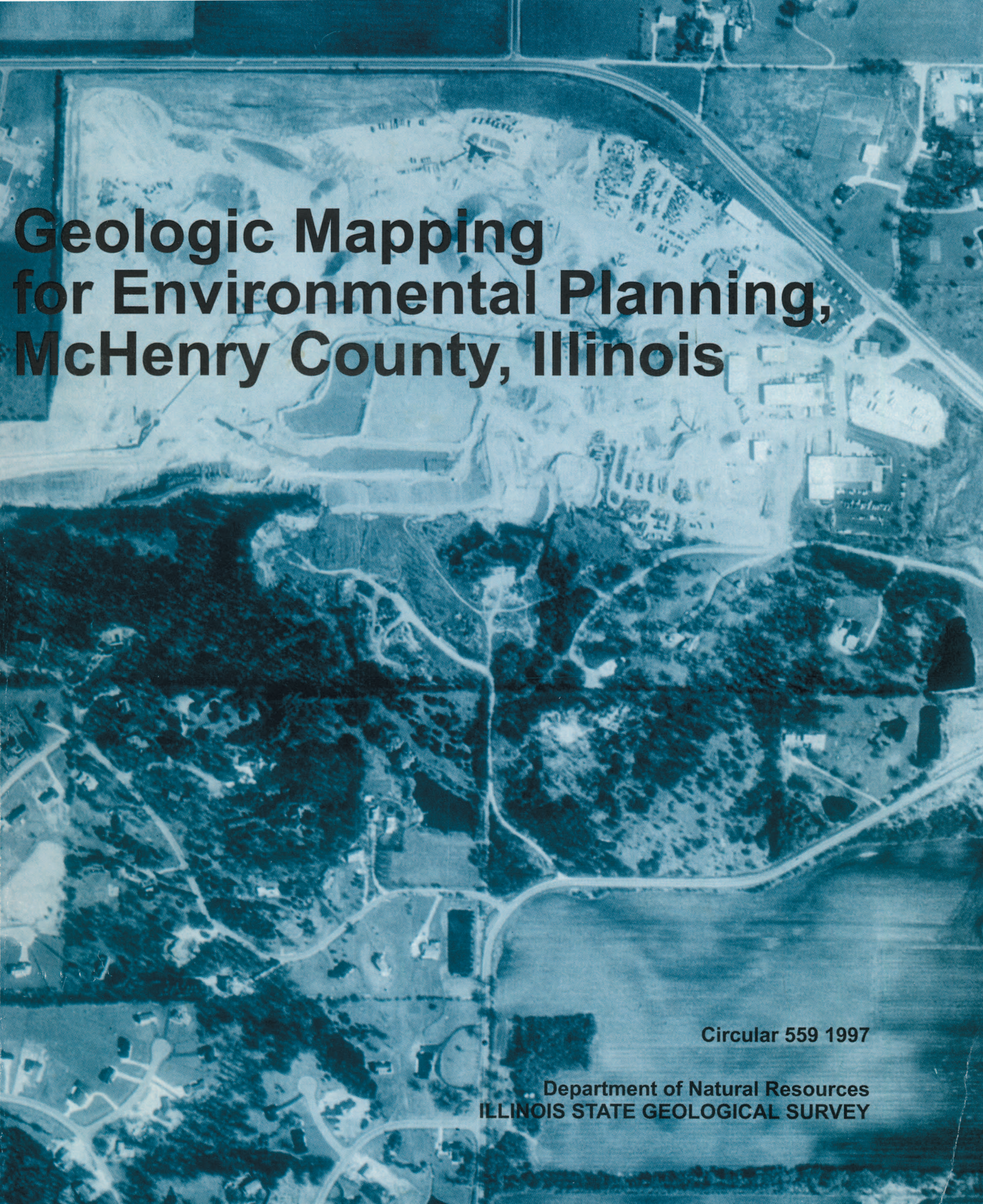

Geologic Mapping for Environmental Planning, McHenry County, Illinois

Circular 559 1997

Department of Natural Resources
ILLINOIS STATE GEOLOGICAL SURVEY

Cover imagery produced from digital orthophotography of the U.S. Geological Survey (National Mapping Division) by Christopher J. Stohr, Illinois State Geological Survey

West of the village of McHenry, Illinois: April 1988 Aerial photo shows the three most common uses of land in McHenry County: sand and gravel mining, farming, and subdivision development. The area (sections 28 and 29, T45N, R8E) is about 1.32 miles from north to south.

Geologic Mapping for Environmental Planning, McHenry County, Illinois

B. Brandon Curry, Richard C. Berg, and Robert C. Vaiden

Circular 559

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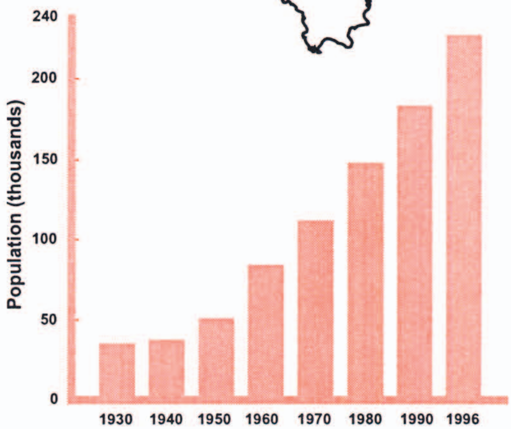
GEOLOGIC MAPPING FOR ENVIRONMENTAL PLANNING, McHENRY COUNTY

McHenry County's public water supply comes from groundwater. About 75% comes from sand and gravel and shallow bedrock aquifers; the rest of the water supply comes from deep bedrock. The county's aquifers, which yield ample supplies of groundwater for business, industry, and homes, are extremely vulnerable to contamination.

In 70% of McHenry County, aquifers lie within 100 feet of land surface. These shallow water sources are vulnerable to contamination, which in fact, has already occurred in some places. For example, concentrations of the volatile organic compound trichloroethane, in excess of concentrations recommended by state and federal regulations, have been detected in water supplies from shallow aquifers serving seven communities, including Harvard, Marengo, and Crystal Lake. Four wells tapping these aquifers are now inactive or abandoned, and other deeper wells have been constructed, at significant expense, to comply with regulations set by the Illinois Environmental Protection Agency (Patrick McNulty, McHenry County Department of Health, pers. comm. 1995).



1 Population growth in McHenry County, 1930-1996.

Since the 1940s, McHenry County has experienced the fastest growth in population of any county in Illinois (fig. 1); it now ranks fifth in U.S. population growth. As more people build homes and businesses in the county, the demand for water increases. People also become concerned about protecting their groundwater from potential contamination due to landfilling of wastes, overapplication of agricultural chemicals, and other waste-generating land-use practices common in rapidly developing areas.

Because of its growing population and potential problems with aquifer contamination, McHenry County was designated in 1991 to be part of the Northern Illinois Groundwater Protection Planning Region. This designation, made by the Illinois Environmental Protection Agency and the Interagency Coordinating Committee on Groundwater, allowed the State of Illinois in 1991 to authorize groundwater protection mapping and assessment by the Illinois State Geological Survey (ISGS) and Illinois State Water Survey (ISWS). The McHenry County Board shared the funding of a 3-year study of the geological and hydrological conditions in the county.

Crucial for decisions about land use are the details of a region's geology—where the aquifers lie, how water moves into and through aquifer materials, and whether any *aquitards*[1] lie between these water-yielding materials and sources of contamination. Geologic information is also vital in the search for new sources of groundwater.

[1]Technical terms in *italics* are defined in a glossary at the end of the report.

Purpose and Scope

This geologic mapping project in McHenry County had three main objectives:

- establish a geologic framework based on the age, thickness, properties, depth, distribution, and continuity of the unconsolidated materials (clay, silt, sand, and gravel) known as *Quaternary glacial deposits;*
- determine the thickness and distribution of aquifers and aquitards (generally clayey, relatively impermeable materials that do not yield water supplies);
- rank areas based on the relative sensitivity of aquifers to contamination.

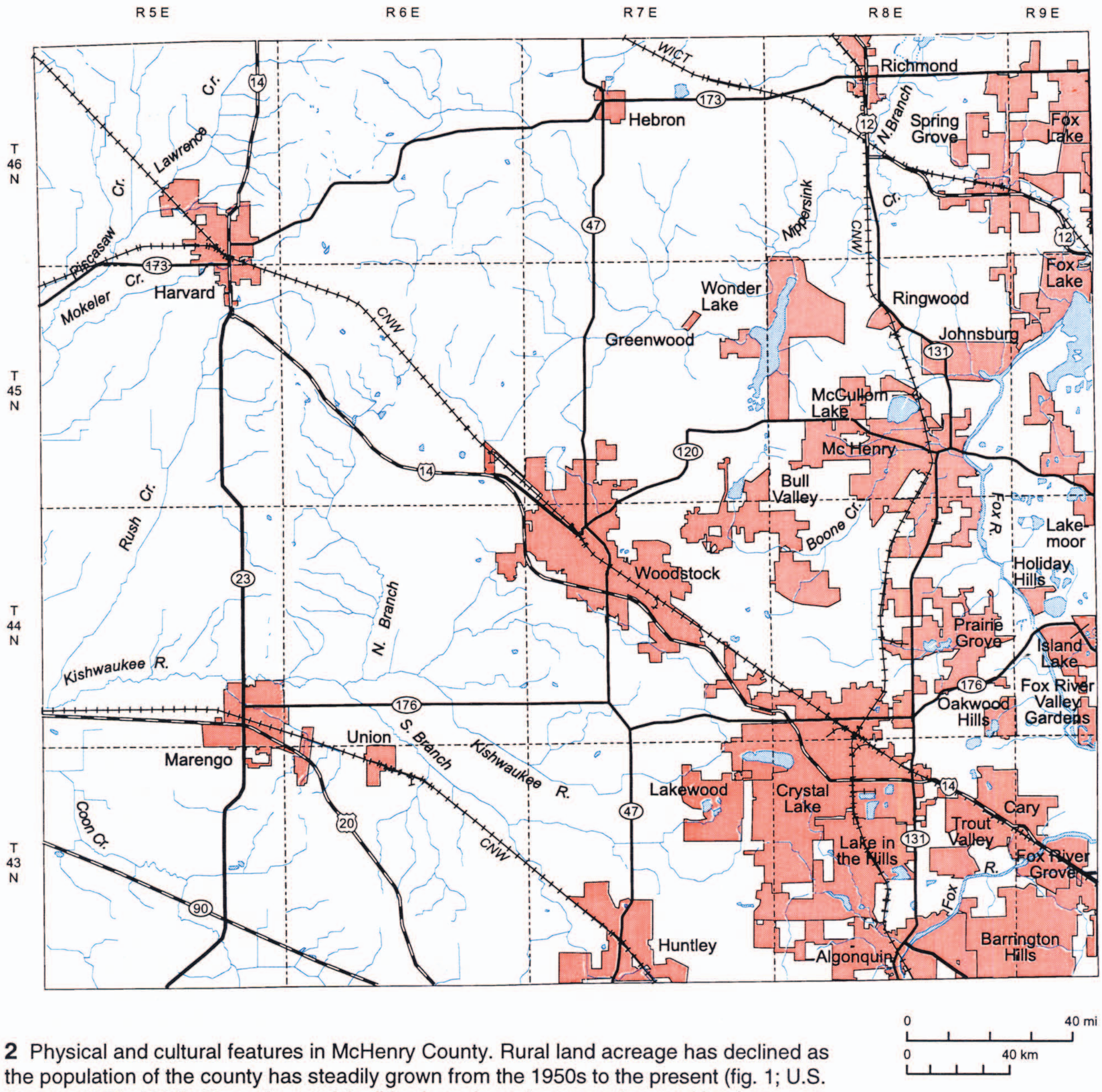
Mapping was conducted at the 1:24,000 scale (1 inch on a map represents 2,000 feet on the ground), which is the level of detail needed to give county and city officials, consultants, and residents essential geologic information for decisions regarding land and water use. (Geologic maps of McHenry County at 1:24,000 scale will be published in the ISGS Open File Series.)

A companion report on the occurrence and movement of water in aquifers is being prepared at the Illinois State Water Survey. When the Water Survey's information, such as the *potentiometric surface* maps for each aquifer, is combined with this report's information on aquifer and nonaquifer materials (as well as the soon-to-be-released 1:24,000-scale maps), geologists and hydrogeologists will be able to predict optimal water-well locations and aquifer yields; they can also evaluate how well each aquifer is protected by fine-grained materials.

The basic geologic information in this report includes

1. brief descriptions of the bedrock and a bedrock topography map showing elevation of the bedrock surface;
2. a drift thickness (isopachous) map, which shows the total thickness of materials (primarily of glacial origin) above the bedrock surface;
3. isopachous maps for each aquifer and a regionally important aquitard, the Tiskilwa Formation;
4. a surficial geology map showing the distribution of geological materials at the land surface (plate 1);
5. 11 cross sections showing the succession of geologic materials from land surface to the bedrock surface;
6. a stack-unit map showing the areal and vertical distribution of deposits to a depth of 100 feet in part of the McHenry 7.5-minute quadrangle;
7. a soil drainage map contrasting poorly drained with better drained soils (plate 2);
8. an aquifer sensitivity map showing geologic materials rated according to their capacity to protect aquifers from potential contamination (plate 3);
9. a shaded relief map (plate 4).

The geologic maps and cross sections, detailed descriptions of geologic materials, and interpretations of aquifer sensitivity will help land-use planners decide where to concentrate on protection and where to avoid overprotection of groundwater resources (Bhagwat and Berg 1991). The information will also be valuable for establishing regulated *recharge* areas, defining *setback zones* for municipal wells, and meeting other regulatory requirements of the Illinois Groundwater Protection Act (PA 85-463).



2 Physical and cultural features in McHenry County. Rural land acreage has declined as the population of the county has steadily grown from the 1950s to the present (fig. 1; U.S. Census 1930–1994). Recently, municipalities have been incorporating rural land at a rate of about 2,000 acres per year (McHenry County Planning Dept., pers. comm. 1994).

Previous Studies

Various aspects of the geology of McHenry County have been previously studied by the Illinois State Geological Survey (Anderson and Block 1962, Specht and Westerman 1976, Masters 1978, Berg, Kempton, and Stecyk 1984, Berg et al. 1985, Wickham et al. 1988). The most comprehensive county study was a geology-for-planning report on McHenry County (Hackett and McComas 1969). Several studies of sites proposed for waste disposal facilities have also been conducted by planning agencies and consultants. Most recently, Berg (1994) completed geologic mapping and a groundwater assessment study of the Woodstock 7.5-minute quadrangle.

The land cover of McHenry County is 74.6% agricultural land, 10.3% forest and woodland, 7.3% urban land, 5.7% wetland, 1.9% open water, and 0.3% active sand and gravel pits (IDNR 1996).

Curry (1995) reported on additional data from a test-drilling program for this study and interpreted numerous logs on file at the Illinois State Geological Survey and the McHenry County Board of Health; the logs supply drill-hole data from engineering projects, landfill siting studies, and test drilling.

Cultural Setting

McHenry County is bordered by two Wisconsin counties, Walworth and Kenosha, and five Illinois counties: Lake County to the east, Boone County to the west, and Kane and parts of De Kalb and Cook Counties to the south. Woodstock, the county seat, is located near the geographic center of the county and about 50 miles northwest of Chicago.

Population growth has been particularly high for townships in southeastern McHenry County; for example, from 1980 to 1995, the population grew 84% from 44,287 to 74,554 in Algonquin Township (T43N, R8E), 97% from 6,837 to 13,218 in Grafton Township (T43N, R7E), and 88% from 18,102 to 32,028 in Nunda Township (T44N, R8E).

Physical Setting

Prominent physical features in McHenry County include the Fox River and Chain-O'-Lakes lowland in the east and segments of the Marengo *Moraine* in the west (fig. 3). The average elevation in the county is about 885 feet above mean sea level, with a maximum of 1,189 feet north of Harvard and a minimum of approximately 731 feet for the Fox River at Algonquin (fig. 3).

The Fox River flows from north to south in eastern McHenry County. The headwaters of the Kishwaukee River and its tributaries arise in the central and western portions of the county; the Kishwaukee River originates at the south edge of Woodstock, whereas most of its tributaries originate west of Woodstock on the Marengo Moraine.

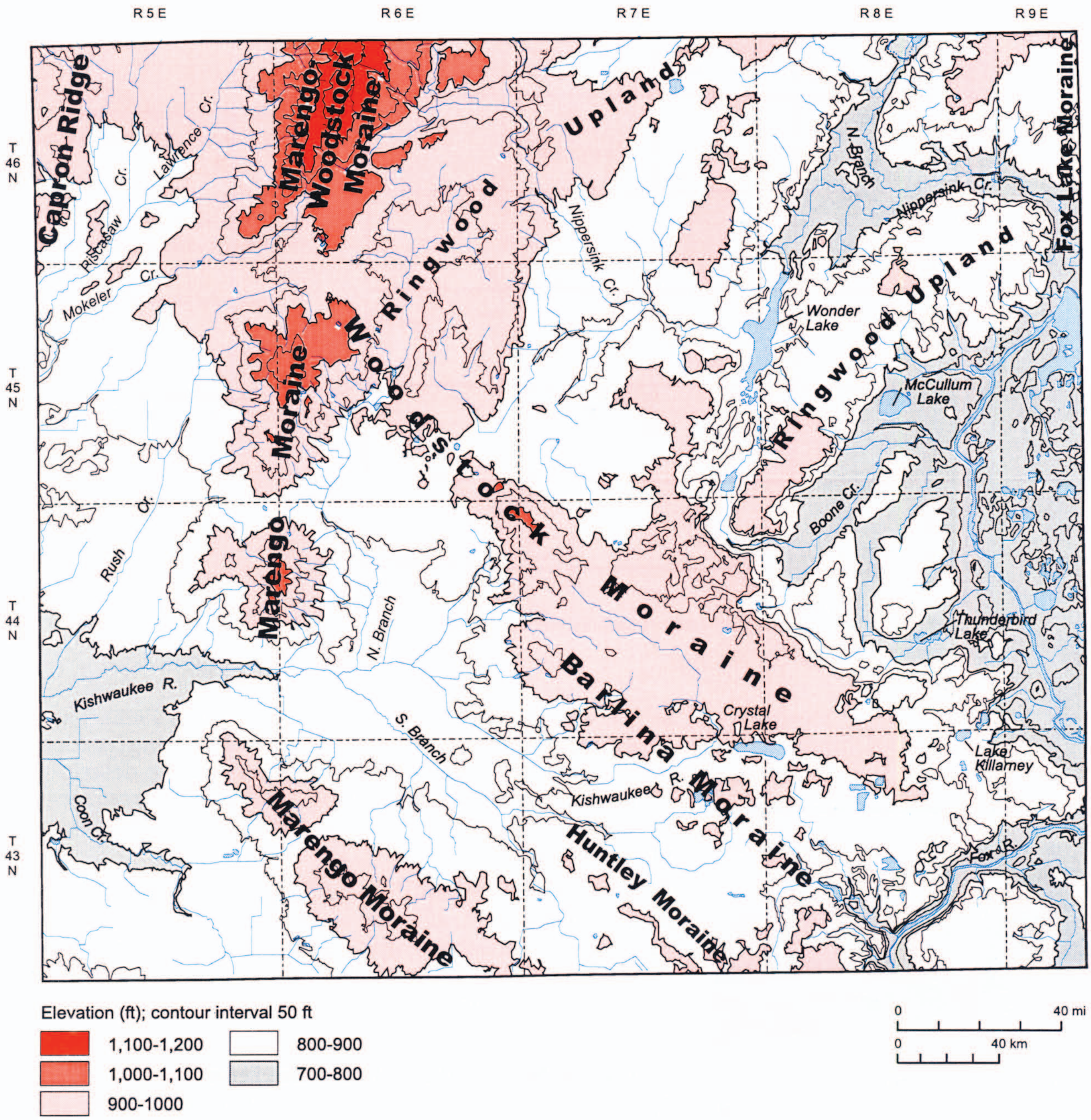
The Marengo Moraine marks the westernmost advance of a large lobe of glacial ice, called the *Lake Michigan Lobe,* during the last glaciation from about 25,000 to 14,000 years ago. Other major moraines that formed during the same interval and now lie within McHenry County include the Huntley, Barlina, Woodstock, and Fox Lake Moraines. Capron Ridge lies west of the wide valley occupied by Piscasaw Creek along the Boone County border. Although probably an erosional feature, not a true moraine, Capron Ridge contains sediments deposited during an early glaciation before about 135,000 years ago.

Geologic Mapping Methods

Subsurface Information

Mapping began with the search and evaluation of the Geological Survey's database for drilling logs of water wells, geologic logs of stratigraphic test borings, and logs of borings for bridge foundations and proposed landfill sites. Water well locations, as specified on the drilling logs, were verified in the field.

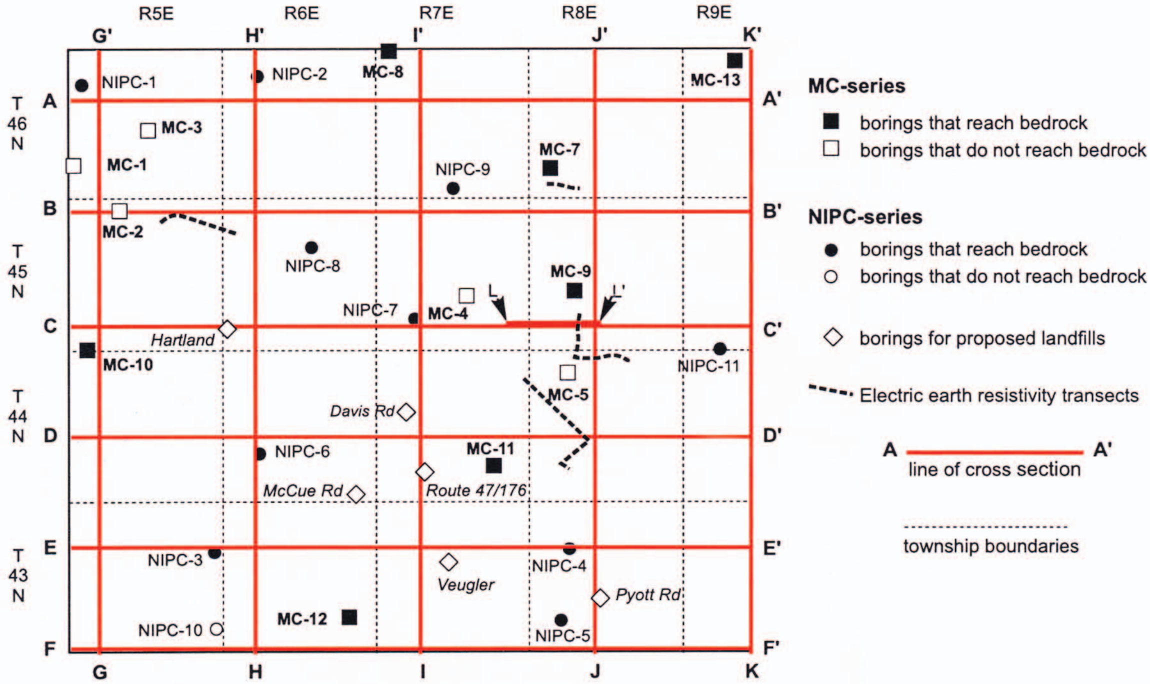
After the existing data were reviewed, 12 more test holes were drilled in areas for which reliable geologic information was not available. Five shallow borings, each less than 65 feet deep, provided samples of glacial drift. Seven other borings from 112 to 321 feet deep provided samples of the glacial drift and cores of the uppermost few feet of the bedrock. All samples



3 Surface topography and primary landforms (from McLean et al. 1995).

were described and subsampled for laboratory analyses that included 272 determinations of *particle-size distribution* and 209 analyses for *clay mineralogy* (Curry 1995). Downhole *neutron and gamma-ray logs* run in all 12 borings were used to identify and confirm boundaries between geologic materials and to supplement the geologic descriptions; these logs are in the Geological Records and Collections Unit at the Illinois State Geological Survey. When the drilling program was completed, *electrical earth resistivity surveys* were conducted to determine the continuity and thickness of sand and gravel aquifers.

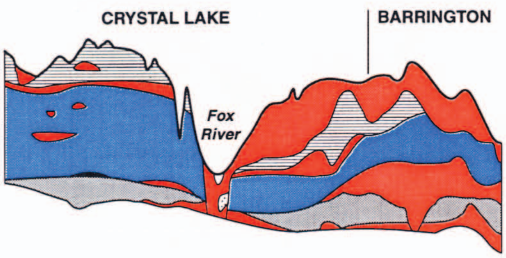
Figure 4 shows locations of test holes MC-1 through MC-13 (MC-6 was not drilled) as well as other stratigraphically significant borings with verified



4 Locations of borings, electric earth resistivity transects, cross sections for figures 15a–f and 16a–e, and cross section L–L′ (fig. 5).

locations and accurate descriptions by geologists (e.g., Lund 1965). The appendix gives the legal description and elevation of each boring location and the quadrangle in which the boring was made. Detailed log descriptions with diagrams, laboratory data tables, and cross sections from borings at selected proposed landfill sites are presented in Curry (1995).

For the purpose of mapping and making cross sections, we have classified geologic units as *lithostratigraphic units.* The fundamental lithostratigraphic unit is the formation, which by definition, must be mappable (Hansel and Johnson 1996). Subdivisions of formations are called members, and a series of similar formations is called a group.



Lithostratigraphic units (litho, from the Greek word for stone, and strata, meaning horizontal layers) discussed in this report are sedimentary deposits with

- ordered sequence (stratigraphic order),
- consistent or predictably variable physical features.

They can be shown in cross section (above) or mapped.

Geologic Materials at Land Surface

Plate 1, which shows the distribution of geologic materials at land surface, was made by combining the 75 soil series mapped by Ray and Wascher (1965) into groups based on geologic interpretations of the soil parent materials. The groups were differentiated by color, particle-size distribution, soil (pedogenic) and sediment structure, position on the landscape, and interpreted origin. The mapped soil types include those developed in *diamicton*[2] (poorly sorted sediments with a wide range of grain sizes), *alluvium* (stream or river sediments), *colluvium* (materials eroded from hillsides), organic sediments, and *lacustrine sediments*

[2]A diamicton deposited by glacial ice is commonly referred to as *till.* In this report, we use the descriptive term *diamicton* rather than till because we have used primarily descriptive data to compile the thickness and distribution of very poorly sorted lithologic units.

(fine-grained lake deposits) (table 1). The map was checked against earlier surficial geologic maps and stack-unit maps of McHenry County (Alden 1904, Hackett and McComas 1969, Specht and Westerman 1976, Kempton et al. 1977, Lineback 1979, Berg and Kempton 1988, Wickham et al. 1988, Berg 1994) and information from borings.

Stack Units

Stack-unit maps show the thickness and distribution of layered geologic materials from the land surface to a specified depth within a specified region, such as a county (Kempton 1981). Stack-unit maps represent the three-dimensional geologic (or lithostratigraphic) units on a two-dimensional map.

An important tool for regional planning, a stack-unit map is especially useful wherever there are concerns about the distribution and depth of buried aquifers (Berg 1994, Kempton and Cartwright 1984). For this study, we mapped stack units at a scale of 1:24,000 and to a depth of 100 feet. This depth is critical because studies of groundwater quality in Illinois and elsewhere in the once-glaciated Midwest indicate that contamination from agrichemicals markedly decreases in water samples collected below 100 feet deep (Schock et al. 1992, Klaseus et al. 1989, Libra et al. 1991).

Stack-unit mapping involved the following steps:

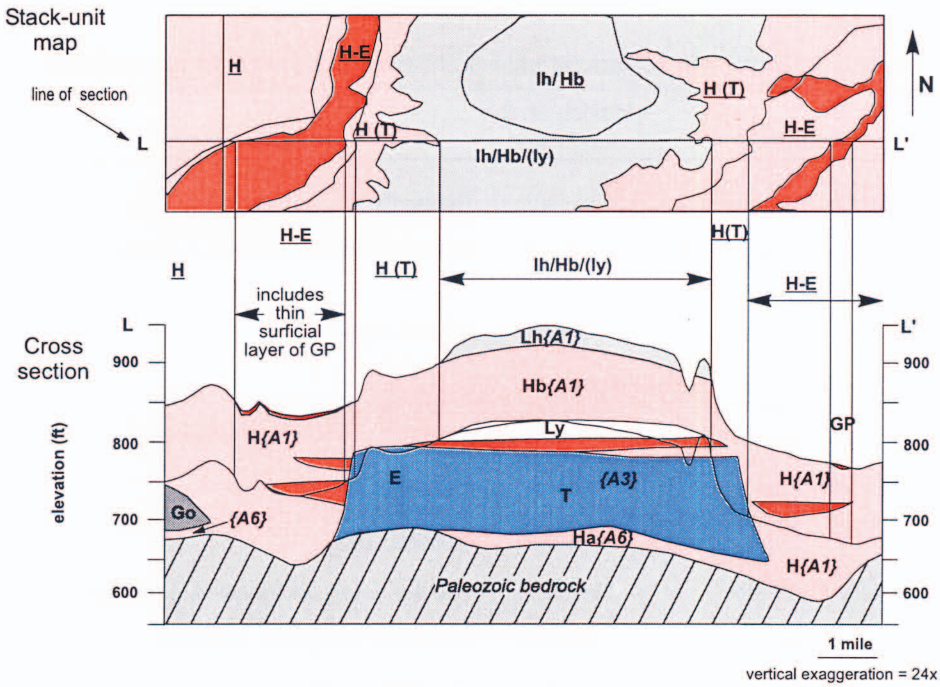
1. Locations of wells and borings were plotted on 1:24,000-scale base maps. The succession of geologic materials, as interpreted from the lithologic logs, was then plotted from Geological Survey borings, engineering borings, water wells, field observations, and other sources.
2. Eleven cross sections showing the glacial drift and bedrock topography were made on the basis of stratigraphic successions indicated by the logs.

