, upper part dolomitic
		Galesville					
		Eau Claire	Lower confining unit	Lower confining unit		300-400	Shale, siltstone, dolomite
			Mt. Simon aquifer	Mt. Simon aquifer			Sandstone (Elmhurst Member)
		Mt. Simon				2500-2800	Sandstone

Figure 6. Generalized geohydrologic column showing stratigraphy and hydrogeologic units in Kendall County , Illinois.

Bedrock Units

The distribution of the bedrock geologic units in Kendall County is affected by the Sandwich *Fault* Zone. The fault zone (fig. 7) is composed of two major faults with smaller associated faults possible beneath the county. The primary fault underlies most of northern Illinois and terminates near the eastern edge of the county. The fault zone is up to a mile in width and formed after deposition of the youngest bedrock units in northern Illinois (*Pennsylvanian* time) but before deposition of the Quaternary materials (about 40,000 years before present) (Kolata and others, 1978). The fault zone trends approximately N 60^{o} W and is nearly vertical, with the upthrown side to the south and downthrown side to the north. Displacement along the fault is as much as 250 ft beneath Kendall County, with more displacement beneath the western part of the county than the eastern part. As a consequence, bedrock units north of the fault are lower in altitude than south of the fault, and some of the units north of the fault have been removed by erosion south of the fault (figs. 7, 8; line of section is shown in figure 7). A second, smaller part of the fault zone is present in Will County to the east (fig. 9), and may extend into the southeastern part of Kendall County. This fault is upthrown to the north, but its effect on the structural geology of Kendall County is not well known.

Precambrian rocks beneath northern Illinois are composed primarily of *granite* and *granodiorite*. These rocks typically appear to be unweathered (Visocky and others, 1985). The altitude of the top of the Precambrian rocks south of the Sandwich Fault Zone ranges from -3,000 ft (negative values for altitude denote feet below NGVD 29) in the western part of Kendall County to about -3,500 ft in the eastern part of the county. In that part of the county north of the Sandwich Fault Zone, the altitude of the top of the Precambrian rocks is above -3,500 ft (fig. 8). The altitude of the top of the Precambrian rocks and all of the overlying bedrock units decreases from northwest to southeast on both sides of the fault zone.

The Mt. Simon *Sandstone* directly overlies the Precambrian rocks (fig. 8). No wells are known to penetrate the Mt. Simon Sandstone in Kendall County; however, the Mt. Simon Sandstone is penetrated by wells in eastern LaSalle, southern Kane, and western Will Counties. The Mt. Simon Sandstone is present throughout northern Illinois and consists of fine- to coarse-grained sandstone. The bottom 350 ft of the unit is *arkosic* and discontinuous, micaceous *shale* beds up to 15 ft thick are present in the upper 300 ft and lower 600 ft of the unit (Visocky and others, 1985). The Mt. Simon Sandstone is estimated to be about 2,500-2,800 ft thick beneath Kendall County. The altitude of the top of the Mt. Simon Sandstone is estimated to be about -1,000 ft beneath Kendall County north of the Sandwich Fault Zone (fig. 8). South of the Sandwich Fault Zone, the altitude of the top of the Mt. Simon Sandstone ranges from about -500 ft in the western part of the county to more than -1,000 ft in the southeastern part of the county.

The Eau Claire *Formation conformably* overlies the Mt. Simon Sandstone (figs. 6, 8). The Eau Claire Formation is present throughout northern Illinois. No logs are known to penetrate more than about 20 ft of the Eau Claire Formation in Kendall County, but the formation is estimated to be about 300-400 ft thick beneath the county based on well logs from nearby areas (Suter and others, 1959; Visocky and others, 1985). The Eau Claire Formation is divided into three *members*; the Elmhurst Sandstone, the Lombard Dolomite, and the Proviso *Siltstone*. The Elmhurst Sandstone is the basal member of the Eau Claire Formation, and consists of fine- to medium-grained fossiliferous sandstone. No wells penetrate the Elmhurst Sandstone in Kendall County, but this unit is about 10 ft thick in southern Kane County. The Lombard Dolomite is the middle member of the Eau Claire Formation and consists of *glauconitic*, sandy dolomite with interbedded, greenish-gray shale in most of northeastern Illinois. No logs penetrate the Lombard Dolomite in Kendall County, but this unit is expected to be about 125 ft thick beneath the county. The Proviso Siltstone is the uppermost member of the Eau Claire Formation and consists of sandy, dolomitic siltstone with pink or red shale in most of northeastern Illinois. No wells penetrate the entire thickness of the Proviso Siltstone in Kendall County, but this unit may be as much as 300 ft thick beneath the county. The altitude of the top of the Proviso Siltstone is estimated to be between -500 and -1,000

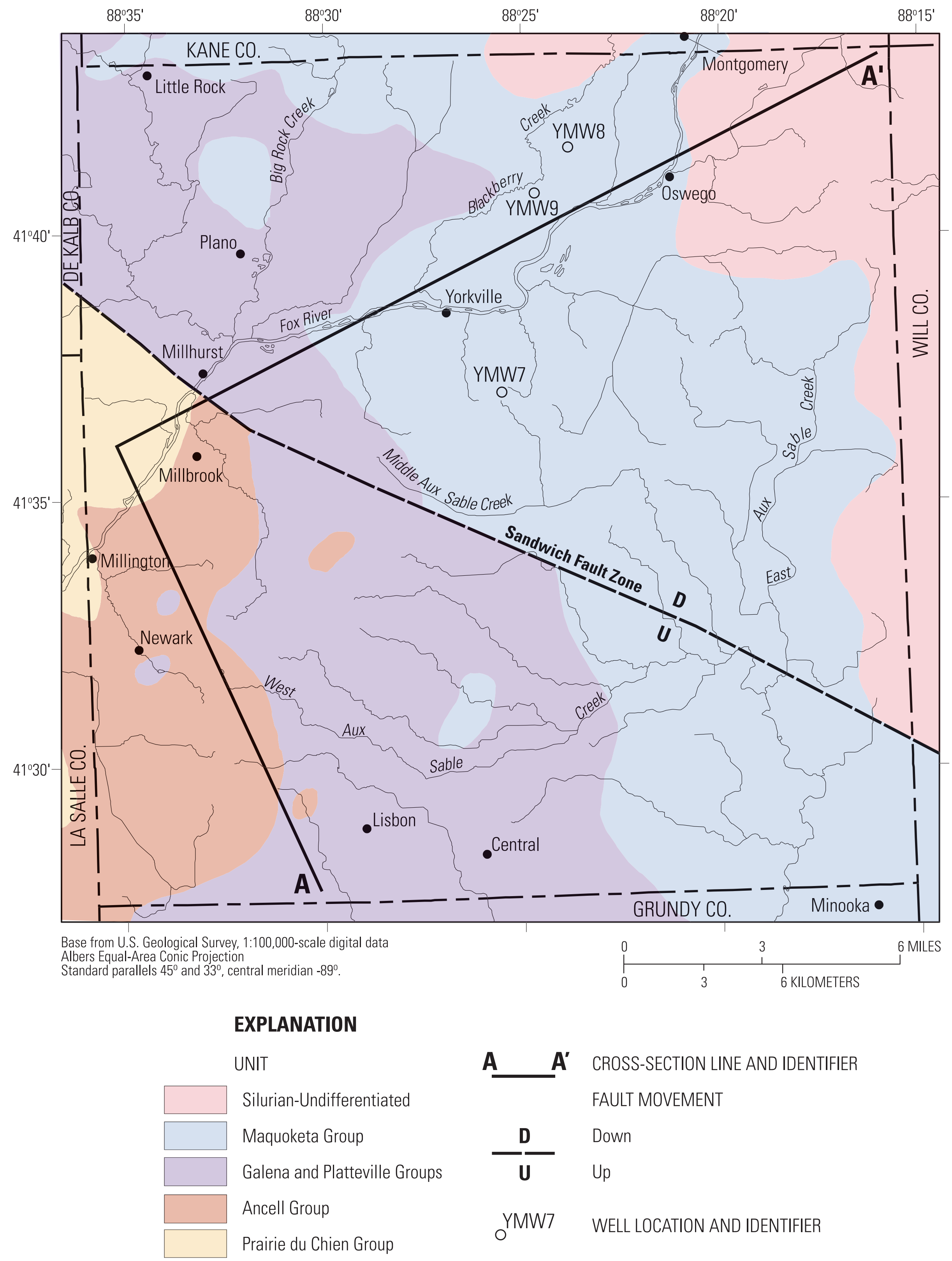


Figure 7. Bedrock-surface geology in Kendall County, Illinois (modified from Willman and others, 1967).

ft in Kendall County north of the Sandwich Fault Zone and from about -100 to -1,100 ft south of the Sandwich Fault Zone. Lithologic logs indicate that the altitude of the top of the Eau Claire Formation is about -780 ft near Oswego and at about -800 ft near Yorkville.

The Eau Claire Formation is overlain conformably by the Galesville Sandstone, a white, fine-grained, well-sorted, slightly dolomitic sandstone composed primarily of well-rounded *quartz* grains (fig. 6). The Galesville Sandstone is overlain by the Ironton Sandstone, a medium- to coarse-grained, partly dolomitic, moderately to poorly sorted sandstone. From top to bottom, the Ironton Sandstone is subdivided into the Mooseheart, Marywood, Fox Valley, and Buelter Members. The Mooseheart Member consists of dolomitic and glauconitic, coarse-grained, poorly sorted sandstone. The Marywood Member consists of sandstone that is less dolomitic and finer grained than the Mooseheart and Fox Valley Members. The Fox Valley Member consists of dolomitic, poorly sorted, medium- to coarse-grained sandstone with beds of sandy dolomite. The Buelter Member consists of medium-grained, moderately to poorly sorted sandstone with small amounts of dolomite. The Ironton and Galesville sandstones, hereafter referred to as the Ironton-Galesville sandstone, are estimated to be about 175-200 ft thick beneath Kendall County based on information from regional investigations (Visocky and others, 1985). North of the Sandwich Fault Zone, the altitude of the top of the Ironton-Galesville sandstone ranges from about -400 ft in the northwestern part of the county to more than -600 ft in the northeastern part of the county (Emrich, 1966) (figs. 8, 9). South of the Sandwich Fault Zone, the altitude of the top of the sandstone ranges from about 0 ft beneath the west-central edge of the county to about -600 ft beneath the southeastern edge. Lithologic and geophysical logs indicate the top of the Ironton-Galesville sandstone is about -550 and -500 ft at Yorkville municipal wells 7 and 9, respectively, and is about 200 ft thick (appendix A). Lithologic logs indicate that the top of the Ironton-Galesville sandstone is -600 to -650 ft near Oswego and is about 155 ft thick. Lithologic logs indicate that the altitude of the top of the Ironton-Galesville sandstone is present between -560 and -580 ft near Montgomery and the unit is about 100-140 ft thick. Porosity estimates for the Ironton Sandstone south of Kendall County range from 1 to 33 percent (Suter and others, 1959). Porosity estimates for the Galesville Sandstone south of Kendall County range from 11 to 35 percent.

The Ironton Sandstone is conformably overlain by the Franconia Formation (fig. 6). In northeast-

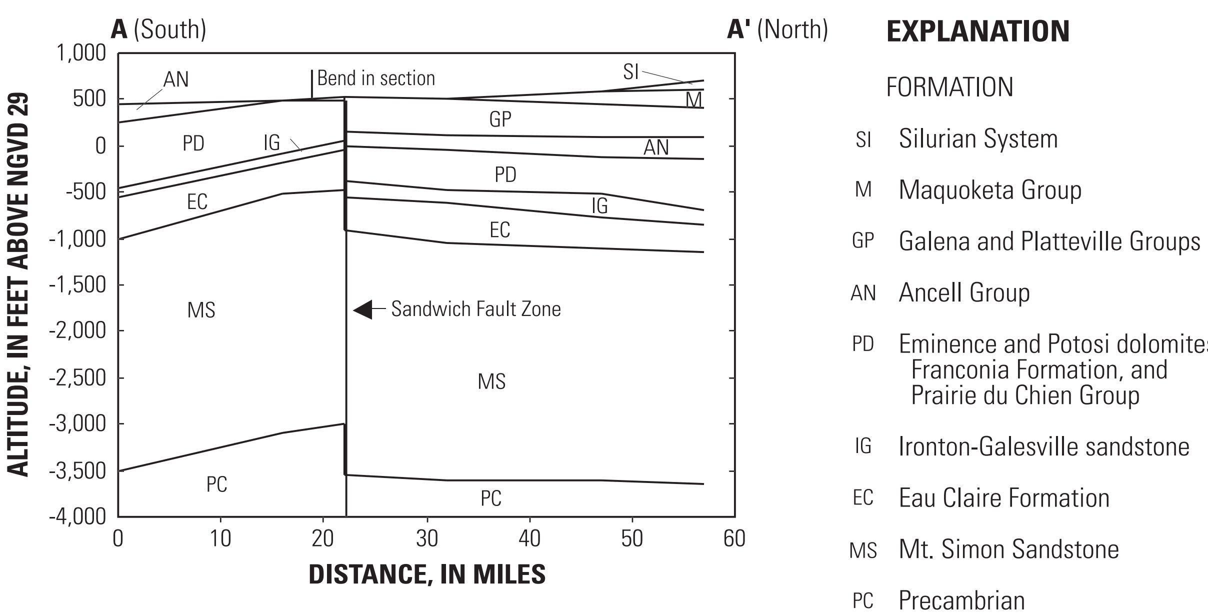
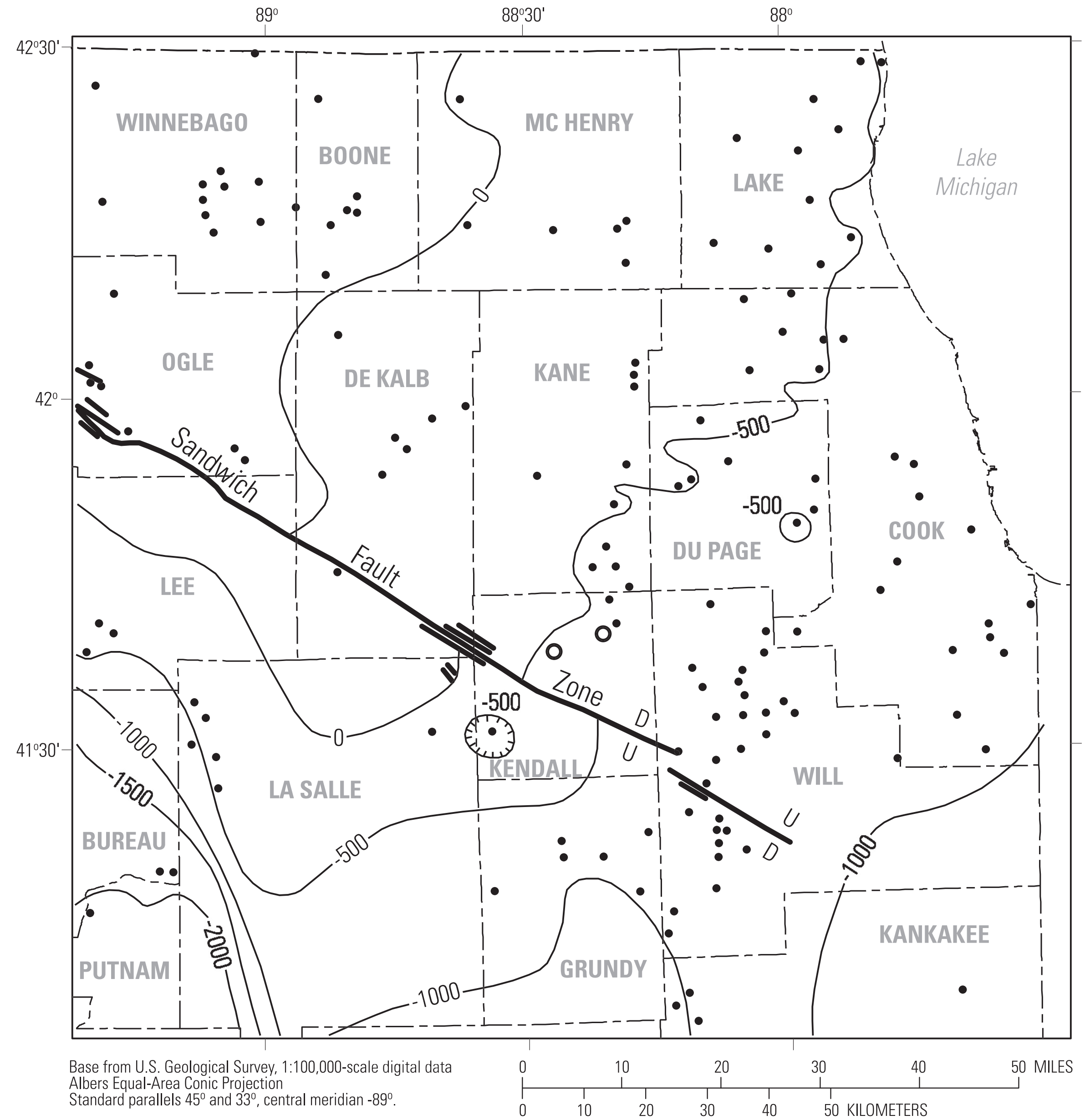


Figure 8. Bedrock geologic section A-A’ through Kendall County, Illinois.



EXPLANATION

—-1000— LINE OF EQUAL ALTITUDE OF TOP OF IRONTON-GALESVILLE SANDSTONE-- Contour interval 500 feet. Datum is NGVD 29.

FAULT MOVEMENT
U Up
Fault
D Down

• DATA POINT

○ LOCATION OF IRONTON-GALESVILLE WELLS INSTALLED IN KENDALL COUNTY SINCE 2000

Figure 9. Altitude of top of the Ironton-Galesville Sandstone in northeastern Illinois (modified from Visocky and others, 1985).

ern Illinois, the Franconia Formation is composed of fine-grained, *argillaceous*, silty, glauconitic sandstone or dolomite with variable amounts of red and green shale. In Kendall County, this formation is composed primarily of dolomite and dolomitic sandstone and is estimated to be about 100 ft thick. The Franconia Formation appears to be about 80 ft thick at Yorkville municipal wells 7 and 9 (shown in figure 7) and the altitude of the top of this unit is about -411 ft.

The Franconia Formation is conformably overlain by the Potosi Dolomite (fig. 6). The Potosi Dolomite is composed of finely crystalline, slightly argillaceous, gray to brown dolomite. The formation is characterized by quartz covering the surfaces of small cavities in the dolomite. The Potosi Dolomite shows large variations in thickness over small areas because of erosion in parts of northeastern Illinois, but it is estimated to be between 100 and 150 ft thick beneath Kendall County. The upper part of the Potosi Dolomite may be highly weathered because of erosion.

The Potosi Dolomite is overlain by the Eminence Formation (fig. 6), which is composed of light gray, brown, or pink, sandy, fine- to medium-grained dolomite. *Oolitic chert* and thin sandstone beds may be present in the formation. The Eminence Formation may be as much as 100 ft thick beneath the county.

The Eminence Formation is overlain disconformably by the Prairie du Chien *Group* (fig. 6), which is composed of cherty dolomite with interbedded sandstones. Prairie du Chien units are absent beneath the southeastern edge of Kendall County (Willman and others, 1967) and are at the bedrock surface in the west-central part of the county south of the Sandwich Fault Zone (fig. 7). The thickness of these units is variable because of erosion, but they are estimated to be as much as 200 ft thick beneath the northern part of the county and 300 ft thick beneath the southern part of the county.

The Prairie du Chien Group is subdivided into four formations. From oldest to youngest, these formations are the Gunter Sandstone, the Oneota Dolomite, the New Richmond Sandstone, and the Shakopee Dolomite (fig. 6). The Gunter Sandstone is composed of medium-grained sandstone. It does not appear to be widespread in northeastern Illinois and may be absent beneath most or all of Kendall County. Where present, the sandstone is up to 15 ft thick. The Oneota Dolomite is composed of coarse-grained, light gray and pink dolomite with some sand and oolitic chert nodules. It appears to be present beneath all but the southeastern edge of Kendall County, and may be as much as 250 ft thick. The New Richmond Sandstone is composed of moderately sorted, medium-grained sandstone with interbedded sandy dolomite. It appears to be absent because of erosion beneath the southeastern and northeastern edges of the county, as well as the area between about Yorkville and Plano. The New Richmond Sandstone is described as being about 65 ft thick on the drillers' logs of a well about 0.5 mi east of Newark and may be substantially thicker in the southwestern part of the county than in the remainder of the county. The Shakopee Dolomite is composed of fine-grained, sandy dolomite with oolitic chert and thin beds of sandstone and shale. It underlies most of Kendall County, but may have been removed by erosion where the New Richmond Sandstone also is absent.

The units of the Prairie du Chien Group, and in the southeastern edge of the county the units of the Eminence Formation, are overlain *unconformably* by the St. Peter Sandstone of the Ancell Group (fig. 6). The St. Peter Sandstone is composed of a lower unit (the Kress Shale Member) consisting of chert conglomerate with beds of red and green shale and medium- to coarse-grained sandstone. The remainder of the St. Peter Sandstone is composed of well-rounded, well-sorted, medium- to coarse-grained sandstone.

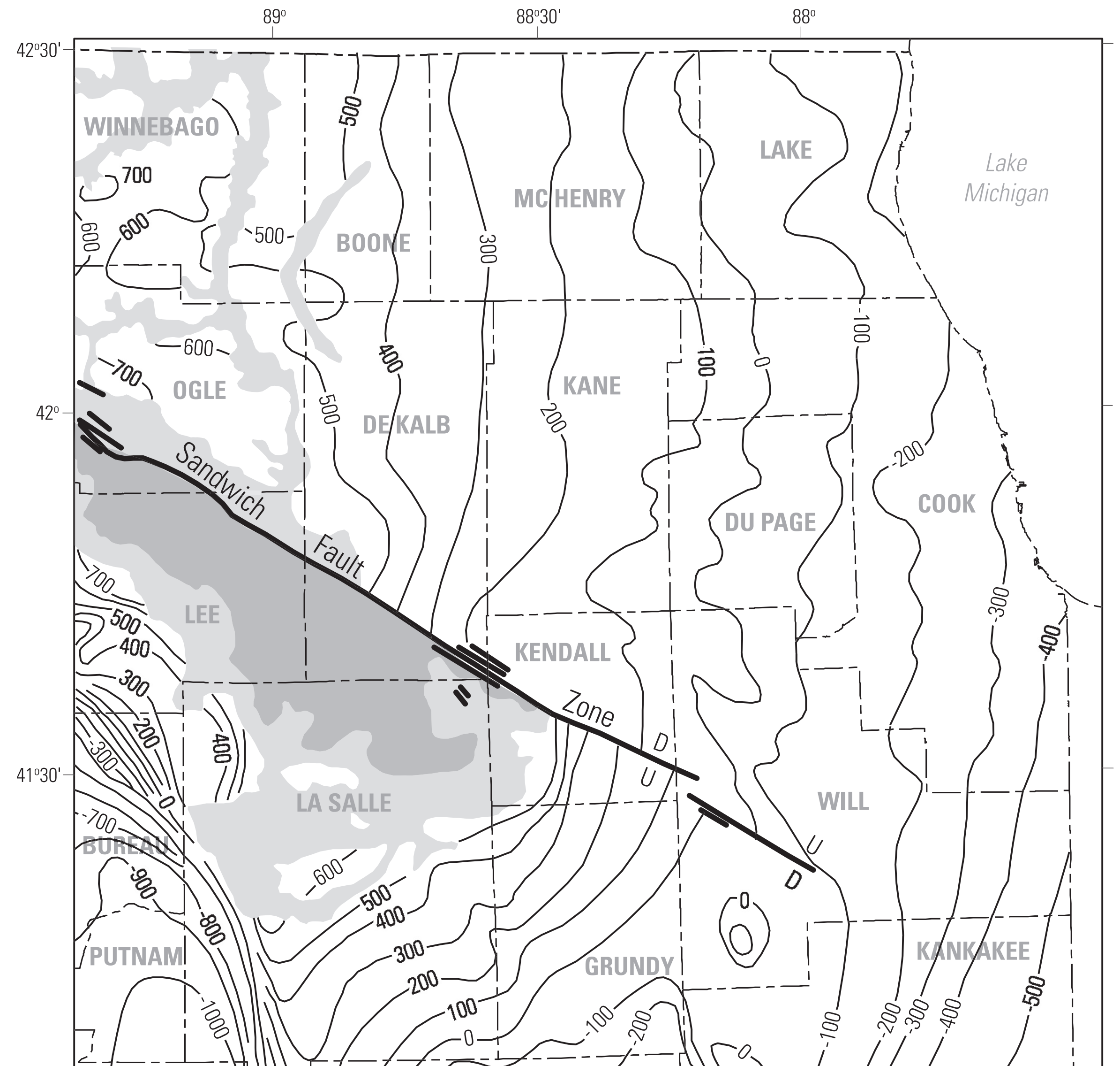
The St. Peter Sandstone is overlain conformably by the Glenwood Formation of the Ancell Group. The Glenwood Formation is composed of interbedded sandstone, dolomite, and shale. The basal member of the Glenwood Formation is the Kingdom Sandstone Member, a well-rounded, medium-grained sandstone. The middle member of the Glenwood Formation is the Daysville Dolomite Member, a sandy, argillaceous dolomite that may be absent in Kendall County. The upper member of the Glenwood Formation is the Loughridge Sandstone Member, an argillaceous, dolomitic sandstone.

Where overlain by younger rocks, the units of the Ancell Group are between about 200 and 300 ft thick beneath most of Kendall County but may be more than 400 ft thick in localized areas. The variation in the thickness of the Ancell Group units is attributed to variation in the thickness of the St. Peter Sandstone because of changes in the altitude of the surface of the Prairie du Chien Group resulting from erosion. The Ancell Group is at the bedrock surface at an altitude of approximately 550 ft above NGVD 29 in the southwestern part of the county south of the Sandwich Fault Zone (fig. 7). The altitude of the top of the group decreases to about 100 ft in southeastern Kendall County (fig. 10). North of the Sandwich Fault Zone, the top of the Ancell Group is at an altitude of about 200 ft in the northwestern corner of the county, and decreases to about 50 ft in the northeastern corner. Lithologic and geophysical logs indicate that the altitude of the top of the sandstone of the Ancell Group is about 165 ft near Yorkville, where the sandstones are about 250 ft thick. Lithologic logs indicate that the altitude of the top of the sandstones of the Ancell Group is between 40 and 100 ft near Oswego, where the sandstones are about 200 ft thick. Lithologic logs indicate the altitude of the top of the sandstones of the Ancell Group is about 90 to 120 ft near Montgomery, where the sandstones are about 125 to 250 ft thick.

The Ancell Group is overlain by the Galena and Platteville Groups. The Galena and Platteville Groups are similar lithologically and commonly are referred to as the Galena-Platteville dolomite. The Galena-Platteville dolomite is composed of pure to argillaceous dolomite with some *limestone*. The Galena-Platteville dolomite has been removed by erosion in the western part of the county south of the Sandwich Fault Zone, is at the bedrock surface in much of the northwestern and south-central parts of the county (fig. 7), and is at the land surface near Lisbon (fig. 11). The thickness of the Galena-Platteville dolomite, where present, increases overall from west to east beneath Kendall County. The Galena-Platteville dolomite is less than 100 ft thick in most of the western part of the county, where erosion has been substantial, and over 350 ft thick in the northeastern part of the county where the dolomite is overlain by younger rocks (fig. 8). The altitude of the top of the Galena-Platteville dolomite is about 625 ft near Lisbon, where it is at the land surface, decreasing to about 550 ft in the northwestern part of the county, and decreasing to less than 400 ft in the eastern part of the county.

The Galena-Platteville dolomite is overlain unconformably by the Maquoketa Group (fig. 6). The Maquoketa Group is composed primarily of dolomitic shale and argillaceous dolomite and limestone. The basal unit of the group is the Scales Formation, a predominately dolomitic shale with interbedded dolomite. Overlying the Scales Formation is the Fort Atkinson Formation, which is composed primarily of pure to argillaceous dolomite and limestone with some interbedded shale. Overlying the Fort Atkinson Formation is the Brainard Formation, a dolomitic shale with some dolomite and limestone. The uppermost unit of the Maquoketa Group in much of northern Illinois is the Neda Formation, a red, oolitic shale that appears to be absent beneath the county. The lithology of the Maquoketa Group is highly variable laterally. The Maquoketa Group has been removed by erosion beneath most of the western half of the county, but it is the uppermost bedrock unit beneath most of the eastern part of the county (fig. 7). The Maquoketa Group is at the land surface in small areas along the Fox River and Aux Sable Creek (fig. 11). Where the Maquoketa Group is overlain by younger units, the altitude of the top of the group ranges from about 600 ft in the northeastern part of the county to about 500 ft in the southeastern part of the county. These units have a maximum thickness of about 125 to 150 ft in the northeastern part of Kendall County.

The Maquoketa Group is overlain unconformably by Silurian dolomites of the Edgewood and Kankakee Formations (fig. 6). The lower part of the Edgewood Formation is composed of argillaceous dolomite. The upper part of the Edgewood Formation is composed of slightly argillaceous dolomite commonly containing white chert. The Kankakee Formation is composed of fine- to medium-grained dolomite with green shale partings. Chert nodules also may be present. Silurian units have been removed by erosion beneath most of the county (fig. 7), but may be over 100 ft thick in northeastern Kendall County.



Base from U.S. Geological Survey, 1:100,000-scale digital data
Albers Equal-Area Conic Projection
Standard parallels 45° and 33°, central meridian -89°.

Altitude information modified from Willman and Payne, 1942; Buschbach, 1964; Willman and others, 1967; Brueckman and Bergstrom, 1968; Bristol and Buschbach, 1973; Willman and others, 1975; Kolata and Buschbach, 1976; and Kolata, Buschbach, and Treworgy, 1978.

EXPLANATION

ANCELL GROUP SANDSTONES ABSENT

ANCELL GROUP SANDSTONES AT THE BEDROCK SURFACE, ERODED

—100— LINE OF EQUAL ALTITUDE OF TOP OF ANCELL GROUP SANDSTONES--Contour interval 100 feet. Datum is NGVD 29.

FAULT MOVEMENT
U Up
Fault
D Down

Figure 10. Altitude of top of the Ancell Group sandstones in northeastern Illinois (modified from Visocky and others, 1985).

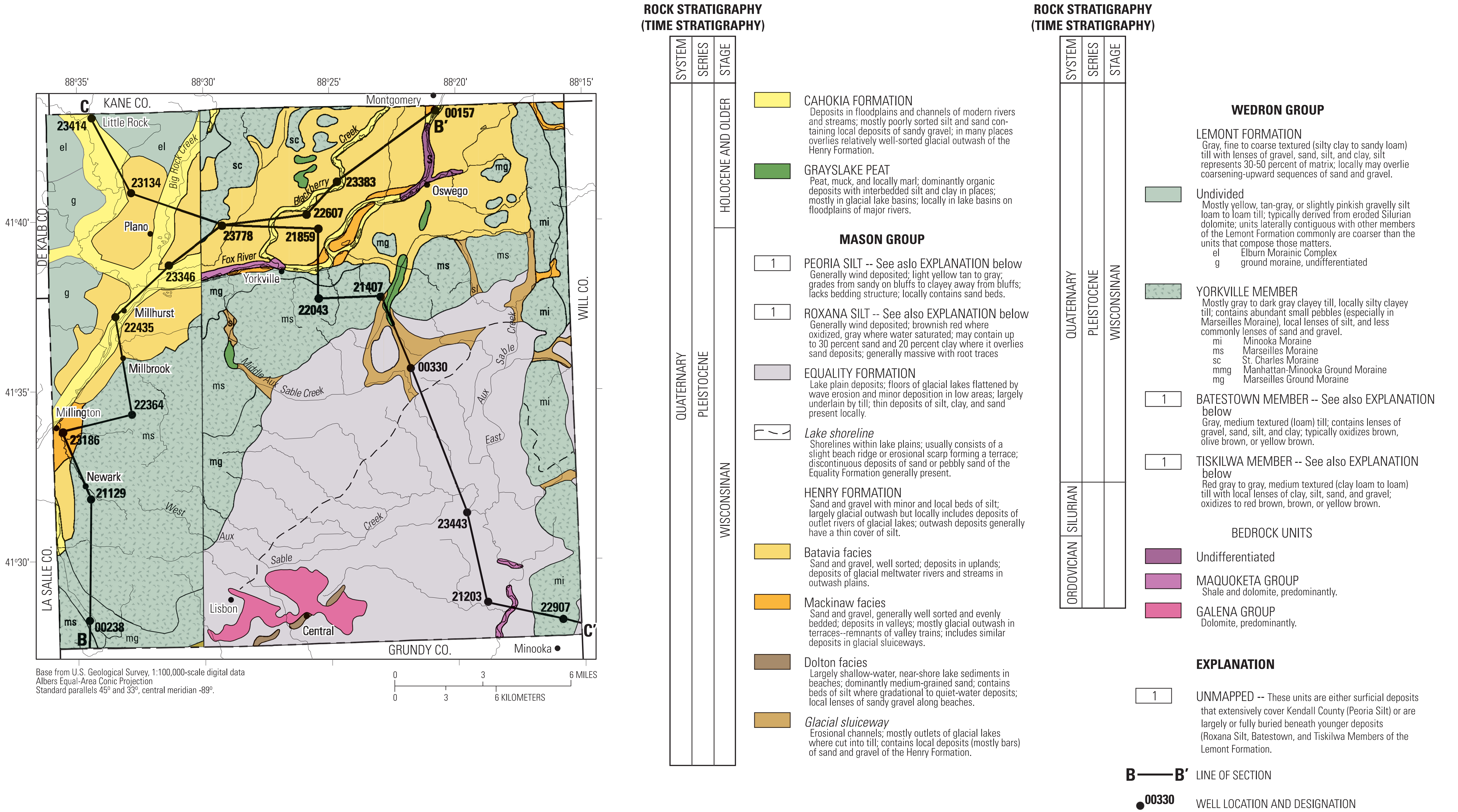


Figure 11. Surficial geology of Kendall County, Illinois (west of 88° 30′ modified from Hansel and Johnson, 1996, plate 1, map scale 1:500,000; east of 88° 30′ and stratigraphic descriptions modified from Willman and Lineback, 1970, map scale 1:250,000, and Hansel and Johnson, 1996; mapping of the eastern and western parts of county at different levels of detail and presentation scale accounts for the apparent discontinuity in surficial geology). Illinois State Geological Survey stratigraphic nomenclature is used.

Quaternary Units

This section includes a discussion of the lithology, distribution, thickness, and stratigraphy of the Quaternary units in Kendall County (fig. 11). Geologic sections for the Quaternary units are shown in figure 12 (lines of section are shown in figure 11).

The unconsolidated units beneath Kendall County primarily are of glacial origin and were emplaced during pulsating advances and retreats of the Lake Michigan Lobe during the Wisconsinan glaciation. Unconsolidated units of *alluvial*, *lacustrine*, and *eolian* origin also are present in local areas.

Stratigraphy

The stratigraphy of the principal unconsolidated units in Kendall County was described originally by Willman and Frye (1970). The most recent reclassification of these units, and the basis for the following discussion, is by Hansel and Johnson (1996).

The primary glacially derived stratigraphic units beneath Kendall County are the Lemont Formation of the Wedron Group and the Equality and Henry Formations of the Mason Group. The units that compose the Wedron and Mason Groups interfinger within and between the groups, accounting for variable subsurface stratigraphy, both vertically and horizontally. The Wedron Group consists of predominately fine-grained till associated with *moraines*. The Mason Group consists of sands and *gravels* deposited by glacial meltwaters (*outwash*) and rivers draining glacial lakes, as well as fine-grained sediments deposited in those lakes (fig. 11). The Lemont Formation is present primarily as the Yorkville Member, but also as stratigraphically undifferentiated deposits.