Table 1 Common parent material and soil series associations in McHenry County

Parent material	Position on the landscape	Soil series
Bedrock	lowland	Platteville
Oregon and Capron Till Members	upland	Russel, Xenia, Saybrook, Lisbon
Tiskilwa Formation	upland	Miami, Strawn
Lemont Formation		
Yorkville Member	upland	Elliot, Varna, Morley
Haegar Member	upland	McHenry, Ringwood, Griswold
Henry Formation	upland	Rodman, Lorenzo, Casco, Warsaw, Fox, Kane, Will
	lowland	Volinia, Lomax
Equality Formation	lowland	Proctor, Brenton, Harvard, Camden
All the above	lowland	Drummer, Harpster, Peotone
Grayslake Peat	lowland	Houghton, Lena
Cahokia Formation	lowland	Otter, Millington

3. *Isopachous maps* were made for selected geologic units, and structure-contour maps were made to show key stratigraphic horizons, such as the top of a buried soil.
4. Stack units, as interpreted from the vertical sequences and unit thicknesses, were labeled on each line of cross section.
5. Stack units were defined and mapped on the basis of (a) the stack units shown on the cross sections, and (b) the distribution and thickness of units indicated by structure contour and isopachous (thickness) maps. Several map units were combined to make the map more readable.
6. The new maps were checked for consistency with other surficial geology maps (Masters 1978, Wickham et al. 1988) and plate 1, the most up-to-date map of geologic materials at the surface of McHenry County. The maps were also compared with other stack-unit maps of the area (Kempton et al. 1977, Berg and Kempton 1988, Berg 1994).
7. The stack-unit map data were cross-checked with the geologic successions indicated by more than 600 water-well logs and water-level data collected for this investigation by the Illinois State Water Survey. Water-level data helped to verify the connectivity of confined sand and gravel aquifers.
8. Map units on the aquifer sensitivity map (plate 3), interpreted from the stack-unit maps, were digitized and input to the Geographic Information System, the State Scientific Surveys' digital data depository.

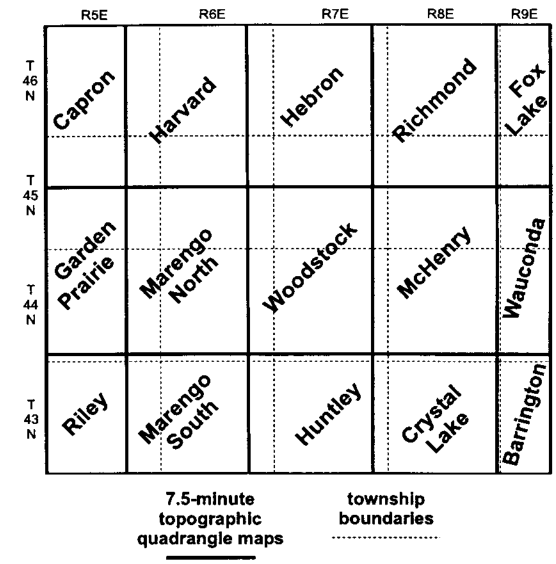
A reduced version of the stack-unit map for a part of the McHenry Quadrangle and its cross section L-L' are shown on figure 5. Surficial river sediments (Cahokia Formation) and organic sediments (Grayslake Peat) are shown on figure 5 as dark orange.



5 Cross section L–L' of part of McHenry 7.5-minute quadrangle (fig. 4). Stack units are mapped to a depth of 100 feet, as shown by the dashed line on the cross section. Key for symbols is on fig. 14.

The accuracy of a stack-unit map depends on the quantity, quality, type, and distribution of basic geological data; the complexity of the areas being mapped; the depth for which data are available; and the scale at which the final product is prepared and printed (Kempton 1981). The availability and accuracy of geologic data decrease with depth. Boundaries based on distinctions in the physical and chemical properties of sediments are most reliable in the upper 50 feet or so. Because geologic deposits commonly pinch out or grade laterally into other materials, the mapped position of a boundary between otherwise well-defined units may be inaccurate; however, as more data become available, boundaries may be mapped more accurately.

Stack-unit maps of materials to a depth of 100 feet and at a scale of 1:24,000 are accompanied by west–east and north–south cross sections showing the geology from land surface to the top of bedrock (fig. 4). They will be available for each of the 15 partial and full U.S. Geological Survey 7½-minute quadrangles that cover the county (fig. 6).



6 Locations of 7.5-minute topographic quadrangle maps and townships.

Characterization of Geologic Units

Particle-size distribution, clay mineralogy, and other physical properties such as moisture content are useful data for identifying geologic units (plate 1). The data on physical characteristics are also useful for correlation; that is, for tracing layered geologic units throughout an area. In this way, geologists explain the distribution and thickness of sediments in areas for which no geologic data are yet available.

The grain size ranges are as follows: sand 2.0–0.63 mm; silt 0.63–0.004 mm, and clay <.004 mm. Clay mineralogy in this report specifically refers to the semiquantitative analysis of minerals in the <.002-mm-size fraction (Wickham et al. 1988). The analyses were performed on oriented, aggregate, glycolated slides of the <.002-mm fraction. Clay minerals were separated into three groups: expandable clay minerals, illite, and kaolinite plus chlorite.

Radiocarbon ages, determined in the radiocarbon laboratory at the State Geological Survey, were used to confirm stratigraphic interpretations. The ages also helped in estimating the timing of fluctuations of the last *continental glacier*, the Laurentide Ice Sheet, as well as its final retreat from northern Illinois.

GEOLOGIC FRAMEWORK

The geologic framework of a region, such as McHenry County or northeastern Illinois, is constructed from information on the age, thickness, properties, depth, distribution, and continuity of its geologic units. The regional framework is established by geologists interpreting ancient sedimentary environments and the relationships between geologic units, materials (clay, silt, sand, and gravel) in the units, and water that flows through or around them.

The regional framework also functions as a frame of reference for classification of lithostratigraphic and stack units. In this report, descriptions of the ancient (Paleozoic) bedrock and the younger (Quaternary) glacial deposits will be presented within the formal framework, progressing from the oldest units at the bedrock surface to the youngest units at the land surface.

Bedrock Geology

Information on the bedrock geology of McHenry County is limited because a thick cover of glacial deposits covers most of the area. Graese (1991) and Kolata and Graese (1983) give the most recent account of the vertical succession of bedrock units. A few samples of geologic materials from water-resource exploration borings and bedrock outcrops in western McHenry County indicate that the Paleozoic *sedimentary* rocks are unfaulted and dip about 0.1° to 0.2° (about 10 feet per mile) to the east (figs. 7, 8) as part of a regional bedrock structure called the Wisconsin *Arch* (Nelson 1995, Graese 1991).

Visocky et al. (1985) provide a regional overview of the groundwater in bedrock *formations* in northern Illinois, whereas Woller and Sanderson (1976) discuss the water quality and bedrock geologic materials that constitute aquifers in the county. Their data show that aquifers in bedrock formations are significant sources of groundwater, especially for municipalities and industry in the county. In 1994, about 37% of the public water supply came from wells finished in bedrock aquifers (Scott Meyer, Illinois State Water Survey, pers. comm. 1996).

Discussion of bedrock units begins with the Galena Group, the oldest unit that occurs at the surface of bedrock lying under the glacial deposits in McHenry County.

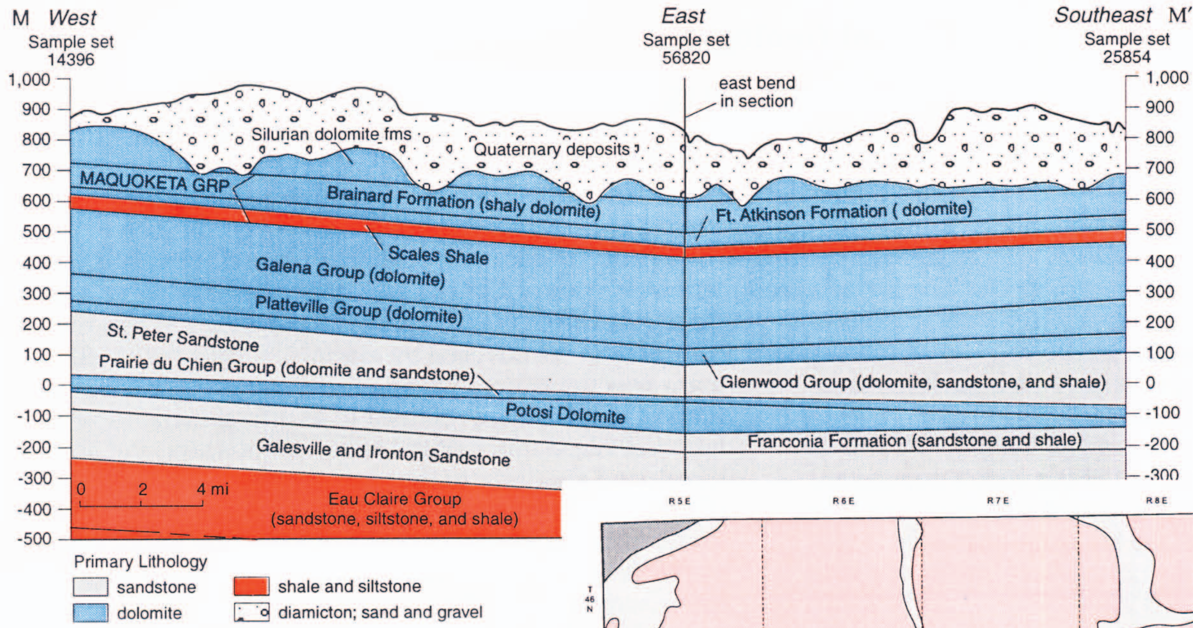
Galena Group

Composed primarily of fossiliferous *dolomite*, the Galena Group is locally shaly and about 200 feet thick (Woller and Sanderson 1976). The elevation of the top of the group is nearly 600 feet above mean sea level in western McHenry County and about 400 feet above mean sea level in eastern McHenry County (fig. 7; Bristol and Buschbach 1973).

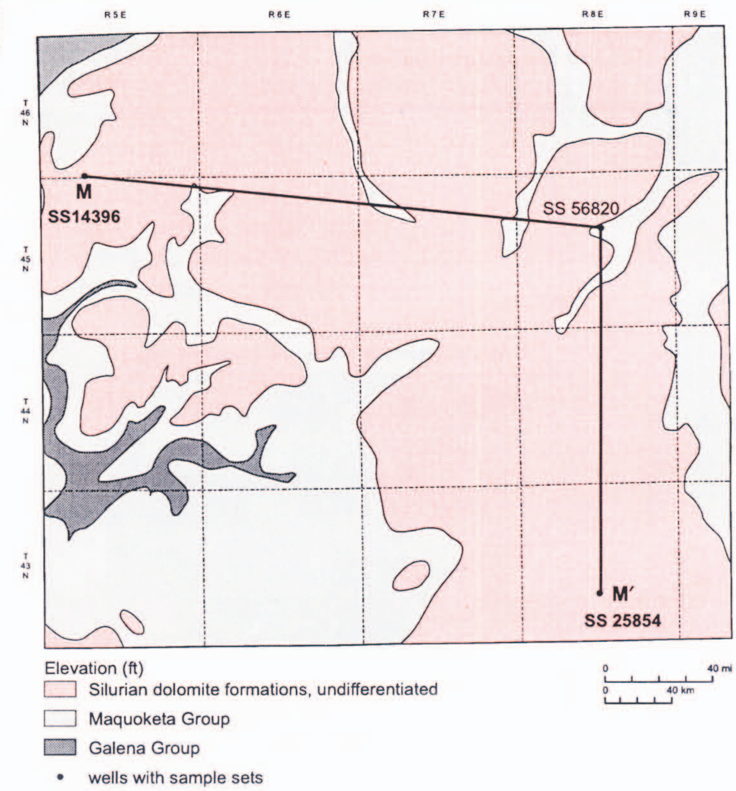
Where present at or near the bedrock surface, Galena dolomite may contain water-filled cracks and crevices that yield plentiful groundwater supplies for residences and small subdivisions; however, these features are not widespread in McHenry County. The Galena is used as a groundwater resource west of the county where the Quaternary drift is thin and overlying rock units are thin or missing (Berg et al. 1984).

Maquoketa Group

The shale and shaly, coarse-grained dolomite and *limestone* of the Maquoketa Group are present at the bedrock surface in several areas of McHenry County (fig. 8). Where overlain by Silurian rocks, the Maquoketa is 150 to 210 feet thick. The elevation of the top of the Maquoketa is about 750 feet above mean sea level in western McHenry County and 600 to 640 feet above mean sea level in the eastern part of the county (fig. 7). By examining several water-well sample sets, Kolata and Graese (1983) identified about 40 feet of basal, low-permeability dolomitic shale correlated with the Scales Shale. The upper 140 feet of the Maquoketa often contains layers of more highly *permeable*, fossiliferous, shaley dolomite of the Fort Atkinson



7 Cross section M–M′ showing Paleozoic bedrock units. Locations of water wells, from which sample sets (SS) were collected, appear on figure 8.



8 Areal geology of the bedrock surface; line of cross section for fig 7.

and Brainard Formations (fig. 7). Water-filled voids in the dolomitic portions of the Maquoketa can yield adequate groundwater supplies for residences and small subdivisions (Woller and Sanderson 1976); however, this bedrock is less reliable as an aquifer than the overlying Silurian dolomite or underlying Galena dolomite (Visocky et al. 1985, Curry et al. 1988, Graese et al. 1988).

Silurian Dolomite Formations

The Silurian dolomite formations (fig. 8), the youngest bedrock units in the region, cover most of the county at the bedrock surface beneath the glacial deposits. These formations are collectively more than 100 feet thick in parts of southeastern McHenry County (Woller and Sanderson 1976).

Groundwater-yielding, fractured, and creviced dolomite forms the Upper Bedrock Aquifer of Visocky et al. (1985). Weathering or dissolution formed and enlarged the secondary openings in the rocks when they were at or near the ground surface. The fractures and crevices connect groundwater in the bedrock with groundwater in the overlying sand and gravel aquifers (Gilkeson et al. 1987).

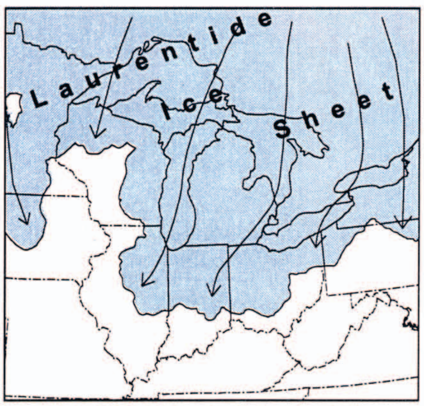
Glacial Geology

Origin of Glacial (Quaternary) Materials

The Quaternary geologic history of McHenry County spans a time during which continental glacial ice of the *Harvard Sublobe* of the Lake Michigan Lobe overrode, then retreated from the area several times. This tongue of ice was part of the great Laurentide Ice Sheet, which covered much of the Great Lakes region of North America and elsewhere (see sidebar below). Thick glacial sediment in McHenry County was deposited during at least three *glaciations* over the past 730,000 years. When the county was not covered by glacial ice, little new sediment was deposited. During these ice-free periods, the longest of which are referred to as *interglaciations*, vegetation covered much of the ancient landscape and soils developed similarly to those on the modern landscape (Curry and Follmer 1992). Ancient soil horizons, buried under younger glacial deposits or loess, are important *marker beds* in Illinois, and represent significant breaks or *unconformities* in the succession of Quaternary sediments lying between land surface and bedrock.

The glacial cover is a great resource. It is the source of sand and gravel for construction and the groundwater for almost half of our state's population, the foundation of our towns and roadways, the burial ground for our wastes, and the parent materials of rich soils.

The following discussion on glacial history synthesizes our geological interpretations of the Quaternary deposits in McHenry County. The glacial history reconstructs the advance and retreat of the Harvard Sublobe and associated geologic events, such as the formation of lakes due to the melting of glacial ice. The configuration of the lobe has been interpreted from surficial and buried landforms as well as the distribution of diamictons and other units deposited during glacial advances, retreats, and stagnation. Reconstruction of the ancient ice margin positions is relevant to the interpretion of the continuity, distribution, and composition of the deposits, all of which are essential for optimal use and protection of earth resources.



In most of Illinois, glacial materials cover bedrock. This cover, also called drift, is what continental glaciers left in Illinois during the Quaternary Period between 730,000 and 14,000 years ago. The glacially derived materials—sand, gravel, silt, and clay—range from as thin as a few feet to as thick as 500 feet in McHenry County.

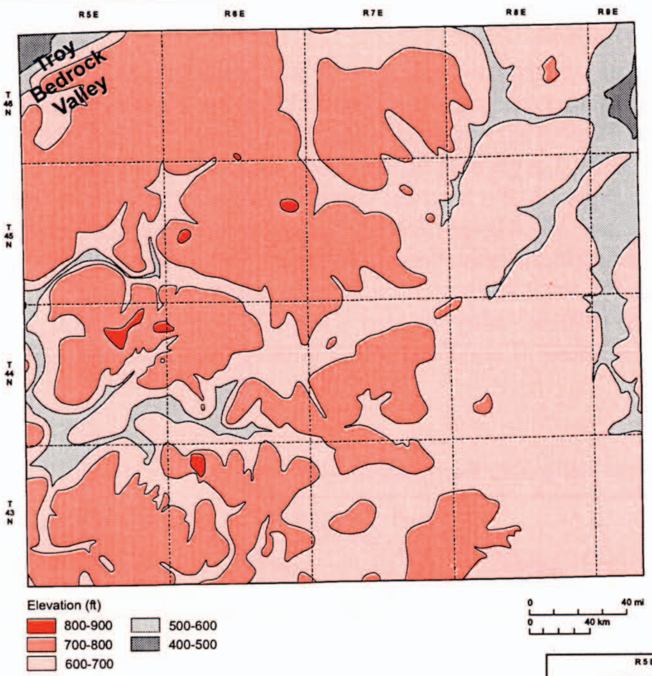
Pre-Illinois, Illinois, and Sangamon Episodes

The history of glacial drift deposits that predate the Illinois Episode is not well understood because these deposits have been eroded by wind, water, mass wasting, and ice. In most of McHenry County, pre-Illinois deposits were overridden by ice during the most recent glaciation. The subsurface and outcrop data for these deposits are limited.

In the Rockford area of Winnebago County, at least three fluctuations of the Lake Michigan Lobe during the Illinois Episode have been identified in deposits such as *proglacial outwash* and buried soils that mark the fluctuations of the glacier margin (Berg et al. 1985). As these deposits are largely missing in McHenry County, the record of fluctuations of the Illinois Episode ice margin is incomplete for the county. The Illinois Episode occurred from about 190,000 to 130,000 years ago (Johnson 1986, Curry and Pavich 1996).

At the Bedrock–Glacial Drift Interface

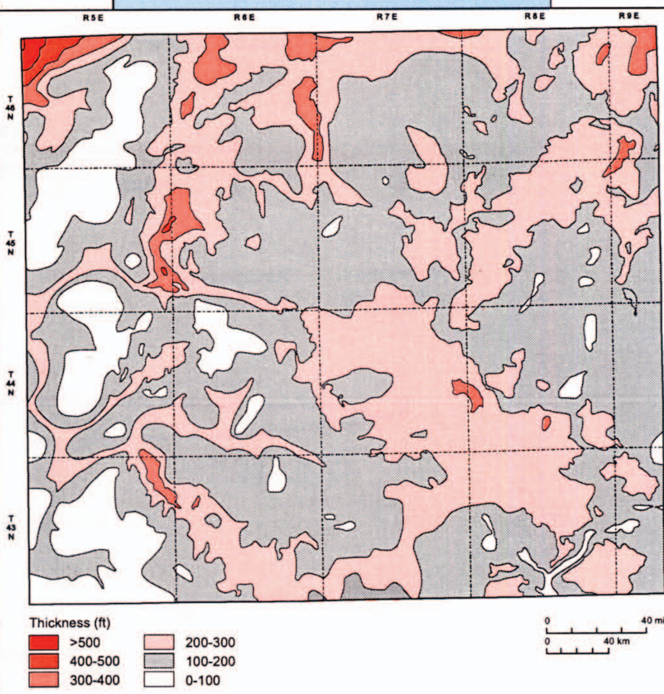
Sediments deposited between about 400 million years ago (the age of the youngest Silurian rocks) and 730,000 years ago (the approximate age of the oldest Quaternary glacial sediment in the county) are not preserved in McHenry County. The Paleozoic bedrock was most likely buried by younger rocks, then later eroded by water and glacial ice.



9 Bedrock topography

The bedrock topography of McHenry County (fig. 9) is characterized by uplands with slopes of less than 1° dissected by valleys. The valleys were likely formed by streams and rivers before the invasion of *continental glaciers*, then further eroded by glaciers and meltwater rivers. Eventually, the bedrock surface was buried by glacial diamicton, lacustrine sediments, and sand and gravel.

Valleys cut into the now buried bedrock surface commonly contain significant glacial sand and gravel deposits, which function as aquifers. The Troy Bedrock Valley in the northwestern corner of the county is one of the region's most important buried bedrock valleys (fig. 9; Berg, Kempton, and Stecyk 1984, Herzog et al. 1994). Bedrock elevations range from about 475 feet above mean sea level in the valley bottom to more than 850 feet above mean sea level in adjoining uplands. Deeply incised tributaries to the Troy Bedrock Valley in western McHenry County and an unnamed bedrock valley system in northeastern McHenry County may contain aquifers and could be targeted for groundwater resource exploration.



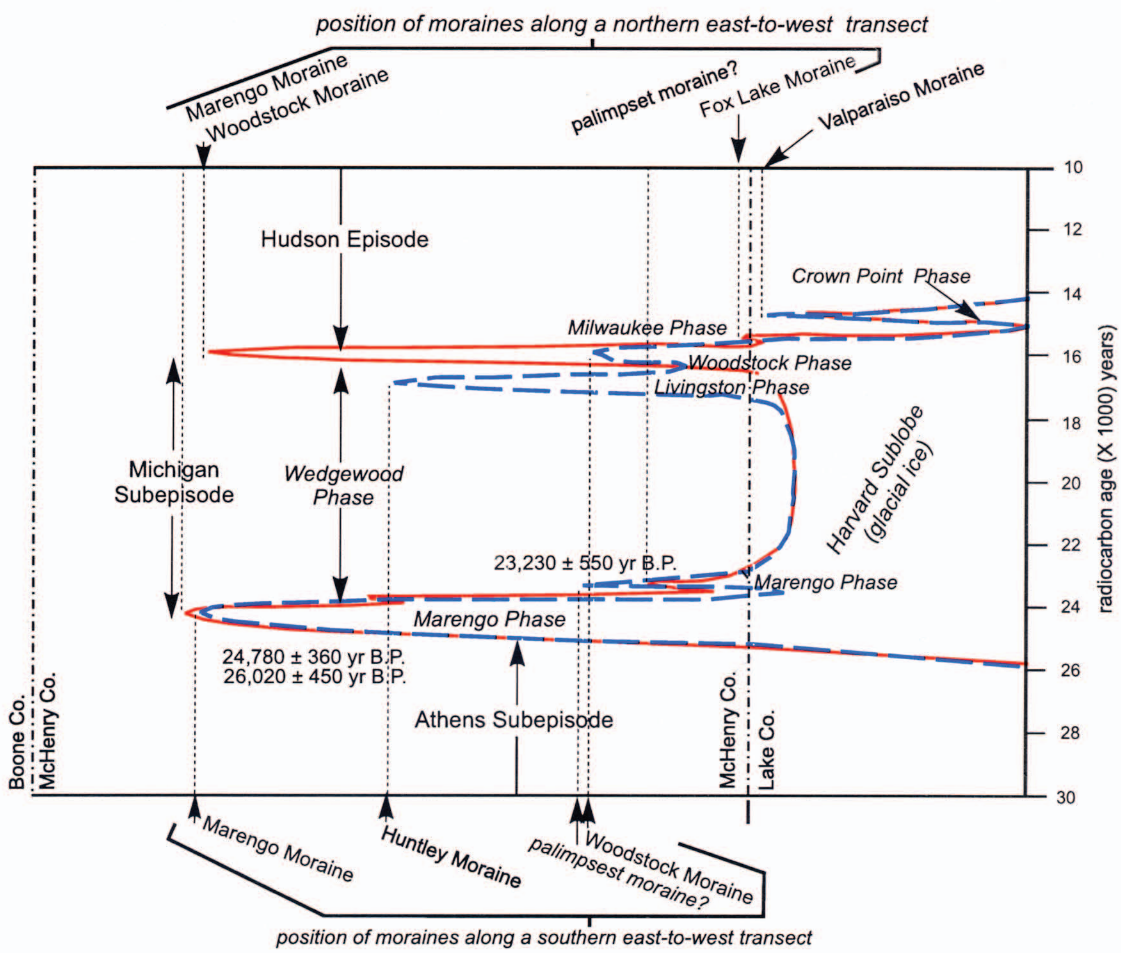
10 Drift thickness

Glacial sediments completely cover McHenry County, except where one small quarry and a few creek banks expose bedrock in the southwestern part of the county. The thickest deposits (more than 500 feet) fill the Troy Bedrock Valley in the northwestern corner (fig. 10). Other areas with drift between 350 and 500 feet thick are associated with the Marengo and Woodstock Moraines (fig. 3). (*Moraines* are the ridges and hummocky hills of debris deposited at a glacier's edge.) Small areas with less than 50 feet of glacial drift occur throughout the county, but the largest areas of thin drift occur in western McHenry County and along the Fox River valley near Algonquin (fig. 10).

The Illinois glacial episode was followed by the Sangamon Episode when climatic conditions were similar to those of today. Soil-forming processes altered and reworked the Illinois Episode glacial deposits, forming the Sangamon Geosol (an ancient buried soil). The Sangamon Episode lasted from about 130,000 to 55,000 years ago.

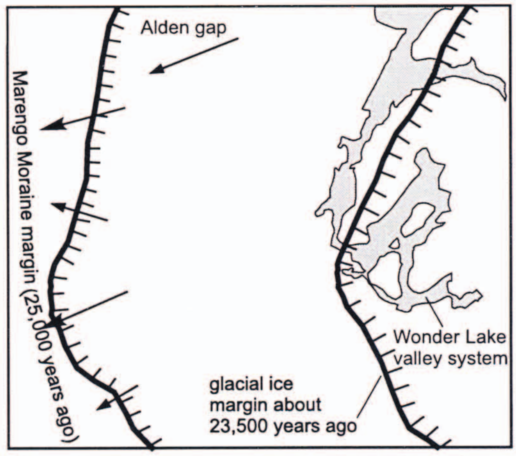
Wisconsin Episode

Soils continued to form and windblown silt slowly accumulated from about 55,000 to 25,000 years ago during the gradual climatic cooling of the Athens Subepisode of the Wisconsin Episode (fig. 11; Follmer 1983, Curry 1989, Curry and Follmer 1992, Leigh and Knox 1993, Curry and Pavich 1996). When the Lake Michigan Lobe formed during the last glaciation, the ice initially flowed from Lake Michigan directly west toward the McHenry County area. Just before the glacier's invasion about 24,780 ±350 radiocarbon years ago (Curry and Pavich 1996), spruce forests covered the landscape of much of northern Illinois (Meyers and King 1985) and seasonal wind storms deposited the loess of the Peoria Silt (Curry and Follmer 1992).