Alluvial deposits of the Cahokia Formation flank most reaches of the Fox River, Blackberry Creek, and Big Rock Creek. *Loess* deposits classified as Peoria *Silt* overlie glacial deposits in most upland areas of the county and are the basis of most modern soils. The Grayslake *Peat* is present locally in the northern part of the county. Because of its small extent, the Grayslake Peat will not be discussed further in this report.

The Robein Member of the Roxana Silt, Batestown Member of the Lemont Formation, and one or more members of the Tiskilwa Formation also are present beneath the county. The Robein Member of the Roxana Silt is present only in small areas beneath the county and will not be discussed further in this report. Discussion of the buried Batestown Member and Tiskilwa Formation will be limited to general descriptions of their *lithology*, because available information is insufficient to describe their distribution in detail.

Distribution and Lithology of Quaternary Units

Quaternary unconsolidated deposits overlie the bedrock beneath about 95 percent of the county. These unconsolidated deposits typically are less than 200 ft thick, but may be about 400 ft thick in some areas. The unconsolidated deposits are thickest where morainic deposits overlie the buried Newark Valley (figs. 12, 13, 14a; alternative interpretations of the bedrock-surface configuration and, thus, the Newark Valley configuration shown in figures 14b and 14c are discussed subsequently in the section “Newark Valley”). Quaternary deposits are absent and bedrock is exposed along various reaches of the Fox River and locally in the southern part of the county east of Lisbon and along Aux Sable Creek (fig. 11).

The glacial ice sheets that covered Kendall County resulted in the deposition of various end moraines and their associated ground moraines (fig. 11). The Elburn Morainic Complex is in the northwestern part of the county. The Minooka Moraine is along almost the entire eastern edge of the county. The St. Charles and Marseilles Moraines trend northeast to southwest through the central part of the county. The Fox River and adjacent coarse-grained deposits of alluvial and glacial origin bisect these morainic deposits at and near the land surface, the St. Charles Moraine being located north of the river and the Marseilles Moraine being primarily located south of the river.

The Elburn Morainic Complex is composed primarily of tills of the undifferentiated Lemont Formation. The St. Charles, Marseilles, and Minooka Moraines are composed primarily of tills of the Yorkville Member of the Lemont Formation. The till units of the undifferentiated Lemont Formation have a greater percentage of sand- and-gravel-sized particles than those of the Yorkville Member (fig. 11) beneath the county. Thin (generally less than 10 ft thick), discontinuous lenses of sorted sand and gravel are present locally within each of the till units.

Within the subsurface, the morainic units in Kendall County locally may be composed of till units of the Batestown Member of the Lemont Formation or the Tiskilwa Formation. Although the presence of these buried units beneath the county has been documented (Hansel and Johnson, 1996), their location and extent is uncertain and one or both of these units may be absent beneath parts of the county. The Tiskilwa Formation underlies the Batestown or Yorkville Members of the Lemont Formation and the Batestown Member usually underlies the Yorkville Member (fig. 11). Of these three units, the till units of the Tiskilwa Formation generally have the highest percentage of *clay*-sized particles and the Batestown Member generally has the lowest percentage.

As glaciers dammed flowages, glacial and post-glacial lakes, including Lake Wauponsee (fig. 4), formed across a substantial part of Kendall County. The Equality Formation is composed of the silt, clay, and organic debris deposited in these lakes (fig. 11). Local lenses of gravel, sand, and *diamicton* also are present locally in the Equality Formation. These units generally are in the comparatively flat areas between end moraines. The silt and clay of the Equality Formation can be lithologically similar to the fine-grained fraction of the till units that compose the adjacent Wedron Group. Bedding in the formation may occur as *rhythmites* or fine indistinct *laminae*; massive structureless units also occur locally. The lacustrine units of the Equality Formation may interfinger with till units of the Wedron Group and other units of the Mason Group, particularly the Henry Formation. The contact with the Henry Formation usually is gradational. Over most of the southeastern part of the county, the units of the Equality Formation are overlain by Peoria Silt or modern soil and underlain by till units of the Wedron Group (fig. 11). The units are described as thin (presumably less than 10 ft thick) and discontinuous (Willman, 1971).

Stream and rivers that flowed from the melting glaciers and glacial lakes deposited the coarse-grained sediments that compose the Henry Formation. The Batavia *facies* of the Henry Formation is composed predominantly of well-sorted sands and gravels, generally deposited in upland areas as outwash plains along the fronts of moraines. The grain size of the usually cross-bedded deposits can vary substantially over short vertical and horizontal distances (feet to tens of feet), with the grain size becoming finer away from moraine fronts. Batavia facies units are widespread across a northeast- to southwest-trending band composing about one-third of the surficial deposits of northwestern Kendall County (fig. 11). The Mackinaw facies of the Henry Formation is represented by well-sorted sands and gravels deposited in valleys as glacial outwash; the units may occur as remnants of terraces in some buried valleys. Units of the Mackinaw facies generally are restricted to various reaches of the Fox River Valley, particularly upriver of Yorkville. Units of the Dolton facies of the Henry Formation sporadically occur as coarse-grained units generally associated with beaches near the shores of glacial and post-glacial lakes. These units appear to be limited to a few northeast- to southwest-trending locations along the flanks of the bedrock exposures near Lisbon (fig. 11). Similar locally restricted deposits may be buried elsewhere in the lake-plain region of the county. Other coarse-grained units of the Henry Formation are present locally around the northern periphery of the lake plain units of the Equality Formation; beds of silt and local sand-and-gravel bars were deposited in sluiceways that drained the glacial lakes.

Coarse-grained units of the Henry Formation interfinger with the fine-grained units of the Wedron Group, the Peoria Silt and the Equality Formation, and post-glacial units of the Cahokia Formation (shown, in part, in figures 11 and 12). At most locations where the Henry Formation is the uppermost glacial unit, there are thin (generally less than 15 ft) overlying units of Peoria Silt and modern soil.

The Cahokia Formation is composed primarily of poorly sorted silt and sand in floodplains and channels of modern rivers and streams. These units are presumed to be generally less than 20 ft thick. Local units of sand and gravel may be present in the

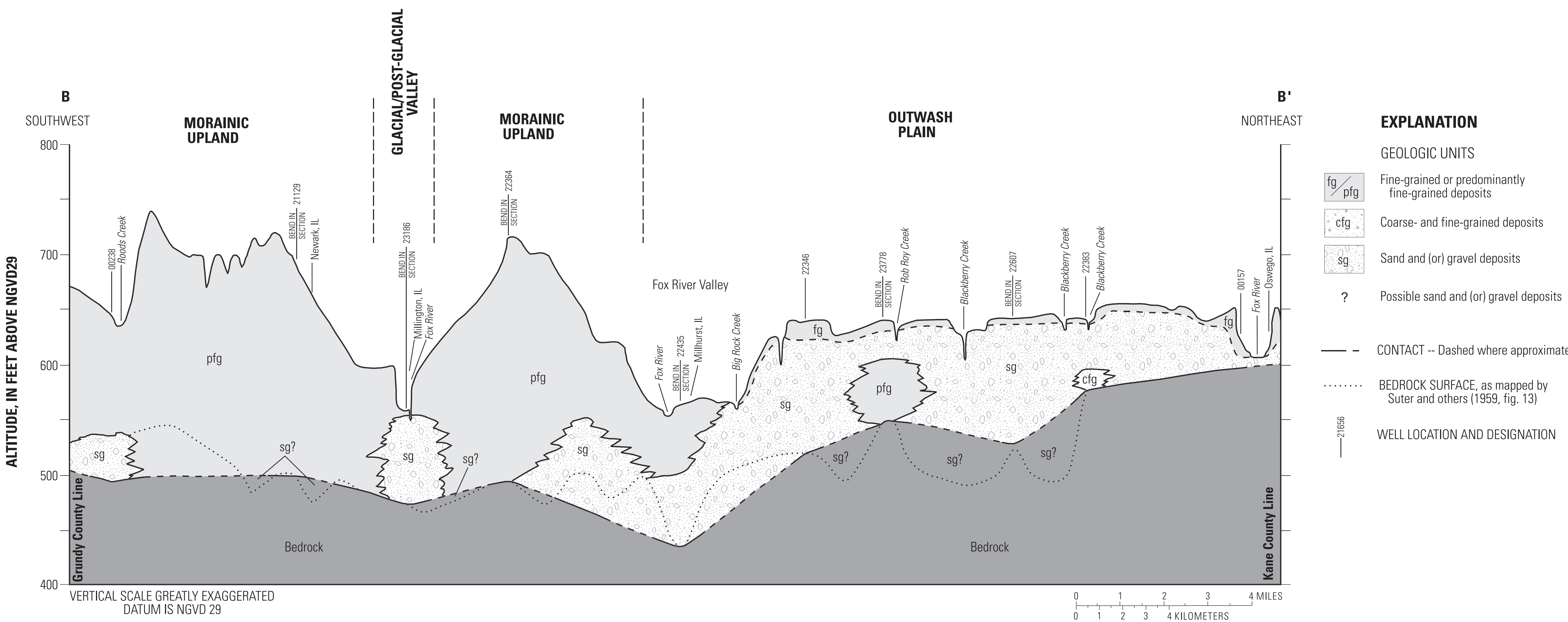


Figure 12A. Geologic section B-B′ through Quaternary deposits of Kendall County, Illinois, along the axis of the buried Newark Valley (line of section shown in figure 11).

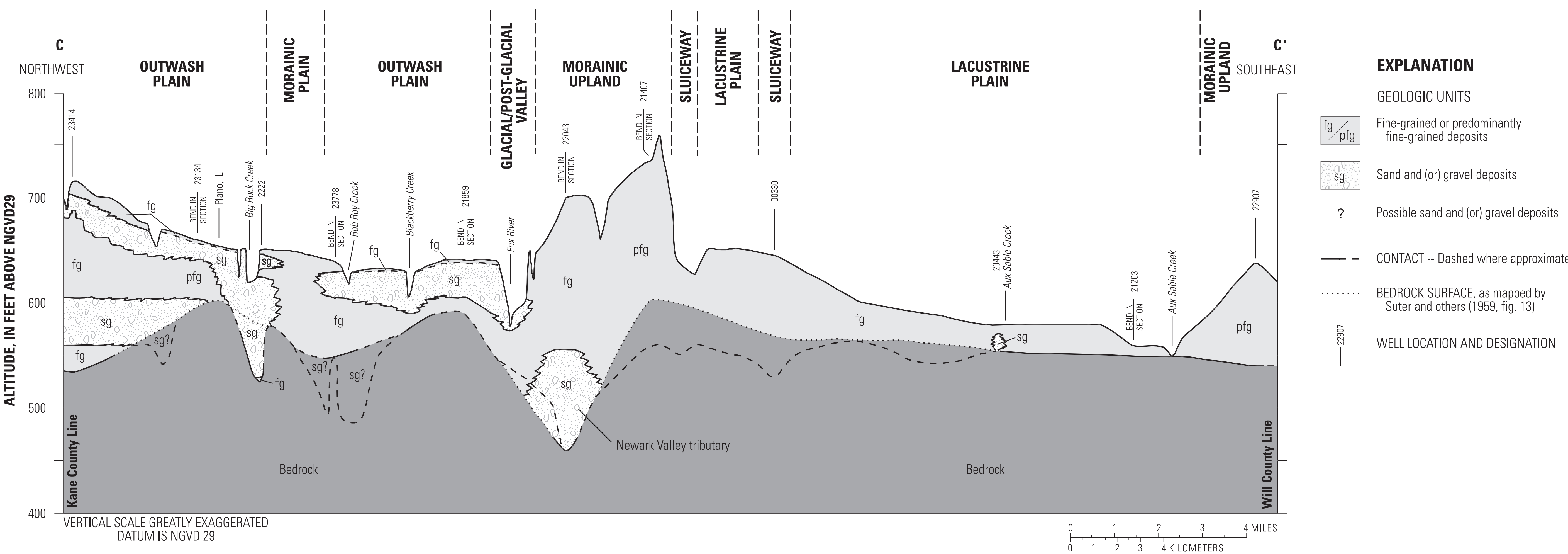


Figure 12B. Geologic section C-C' through Quaternary deposits of Kendall County, Illinois, through the various glacial physiographic regions (line of section shown in figure 11).

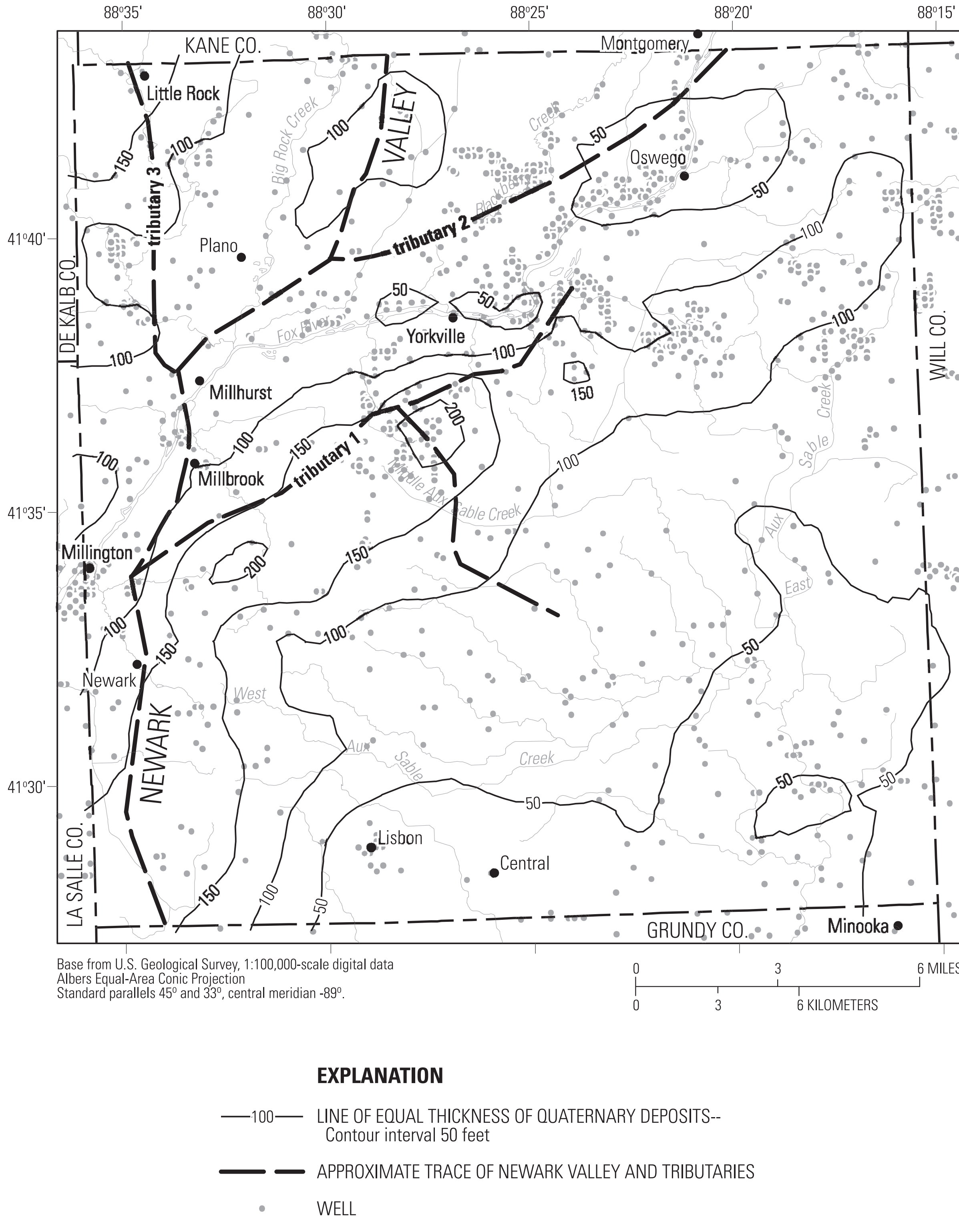


Figure 13. Thickness of Quaternary deposits in Kendall County, Illinois (made by kriging of data from well logs).

lower part of the Cahokia Formation, at the mouths of tributary streams, and in bars within the present stream channels. In northern Kendall County, the Cahokia Formation may overlie and grade into the generally well-sorted sands and gravels of the Henry Formation where the Henry Formation is present (fig. 11). These areas are mined for gravel in the county, particularly along the Fox River and Big Rock Creek.

Detailed mapping of the location and thickness of the fine- and coarse-grained units that compose the Quaternary-age formations of Kendall County

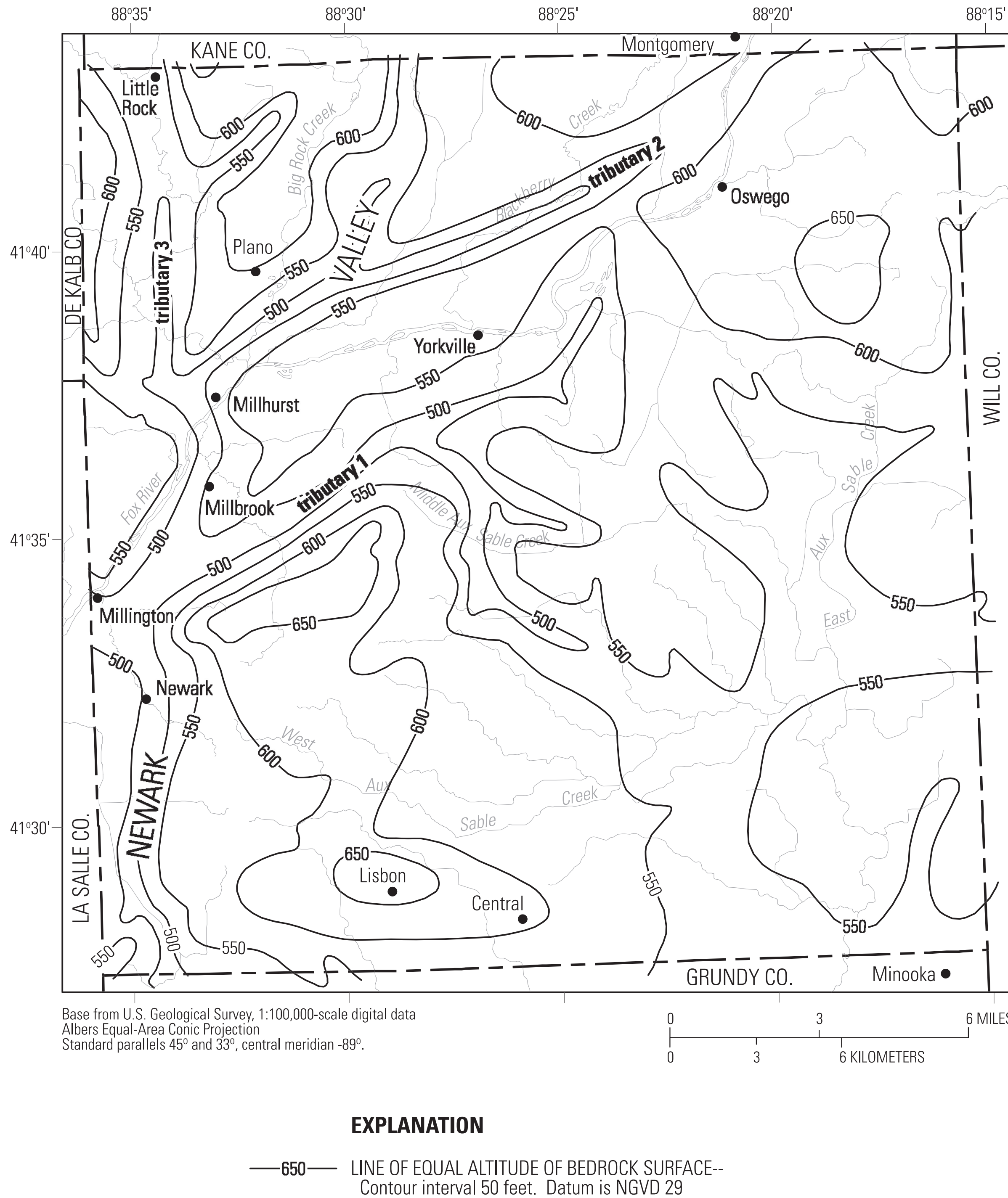


Figure 14a. Altitude of bedrock surface in Kendall County, Illinois, as depicted by Suter and others (fig. 14, 1959).

is beyond the scope of the present study. Generally, the unconsolidated units predominantly are fine grained throughout their vertical extent across all but the northern part of the county, where coarse-grained outwash units of the Mason Group are present (fig. 11). The collective thickness of the generally fine-grained units of the Wedron (Lemont and Tiskilwa Formations) and Mason (Peoria Silt, Robein Member of the Roxana Silt, and Equality Formation) Groups (fig. 11) can be as much as 220 ft (figs. 12, 13). The units are thickest in the southwestern part of the county along the trace of the

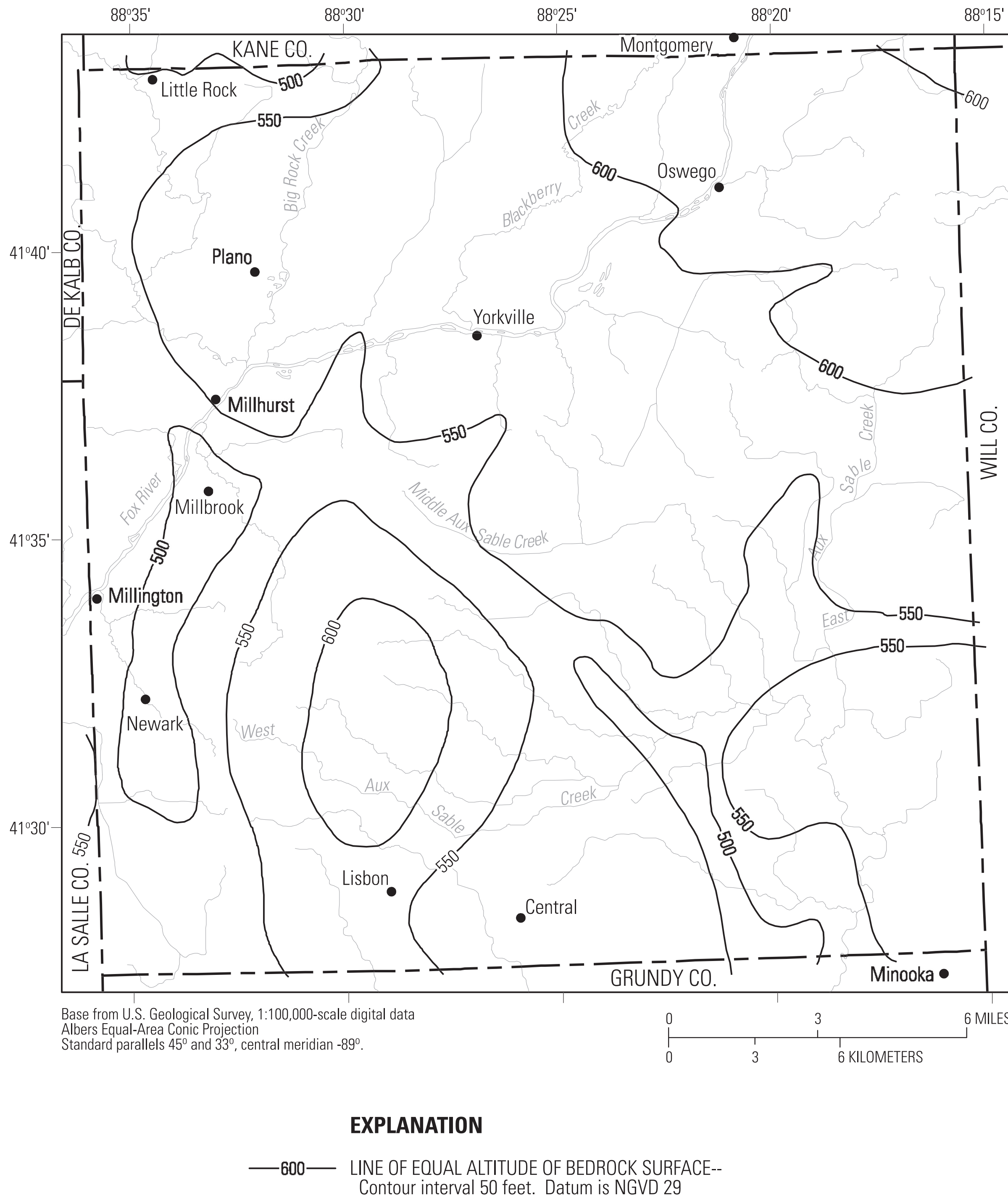


Figure 14b. Altitude of bedrock surface in Kendall County, Illinois, as depicted by Herzog and others (1994).

Marseilles Moraine, particularly where the morainic units overlie the Newark Valley and its tributaries (figs. 11, 12, 13, 14a). North of the Fox River, the fine-grained units generally are 25 ft thick or less, except in an area between Big Rock Creek and Rob Roy Creek where they possibly are as thick as 100 ft (figs. 12a, 13). In the southeastern part of the county, the fine-grained units generally are about 40 ft thick or less; locally, the units are 10 ft thick or less (figs. 12b, 13).

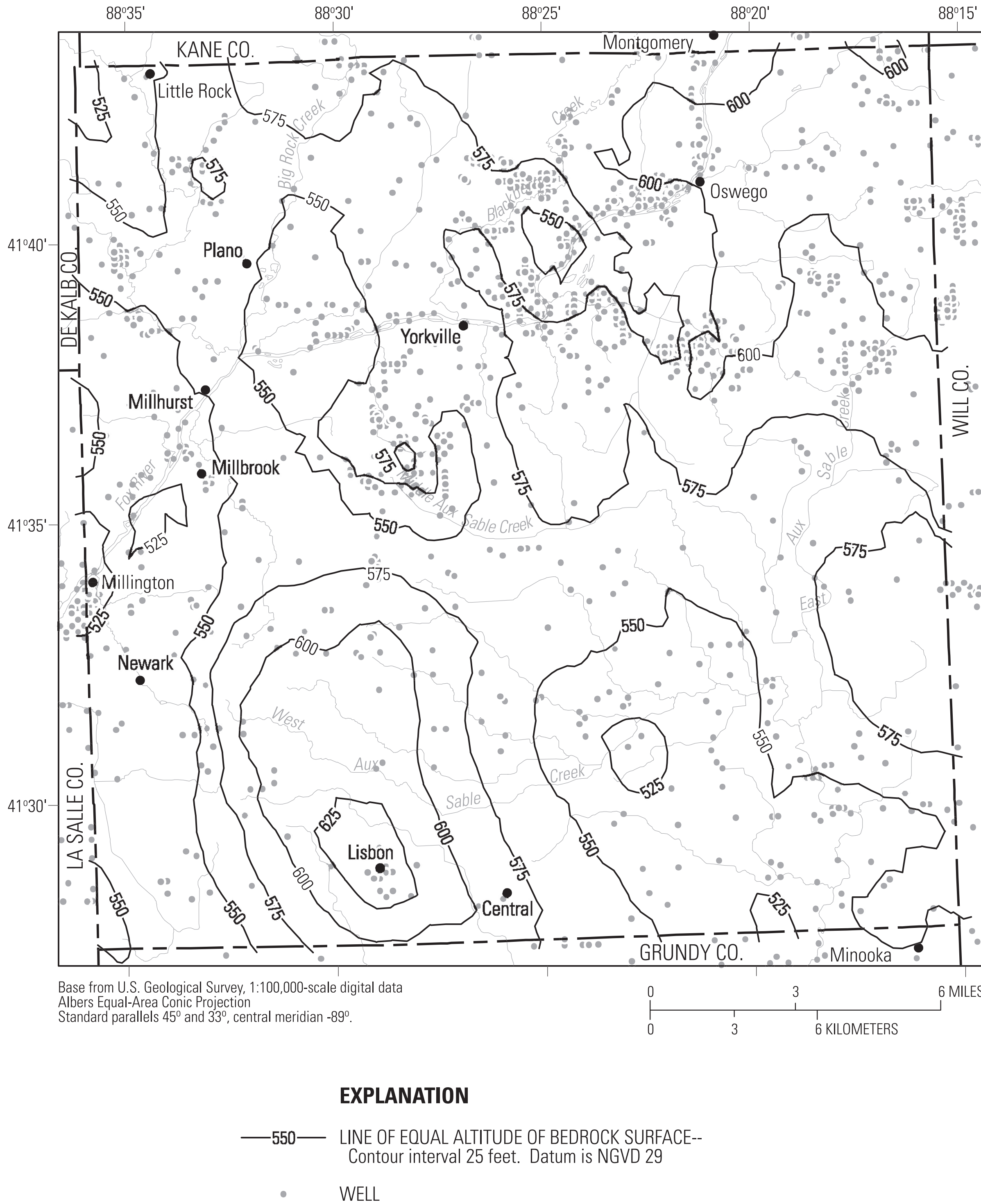


Figure 14c. Altitude of bedrock surface in Kendall County, Illinois, as depicted by kriging of information from well logs.

The distribution and thickness of coarse-grained units beneath Kendall County were evaluated by analysis of available surficial and subsurface geologic maps (Willman and Frye, 1970; Hansel and Johnson, 1996; Berg and others, 1984; Schicht and others, 1976) and by examination of selected well-construction logs. This information was used to prepare two geologic sections (fig. 11) — one along the buried Newark Valley (figs. 12a, 14a) and one cross-cutting the principal glacial features in the county (fig. 12b). The thickness of continuous coarse-grained units can be a great as about 100 ft, particularly between Big Rock and Blackberry Creeks. The thickness of continuous coarse-grained units exceeds 25 ft northwest of Plano, west of Little Rock Creek, south of Yorkville near the headwaters of the Middle Aux Sable Creek, along much of the Fox River Valley between Millhurst and Millington, and southwest of Newark near Roods Creek. The thick coarse-grained units northeast of Plano and southwest of Newark are associated with the Batavia facies of the Henry Formation, are at or within 20 ft of land surface, and usually locally overlie the buried Newark Valley. The units northwest of Plano are part of the Henry Formation and seem to interfinger with the till units of the Lemont Formation. The thick coarse-grained units southwest of Millhurst to Millington consist of Cahokia Formation alluvium deposited along the Fox River Valley and deeper units of the Mason Group interfingering with fine-grained units of the Lemont Formation. The thickness of the coarse-grained units generally is greatest where they infill the coincidental buried Newark Valley or one of its tributaries. In the southeastern part of the county, the coarse-grained units generally are 20 ft thick or less. These units likely are laterally discontinuous lenses within the fine-grained units of the Equality or Lemont Formations.

Newark Valley Units

The buried Newark Valley underlies parts of western and northern Kendall County, generally from the Grundy County line south of Newark to the Kane County line northeast of Plano (figs. 11, 12a, 14a). Three prominent tributaries to the valley are in the northwestern part of the county. They are named tributaries 1, 2, and 3 for the purposes of this report (fig. 14a). Tributary 1 trends northeast-southwest generally from Millington to Yorkville; tributary 2 trends northeast-southwest generally from Millhurst to Montgomery (Kane County); and tributary 3 trends north-south generally from Millhurst to Little Rock. The location of the present-day Fox River Valley and its associated drainages seemingly is related to the location of the ancestral Newark Valley; however, the similar locations are considered coincidental (Suter and others, 1959). The maximum thickness of the unconsolidated units within the approximately 1- to 2-mi wide Newark Valley may approach 400 ft at a few locations (as indicated by about 1 percent of available well logs), and is almost 250 ft along tributary 3 northeast of Millington, where the eroded bedrock is infilled with units of the Marseilles Moraine (figs. 12, 13, 14a). Units within the valley thin to about 30 ft where tributary 2 underlies the Montgomery area (figs. 12a, 14a).

The units that infill the Newark Valley and its tributaries are composed of various stratigraphic units and lithologies. Fine-grained valley-fill units generally are tills of the Lemont Formation. Coarse-grained units primarily are sands and gravels of the Henry Formation, but include the Cahokia Formation where the bedrock valley underlies the Fox River and its principal tributaries. In the southern part of the valley, units primarily are fine grained. Near Millington, where the Newark Valley is overlain by the Fox River Valley, coarse-grained units are about 80 ft thick. Near Millbrook and northward, near-surface, coarse-grained units of the Cahokia Formation are about 25-50 ft thick and may be present where the Newark Valley is overlain by the Fox River Valley. Coarse-grained units of the Henry Formation may be buried beneath almost 75 ft of fine-grained units of the Lemont Formation where these units interfinger. North of the Fox River, near Millhurst, fine-grained valley-fill units grade to predominantly coarse-grained units where the outwash units of the Batavia facies (fig. 11) are present. The thickness of the coarse-grained units in the northern parts the bedrock-valley system generally is between 50 and 100 ft, but is about 30 ft along tributary 2 near Montgomery. The thick coarse-grained units in the northern reaches of the valley system typically are overlain by 15 ft or less of Peoria Silt. Basal coarse-grained units may be present in parts of the valley infilled predominantly by fine-grained units (figs. 11, 12, 14a). The thickness of these buried coarse-grained units may approach 100 ft, as indicated in the tributary 1 valley south of Yorkville (figs. 11, 12b, 14a).

As the result of interfingering of the various Quaternary units, drilling may be necessary to specifically locate thick (greater than about 25 ft) coarse-grained units in the Newark Valley. Additionally, the configuration of the bedrock valley may not be as well defined as that depicted in figure 14a. This configuration, originally presented by Suter and others (1959), was based on data from fewer wells than presently (2004) are available. Review of well-construction records and regional mapping of the bedrock surface by Herzog and others (1994) (fig. 14b) and for this investigation (fig. 14c) indicate that the location and altitude of the Newark Valley and its tributaries differs in some areas from the depiction in figure 14a. The cross sections of the Newark Valley presented in figure 12b depict possible basal configurations of the valley center, as determined from (1) the deepest bedrock surfaces indicated from well-construction records available in 2004, and (2) the projected basal configuration, based on construction records of areally distributed wells, mapped by Suter and others (1959). Although the bedrock configurations shown in figures 14b and 14c are based on geologic information from substantially more wells than the configuration shown in figure 14a, projected three-dimensional surfaces are not considered in the mapping of these configurations. By not considering projected three-dimensional surfaces, valley traces and deep parts of the valley may have gone undetected in these mapped bedrock configurations.

A minor, unnamed bedrock valley that may represent a former tributary of the Illinois River Valley underlies the southeastern part of Kendall County (figs. 14b, 14c). This valley appears to be infilled almost exclusively with fine-grained lake-plain or morainic deposits.

SURFACE-WATER RESOURCES

The Fox River is the primary surface-water body in Kendall County. Big Rock Creek, Blackberry Creek, Clear Creek, Hollenbeck Creek, Little Rock Creek, Morgan Creek, Rob Roy Creek, and Waubansee Creek are the primary tributaries to the Fox River in Kendall County (fig. 15). Aux Sable Creek and Lisbon Creek drain the southern two-thirds of Kendall County and discharge into the Illinois River.

Surface-Water Diversions and Returns

Sixteen select wastewater-treatment plant dischargers (at least 1 Mgal/d) are located on the Fox River in Illinois, 1 in northern Kendall County and 15 additional select dischargers in Kane County, McHenry County, and Lake County (fig. 16, table 3). The Fox Metro Water Reclamation District (FMWRD) wastewater-treatment plant, in Kendall County north of Oswego, had a maximum and minimum monthly mean discharge of 47.9 and 22.6 Mgal/d, respectively, from January 1998 through December 2002 (Greg Buchner, Fox Metro Water Reclamation District, oral commun., 2003). The Yorkville-Bristol Sanitary District discharged an average of 1.0 Mgal/d into the Fox River at Yorkville from September 2002 through August 2003 (Ralph Pfister, Yorkville-Bristol Sanitary District, oral commun., 2003). The average allowable discharges for selected wastewater-treatment plant dischargers are listed in table 3.

The Fox River currently (2004) is used as a source of drinking water by the Cities of Elgin and Aurora in Kane County. The City of Elgin's Riverside Treatment Plant and Airlite Water Treatment Plant process about 13.5 Mgal/d of drinking water. About 95 percent of the water originates from the Fox River and about 5 percent originates from deep wells within the Cambrian-Ordovician aquifer system (Kurt Eshelman, City of Elgin, oral commun., 2003). The combination of ground water and surface water is chemically treated, primarily for organics removal and hardness reduction (Paul Miller, City of Elgin, oral commun., 2003). Treatment also removes compounds from the deep well water such as radium and barium, which leach from

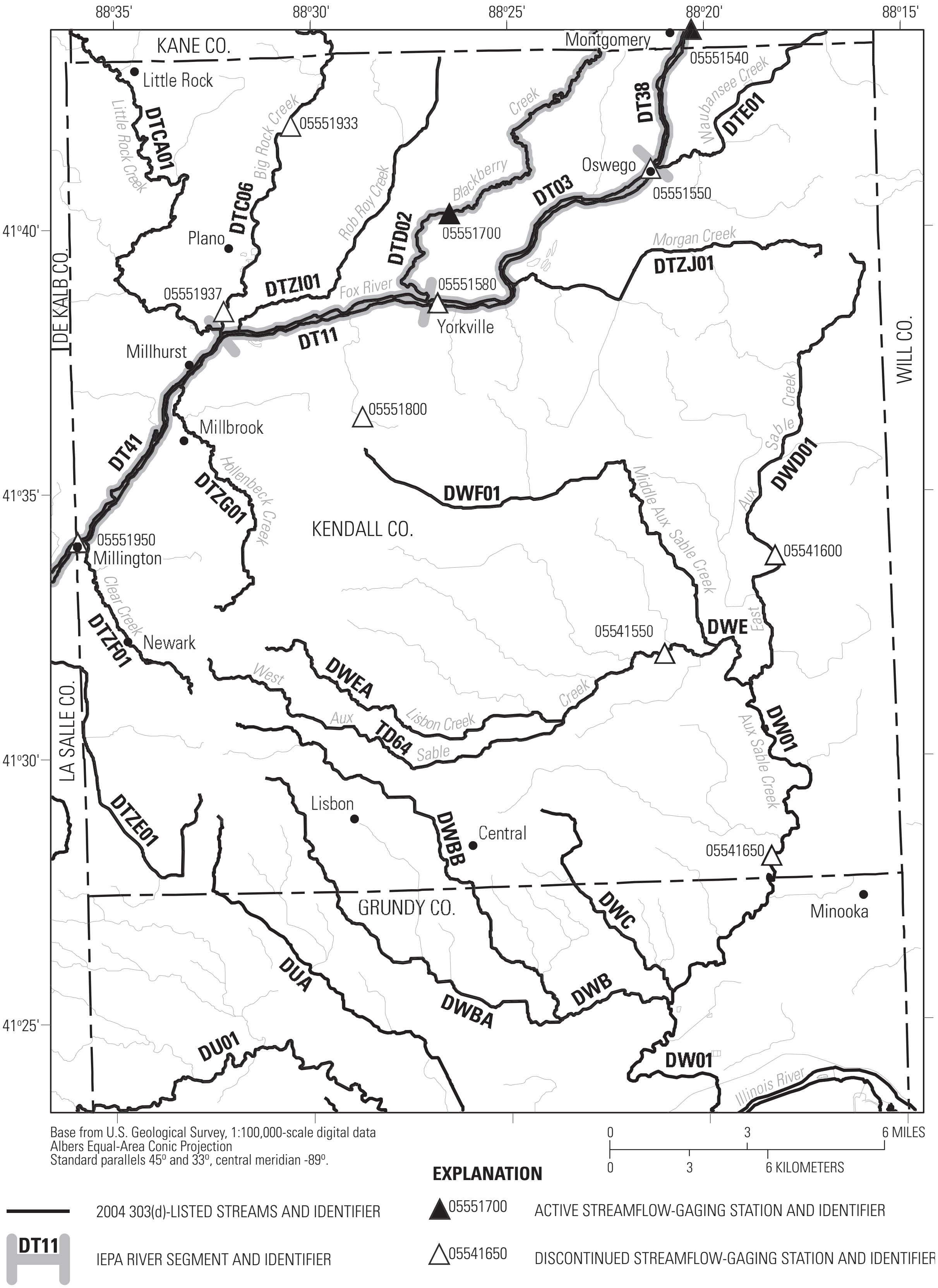


Figure 15. U.S. Geological Survey streamflow-gaging stations and Illinois Environmental Protection Agency (IEPA) Section 303(d)-listed streams in and near Kendall County, Illinois. The IEPA Section 303(d) list identifies waterbodies in the State that exceed water-quality standards, ranks them from low to high priority based on the severity of their pollution, and establishes the use and impairment of the waterbodies based on the degree of pollution. 2004 303(d)-listed streams from http://maps.epa.state.il.us/website/wqinfo/viewer.html, accessed July 2005.

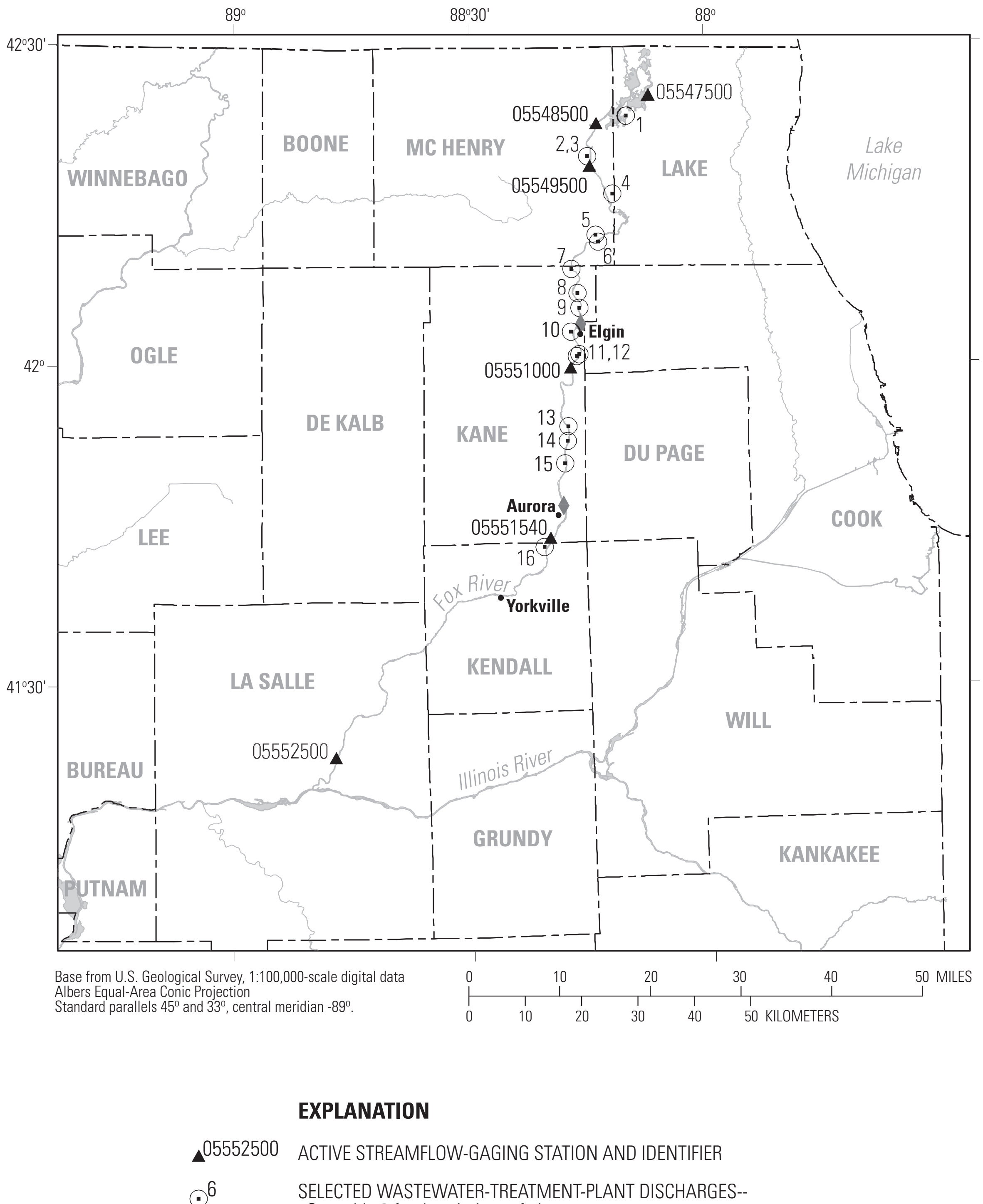


Figure 16. U.S. Geological Survey streamflow-gaging stations, selected wastewater-treatment-plant dischargers, and surface-water intakes for municipal drinking water located on the Fox River in Illinois.

Table 3. Selected wastewater-treatment plants located on the Fox River in and upstream of Kendall County, Illinois.

[**Mgal/d**, million gallons per day]

Wastewater-treatment plant	Map identifier (fig. 16)	County	Latitude, longitude in degrees, minutes, seconds	[1]Average allowable discharge (Mgal/d)
Fox Lake Regional Sewage Treatment Plant	1	Lake	42º 23’17”, 88º10’25”	9.0
McHenry South Sewage Treatment Plant	2	McHenry	42º 19’30’, 88º 15’24”	1
City of McHenry Central Sewage Treatment Plant	3	McHenry	42º 19’29”, 88º 15’25”	3
Island Lake School District Wastewater Treatment Facility	4	McHenry	42º 16’00”, 88º 12’13”	2
Village of Cary Wastewater Treatment Plant	5	McHenry	42º 12’10”, 88º 14’27”	2
Fox River Grove Wastewater Treatment Plant	6	McHenry	42º 11’27”, 88º 14’04”	1.25
Algonquin Sewage Treatment Plant	7	Kane	42º 09’16”, 88º 17’38”	2.2
Carpentersville Main Sewage Treatment Plant	8	Kane	42º 06’42”, 88º 16’46”	5
Village of East Dundee Wastewater Treatment Plant	9	Kane	42º 05’18”, 88º 16’30”	1.15
Fox River Water Reclamation District North Sewage Treatment Plant	10	Kane	42º 03’04”, 88º 17’36”	7.75
Fox River Water Reclamation District	11	Kane	42º 00’57”, 88º 16’36”	25
Fox River Water Reclamation District West Sewage Treatment Plant	12	Kane	42º 00’48”, 88º 16’54”	1.5
St. Charles Wastewater Treatment Facility	13	Kane	41º 54’12”, 88º 18’00”	9
City of Geneva Sewage Treatment Plant	14	Kane	41º 52’50”, 88º 18’10”	4
City of Batavia Wastewater Treatment Facility	15	Kane	41º 50’44”, 88º 18’30”	3.58
Fox Metro Water Reclamation District	16	Kendall	41º 42’53”, 88º 21’11”	42

1. U.S. Environmental Protection Agency Envirofacts Data Warehouse, accessed at *http://www.epa.gov/enviro/*

natural units in the aquifer system.

The City of Aurora Water Treatment Plant (COATP) treats an average of about 16.5 Mgal/d and a maximum of 32 Mgal/d (Arnold Eggleston, City of Aurora, oral commun., 2004). An average of 65 percent of the city’s drinking water originates from the Fox River, and 35 percent originates from a combination of shallow wells and deep wells in the Cambrian-Ordovician aquifer system (Arnold Eggleston, City of Aurora, oral commun., 2004). The combination of ground water and surface water is treated with power-activated carbon, lime-softened, filtered, and disinfected (Steven Booth, City of Aurora, oral commun., 2003).

Currently (2004), surface water is not used for water supply in Kendall County. This situation is not expected to change in the foreseeable future. However, should the Fox River be used as a source of water supply in Kendall County in the future, treatment would be required prior to use.

Water Quality

The water quality of the Fox River flowing into Kendall County is characterized by sampling at the COATP. Untreated water from the Fox River just north of Kendall County is sampled and analyzed by the COATP once each month. From January 2000 through December 2002, the median turbidity of these untreated water samples was 19.3 nephelometric turbidity units (NTUs) (all COATP results are from Arnold Eggleston, City of Aurora, written commun., 2004). After river water is treated at the COATP, the turbidity of the water must be lower than the USEPA primary maximum contaminant level (MCL) drinking-water standard of 0.3 NTUs in 95 percent of monthly treated water samples, and must not exceed 1.0 NTUs in any of the treated water samples (U.S. Environmental Protection Agency, 2004). The MCL is an enforceable, health-based maximum concentration of a constituent allowed in drinking water (U.S. Environmental Protection Agency, 2004). The median aluminum concentration of untreated river samples was 0.34 mg/L from January 2000 through December 2002.

After treatment is complete, the water must meet the USEPA maximum contaminant level secondary drinking-water standard (SMCL) of 0.05-0.2 mg/L. Although the SMCL is not an enforceable standard, it is the suggested maximum concentration of a constituent in drinking water based on aesthetic considerations (odor, taste, appearance). Concentrations of cadmium, thallium, antimony, and turbidity exceeded their MCLs in at least one untreated river sample from January 2000 through December 2002. Concentrations of total dissolved solids (TDS), chloride, manganese, aluminum, pH, and iron exceeded their SMCLs in at least one untreated river sample from January 2000 through December 2002. After treatment, all water samples met the USEPA MCL or SMCL standard.

Water-quality data for Fox River collected by the COATP from January 2000 through December 2002 indicated that turbidity levels and the concentrations of aluminum were highest in the fall and summer months and lowest in the spring and winter months (figs. 17). Manganese concentrations were highest in the summer months and lowest in the winter months (fig. 17).

As the combination of ground water and surface water is pretreated (with power-activated carbon, lime-softened, filtered, and disinfected), constituent concentrations in the water are reduced below their MCLs. Left untreated, these constituents could cause mild to serious health risks (U.S. Environmental Protection Agency, 2004).

The IEPA 303(d) list identifies water bodies in Illinois that exceed water-quality standards, ranks them from low to high priority based on the severity of their contamination, and establishes the use and impairment of the water bodies based on the degree of contamination (Illinois Environmental Protection Agency, 2003) (table 4). Four IEPA 303(d)-listed segments of the Fox River are located in Kendall County (fig. 15). The Fox River at Route 34 in Oswego (IEPA Segment Identifier DT03) was listed in 2004 partial fish-consumption impairment due to above-background PCB concentrations (Illinois Environmental Protection Agency, 2004). The Fox River below Yorkville (IEPA Segment Identifier DT11) was listed in 2004 for partial aquatic-life use and fish-consumption impairment due to sedimentation/siltation, pH levels, low dissolved oxygen

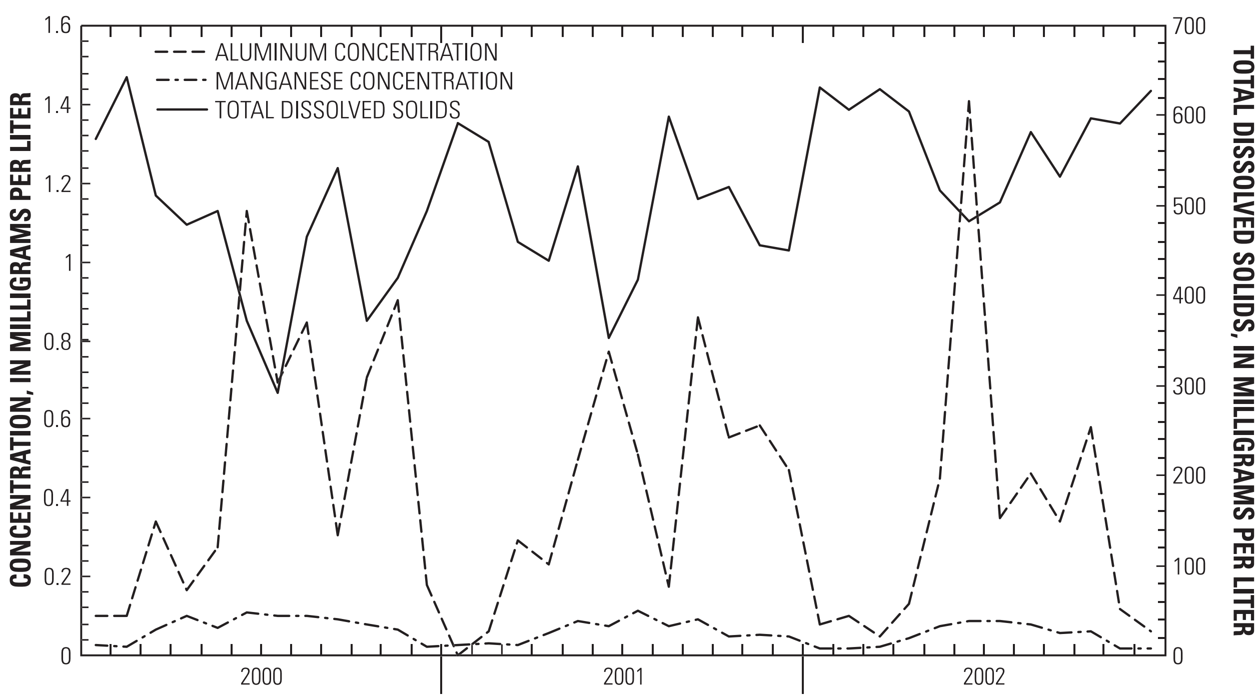


Figure 17. Aluminum, manganese, and total dissolved solid concentrations in untreated, raw water from the Fox River collected at the City of Aurora Illinois Treatment Plant, 2000 through 2002 (data provided by Arnold Eggleston, Superintendent of Water Production, City of Aurora, 2004).

concentrations, PCB concentrations, flow alteration, aldrin concentrations, and phosphorus concentrations (Illinois Environmental Protection Agency, 2004). The Fox River near the Kendall and La Salle County line (IEPA Segment Identifier DT41) was listed in 2004 for partial fish consumption impairment due to PCB concentrations (Illinois Environmental Protection Agency, 2004). The Fox River at Montgomery (IEPA Segment Identifier DT38) also was 303(d)-listed in 2004 as partial primary contact, aquatic life-use, and fish consumption due to low dissolved oxygen, pH levels, PCB concentrations, sedimentation/siltation, flow alteration, stream habitat assessments, total fecal coliforms, excess algal growth, total phosphorus, and total suspended solids (Illinois Environmental Protection Agency, 2004). Blackberry Creek at Route 47 North of Yorkville (IEPA Station Identifier ILDTD02-DTD02) also was listed in 2002 as nonsupportive of primary contact (Illinois Environmental Protection Agency, 2003).

Water-quality data were collected by the USGS from the Fox River at Montgomery (USGS Station Identifier 05551540) from December 1977 through April 1997, from the Fox River at Dayton (USGS Station Identifier 05552500) from January 1978 through April 1997, and from Blackberry Creek near Yorkville (USGS Station Identifier 05551700) from December 1977 through April 1997 (table 5). If a constituent value was reported as less than or greater than a certain number, that number was used when calculating the median, maximum, and minimum values. Consequently, values in table 5 may be slightly greater than the actual values when values were reported as equal to values with less than qualifiers. Null values were set to detection limits for that site. Estimated values were set equal to that value.

The median fecal coliform bacteria counts in the Fox River at Montgomery (590 colonies/100 mL) and Blackberry Creek near Yorkville (635 colonies/100 mL) exceeded the 2002 Illinois Water-Quality Standard (IWQS) for general use (200 colonies/100 mL, May-October) during May through October from 1978 to 1996 (table 4). Median fecal coliform counts in Blackberry Creek were higher during May through October (635 colonies/100 mL) than during November through April (200 colo-

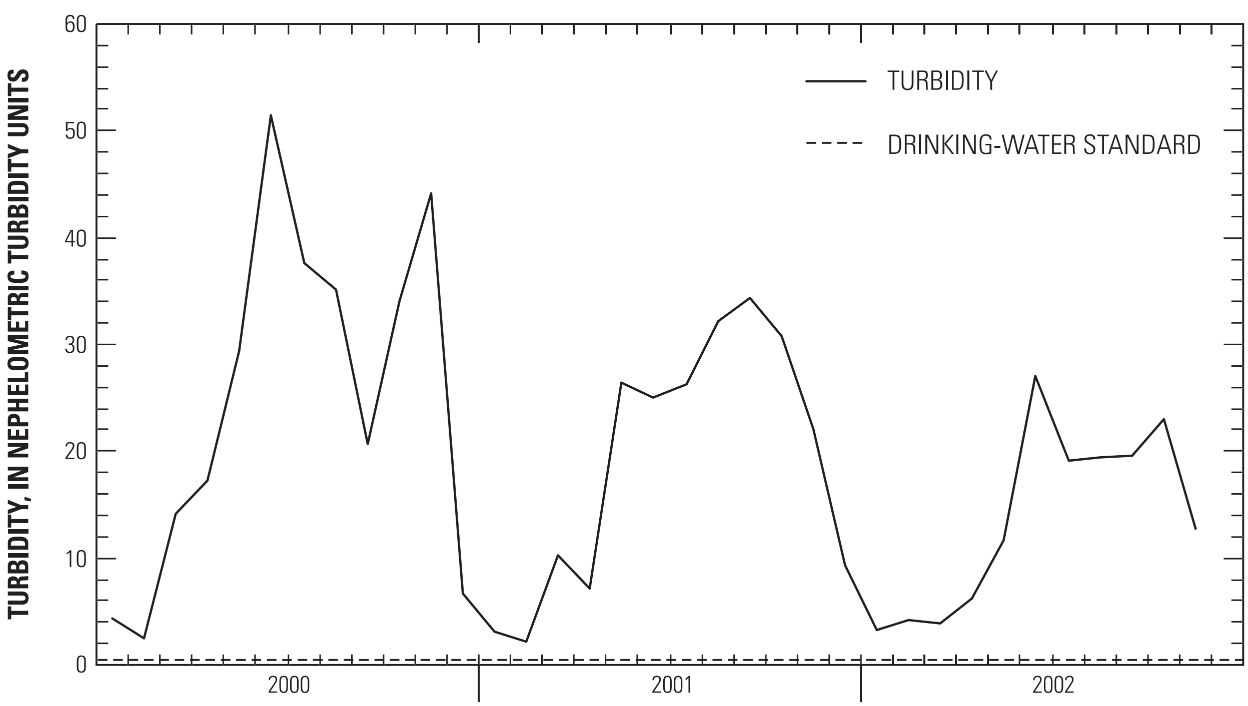


Figure 18. Turbidity levels in untreated, raw water from the Fox River collected at the City of Aurora Illinois Treatment Plant, 2000 through 2002 (data provided by Arnold Eggleston, Superintendent of Water Production, City of Aurora, 2004).

nies/100 mL), but were lower in the Fox River at Montgomery and Dayton during May through October (590 colonies/100 mL and 127 colonies/100 mL, respectively) than November through April (655 colonies/100 mL and 160 colonies/100 mL, respectively). Median fecal coliform counts did not exceed the 2002 IWQS for water-supply use (2,000 colonies/100 mL) during November through April at these stations.

Excluding fecal-coliform bacteria, the median concentration of every constituent at these sampling locations was below its 2002 IWQS for general use or water-supply use. However, individual concentrations of numerous constituents exceeded the 2002 IWQS in one or more samples at each station (table 5).

For samples taken from the station on the Fox River at Montgomery from December 1977 through April 1997 the concentration of man-

Table 4. Illinois Environmental Protection Agency guidelines for assessing the use of Illinois streams and lakes for fish consumption, primary contact, aquatic life use, and water-supply use (modified from Illinois Water Quality Section 305(b) Report, *http://www.epa.state.il.us/water/water_quality/report-2002/305b-2002.pdf*, accessed August 2003).

[mL, milliliters; MCL, maximum contaminant level]

Type of guideline	Degree of use support	Guidelines
Fish consumption	Full	Fish-tissue samples indicate that no contaminants are at high concentrations.
Fish consumption	Partial	A restricted consumption fish advisory is in effect for the general population or for those at greater risk, such as pregnant women or children.
Fish consumption	Nonsupport	A no consumption advisory is in effect for the general population for at least one fish species, or commercial fishing is banned.
Primary contact (swimming)	Full	Geometric mean of all fecal coliform samples is less than or equal to 200/100 mL and less than or equal to 10 percent of the samples exceed 400/100 mL when the total suspended-solid concentration is less than or equal to the 50th percentile.
Primary contact (swimming)	Partial	Geometric mean of all fecal coliform samples is less than or equal to 200/100 mL and greater than 10 percent of the samples exceed 400/100 mL when the total suspended-solid concentration is less than or equal to the 50th percentile, or the geometric mean of all fecal coliform samples is greater than 200/100 mL and less than or equal to 25 percent of samples exceed 400/100 mL when the total suspended-solid concentration is less than or equal to the 50th percentile.
Primary contact (swimming)	Nonsupport	The geometric mean of all fecal coliform samples is greater than 200/100 mL and greater than 25 percent of samples exceed 400/100 mL when the total suspended-solid concentration is less than or equal to the 50th percentile.
Aquatic-life use	Full	Less than or equal to 10 percent of samples exceed a standard for every constituent.
Aquatic-life use	Partial	Greater than 10 percent but less than or equal to 25 percent of samples exceed a standard for one constituent.
Aquatic-life use	Nonsupport	Greater than 25 percent of samples exceed a standard for one constituent.
Water-supply use	Full	Less than or equal to 10 percent of every constituent in untreated water samples exceed a Public and Food Processing Water Supply Standard for samples collected in 1999 or later, or no concentrations of any constituent in treated water samples exceed a MCL during the most recent 3 years of data.
Water-supply use	Partial	Greater than or equal to 10 percent of one constituent in untreated water samples exceed a Public and Food Processing Water Supply Standard for samples collected in 1999 or later, or at least one concentration of a treated water sample exceeds a MCL during the most recent 3 years of data, or without conventional treatment of the water the public water-supply use exceeds a MCL during the most recent 3 years of data.
Water-supply use	Nonsupport	Source may not be used for public water-supply use.

ganese exceeded the water-supply use standard (150 mg/L) in five samples, the concentration of nitrate exceeded the drinking-water and water-supply use standards (10 mg/L) in one sample (12 mg/L). Nitrite concentrations generally were low (<0.01 mg/L) in surface-water samples collected for this site and other sites. The concentration of silver exceeded the general use and water-supply use standards (both standards are 5 µg/L) in two samples (6 µg/L and 7 µg/L). The concentration of lead (100 mg/L) exceeded the water-supply use standard (50 mg/L) in 8 samples. The concentration of cadmium (10 µg/L) exceeded the drinking-water standard (5 µg/L) in 1 sample. The concentration of boron exceeded the general use and water-supply use standards (both standards are 1,000 µg/L) in one sample (2,110 µg/L), the concentration of chromium exceeded the water-supply use standard (50 µg/L) in two samples (68 µg/L and 96 µg/L), and the concentration of dissolved iron exceeded the water-supply use standard (300 µg/L) in one sample (350 µg/L).

For samples collected from the station on the Fox River at Dayton from January 1978 through April 1997 the concentration of chromium exceeded the water-supply use standard (50 µg/L) in 3 samples (77 µg/L, 90 µg/L, and 419 µg/L), the concentration of dissolved iron exceeded the water-supply use standard (300 µg/L) in 1 sample (410 µg/L), the concentration of manganese exceeded the water-supply use standard (150 µg/L) in 14 samples and the general use standard (1,000 µg/L) in 1 sample, the concentration of nitrate exceeded the drinking-

Table 5. Select surface-water-quality data from three stations in and near Kendall County, Illinois, 1977 through 1997.

[All concentrations with a less than value were converted to that value. Bold values indicate that all values were reported as the detection limit. IWQS, Illinois Water Quality Standard; MRL, minimum reporting level; µg/L, micrograms per liter; na, not available; mL, milliliters; mg/L, milligrams per liter]

			IWQS	
Constituent and units	**MRL**	**[1] National drinking water regulation**	**[2] General use**	**Water-supply use**
Arsenic(µg/L)	1	10 (as of 1/23/2006)	360/190 (acute/chronic)	50
Barium (µg/L)	100	2,000	5,000	1,000
Boron (µg/L)	5	na	1,000	1,000
Cadmium (µg/L)	0.01	5	formula	10
Calcium (µg/L)	na	na	na	na
Chromium (µg/L)	5	100	na	50
Fecal coliform (colonies/100 mL): May-Oct./Nov.-April	10	na	200/na	2,000/2,000
Fluoride (mg/L)	na	4	1.4	1.4
Iron (dissolved) (µg/L)	50	na	1,000	300
Lead (µg/L)	5	[3] 15	formula	50
Manganese (µg/L)	20	[4] 50	1,000	150
Nickel (µg/L)	5	na	1,000	1,000
Nitrate, as N (mg/L) [5]	.1	10	na	10
Total Nitrogen, as N (mg/L)	na	na	na	na
Selenium (µg/L)	1	50	1,000	10
Silver (µg/L)	1	[4] 100	5	5
Total Phosphorus, as P(mg/L)	.01	na	[6] .5	[6] .5
Zinc (µg/L)	5	[4] 5,000	1,000	1,000

1. List of contaminants and their maximum contaminant level (MCLs), *http://www.epa.gov/safewater/mcl.html*, accessed August 2003.

2. List of 2002 Illinois Water-Quality Standards (Illinois Environmental Protection Agency Bureau of Water, 2002).

3. If more than 10% of samples exceed this action level, water systems must take additional steps.

4. Secondary drinking water regulation.

5. Nitrate plus nitrite.

6. This standard is applicable only for certain lakes and reservoirs and at the point of entry of any stream to these lakes and reservoirs.

Table 5. Select Surface-water-quality data from three stations in and near Kendall County, Illinois, 1977 through 1997—Cont.

[All concentrations with a less than value were converted to that value. Bold values indicate that all values were reported as the detection limit. µg/L, micrograms per liter; na, not available; mL, milliliters; mg/L, milligrams per liter; <, less than]

Constituent and units	Median	Maximum	Minimum	Period of record (month/year)	Number of calculated values
	Blackberry Creek near Yorkville, Illinois (5551700)				
Arsenic (µg/L)	1	4	1	01/1978-01/1983	13
Barium (µg/L)	**100**	**100**	**100**	02/1981-06/1993	10
Boron (µg/L)	50	200	20	01/1978-04/1997	149
Cadmium (µg/L)	< 3	< 5	< 3	01/1978-04/1997	144
Calcium (µg/L)	91	116	38	10/1980-04/1997	143
Chromium (µg/L)	5	96	5	01/1978-01/1991	151
Fecal coliform (colonies/100 mL): May-Oct./Nov.-April	635/200	20,000/32,000	70/9	05/1978-08/1996 / 12/1977-11/1996	76/73
Fluoride (mg/L)	**.2**	**.2**	**.2**	05/1982-01/1983	5
Iron (dissolved) (µg/L)	50	430	10	10/1980-04/1997	117
Lead (µg/L)	< 5	< 100	< 5	01/1978-04/1997	173
Manganese (µg/L)	100	650	30	01/1978-04/1997	158
Nickel (µg/L)	5	300	< 5	02/1981-04/1997	107
Nitrate, as N (mg/L) [1]	2.9	10	.6	12/1977-04/1997	185
Total Nitrogen, as N (mg/L)	3.7	11	1.1	02/1979-04/1997	165
Selenium (µg/L)	na	na	na	na	0
Silver (µg/L)	3	8	3	10/1980-04/1997	143
Total Phosphorus, as P (mg/L)	.1	.61	.02	12/1977-04/1997	185
Zinc (µg/L)	< 50	360	5	01/1978-04/1997	154
	Fox River at Montgomery, Illinois (5551540)				
Arsenic (µg/L)	2	5	1	01/1978-04/1997	174
Barium (µg/L)	**100**	**100**	**100**	03/1981-10/1996	33
Boron (µg/L)	70	2,110	5	01/1978-04/1997	148
Cadmium (µg/L)	3	10	3	01/1978-04/1997	179
Calcium (µg/L)	69	95	41	10/1980-04/1997	141
Chromium (µg/L)	5	96	5	01/1978-04/1997	180
Fecal coliform (colonies/100 mL): May-Oct./Nov.-April	590/655	42,000/55,000	25/10	05/1978-08/1996 / 01/1978-11/1996	74/76
Fluoride (mg/L)	.2	.5	.1	08/1981-04/1997	136
Iron (dissolved) (µg/L)	50	350	< 5	10/1980-04/1997	135
Lead (µg/L)	< 5	<100	< 5	01/1978-04/1997	154
Manganese (µg/L)	80	270	10	01/1978- 04/1997	151
Nickel (µg/L)	< 5	25	< 5	03/1981-04/1997	101
Nitrate, as N (mg/L) [1]	1.6	12	.01	12/1977-04/1997	184
Total Nitrogen, as N (mg/L)	3.5	14	1.3	03/1979-04/1997	162
Selenium (µg/L)	< 5	10	< 1	04/1993-04/1997	35
Silver (µg/L)	3	7	3	03/1981-04/1997	140
Total Phosphorus, as P (mg/L)	.25	2.3	.08	12/1977-04/1997	184
Zinc (µg/L)	70	580	10	01/1978-04/1997	153

1. Nitrate plus nitrite.

Table 5. Surface-water-quality data from three stations in and near Kendall County, Illinois, 1977 through 1997—Cont.

[All concentrations with a less than value were converted to that value. Bold values indicate that all values were reported as the detection limit. µg/L, micrograms per liter; n/a, not available; mL, milliliters; mg/L, milligrams per liter; <, less than; E, estimated value]

	Fox River at Dayton, Illinois (5552500)				
Constituent and units	**Median**	**Maximum**	**Minimum**	**Period of record (month/year)**	**Number of calculated values**
Arsenic (µg/L)	2	8	1	03/1978-04/1997	201
Barium (µg/L)	100	300	100	03/1981-11/1995	26
Boron (µg/L)	80	700	5	03/1978-04/1997	170
Cadmium (µg/L)	< 3	< 10	.01	03/1978-04/1997	157
Calcium (µg/L)	72	140	29	10/1980-04/1997	163
Chromium (µg/L)	5	419	2	03/1978-04/1997	208
Fecal coliform (colonies/100 mL): May-Oct./Nov.-April	E127/ E160	E400,000/ ≤ 10,000	E9/ E9	06/1978-08/1995 / 04/1978-11/1996	87/89
Fluoride (mg/L)	.3	.7	.01	08/1981-04/1997	152
Iron (dissolved) (µg/L)	50	410	4	10/1980-04/1997	169
Lead (µg/L)	< 5	<100	< 5	03/1978-04/1997	186
Manganese (µg/L)	70	1,150	10	03/1978-04/1997	171
Nickel (µg/L)	< 5	< 25	3	03/1981-04/1997	123
Nitrate, as N (mg/L) [1]	2.8	14	.01	03/1978-04/1997	202
Total Nitrogen, as N (mg/L)	4.55	17	1	04/1979-04/1997	216
Selenium (µg/L)	< 5	< 10	< 1	03/1993-04/1997	36
Silver (µg/L)	3	6	< 1	10/1980-04/1997	167
Total Phosphorus, as P (mg/L)	.26	4.38	≤ .01	03/1978-04/1997	250
Zinc (µg/L)	60	340	< 5	03/1978-04/1997	174

1. Nitrate plus nitrite.

water and water-supply use standard (10 mg/L) in 1 sample (14 mg/L), and concentration of silver exceeded the water-supply use standard (5 µg/L) in 1 sample (6 µg/L). The concentration of lead (100 µg/L) exceeded the water-supply use standard (50 µg/L) in 4 samples.

For samples collected from the station on Blackberry Creek near Yorkville from January 1977 through April 1997 the concentration of manganese exceeded the water-supply use standard (150 µg/L) in 27 samples, the concentration of silver exceeded the general use and water-supply use standards (both standards are 5 µg/L) in 1 sample (8 µg/L), the concentration of chromium exceeded the water-supply use standard (50 µg/L) in 2 samples (96 µg/L and 54 µg/L), the concentration of lead exceeded the water-supply use standard (50 µg/L) in 3 samples (100 µg/L), and the concentration of dissolved iron exceeded the water-supply use standard (300 µg/L) in 2 samples (330 µg/L and 430 µg/L).