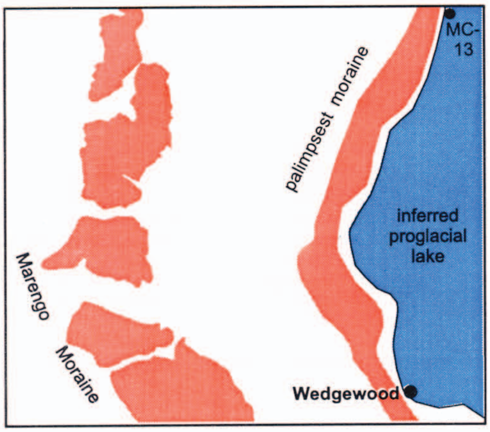


11 Diagram of time vs distance: Harvard Sublobe of the Lake Michigan Lobe during the Michigan Subepisode. Y-axis indicates when the Harvard Sublobe was in McHenry County, and the x-axis indicates how far the ice extended from east to west across the county. Orange line shows fluctuations of the sublobe in the southern part of the county (cross-section line E–E′, fig. 4); blue line shows the fluctuations in the northern part of the county (cross-section line A–A′, fig. 4).

Most people in McHenry County live on sediments deposited during the last glaciation—the Michigan Subepisode of the Wisconsin Episode (fig. 11). Phases refer to the intervals when sediments were deposited during a single fluctuation of the Harvard Sublobe. For the most recent glaciation, the sublobe first flowed into McHenry County during the Marengo Phase from about 25,000 to at least 23,500 radiocarbon years ago. In that interval, the diamicton of the Tiskilwa Formation and the sand and gravel of the Ashmore Tongue were deposited, as the Marengo Moraine formed in western McHenry County (fig. 12a). At least one more moraine formed during the retreat of the Harvard Sublobe about 23,500 years ago in the Marengo Phase (fig. 12a). Also composed of Tiskilwa diamicton, this second moraine was later buried by sediments during subsequent readvances of the sublobe.

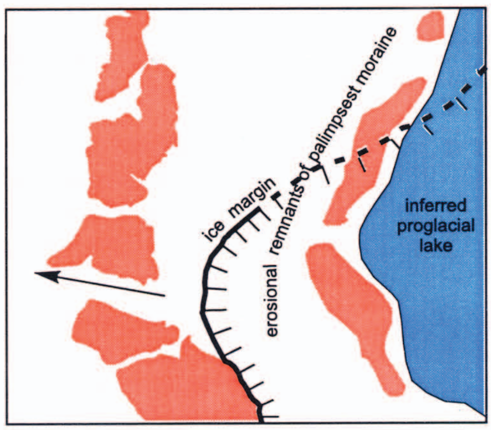


12a Marengo Phase. Arrows show flow of glacial meltwater below and in front of the ice.



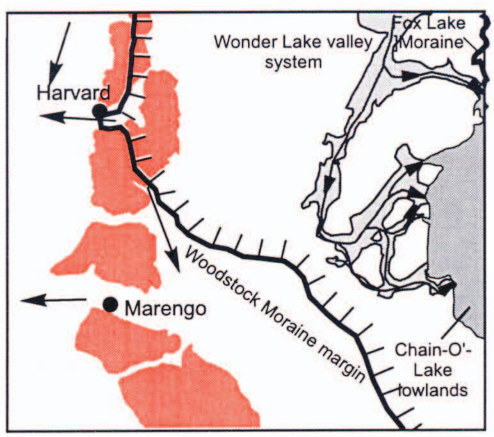
12b Wedgewood Phase

As the Harvard Sublobe retreated from the McHenry County area, a large lake formed behind the second moraine. A tongue of the Equality Formation was deposited in the lake during the Wedgewood Phase (fig. 12b).



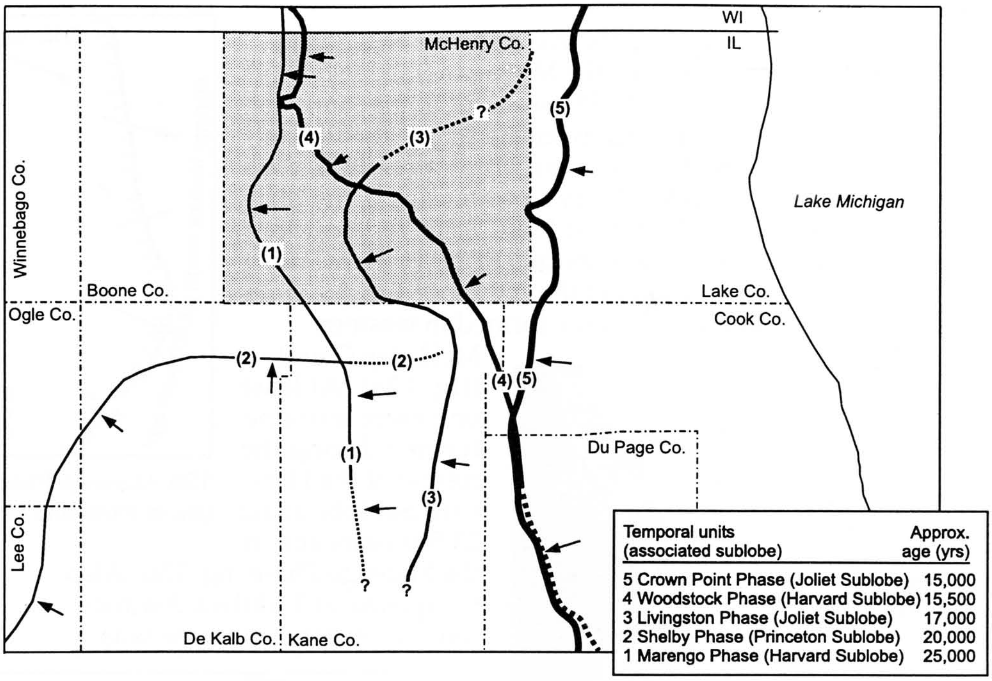
12c Livingston Phase

The Harvard Sublobe readvanced into this region and deposited the Yorkville Member of the Lemont Formation during the Livingston Phase (fig. 12c). Unknown factors inhibited deposition of the Yorkville diamicton in northern McHenry County during that time; ice movement may have been blocked by glacial ice that had persisted from the previous ice advance. The western margin of glacial deposition at this time is marked by the broad, hummocky uplands of the Huntley and Barlina Moraines. After the Yorkville unit was deposited, the Harvard Sublobe margin retreated to near the present Chain-O'-Lakes lowland.



12d Woodstock Phase

During the Woodstock Phase, the Harvard Sublobe overrode many previously deposited sediments, and formed the Woodstock Moraine (fig. 12d). North of Harvard, the ice margin deposited Haeger diamicton atop the Marengo Moraine, forming the Marengo-Woodstock Moraine. Sand and gravel of the Beverly Tongue of the Henry Formation and undifferentiated Henry Formation, and diamicton of the



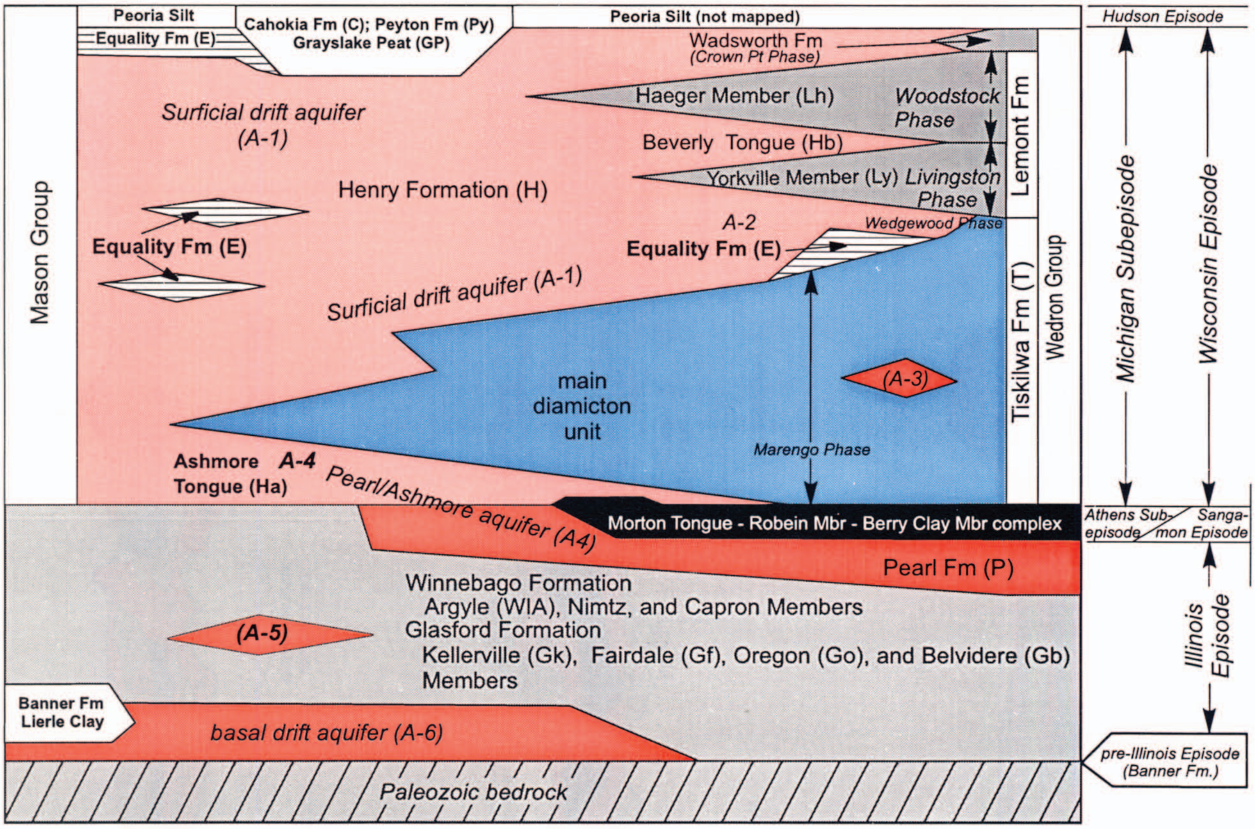
13 Position of ice margins (including possible ice-marginal debris flows or landslides) of selected sublobes of the Lake Michigan Lobe.

margin deposited Haeger diamicton atop the Marengo Moraine, forming the Marengo-Woodstock Moraine. Sand and gravel of the Beverly Tongue of the Henry Formation and undifferentiated Henry Formation, and diamicton of the Haeger Member of the Lemont Formation, were deposited during this phase.

Henry Formation sand and gravel deposited during the last phase of glacial activity (fig. 12d) constitute much of the surficial aquifer in McHenry County. Proglacial alluvial fans and plains were buried by the ice in uplands covering much of northeastern McHenry County, while in western McHenry County large alluvial fans composed of thick sand and gravel were deposited beyond the ice margin adjacent to the Marengo Moraine. In the Wonder Lake valley system, coarse-grained sediments 20 to 40 feet thick were deposited by glacial meltwater. As the ice retreated, a minor readvance or standstill of the ice margin led to formation of the Fox Lake Moraine in northeastern McHenry County.

As deglaciation progressed, the Wonder Lake valley system was modified by meltwater that eroded the sides of valleys in a few areas and by the deposition of sand and gravel in *kames* and *kame terraces* in the Wonder Lake and Glacial Park areas. Also during this time, meltwater flowed across the large channel that cuts across the Marengo Moraine near the town of Marengo (fig. 12d). The ice margin retreated rapidly to near the Milwaukee area from about 15,500 to 15,000 radiocarbon years ago during the Milwaukee Phase (fig. 11). The final advance of the Harvard Sublobe during the Michigan Subepisode that directly affected McHenry County occurred from about 15,000 to 14,000 radiocarbon years ago during the Crown Point Phase when the Valparaiso Morainic System formed just east of McHenry County (fig. 13).

The postglacial history of McHenry County has not been studied in detail, although records of pollen and other fossils likely exist in the sediment of



14 Relationship of aquifers (orange) to lithostratigraphic and temporal units.

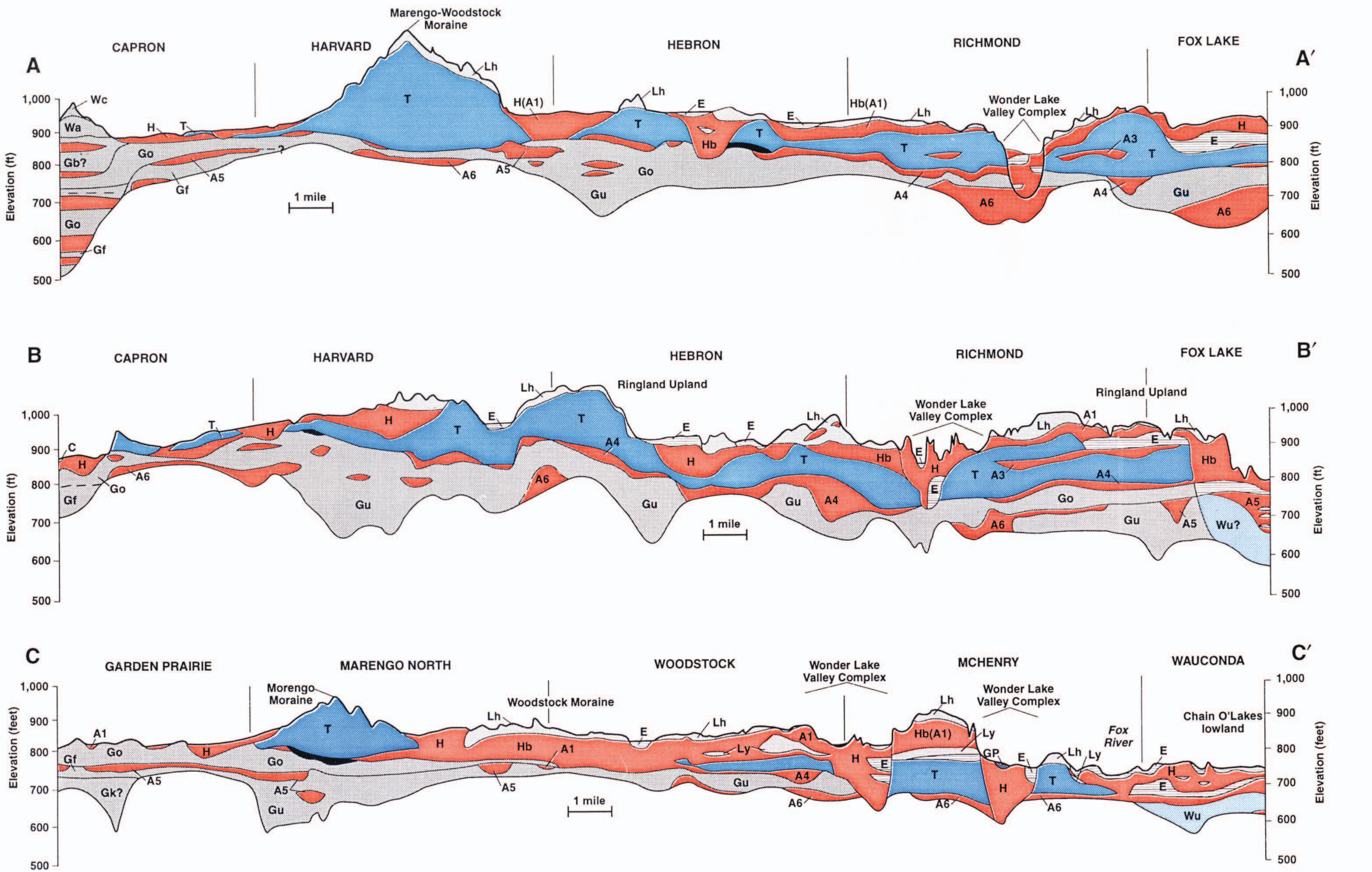
Crystal Lake and in other lakes in eastern McHenry County. Deglaciation began in northeastern Illinois about 14,000 radiocarbon years ago (Hansel and Johnson 1992).

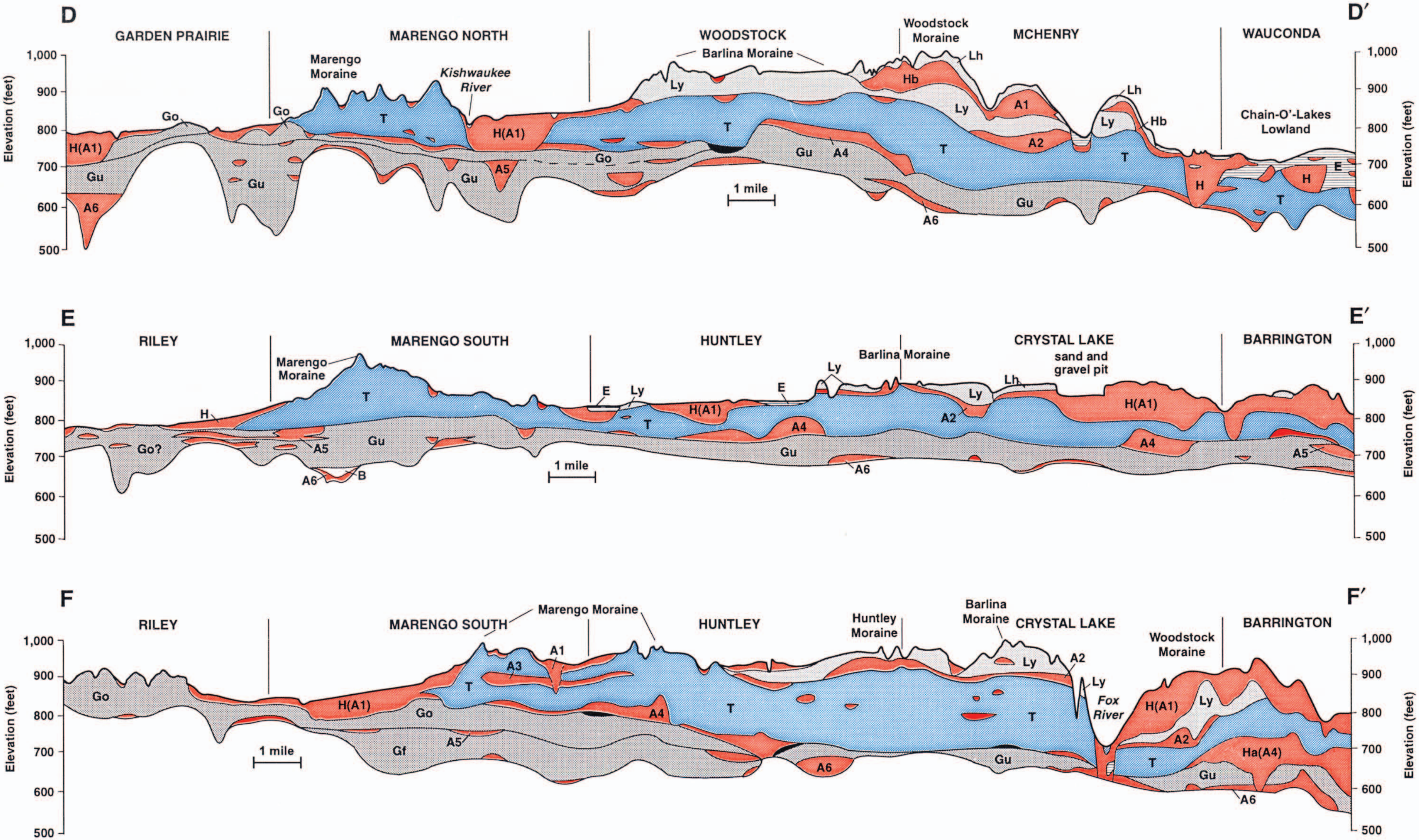
Deposits of Quaternary Materials

The deposits of three glaciations and two intervening interglaciations are found in McHenry County (fig. 14). The oldest Quaternary materials in the county belong to the Banner Formation, deposited between about 730,000 and 190,000 years ago (Miller et al. 1994, Kempton et al. 1991). Organic-rich soils and some sandy alluvium of the Lierle Clay were deposited above the Banner Formation and later buried by glacial sediment of the Illinois Episode 190,000 to 130,000 years ago (Johnson 1986, Curry and Pavich 1996, Hansel and Johnson 1996). These deposits of the Glasford and Winnebago Formations were first described in studies of Boone and Winnebago Counties (Willman and Frye 1970, Berg, Kempton, and Stecyk 1984).

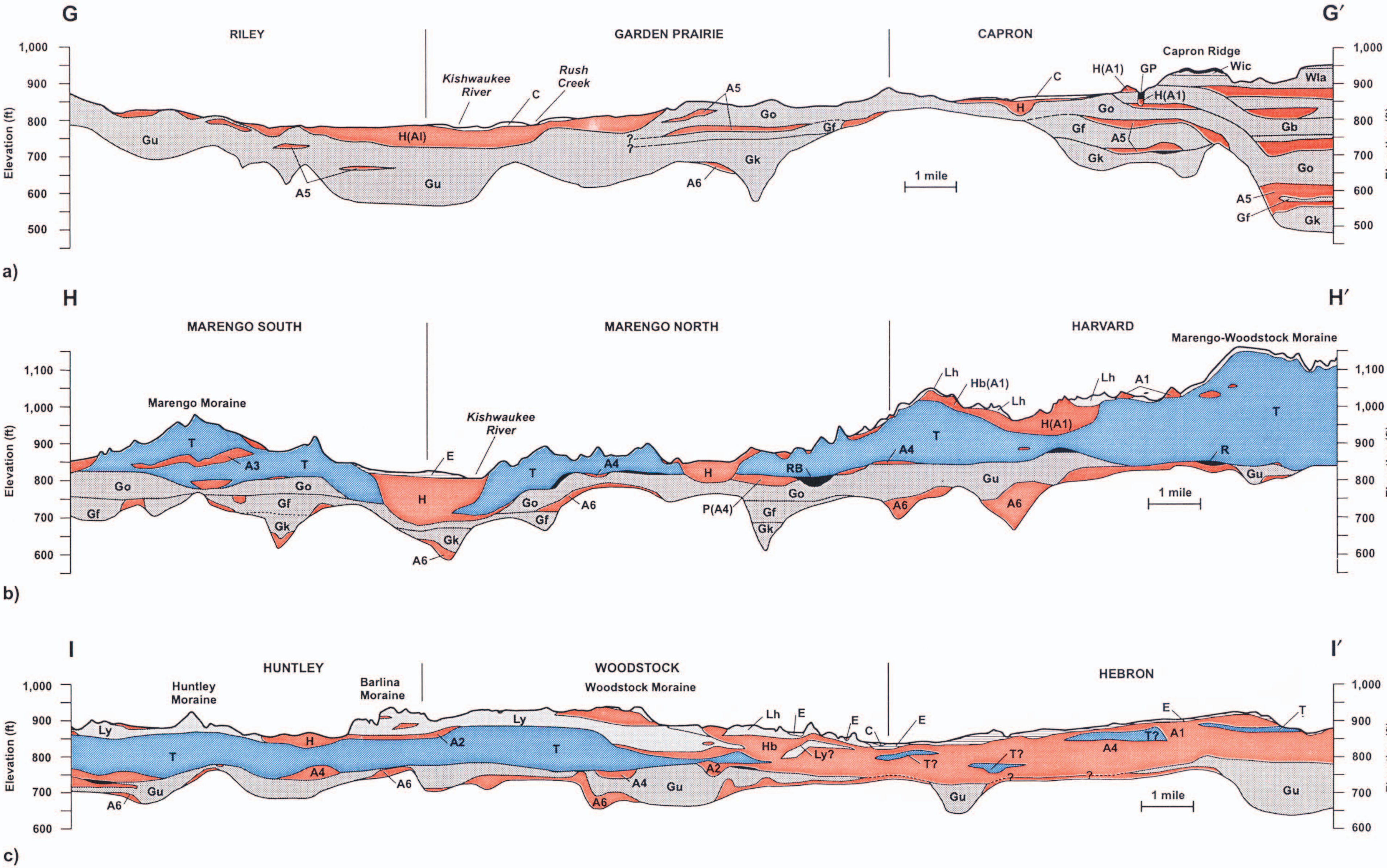
Illinois Episode sediments were weathered during the Sangamon Episode about 130,000 to 55,000 years ago. As a result of distant glaciation of the upper Mississippi River valley 55,000 to 25,000 years ago, windblown, weathered, and frequently organic-rich silt accumulated on the ancient land surface. This material is a distinctive marker bed called the Morton–Robein–Berry Clay complex (fig. 14).

Deposits of the last glaciation are largely sand and gravel of the Mason Group interlayered with diamictons of the Wedron Group (fig. 14); the Mason and Wedron sediments were deposited about 25,000 to 14,000 years

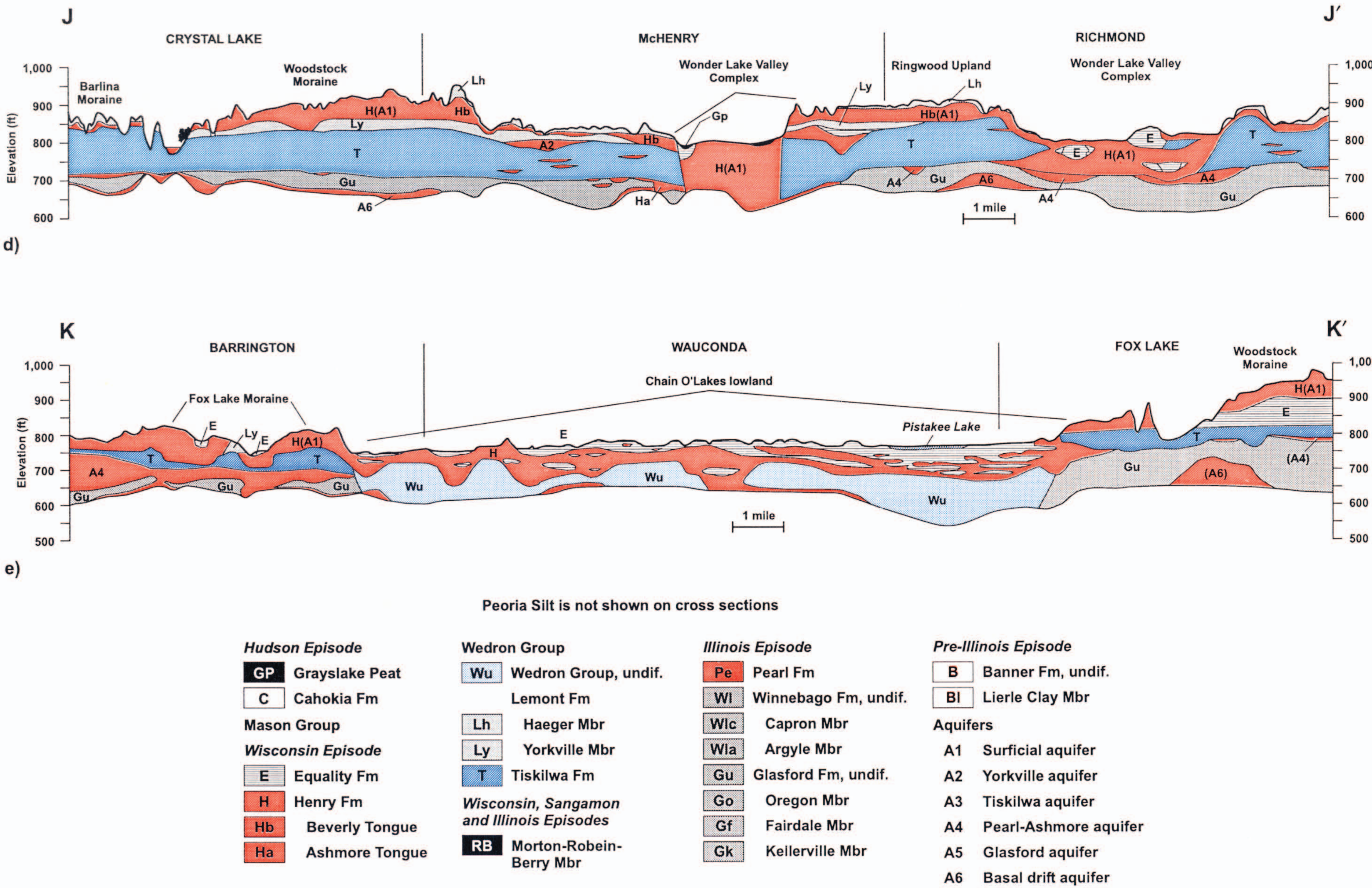

A
A′
CAPRON
HARVARD
HEBRON
RICHMOND
FOX LAKE
Marengo-Woodstock Moraine
Wonder Lake Valley Complex
Elevation (ft)
1 mile
B
B′
CAPRON
HARVARD
HEBRON
RICHMOND
FOX LAKE
Ringland Upland
Wonder Lake Valley Complex
Ringland Upland
Elevation (ft)
1 mile
C
C′
GARDEN PRAIRIE
MARENGO NORTH
WOODSTOCK
MCHENRY
WAUCONDA
Morengo Moraine
Woodstock Moraine
Wonder Lake Valley Complex
Wonder Lake Valley Complex
Fox River
Chain O'Lakes lowland
Elevation (feet)
1 mile