Median concentrations of total nitrogen and nitrate in the Fox River at Montgomery were highest in the winter during October 1988 through April 1997 (4.1 mg/L and 2.7 mg/L, respectively), and nitrate concentrations were lowest in the summer (0.64 mg/L) (fig. 19). Winter was defined as December 21 to March 20, and summer was defined as June 21 to September 20. Nitrogen species originate largely from the run-off of *nonpoint sources*. The primary land use in the *watershed* upstream of the Fox River at Montgomery is agricultural, and sub-characterized as row crop (39 percent) and pasture/hay (20 percent).

Nitrate concentrations were more widely distributed in the Fox River at Dayton in the spring than in the Fox River at Montgomery (figs. 20, 21). A wider distribution of nitrate in the spring may be attributed to springtime fertilizer application and rainfall runoff. The watershed at Dayton has more row-crop land use (52 percent) than at Montgomery (39 percent). The Fox River at Dayton has greater discharge than at Montgomery (fig. 22), which may reduce the consumption of nitrate and increase its distribution in the spring.

Boron concentrations in the Fox River increased during the summer and fall at Montgomery and Dayton (figs. 20, 21). This increase may be attributed to wastewater dominating the stream water during base flow. Manganese concentrations also increased in the spring and summer at Montgomery and Dayton, possibly in response to changes in geochemical and biological conditions. Calcium concentrations in the Fox River decreased during the summer and fall at Montgomery and Dayton (figs. 20, 21).

Discharge

No active streamflow-gaging stations are located on the Fox River in Kendall County. The Fox River at Montgomery is the nearest USGS streamflow-gaging station on the Fox River upstream from Kendall County (fig. 16). Daily discharge has been calculated from river stage beginning in *water year* 1978. The Fox River at Dayton is the nearest USGS streamflow-gaging station on the Fox River downstream from Kendall County (fig. 16). Daily discharge has been calculated from river stage at this station beginning in water year 1916.

The daily mean discharge of the Fox River was greater at Dayton than at Montgomery from October 2002 through September 2003 (fig. 22). The maximum daily mean discharge of the Fox River

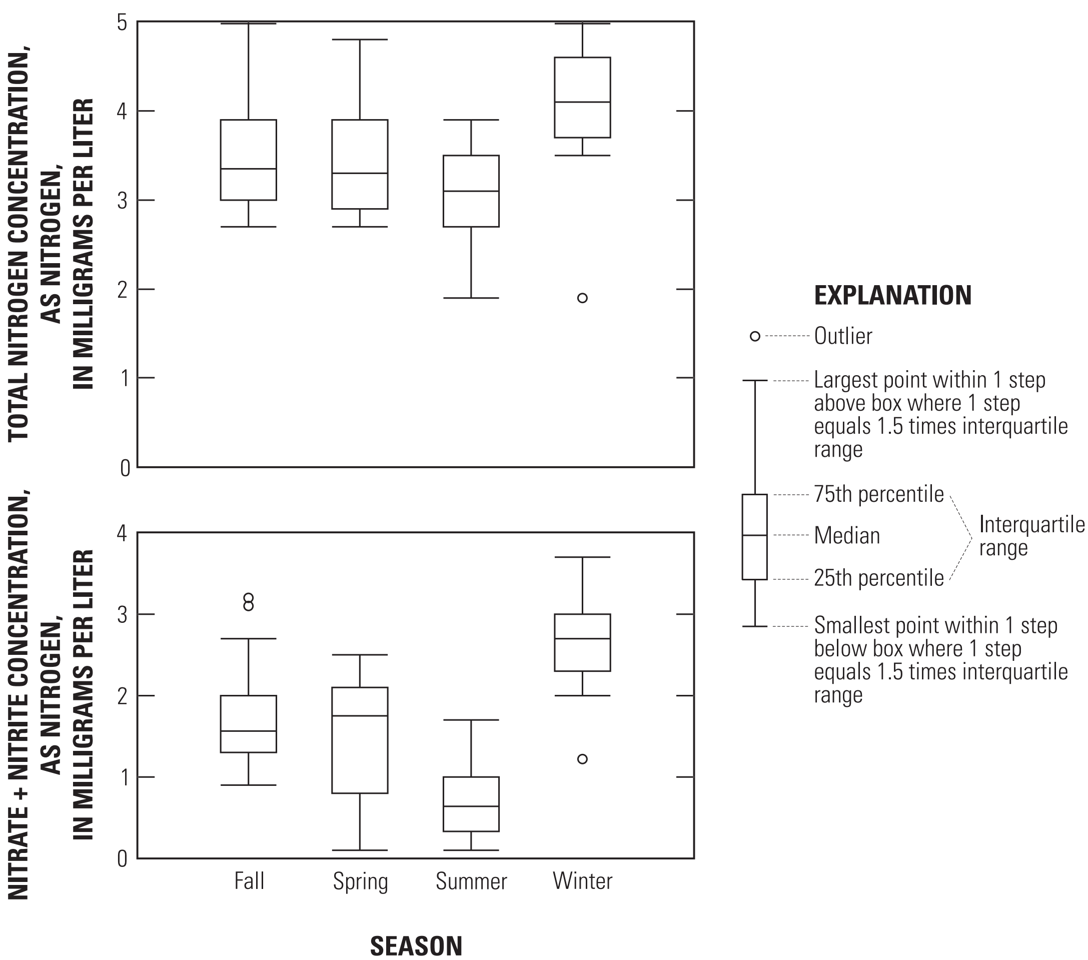


Figure 19. Seasonal changes in total nitrogen and nitrate concentrations at the Fox River at Montgomery, Illinois, October 1988 through April 1997.

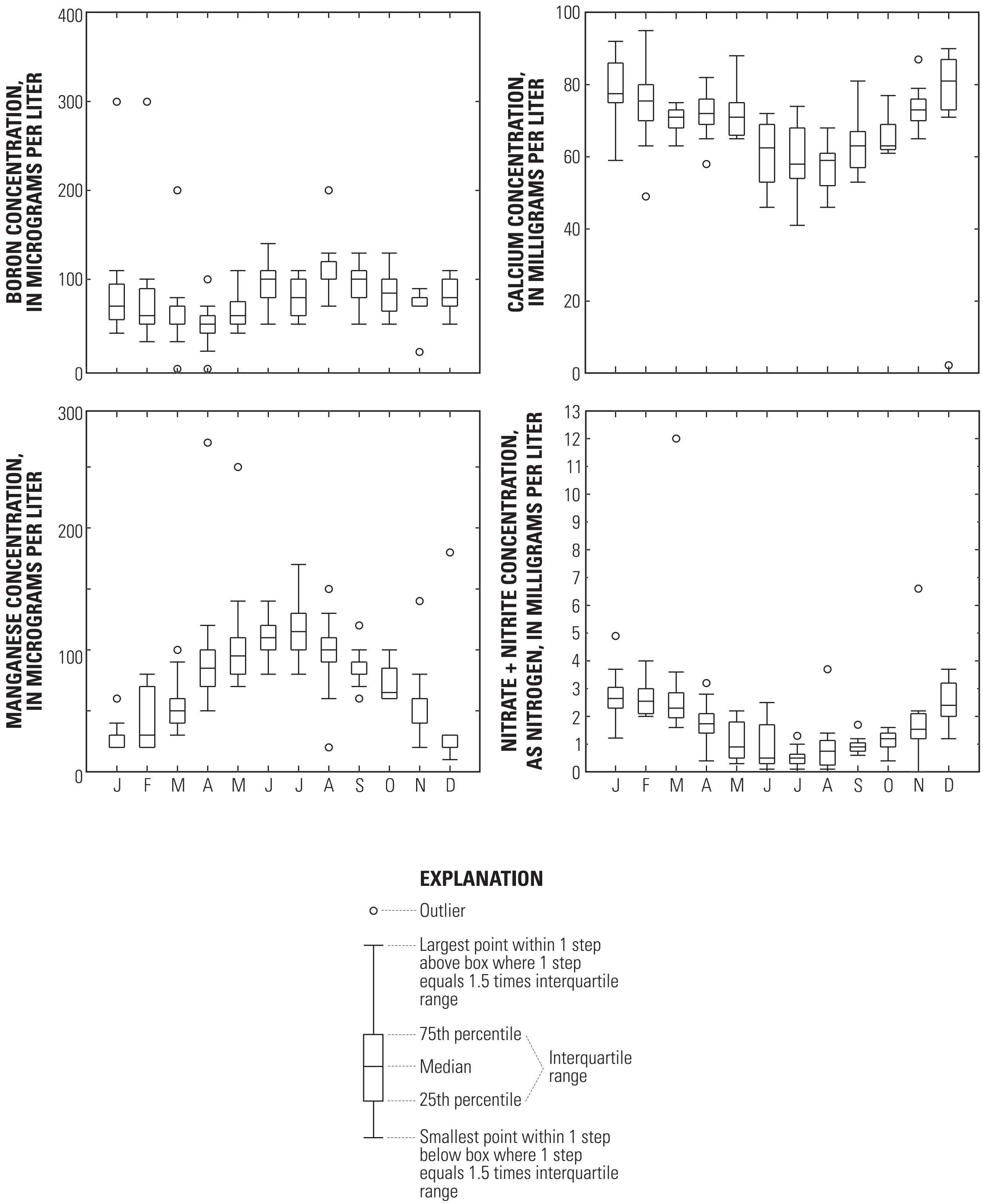


Figure 20. Monthly constituent concentrations in water samples from the Fox River at Montgomery, Illinois, December 1977 through April 1997.

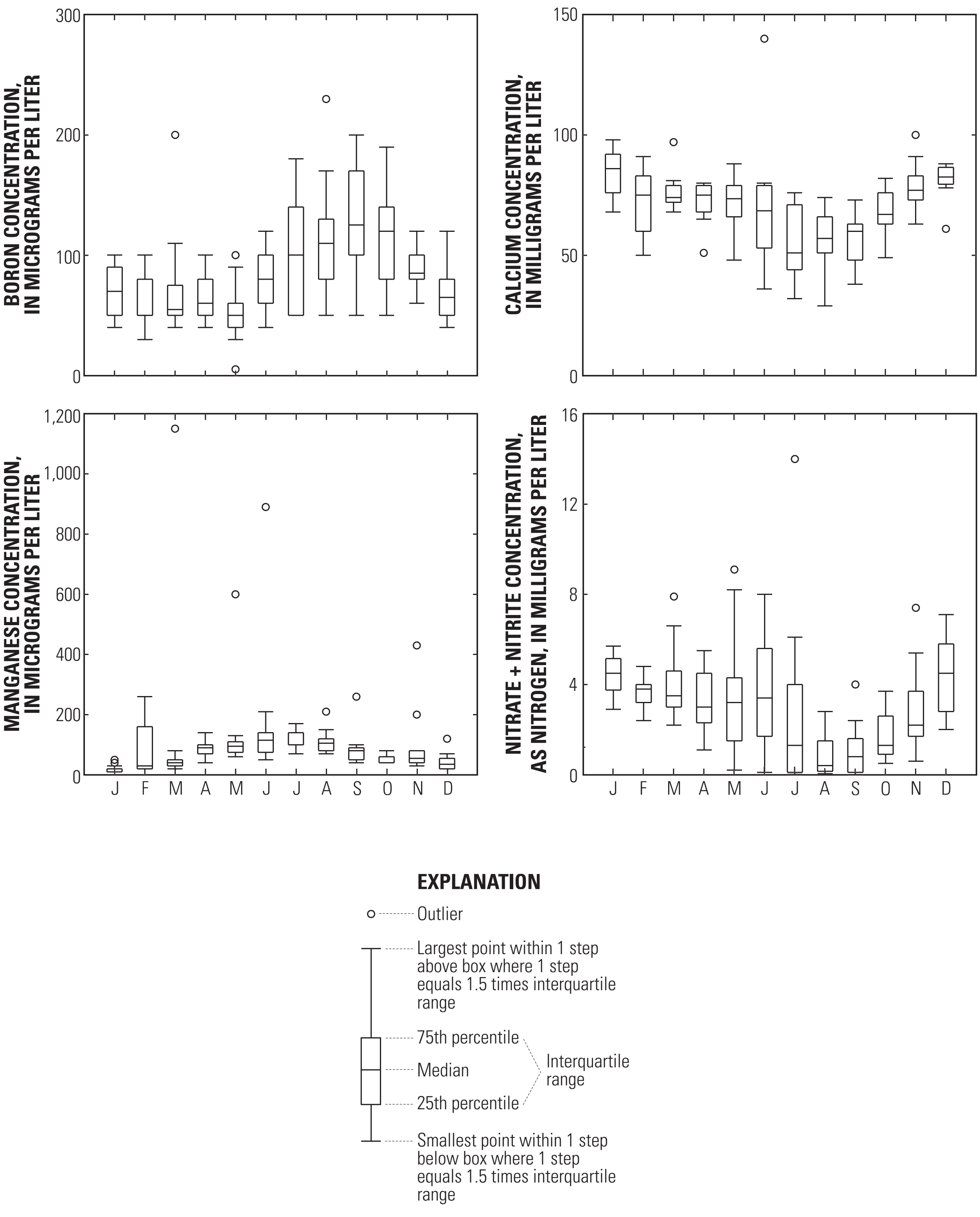


Figure 21. Monthly constituent concentrations in water samples from the Fox River at Dayton, Illinois, January 1978 through April 1997.

occurred at Dayton and Montgomery during May (6,260 and 4,090 ft^3/s, respectively), and the minimum occurred during September (215 and 131 ft^3/s, respectively) .

Blackberry Creek near Yorkville is the only active streamflow-gaging station in Kendall County. Daily discharge has been calculated from river stage at this station beginning in water year 1961. Daily mean discharge from October 1960 through September 2003 is shown in figure 22.

GROUND-WATER RESOURCES

The hydrogeologic units of primary importance for water supply in Kendall County are the glacial drift aquifers, composed of Quaternary sand and sand-and-gravel units; the shallow bedrock aquifers, composed of bedrock units within about 170 ft of the bedrock surface; and the Cambrian-Ordovician aquifer system, composed primarily of the Ironton-Galesville sandstone and sandstones of the Ancell Group (fig. 6). Although the Mt. Simon aquifer underlies Kendall County, it is not used for water supply. The aquifers are separated by confining unit*s*, which restrict ground-water flow between the aquifers.

Glacial Drift Aquifers

Glacial drift aquifers are composed of sand and sand-and-gravel units of sufficient saturated thickness (typically greater than 25 ft) and *permeability* to support a sustainable *yield* of at least 50 gal/min, the approximate minimum required for municipal supply. Thinner, less permeable sand and sand-and-gravel units also serve the water-supply needs of residential users. The glacial drift aquifers are capable of sustaining additional use in most of Kendall County. However, further characterization of these aquifers would be required in many areas to determine their optimal potential.

Location of Aquifers and Confining Units

Presently (2004), glacial drift aquifers in the county are not mapped specifically. Previous investigators have described where deposits of sand and gravel are expected to be thickest and most widespread, thus having the greatest potential to yield sufficient water to meet demands for municipal supply (more than 100 gal/min). Sand-and-gravel units are expected to be most widespread and thickest (up to 100 ft thick) in the area of the county underlain by outwash units of the Henry Formation. This

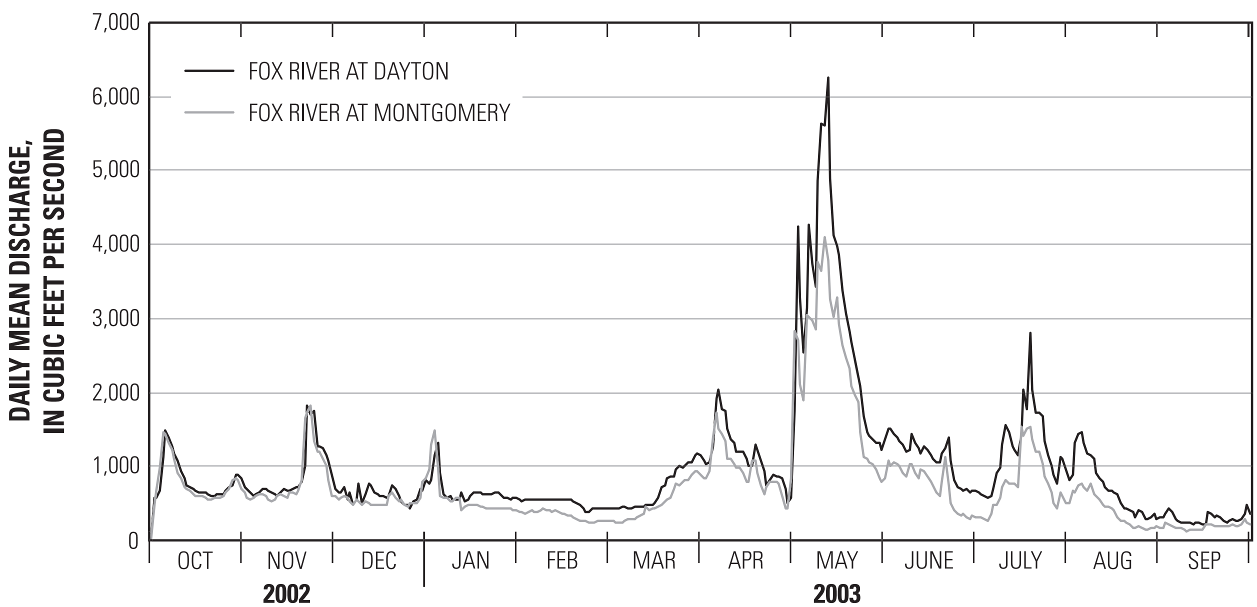


Figure 22. Daily mean discharge measurements at the Fox River at Dayton and Montgomery, Illinois, October 2002 through September 2003.

area includes much of northern Kendall County, where near-surface (generally within about 15 ft) sand-and-gravel units generally coincide with the Fox River Valley alluvial units as well as the Newark Valley and its tributaries (figs. 11, 12, 14a, 24). Localized units of sand and gravel buried within the southwestern part of the Newark Valley and tributary 1 northeast of Millington and tributary 2 northwest of Millhurst also may be sufficiently thick and permeable to yield sufficient water for municipal supplies.

Thin, discontinuous sand and sand-and-gravel units sufficient to meet the demands of residential users (more than about 10 gal/min) may be present in areas composed predominantly of less permeable, fine-grained units. Surficial sand units near Lisbon, accumulated at the edge of ancestral Lake Wauponsee (Dolton facies of the Henry Formation) (figs. 4, 11), also may have the capacity to support residential supplies. Because of the complex glacial depositional processes, the exact locations of these local aquifers cannot be determined without focused geotechnical field surveys and analysis of available drilling records. Quaternary units in some areas of the county, including near the southeastern edge, are thin (likely less than 25 ft thick), composed almost entirely of fine-grained materials, and have little potential as a source of municipal or residential water supply (fig. 24).

Determining the location of individual confining units within the Quaternary units beneath Kendall County and the extent of confinement of individual aquifers is not feasible on the basis of available data. Generally, an aquifer is expected to be *unconfined* if its top is within about 10 ft of the land surface. Aquifers that are overlain by thicker units of fine-grained sediments are expected to be confined. Where aquifers are unconfined, groundwater-recharge rates are likely to be greatest, as is the potential for contamination. Confined aquifers are expected to include those composed of basal sand-and-gravel units within the Newark Valley and its tributaries (generally within the southern part of the valley and its tributary 1 trending northeast from Millington (fig. 14a)). Confined aquifers also are expected where buried units of the Henry Formation interfinger with those of the Lemont Formation (generally northwest of Plano and south

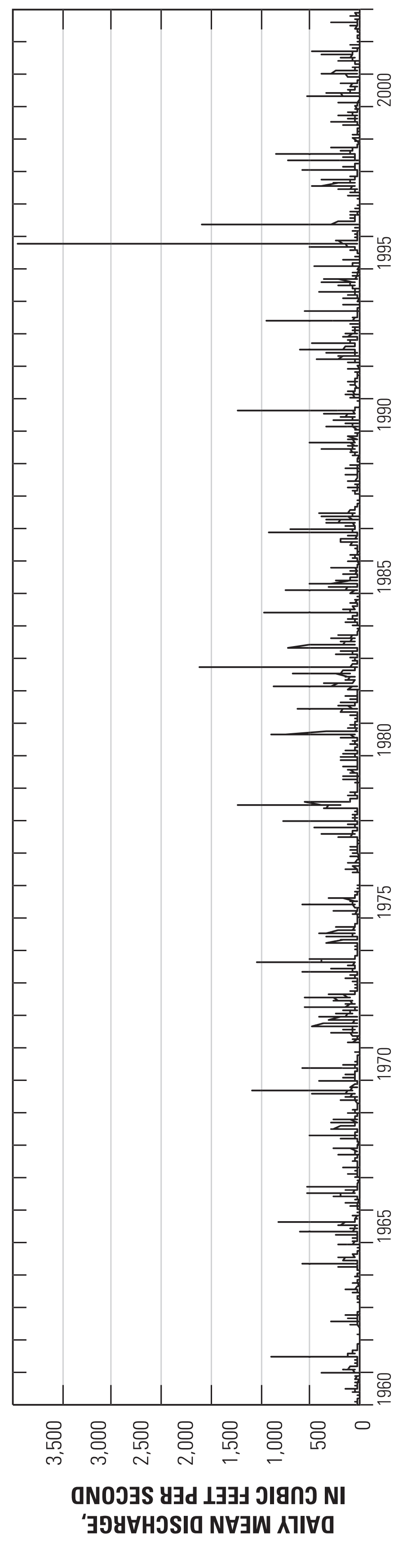


Figure 23. Daily mean discharge at Blackberry Creek near Yorkville, Illinois, October 1960 through September 2003.

of Millhurst) (figs. 11, 12). Glacial drift aquifers composed of discontinuous lenses of sand and gravel within the fine-grained units of the Lemont and Equality Formations also are likely to be confined. Aquifers in the northern part of the county, composed of the near-surface outwash units of the Henry Formation, are expected to be unconfined (figs. 11, 12, 24).

Ground-Water Levels and Directions of Flow

Ground-water levels in wells open to glacial drift aquifers beneath Kendall County were plotted based on water-level data reported from well logs at the time of drilling (fig. 25). These measurements were taken from different aquifers and different depths at different times; therefore, figure 25 does not depict the actual *potentiometric surface* of the glacial drift aquifers at any given time. However, the data indicate that ground-water levels in wells open to the glacial drift aquifers in Kendall County tend to mirror land-surface topography (fig. 5). Ground-water levels are about 650 ft above NGVD 29 beneath topographic highs associated with the central morainic ridge at locations south of Yorkville and east and south of Oswego (fig. 25). Ground-water levels are as low as about 575 ft near the Fox River in the western part of the county and less than about 525 ft in the southeastern part of the county.

Water-level data shown in figure 25 indicate that lateral ground-water flow in the glacial drift aquifers is from the uplands toward the Fox River and its principal tributaries in the northern part of the county and south toward Grundy County in the southern part of the county. It is probable that the shallowest ground water discharges to small ditches, streams, and ponds. In most of the county, vertical ground-water flow in the unconsolidated units is expected to be downward to underlying bedrock units. Upward flow may occur in areas where ground water discharges to the larger streams and rivers.

Hydraulic Properties

Hydraulic-property data for Quaternary units in Kendall County are sparse. Horizontal *hydraulic conductivity* (K_h) and *transmissivity* values were estimated from aquifer tests performed by other investigators in 13 wells at four waste-disposal sites in or near Oswego, Plano, and Yorkville (Alan Wehrmann, Illinois State Water Survey, written commun., 2004; Metcalf and Eddy, Inc., 1995) and by USGS investigators at a test well northeast of Yorkville (table 6) (appendix A). The wells are less than 80 ft deep and are open to sand or sand and gravel. Estimated values of K_h range from about 3 to 7,100 ft/d, with geometric means at each site ranging from 5 to 1,500 ft/d. Because values for K_h in excess of about 500 ft/d for a sand and gravel aquifer are unlikely, the high values reported from some of these tests are suspect. Estimated transmissivities range from 8 to 68,000 ft^2/d, with geometric means at each site ranging from 27 to 56,500 ft^2/d. Estimated *storage coefficients*, as measured at one site in Oswego, range from 0.08 to 0.5, with a geometric mean of 0.17.

Recharge

Ground-water recharge in the vicinity of Kendall County was estimated using a method based on streamflow-hydrograph separation (Rutledge, 1993). Ground-water recharge is water made available to the saturated zone at the *water table*, (which is within the Quaternary units in the area investigated by use of this method) and water made available to hydrogeologic units below the water table. In hydrograph separation, it is assumed that: (1) the hydraulic properties of the contributing hydrogeologic units (as represented by the recession index) can be estimated from streamflow records; (2) periods of exclusive ground-water discharge can be identified reliably; and (3) streamflow peaks approximate the magnitude and timing of recharge events. These assumptions are considered to be met or approximated for the vicinity of Kendall County.

Ground-water recharge estimated by the hydrograph-separation method generally is less than actual recharge because the method only represents recharge that becomes streamflow. Ground-water evapotranspiration, ground water withdrawn by pumping and then exported from the basin, and recharge to deeper aquifer systems are not considered in the estimate. Although the method provides

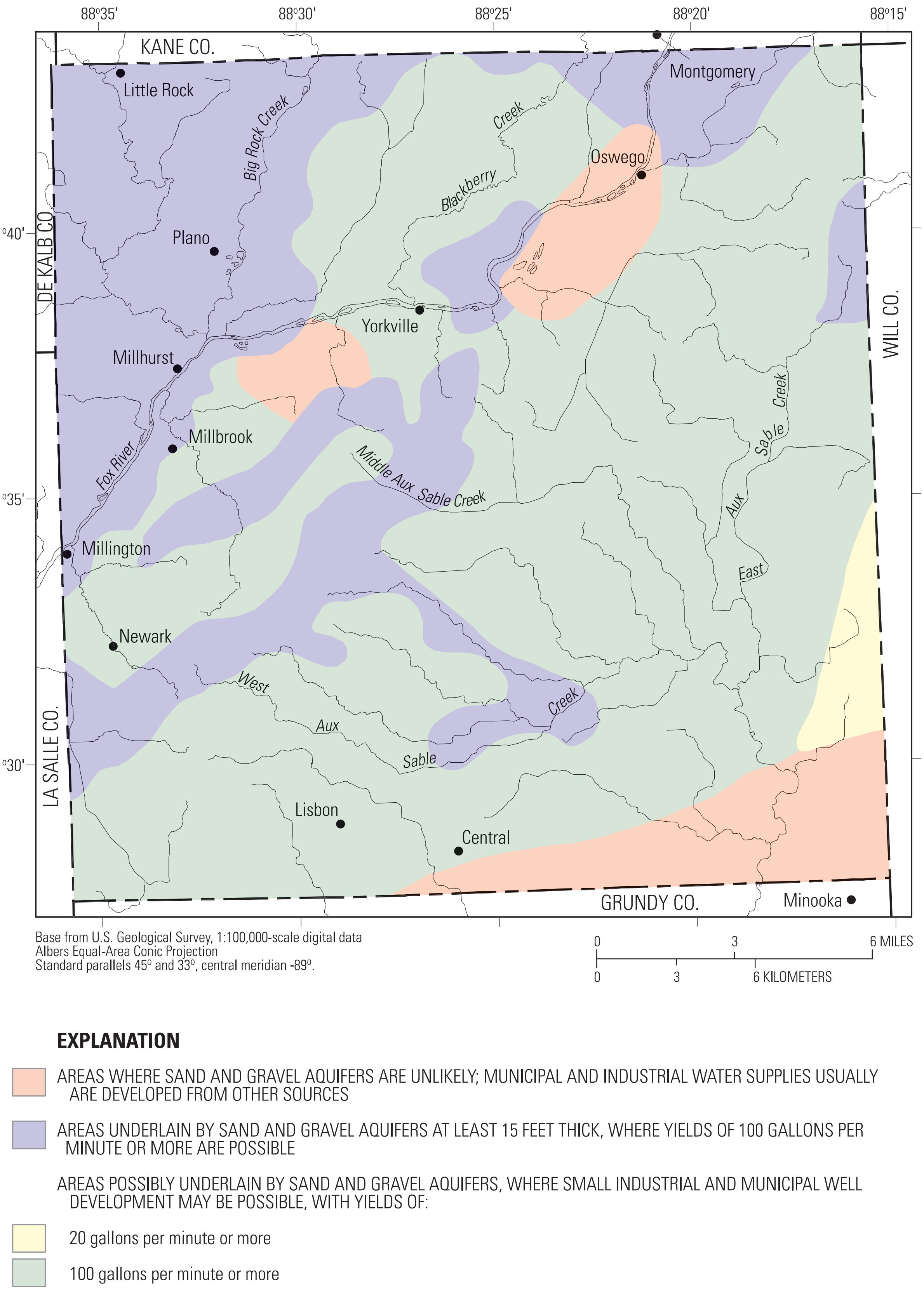
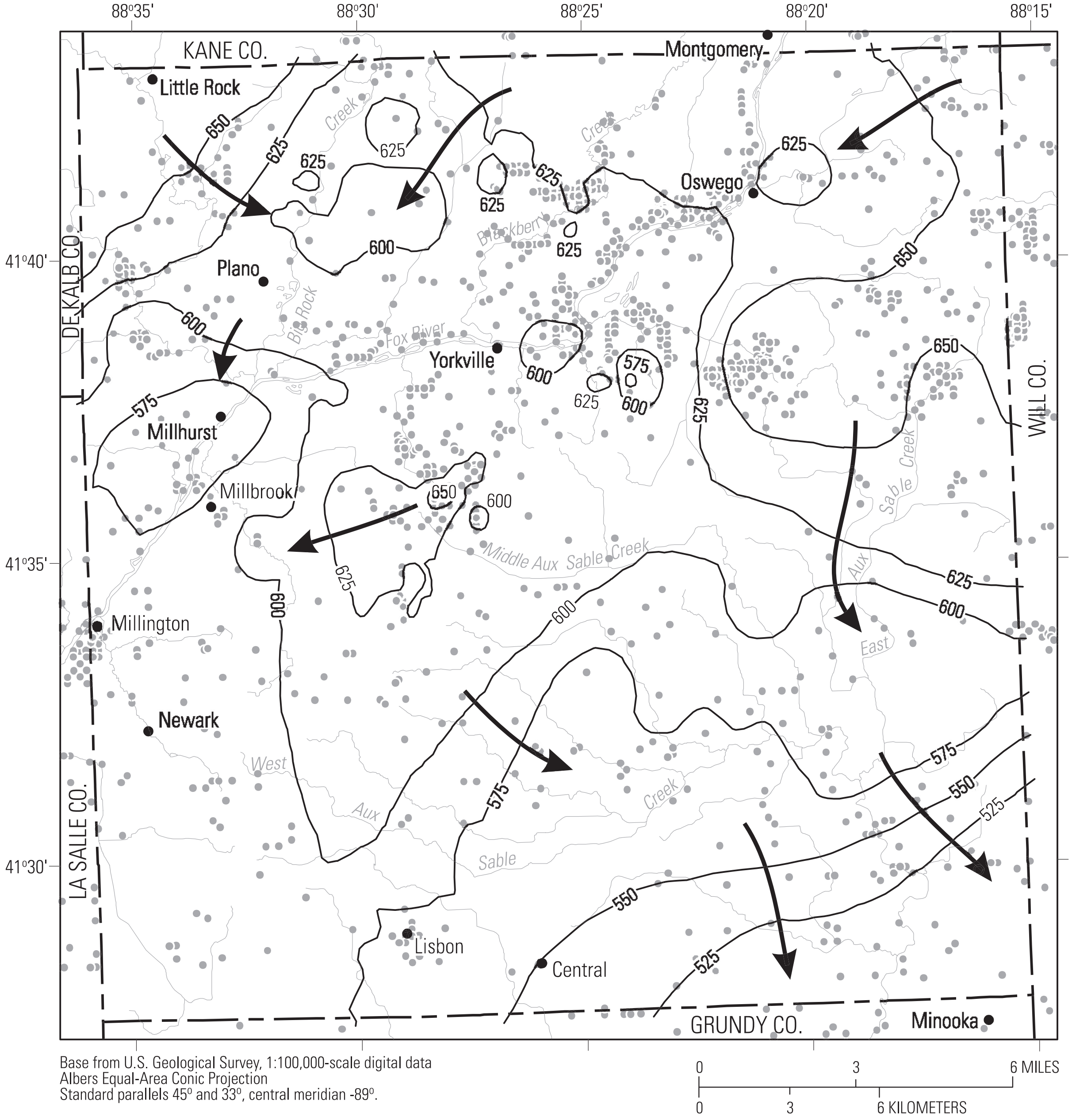


Figure 24. Well yields of glacial drift aquifers in Kendall County, Illinois (modified from Schicht and others, 1976).



EXPLANATION

—600— ALTITUDE AT WHICH WATER WOULD HAVE STOOD IN TIGHTLY CASED WELLS. Contour interval 50 feet. Datum is NGVD 29.

APPROXIMATE DIRECTION OF GROUND-WATER FLOW

WELL

Figure 25. Approximate water-level altitude in wells open to glacial drift aquifers in Kendall County, Illinois, at the time of drilling (about 1980 through 2000).

a conservative (low) estimate of ground-water recharge, that estimate is assumed to reasonably approximate actual ground-water recharge for the studied basin in Kendall County. Ground-water evapotranspiration and exportation are considered to be limited in this basin; recharge to the deeper Cambrian-Ordovician aquifer system is estimated to be less than 1 in/yr (Walton, 1960; 1965).

Streamflow records from the streamflow-gaging station on Blackberry Creek near Yorkville (05551700) (fig. 15) were used for the estimate of ground-water recharge. Whereas only about 25 percent of the gaged drainage area of 70.2 mi^2 is within Kendall County, about 75 percent of the drainage area is overlain by near-surface outwash units, a proportion similar to that for northern Kendall County. Most of the surficial bedrock underlying the Blackberry Creek drainage basin consists of the Maquoketa Group, which is present throughout much of northern Kendall County. The similarity between the geology of the gaged basin and most of northern part of the county indicates that recharge estimates for the basin generally should be representative of the northern part of the county.

Average recharge for the decadal period of 1991-2000 is estimated to be about 9 in/yr, which is about 23 percent of the average annual precipitation. Annual recharge for this period ranged from about 6.5 in/yr in 1994 and 2000 to about 14 in/yr in 1993, a year of greater than normal precipitation in northeastern Illinois.

No other estimates of shallow ground-water recharge have been made for Kendall County, but estimated recharge rates to glacial drift aquifers at or near the surface in Kane and Will Counties that are continuations of, or similar to, those aquifers in Kendall County range from about 5.3 to 7.3 in/yr (Schicht and others, 1976). Estimated recharge rates for intermediate depth glacial drift aquifers in Kane County that are continuations of those aquifers in Kendall County range from about 3.1 to 4.2 in/yr. Estimated recharge rates for glacial drift aquifers in contact with the bedrock surface in Kane and Will Counties that are continuations of, or similar in origin and composition to, those aquifers in Kendall County range from about 2.1 to 7.3 in/yr.

Well Yields

Potential yield is the maximum amount of ground water that can be extracted from wells and well fields without resulting in water levels low enough to prevent efficient pumping or exceeding ground-water recharge rates in the area contributing water to the well. Potential yields of wells open to glacial drift aquifers in Kendall County were estimated based on hydrogeologic information such as estimated recharge rate and the locations and hydraulic properties of the aquifers and adjacent confining units (Schicht and others, 1976). Possibilities for well yields of 100 gal/min or more are considered good in much of the northwestern part of the county where sand-and-gravel units of the Henry Formation are 15 ft or thicker (fig. 24). Municipal-supply wells open to these units in Plano and Yorkville have been pumped at rates up to 430 and 200 gal/min, respectively, with less than 18 ft of *drawdown* (Woller and Gibb, 1974). In most of the remaining area of the county, sand-and-gravel units generally are expected to be discontinuous and less than 15 ft thick. In these areas, yields of 100 gal/min locally may be possible. In southeastern

Table 6. Hydraulic properties of unconsolidated deposits in Kendall County, Illinois.