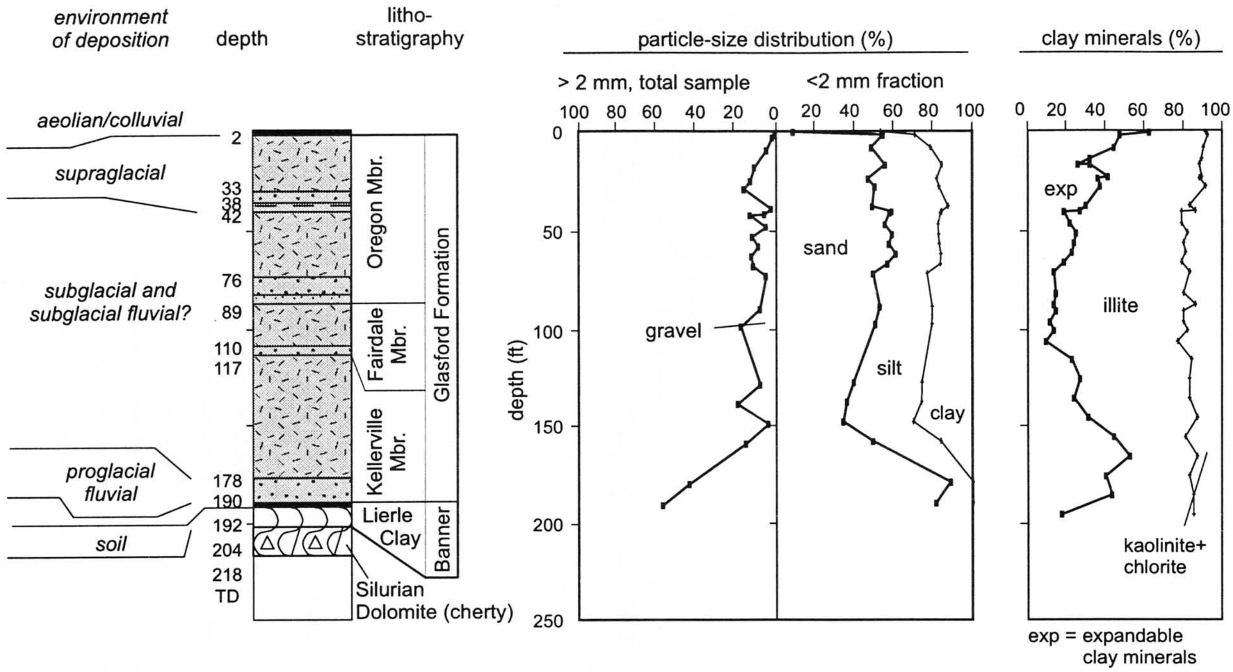
15a-f Six east-to-west cross sections. The names and boundaries of the topographic maps are shown above each cross section for reference. (lines of cross sections shown on fig. 4). Refer to legend on fig. 16a-e



G
G′
RILEY
GARDEN PRAIRIE
CAPRON
Capron Ridge
Kishwaukee River
Rush Creek
Elevation (ft)
1,000
900
800
700
600
500
H(AI)
Gu
A5
C
Go
Gf
Gk
A6
H
H(A1)
GP
Wic
Wla
Gb
1 mile
a)
H
H′
MARENGO SOUTH
MARENGO NORTH
HARVARD
Marengo-Woodstock Moraine
Marengo Moraine
Kishwaukee River
1,100
T
A3
E
A4
RB
P(A4)
Lh
Hb(A1)
A1
R
b)
I
I′
HUNTLEY
WOODSTOCK
HEBRON
Huntley Moraine
Barlina Moraine
Woodstock Moraine
Ly
A2
Hb
Ly?
T?
c)

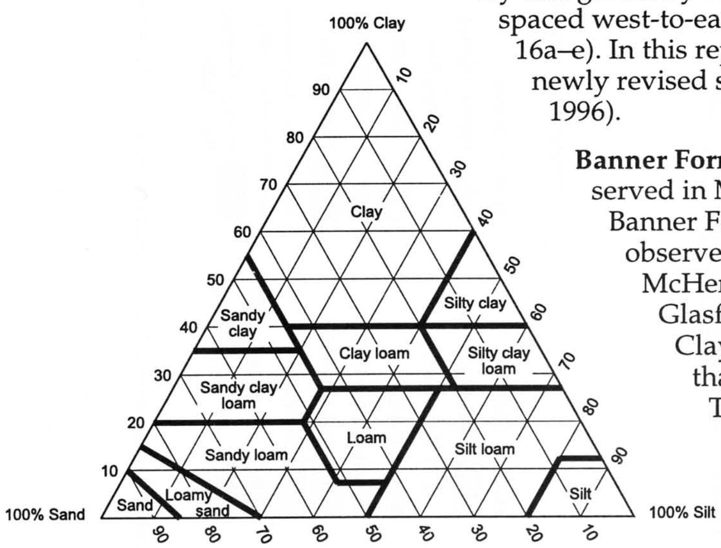


16a-e Five north-to-south cross sections. Names and boundaries of the topographic maps are shown above each cross section for reference. (Lines of cross sections appear on fig. 4).



17 Lithofacies log, interpreted environments of deposition, lithology, and age of sediments cored in boring MC-10 (from Curry 1995).

ago in McHenry County. Nonglacial surficial deposits that overlie the Glasford and Winnebago Formations and the Wedron and Mason Groups were deposited from about 14,000 years ago to the present. These deposits include the Grayslake Peat, Cahokia Formation alluvium (river and stream sediments), and Peyton Formation colluvium (slope debris). The continuity and geometry of the deposits is illustrated in a series of evenly spaced west-to-east and north-to-south cross sections (figs. 15a–f, 16a–e). In this report, presentation of Quaternary units reflects a newly revised strati- graphic nomenclature (Hansel and Johnson 1996).



18 Soil texture classes plotted on a triangular diagram.

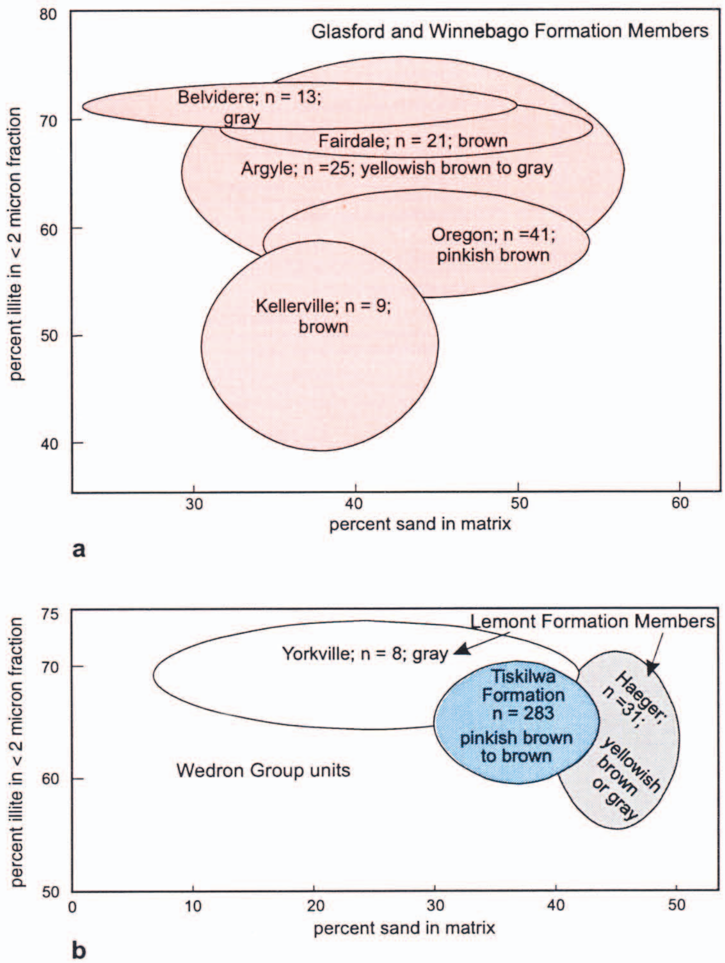
Banner Formation The oldest named Quaternary unit observed in McHenry County is the Lierle Clay Member of the Banner Formation (Willman and Frye 1970). This unit was observed only in boring MC-10 (fig. 17) in west-central McHenry County, where it is overlain by members of the Glasford Formation (Curry 1995). At this site, the Lierle Clay Member is a 13.5-foot-thick, clayey diamicton that is weathered and leached of carbonate minerals. The Banner Formation may also lie below a layer of buried organic-rich Lierle Clay in a small bedrock valley in the western part of the Marengo South 7.5-minute quadrangle (fig. 15e).

Glasford Formation The oldest unit of the Glasford Formation, the Kellerville Member, is light brown, *silt loam* to *loam* (fig. 18) diamicton that contains less illite and more expandable clay minerals than the other Glasford units (table 2 , fig. 17). In McHenry County, the Kellerville is buried by younger glacial sediment. In boring

MC-10 (fig. 17), the Kellerville is 73 feet thick. This is the thickest known deposit of the Kellerville Member in McHenry County.

Overlying the Kellerville is a diamicton unit, the Fairdale Member, which is pinker and sandier than the Kellerville (fig. 19a). The Fairdale was mapped in the Marengo South 7.5-min- ute quadrangle but was not identified east of there (figs. 15c, d). Its maximum known thickness, 27.5 feet, was encountered in boring NIPC-8 (fig. 4; Curry 1995).

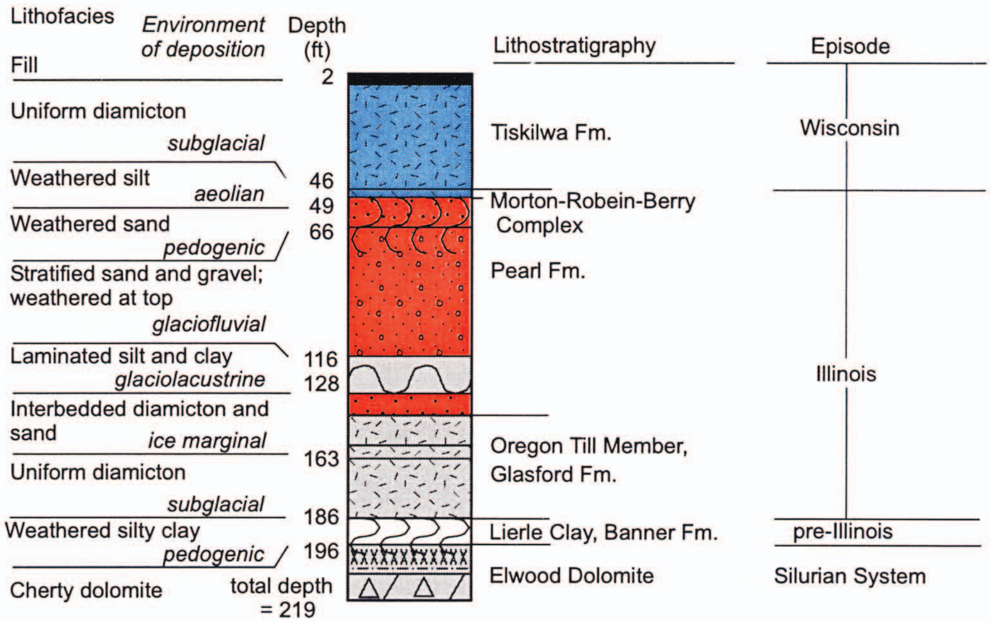
The most widespread Glasford Formation unit in McHenry County is the Oregon Member (Berg et al. 1985) composed of interbedded layers of pinkish brown loam diamicton and sand and gravel. An example of its lithologic complexity is seen in boring MC-10 (fig. 17), where sand and gravel beds constitute 21 feet of the unit's 87 feet of total thickness; the remaining sediment is glacially derived diamicton. In McHenry County, the Oregon Member is as much as 194 feet thick in boring NIPC-1 (fig. 4; Curry 1995). Both *sandy loam* and silty diamicton facies of the Oregon Member were identified in Boone and Winnebago Counties (Berg et al. 1985), but only the sandy loam facies was found in McHenry County.



19 Elliptical fields representing the mean and standard deviation of the percentage of sand in the matrix (x-axis) relative to the percentage of illite in the <2μm fraction (y-axis) for (a) till members of the Glasford and Winnebago Formations and (b) Wedron Group diamicton units.

The Belvidere Member, the youngest Glasford unit in north-central Illinois, was only identified in the Troy Bedrock Valley (boring NIPC-1) in McHen- ry County (Curry 1995). The Belvidere unit, which contains more illite than most other Glasford units (fig. 19a), is gray silt loam or silty clay loam diamicton. Diamicton of the Belvidere Member is commonly associated with silty glacial lake sediment (Berg et al. 1985).

Winnebago Formation The Winnebago Formation is present only in the northwestern part of the county on Capron Ridge, where it caps the succession of glacial materials (plate 1). The Argyle Till Member, a sandy loam diamicton, constitutes most of the Winnebago Formation. Although the Argyle is as much as 75 feet thick in adjoining Boone County (Berg et al. 1985), water well logs reveal that it is about 25 feet thick on Capron Ridge (fig. 15a). The Nimtz Till Member was identified beneath the Argyle in Boone and Winnebago Counties (Berg et al. 1985), but its presence in McHenry County has not been confirmed. The Capron Till Member, the uppermost member of the Winnebago succession, is as much as 30 feet thick on Capron Ridge (Krumm and Berg 1985). The Capron Member is loam to *clay loam* diamicton with abundant inclusions of silt and clay and



20 Lithofacies log, interpreted environments of deposition, lithology, and age of sediments cored in boring MC-8 (from Curry and Pavich 1996).

beds of sand and gravel. The texture is more variable than the underlying Argyle unit (Krumm and Berg 1985).

Pearl Formation The Pearl Formation is primarily sand and gravel and lesser amounts of loamy diamicton or silt; it lies above members of the Glasford Formation and below the combined Morton Tongue–Robein Member–Berry Clay Member or the Wedron and Mason Groups (fig. 14). The Pearl Formation is as much as 67 feet thick in northernmost central McHenry County (boring MC-8, fig. 20). It probably occurs extensively in this part of the county. After deposition, Pearl sediments were modified by the soil-forming processes that formed a *geosol* during the Sangamon Episode, a long interval between the Illinois and Wisconsin glacial episodes. The Sangamon Geosol, developed in Pearl sediment, contains as much as 40% clay; but most of the Pearl Formation contains less than 10% clay (Curry 1995). Differentiating the Pearl from the overlying Henry Formation in north-central McHenry County is difficult where the Sangamon Geosol or Wedron units are missing or discontinuous. (For example, see the northern part of cross section I–I′, fig. 16c).

Mason Group

The layers of sand and gravel, silt, or silty clay that make up the Mason Group occur above and below, as well as *intertongue* with, diamicton units of the Wedron Group (fig. 14); these units are always found above the Glasford and Pearl Formations (when present) or older units. In McHenry County, the Mason Group comprises four primary units (Hansel and Johnson 1996):

1. The Henry Formation, a sand and gravel unit, includes the Ashmore Tongue beneath the Tiskilwa Formation and the Beverly Tongue beneath the Haeger Member of the Lemont Formation.
2. The Equality Formation consists of clay, silt, and fine sand.

3. The Peoria Silt, a massive silty clay, has been altered by modern soil-forming processes. The Peoria includes the Morton Tongue (calcareous silt), which extends beneath the Tiskilwa Formation.
4. The Robein Member of the Roxana Silt is black, organic-rich, silty clay and silt loam. The unit occurs beneath the Tiskilwa Formation, Ashmore Tongue (Henry Formation), or Morton Tongue (Peoria Silt). The Morton Tongue, Robein Member, and Berry Clay were mapped as a single unit.

Morton Tongue–Robein Member–Berry Clay Member This combined unit is calcareous silt and leached, organic-rich or *gleyed*, silty to clayey sediment that lies above the Glasford, Winnebago, and Pearl Formations and below the Wedron and Mason Groups (fig. 14). In McHenry County, the Robein Member is usually less than 10 feet thick and the other units less than 5 feet thick, so that it is useful to combine them for mapping. Almost all combined units were altered by soil-forming processes (Follmer 1982, 1983, Curry 1989, Curry and Pavich 1996). The Robein Member is mostly leached, organic-rich silt. The overlying Morton Tongue, also silty, is calcareous and contains less organic matter. The lowest part of the unit, the Berry Clay Member, is gleyed, fine-grained diamicton leached of carbonate minerals. The Berry Clay Member is part of the Glasford Formation (Willman and Frye 1970).

The Morton Tongue–Robein Member–Berry Clay Member has been found in several borings, including MC-8 (fig. 20), MC-12, NIPC-3, NIPC-5, and NIPC-8, where it is 3.3, 5.5, 7.0, 5.0, and 15 feet thick, respectively. It has also been found in borings drilled for landfill siting investigations near Hartland, Woodstock, and Crystal Lake (Curry 1995).

Henry Formation ➤***Ashmore Tongue*** The Ashmore Tongue of the Henry Formation is predominantly *stratified* sand and gravel, but contains some lenses of laminated (finely stratified) clay and silt and clay loam diamicton. The sand and gravel of the Ashmore in southeastern McHenry County is more than 100 feet thick. The Ashmore Tongue occurs under diamicton of the Tiskilwa Formation (Hansel and Johnson 1996).

➤***Beverly Tongue*** Primarily thick, coarse, sand and gravel, the Beverly Tongue of the Henry Formation underlies the Haeger Member of the Lemont Formation (fig. 14; unit Hb in figs. 15, 16) and overlies the Tiskilwa and Yorkville units. The Beverly Tongue is more than 100 feet thick in eastern McHenry County and pinches out to the west against the Huntley and Barlina Moraines (figs. 15e, 16c). The Beverly Tongue is the thickest, most extensive component of the surficial drift aquifer. It is extensively mined as an aggregate resource in McHenry County (fig. 21, Masters 1978).

21 Highwall exposure (about 40 feet high) at the Meyers Material Company, McHenry West Pit 26.

Equality Formation ➤***Unnamed tongue*** In central and northeastern McHenry County, as much as 112 feet of finely bedded, very fine-grained sand, silt, and clay overlies Tiskilwa diamicton and underlies other Wedron diamicton units or thick Henry sand and gravel (figs. 15a, b). This layer of fine-grained sediment, given its composition and its stratigraphic position, is classified as a tongue of the Equality Formation. A 15-foot thickness of this tongue was also observed in boring MC-9 (fig. 4), as well as in an excavation during construction of a flood-control basin at what is now the Wedgewood Subdivision in the City of Crystal Lake.

The laminated to uniform silt and clay of the Equality Formation is commonly found with, and intertongues with, the Henry Formation (fig. 14). The fine layering, fine-grained texture, fossil content, and landform associations indicate that the Equality Formation was deposited in lakes, especially those associated with glaciers. The Equality Formation also includes any organic-rich, laminated to uniform silt and clay deposited in lakes since the last glacier melted away. The thickness of the Equality Formation below most existing lakes is unknown, but it is more than 50 feet thick in Nelson Lake, Kane County (Eric Grimm, Illinois State Museum, pers. comm. 1995). The silt and clay at the bottom of Wonder Lake, a reservoir built in 1929, has accumulated to about 20 feet thick.

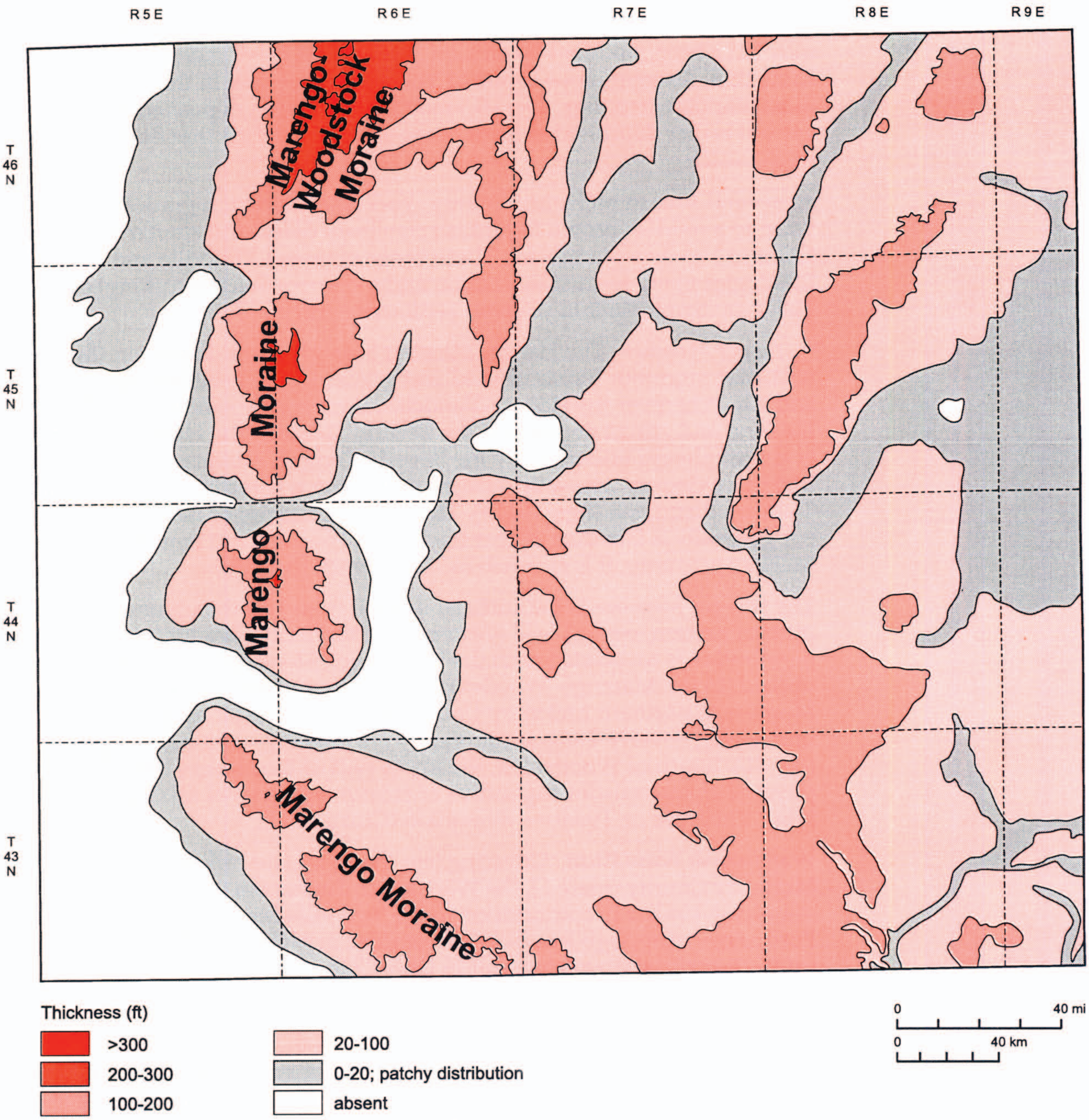
Wedron Group

Predominantly glacially deposited diamicton interbedded with *lenses* of sand and gravel, the Wedron Group overlies the Glasford, Winnebago, and Pearl Formations or the combined Morton Tongue–Robein Member–Berry Clay Member (fig. 14).

Tiskilwa Formation The thickest and most widespread glacial diamicton unit in McHenry County is the Tiskilwa Formation; it is absent in westernmost McHenry County, but more than 200 feet thick in several other areas of the county (fig. 22). Forming the prominent Marengo Moraine (plate 1, fig. 15) and the core of other buried ridges, the unit is reddish brown to pinkish clay loam diamicton and scattered sand and gravel lenses. Criteria used to identify the Tiskilwa include (1) its stratigraphic position above the combined Morton Tongue–Robein Member–Berry Clay Member and the Ashmore Tongue of the Henry Formation, (2) its relationship with the Marengo Moraine and other landforms, and (3) its reddish brown to pinkish color, particle-size distribution, and clay mineralogy (fig. 19b, Wickham et al. 1988). The thickest known deposit of Tiskilwa in Illinois, about 291 feet, was measured in boring NIPC-2 on the Marengo Moraine in northwestern McHenry County (fig. 4; Wickham et al. 1988). This is the thickest till known to have been deposited during a single fluctuation of the Lake Michigan Lobe in Illinois (fig. 14; Hansel and Johnson 1992, Hansel and Johnson 1996).

Several discontinuous ridges, largely diamicton of the Tiskilwa Formation, underlie younger diamicton units in north-central McHenry County. In one of the buried ridges east of Wonder Lake, a nearly continuous layer of sand and gravel 10 to 20 feet thick lies within diamicton of the Tiskilwa Formation (unit A3 in figs. 15a, b). This layer of sand and gravel is a confined aquifer informally named the Tiskilwa aquifer.

Lemont Formation ➤Yorkville Member These deposits of uniform gray, silty clay diamicton as much as 60 feet thick also contain some lenses and beds of sand and gravel. Yorkville diamicton is generally finer grained than either the underlying Tiskilwa diamicton or overlying Haeger diamicton (fig. 19b).



22 Thickness of the main diamicton unit of the Tiskilwa Formation.

The Yorkville Member forms the broad Barlina and Huntley Moraines in central and southeastern McHenry County (figs. 3, 15d, 16c). Water-well logs imply that Yorkville diamicton occurs as far north as the uplands south of Nippersink Creek northeast of Wonder Lake (fig. 3). The northernmost known outcrop of Yorkville diamicton is in the Meyer Material Company pit west of the village of McHenry. Here, folded layers of Yorkville diamicton intrude into beds of sand and gravel of the Beverly Tongue of the Henry Formation.

Two interpretations may explain the distribution of the Yorkville: (1) it may have been modified by erosion from glacial ice or meltwater, or (2) some thin, discontinuous layers of Yorkville diamicton in the northernmost mapped area (figs. 15c, 16c) may not have been deposited by glacial ice, but rather deposited in front of the glacier as debris that flowed away from the ice.

At several sites in McHenry County, Yorkville diamicton grades downward to a reddish brown to pinkish clay loam diamicton similar in composition to Tiskilwa diamicton. These zones of mixed Yorkville and Tiskilwa lithologies likely formed by erosion and incorporation (reworking) of Tiskilwa diamicton into younger sediment (Curry 1995).

➤ ***Haeger Member*** The Haeger Member is sandy loam diamicton (fig. 19b) with discontinuous lenses of sand and gravel, and thin beds of silty clay and silt. Wherever the Haeger diamicton is especially sandy, it may resemble sand and gravel deposits of the Beverly Tongue. The Haeger Member is almost always underlain by the Beverly Tongue, except in northwestern McHenry County where the Haeger diamicton is directly underlain by the Tiskilwa diamicton (figs. 15a, b). The diamicton facies of the Haeger Member generally is less than 20 feet thick (figs. 15c, 16c), but in north-central McHenry County, it is as much as 70 feet thick (fig. 15b).

The Haeger Member is the surficial deposit found on the uplands across most of eastern, central, and north-central McHenry County (plate 1). Its distribution is associated with the Woodstock Moraine and the Ringwood upland. In the Marengo–Woodstock Moraine, and east of the Woodstock Moraine in northern McHenry County, both the Haeger diamicton and the underlying Beverly Tongue commonly are missing, as in boring MC-8 (fig. 20). South of Woodstock, the lower part of the Haeger diamicton has physical characteristics suggestive of erosion and partial mixing of underlying Yorkville or Tiskilwa diamicton (Curry 1995).

Wadsworth Formation Covering less than 1 square mile in southeastern McHenry County (plate 1), the Wadsworth Formation is gray, silty clay diamicton similar in composition to the Yorkville Member of the Lemont Formation. Although less than 20 feet thick in McHenry County, it is the primary surficial diamicton unit in Lake County, where it is more than 150 feet thick (Hansel 1983).

Other Surficial Units

McHenry County is covered by a thin mantle of surficial materials classified as several formations including the Peoria Silt, Grayslake Peat, and the Cahokia and Peyton Formations. Their distribution in the county (plate 1) has been interpreted from soil mapping by the Soil Conservation Service (Ray and Wascher 1965), well records, and topographic interpretations. These surficial units were not studied in detail in this investigation.

Peoria Silt The Peoria Silt is noncalcareous (leached), organic-rich silty clay that is no more than 4 feet thick in McHenry County. The most striking physical features in the Peoria Silt are related to biological processes associated with modern soil development such as rooting and burrowing. Krotovina (filled crayfish burrows) are common where the Peoria Silt deposits are poorly drained. Typically, these burrows are 1 to 2 inches in diameter, filled with black silty clay, and extend to more than 10 feet below ground surface.

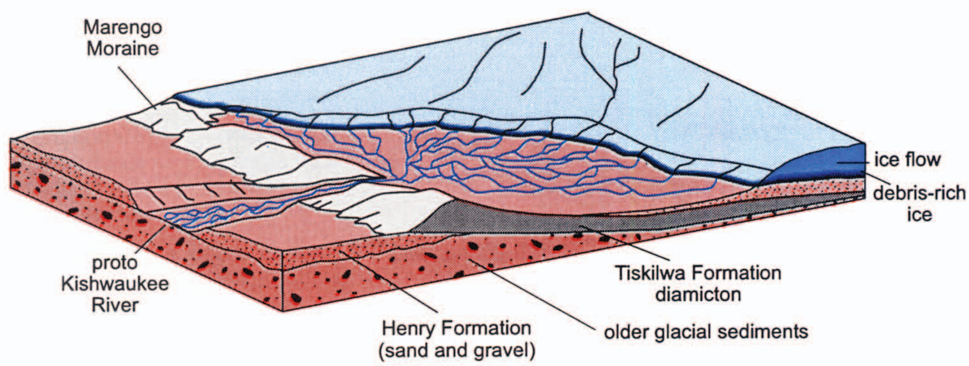
Grayslake Peat The Grayslake Peat is composed of organic-rich soils, including fibrous to mucky peat and marl (a soft, light gray, fossil-rich deposit). Generally less than 3 feet thick, it can be found in small, widely scattered areas across McHenry County (plate 1). The thickest Grayslake Peat in the county is probably in the Chain-O'-Lakes lowland on the margins of the lakes and in broad reaches of the *floodplain* along the Fox River valley. The Grayslake was sampled during test drilling for the Port Barrington Marina facility on the Fox River about 0.5 mile east of the McHenry–Lake county line; surficial peat as much as 7 feet thick was underlain by marl to a depth of as much as 24 feet (Soil Testing Services 1984). On the west side of McHenry County in a drained wetland on Capron Ridge, the Grayslake Peat is 17.3 feet thick in boring MC-1 (Curry 1995) and composed of fibrous peat interbedded with clean, medium- to fine-grained sand. It is underlain by fossiliferous silts and clays of the Equality Formation to a depth of about 30 feet.

Cahokia Formation The Cahokia Formation is composed of sandy alluvial deposits within and adjacent to stream and river channels. Away from the channels, it becomes finer grained, grading laterally to organic-rich silty clay. These lithologic distinctions, although significant, are not shown on our maps. Along large streams and rivers, the Cahokia Formation is underlain by sand and gravel of the Henry Formation. In floodplains, the Cahokia generally overlies fine sand of the Henry Formation or silt and clay of the Equality Formation. The Cahokia Formation is as much as about 10 feet thick.

Peyton Formation A generally soft, stratified diamicton or sorted sediment, the Peyton is usually no more than 5 feet thick. It is colluvium, material that has moved or is moving downslope because of mass wasting; it overlies or can be traced upslope to its source. The Peyton Formation usually can be differentiated from in-place material by its high moisture content and low *load-bearing capacity* for foundations and engineered structures.

Genesis and Composition of Landforms

Interpretation of the genesis of landforms is important when evaluating the continuity, thickness, range of physical characteristics, and complexity of glacial deposits. Glacial moraines and glaciofluvial features are the two main types of landforms in McHenry County. Glacial moraines, which form at the edges of glacial ice, are composed primarily of diamicton in most of Illinois. But in McHenry County, moraines and morainic (hummocky) topography are sand and gravel as well as diamicton (table 2). Glaciofluvial features, formed by flowing water beneath or beyond the glacial ice, are largely Henry Formation sand and gravel.



The geologic composition of each feature on the glacial landscape depends on its environment of deposition—how geologic materials were deposited to create a landform. In McHenry County, the diamicton units and sand and gravel of the Henry Formation were deposited in several distinct sedimentary environments.

Moraines and morainic uplands

- Marengo Moraine, an end moraine formed by active glacial ice,
- Woodstock, Barlina, and Huntley Moraines, and the Ringwood upland formed by less active, partly stagnant glacial ice,
- Fox Lake Moraine formed at the end of a stagnating or receding glacier, an example of kamic topography.

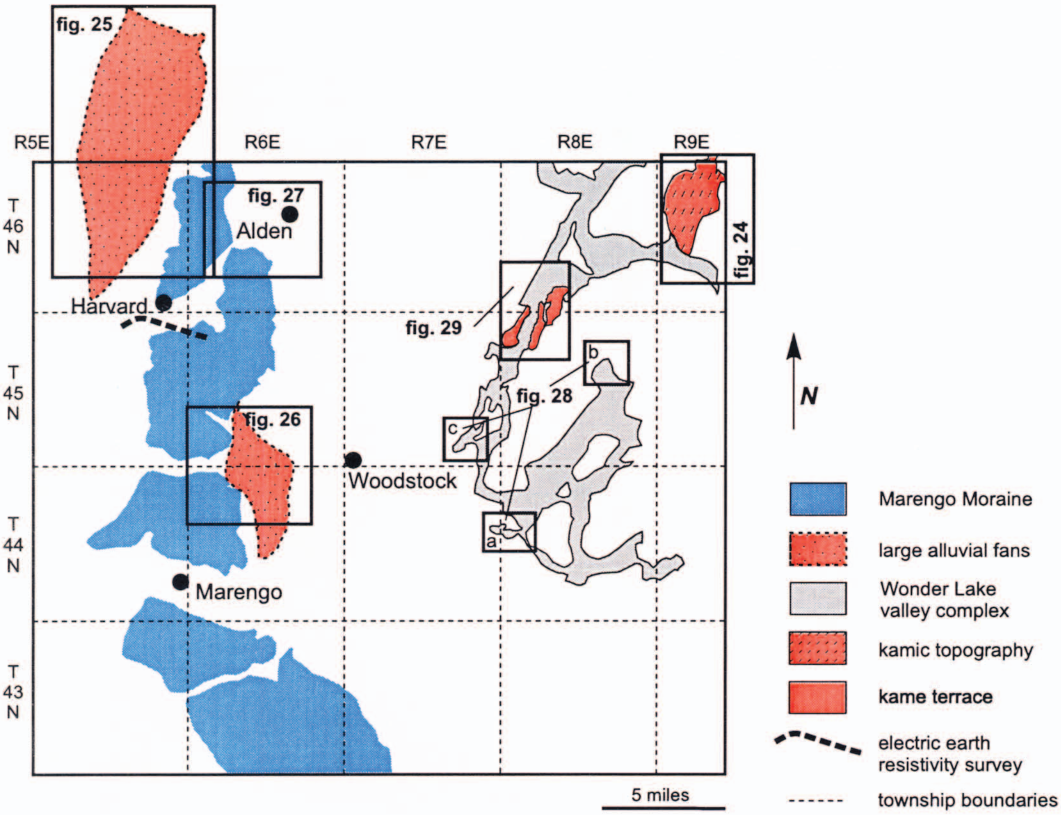
Glaciofluvial landforms

- *alluvial fans* along the Marengo and Woodstock Moraines,
- channels bisecting the Marengo Moraine, including the Kishwaukee lowland and the Alden gap,
- Wonder Lake valley system,
- alluvial fans and outwash plains south and southwest of Woodstock,
- Chain-O'-Lakes lowland.

The physical characteristics of the sediments in these landforms is assumed to be similar to those described for the county by Cobb and Fraser (1981) and elsewhere in the region (Hansel and Johnson 1987). Evidence used to determine the composition and continuity of the deposits included the *environments of deposition* inferred from their landscape position and form (*geomorphology*) (Anderson 1989), electric earth resistivity surveys, and the few available water-well logs.

Table 2 Characteristics of moraines

Landform	Lithostratigraphic units	Approx. range in elevation = relief (ft)	Landscape	Environment of deposition	Episode	Aquifer association	Aquifer sensitivity unit
Fox Lake Moraine	Mason Group Henry Fm	850–737 = 113	hummocky	ice contact	Wisconsin Episode Woodstock Phase	1	A
Marengo-Woodstock Moraine	Wedron Group Lemont Fm Haeger Mbr Tiskilwa Fm	1,189–950 = 239	smooth, steep ridge	first by active basal ice; then by thin, fast-moving ice	Woodstock Phase and Marengo Phase	3,4	B,D
Woodstock Moraine	Lemont Fm Haeger Mbr	1,150–840 = 310	hummocky uplands with depressions	active and stagnating ice; thin, fast-moving ice	Woodstock Phase	1	A
Ringwood upland	Haeger Mbr	1,100–790 = 310	broad, hummocky uplands with depressions	active and stagnating ice; thin, fast-moving ice	Woodstock Phase	1	A,B
Huntley and Barlina Moraines	Yorkville Mbr	980–850 = 130	hummocky with small depressions	stagnating ice margin; some deposition by active basal ice	Livingston Phase	2	C,D
Marengo Moraine	Tiskilwa Fm	1,150–810 = 340	smooth, steep ridge bisected by wide valleys	ice margin; deposition by active basal ice, rarely by stagnating ice	Marengo Phase	3,4	D,E
Capron Ridge	Winnebago Fm Capron and Argyle Till Mbrs Glasford Fm Oregon Till Mbr	1,010–860 = 150	broad, dissected ridge	erosional remnant of till plain	Illinois Episode	5	C,D

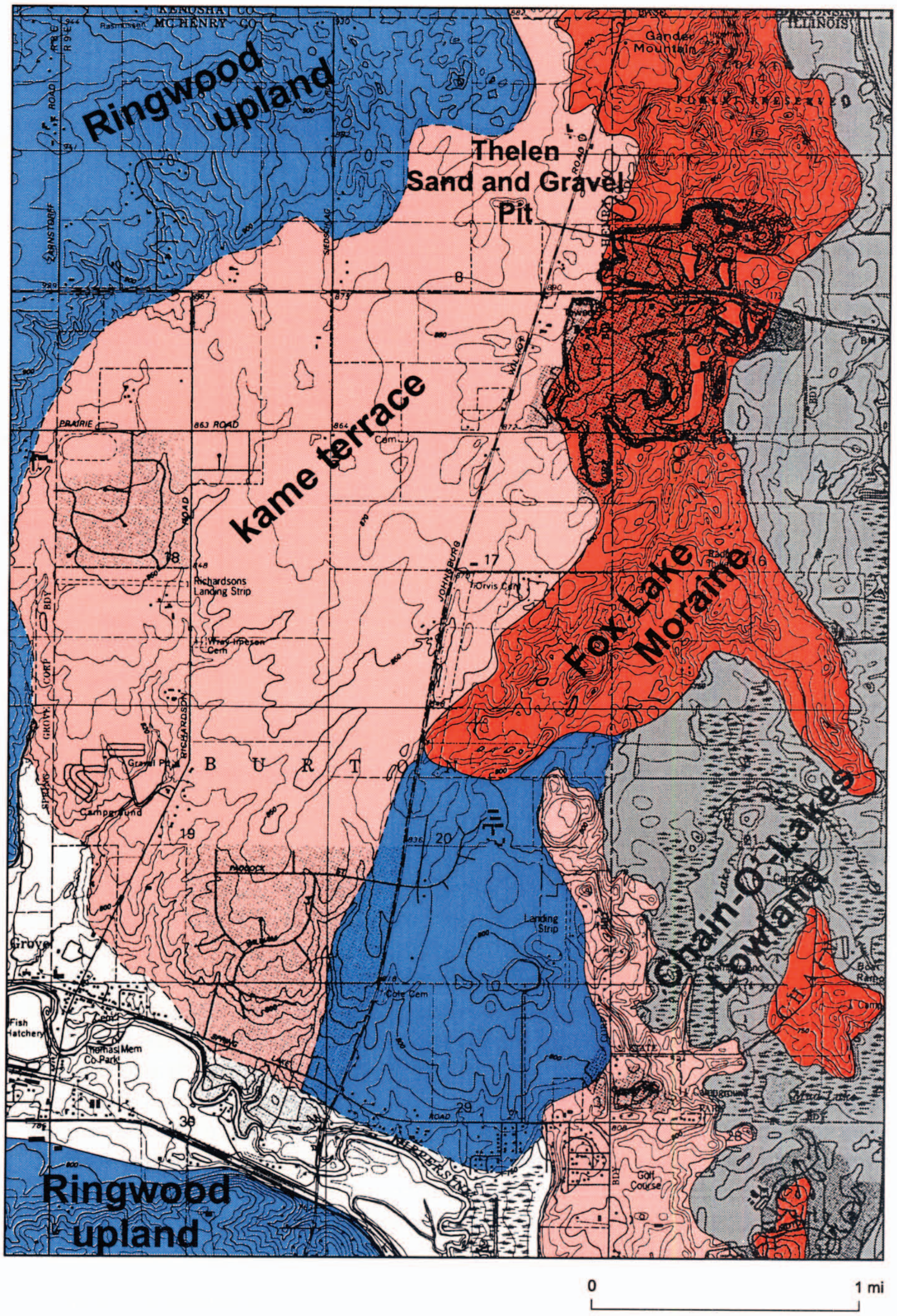


23 Location guide for figures 24–29, the Marengo Moraine and the Wonder Lake valley system.

Moraines

Marengo Moraine The Marengo Moraine is a prominent ridge-like end moraine associated with the westernmost occurrence of subglacial diamicton formed by the Harvard Sublobe at the onset of the last glaciation (fig. 23). Because it is a thick, continuous deposit of Tiskilwa diamicton that has high topographic relief (plate 4), the Marengo Moraine is thought to have been deposited by active glacial ice (Wickham et al. 1988). There is so little sand and gravel in the moraine that, most likely, meltwater drained away from the moraine in distinct channels as the diamicton was deposited. The valleys bisecting the moraine (Alden Gap, for example) are evidence that former subglacial channels promoted efficient drainage of meltwater while the Marengo Moraine was being formed. North of Harvard, the Marengo Moraine is overtopped by the Woodstock Moraine, forming the Marengo–Woodstock Moraine.

Woodstock, Huntley, and Barlina Moraines These moraines were deposited under subglacial drainage conditions that were less efficient than those for the Marengo Moraine (Hansel and Johnson 1987). As a result, abundant sand and gravel was deposited in the Woodstock, Huntley, and Barlina Moraines. The Ringwood upland east and north of these moraines (fig. 3) shares several of their characteristics, such as a subdued, hummocky surface. Each of these landforms, but especially the Woodstock Moraine in central and southern McHenry County, has a thin layer of glacial diamicton capping the sand and gravel. The diamicton cap on the Huntley and Barlina Moraines is a fine-grained deposit of the Yorkville Member; whereas the diamicton cap on the Woodstock is the sandy Haeger Member. This distinction is important when considering protection of shallow aquifers.

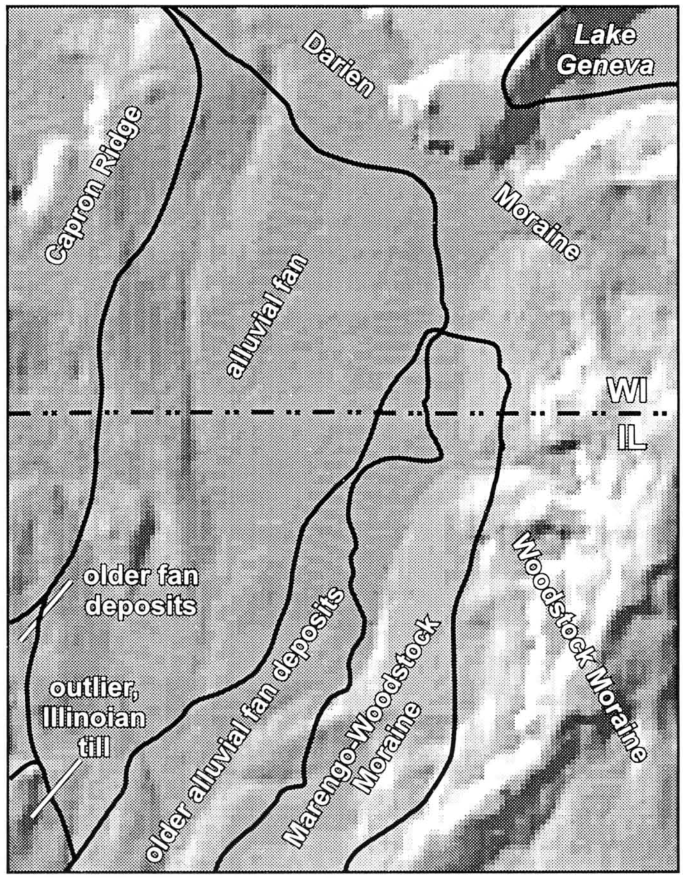


24 Topography of the Fox Lake Moraine and associated kame terrace in the Richmond and Fox Lake 7.5-minute quadrangles. The map location is shown on figure 23.

Fox Lake Moraine and Kame Terrace Unlike other moraines in Illinois, the Fox Lake Moraine in northeastern McHenry County is largely hummocky deposits of sand and gravel. The Fox Lake Moraine thus is classified as a *kamic moraine.* Vertical faults and folded-to-chaotic bedding have been observed in more than 50 feet of the moraine's sand and gravel exposed in the large Thelen aggregate pit. The surface of the moraine is also extremely irregular (fig. 24). As these features indicate, the sediment forming the moraine was deposited against the glacial ice, and eventually, melting distorted the sediment layering.

Paralleling the Fox Lake Moraine on the west is an upland surface about 1.5 miles wide. The elevation of the surface is generally intermediate between the Chain-O'-Lakes lowland and uplands underlain by Haeger diamicton (fig. 24). Test borings and water-well records indicate that this surface is underlain by 30 to 50 feet of bouldery, gravelly sand of the Henry Formation. The north-to-south slope of the surface, and low elevation relative to the moraine to the east and upland to the west, implies that this surface and underlying sorted sediment is a *kame terrace;* it was probably deposited by sediment-laden meltwater confined between the glacier to the east and the uplands to the west.

Capron Ridge In westernmost McHenry County is Capron Ridge, an erosional remnant of the Illinoian till plain (figs. 3,25). Krumm and Berg (1985) showed that this landform is composed of several stratigraphic units, including a discontinuous cap of Capron Till. These relationships indicate that Capron Ridge is an erosional, rather than a depositional, feature such as a moraine. Because Capron Ridge is largely parallel with the Marengo Moraine, we think that much of the erosion occurred during formation of the Marengo Moraine as meltwater flowed through the valley between the moraine and the ridge.

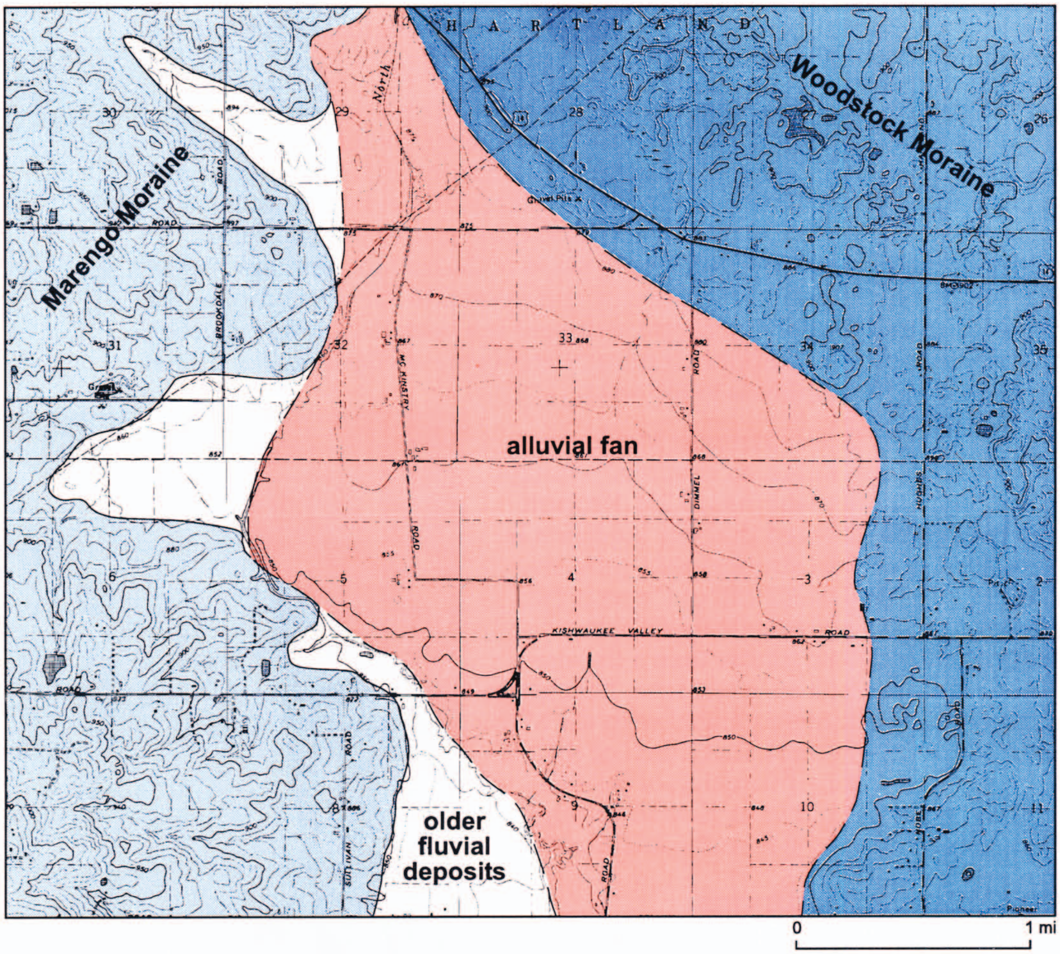


25 Shaded relief map of northwestern McHenry County and part of Wisconsin. Map shows an alluvial fan associated with the Darien Moraine that overlaps older fans west of the Marengo Moraine. The figure includes parts of the Capron, Harvard, Sharon, and Walworth 7.5-minute topographic quadrangle maps. (Enlarged from the statewide *Shaded Relief Map of Illinois* [Abert 1996].)

Glaciofluvial Landforms

Alluvial Fans West of Marengo and Woodstock Moraines Many areas with thick Henry Formation are alluvial fans of glacial outwash deposited by sediment-laden meltwater streams (Masters 1978, Ashley et al. 1985). In most cases, these deposits contain lenses of diamiction or may be traced to where they intertongue with diamicton units of the Wedron Group. The alluvial fans likely contain high-quality aggregate resources. Most are also coarse and porous, so rainwater rapidly enters and moves through these materials, contributing significantly to groundwater *recharge*.

The valley of Piscasaw Creek in the northwestern corner of McHenry County includes deposits of an alluvial fan that originates in Wisconsin and overlaps older fan deposits extending west from the Marengo Moraine (figs. 23, 25). The younger fan deposits are only about 20 feet thick in Illinois and generally fine grained, whereas the older fan deposits are mostly coarser grained materials. Water-well logs and an electrical earth resistivity survey transect southwest of Harvard (fig. 23) suggest that the older alluvial fan is underlain by interbedded sand and gravel and fine-grained sediment as much as 50 feet thick. The highest alluvial fan surfaces in the

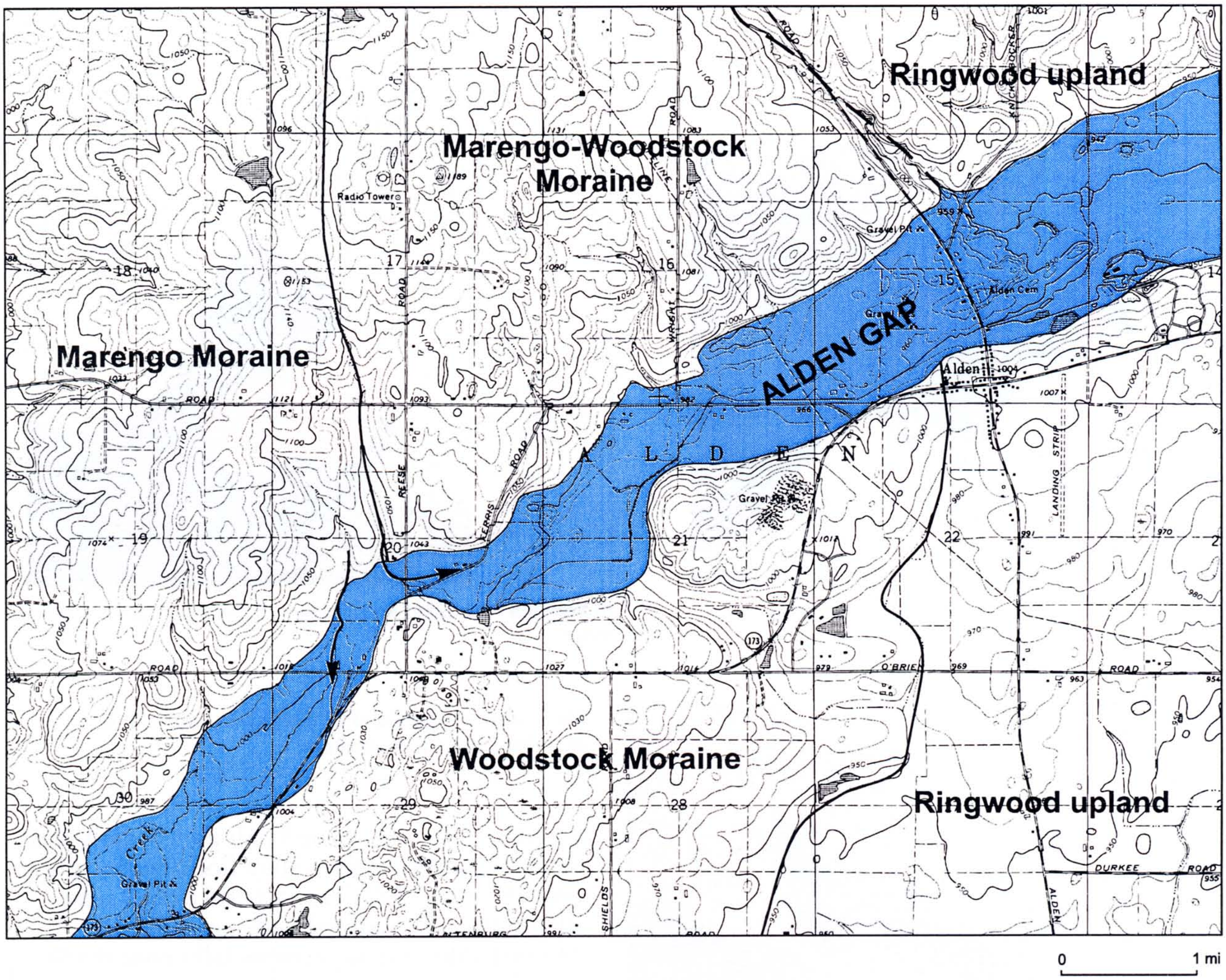


26 Topography of an alluvial fan that heads in the Woodstock Moraine where it crosses the Marengo Moraine (Marengo North 7.5-minute quadrangle).

Piscasaw lowland in northwestern McHenry County are underlain by about 20 feet of loam diamicton of the Tiskilwa Formation and thin beds of laminated, fine-grained sediment and bouldery, gravelly sand of the Henry Formation (fig. 15b).

Another prominent alluvial fan heads south of where the Woodstock Moraine overlaps the Marengo Moraine (figs. 23, 26). The limited number of water-well logs from this area indicate that 100 feet of very coarse-grained, gravelly sand overlie about 75 feet of diamicton of the Glasford Formation. Additional evidence for the coarseness of the outwash includes the lack of a drainage network on the fan surface (fig. 26), indicating rapid infiltration of rainfall rather than *runoff* in surface streams.

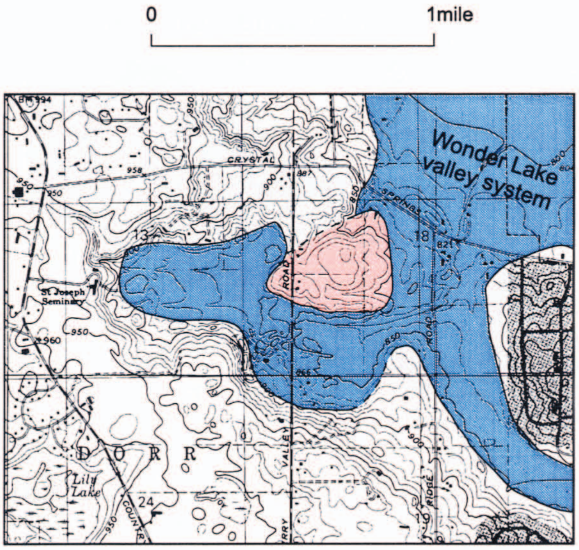
Channels through Marengo Moraine Prominent channels bisect the Marengo Moraine in several places in McHenry County. Boring NIPC-6 shows that the sand and gravel underlying the largest of these channels near the town of Marengo is about 70 feet thick and overlies 23 feet of diamicton of the Tiskilwa Formation (Curry 1995). The Alden Gap (figs. 23, 27), the narrow valley that cuts through the northern part of the Marengo Moraine, is underlain by more than 100 feet of sand and gravel directly north of the village of Alden.