[ft/d, feet per day; ft^2/d, feet squared per day; -, no data]

Number of wells	Location	Geometric mean of horizontal hydraulic conductivity (ft/d)	Range of horizontal hydraulic conductivity (ft/d)	Geometric mean of transmissivity (ft^2/d)	Range of transmissivity (ft^2/d)	Range of storage coefficients (dimensionless)
5	Oswego	660	100-7,100	6,400	2,600-15,000	0.08
5	Oswego	5	3.2-9.8	27	8-72	-
2	Plano	1,500	1,300-1,700	56,500	47,000-68,000	-
1	Yorkville	1,300	-	32,500	-	-
1	Yorkville	-	-	-	40	-

Kendall County, Quaternary units generally are fine grained throughout and are considered unlikely to yield amounts of water necessary to satisfy municipal-supply needs and most residential needs.

Bedrock Aquifers

The bedrock geologic units beneath Kendall County can be classified as different hydrogeologic units based on the scale of investigation. For example, the Maquoketa Group can be considered an aquifer when the area of investigation is small (approximately subcounty) but is considered a confining unit when considered on a regional (multicounty) scale. The bedrock units beneath Kendall County also can be classified as different hydrogeologic units based on the length of the flow pathway, and the hydraulic properties of the units, which are affected by the presence or absence of overlying units. For example, the Galena-Platteville dolomite functions as an aquifer where it is at the bedrock surface, but functions more as a confining unit where overlain by the Maquoketa Group. The Ancell Group is part of the Cambrian-Ordovician aquifer system in northern Illinois, but is considered part of the shallow bedrock aquifer where it is at the bedrock surface for the purposes of this report.

Shallow Bedrock Aquifer

The shallow bedrock aquifer is composed of the sandstones of the Ancell Group, the Prairie du Chien and Galena-Platteville dolomites, the Maquoketa Group, and the Silurian dolomite where these units are at the bedrock surface (figs. 6, 7). This aquifer is equivalent to the Upper Bedrock Aquigroup described by Visocky and others (1985).

Lithologic logs for water-supply wells drilled into the bedrock units in Kendall County show a bimodal distribution (fig. 26). More than 700 wells penetrate less than 161 ft of bedrock, decreasing consistently to approximately 125 wells penetrating 260 to 400 ft of bedrock, then increasing to about 200 wells penetrating 420 to 500 ft of bedrock. The distribution in the depth of well penetration indicates that the shallow bedrock aquifer can be (arbitrarily) considered to correspond approximately to the upper 160 ft of the bedrock.

Water-level measurements taken from well-construction logs indicate that the water levels in wells open to the shallow bedrock aquifer (fig. 27) tend to mirror surface topography (fig. 5) and water levels in the unconsolidated units (fig. 25). Water-level altitudes in the shallow bedrock aquifer are above 650 ft in the northwestern and northeastern parts of the county, between 550 and 600 ft near the Fox River, and less than 550 ft in the southeastern part of the county in the lower part of the Aux Sable Creek watershed. Water levels in both the shallow bedrock aquifer and unconsolidated units display similar spatial patterns, indicating that they are hydraulically interconnected. Water levels in the shallow bedrock aquifer tend to mirror surface topography, indicating the shallow bedrock aquifer is characterized by a local flow system. In addition to recharge from the small areas where the bedrock is at the land surface, water from the overlying unconsolidated (Quaternary) units enters the shallow bedrock aquifer and flows from areas beneath the topographic uplands and discharges to the Fox River and Aux Sable Creek. Water levels in the shallow bedrock aquifer are likely to be susceptible to changes in recharge from precipitation and flow in the unconsolidated units.

The availability of water from the shallow bedrock aquifer depends primarily on the geologic unit utilized. The Silurian dolomite yields quantities of water from *fractures* and *solution openings* that usually are sufficient for residential and municipal supply, including some of the wells used by Oswego (table 1) and Montgomery. This unit constitutes a distinct aquifer (the Silurian aquifer) in northeastern Illinois, but is classified as part of the shallow bedrock aquifer for this report (fig. 6) because of its limited spatial extent in Kendall County. Fractures and solution openings in the Silurian aquifer tend to be preferentially developed in the upper, weathered, part of the rock; along lithologic changes; and perhaps near rivers and beneath bedrock valleys (Csallany and Walton, 1963). The Silurian aquifer usually is in good hydraulic connection with the overlying glacial drift aquifers and is recharged by vertical flow from these aquifers. The average transmissivity of the Silurian aquifer is not known for Kendall County, but for Kane County, it is estimated to be about 1,880 ft^2/d

(Suter and others, 1959). There is no indication of widespread overutilization of the Silurian aquifer in northeastern Illinois (George Roadcap, Illinois State Water Survey, oral commun., 2004).

The units of the Maquoketa Group typically yield little water. However, water from fractures and solution openings in these units may be sufficient for residential supply and even a small municipal supply (Woller and Gibb, 1974) in parts of Kendall County, especially where these units are at the bedrock surface. Fractures and solution openings in the Maquoketa Group tend to be preferentially developed in the upper, weathered part where it is composed of limestone and dolomite or in the Fort Atkinson Formation.

The Galena-Platteville dolomite yields water from fractures and solution openings that can be sufficient for residential supply and small public supplies, particularly in the western part of the county where these units are at the bedrock surface. Where overlain by the Maquoketa Group, the dolomite is substantially less fractured and has a much lower yield than in areas where it is at the bedrock surface. However, the Galena-Platteville dolomite is used in a limited capacity for residential supply even where overlain by the Maquoketa Group. Wells open to the dolomite where the Maquoketa Group is present deliver much of their water from storage in the wellbore, which is slowly replenished during times when the well isn't pumped, rather than primarily by the rapid flow of water from the aquifer to the well, as is typical of conditions where the unit is more permeable.

The sandstones of the Glenwood Formation and the St. Peter Sandstone constitute the Ancell aquifer. Although part of the Cambrian-Ordovician aquifer system at the regional scale (fig. 6), these units are considered to be part of the shallow bedrock aquifer where they are at the bedrock surface in Kendall County because of the local flow pathways in this area. Where present at the bedrock surface, the Ancell aquifer is used for residential water supply as well as for municipal supply by the City of Newark (table 1).

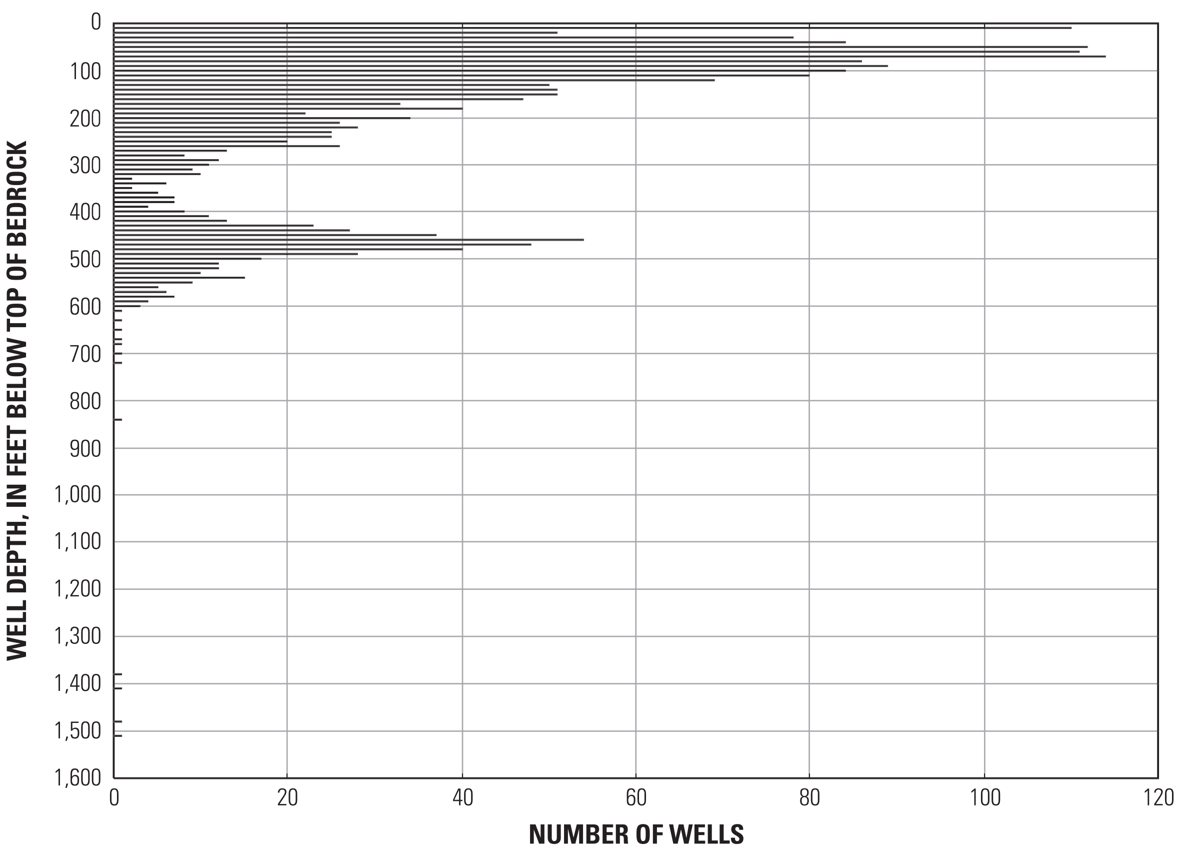


Figure 26. Number of wells and depth of penetration into bedrock in Kendall County, Illinois.

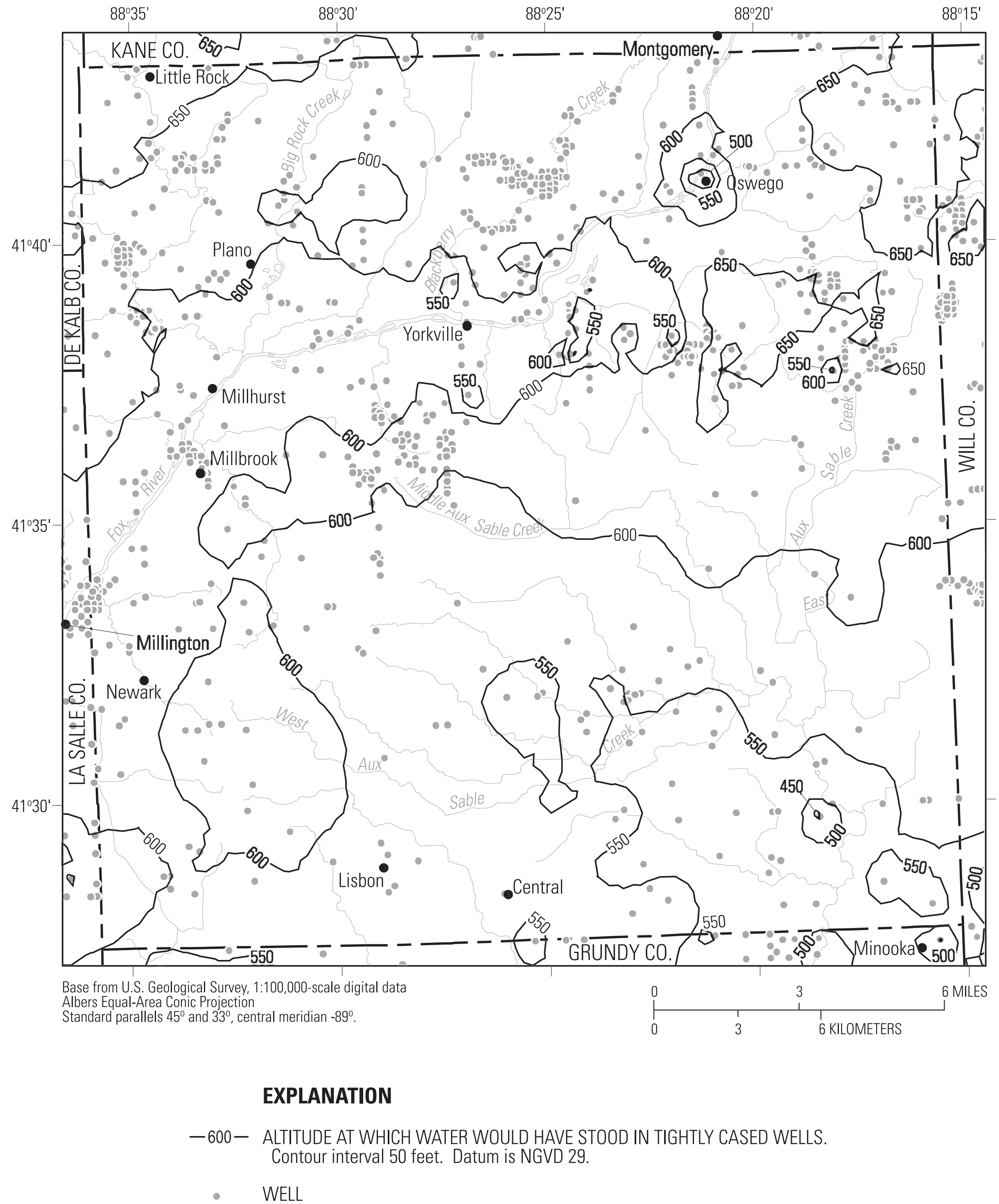


Figure 27. Approximate water-level altitude in wells open to the shallow bedrock aquifer beneath Kendall County, Illinois at the time of drilling (about 1980 through 2000).

The units of the Prairie du Chien Group yield sufficient water for residential supply near the western edge of the county where the units are at the bedrock surface. The Prairie du Chien Group also is part of the Cambrian-Ordovician aquifer system at the regional scale.

Estimated recharge rates for the shallow bedrock aquifer in Kane, Will, and DuPage Counties, where the aquifer is composed primarily of Silurian dolomite, range from about 0.5 to 7.3 in/yr (Schicht and others, 1976). This range is likely to be similar in Kendall County. The lowest recharge rates would be expected where till units overlie the bedrock and the highest rates would be expected where sand-and-gravel units overlie the bedrock (such as at the Newark Valley and its tributaries and where bedrock deposits are at land surface).

The shallow bedrock aquifer appears to have the capacity to support additional water withdrawals for residential use in Kendall County. In the spatially limited areas where it is composed of Silurian and Ancell units, the shallow bedrock aquifer also may have the capacity to support additional water withdrawals for municipal supply.

Upper Confining Unit

At a regional scale, the Maquoketa Group and the Galena-Platteville dolomite (only where overlain by the Maquoketa Group) constitute the upper confining unit (fig. 6). Although these units provide sufficient water for domestic water supplies in Kendall County, they generally have low permeability and restrict flow between the overlying glacial drift and Silurian aquifers and the underlying Ancell aquifer. The leakage coefficient of the upper confining unit in northeastern Illinois is estimated to be 2.5 x 10^{-7} (gal/d)/ft^3 (Visocky and others, 1985) and the average vertical hydraulic conductivity (K_v) is about 6.7 x 10^{-6} ft/d.

Cambrian-Ordovician Aquifer System

Previous investigators working at a regional scale (Sutter and others, 1959; Csallany and Walton, 1963) considered the Cambrian-Ordovician aquifer system to be composed of the units extending from the bottom of the Ironton-Galesville sandstone to the top of the Galena-Platteville dolomite. Because the Galena-Platteville dolomite is considered part of either the shallow bedrock aquifer or the upper confining unit, and because the dolomite has low permeability beneath much of Kendall County, the top of the Cambrian-Ordovician aquifer system is considered to correspond to the top of the Ancell aquifer for this report. The Cambrian-Ordovician aquifer system contains some of the most productive, widespread aquifers in the upper Midwest and is extensively used for municipal-water supply in northeastern Illinois, including Kendall County (table 1). The Cambrian Ordovician aquifer system has an average transmissivity of 2,280 ft^2/d in northeastern Illinois, decreasing to the south and east (Suter and others, 1959) and is about 2,550 ft^2/d in Kendall County (Csallany and Walton, 1963). The storage coefficient of the aquifer system in northeastern Illinois ranges from 0.00035 to 0.0006.

Many of the municipal-supply wells are open to multiple hydrogeologic units in the Cambrian-Ordovician aquifer system to improve yield and are cased only to prevent collapse. Therefore, it can be difficult to identify the properties of the individual hydrogeologic units that make up the aquifer system. However, some information on the individual units is available.

Where part of the Cambrian-Ordovician aquifer system, (where not at the bedrock surface and, therefore, part of the shallow bedrock aquifer) dozens of municipal-supply wells in northern Illinois, including wells used by Yorkville and Oswego (table 1), pump water partly or entirely from the Ancell aquifer. The Ancell aquifer also is utilized by numerous residential-supply wells throughout Kendall County. In northeastern Illinois, the sandstones in the upper part of the Ancell Group tend to be argillaceous or dolomitic and the lowermost part is shaley. As a result, the most productive part of the Ancell aquifer is thought to be about 60 to 80 ft thick and is present 35 to 200 ft below the top of the sandstones (Suter and others, 1959). Lithologic and geophysical logging at Yorkville municipal wells 7, 8, and 9 (appendix A) indicates that the sandstones in the upper part of the Ancell Group are not argillaceous in this area and these sandstones are permeable (appendix A). Although not directly related, the yield of the Ancell aquifer tends to increase with increasing sandstone thickness. Transmissivity of the Ancell aquifer at 17 locations in northeastern Illinois varies from 66 to 4,290 ft^2/d, with a value of 530 ft^2/d for the one test location in Kendall County (Visocky and others, 1985). The horizontal hydraulic conductivity of the aquifer ranges from 1.2 to 2.0 ft/d. The Ancell aquifer constitutes an estimated 15 percent of the total transmissivity of the Cambrian-Ordovician aquifer system in northeastern Illinois (Suter and others, 1959).

The units of the Franconia Formation, the Potosi Dolomite, and the Prairie du Chien Group form a major confining unit between the Ironton-Galesville and Ancell aquifers (Visocky and others, 1985). However, sandy units associated with the New Richmond Sandstone and parts of the Franconia Formation, as well as fractures in the weathered surface of the Prairie du Chien Group and the Potosi Dolomite, yield water in some areas. The Franconia, Potosi, and Prairie du Chien units are not used as a primary source of water supply in most of northeastern Illinois, but many wells open to the Ancell and Ironton-Galesville sandstones also are open to these units to increase yield. Where encountered, such as at Yorkville municipal well 8, fractures in the Prairie du Chien Group or the Potosi Dolomite can yield substantial amounts of water. The transmissivity and K_h of these units is estimated to be about 804 ft^2/d and about 0.8-2.7 ft/d, respectively, beneath the county (Csallany and Walton, 1963). These units account for an estimated 35 percent of the yield of wells open to the Cambrian-Ordovician aquifer system. As part of the present study of production-test data from a well described as open to the Ancell aquifer, the Shakopee Dolomite, and the New Richmond Sandstone near Newark yielded an estimated transmissivity of about 2,300 ft^2/d, with a K_h value of about 10.3 ft/d.

The Ironton-Galesville sandstone constitutes the Ironton-Galesville aquifer. Wells used for water supply by dozens of municipalities in northern Illinois, including Yorkville and Oswego in Kendall County, draw water exclusively or in part from the Ironton-Galesville aquifer (table 1). The Ironton-Galesville is the most productive aquifer in northeastern Illinois (Visocky and others, 1985). The Galesville Sandstone and the Buelter Member of the Ironton Sandstone (the lowermost units in the sandstone), are considered to be the most permeable part of the aquifer (Suter and others, 1959), primarily because of the lower dolomite content of these units in comparison to the rest of the Ironton-Galesville sandstone (Emrich, 1966). The Buelter Member and the Galesville Sandstone have an estimated thickness of about 75 to 100 ft beneath Kendall County. The K_h of the Ironton-Galesville aquifer is between about 3.3 and 5.3 ft/d and the transmissivity is estimated to be between 670 and 930 ft^2/d (Visocky and others, 1985). These values are similar to those calculated from USGS analysis of data obtained during production tests of Oswego well 7 and Yorkville wells 7 and 9, which are open only to the Ironton-Galesville aquifer (table 1) (appendix A). Calculated transmissivity of the Ironton-Galesville aquifer at Oswego 7, Yorkville 7, and Yorkville 9 was 1,050, 560, and 2,600 ft^2/d, respectively. Calculated K_h of the Ironton-Galesville aquifer at Oswego 7, Yorkville 7, and Yorkville 9 was 6.8, 2.8, and 13.0 ft/d, respectively. The permeability of the Ironton-Galesville aquifer is likely to decrease from north to south in northeastern Illinois and Kendall County because of an increase in carbonate content (from less than 10 to more than 15 percent) to the south. It is estimated that the Ironton-Galesville aquifer constitutes about 50 percent of the total transmissivity of the Cambrian-Ordovician aquifer system in northern Illinois (Suter and others, 1959).

The Cambrian-Ordovician aquifer system is recharged primarily from the glacial drift, Galena-Platteville and Ancell units in north-central Illinois where the Maquoketa Group and, thereby, the upper confining unit, is absent. A smaller amount of recharge is from the upper confining unit, where present. The recharge rate to the aquifer system (including the Galena-Platteville units) in DeKalb and Kendall Counties, where the upper confining unit is absent, is about 0.38 in/yr (Walton, 1965). The recharge rate to the aquifer system in northeastern Illinois where the upper confining unit is present is about 0.03 in/yr (Walton, 1960). The role of the Sandwich Fault Zone on recharge to the aquifer system has not been characterized.

Oxygen and hydrogen isotopic data also indicate that a substantial portion of the water in the Cambrian-Ordovician aquifer system in northeastern Illinois may have recharged to the aquifer more than 10,000 years ago (Perry and others, 1982). Isotope samples collected from the Ironton-Galesville aquifer in Yorkville as part of this investigation indicate that as much as 19 percent of the water in the aquifer may be more than 10,000 years old (appendix A). These age estimates indicate low volumes of flow through the aquifer under natural (predevelopment) conditions and that the aquifer is in poor hydraulic communication with overlying and underlying geologic units and surface-water bodies. Interpretations based on analysis of isotopic data are consistent with interpretations based on geologic and hydrologic analysis.

Prior to its extensive utilization for water supply, which began in the 1850's, the potentiometric surface of the Cambrian-Ordovician aquifer system in northeastern Illinois was presumed to be between about 675 and 750 ft above NGVD 29 in Kendall County (fig. 28). Flow through the aquifer system beneath the county was generally from north to south, from recharge areas in and near DeKalb County toward the Illinois River (located near the 550 ft contour on figure 28). Beginning sometime after the mid 1860's and continuing to the present (2004), pumping from the Cambrian-Ordovician aquifer system in northeastern Illinois has resulted in a decline in water levels in the aquifer system. By 2000, the altitude of the potentiometric surface varied from about 650 ft in the northwestern part of the county to less than 150 ft in the eastern part (fig. 29). Ground-water flow is now from west to east toward pumping centers in the greater Chicago area (Sasman and others, 1967; Kirk and others, 1979, 1982, 1985; Kirk, 1987). These data indicate a decrease in the potentiometric surface of between about 100 and 600 ft beneath the county, which may have resulted in the desaturation of the upper part of the Ancell aquifer in small area in the northeastern part of the county.

Lower Confining Unit

The Proviso and Lombard Members of the Eau Claire Formation form a major confining unit in northern Illinois. This unit, referred to as the lower confining unit in this report, is equivalent to the Basal Sandstone Confining Unit identified by Visocky and others (1985). The lower confining unit restricts flow between the Mt. Simon aquifer and the Ironton-Galesville aquifer. In northern Illinois, this confining unit has an estimated K_v of 4.7 x 10^{-6} ft/d and a leakage coefficient of 1.0 x 10^{-8} to 2.0 x 10^{-7} ft/d/ft.

Mt. Simon Aquifer

The Elmhurst and Mt. Simon Sandstones constitute the Mt. Simon aquifer. The upper part of the Mt. Simon aquifer is used for water supply in parts of north-central Illinois, including southern Kane County. The Mt. Simon aquifer is not utilized in Kendall County, but is a potentially viable source of additional water supply if properly utilized. Because much of the sandstone that composes the aquifer is well cemented, the upper 300-600 ft of the aquifer is the most productive part. At an altitude of more than about -1,300 ft NGVD 29, water in the Mt. Simon aquifer is too saline for use as drinking water (Suter and others, 1959). The Mt. Simon aquifer in Kendall County may have a transmissivity of about 1,400 ft^2/d and a storage coefficient of about 0.00018 based on the results of aquifer testing at one location in northwestern LaSalle County (Visocky and others, 1985). The Mt. Simon aquifer is estimated to have an average K_h of about 2.1 ft/d (Suter and others, 1959). Post-development water levels in the Mt. Simon aquifer appear to be more than 50 ft higher than in the overlying Ironton-Galesville aquifer in northeastern Illinois, indicating the potential for upward flow from the Mt. Simon aquifer into the lower confining unit and the Ironton-Galesville aquifer (Csallaney and Walton, 1963).

GROUND-WATER QUALITY

Water quality of the glacial drift and bedrock aquifers of Kendall County was evaluated by review of publicly accessible data available from ground-water studies conducted by the USGS, USEPA, ISWS, Illinois State Geological Survey (ISGS), and other agencies, and from routine sampling of municipal-supply wells by the IEPA. Aside from nitrate sampling performed on new residential-supply wells, publicly available ground-water-quality

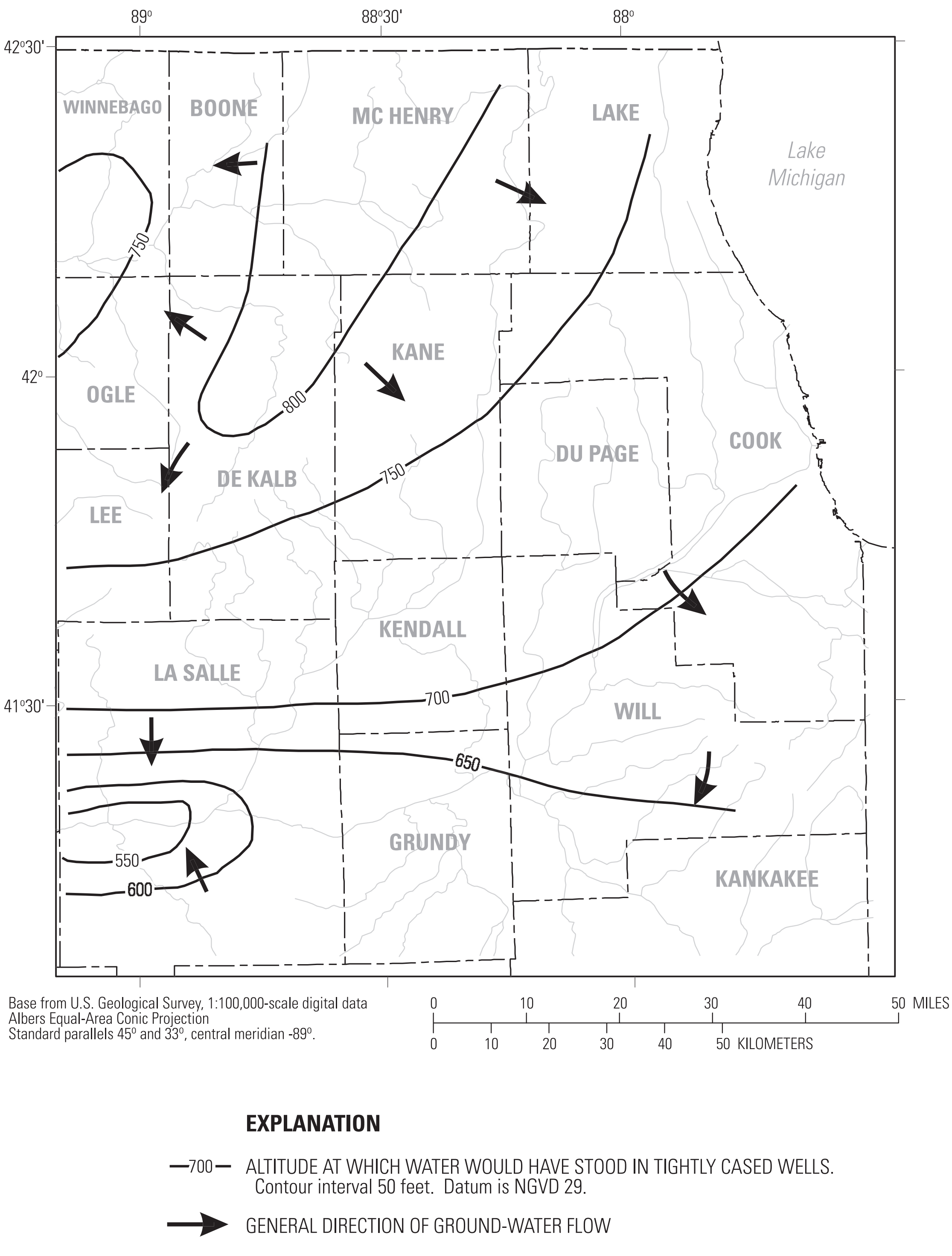


Figure 28. Potentiometric surface of the Cambrian-Ordovician aquifer system in northeastern Illinois in 1865 (modified from Burch, 2002).

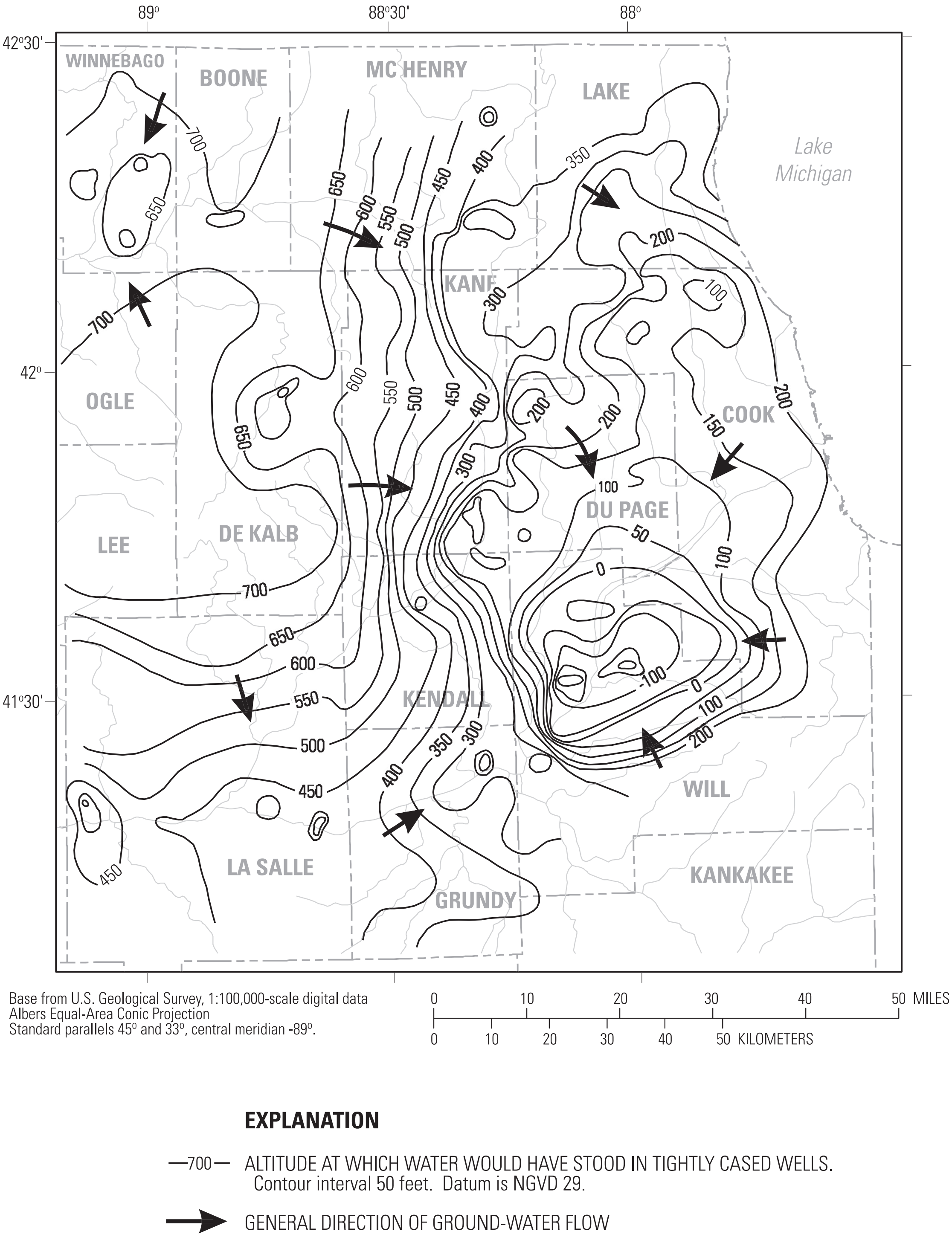


Figure 29. Potentiometric surface of the Cambrian-Ordovician aquifer system in northeastern Illinois in 2000 (modified from Burch, 2002).

data were limited to sample results from 41 municipal-supply, industrial-supply, residential, and monitoring wells in the county. Therefore, water-quality data available at a multicounty scale were used to supplement the understanding of the distribution and concentration of selected constituents in ambient ground water in Kendall County. Hydrogeologic conditions that may allow for contamination of near-surface (within about 50 ft) ground water in the county also are evaluated.

Investigative reports pertaining to possible ground-water contamination from *point sources* typically are not publicly available or widely distributed. Only water-quality data from wells at or near the four known hazardous-waste disposal sites on file at the USEPA Office of Superfund, Chicago, Ill., were evaluated for this study (Illinois Environmental Protection Agency, 1989, 1990a, 1990b, 1992, 1993, 1995,1997; Metcalf and Eddy, Inc., 1995, 1996; Ecology and Environment, Inc., 1987, 1988). Contaminants from wastes deposited at these sites may have affected local ground-water quality. Thus, water quality associated with selected wells at these sites is described separately from that of ambient water quality.

Glacial Drift Aquifers

Water-quality data from four current (2004) and two abandoned municipal-supply wells open to glacial drift aquifers in Plano and Yorkville were reviewed. Sample collection began in the early 1970's, with most of the samples collected from 1985 through 2000. Water-quality data from three unaffected residential or monitoring wells near hazardous-waste disposal sites in or near Oswego, Plano, and Yorkville also were reviewed. Water-quality data generally are from wells 40-ft deep or less. The data do not indicate substantial water-quality concerns that would prevent the use of water from the glacial drift aquifers underlying Kendall County.

Selected Major Ions and Trace Elements

As many as 24 water samples collected from nine wells open to glacial drift aquifers in Kendall County were analyzed for major ions and trace elements, including indicators of the aesthetic ground-water quality (iron, fluoride, chloride, sulfate, and total dissolved solids (TDS)) (table 7). For most samples, concentrations of major ions, selected trace elements, and aesthetic indicators were below their established SCMLs. The concentration of iron in one sample exceeded the SCML.

Analyses of major ions in ground water from glacial drift aquifers in neighboring counties indicate the water is of calcium-bicarbonate type, typified by alkalinity concentrations that are often greater than hardness concentrations and almost equal to the TDS content (Suter and others, 1959). Hardness in ground water from northeastern Illinois typically ranges from about 100 to 450 mg/L, with a median of 275 mg/L. Although iron concentrations in samples collected from Kendall County were below the SMCL of 0.3 mg/L in all but one sample, the SMCL was exceeded in 80 percent of samples collected from glacial drift aquifers (or the hydraulically connected Silurian aquifer) in northeastern Illinois.