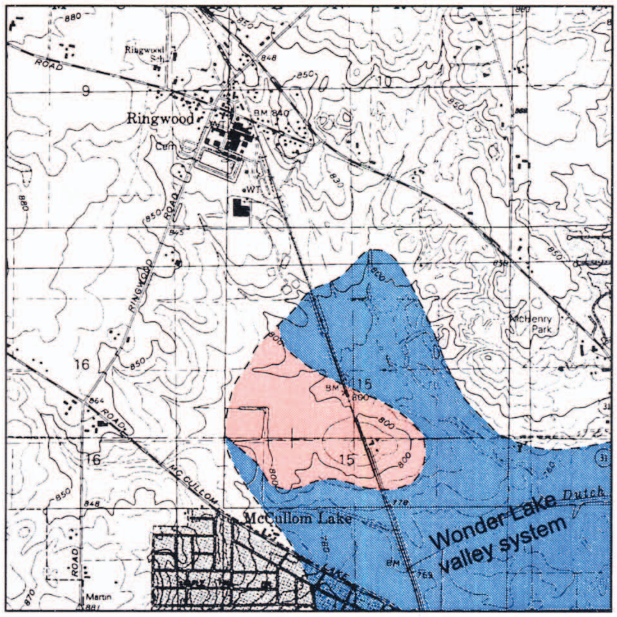
27 Topography of part of the Alden Gap, a valley underlain by more than 100 feet of sand and gravel. Arrows indicate a drainage divide in Alden Gap (Harvard 7.5-minute quadrangle).

Wonder Lake Valley System The Wonder Lake valley system is an array of interconnected valleys occupied by Nippersink Creek, Boone Creek, Wonder Lake, Lake Elizabeth, McCullum Lake, and Thunderbird Lake (fig. 23). From foundation borings drilled by the Illinois Department of Transportation (IDOT), borings MC-4 and MC-7 (fig. 4; Curry 1995), and the results of several electric earth resistivity surveys performed for this study, we can infer several characteristics of the Wonder Lake valley system. Of hydrogeological importance is the observation that the larger valleys are underlain by sorted sediment of the Henry and Equality Formations and little or no diamicton (fig. 15). The upper 20 to 30 feet of the valley-fill sediments are coarser grained than the lower part. Short valley segments, however, are underlain by less than 30 feet of sand and gravel overlying diamicton of the Tiskilwa Formation.

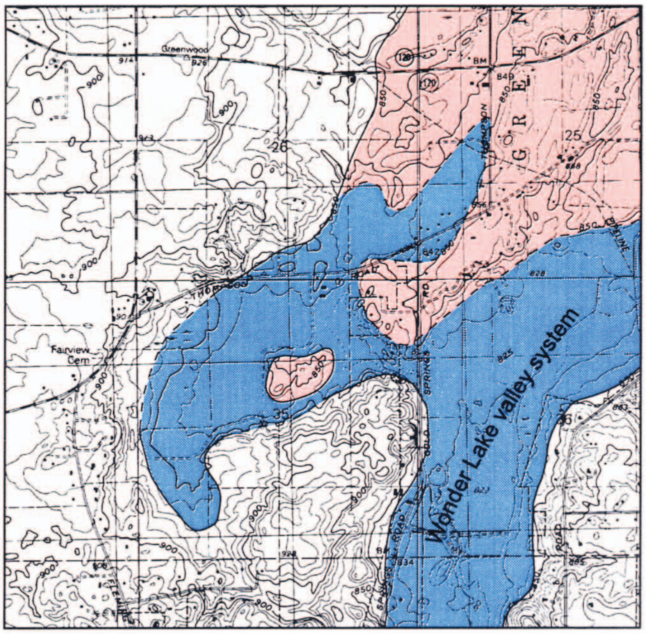
The Wonder Lake valley system is complicated by a variety of *ice-contact deposits* and their associated landforms. Examples of late-glacial modification of the Wonder Lake valley system are three short valleys tributary to the channel (figs. 23, 28). The heads of the valleys are steep-walled and



a) from the McHenry 7.5-minute quadrangle map



b) from the Richmond and McHenry 7.5-minute quadrangle maps



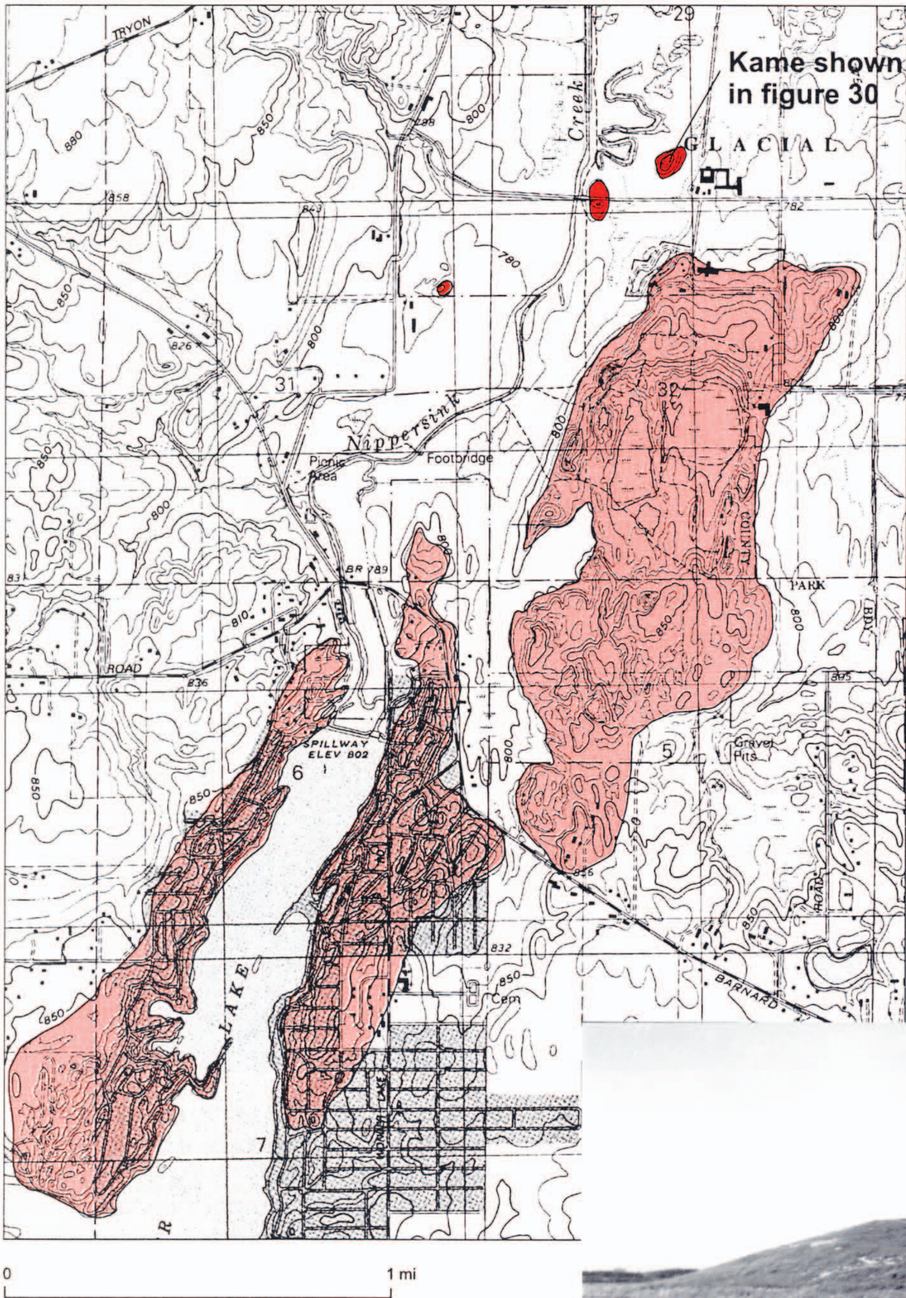
c) from the Woodstock and McHenry 7.5-minute quadrangle maps

28 Three unusual short valleys tributary to the Wonder Lake valley system.

semicircular, and abruptly slope to nearly the same elevation as the valley floor. Each valley contains small hills of sand and gravel near its mouth. The valley heads are sites of groundwater *discharge*, especially near the St. Joseph Seminary, where there are several fens (fig. 28a; Panno et al. 1995). Headward migration due to groundwater sapping may explain the formation of the ampitheatre-like valley heads (Dunne 1990). Alternatively, the valleys may be vestiges of locally intense erosion by glacial meltwater (*moulins*) during the final stages of deglaciation.

Kame terraces, another type of ice-contact deposit, are common on the sides of the Wonder Lake valley system. The best examples in McHenry County are protected in Glacial County Park (fig. 29). The kame terraces, as well as small kames (figs. 29, 30) were deposited in the valley occupied by Nippersink Creek, as the glacier melted back for the last time (fig. 12d).

Alluvial Fans and Outwash Plains South and Southeast of Woodstock
Coalescing alluvial fans and outwash sand and gravel plains occur between the Woodstock and Huntley–Barlina Moraines and between the Huntley–Barlina and Marengo Moraines. Unlike the gently sloping lobate forms of the fans discussed previously, the topography in these areas is irregular and hummocky. Excavated walls in active sand and gravel pits reveal that



29 Kamic topography (dark orange) associated with the Wonder Lake valley complex in Glacial County Park and Wonder Lake. Three kames in the valley of Nippersink Creek are shaded (light orange), including the one shown in figure 30 (Richmond 7.5-minute quadrangle).

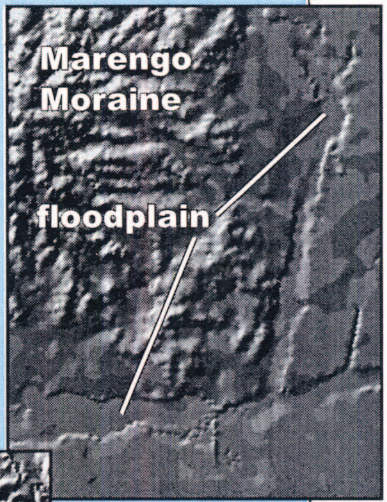
30 Isolated kame of sand and gravel in the valley of Nippersink Creek in Glacial Park. The kame's location is shown in figure 29.

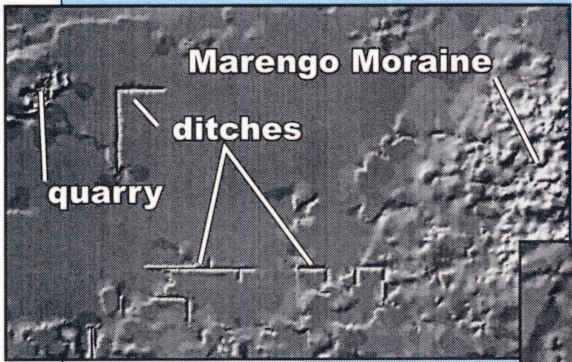
the sand and gravel is interbedded with, and often overlain by, diamicton of the Haeger Member. Contorted and faulted contacts between the sorted sediment and diamicton indicates that active ice overrode the sand and gravel deposits during deposition of the diamicton (Cobb and Fraser 1981).

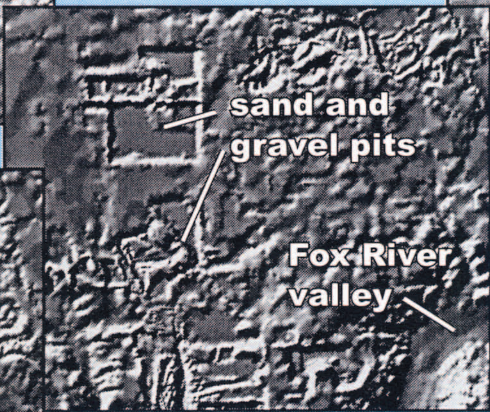
Chain-O'-Lakes Lowland Numerous lakes and swamps occupy the Chain-O'-Lakes lowland along the Fox River on the Wauconda and Fox Lake Quadrangles in eastern McHenry County (fig. 16e). In the Pistakee Lake area, closely spaced bridge borings

Modern Processes Shaping the Landscape

The modern landscape reflects its glacial legacy, although postglacial geomorphic processes have slowly eroded the sediment and landforms deposited by glacial ice and meltwater (plate 4). Some of the more important processes include river transport of alluvium, mass movements of materials (landsliding), accumulation of peat and lake sediments, and weathering by chemical and physical agents as soils formed.







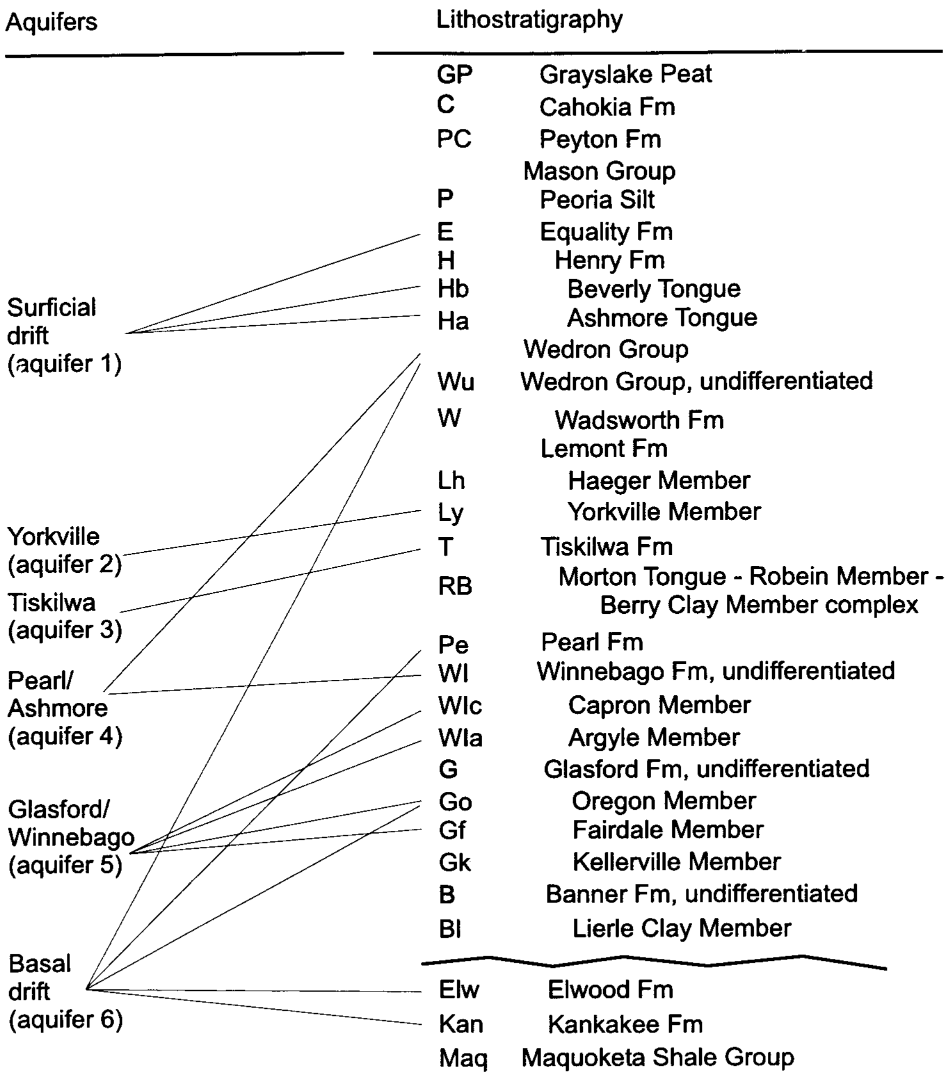
Since the arrival of European settlers in McHenry County more than 150 years ago, many trees have been removed, swampy soils have been drained for agriculture, large amounts of sand and gravel have been mined for construction of roads and foundations, and lakes have partly filled with sediment eroded from agricultural fields and urban areas. As the population of McHenry County grows, the glacial deposits have taken on new significance, both as a source of groundwater and a receptacle for disposal of waste. At present, all McHenry County residents rely on groundwater for their water supply. In the future, a balance must be attained so that development can proceed as groundwater quality is protected.

indicate that the lowlands are underlain by a complex of interbedded sands, silts, and clays to a depth of about 100 feet. These deposits, mapped as interbedded Henry and Equality Formations, were probably deposited in a delta. South of Pistakee Lake, numerous borrow pits expose about 30 to 40 feet of poorly sorted sand and gravel capped, in places, with about 10 feet of Haeger diamicton.

HYDROGEOLOGIC FRAMEWORK

For predicting the extent of a sand and gravel aquifer, it's important to know whether the aquifer material was deposited in front of a glacier in a proglacial fluvial environment or underneath or inside a glacier in a subglacial fluvial environment. A sand and gravel unit deposited in a proglacial environment is more likely to be continuous than one deposited beneath flowing ice (Troost and Curry 1991).

Six aquifers have been given informal names relating to lithostratigraphic units. On maps and cross sections in this report, they are numbered from top to bottom (fig. 31). Because the glacial sediments are so complex, aquifers are seldom single units and often merge with one another. When aquifers are merged, the upper aquifer takes precedence for naming and



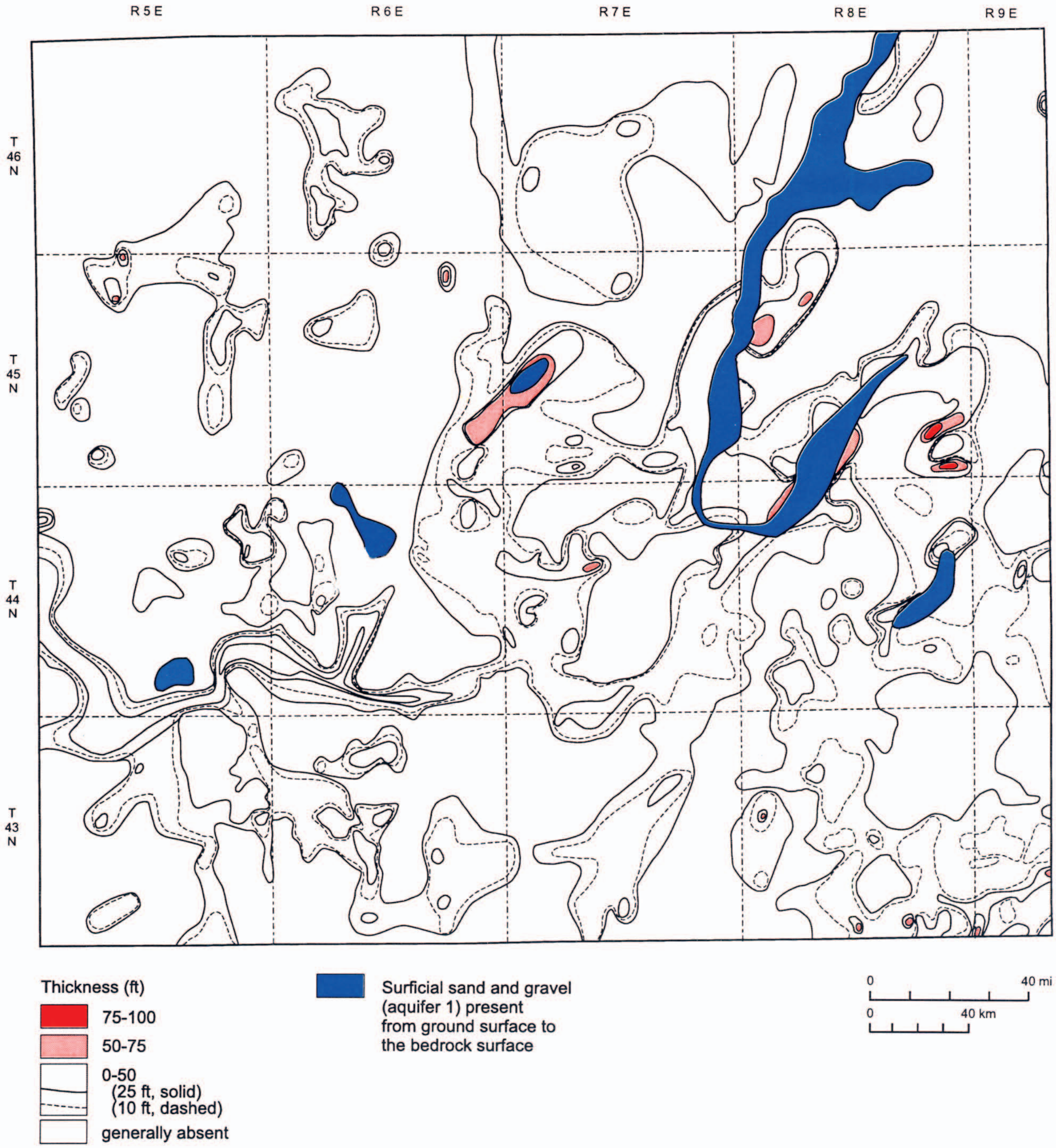
31 Association between aquifers and lithostratigraphic units. Symbols for lithostratigraphic units refer to figures 14, 15, and 16.

numbering; for example, when aquifer 1 merges with aquifer 2, the unit is designated as aquifer 1.

Basal Drift Aquifer

The basal drift aquifer (aquifer 6) comprises any sand and gravel deposits that are at the base of the glacial drift and confined by overlying fine-grained sediment; it also includes any part of the directly underlying bedrock that contains exploitable groundwater. The basal glacial drift and the upper fractured bedrock are hydraulically connected and act as a single aquifer (Gilkeson et al. 1987).

The thickness of confining layers and depth to the basal drift aquifer ranges from 30 feet in western McHenry County to more than 300 feet beneath the Marengo Moraine (fig. 32). This aquifer merges with the surficial aquifer (aquifer 1) in areas shown on figure 32. In these areas, the basal drift aquifer is most susceptible to near-surface contamination.

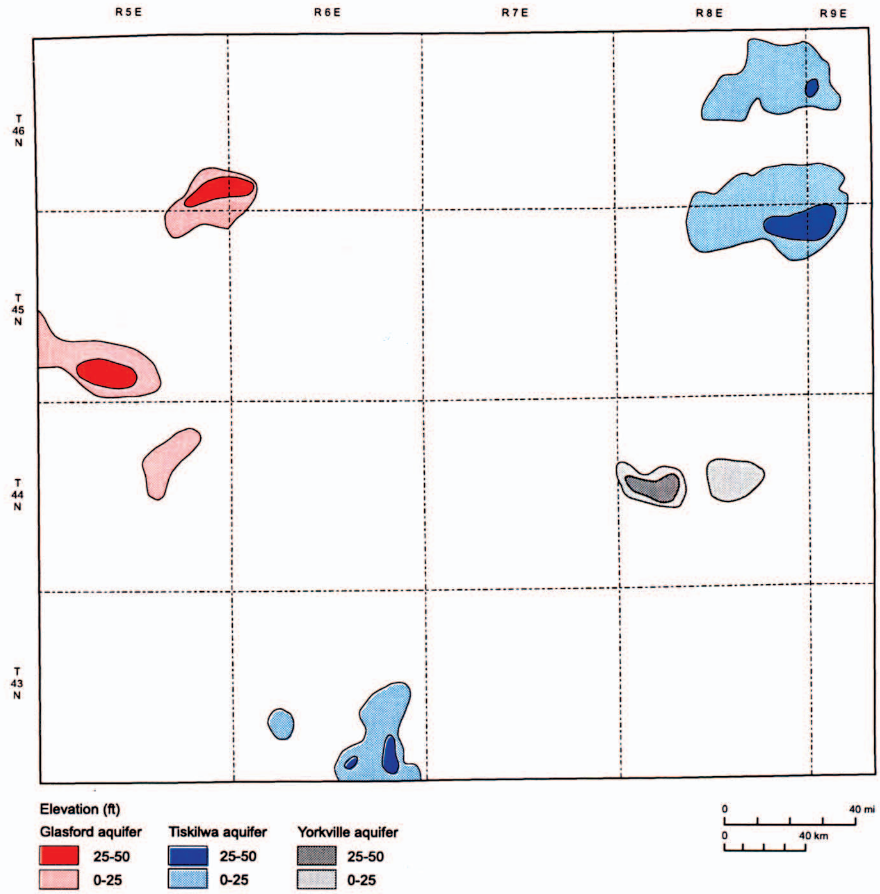


32 Thickness of the glacial drift portion of the basal drift aquifer (aquifer 6). The thickness of the underlying bedrock portion is not included on the map.

In eastern McHenry County, the basal drift aquifer is covered (confined) by diamicton members of the Glasford Formation, and more rarely, by the Banner Formation (fig. 15e). Although unverified, significant deposits of the basal drift aquifer may be present in buried bedrock valleys tributary to the Troy Bedrock Valley in western McHenry County. In central and eastern McHenry County, the basal drift aquifer includes the Ashmore Tongue where it is confined by the overlying Tiskilwa diamicton (fig. 15c).

Glasford/Winnebago Aquifer

The Glasford/Winnebago aquifer (aquifer 5) is interbedded with diamicton units of the Glasford and Winnebago Formations, especially at the base of the Oregon Member (fig. 15f). The Glasford/Winnebago aquifer, as much as 40 feet thick (fig. 33), is an important source of groundwater for the village of Harvard (fig. 15b). East of the Marengo Moraine, the aquifer is buried by deposits from the last glaciation. In tributaries of the Troy Bedrock Valley, the Glasford/Winnebago aquifer intertongues with silty sediment that was probably deposited in a lake (fig. 15a). In such cases, the Glasford/Winnebago aquifer may be finer grained than the underlying basal drift aquifer or the overlying Pearl/Ashmore aquifer.



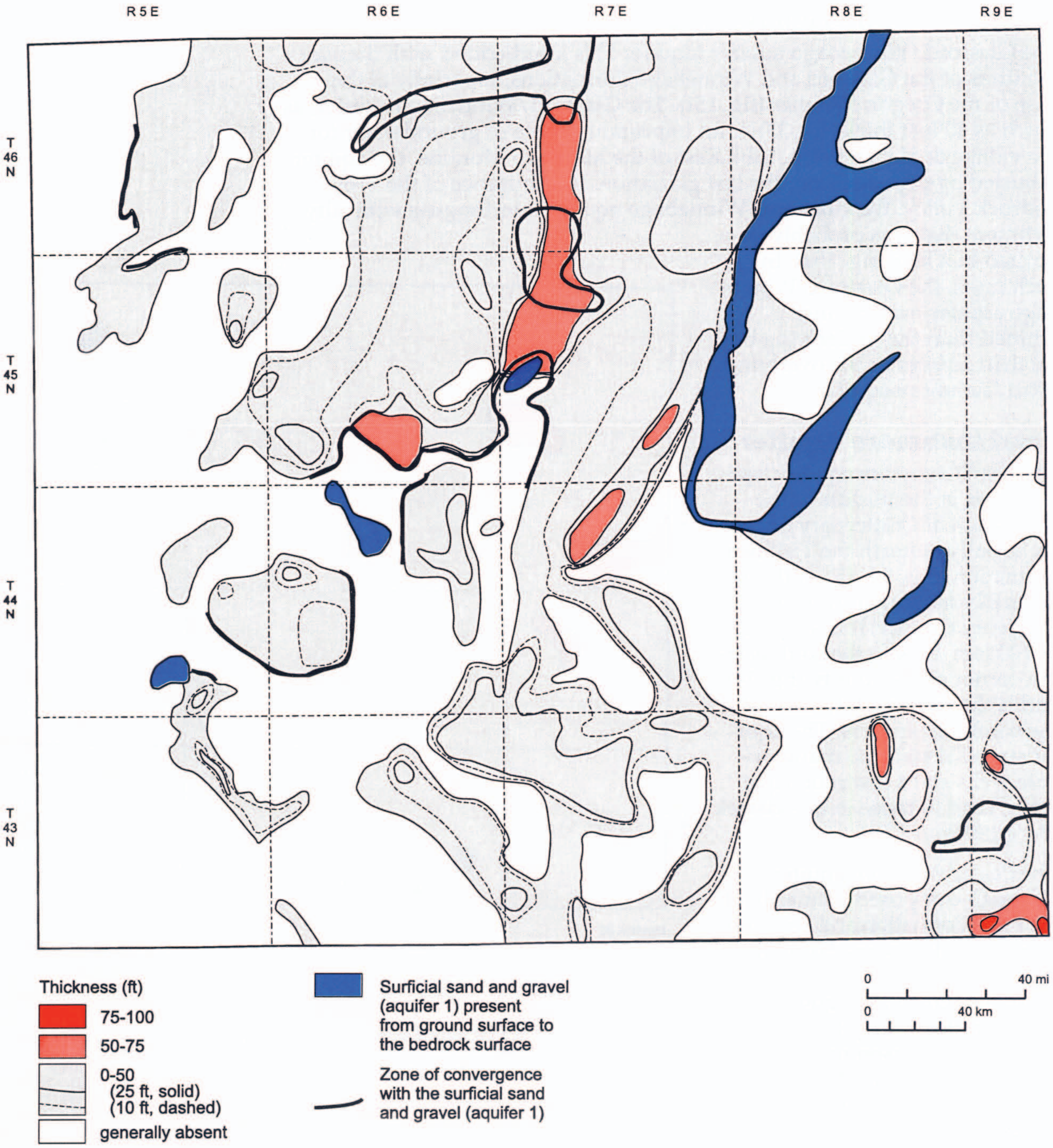
33 Thickness of the Glasford aquifer (aquifer 5), the Tiskilwa aquifer (aquifer 3) and the Yorkville aquifer (aquifer 2).