Trace-element analyses include metals, cyanide, and arsenic. Concentrations of essentially all metals were below established MCLs or SMCLs. Manganese concentrations in various samples (maximum of 0.43 mg/L, Yorkville) exceeded the SCML of 0.05 mg/L. Cadmium concentrations equal to the MCL of 0.005 mg/L were detected in samples from one well in Plano in 1982 and 1990, but the concentration was less than the reporting limit of 0.005 mg/L when this well was sampled in 1997 (Illinois Environmental Protection Agency, written commun., 2004). Lead was detected at a concentration of 0.005 mg/L in a single sample from a well in Plano; however, lead concentrations were less than the reporting limit of 0.005 mg/L in subsequent samples.

Arsenic commonly is detected at concentrations above its MCL (0.01 mg/L) in samples from glacial drift aquifers in Illinois (Warner and others, 2003) and is a compound of special concern because of its low MCL. Arsenic was not detected in the available samples from Kendall County at the variously applied reporting limits of 0.01 and 0.02 mg/L; thus, arsenic concentrations in glacial drift aquifers in Kendall County can be assumed to be generally below the MCL. Arsenic concentrations also can be estimated based on iron and manganese concentrations (Warner and others, 2003). Using this technique, arsenic concentrations are estimated to range from less than 0.001 mg/L in the north-central and far southeastern parts of the county to between about 0.005 and 0.025 mg/L in the far southwestern part (fig. 30); note that concentrations and their uncertainty are given in micrograms per liter (μg/L) in this figure. However, because of the scarcity of arsenic data collected in and near Kendall County, the uncertainty in these estimates is substantial; concentrations could approach 0.013 mg/L in the north-central and far southeastern parts of the county and range from less than 0.001 mg/L to as much as 0.037 mg/L in the far southwestern part (fig. 30).

Radionuclides and Volatile Organic Compounds

Data on radionuclides in glacial drift aquifers in Kendall County are available from only two wells (Plano and Yorkville). One sample from each well has been analyzed for gross-alpha and -beta activity, with measured activities below MCLs (table 7). This result is consistent with other studies indicating that concentrations of radionuclides in water from the glacial drift and shallow bedrock aquifers in northern Illinois are below MCLs (Emrich and Lucas, 1963). Statewide sampling for radon in ground water from glacial drift and bedrock aquifers has been conducted recently (2001-02) by the IEPA (Joseph Konczyk, Illinois Environmental Protection Agency, oral commun., 2004). Although the data and interpretive results of this sampling are not available, these results may prove useful for future considerations of radionuclide concentrations in ground water in Kendall County and the surrounding area.

Water samples from nine wells open to glacial drift aquifers in Kendall County have been analyzed for the presence of volatile organic compounds (VOCs). 1,1,1-trichloroethane (111-TCA) (at a maximum concentration of 80 μg/L; subsequent analyses indicated concentrations less than 10 μg/L) and other VOCs were detected in samples from two municipal-supply wells in Plano. Concentrations of all detected VOCs are below their respective MCLs, indicating that this water does not present a health risk (table 7) (U.S. Environmental Protection Agency, 2004).

Agricultural-Related Constituents

As many as 15 water samples were collected from six municipal wells open to glacial drift aquifers in Kendall County and analyzed for the agricultural-related constituents nitrogen (in the form of nitrate (plus nitrite, which generally is not detected in ground water) and ammonium) and phosphorus (in the form of phosphate) (table 7). The concentration of nitrate (as nitrogen) exceeded the MCL (10 mg/L) in only one sample (13.2 mg/L), collected in 1971 from a well open to the glacial drift in Yorkville that has since been abandoned. Nitrate concentrations as high as 9.7 mg/L have been detected in samples from wells in Plano (Illinois Environmental Protection Agency, written commun., 2004). Ammonium concentrations typically were less than the detection limit of 0.1 mg/L in the glacial drift aquifers at Plano and Yorkville. Phosphorus concentrations were 0.64 mg/L or less in all samples.

Nitrate analyses of samples collected from 17 residential-supply wells open to glacial drift aquifers during 1994-95 on file with the Kendall County Health Department were reviewed. The wells ranged in depth from 56 to 260 ft. The nitrate concentration of one sample equaled the MCL (10 mg/L), which also was the reporting limit for most of these samples. This sample was from a 256-ft deep well. Nitrate was detected at a concentration of 4 mg/L in one other well in the Plano area. The high reporting limit (usually 10 mg/L) for the sample analyses precludes readily assuming a low susceptibility of the glacial drift aquifer to nitrate contamination from the results of this assessment.

As many as seven water samples were collected from three municipal wells open to glacial drift aquifers in the county and analyzed for pesticides (insecticides and herbicides). Of the various organic compounds analyzed, only the herbicide atrazine (maximum concentration of 0.37 μg/L) was detected intermittently in samples from one municipal-supply well in Plano. Concentrations were substantially below the MCL (3 μg/L) (table 7). Degradates (also referred to as transformation products or metabolites) of atrazine and the herbicides alachlor

Table 7. Maximum concentration of selected constituents in ambient ground water from glacial drift aquifers underlying Kendall County, Illinois.

[µg/L, micrograms per liter; mg/L, milligrams per liter; --, not applicable; MCL, Maximum Contaminant Level (U.S. Environmental Protection Agency, 2004); SMCL, Secondary Maximum Contaminant Level (U.S. Environmental Protection Agency, 2004); <, less than; TT, treatment technology; pCi/L, picocuries per liter]

Constituent[1]	Maximum concentration (µg/L)	Maximum concentration (mg/L)	Approximate number of samples/wells	Water-quality standard or guideline, in respective units
Volatile organic compounds	[2]80	--	28/9	[3]200 MCL
Phenols	<10	--	10/16	--
Methyl *Tert*-Butyl Ether (MTBE)	--	--	0/0	--
Atrazine	[4]0.37	--	7/3	3 MCL
Alachlor ESA[5]	.30	--	2/1	--
Metolachlor ESA	.71	--	1/1	--
Ammonium, as N	--	0.17	15/6	--
Nitrate, as N [6]	--	13.2	15/6	10 MCL
Phosphate, as P	--	.01	10/6	--
Iron	--	[7]2.6	18/7	0.3 SMCL
Sodium	--	9	24/9	--
Potassium	--	4.3	24/9	--
Calcium	--	102	24/9	--
Magnesium	--	49.4	24/9	--
Strontium	--	.15	15/6	--
Boron	--	.05	15/6	--
Silica	--	17	24/9	--
Fluoride	--	.21	15/6	2 SCML
Chloride	--	41.8	15/6	250 SMCL
Sulfate	--	106	18/8	250 SMCL
Alkalinity, as $CaC0_3$	--	303	15/6	--
Hardness, as $CaC0_3$	--	446	5/3	--
Total dissolved solids	--	480	1/1	500 SMCL
Arsenic	--	<.02	18/7	0.01 MCL
Barium	--	.07	22/9	2 MCL
Copper	--	.11	24/9	1 SCML
Cadmium	--	.01	18/7	0.005 MCL
Chromium	--	.05	24/9	0.1 MCL
Cyanide	--	<.01	18/7	0.2 MCL
Lead	--	.01	24/9	TT MCL
Manganese	--	[6] .433	24/9	0.05 SCML
Mercury	--	.0002	18/7	0.002 MCL
Nickel	--	<.025	16/7	0.1 MCL
Silver	--	<.0003	21/8	0.1 SMCL
Selenium	--	.0002	22/9	0.05 MCL
Zinc	--	.079	24/9	5 SMCL
Alpha activity, in pCi/L	2	--	2/2	15
Beta activity, in pCi/L	3	--	2/2	[8]4

1. Reviewed sample concentrations determined primarily, but not exclusively, from unfiltered raw-water samples. Data from various sources (Gilkeson and others, 1983; Illinois Environmental Protection Agency, 1989, 1990a, 1990b, 1992, 1993, 1995,1997; Illinois Environmental Protection Agency, written commun., 2002; Kolpin and others, 1993; Kolpin and others, 1996; Metcalf and Eddy, Inc., 1995, 1996; Mills and McMillan, 2004; Woller and Gibb, 1974). Note that units for alpha and beta radioactivity are picocuries per liter.

2. 111-trichloroethane. Also detected chloroform and total xylenes.

3. Maximum Contaminant Level for 111-trichloroethane.

4. Also detected degradates (transformation products) of the parent triazine herbicide.

5. Ethane sulfonic acid; degradate of the parent chloracetanilide herbicide.

6. Nitrate + Nitrite. Nitrate, however, generally is not detected in ground water.

7. Detected in one sample, Yorkville, Ill.; other values 0.21 mg/L or less.

8. millirems per year (mrems/yr). Average annual concentrations assumed to produce a total body (or organ) dose of 4 mrems/yr—tritium=20,000 pCi/L; strontium-90= 8 pCi/L.

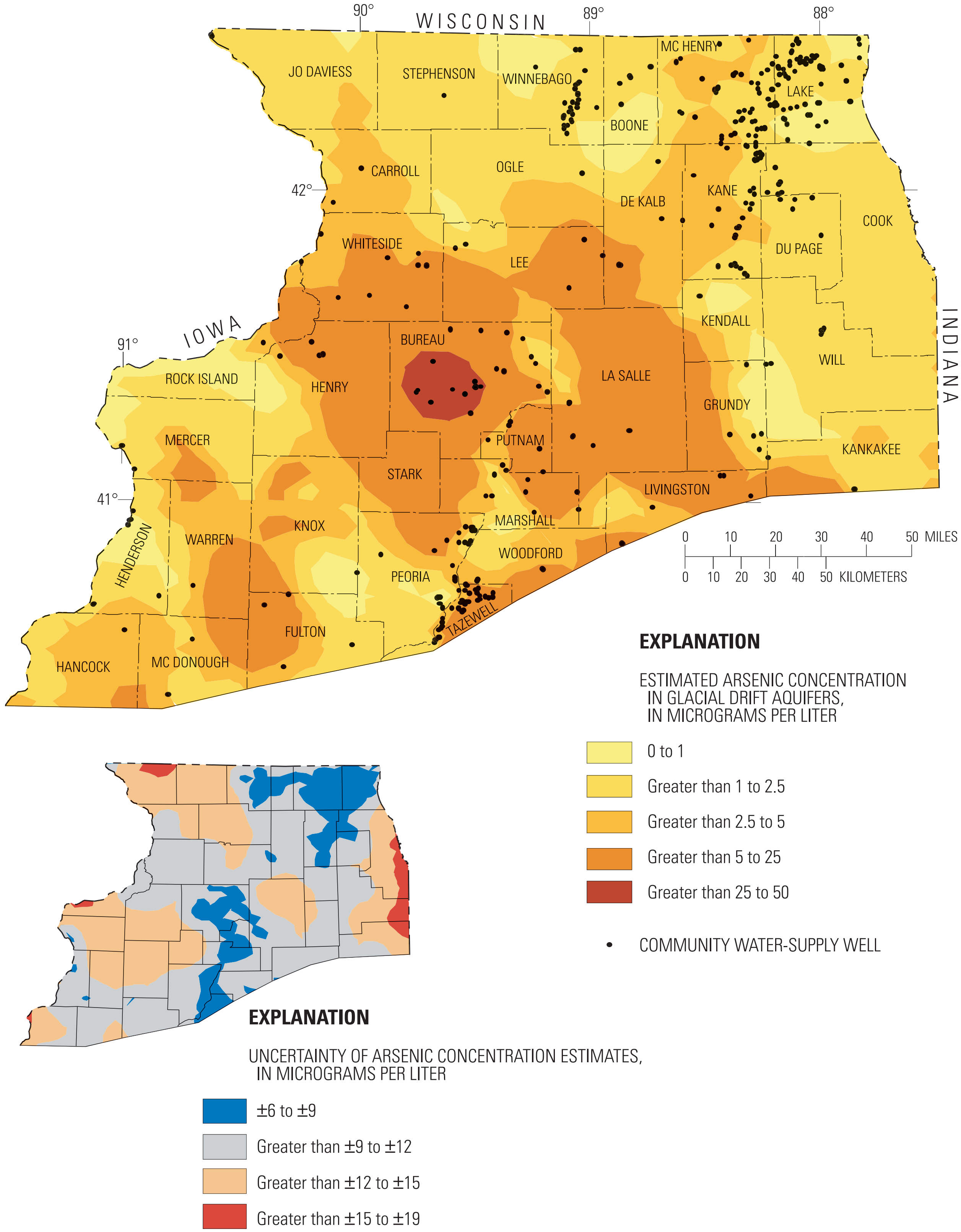


Figure 30. Estimated arsenic concentrations in association with iron and manganese in glacial drift aquifers in northern Illinois (modified from Warner and others, 2003).

and metalochlor also have been detected in the one sample where these analyses were performed (table 7).

Analysis of water-quality data indicate that the glacial drift aquifers in parts of Kendall County are susceptible to contamination by industrial and agricultural chemicals, particularly those aquifers that are near the land surface. Because these aquifers appear to have the capacity for additional water-supply development, water-quality issues should be considered prior to development.

Bedrock Aquifers

Water-quality data from 14 current (2004) and 1 abandoned municipal-supply well open to bedrock aquifers in Kendall County were reviewed. The wells are in or near Newark, Oswego, Plano, and Yorkville. Sample collection began in the early 1970's, but most samples were collected from 1985 through 2004. The wells range in depth from 187 to 1,483 ft and are open, in part, or entirely to the shallow bedrock aquifer, the Ancell aquifer, the undifferentiated Cambrian-Ordovician aquifer system, or the Ironton-Galesville aquifer. Water-quality data from 14 residential or monitoring wells located, in part, near two hazardous-waste sites in or near Oswego and Yorkville and three industrial wells; located in Yorkville, Plano, and Newark, also were reviewed. Water-quality data from wells open to the shallow bedrock aquifer are included in this discussion of bedrock aquifers. However, water quality in the shallow bedrock aquifer usually is similar to that of the overlying glacial drift aquifers, with which they are usually in direct hydraulic connection (Suter and others, 1959).

Selected Major Ions and Trace Elements

As many as 50 water samples were collected from 22 wells open to bedrock aquifers in the county and analyzed for major ions and trace elements, including indicators of the aesthetic quality of ground water (table 8). For most constituents with established SMCLs (fluoride, chloride, sulfate, and TDS), concentrations typically were below SMCLs.

Iron concentrations exceed the SMCL (0.3 mg/L) in samples taken from about 60 percent of the wells sampled and in 38 percent of all samples collected. The wells are open to all bedrock aquifers used for water supply in the county. The highest concentration of iron (5.57 mg/L) was detected in a sample from a well in Yorkville. This well was constructed in 1900 and is open to the Ancell aquifer. Other iron concentrations that exceeded the SMCL in this well ranged from about 1.14 to 5.0 mg/L. Because lower concentrations of iron were detected in nearby wells open to the Ancell aquifer, the elevated concentrations of iron in the Yorkville well may represent localized conditions. Throughout most of northeastern Illinois, iron concentrations in the Ancell and Ironton-Galesville aquifers typically were less than 0.4 mg/L (Suter and other, 1959). Iron concentrations above the SMCL in samples from these aquifers have been attributed, in part, to contributions from the glacial drift and Silurian aquifers, either where wells are not cased through the overlying aquifers or the annulus adjacent to the well casing is inadequately grouted, allowing for leakage around the wellbore. In addition, the metallic well casing or distribution lines of these typically deep wells (200 to 1,378 ft), and of some wells constructed more than about 40 years ago, may contribute to the elevated iron concentrations in the water samples.

Analyses of water samples from the Cambrian-Ordovician aquifer system in northeastern Illinois indicate hardness, as $CaCO_3$, ranged from about 200 to 250 mg/L; fluoride concentrations typically were about 1.0 mg/L (Suter and others, 1959). Water from the Galena-Platteville aquifer regionally is characterized by alkalinity greater than about 350 mg/L, hardness less than about 100 mg/L, a general absence of sulfate, and a common presence of detectable hydrogen sulfide (Suter and others, 1959).

Total dissolved solids concentrations marginally exceeded the SMCL of 500 mg/L in samples from two public-supply wells in the eastern part of the county (table 8). These wells are finished at depths of 187 ft (shallow bedrock aquifer) and 700 ft (Ancell aquifer). Typical TDS concentrations in samples from wells open to the Cambrian-Ordovician aquifer system in Kendall County are about

300 to 500 mg/L. Generally, these concentrations are highest in the deep units of the Cambrian-Ordovician aquifer system. Concentrations of TDS typically are correlated highly with concentrations of chloride. Chloride concentrations as high as 600 mg/L have been recorded in samples from wells open to the deeper units of the Cambrian-Ordovician aquifer system and the Mt. Simon aquifer in Kane and Du Page Counties (Balding, 1991). Chloride concentrations, as high as 37,000 mg/L, have been recorded in samples from a test well in Lake County open to the basal part of the Mt. Simon aquifer and the top of the Precambrian crystalline-basement rocks (Nicholas and others, 1987). The high chloride and TDS values are attributed to connate waters that remain from the initial deposition of these inland-sea units. In some wells open to the lower units of the Cambrian-Ordovician aquifer system in northeastern Illinois, chloride (and TDS) concentrations have increased substantially during decades of pumping. The increased concentrations are partly attributed to the movement of saline water from the Mt. Simon aquifer into the Ironton-Galesville aquifer as water levels in the Cambrian-Ordovician aquifer system declined in response to pumping. In part, because of these increases in chloride and TDS concentrations, some of the wells open to the Mt. Simon aquifer and the Cambrian-Ordovician aquifer system in northeastern Illinois have been shut down since the 1970's, with Lake Michigan providing a replacement source for municipal-water supply.

Trace-element analyses of ground-water samples from wells in Kendall County include metals, cyanide, and arsenic. Concentrations of all metals were below established MCLs (table 8). The concentration of manganese (0.173 mg/L) exceeded the SMCL in one sample. Concentrations of lead ranging from 0.007 to 0.036 mg/L were detected in one sample from each of five wells; however, lead was not detected in subsequent samples from three of the wells. Arsenic concentrations were below the MCL in all samples.

Radionuclides and Volatile Organic Compounds

Gross-alpha radioactivity is an indicator of the concentration of radium and uranium in a sample. Concentrations in samples collected from municipal-supply wells open to the Ancell aquifer at Newark, the Galena-Platteville aquifer near Plano, and the Maquoketa Group at Oswego were below the gross-alpha MCL of 15 pCi/L. These wells are all open to the shallow bedrock aquifer and these results are consistent with regional analyses that indicate radionuclide concentrations in the shallow bedrock aquifer are low (Gilkeson and others, 1983; Illinois Environmental Protection Agency, written commun., 1998). Concentrations of gross-alpha and gross-beta radioactivity were below the MCL in one sample from the Ancell aquifer near Oswego. Gross-alpha radioactivity exceeded the MCL in samples from two wells open to the Cambrian-Ordovician aquifer system in Kendall County. Samples collected from seven municipal-supply wells open to the Cambrian-Ordovician aquifer system in Yorkville, Oswego, and Montgomery (Gilkeson and others, 1983; Illinois Environmental Protection Agency, written commun., 1998), one industrial-supply well open to the Ancell aquifer near Plano, and one well open to the Ancell through New Richmond Sandstones near Newark were analyzed for concentrations of radium (226 or 226+228). Combined radium concentrations in these samples ranged from 5.1 to 15.4 pCi/L, exceeding the MCL (table 8).

These results are consistent with regional investigations that indicate radium naturally occurs at concentrations above its MCL in the Cambrian-Ordovician aquifer system (figs. 31a, b) and the Mt. Simon aquifer (fig. 31c) in parts of northern Illinois (Emrich and Lucas, 1963; Gilkeson and others, 1983; Kay, 1999; U.S. Geological Survey, 2004). Radium concentrations in these aquifers are most likely to exceed the MCL where the Maquoketa Group (upper confining unit) is present. However, radium concentrations may exceed the MCL where the confining unit is absent and may be below the MCL where it is present. On the basis of the regional analyses and the data collected in the county, radium concentrations in the Ironton-Galesville aquifer may exceed the MCL throughout the county, but are most likely to exceed the MCL in the eastern half of the county (fig. 31b). Radium concentrations in the Ancell aquifer are unlikely to exceed the MCL where the Ancell Group is at

Table 8. Maximum concentration of selected constituents in ambient ground water from bedrock aquifers underlying Kendall County, Illinois.

[µg/L, micrograms per liter; mg/L, milligrams per liter; --, not applicable; MCL, Maximum Contaminant Level (U.S. Environmental Protection Agency, 2004); SMCL, Secondary Maximum Contaminant Level (U.S. Environmental Protection Agency, 2004); <, less than; ND, not detected; TT, treatment technology; pCi/L, picocuries per liter]

Constituent[1]	Maximum concentration (µg/L)	Maximum concentration (mg/L)	Approximate number of samples/wells	Water-quality standard or guideline, in respective untis
Volatile organic compounds	[2]2.4	--	38/28	1 MCL
Phenols	<10	--	27/13	--
Pesticides or degradates	ND	--	8/3	--
Ammonium, as N	--	1.3	42/13	--
Nitrate, as N [3]	--	5.6	46/16	10 MCL
Phosphate, as P	--	0.64	37/13	--
Iron	--	5.57	53/23	0.3 SMCL
Sodium	--	162	52/22	--
Potassium	--	20	48/19	--
Calcium	--	99	53/23	--
Magnesium	--	52	52/22	--
Strontium	--	2.06	42/13	--
Boron	--	.66	42/13	--
Silica	--	17.5	49/20	--
Fluoride	--	1.5	44/14	2 SCML
Chloride	--	112	46/16	250 SMCL
Sulfate	--	160	46/16	250 SMCL
Alkalinity, as $CaC0_3$	--	396	45/15	--
Hardness, as $CaC0_3$	--	390	46/16	--
Total dissolved solids	--	550	12/10	500 SMCL
Arsenic	--	.005	52/22	0.01 MCL
Barium	--	1.18	52/22	2 MCL
Copper	--	.167	52/22	1 SCML
Cadmium	--	<.003	50/20	0.005 MCL
Chromium	--	.013	52/22	0.1 MCL
Cyanide	--	.09	50/21	0.2 MCL
Lead	--	.036	52/22	TT MCL
Manganese	--	.173	52/22	0.05 SCML
Mercury	--	.00008	52/22	0.002 MCL
Nickel	--	.058	50/21	0.1 MCL
Silver	--	.0004	49/20	0.1 SMCL
Selenium	--	<.0001	52/22	0.05 MCL
Zinc	--	.29	52/22	5 SMCL
Alpha activity, in pCi/L	17	--	11/11	15
Beta activity, in pCi/L	23	--	9/9	[4] 4
Radium-226 or 226+228, in pCi/L	15.4	--	9/9	5 MCL
Uranium-234+238, in pCi/L	1.3	--	3/3	[5] 30 MCL

1. Reviewed sample concentrations determined primarily, but not exclusively, from unfiltered water samples. Data from various sources (Gilkeson and others, 1983; Illinois Environmental Protection Agency, written commun., 2002; Illinois Environmental Protection Agency, 1990a, 1995,1997; Kendall County Health Department files; Kolpin and others, 1993; Kolpin and others, 1996; Metcalf and Eddy, Inc., 1995, 1996; Mills and McMillan, 2004; Woller and Gibb, 1974). Note that units for alpha and beta radioactivity are picocuries per liter.

2. Toluene. Also detected trichlorofluoromethane, Oswego, Ill., residential well; chloromethane and chloroform, Yorkville, Ill., residential well.

3. Nitrate + Nitrite. Nitrate, however, generally is not detected in ground water.

4. millirems per year (mrems/yr). Average annual concentrations assumed to produce a total body (or organ) dose of 4 mrems/yr—tritium=20,000 pCi/L; strontium-90=8 pCi/L.

5. MCL units are in mg/L.

the bedrock surface, may exceed the MCL in the western part of the county where the upper confining unit is absent, and are likely to exceed the MCL in the eastern part of the county where the confining unit overlies the aquifer (fig. 31a). The vertical distribution of radium concentrations in the Ancell aquifer is not known and the potential for radium concentrations to exceed MCLs in residential-supply wells beneath the county, which typically are open to less than 50 ft of the aquifer, has not been determined.

Uranium (236+238) concentrations have been analyzed for in one sample from a well open to the Cambrian-Ordovician aquifer system in Yorkville (Gilkeson and others, 1983) and two wells open to the Ironton-Galesville aquifer. The uranium concentration in these samples was substantially below the MCL (table 8).

Thirty-eight water samples from 28 wells open to bedrock aquifers have been analyzed for VOCs in Kendall County. Toluene (maximum concentration, 2.4 μg/L), as well as other VOCs (primarily well-disinfectant products) have been detected in samples from two residential wells in Oswego and Yorkville. All VOC concentrations were below MCLs (U.S. Environmental Protection Agency, 2004). The infrequent occurrence and low concentration of VOCs in samples from the bedrock aquifers indicate that these aquifers are generally not as vulnerable to contamination as the glacial drift aquifers. Ground-water contamination may occur locally where bedrock units are within about 50 ft of the land surface (fig. 13), particularly if the overlying units are sand and gravel and a VOC source is nearby.

Agricultural-Related Constituents

As many as 42 water samples collected during multiple sampling events of 16 municipal-supply wells open to the bedrock aquifers have been analyzed for the agricultural-related nutrients nitrogen (as nitrate and ammonium) and phosphate (table 8). Concentrations of nitrate (as nitrogen) were below the MCL in all samples. Ammonium was detected in almost all of the samples, almost always at concentrations of less than 1 mg/L. These concentrations indicate that the bedrock aquifers underlying the county generally are not as vulnerable to contamination by nitrogen-based fertilizers or other nutrients as the glacial drift aquifers.

Results of nitrate analyses on file with the Kendall County Health Department were reviewed for 129 residential-supply wells open to the bedrock aquifers collected during 1994-95. These wells ranged in depth from 42 to 640 ft. Nitrate was detected at a concentration of 2 mg/L or less in five of these wells at locations scattered throughout the county and at depths as great as 540 ft. These low nitrate concentrations indicate the generally low susceptibility of bedrock aquifers in Kendall County to contamination by nitrogen-based fertilizers.

As many as eight water samples collected from three wells open to the bedrock aquifers have been analyzed for insecticides and herbicides. One sample also was analyzed for herbicide degradates. None of these pesticide compounds were detected.

Water Quality at and near Hazardous-Waste Disposal Sites

Hazardous-waste disposal sites that may contribute to environmental contamination are routinely identified and investigated by the IEPA or USEPA. Review of records maintained by the USEPA, Office of Superfund, Chicago, of industrial or landfill sites that may have degraded surface- or ground-water quality in Kendall County identified four sites considered hazardous-waste disposal sites by USEPA or IEPA: Saw Wee Kee Park, about 1.5 mi southwest of Oswego; Remline (Model Industries) about 1 mi north of Yorkville; Nelson Landfill, about 3.5 mi northwest of Yorkville; and Monarch Foundry, Plano (Illinois Environmental Protection Agency, 1989, 1990a, 1990b, 1992, 1993, 1995,1997; Metcalf and Eddy, Inc., 1995, 1996; Ecology and Environment, Inc., 1986, 1987, 1988). Preliminary investigations at these sites during 1984-97 indicated periodic detections of VOCs, major ions, and trace elements in ground water at concentrations that exceeded MCLs (U.S. Environmental Protection Agency, 2004). Presently (2004), the distribution and concentrations of these constituents in ground water have not been considered substantial enough by USEPA to warrant placement of these sites on the USEPA National Priorities List (that is, designation as Superfund sites requiring remediation).

Saw Wee Kee Park currently (2004) is a unit of the Oswego Park District and is located along the south side of the Fox River. Prior to the 1940's, gravel mining was conducted in the area of the park and the mined areas were later used for landfilling of municipal wastes, reportedly including some industrial and medical wastes (Metcalf and Eddy, Inc., 1995, 1996). Quaternary units at the site consist of sand and gravel. Bedrock is within about 18 ft and the water table is within about 5 ft of land surface. During 1995-97, water samples were collected from three area ponds, six monitoring wells at the site open to the sand-and-gravel units, and eight residential wells near the site that were open to the bedrock units. Arsenic, beryllium, cadmium, chromium, antimony, lead, and nickel each have been detected periodically at concentrations less than an order of magnitude above their respective MCLs (U.S. Environmental Protection Agency, 2004) in samples from at least one well. One of the

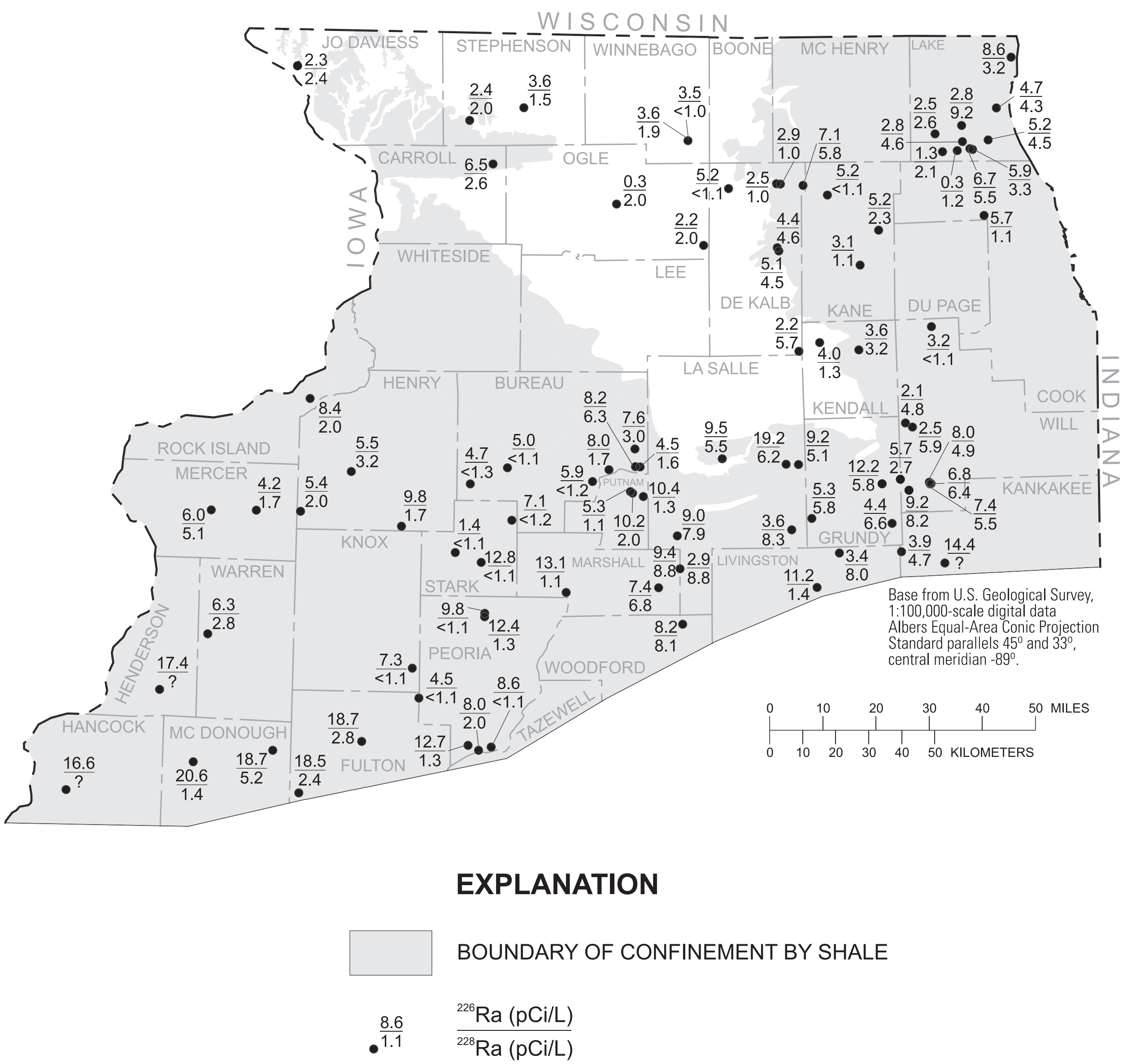


Figure 31a. Radium concentrations in select wells finished in the Ancell aquifer in northern Illinois (data primarily from Gilkinson and others, 1983; and Illinois Environmental Protection Agency, written comm., 1998. ^{226}Ra, Radium 226; ^{228}Ra, Radium 228; pCi/L, picocuries per liter).

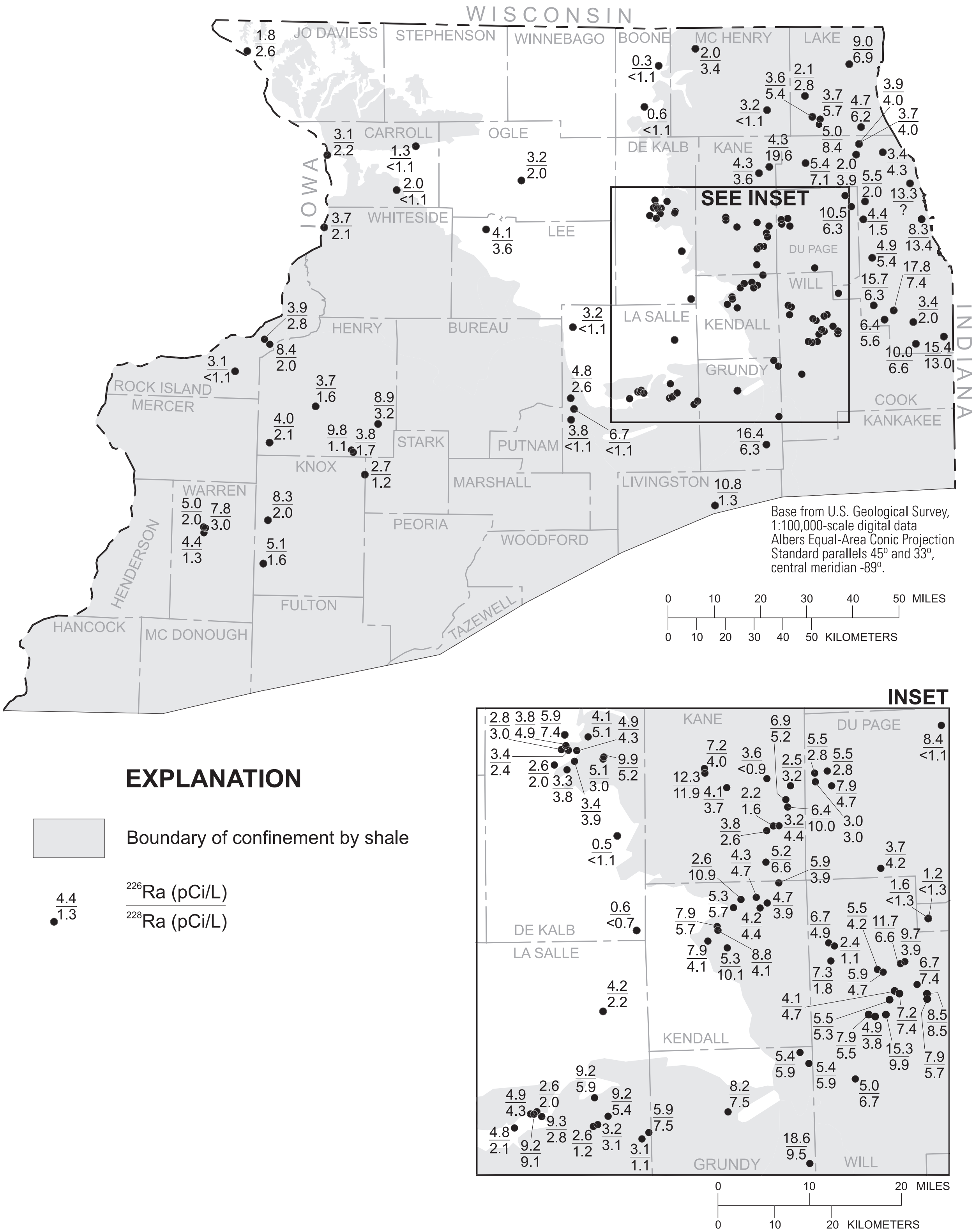


Figure 31b. Radium concentrations in select wells finished in the Ironton-Galesville aquifer in northern Illinois (data primarily from Gilkinson and others, 1983; and Illinois Environmental Protection Agency, written comm., 1998. ^{226}Ra, Radium 226; ^{228}Ra, Radium 228; pCi/L, picocuries per liter).

wells where constituents with concentrations above MCLs were detected was upgradient (upriver) of the site, indicating that surface- and shallow ground-water quality may be degraded along localized reaches of the Fox River within and downstream of urbanized areas of the county. Pesticides, VOCs, and semivolatile organic compounds (SVOCs) were not detected in samples collected from the monitoring wells (Metcalf and Eddy, Inc. 1995, 1996). Ground-water gradients at the site indicate that shallow flow within Quaternary units is predominantly towards the Fox River. Low concentrations of a chlorinated solvent (trichloroethene (TCE), 0.6 μg/L) and a petroleum-related compound (toluene, 2.4 μg/L) detected in one sample from a 310-ft-deep residential well indicate the potential for downward flow from the sand-and-gravel to the bedrock units (should these VOCs be evidence of in-situ water quality and not a sampling artifact). There is no record of sampling for medical wastes in surface or ground water at the site.

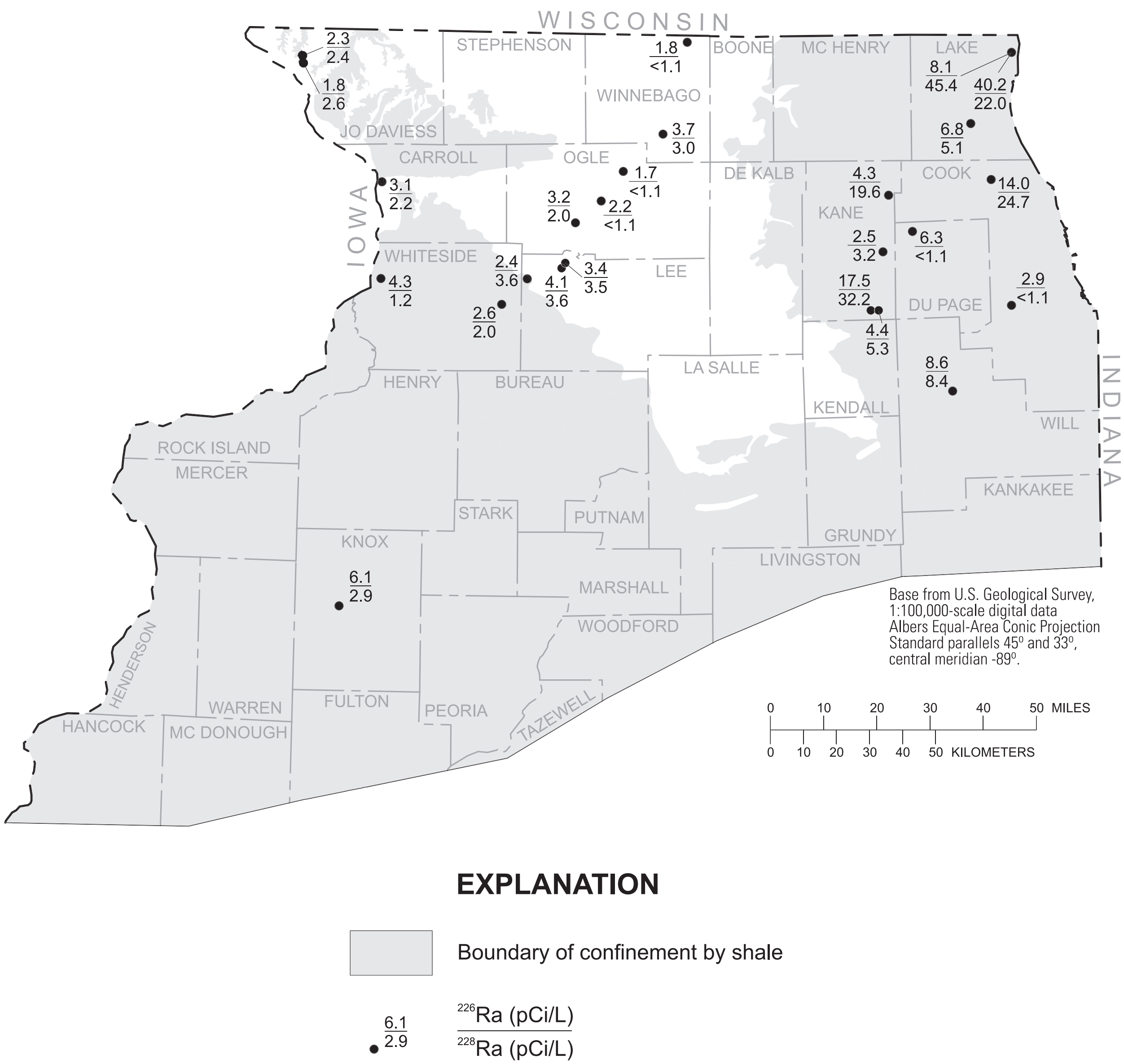


Figure 31c. Radium concentrations in select wells finished in the Mt. Simon aquifer in northern Illinois (data primarily from Gilkinson and others, 1983; and U.S. Environmental Protection Agency, written comm., 1998. ^{226}Ra, Radium 226; ^{228}Ra, Radium 228; pCi/L, picocuries per liter).

Remline (Model Industries) operated a manufacturing facility prior to about 1990 where paints, paint wastes, and organic solvents were buried, stored in underground tanks, or disposed of in a septic field (Illinois Environmental Protection Agency, 1990a, 1997). Quaternary units at the site consist of sand and gravel within about 10 ft of land surface. Bedrock is within about 60 ft and the water table is within about 5 ft of land surface. In 1993, water samples were collected from six water-supply wells, three on the site and three near the site (Illinois Environmental Protection Agency, 1997). One well was open to the sand-and-gravel units and the remaining five wells were open to the bedrock units. Concentrations of all major and trace elements were less than their respective regulatory levels. Although the chlorinated solvent TCE was detected at a concentration of 740,000 μg/L in a sample from the septic leach field in 1984 (prior to the documented site investigations), detection of VOCs in the 1993 samples from the water-supply wells were below MCLs. Less than 1 μg/L of TCE and two other organic compounds were detected in one of the water-supply wells on the site; similarly low concentrations of disinfectant-related compounds were detected in samples from three wells near the site. Trace concentrations of three or fewer tentatively identified SVOCs were detected in all the wells open to the bedrock aquifers.

Nelson Landfill operated initially as a gravel-mining facility and later was used for landfilling municipal wastes, reportedly including some industrial wastes (Ecology and Environment, Inc., 1986, 1987, 1988). Leachate samples indicated toluene at a concentration (1,800 μg/L) above its MCL. Phenols and alcohol compounds also were detected. Quaternary units at the site consist of surficial sand and gravel likely to be in excess of 100 ft thick. Bedrock in the area of the site is about 100 ft deep and the water table is within about 12 ft of land surface. During 1985-88, water samples were collected for analysis from seven monitoring wells at the landfill and five nearby residential-supply wells. The trace element mercury (in a well not affected by the landfill), the pesticide aldrin, various VOCs, and cyanide were detected in the monitoring-well samples, with concentrations of mercury and the VOC vinyl chloride exceeding their respective MCLs in at least one sample from the immediate vicinity of the landfill. SVOC analyses did not indicate the presence of these compounds in the ground water. Pesticides, VOCs, and cyanide were not detected in samples from the residential-supply wells.

Monarch Foundry operated a manufacturing facility prior to about 1990 where metal wastes were buried in an adjacent landfill (Illinois Environmental Protection Agency, 1989, 1990b, 1992, 1993). Although use of chlorinated solvents or other organic compounds at the facility has not been recorded, the solvents 111-TCA and tetrachloroethene (PCE) have been detected in near-surface (within 6 in.) soil samples from the area of the landfill. 111-TCA also has been detected in samples from two of Plano's municipal-supply wells since 1985; these shallow (40 ft or less) wells are located hydraulically downgradient and within about 800 ft of the foundry and landfill. Concentrations of 111-TCA in samples from Plano well 4 reached a maximum of 80 μg/L in 1986 (MCL, 200 μg/L). Since 1986, detections have been sporadic, with concentrations less than 10 μg/L. Quaternary units at the site consist of sand and gravel, estimated to be within about 20 ft of land surface. Bedrock is within about 100 ft and the water table is estimated to be within about 20 ft of land surface. During 1990-93, samples were collected for analysis from Plano's four municipal-supply wells and three nearby (within about 0.5 mi) monitoring wells open to the shallow sand-and-gravel units. Detected concentrations of all major and trace elements and 111-TCA were less than their respective MCLs (U.S. Environmental Protection Agency, 2004). No SVOCs or pesticides were detected.

Potential for Ground-Water Contamination

Aquifers, particularly those within about 50 ft of land surface, are susceptible to contamination by a variety of anthropogenic compounds, including agricultural-related constituents and septic and industrial wastes (Kolpin and others, 1993, 1994; Keefer, 1995; Mills and McMillan, 2004). The susceptibility of an aquifer to contamination increases where overlying low permeability materials are thin (less than about 20 ft) or absent. Other lithologic and hydrologic factors that can enhance the leaching potential of soils and, thus, susceptibility of ground water to contamination include well-drained to excessively drained soils (as classified by the U.S. Department of Agriculture (1993)), available water capacity of soil layers (amount of water that a soil can store that is available for use by plants), absence of a *fragic horizon*, soils with slopes less than about 15 percent, and soils with comparatively thick profiles (that may contain crop-related macropores) (Keefer, 1995). For some contaminants, such as organic compounds, the amount of organic carbon in the overlying material also affects the susceptibility of an aquifer to contamination (Keefer, 1995). On the basis of these hydrologic and lithologic factors, the susceptibility of shallow aquifers and other hydrogeologic units to ground-water contamination has been determined in Illinois, including Kendall County.

Four state-scale susceptibility maps have been prepared by the ISGS (Berg and others, 1984; Keefer and others, 1990; Keefer, 1995). A detailed description of the susceptibility categories of these maps is available in their respective cited references. One map (Berg and others, 1984)(scale of 1:500,000) is useful for depicting areas in Kendall County where the potential for contamination of shallow aquifers (less than 50 ft deep) from land burial of municipal wastes is greatest (fig. 32). As depicted, this potential generally is greatest in the areas adjacent to the Fox River and its tributaries, including the west-central, north-central, and northeastern parts of the county. In these areas, sand-and-gravel or permeable bedrock units are within 20 ft of land surface. A high potential for contamination also is present in the south-central part of the county, where thick (more than 50 ft) permeable bedrock units are within 20 ft of land surface. Elsewhere in the county, the potential for aquifer contamination is more limited because thick sequences of low permeability material overlie the aquifers. Areas of the county that are susceptible to ground-water contamination also are depicted in maps of potential for aquifer recharge (Keefer and others, 1990)(scale 1:1,000,000), aquifer sensitivity to contamination by nitrate leaching (Keefer, 1995, fig. 3)(scale 1:1,700,000) (fig. 33), and aquifer sensitivity to contamination by pesticide leaching (Keefer, 1995, fig. 5)(scale 1:1,700,000) (fig. 34). The areas of the county that are depicted in these maps as susceptible to ground-water contamination are similar to those depicted in the map by Berg and others (1984). The southern two-thirds of the county is indicated to have a low susceptibility to ground-water contamination by pesticide leaching (fig. 34) because of the high amounts of organic carbon in the soils in this area.

The potential for contaminant movement within the shallow bedrock aquifer beneath Kendall County is affected by the characteristics of the bedrock. In most of the areas of the county where ground water is susceptible to contamination (fig. 32), the bedrock is composed of dolomite (Silurian or Galena-Platteville units) (fig. 7), often with a network of steeply inclined fractures that project to the bedrock surface and intersect deeper near-horizontal bedding-plane partings. These fractures and partings may penetrate to depths of 300 ft or more, providing conduits for contaminant movement deep within the aquifer (Kay, 2000; Mills and others, 2002). In some locations along the Sandwich Fault Zone (fig. 7), the shallow bedrock aquifer is composed of the St. Peter Sandstone, which may be susceptible to contamination because of its shallow depth and comparatively high permeability. Presently (2004), available water-quality and ground-water-flow data are insufficient to validate assumptions regarding movement of water and contaminants in the shallow bedrock aquifer beneath Kendall County.

WATER USE

All of the water used by the population of Kendall County is supplied by ground water. Detailed estimates of water use collected at least every 5 years for the period from 1957 through 2000 indicate that total water use (and withdrawals from ground water) increased from about 1.2 Mgal/d in 1957 to about 5.2 Mgal/d in 1980, and typically was between about 5.2 and 5.7 Mgal/d from 1980 through 2000 (fig. 35) (Kirk and others, 1979, 1982, 1985; Kirk, 1987; Avery, 1995, 1996, 1999). Although total water withdrawals typically have been consistent since about 1980, the use of the water has varied. The amount of water withdrawn by municipal-supply systems for distribution to their customers (residences, industries, commercial establishments) has increased steadily from about 0.6 Mgal/d in 1957 to about 2.2 Mgal/d in 2000. The amount of water withdrawn by homeowners who rely on their private wells (rural domestic use) has increased steadily from about 0.6 Mgal/d in 1957 to nearly 3.0 Mgal/d in 2000, making this category the single largest use of water in Kendall County. Water withdrawn by industries from their private wells (industrial self supply) was reported to be zero in 1957, increased to about 1.0 Mgal/d in 1970, and has decreased overall to about 0.30 Mgal/d for most of the period from 1988 through 2000. Water withdrawals for use by livestock have decreased slightly from more than 0.30 Mgal/d from 1978 (the first year data were available) through 1990 to less than 0.20 Mgal/d in 1995 and 2000. The amount of water withdrawn for irrigation (including watering of golf courses) has been highly variable, typically about 0.10 Mgal/d but occasionally reaching more than 0.40 Mgal/d. Water withdrawals for use in the generation of thermoelectric power and mining or quarrying operations have not been recorded in Kendall County.

A more detailed analysis of the 2000 water-use data indicates that commercial water use (water used by commercial facilities such as restaurants and office buildings) totaled 0.28 Mgal/d, essentially all of which was delivered from municipal-water supply systems and, therefore, presented as municipal supply in figure 35. Industrial water use totaled 0.35 Mgal/d at six facilities, of which 0.29 Mgal/d was self-supplied and 0.06 Mgal/d was delivered from municipal-supply systems. All withdrawals for irrigation and livestock were self-supplied. Total residential water use (water used by individual homeowners for bathing, drinking, and other uses) for both rural domestic and municipal water supplies was not calculated in 2000, but withdrawals for residential supply totaled about 4.08 Mgal/d in 1995, of which about 1.34 Mgal/d (33 percent) was delivered by municipal supplies and about 2.74 Mgal/d was self-supplied. Per capita residential water use in 1995 was estimated to be about 90 gal/d.

Post-1970 estimates are unavailable for the volume of pumping from each of the aquifers used for water supply in Kendall County. However, analysis of residential well logs on file with the Kendall County Health Department and the ISWS indicates about 12 percent of the rural-domestic wells in the county are open to the glacial drift aquifers. About 8 percent of rural domestic supply wells are open to the Ancell aquifer, about 44 percent are open to the shallow bedrock aquifer, and about 36 percent are open to the Galena-Platteville and Maquoketa Group units more than 160 ft below the bedrock surface. Total aquifer withdrawals for rural domestic use in 2000 were about 0.22 Mgal/d from the Ancell aquifer, about 0.33 Mgal/d from the glacial drift aquifers, about 1.21 Mgal/d from the shallow bedrock aquifer (including the Ancell aquifer where it is at the bedrock surface), and about 0.99 Mgal/d from the deeper Galena-Platteville and Maquoketa Group units above the Ancell aquifer.

There are six municipal water-supply systems in Kendall County: Bonnie Lane, Valley Marine, Morgan Creek, Fox Lawn, Hollis Park, and the Cities of Plano, Newark, Yorkville, Oswego, and parts of Montgomery. Currently (2004), Plano draws water from the glacial drift aquifer, whereas the remaining municipal-supply systems in the county withdraw water primarily from either the Ancell aquifer, or the entire Cambrian-Ordovician aquifer system. Of the approximately 2.20 Mgal/d withdrawn by municipal supply systems in Kendall County in 2000, about 0.84 Mgal/d was pumped from the glacial drift aquifers, about 0.23 was pumped primarily from the Ancell aquifer, and about 1.13 Mgal/d was pumped from the Cambrian-Ordovician aquifer system. Although not on line in 2000, there are currently five municipal-supply wells in Kendall County that are open solely or primarily to the Ironton-Galesville aquifer. Only one of these wells is currently being pumped, but all of them are expected to be utilized by the end of 2005. The preponderance of pumping from the Cambrian-Ordovician aquifer system for municipal supply in 2000 differs from the period from 1957 through 1970, when at least 60 percent of withdrawals for municipal supplies were from glacial drift aquifers. This change can be attributed primarily to abandonment of a well open to the glacial drift aquifer by the City of Yorkville and a shift to pumping from the Cambrian-Ordovician aquifer system.

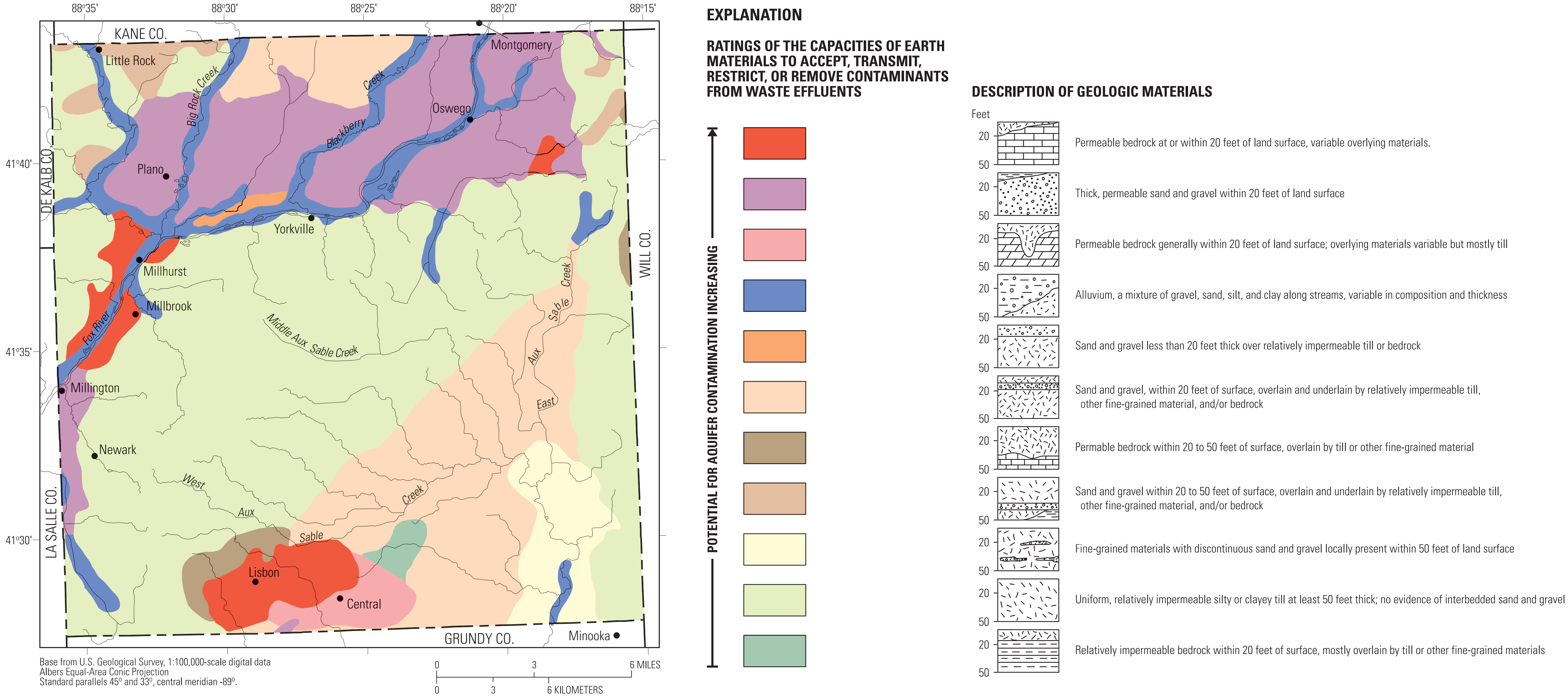


Figure 32. Susceptibility of shallow aquifers to contamination from land burial of municipal wastes in Kendall County, Illinois (modified from Berg and others, 1984).

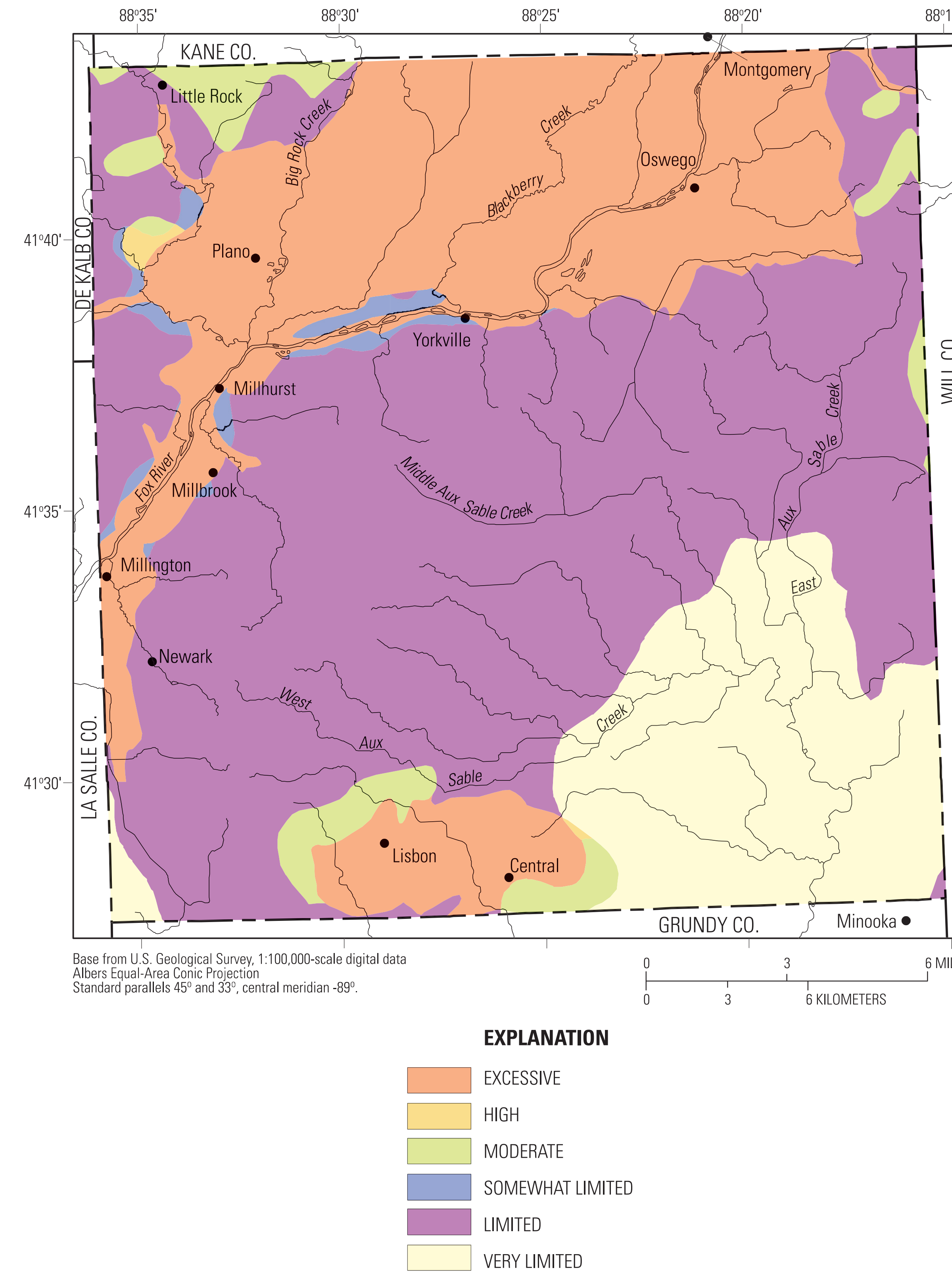


Figure 33 Susceptibility of shallow aquifers to contamination from nitrate leaching in Kendall County, Illinois (modified from Keefer, 1995).

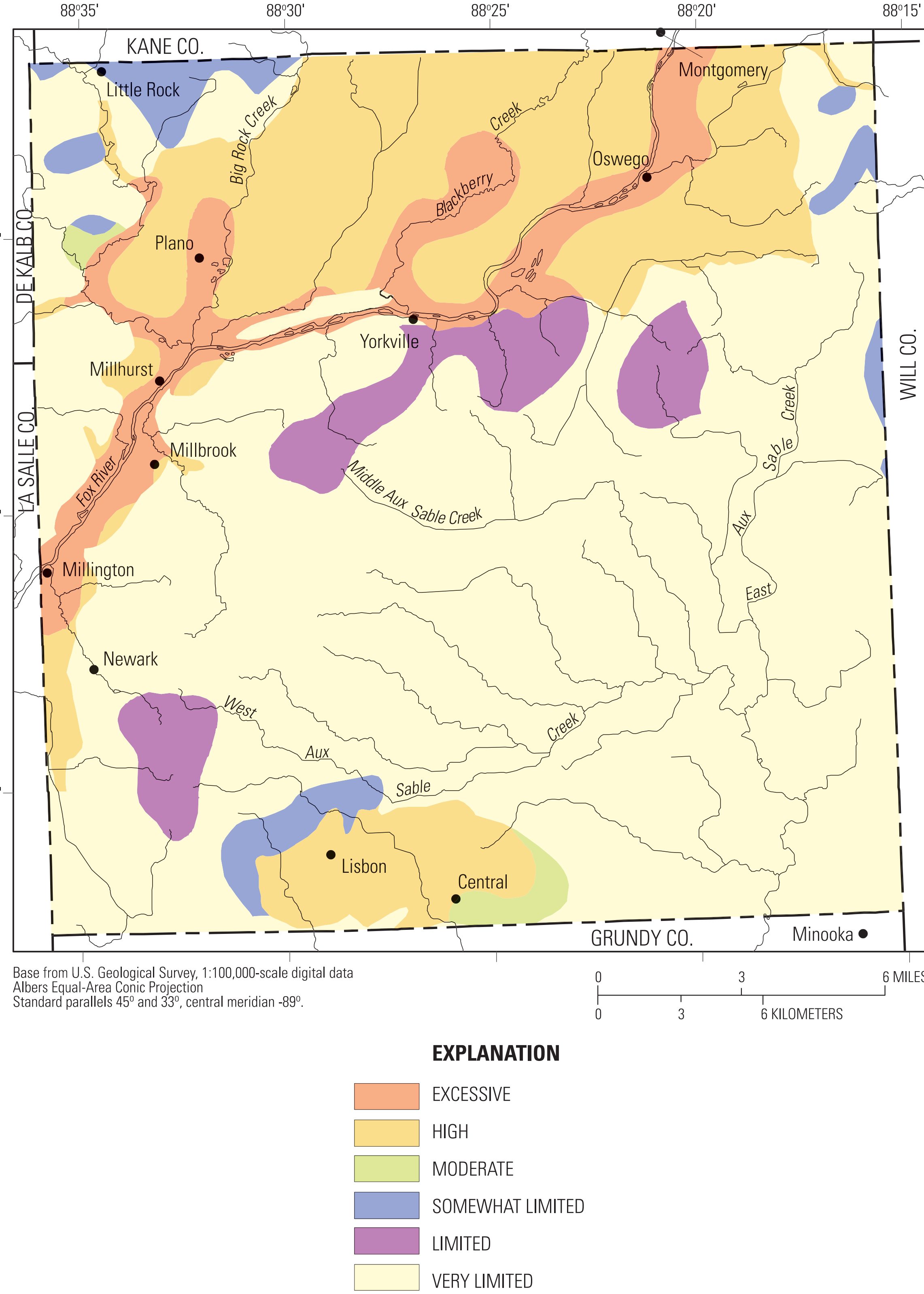


Figure 34. Susceptibility of shallow aquifers to contamination from pesticide leaching in Kendall County, Illinois (modified from Keefer, 1995).

SUMMARY

Water-supply needs in Kendall County are met exclusively from ground water derived from glacial drift aquifers and bedrock aquifers open to Silurian, Ordovician, and Cambrian units. The population of Kendall County has increased steadily since about 1950 and is expected to triple by 2030, thereby increasing water use and the potential for overutilization of the water resources in the county. The water resources of Kendall County need to be characterized so that the long-term sustainability of the resource can be determined. The information gathered by this study will be useful to water-resources managers and will aid in characterizing flow in shallow aquifers, ground-water interaction with surface water, and improved understanding of the hydrogeologic framework of regional aquifers and confining units. Therefore, the USGS, in cooperation with the Kendall County Soil and Water Conservation District and the Kendall County Municipalities, conducted an investigation of the water resources of Kendall County.

Land use in Kendall County primarily is agricultural, with urban land use focused in the northern part of the county along the Fox River. Smaller communities are present in the southern part of the county. Residential growth is expected to increase primarily in the northern and eastern parts of the county as the larger communities in Kendall County and neighboring Will County expand.

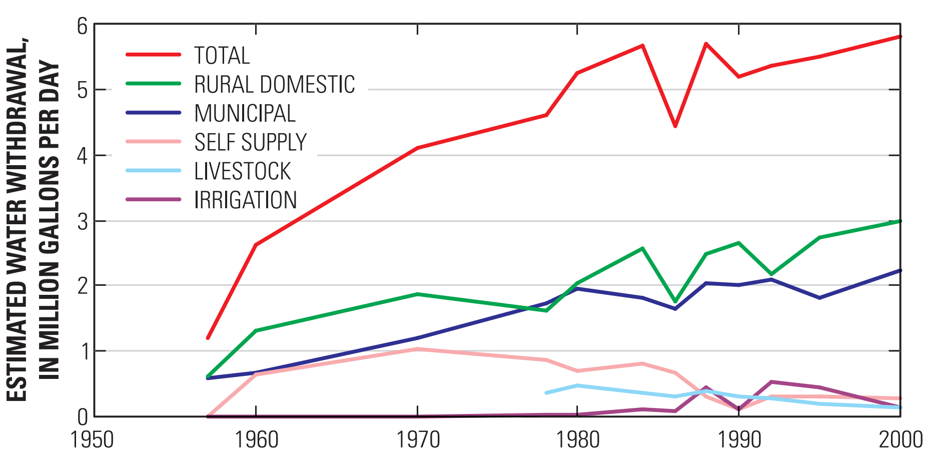


Figure 35. Estimated water use in Kendall County, Illinois, 1957 through 2000 (Kirk and others, 1979, 1982, 1985; Kirk, 1987; Avery, 1995, 1996, 1999).

The distribution of the bedrock units in Kendall County is affected by the Sandwich Fault Zone. The units are shallower, and in some cases absent, on the southern side of the fault than on the northern side. The altitude of the bedrock units decreases from northwest to southeast on both sides of the fault zone.

The bedrock units beneath Kendall County range from Precambrian to Silurian. From oldest to youngest, these units are described as follows. The Mt. Simon Sandstone is the basal sedimentary unit beneath Kendall County and is estimated be about 2,500 to 2,800 ft thick beneath the county. The Eau Claire Formation consists of 300 to 400 ft of silty, argillaceous, dolomitic sandstone, and sandy dolomite. The Galesville and Ironton sandstones are estimated to be about 175 to 200 ft thick. The Franconia Formation is composed primarily of dolomite and dolomitic sandstone and is estimated to be about 100 ft thick. The Potosi Dolomite is estimated to be between 100 and 150 ft thick and is overlain by the Eminence Formation, which is composed of sandy, fine- to medium-grained dolomite. The Eminence Formation may be absent because of erosion beneath the county, but, where present, the formation but may be as much as 150 ft thick. The Prairie du Chien Group is composed of cherty dolomite with interbedded sandstones. The thickness of these units is variable because of erosion, but they are estimated to be from 200 to 300 ft thick beneath the county. The Prairie du Chien Group is at the bedrock surface in the west-central part of the county. The St. Peter Sandstone and Glenwood Formation of the Ancell Group comprise a 200- to 400-ft thick sequence of predominantly sandstone. The Ancell Group is at the bedrock surface in the southwestern part of the county. The Galena-Platteville dolomite has been removed by erosion in southwestern Kendall County, is at the bedrock surface beneath much of the northwestern and southeastern parts of the county, and is more than 350 ft thick in the northeastern part of the county. The Maquoketa Group is composed primarily of dolomitic shale, and argillaceous dolomite and limestone. The Maquoketa Group has been removed by erosion beneath most of the western half of Kendall County, but it is the uppermost bedrock unit beneath most of the eastern part of the county, and has a maximum thickness of about 125-150 ft. Silurian dolomites are the youngest bedrock units beneath Kendall County. These units have been removed by erosion beneath most of the county, but may be over 100 ft thick in the northeastern part of the county, where they are at the bedrock surface.

The principal Quaternary units in the county are the Cahokia , Lemont, Equality, and Henry Formations. These units are present beneath about 95 percent of the county, generally are up to about 200 ft thick, and predominantly are composed of till, silt, and clay. Thick, laterally extensive sand-and-gravel units are present beneath parts of the county, particularly north of the Fox River and between Big Rock and Blackberry Creeks. The thickness of sand-and-gravel units exceeds 25 ft northwest of Plano, west of Little Rock Creek; south of Yorkville, near the headwaters of the Middle Aux Sable Creek; along much of the Fox River Valley between Millhurst and Millington; and southwest of Newark. These areas have the potential to support development of additional ground-water supplies.

The buried Newark Valley underlies parts of western and northern Kendall County and may support development of additional ground-water supplies. However, the units that infill the Newark Valley and its tributaries contain variable lithologies and focused investigation would be necessary to locate deposits that can be developed for water supply.

The Fox River is the primary surface-water body in Kendall County and is used for both wastewater disposal and as a drinking-water source upstream of the county. Water quality from the river exceeds MCLs or SMCLs for some constituents, particularly turbidity, necessitating pretreatment for use as drinking water. The river is a viable additional source of water supply for parts of Kendall County.

Glacial drift aquifers composed of sand and sand-and-gravel units of sufficient thickness and permeability to support municipal supply are expected to be most widespread in the northern part of the county, particularly north of the Fox River and between Big Rock and Blackberry Creeks. Less extensive aquifers also may be present along parts of the Fox River Valley and within the buried Newark Valley and its tributaries in the western and northern parts of the county. Glacial drift aquifers sufficient to meet the needs of residential users are expected to be present in all but the southeastern part of the county.

Calculated values of horizontal hydraulic conductivity for the glacial drift aquifers in Kendall County range from about 3 to 7,100 ft/d. Estimated transmissivity values range from 8 to 68,000 ft^2/d. Estimated values for storage coefficient range from 0.08 to 0.5. Ground-water flow in the Quaternary units appears to be from the uplands to the major surface-water bodies in the area. Average recharge to the glacial drift aquifers in the northern part of county is estimated to be about 9 in/yr. Estimated recharge rates for glacial drift aquifers in nearby areas range from about 2.1 to 7.3 in/yr.

The shallow bedrock aquifer is composed of the sandstone units of the Ancell Group, the Prairie du Chien and Galena-Platteville dolomites, the Maquoketa Group, and the Silurian dolomite where these units are at the bedrock surface. Ground-water levels in the shallow bedrock aquifer tend to mirror surface topography, with flow from the upland areas toward the Fox River, Aux Sable Creek, and south toward Grundy County.