Pearl/Ashmore Aquifer

The Pearl/Ashmore aquifer (aquifer 4) lies in the middle of the succession of Quaternary deposits, usually beneath the Tiskilwa Formation (figs. 14, 15). Although generally missing in western McHenry County, it is as much as 100 feet thick in the southeastern corner of the county (fig. 34) and is the most widely used of the confined aquifers. The aquifer supplies water to many private wells and a few municipal wells, such as those in Woodstock (Berg 1994).

The Pearl/Ashmore aquifer, although composed primarily of the Pearl Formation and Ashmore Tongue of the Henry Formation, includes thin, discontinuous layers of the Morton Tongue–Robein Member–Berry Clay Member (fig. 14). The reason for the complexity of the Pearl/Ashmore aquifer is that its lower and upper parts consist of sand and gravel layers deposited during the Illinois and Wisconsin glacial episodes, respectively. The middle of the aquifer contains thin and discontinuous layers of clayey and silty sediments with ancient soils developed and deposited during the Sangamon Episode and the early Wisconsin Episode.

Although commonly confined by Tiskilwa diamicton, the Pearl/Ashmore aquifer locally merges with the surficial aquifer, as it does with thick deposits in and adjacent to the Wonder Lake valley system (fig. 34). In some areas north and northeast of Woodstock (fig. 15c), the Pearl/Ashmore aquifer merges with the Yorkville aquifer and the surficial drift aquifer (Berg 1994).



34 Thickness of the Pearl/Ashmore aquifer (aquifer 4).

Tiskilwa Aquifer

The Tiskilwa aquifer (aquifer 3) consists of large, discontinuous lenses of sand and gravel that contain exploited groundwater associated with diamicton of the Tiskilwa Formation (fig. 33). Other layers of sand and gravel occur within the Tiskilwa diamicton throughout the county, but are not now exploited for groundwater. Aquifer 3 was mapped in only two areas of the county (fig. 33): (1) In the south-central part of the county, the Tiskilwa aquifer is more than 25 feet thick and confined above and below by diamicton. The lower confining diamicton layer is discontinuous, and there are several areas where the Tiskilwa aquifer merges with, and is included with, the Pearl/Ashmore aquifer. (2) In northeastern McHenry County, the Tiskilwa aquifer is generally less than 25 feet thick and confined below by the main diamicton unit of the Tiskilwa Formation and above by a silt and clay tongue of the Equality Formation (figs. 15a, b). In both areas, the Tiskilwa aquifer is used only by private households.

Yorkville Aquifer

The Yorkville aquifer (aquifer 2) generally occurs at the base of the Yorkville Member, but may also occur within the unit. The aquifer is more than 25 feet thick in an area between McHenry and Crystal Lake (figs. 15d–f, 33) where it is a water source for private wells. North and northeast of Woodstock, lenses of the Yorkville aquifer have been mapped as part of the surficial drift aquifer where the Yorkville diamicton is thin and discontinuous (fig. 15c).

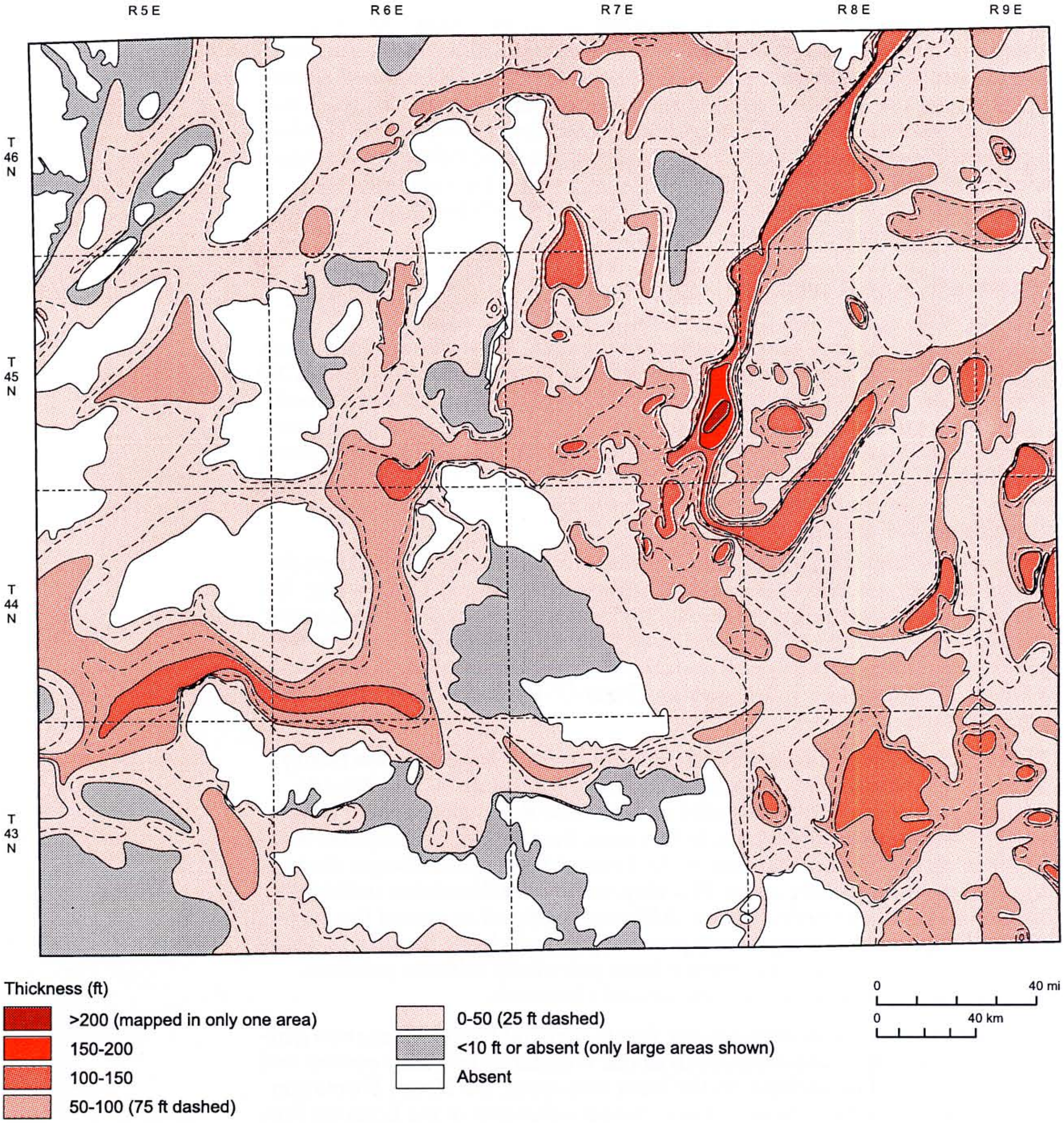
Surficial Drift Aquifer

The surficial drift aquifer (aquifer 1), primarily saturated, near-surface deposits of sand and gravel, is present throughout McHenry County (fig. 35). There is more information on the thickness and distribution of this aquifer than for the deeper ones. In several areas, the aquifer merges with the previously described aquifers that underlie it, especially in valleys associated with the Wonder Lake valley system, Chain-O'-Lakes lowland, and Marengo Moraine.

The surficial drift aquifer includes both the Beverly Tongue of the Henry Formation and surficial deposits of the Henry Formation. The Beverly Tongue part of the surficial aquifer occupies the Ringwood upland lying east of the Woodstock Moraine. In this area, the surficial drift aquifer is overlain by the Haeger Member of the Lemont Formation. Haeger diamicton, which contains only about 15% clay, is the only diamicton unit in the county that is not a confining unit. Although mapped as part of the surficial drift aquifer, the Haeger may provide the underlying Beverly Tongue sand and gravel minimal protection from potentially adverse practices such as the overapplication of agricultural chemicals.

The part of the surficial drift aquifer that is surficial Henry Formation generally occurs in lowland areas, such as the Wonder Lake valley system and the Chain-O'-Lakes lowland. In the latter two areas, the Henry Formation is commonly interbedded with fine-grained sediments of the Equality Formation (figs. 15c, 16c). The surficial drift aquifer is as much as 200 feet thick and more than 100 feet thick in and around the municipalities of Crystal Lake, McHenry, and Woodstock (fig. 35).

The properties of the aquifer in the Wonder Lake valley system and Chain-O'-Lakes lowland are not well understood; they probably vary from place to place (fig. 16e). In many areas of the Wonder Lake valley system, the Tiskilwa and Pearl/Ashmore aquifers are under artesian conditions where they merge with the surficial drift aquifer. These conditions exist where thin layers of Tiskilwa diamicton, or silt and clay of the Equality Formation, extend out into the valley-filling sediments. Where the confining layers of Tiskilwa diamicton pinch out, the groundwater from the surficial aquifer



35 Thickness of the surficial drift aquifer (aquifer 1).

is released from confinement, and springs and fens have formed in the Wonder Lake valley north of Wonder Lake. The artesian conditions may be caused by the artificially high water levels in Wonder Lake, a reservoir built in 1929. The storage of water at the surface may have pressurized groundwater in the underlying Tiskilwa and Pearl/Ashmore aquifers.

ENVIRONMENTAL APPLICATIONS OF GEOLOGIC MAPPING

The geologic materials of McHenry County supply drinking water, aggregate for buildings and roads, and potential sites for safe disposal of various wastes. Weathering of the glacial parent materials and accumulation of organic matter produced the county's fertile soils. All these resources require sensible management, but the groundwater resources also need protection.

The aquifer sensitivity map (plate 3), an interpretation of the geologic and hydrogeologic framework, makes it apparent to land-use planners and others where groundwater is most at risk. The areal distribution, thickness, and depth of burial by clayey, fine-grained sediments directly affects an aquifer's potential for contamination by wastes and chemicals.

Geologic mapping for McHenry County was undertaken to establish a geologic framework based on the age, thickness, properties, depth, distribution, and continuity of the unconsolidated materials (clay, silt, sand and gravel) that are primarily Quaternary glacial deposits. In the second part of this report, we will describe and discuss the thickness and distribution of aquifers and aquitards and rank areas according to the relative sensitivity of aquifers to contamination.

Once the geologic framework has been established, then McHenry County's geologic resources—mainly unconsolidated Quaternary materials—can be evaluated for specific environmental and economic purposes:

- developing and maintaining residential, commercial, industrial, and agricultural areas,
- creating or restoring parks, preserves, and natural areas such as wetlands,
- mining deposits of sand, gravel, and stone (construction materials) for buildings and roadways,
- assessing the risk of flooding, landslides, and other geologic hazards,
- siting waste disposal or treatment facilities,
- deciding which residential areas should be served by city water and sewers and which are suitable for private wells and septic systems,
- locating and protecting groundwater resources.

Development near Crystal Lake

Geology is basic to every aspect of land use, development, and management. Through geologic research, the answers are ready and waiting when people ask, "What lies under our towns and farms? Where can we safely build, mine, bury wastes, or drill for water? Tell us what's likely to happen and why."

Soil Drainage

Regional variations in soil drainage should affect decisions on planning and development in McHenry County, particularly decisions involving suitability of land areas for *septic systems* and other types of waste disposal. Construction operations must also plan for soil drainage conditions.

Soil drainage is directly dependent upon topography, both local and regional. Other factors include (1) depth to and fluctuations of the *water table* (top of the zone of saturation), (2) *hydraulic conductivity* of soils and the underlying geologic parent materials, (3) position within local and *regional groundwater flow systems*, and (4) location of surface water bodies and drainageways (Berg, Kempton, and Cartwright 1984). Poor soil drainage conditions prevail in about 40% of the county (plate 2; Ray and Wascher 1965) but do not always pose environmental problems.

Sterne's Woods Park

Soil maps show the distribution of named soil series defined partly by the composition and origin of the soil's parent material (table 1) and partly by the soil drainage class. The soil survey of McHenry County (Ray and Wascher 1965) is currently being revised by the Natural Resource Conservation Service; it is also being mapped on *orthophotographic* quadrangle maps at a scale of 1:15,840 (1 inch represents ¼ mile). Some soil names from 1965 are now obsolete and have either been renamed, redefined, or correlated with other soils; however, these changes will not change the drainage classifications of the soils.

Surface runoff conditions are altered when agricultural land is urbanized. Most changes are caused by grading, cut and fill, and construction of buildings, parking lots, paved roads, and flood-control ponds. Before urbanization became a problem, agricultural drainage tiles extensively installed from the 1920s to the 1940s modified the natural runoff and soil drainage of much agricultural land in the midwestern United States (Illinois State Tax Commission 1941, McCorvie and Lant 1993). Sometimes when agricultural *tile systems* are disrupted by construction, an area may revert to its natural, poorly drained condition (Berg, Kempton, and Cartwright 1984).

Regions shown in black on plate 2 represent water bodies as well as soils classified as very poorly, poorly, and somewhat poorly drained (Ray and Wascher 1965). Under natural conditions, these areas are subject to flooding or seasonally high water tables. Wet basements are more likely to occur in these areas. The soils characterized by a seasonal water table lie less than 30 inches below the surface, as indicated by gray mottling . A McHenry County subdivision ordinance states that the seasonal water table must be deeper than 30 inches to help ensure proper functioning of conventional septic tanks and leach fields and to protect groundwater and surface water from contamination.

Areas mapped by Ray and Wascher (1965) as having very poorly, poorly, and somewhat poorly drained soils (plate 2) include those in which the geologic parent materials are (1) peat or organic-rich sediments of the Grayslake Peat, (2) inorganic colluvial sediments of the Peyton Formation, or (3) relatively impermeable sediments, such as lake sediment of the Equality Formation. All occur on nearly flat surfaces with limited surface drainage. In the latter two areas, shallow water table conditions during wet years or periods of intense rainfall may result in standing water in low areas. During dry years, however, these areas may show no evidence of poor drainage (Berg, Kempton, and Cartwright 1984). Very poorly drained areas commonly have ponded water in depressions or level areas throughout the growing season; whereas poorly and somewhat poorly drained areas are characterized by water at or near the surface periodically throughout the growing season.

Areas of poor soil drainage also occur along stream and river drainageways, most of which are local or regional groundwater discharge areas subject to periodic flooding. Such areas are shown on the U.S. Geological Survey's flood hazard maps, and in more detail, on the Federal Flood Insurance Program's maps—the most up-to-date maps for municipalities. The McHenry County Planning Department has 100-year flood maps for specific areas of the county.

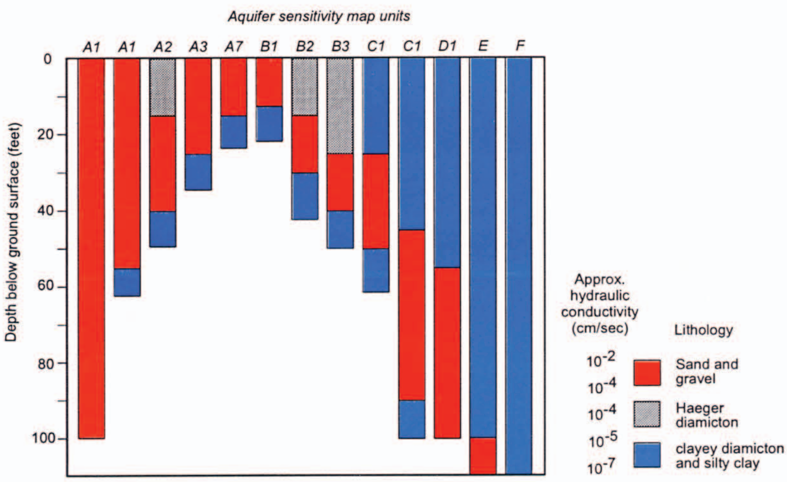
Residential, commercial, and industrial development have destroyed most wetlands in Illinois. Now natural areas, such as this wetland in Sterne's Woods Park, are protected to improve water quality and restore unique plant and animal communities. Although traditionally classified by type of vegetation, wetlands are really based on water and geology—the hydrogeology—of an area.

Thirty-six of the 75 mapped soil series in McHenry County are classified as very poorly, poorly, or somewhat poorly drained (Ray and Wascher 1965). The most extensive regions of poorly drained soil conditions in the county are found (1) west of the Marengo Moraine and in the lowlands along Piscasaw Creek, Rush Creek, Coon Creek, and the Kishwaukee River, (2) north of Woodstock in flat areas, (3) south of Woodstock in the upper Kishwaukee valley, and (4) in eastern McHenry County along Nippersink Creek, Boone Creek, North Branch, and the Fox River (fig. 2).

A range of moderately to excessively well-drained soil conditions occurs on uplands of sandy materials of the Haeger diamicton and related outwash deposits associated with the Woodstock Moraine and Ringwood upland in central and eastern McHenry County (fig. 3). The largest well-drained soil area lies between the towns of Algonquin, Fox River Grove, and Terra Cotta. Large tracts with well-drained soils (interspersed with small drainageways with poorly drained soils) also occur on uplands in western McHenry County on the Marengo Moraine and Capron Ridge. Lowlands containing extensive areas with well-drained soils are found on terraces of sand and gravel west of Harvard and adjacent to the Marengo Moraine, and along the Kishwaukee River and lower South Branch (fig. 3).

Aquifer Sensitivity

Plate 3 shows geologic materials mapped to a depth of 100 feet and rated according to their capacity to protect aquifers from potential contamination from septic systems, land burial of municipal wastes, surface applications of wastes (sewage sludge, septage, and manures) and chemicals (agricultural and domestic chemicals and fertilizers), and accidental spills of wastes, chemicals, and other potentially harmful substances. Thick deposits of fine-grained geologic materials, such as diamicton of the Tiskilwa Formation and Yorkville Member, serve as aquitards providing the most protection to underlying aquifers.



36 Schematic lithologic columns of selected aquifer sensitivity map units (plate 3) and the approximate range in hydraulic conductivity of the three types of materials that make up the map units, including sand and gravel, Haeger diamicton, and silty and clayey sediment.

The aquifer sensitivity ratings shown on plate 3 and figure 36 depend on the interpreted hydrogeologic properties of the sediment sequences. These properties include (1) the capacity of the materials to retain liquid wastes (or leachate) over time, (2) their ability to extract and retain polluting ions or compounds from a solution (attenuation characteristics), and (3) the rate that the geologic materials release nonattenuated ions, compounds, and complexes into the environment. These properties have not actually been measured; the categories are qualitative assumptions based on the sequence of geologic materials and the other factors discussed above. The physical state of the potential waste product (solid, semisolid, or liquid) was not considered in the ratings.

Mapped areas with low potential for contamination have the highest probability for having geologically suitable sites for waste disposal. These are also areas where chemicals or wastes spilled, applied, or otherwise introduced into the environment are least likely to contaminate the groundwater. Conversely, waste disposal or other potentially adverse land-use activities should be avoided in mapped areas with a high potential for contamination.

The aquifer sensitivity map (plate 3) cannot substitute for evaluation of individual sites. All sites and regions where proposed or present land-use activities could adversely affect groundwater quality should be separately investigated because of the variations in aquifer sensitivities due to variations in earth materials and the uneven distribution of the data used to produce the geologic maps.

Evaluating the Capacity of Geologic Materials to Protect Aquifers

Plate 3 was developed directly from the 1:24,000-scale stack-unit maps of the county. Each stack unit represents a vertical succession of materials combined on the basis of the lithology, particle size, and *permeability* of materials as well as their depth, thickness, and position in the sequence. Each stack unit was rated for relative aquifer sensitivity by qualitatively assessing the capacities of its earth materials to transmit, restrict, or remove potential contaminants from a hypothetical waste stream.

Porous, coarse-grained sand and gravel, sand, and fractured carbonate bedrock were mapped as aquifers. Fine-grained diamicton, clay and silt-rich deposits, and shale were mapped as aquitards.

An aquifer is more likely to become contaminated in areas where overlying fine-grained deposits (aquitards) are thin or missing, as reflected by aquifer sensitivity ratings A–F on plate 3 (fig. 36). It was also assumed that the rate at which groundwater or a contaminant travels through an earth material will be faster where the grain size of the geologic materials in the sequences is coarser; this is particularly evident in aquifer sensitivity rating groups A and B, where sand and gravel, fine-grained sediment, and Haeger diamicton are differentiated. In addition, the thickness of an aquifer was considered from a risk assessment perspective (Berg and Abert 1994). It is reasonable to assume that thick sand and gravel aquifers have the potential to yield the most water, probably supply a large population, and require the greatest protection. Hence, aquifer sensitivity groups are also subdivided on the basis of the thickness of sand and gravel deposits.

Geologic materials were evaluated for their capacity to protect aquifers from potential contamination by giving consideration to their porosity,

Table 3 "Building blocks" of the aquifer sensitivity map*

Geologic material (generalized)	Hydraulic conductivity (cm/sec)*	Fractures	Lithostratigraphic units	Clay content (average %)	Thickness
Clean sand/gravel	10^{-3}	no	Cahokia, Henry, and Pearl Fm	<2	variable
Fine and/or silty sand with gravel	10^{-5} to 10^{-3}	no	Cahokia, Henry, and Pearl Fm; and lenses in fine-grained deposits	≈5	variable; up to 290 ft
Silt	10^{-6} to 10^{-4}	yes	Equality Fm	<60	<40 ft
Haeger diamicton	$\approx 10^{-5}$	yes	Haeger Mbr	15	usually 20 ft, up to 60 ft
Fine-grained sediments	10^{-9} to $<10^{-5}$	yes	Equality Fm, Yorkville Mbr, Tiskilwa Fm, Wadsworth Fm, Winnebago Fm, Glasford Fm	25–40**	variable; up to 290 ft
Fractured rock	$>10^{-4}$	yes	all bedrock units	NA	usually upper 40 ft or less
Shale	$\approx 10^{-10}$	yes	Scales Shale, Maquoketa Grp	NA	≈40 ft

* Estimated hydraulic conductivity of typical geologic materials in Illinois from Berg, Kempton, and Cartwright 1984, Cartwright and Hensel 1993.

** Tiskilwa Fm = 25% clay, Yorkville Mbr = 40% clay

NA not applicable

hydraulic conductivity, and attenuation capacity. The following discussion is modified from Berg, Kempton, and Cartwright (1984).

Porosity, permeability, and hydraulic conductivity are characteristics primarily related to the size of the particles that make up the geologic materials (Todd 1980). Generally, the larger and more uniform the grain size of the sediment, the greater its hydraulic conductivity—that is, the faster that groundwater under pressure flows through the pores of a given earth material. Table 3 shows that diamicton (till), other fine-grained sediments (lacustrine silt and clay), and shale typically have hydraulic conductivities less than $1x10^{-5}$ centimeters per sec (cm/sec), whereas sand and gravel and fractured carbonate rocks typically have values greater than $1x10^{-5}$ cm/sec (Cartwright and Hensel 1993). The Oregon, Capron, Tiskilwa, Yorkville, and Wadsworth diamictons, Equality silt and clay, and Maquoketa bedrock are considered nonaquifer materials with relatively low hydraulic conductivities. Henry and Cahokia sand and gravel and Silurian carbonates are considered aquifers with relatively high hydraulic conductivities.

The hydraulic conductivity of the diamicton of the Haeger Member in McHenry County is higher than the "typical" ranges for diamicton in Illinois. In places, the Haeger is very firm and compact and exhibits a till-like structure with a matrix composition of 53% sand, 34% silt, and 13% clay (Curry 1995); however, the unit commonly contains discontinuous beds of sand and gravel, which can make the unit difficult to differentiate from sand and gravel, unless core samples or exposures are available. As a result, Ray and Wascher (1965) mistakenly mapped soils derived from Haeger diamiction as soils derived from sand and gravel in some places in eastern McHenry County (Bruce Putnam, consultant, Woodstock, Illinois, pers. comm. 1995).

Haeger diamicton is not likely to provide much protection to underlying aquifers, not only because of its sand and gravel lenses and low clay content but also because it is a weathered, fractured surface deposit generally less than 20 feet thick. However, the Haeger's 15% clay content and lower hydraulic conductivity, perhaps 1 to 2 orders of magnitude less than that of sand and gravel, can somewhat reduce infiltration of any contaminants into an underlying aquifer. Therefore, the presence/absence and thickness of Haeger diamicton are used as criteria to subdivide aquifer sensitivity rating groups A and B.

Haeger diamicton occurs directly above diamicton of the Tiskilwa Formation in north-central McHenry County, where it is mapped as sensitivity rating groups C3', D1', D3', and E' (plate 3). Although its occurrence without the presence of underlying sand and gravel does not constitute an aquifer, the potential is slightly greater in these areas for downward migration of a contaminant along the Haeger/Tiskilwa contact and discharge into a surface water body.

Attenuation capacity is the capacity of earth materials to remove contaminants from groundwater. Most chemical contaminants are removed by infiltration, dilution (due to shallow groundwater), or most importantly, exchange with elements (*cations*) loosely held by soil mineral or organic particles. Attenuation capacity is generally a function of the particle-size distribution (which affects porosity and permeability), mineralogy (especially the amount and type of clay minerals in the sediment), and organic matter content. These properties help in distinguishing the mapped geologic units and serve as indicators of the contamination potential of groundwater within sequences of these units. For example, the movement of a pesticide through the soil profile (about the upper 5 feet) is greatly affected by the extent to which it adsorbs to soil organic matter or clay particles; adsorption retards pesticide movement through the soil or other geologic unit (Keefer 1995). Organic matter is more likely than clay particles to adsorb pesticides; but when the organic matter content of the soil is less than 1%, clays become significant adsorption sites. Nitrates and other *anions* such as chloride are minimally affected by either organic matter or clays, however, and readily move into soil water and groundwater.

Limitations of Aquifer Sensitivity Mapping for Evaluating Waste Disposal Sites

The aquifer sensitivity map (plate 3) is intended as a regional guide for assessing the potential for aquifers within 100 feet of land surface to become contaminated by waste disposal or land treatment practices. The map also provides a model to help in evaluating potential contamination problems at specific sites. When combined with plate 2 showing poorly drained soils, the map can also indicate where the groundwater quality could be degraded, given dense distribution of septic systems or waste disposal facilities, or heavy applications of sewage sludge, manure, or agricultural chemicals.

The composition, position, and extent of the geological deposits, as well as depth to an aquifer and surface drainage, were considered when rating the units for the aquifer sensitivity map. Groundwater flow in various aquifers (shown in unpublished maps of the State Water Survey) was also used to help verify the existence and continuity of sand and gravel aquifers and to develop the sensitivity map, particularly in the areas for which data are sparse. The Illinois State Geological Survey cooperated with the Illinois State Water Survey to complete water-level measurements in several hundred water wells during an observation period of a few weeks in McHenry County; the objective was to determine the groundwater flow direction in each of the drift aquifers and the shallow bedrock. The Water Survey's investigations, conducted at the same time as the geologic mapping, will be published in a separate report.

Several factors signficant for determining the contamination potential of specific sites could not be included on the generalized regional map:

- saturation of sand and gravel units, all classified as aquifers, regardless of water-yielding potential;
- hydraulic conductivity, porosity, and *cation exchange capacity* of specific soils developed in the geologic units;
- detailed geology of a site, especially the character of the sediments lying between the top of the uppermost aquifer and the location of potential contaminant(s);
- seasonal conditions such as frost depth and depth to the water table;
- slope and other local variations of landforms and geologic materials;
- density of septic systems and waste disposal sites; volume and concentration of waste or chemical that may be disposed of, spilled, or applied (loading factors);
- distance of wells or natural discharge points such as lakes and streams from contamination input area(s);
- number of nearby wells and distance separating wells;

- position of the waste site or application area relative to groundwater recharge, discharge, and points between recharge and discharge areas;
- areas at or near mapped material boundaries;
- composition of waste materials;
- the liquid, semiliquid, or solid state of waste materials.

In addition, some generalizations in map units were made by combining or eliminating small units or omitting specific details. The surface drainage, for example, was not mapped in detail.

The following mapping conventions were used in preparing plate 3:

- Sand and gravel pits were mapped as if the original materials were present; however, each pit must be evaluated to determine its suitability for specific land uses. In a deeply excavated pit, for example, the water table may be artificially lowered by pumping and/or may be closer to the ground surface than it is in a shallower excavation. The water level of ponds in abandoned sand and gravel pits is a conservative indication of the elevation of the local water table; but because pond water evaporates, the actual water table adjacent to the pit is likely to be somewhat higher. The groundwater discharging into the pit may be balanced by an equal volume of water flowing out of the pit.

Sand and gravel dredging operation south of Crystal Lake.