The availability of water from the shallow bedrock aquifer depends primarily on the geologic unit that is utilized. The Silurian dolomite typically yields sufficient water for residential and municipal supply. The units of the Maquoketa Group typically yield little water, but are sufficient for residential-water supply in some locations. The Galena-Platteville dolomite typically yields sufficient water for residential supply and can yield sufficient water for small public supplies in the western part of the county. Where overlain by the Maquoketa Group, the Galena-Platteville dolomite yields little water, but is still used in a limited capacity for residential supply. The sandstones of the Glenwood Formation and the St. Peter Sandstone constitute the Ancell aquifer, which is used for municipal and residential water supply. The Prairie du Chien Group yields sufficient water for residential supply in the far western part of the county where it is at the bedrock surface. The shallow bedrock aquifer has the capacity to support additional water withdrawals for residential use. The Silurian and Ancell units in this aquifer also may be capable of supporting limited additional municipal supply.

At a regional scale, the Maquoketa Group is a confining unit. In combination with the Galena-Platteville dolomite where it is overlain by the Maquoketa Group, the confining unit restricts flow between the glacial drift and Silurian aquifers and the Ancell aquifer.

This report considers the Cambrian-Ordovician aquifer system to be composed of the sequence of units from the Ancell aquifer through the Ironton-Galesville aquifer. The Cambrian-Ordovician aquifer system is used for water supply by a number of municipalities in northern Illinois, including some in Kendall County, and has an average transmissivity of about 2,550 ft^2/d in the county.

The Ancell aquifer constitutes an estimated 15 percent of the total transmissivity of the Cambrian-Ordovician aquifer system in northeastern Illinois. The units of the Franconia Formation, the Potosi Dolomite, and the Prairie du Chien Group form a confining unit between the Ironton-Galesville and Ancell aquifers. These units can be permeable and account for an estimated 35 percent of the yield of wells open to the Cambrian-Ordovician aquifer system. The Ironton-Galesville sandstone forms the Ironton-Galesville aquifer, which is estimated to constitute about 50 percent of the total transmissivity of the Cambrian-Ordovician aquifer system in northern Illinois.

The potentiometric surface of the Cambrian-Ordovician aquifer system has declined by about 100 to 600 ft beneath the county because of pumping from the aquifer system in northeastern Illinois since about 1850. Water-level declines may have resulted in the desaturation of the upper part of the Ancell aquifer in the northeastern part of Kendall County.

The Proviso and Lombard Members of the Eau Claire Formation form the lower confining unit. This confining unit overlies the Elmhurst and Mt. Simon Sandstones, which compose the Mt. Simon aquifer. The Mt. Simon aquifer is not utilized in Kendall County and there are concerns over salinity in the deeper part of the aquifer. The Mt. Simon aquifer has an estimated transmissivity of 1,400 ft^2/d and is used for water supply in parts of north-central Illinois. The Mt. Simon aquifer is a potentially viable alternative source of water supply in Kendall County.

On the basis of water-quality samples collected from 1970 through 2003, the glacial drift and shallow bedrock aquifers did not contain concentrations of major ions, trace elements, metals, volatile organic compounds, semivolatile organic compounds, radionuclides, or pesticides above drinking-water standards in areas away from the immediate vicinity of water-disposal sites. Nitrate was detected infrequently in samples from glacial drift aquifers at concentrations above drinking-water standards. Volatile organic compounds and selected trace metals and pesticides were detected at low concentrations near waste-disposal sites. Herbicides have been detected infrequently at concentrations below drinking-water standards near areas of agricultural application. Glacial drift and bedrock aquifers in the county appear to be susceptible to low levels of contamination where the aquifers are not overlain by more than about 50 ft of low-permeability units.

Water-quality data have indicated the Cambrian-Ordovician aquifer system did not contain concentrations of major ions, trace elements, metals, volatile organic compounds, and agriculture-related constituents above primary drinking-water standards. However, radium concentrations in the aquifer system were above established standards beneath much of the county.

Total water use in Kendall County increased from about 1.2 Mgal/d in 1957 to about 5.2 Mgal/d in 1980, and typically was between about 5.2 and 5.7 Mgal/d from 1980 through 2000. The amount of water withdrawn for municipal supply has increased from about 0.6 Mgal/d in 1957 to about 2.2 Mgal/d in 2000. The amount of water withdrawn for rural domestic use increased from about 0.6 Mgal/d in 1957 to nearly 3.0 Mgal/d in 2000, making this the single largest category of water use. Water withdrawals for rural domestic use in 2000 were about 0.22 Mgal/d from the Ancell aquifer, about 0.33 Mgal/d from the glacial drift aquifers, about 1.21 Mgal/d from the shallow bedrock aquifer, and about 0.99 Mgal/d from the deeper bedrock aquifers above the Ancell aquifer. Of the approximately 2.20 Mgal/d for municipal supply in Kendall County in 2000, about 0.84 Mgal/d was pumped from the glacial drift aquifers, about 0.23 Mgal/d was pumped primarily from the Ancell aquifer, and about 1.13 Mgal/d was pumped from the Cambrian-Ordovician aquifer system.

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GLOSSARY

Alluvial—pertaining to or composed of alluvium, or deposited by a stream or running water.

Aquifer—a formation, group of formations, or part of a formation that contains sufficient saturated permeable material to yield appreciable quantities of water to wells and springs.

Aquifer test—a test to determine hydraulic properties of the aquifer involving the withdrawal of measured quantities of water from or addition of water to a well and the measurement of resulting changes in water level in the aquifer both during and after the period of discharge or additions.

Argillaceous—containing clay minerals.

Arkose—sandtone deposit containing notable quantities of the mineral feldspar.

Bedrock—the solid rock that lies below soil and other loose surface materials.

Cambrian System—period of geologic time extending from about 570 to 500 million years before the present.

Chert—a rock type composed primarily of cryptocrystalline silica.

Clay—detrital particles less than 1/256 millimeter in size or an unconsolidated detrital sedimentary deposit composed primarily of particles less than 1/256 millimeter in size.

Conformable—rock layers that were deposited in sequence without episodes of erosion between deposition of layers.

Confined—a modifier that describes a condition in which the potentiometric surface is above the top of the aquifer.

Confining unit—a hydrogeologic unit of impermeable or distinctly less permeable material stratigraphically adjacent to one or more aquifers.

Contaminant—an undesirable substance that is not normally present naturally, or that is present at concentrations higher than would occur due to natural processes.

Diamicton—massive, poorly sorted sediments containing gravel or larger-sized particles.

Drawdown—the decline in water level at a point caused by the withdrawal of water from a hydrogeologic unit.

Drift—all glacial and fluvioglacial deposits left after the retreat of glaciers and ice sheets.

Dolomite—rock composed of calcium and magnesium carbonate.

Eolian—pertaining to the activity of wind.

Evapotranspiration—the combined loss of water from a given area by evaporation from the land and transpiration from plants.

Facies—the sum total of features that characterize a sediment as having been deposited in a given environment.

Fault—a fracture in rock along which there has been an observable amount of displacement.

Formation—aggregation of related strata distinguishable from beds above and below and of mappable extent.

Fracture—breakage in the rock not related to the crystalline structure of the minerals that compose the rock, often having a preferred orientation.

Fragic horizon—dense soils that greatly restrict flow of water.

Glauconite—a phyllosilicate mineral of formula $(K,Na)(Fe^{3+},Al,Mg)_2(Si,Al)_4O_{10}(OH)_2$. Its color ranges from olive green, black green to bluish green. It is normally found in dark green rounded nodules of sand size dimension. Normally, glauconite is considered diagnostic of continental shelf marine depositional environments with slow rates of accumulation. It develops as a consequence of diagenetic alteration of biotite micas or volcanic glass. Glauconite forms under reducing conditions in sediments and is commonly found in nearshore sandstones.

Geophysical log—a record of the chemical or physical properties of fluids or rocks at a well site, such as thermal or electrical properties, density, resistivity, sonic potential and gamma ray activity. It is recorded by dropping a tool down the bore hole and recording the property value versus depth.

Granite—a coarse-grained igneous rock consisting essentially of quartz (20-40 percent) and alkalai feldspar.

Granodiorite—a coarse-grained igneous rock consisting of quartz (20-40 percent) calc-alkalai feldspar, and various ferromagnesian minerals.

Gravel--coarse-grained particles between 2 and 4 millimeters in size. Loosely used to denote unconsolidated detrital sedimentary deposits composed primarily of particles greater than 2 millimeters in size.

Ground moraine—till deposited from a glacier as veneer over landscape and forming a hummocky or gently rolling surface.

Ground water—subsurface water that fills available openings in rock or soil materials to the extent they are considered water-saturated.

Group—the lithostratigraphic unit next in rank above formation, consisting partly or entirely of two or more adjacent formations having prominent features in common.

Hydraulic conductivity—a proportionality constant relating hydraulic gradient to specific discharge, which for an isotropic medium and homogeneous fluid equals the volume of water at the prevailing kinematic viscosity that will move in unit time under a unit hydraulic gradient through a unit area measured at right angles to the direction of flow.

Hydrogeologic unit—any soil or rock unit, which by virtue to its hydraulic properties has a distinct effect on the storage or movement of ground water.

Isotope—forms of the same element that have the same number of protons but differing numbers of neutrons. This mass difference gives rise to slightly differing chemical properties for each isotope.

Lacustrine—pertaining to lakes.

Laminae—thin, discrete layers in rock.

Lithologic log—description of the geologic deposits encountered during drilling.

Lithology—the description of rocks on the basis of color, structure, mineral composition, and grain size; the physical character of a rock.

Limestone—sedimentary rock composed primarily of calcium carbonate.

Loess—a homogeneous, unstratified accumulation of silt-sized sediments deposited by wind action. Usually associated with the margins of continental ice sheets.

Member—units of lesser rank in a heterogeneous formation that are lithologically distinct.

Moraine—a mound, ridge, or other distinct accumulation of glacial drift, predominantly till, deposited chiefly by direct action of glacial ice in a variety of topographic landforms that are independent of control by the surface on which the drift lies.

Nonpoint source pollution—pollution from diffuse sources

Oolite—a spherical or subspherical rock particle that has grown around a nucleus.

Ordovician System—period of geologic time extending from about 500 to 435 million years before the present.

Outwash—material deposited by streams eminating from a melting glacier.

Peat—a partially decomposed mass of vegetation that has typically grown in a marsh or shallow lake.

Pennsylvanian System—period of geologic time extending from about 330 to 290 million years before the present.

Permeability—a measure of the relative ease with which a porous medium can transmit a fluid under a potential gradient and is a property of the medium alone.

Physiography—the study and classification of the surface features of earth on the basis of similarities in geologic structure and the history of geologic changes.

Point-source pollution—pollution emanating from a discharge point such as a pipe or industrial facility, which can be specifically identified.

Porosity—the ratio, usually expressed as a percentage, of the total volume of voids of a given porous medium to the total volume of the porous medium.

Potentiometric surface—an imaginary surface representing the static head of ground water and defined by the level to which water will rise in a tightly cased well.

Precambrian—period of geologic time prior to about 570 million years before the present.

Quartz—mineral consisting of silicon dioxide.

Quaternary—the latest period of geologic time represented in Illinois by accumulations of glacial (Pleistocene) and post-glacial (Holocene) deposits that were deposited above the Pliocene series.

Recharge—the process of addition of water to the saturated zone or a well.

Rhythmites—sediments that change their character progressively from one type to another followed directly by a return to the original type. Patterns in lake sedimentation occurring over a period of a year would be one example.

Sand—typically a silicate mineral between 1/16 and 2 millimeters in size or an unconsolidated detrital sedimentary deposit composed of particles between 1/16 and 2 millimeters in size.

Sandstone—detrital sedimentary rocks composed primarily of silicate minerals that typically vary in size between 1/16 and 2 millimeters.

Shale—detrital sedimentary rock composed primarily of particles less than 1/256 millimeter in size.

Silt—particle between 1/16 and 1/256 millimeter in size or an unconsolidated detrital sedimentary deposit composed primarily of particles between 1/16 and 1/256 millimeter in size.

Siltstone—detrital sedimentary rocks composed primarily of particles between 1/16 and 1/256 millimeter in size.

Silurian System—period of geologic time extending from about 435 to 410 million years before the present.

Solution opening—a large cavity in a rock formed by chemical dissolution.

Storage coefficient—the volume of water an aquifer releases from storage per unit surface area of the aquifer per unit change in head.

Stratigraphy—the study, definition, and description of major and minor natural divisions of rocks, particularly the study of their form, arrangement, geographic distribution, chronologic succession, classification, correlation, and mutual relations of rock strata.

Till—unsorted, unstratified material deposited beneath glacial ice or deposited from melting glacial ice.

Transmissivity—the rate at which water of the prevailing kinematic viscosity is transmitted through the unit width of the aquifer under a unit hydraulic gradient. It is equal to an integration of the hydraulic conductivities across the saturated part of the aquifer perpendicular to the flow paths.

Unconfined aquifer—an aquifer that has a water table.

Unconformable—feature of strata that do not succeed the underlying rocks in immediate order of age or in parallel position. A general term applied to any strata deposited directly upon older rocks after an interruption in sedimentation, with or without any deformation or erosion of the older rocks.

Unconsolidated deposit—geologic material that has not been lithified.

Watershed—drainage area; the land surface surrounding a surface-water body (lake, river) that contributes water by way of surface runoff to the body.

Water table—the upper surface of the zone of saturation on which the water pressure equals the atmospheric pressure.

Water Year—the 12-month period October 1 through September 30. The water year is designated by the calendar year in which it ends and which includes 9 of the 12 months. Thus, the year beginning October 1, 1977, and ending September 30, 1978, is referred to as the 1978 water year.

Well—a bored, drilled, or driven shaft of a dug hole, whose depth is greater than the largest surface dimension.

Yield—volume of water supplied to a receptor per unit time.

APPENDIX A. Results of Investigations at Selected Municipal-Supply Wells in Kendall County, Illinois

As a supplement to the compilation of historical information in Kendall County, data were collected at three municipal-supply wells drilled for the City of Yorkville in the spring and summer of 2004. These wells are Yorkville municipal wells 7, 8, and 9 (YMW7, YMW8 and YMW9) (fig. A1). YMW7 and YMW9 are open only to the Ironton-Galesville aquifer (table 1). YMW8 is open to the Prairie du Chien Group, Eminence Formation, Potosi Dolomite (which make up the Prairie du Chien aquifer for the purposes of this discussion), and the Ironton-Galesville sandstone. Well YMW8 was originally intended to be open only to the Ironton-Galesville aquifer. However, substantial water-bearing zones were encountered in the Prairie du Chien, Eminence, and Potosi units and the well was left open to these units to improve yield. The investigation involved geophysical logging, aquifer testing, and isotope sampling.

Geophysical Logging

Natural-gamma, fluid-resistivity, normal-resistivity, and fluid-temperature logs were performed in wells YMW8 and YMW9 prior to installation of casing above the completion interval of these wells. Well YMW8 was filled with drilling mud when logged. Logging of wells YMW7 and YMW9 was performed in water. Well YMW8 was open to the geologic units from an altitude of about 490 feet (ft) above the National Geodetic Vertical Datum of 1929 (NGVD 29) to about -380 ft (negative values denote feet below NGVD 29) during that logging event. Well YMW9 (fig. A2a) was open from about -516 to 524 ft during that logging. Natural-gamma, fluid-resistivity, normal-resistivity, and fluid-temperature logs also were run in YMW7 and YMW9 after the wells had been cased and drilled to their final depth. Well YMW7 was open to the aquifer from about -760 to -555 ft during that logging event. Well YMW9 was open to the aquifer from about -710 to -516 ft during that logging event (fig. A2b). Water-quality parameter profiles (temperature, pH, specific conductance, oxidation-reduction potential, and chloride and nitrate concentrations) were collected in YMW9 prior to installation of the casing above the open interval when the well was open from about -490 to 490 ft. Water-quality parameter profiles also were run in the open intervals of YMW7 and YMW9 after the wells were drilled and cased at their final depths.

Well YMW9

Natural-gamma, normal-resistivity, and drillers' logs for well YMW9 indicate that unconsolidated units extend from the ground surface at an altitude of about 644 ft to about 553 ft above NGVD 29 (fig. A2a). Units of the Maquoketa Group underlie the unconsolidated units, with shale units most prominent from about 500 to 529 ft. Dolomite of the Galena and Platteville Groups underlies the Maquoketa Group from about 164 to 464 ft. The top of sandstones of the Ancell Group is at about 164 ft, and the bottom of the Ancell Group units appears to be about -196 ft, with lithologic logs indicating the Kress Member may be present below about 40 ft. Well YMW9 appears to be in an area of greater-than-average thickness of the Ancell Group, indicating that this also is an area of enhanced erosion of the underlying units. The Prairie du Chien Group, Eminence Formation, and Potosi Dolomite units extend from about -196 to -411 ft. The lithologic description indicates the Potosi Dolomite may extend from about -371 to -411 ft. The units overlying the Potosi Dolomite cannot be readily differentiated with the available information, but based on the increased thickness of the Ancell Group, the Shakopee units are likely to have been at least partly removed by erosion. The Franconia Formation extends from about -411 to -501 ft and the Ironton-Galesville sandstone extends from about -506 to -700 ft (fig. A2b). The top of the Proviso Siltstone is about -700 ft.

Temperature, fluid-resistivity, fluid-conductivity, and oxidation-reduction potential logs were run prior to the installation of casing from about -516 to

524 ft in well YMW9 (figs. A2a, b). Temperature, fluid-conductivity, and fluid resistivity logs show abrupt changes associated with the top of the sandstones of the Ancell Group at about 164 ft, indicating water movement and enhanced permeability associated with these sandstones. Temperature, fluid-conductivity, and oxidation-reduction potential logs all show changes beginning in the Prairie du Chien Group or Eminence Formation units at about -316 ft and increasing to the top of the Ironton-Galesville sandstone at about -501 ft, indicating water movement and enhanced permeability associ-

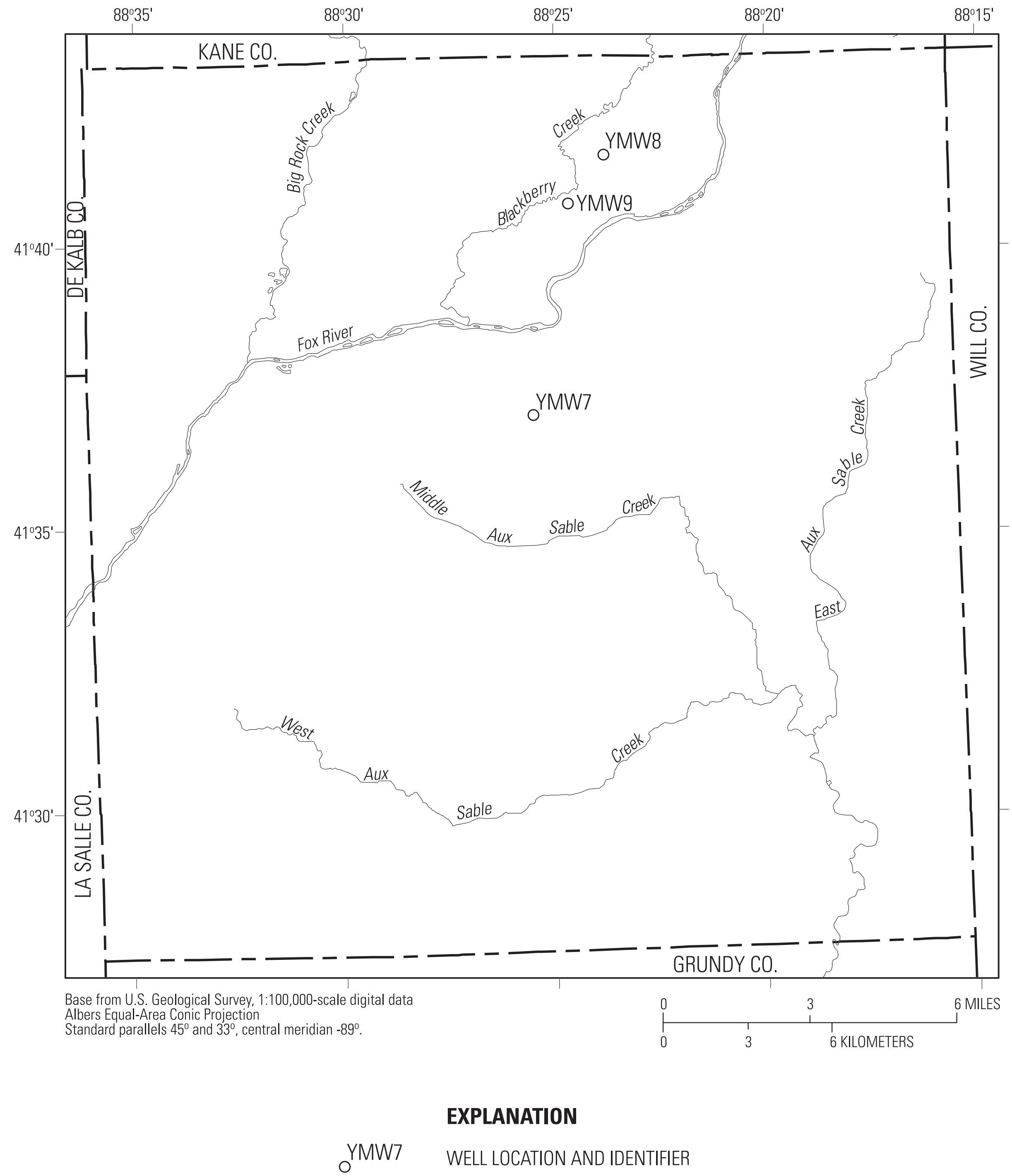

Figure A1. Location of wells YMW7, YMW8, and YMW9 in Kendall County, Illinois.

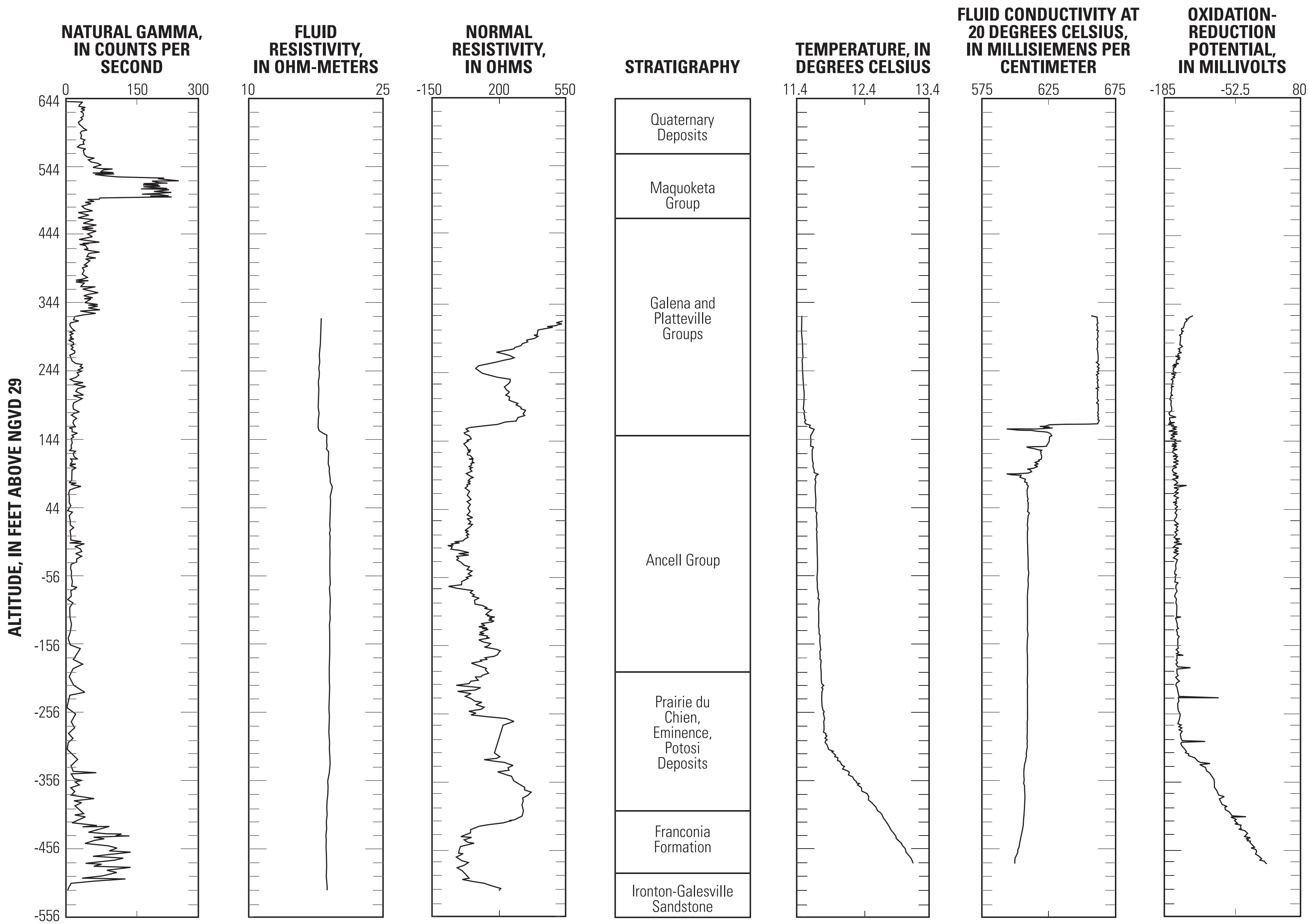

Figure A2a. Geophysical logs from Yorkville municipal well 9, Kendall County, Illinois (well open to aquifer from -516 to 524 feet above National Geodetic Vertical Datum of 1929 (NGVD 29)).

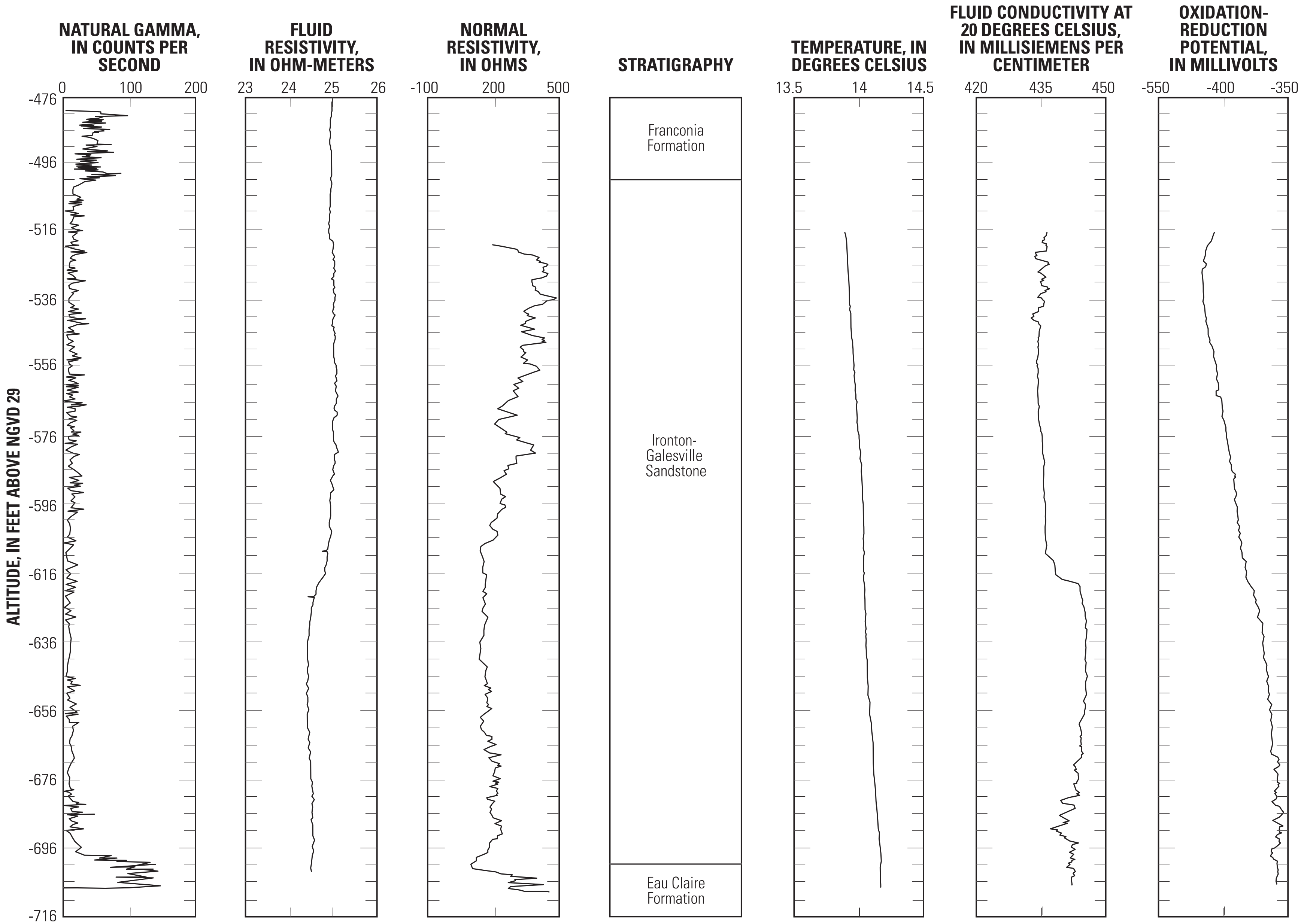

Figure A2b. Geophysical logs from Yorkville municipal well 9, Kendall County, Illinois (well open to aquifer from -516 to -710 feet above National Geodetic Vertical Datum of 1929 (NGVD 29)).

ated with parts of the Prairie du Chien, Eminence, Potosi, Franconia, and Ironton-Galesville units. This interpretation is consistent with the presence of water-bearing features in the undifferentiated Prairie du Chien Group, Eminence Formation, and Potosi Dolomite units at nearby well YMW8. Temperature, fluid-resistivity, fluid-conductivity, and oxidation-reduction potential logs run in the open interval of well YMW9 from -516 to -710 ft after casing installation (fig. 24b) indicate a change in fluid conductivity, resistivity, and perhaps oxidation-reduction potential associated with an area of lower normal resistivity in the lower part of the Ironton-Galesville sandstone at about -620 ft. This change indicates water movement and enhanced permeability (and increased concentrations of dissolved solids) associated with the lower part of the Ironton-Galesville aquifer.

Well YMW8

Natural-gamma, normal-resistivity, and drillers' logs for well YMW8 indicate that unconsolidated units extend from the ground surface at about 649 ft to about 564 ft above the NGVD 29. Carbonate bedrock units of the Maquoketa Group underlie the unconsolidated units, with the shale units being most prominent from about 464 to 529 ft. Dolomite of the Galena and Platteville Groups underlies the Maquoketa Group from about 169 to 464 ft. The top of the sandstones of the Ancell Group is about 169 ft, and the bottom of the sandstones is at about -136 ft. The Kress Member of the Ancell Group and the Prairie du Chien Group, Eminence Formation, and perhaps part of the Potosi Dolomite extend from about -136 ft to the bottom of the hole (-380 ft).

Well YMW7

Natural-gamma, normal-resistivity, and drillers' logs for YMW7 indicate that unconsolidated units extend from the ground surface at an altitude of about 765 ft above the NGVD 29 to about 630 ft. Bedrock units of the Maquoketa Group underlie the unconsolidated units, with shale units most prominent from about 495 to 565 ft. Dolomite of the Galena and Platteville Groups underlies the Maquoketa Group from about 125 to 495 ft. The top of the sandstones of the Ancell Group is at about 125 ft, with the bottom of these units at about -80 ft. The Prairie du Chien Group, Eminence Formation, and Potosi Dolomite extend from about -80 to -535 ft. The Franconia Formation extends from about -595 to -535 ft. The Ironton-Galesville sandstone extends between about -762 and -595 ft.

Temperature, fluid-resistivity, fluid-conductivity, and oxidation-reduction potential logs run in the open interval of well YMW7 from -760 to -555 ft after casing installation indicate a change in fluid conductivity and perhaps oxidation-reduction potential in the lower part of the Ironton-Galesville sandstone at about -700 ft. These changes indicate water movement and enhanced permeability (and increased concentrations of dissolved solids) associated with the lower part of the Ironton-Galesville aquifer. This change is consistent with the results of logging in the Ironton-Galesville aquifer at well YMW9.

Aquifer Testing

Water-level measurements taken in wells YMW7, YMW8, and YMW9 during 24-hour production tests in these wells were analyzed using the straight-line solution of Cooper and Jacob (1946) to estimate the hydraulic properties of the Ironton-Galesville aquifer at YMW7 and YMW9 and combined Ironton-Galesville and Prairie du Chien aquifers at YMW8. Transmissivity values from these single-well tests were calculated to be 558 ft^2/d for YMW7, 3,300 ft^2/d for YMW8, and 2,600 ft^2/d for YMW9. Horizontal hydraulic conductivity values were calculated to be 2.8, 7.2, and 13.0 ft/d, for YMW7, YMW8, and YMW9, respectively. If it is assumed that the transmissivity of the Ironton-Galesville aquifer at YMW8 is the same as at YMW9 (the wells are located about 6,800 ft apart), then by subtraction of the calculated transmissivity at YMW9 from that at YMW8, the transmissivity of the Prairie du Chien aquifer at YMW8 is calculated to be about 700 ft^2/d.

In addition to the single-well tests, a multiple-well aquifer test was performed. Water levels measured in well YMW9 during the 24-hour, constant-discharge production test in well YMW8 were plotted and analyzed using the straight-line solution of Cooper and Jacob (1946) to estimate the hydraulic properties of the Ironton-Galesville aquifer. Because well YMW8 is open to both the Prairie du Chien and Ironton-Galesville aquifers, it was assumed that the amount of discharge from each unit was proportional to the transmissivity of each unit. Therefore, of the total discharge from well YMW8 of 1,313 gal/min, 78 percent (1,034 gal/min) was assumed to be pumped from the Ironton-Galesville aquifer. Based on the data and these assumptions, the transmissivity of the Ironton-Galesville aquifer was calculated to be 3,160 ft^2/d and the storativity was calculated to be 4.9×10^{-5}.

Isotope Sampling

Water samples were collected from wells YMW8 and YMW9 and analyzed for the ratios of the H^2/H^1 and O^{18}/O^{16} isotopes in the water molecule. These ratios can be used to determine the approximate temperature of the water at the time of recharge to ground water. Water temperature can be used to help determine if the water was recharged as precipitation under climatic conditions representative of the past 10,000 years; glacial meltwater from the ice age that occurred approximately from 40,000 to 10,000 years before present; or a mixture of the two. Further discussion of the use of isotopes for determining the source and age of recharge in northern Illinois is available from Perry and others (1982) and Kay and others (2002).

Results of isotope sampling from well YMW9 were δ^2H of -54.1 per mil and $\delta^{18}O$ of -8.13 per mil. Results from well YMW8 were δ^2H of -55.1 per mil and $\delta^{18}O$ of -8.35 per mil. These values are similar and do not indicate a difference in the source and age of water in the Ironton-Galesville or Prairie du Chien/Eminence/Potosi/Franconia units. Perry and others (1982) predicted that the oxygen isotopic composition of a sample could be used to estimate the percentage of Pleistocene water in the Cambrian-Ordovician aquifer (%P) in northern Illinois by the following equation:

$$\%P = [(-7.29 - \delta^{18}O)/4.71] \times 100.$$

Using this technique, averaging the $\delta^{18}O$ isotopic values indicates that water in the lower part of the Cambrian-Ordovician aquifer system in the Yorkville area is derived from a combination of recent (within the past 10,000 years) meteoric and Pleistocene-aged (10,000-40,000 years) meteoric or glacial melt water, with Pleistocene water accounting for about 20 percent of the water in the aquifer system.

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