- The 100-foot depth was chosen for mapping because studies in Minnesota (Klaseus et al. 1989) and Iowa (Libra et al. 1993), both in glacial hydrogeologic settings similar to McHenry County, reported a very low incidence of agricultural chemicals in aquifers more than 100 feet below the surface.
- The aquifer sensitivity ratings are based on depth to the uppermost aquifer, regardless of whether underlying aquifers are separated from the uppermost aquifer by fine-grained deposits. This provides for the most conservative assessment.

Special criteria for mapping the 23 units on plate 3 included the following:

- Stack-units with layers of variable thickness were simplified so that an average layer thickness was mapped (i.e., the parenthetic part of the stack-unit labels was not considered).
- Fine-grained Equality Formation layers interbedded with Henry Formation sand and gravel layers were mapped as if they were totally composed of sand and gravel. These map areas occur in eastern McHenry County in the Chain-O'-Lakes lowland and in north-central McHenry County in the Wonder Lake valley complex.

- Areas of less than 5 feet of fine-grained, surficial deposits overlying sand and gravel were treated as if the sand and gravel aquifer extended to ground surface.

Aquifer Sensitivity Map Units

Map units A to F are listed in order of decreasing sensitivity to contamination (fig. 36). Four basic units were considered; they include, in order of increasing hydraulic conductivity, (1) shale of the Maquoketa Group, (2) fine-grained silt and clay of the Equality Formation and various glacial diamicton units, except for, (3) the sandy loam diamiction of the Haeger Member of the Lemont Formation, and (4) sand, gravel, boulders, and fractured carbonate (table 3). Each of the 23 map units is described below.

Map Unit A: High Potential for Aquifer Contamination

Where sand and gravel is more than 20 feet thick (commonly 50 feet thick) and lies within 20 feet of the surface, the potential for groundwater contamination is high. About 50% of McHenry County is classified as unit A; it is most prevalent in eastern McHenry County and in lowlands of western McHenry County. In these areas, contaminants from any source can move rapidly through these sand and gravel deposits to wells or nearby streams. In addition, this thick surficial aquifer is commonly hydraulically connected to underlying aquifers (Berg 1994). Land-use practices should be very conservative in all areas mapped as unit A.

Unit A1 Sand and gravel deposits *more than* 50 feet thick occur at the land surface. Unit A1 areas occur principally in the Kishwaukee River and North Branch valleys in western McHenry County, east and southeast of Woodstock in central McHenry County, and through large parts of eastern McHenry County.

Unit A2 Sand and gravel deposits *more than* 50 feet thick are overlain by the Haeger, a sandy diamicton *less than* 20 feet thick. The largest A2 areas lie northwest and north of Woodstock and west of McHenry.

Unit A3 Sand and gravel deposits 20 to 50 feet thick occur at the surface. Unit A3 areas occur throughout western McHenry County, adjacent to the North Branch and Nippersink valleys in northeastern McHenry County, and east of Crystal Lake.

Map unit A3 area, St. Joseph Seminary.

Unit A4 Sand and gravel deposits 20 to 50 feet thick are overlain by Haeger sandy diamicton *less than* 20 feet thick. Unit A4 areas mostly occur just east of Wonder Lake.

Unit A5 Sand and gravel deposits 20 to 50 feet thick are overlain by Haeger sandy diamicton *more than* 20 feet thick. Unit A5 occurs only in two areas—just west of Pistakee Lake and east of Richmond.

Unit A6 Sand and gravel deposits *more than* 50 feet thick may be overlain by fine-grained deposits *less than* 20 feet thick, for example, the Tiskilwa, Yorkville, Wadsworth, Capron, and Oregon diamictons or silts and clays of the Equality Formation. The largest A6 area occurs along the Boone Creek valley in east-central McHenry County.

Unit A7 Sand and gravel deposits 20 to 50 feet thick are overlain by fine-grained deposits *less than* 20 feet thick. This unit is common along the Piscasaw River valley and its tributaries in western McHenry County, just southwest and southeast of Hebron in central McHenry County, and east and southeast of McHenry.

Map Unit B: Moderately High Potential for Aquifer Contamination

In unit B areas, sand and gravel deposits less than 20 feet thick generally lie within 20 feet of the surface and are either at land surface or overlain by the Haeger diamicton or fine-grained deposits. Groundwater remains very sensitive to contamination, despite the minimal barrier of diamiction or fine-grained deposits. About 27% of the county is classified as unit B. The largest unit B areas are in the lowlands of western McHenry County and throughout eastern McHenry County.

Groundwater in these thin sand and gravel deposits is not commonly tapped for a water resource; however, contaminated groundwater may flow into aquifers of adjoining units, or it may migrate through the sand and gravel, especially along the contact with underlying fine-grained deposits, and discharge on slopes or into surface-water bodies.

Unit B1 Sand and gravel deposits *less than* 20 feet thick lie at the surface and overlie fine-grained deposits. In western McHenry County along the Piscasaw River and its tributaries, the Rush and Coon Creek valleys, unit B1 areas are extensive. Another widespread area of unit B1 occurs in eastern McHenry County northwest of Crystal Lake.

Unit B2 Sand and gravel deposits *less than* 20 feet thick are overlain by the Haeger, a sandy diamicton *less than* 20 feet thick. Extensive areas of this succession are found northwest of Woodstock near Hartland, west and northwest of Wonder Lake, and east of Richmond.

Unit B3 Sand and gravel deposits *less than* 20 feet thick are overlain by Haeger sandy diamicton *more than* 20 feet thick. Two extensive areas of this succession lie southwest of Richmond and south of McHenry.

Unit B4 Sand and gravel deposits *less than* 20 feet thick are overlain by fine-grained deposits (clayey diamicton or silty clay lake deposits *less than* 20 feet thick). Extensive areas of unit B4 can be found in the eastern part of Woodstock, as well as east and south of Woodstock.

Map Unit C: Moderate Potential for Aquifer Contamination

In unit C areas, sand and gravel 20 to 50 feet thick is buried by 20- to 50-foot-thick, fine-grained deposits, including the Tiskilwa, Yorkville, Capron, and Oregon diamictons and Equality silts and clays. These areas make up about 8% of the county.

Fine-grained materials 20 to 50 feet thick offer moderate protection for underlying aquifers (particularly where the Yorkville and/or Tiskilwa diamictons overlie the sand and gravel) from waste spreading or septic systems. For example, Schock et al. (1992) reported that pesticide and nitrate detections in Illinois were significantly fewer where aquifers were buried 20 to 50 feet than where aquifers were shallower.

Unit C1 Sand and gravel deposits *more than* 50 feet thick are overlain by fine-grained deposits 20 to 50 feet thick. Map areas with this succession are found east and northeast of McHenry.

Unit C2 Sand and gravel deposits 20 to 50 feet thick are overlain by fine-grained deposits 20 to 50 feet thick. This relatively rare succession occurs only in small areas of north-central and east-central McHenry County.

Unit C3 Sand and gravel deposits *less than* 20 feet thick are overlain by fine-grained deposits 20 to 50 feet thick. The most extensive areas with this succession occur in the northwest corner of the county and between Huntley and Algonquin.

Unit C3′ Haeger diamicton directly overlies fine-grained deposits 20 to 50 feet thick south of Hebron.

Map Unit D: Moderately Low Potential for Aquifer Contamination

Where sand and gravel deposits 20 to 50 feet thick or Silurian carbonate bedrock are buried beneath fine-grained deposits 50 to 100 feet thick, the probability that groundwater will become contaminated is moderately low. The thick fine-grained materials shield the aquifer from any source of contamination at the surface. As Schock et al. (1992) previously reported, there was a significant number of pesticide and nitrate detections in a study area of Illinois where the aquifer was buried 20 to 50 feet and none in a study area where aquifers were buried more than 50 feet.

Unit D areas, about 6% of the county, are most extensive along the Marengo Moraine in western McHenry County, where the fine-grained deposits are diamicton of the Tiskilwa Formation.

Differences in aquifer sensitivity are probably due to differences in the clay content of the diamictons. The most protection for aquifers is provided by the Yorkville and Wadsworth diamictons with their high clay content and low hydraulic conductivity, then by the Tiskilwa, Capron, and Oregon diamictons, respectively. Thick Tiskilwa diamicton is the most extensive unit in McHenry County, especially in the Marengo Moraine.

Caution should be exercised when evaluating diamicton for groundwater protection in map areas D, E, and F of McHenry County because each diamicton unit contains lenses of sand and gravel. Identifying the environments of deposition is one way to evaluate the continuity of sand and gravel layers and lenses. The thicker and more continuous sands and gravels tend to occur above and below the main diamicton units, whereas the thinner and less continuous sands and gravels tend to occur within diamicton units (Troost and Curry 1991).

Another concern regarding the groundwater protection provided by diamicton units relates to the potential for migration of liquid wastes along cracks or other discontinuities that may extend as much as 50 feet below ground surface (Curry et al. 1994). Such discontinuities, which can develop with soil drying out or weathering, can increase the hydraulic conductivity of fine-grained sediment from about 10^{-6} cm/sec to 10^{-4} cm/sec (Herzog and Morse 1989).

Unit D1 Sand and gravel deposits *more than* 50 feet thick or Silurian carbonate bedrock are overlain by fine-grained deposits 50 to 100 feet thick. Unit D1 areas are most common along the Boone County line in west-central McHenry County.

Unit D1' Haeger diamicton directly overlies fine-grained deposits 50 to 100 feet thick in north-central McHenry County.

Unit D2 Sand and gravel deposits 20 to 50 feet thick are overlain by fine-grained deposits 50 to 100 feet thick. These areas are most prevalent in the northwestern corner of the county and west of Huntley.

Unit D3 Sand and gravel deposits *less than* 20 feet thick are overlain by fine-grained deposits 50 to 100 feet thick. Extensive D3 areas occur northwest and west of Huntley.

Unit D3' Haeger diamicton directly overlies fine-grained deposits 50 to 100 feet thick. Equality Formation silt and clay may overlie Haeger diamicton in some places in north-central McHenry County.

Map Unit E: Low Potential for Aquifer Contamination

Diamiction of the Tiskilwa Formation is at least 100 feet thick along the Marengo and Woodstock Moraines, where it constitutes map unit E.

On the horizon is Marengo Moraine, mapped as unit E.

Drift and bedrock aquifers may or may not be present below a depth of 100 feet. Areas mapped as unit E, only about 8% of the county, are among the least sensitive to groundwater contamination because of the absence of aquifers and presence of thick fine-grained deposits; however, discontinuous lenses of sand and gravel may be present within the diamicton. Map unit E' occurs where the Haeger diamicton directly overlies fine-grained deposits 100 feet thick. Equality Formation silt and clay may overlie the Haeger diamicton in some places. E' areas occur north of Harvard.

Map Unit F: Low Potential for Aquifer Contamination

Shale of the Maquoketa Group is present within 100 feet of land surface and overlain by diamicton of the Tiskilwa Formation. No drift or shallow bedrock aquifers have been identified in areas mapped as unit F; however, discontinuous lenses of sand and gravel may be present within the diamicton.

Areas mapped as unit F, less than 1% of the county, are found only in the southwestern corner of the county where the Maquoketa Shale lies near land surface.

Waste Disposal by Septic Systems

Plate 3 can be used to evaluate the potential for contamination of aquifers by septic systems. The principle consideration in rating the suitability of land areas for septic systems is the permeability and attenuation capacity of the geologic materials. Also important is the number of septic systems within a specified area; it is essential not to overload geologic settings with septic effluent. The most common wastes in septic effluent include bacteria, nitrates, and solvents (for example, from household cleaners).

Materials with high hydraulic conductivity (such as sand and gravel) will readily accept septic effluent, but may become a contamination hazard if effluent escapes too quickly for natural decomposition and attenuation. Conversely, the potential for aquifer contamination is low in materials with low hydraulic conductivity (such as the Yorkville diamicton), but the septic systems may not operate properly because of poor soil drainage.

The most widely used type of septic system is a buried tank with a shallow overflow seepage (filter) field at depths less than 3 feet. If the filter field is installed below this depth, the attenuation of contaminants by organic matter and clay in the soil is less effective, particularly if the underlying material is well drained and has a relatively high hydraulic conductivity (Berg, Kempton, and Cartwright 1984). Even when properly installed, septic systems spaced close together (5 to 25 systems per sqare mile) are likely to produce a high concentration of septic effluent that will enter shallow aquifers, particularly when the systems are parallel to the groundwater flow direction.

The U.S. Department of Agriculture has established criteria relating soil characteristics to the operation of septic systems (Ray and Wascher 1965). Their criteria, together with county ordinances and regulations of the McHenry County Board of Health, should be consulted before installing a septic system.

Map Units A and B: High Potential for Aquifer Contamination from Densely Spaced Septic Systems

Areas designated A and B, particularly where sand and gravel is at the surface (units A1, A3, and B1), are extremely vulnerable to potential contamination from septic system effluent. Aquifers are only minimally protected where they are overlain by less than 20 feet of Haeger diamicton (units A2, A4, and B2). Where Haeger diamicton is greater than 20 feet thick (units A5 and B3), aquifers are slightly better protected; however, this succession is relatively rare because Haeger diamicton generally mantles uplands to depths of less than 20 feet. Finer grained materials overlying a shallow aquifer (units A6, A7, and B4) provide a better barrier than if the Haeger diamicton overlies it. In unit B4 areas south of Woodstock, for example, the silty clay Yorkville diamicton should adequately protect the underlying sand and gravel, if septic systems are not too densely spaced.

There is less potential to transmit potential contaminants to underlying aquifers in unit B areas than in A1 or A3 areas. Contaminants in thin unit B aquifers would be more likely to migrate along the underlying contact with materials of lower hydraulic conductivity and enter lakes, rivers, and streams.

Map Units C, D, E, and F: Low Potential for Aquifer Contamination from Densely Spaced Septic Systems

Fine-grained sediments more than 20 feet thick will moderately protect an underlying aquifer from septic effluent. Although the risk of groundwater contamination is minimal in unit C, D, E, and F areas, some geologic factors may cause problems. On steep slopes, septic effluent may move rapidly to the land surface and into surface water bodies before it has been adequately filtered and attenuated by soil materials. In other places, high water table conditions and poorly drained soils may prevent septic effluent from entering the ground.

Another problem that can occur in unit C, D, E, and F areas is perched water. Perched conditions occur where infiltration is impeded by an underlying layer of fine-grained or compacted earth materials. Perched water may be found in otherwise well-drained areas, particularly where the Tiskilwa and Yorkville diamictons lie at land surface. The low hydraulic conductivity of the diamictons can create a serious infiltration problem. Septic systems may work well under dry conditions but perform poorly during periods of heavy rainfall, particularly during the spring.

Municipal Solid Waste and Hazardous Waste Sites

Plate 3 can be used to evaluate the potential for contamination of aquifers by municipal and hazardous waste disposal facilities (Berg, Kempton and Cartwright 1984).

Siting waste-disposal facilities along major rivers is generally considered unsuitable, first, because of the probability of flooding, and second, because of the generally channelized, porous, coarse-grained sediments with moderately high hydraulic conductivities and low cation exchange capacities. Groundwater contamination plumes move rapidly in river valley settings. The only mitigating factor is that the path of a plume from facility to river is generally predictable and may be detected and monitored prior to discharge into a stream.

One consideration in analyzing the suitability of river valleys for siting waste-disposal facilities is whether the concentration and distribution of contamination is acceptable. Although the contamination will be limited and finite, such sites are off limits under present Illinois Pollution Control Board standards. Another consideration is whether there are, or may be, pumping wells nearby that could alter flow paths and cause contaminated groundwater to migrate outside of a predictable "zone."

Map Units A, B, and C: High Potential for Aquifer Contamination from Waste Disposal Facilities

Areas designated as A, B, and C, all containing sand and gravel aquifers within 50 feet of land surface, are extremely sensitive to potential contamination from waste disposal facilities. Waste buried in a pit or trench up to 50 feet deep may be in direct contact with sand and gravel deposits. If this is the case, there is little or no natural protection of the aquifer by overlying finer grained materials. Trench depths of 50 feet are now fairly common (and some up to 100 feet deep have been proposed) because operators desire to maximize their landfill capacities because of difficulties in obtaining permits for new facilities.

In unit B1 areas, where the thin sand and gravel is underlain by thick diamicton, such as the Yorkville and Tiskilwa diamictons (for example, west and south of Woodstock), it may be possible to remove the sand and gravel to the top of the fine-grained deposit; however, the landfill should be designed to shield waste and effluent from sand and gravel at the sides of the trench. If site-specific investigations show that the buried, thin sand and gravel layer is discontinuous, land in unit C3 areas may be suitable for a waste-disposal facility.

Map Unit D: Moderate Potential for Aquifer Contamination from Waste Disposal Facilities

In unit D areas, sand and gravel deposits or Silurian carbonates are present and overlain by fine-grained deposits 50 to 100 feet thick. Although the sensitivity of aquifers to contamination is relatively low because fine-grained materials separate the aquifer from land surface, aquifers can be as shallow as 50 feet from land surface.

Areas mapped as unit D should not be considered for disposal of hazardous wastes. Municipal waste disposal may be acceptable at sites where an aquifer is close to 100 feet deep (Berg 1994). If a landfill trench 100 feet deep is proposed, then the potential for contamination of an underlying aquifer increases from a rating of moderate to *high*.

Parts of unit D areas may have poor surface drainage or be subject to a seasonally high water table. Although thick deposits of diamicton reduce the potential for aquifers to become contaminated, they do not eliminate the potential for surface water contamination. As a result, landfills may be difficult to design, engineer, and operate in poorly drained areas (plate 2).

Map Units E and F: Low Potential for Aquifer Contamination from Waste Disposal Facilities

In unit E and F areas, at least 100 feet of fine-grained deposits lie at the surface, or shale of the Maquoketa Group is present within 100 feet of land surface and overlain by fine-grained deposits. The potential for contamination of aquifers from waste disposal facilities is low in areas mapped as units E and F because aquifers, if present, can be buried by fine-grained materials as much as 250 feet thick (figs. 15, 16). The risk to groundwater of contamination from municipal or even hazardous wastes is minimal; however, waste disposal facilities must always be constructed, operated, and monitored to ensure the continued safety of groundwater resources.

As in unit D areas, poor drainage conditions are common in areas mapped as units E and F; contaminants can travel to surface water bodies via surface flow. The map of poorly drained soils (plate 2) shows an integrated network of poorly drained soils covering much of the Marengo and Woodstock Moraines where unit E areas are prevalent. Also, detailed site-specific investigations for waste-disposal suitability must be conducted to verify the absence of aquifer materials in these areas.

Surface Spreading of Wastes, Accidental Chemical Spills, and Application of Agricultural Chemicals

The potential for contamination of groundwater due to surface spreading of wastes (including sewage sludge, manure, and septage), accidental chemical spills, and application of agricultural chemicals is similar to that due to septic systems, except these wastes are more likely to be reduced through attenuation in the soil profile before reaching the groundwater system. Application rates for surface spreading of wastes and agricultural chemicals are dependent on the slope, soil type, soil characteristics, and amount of precipitation. Rates, depth of injection, and timing of applications should be adjusted to prevent overloading of the soil and to supply plant needs for only one season because excess amounts would migrate down to aquifers (Graffis et al. 1977).

Geologic conditions that permit rapid downward movement of contaminants into shallow aquifers or runoff of contaminants into surface water bodies increase the probability of contamination from surface spreading of wastes, application of agricultural chemicals, and chemical spills. Contaminants migrate rapidly into shallow aquifers where sand and gravel lies (1) at land surface (A1, A3, and B1 units), (2) directly below the Haeger diamicton, but more commonly within 20 feet of land surface (A2, A4, A5, B2, and B3 units), and (3) within 20 feet of land surface, but buried by fine-grained deposits (A6, A7, and B4). Runoff of contaminants into surface water bodies is likely in areas mapped as units C, D, E and F, where the surface drainage is poor and/or steep slopes might cause surface-water contamination.

Throughout McHenry County, overapplication of chemical fertilizers and improper spreading or overconcentrating of sludge and manure applications concern rural and suburban homeowners. Nitrogen, one of the most mobile elements in fertilizer and sludge/manure, is a common contaminant of groundwater supplies, particularly when liquid ammonia is overapplied. Local buildup of nitrogen compounds, especially nitrates, is common around feedlots. The lawn fertilizers used in subdivisions and other residential areas can also contribute significantly to contamination.

Concentrations of trace elements, such as metals, and nitrates where sewage sludge is applied as fertilizer, can also cause local contamination. For example, Berg et al. (1987) found higher levels of nitrates in the shallow groundwater in downgradient wells than in upgradient wells at agricultural sludge application sites near Rockton in Winnebago County, Illinois. Finally, agrichemical and other agricultural pollution of glacial drift aquifers tends to be confined to depths of less than 50 feet in Illinois (Schock et al. 1992) and less than 100 feet in Iowa and Minnesota (Klaseus et al. 1989, Libra et al. 1993); however, the groundwater in McHenry County has not been extensively sampled for agricultural chemicals.

When agricultural chemicals are properly applied, residual amounts are likely to be confined to the active soil zone. Diamictons and other fine-grained sediments generally contain sufficient clay to attenuate and adsorb some organic compounds. As several studies suggest (Libra et al. 1993, Schock et al. 1992, Klaseus et al. 1989), however, extreme caution is advisable when handling and applying agricultural chemicals, spreading surface wastes, or installing septic fields. Aquifers less than 100 feet deep, even in areas mapped as unit D, may be vulnerable to contamination.

Construction Conditions

Construction is affected by geologic factors such as the capacity of a material to support structures (bearing capacity) and the ease of excavating for foundations, basements, and utilities. Soil drainage is also a significant factor. Generally, the poorer the drainage, the poorer the conditions are for construction (Ray and Wascher 1965, Berg, Kempton, and Cartwright 1984). Ideal sites for most construction activities are not subject to flooding or other natural hazards and have thick, well-drained materials of high-bearing capacity. The McHenry County soil report (Ray and Wascher

1965) should be consulted for detailed information on potential construction problems associated with specific soils.

The following conditions are considered critical for general construction (Berg, Kempton, and Cartwright 1984). Where reference is made to specific geologic deposits, consult plate 1 for the distribution of these materials at land surface.

Drainage Characteristics

Surface runoff and infiltration capacities of surface soils and underlying geologic materials affect soil drainage. Well-drained soils, such as those on sand and gravel uplands of eastern McHenry County, offer the most desirable conditions for construction; whereas poorly drained soils, such as those developed on lowland alluvial deposits (plates 1,2), can make construction difficult and lead to other problems such as settling and cracking of foundations.

Bearing Capacity

The bearing capacity of a geologic material depends on its drainage characteristics, moisture content, material type, and whether previous loads (such as glacial ice or a building) had compacted the material. Bedrock, diamicton, and sand and gravel generally have high load-bearing capacities, whereas peat, muck, alluvium, colluvium, lacustrine silt and clay, and loess have low load-bearing capacities.

Excavation

Ease of excavation depends primarily on the position of geologic materials on the landscape and secondarily on the type of machinery used, the skill of the operator, and weather conditions. Sand, gravel, and loess generally are relatively easy to excavate, whereas some diamictons and most bedrock are difficult to excavate.

Natural Hazards

Flooding Most flooding occurs within the 100-year floodplain of rivers and streams, although it may spread to the 500-year floodplain during exceptional rainfall events. The 500-year floodplain and the *geomorphic floodplain* should also be evaluated if any questions arise about the proximity of a subdivision or a waste disposal facility to surface-water bodies. The 100- and 500-year-floodplain maps show the potential for either type of flood to occur on an annual basis. The 100- and 500-year floods are statistical predictions (Ritter et al. 1995) based only on about 90 years of data on certain rivers and streams in McHenry County. Maps of the 100-year floodplain are produced by the Federal Emergency and Management Agency (FEMA) and available at the Illinois State Water Survey or from county and local planning departments. Maps of the 500-year floodplain are not generally available unless previously produced for a specific purpose by a planning department, developer, or consultant.

Peat and muck deposits Grayslake Peat, consisting of organic matter and some clay, silt, and sand, contains large amounts of water. The upper 5 feet or so of these deposits undergo seasonal freeze/thaw cycles. Because water in these deposits readily squeezes out when a load is placed on the surface, they are unsuitable for fill or building foundations. In McHenry County, the Grayslake Peat is widespread, covering more than 20,000 acres or about 5.7% of the county (Ray and Wascher 1965). The most extensive deposits are north of Hebron, south of Richmond, east and southeast of Woodstock, south of Wonder Lake, adjacent to Pistakee Lake, in the lowlands near Terra Cotta, southwest of Crystal Lake, and northeast of Silver Lake (plate 1).

Fine-grained silts and clays Surficial glacial lake sediments mapped as Equality Formation (plate 1) can cause significant construction problems. Variations in soil drainage and compaction can result in differential settlement of structures on these materials. In addition, poor soil drainage, low topographic relief, and high water tables may result in buoyant foundations and wet basements, unless the groundwater is drained or pumped to depths below the excavation. Constructing basements in surficial lake sediments is generally not advisable, unless special building and drainage techniques are used. The most extensive deposits of silt and clay are found south and southeast of Richmond and directly east and west of McHenry (plate 1).

Artesian conditions Where groundwater in permeable geologic materials is confined by significantly less permeable materials, the confined (pressurized) groundwater rises in wells to levels above the top of the aquifer. Flowing artesian wells or springs are found where the pressurized water flows out of the ground.

Most buried aquifers in McHenry County are artesian aquifers covered (confined) by fine-grained sediments. Groundwater discharging from artesian aquifers has a low potential to become contaminated because, near discharge points, water is under relatively high pressure and moving upward. Areas of groundwater discharge can severely hinder construction of foundations and result in leaky basements. This is most critical in sandy low-lying areas, such as eastern McHenry County (mapped as Henry Formation), adjacent to uplands of diamicton confining sand and gravel, where recharge is relatively rapid. A complicating factor in some places is that artesian conditions may not be apparent during dry seasons, so that serious problems can unexpectedly arise in wet weather.

In McHenry County, flowing artesian wells occur in several locations. Any lowland setting with a few feet of Tiskilwa or Yorkville diamicton or Equality silt and clay covering sand and gravel is susceptible to artesian conditions.

Landslides Although relatively rare and difficult to predict, landslides may occur along any steep slope, particularly stream and river banks of loose sand and gravel or soft diamicton. Stream and river bank erosion may be exacerbated by the increased surface-water runoff due to paving and construction. Increased stream flow can destablize slopes, particularly the outside cutbanks of meander bends. Control of runoff and protection of stream banks may be necessary to prevent structural damage to buildings and bridges along such streams.

Shrinkage, swelling, and frost heave of soils Foundations and roads are commonly damaged by swelling or heaving of the ground surface as soils expand with absorption and/or freezing of water. When dried out, soils crack or fracture. Areas in which surface sediments are most vulnerable to shrinkage, swelling, and/or frost heave in McHenry County are mapped as peat, lake sediment, loess, or colluvium (Grayslake, Equality, Peoria and Peyton units, respectively, on plate 1). Sand and gravel deposits in Illinois are not generally susceptible to shrinkage, swelling, or frost heave.

FUTURE GEOLOGIC RESEARCH TO BENEFIT McHENRY COUNTY

This investigation of McHenry County discovered many unique geologic features and revealed several geological and environmental issues that should be pursued through additional research.

Regional Geologic Framework

➢ Investigations into the glacial origin of geologic terranes, including the outwash and lake sediments of the Wonder Lake valley complex as well as the deltaic and lake sediments and diamicton in the Chain-O'-Lakes region, could yield valuable data for constructing models of glacial deposition. As the geologic models improve, so will interpretations of these glacial deposits and predictions of their environmental assets and limitations.

➢ Additional borings in the lowland between Hebron and Woodstock will indicate the total thickness of sand and gravel deposits. At present, we are uncertain whether all the sand and gravel in this area is unconfined and thus more vulnerable to contamination. Also, we are uncertain about the relationship between these sand and gravel deposits and nearby diamictons. This information is relevant for models of glacial sedimentation.

➢ Radiocarbon ages of fossiliferous lake sediment should be determined to help establish the chronology of the various pulses of ice during the last glaciation. At present, only two radiocarbon ages for this region of Illinois are available to help in dating the multiple fluctuations of the Lake Michigan Lobe. This information is needed to validate regional and global correlations of geologic and climatic events, as well as establish the local chronology of geologic events and materials.

The highs and lows of McHenry County: well-drained soils of the Marengo Moraine (*top*) contrast with very poorly drained organic soils of the Chain-O'-Lakes lowland.

Environmental Geology

➤ Establishing baseline conditions for groundwater quality would aid in tracking changes in water quality and in targeting areas that might need special protection in this rapidly urbanizing county. About 800 water wells are drilled each year in the county (J. Maichle Bacon, McHenry County Department of Health, pers. comm. 1996). New wells could be sampled for nitrates, bacteria, and other contaminants soon after installation, and then periodically monitored for potential degradation due to the changes in land use (for example, from septic systems, lawn fertilizer, and pesticide applications). Related studies could evaluate the relationship between septic tank density or sludge/manure application rates and groundwater quality in McHenry County.

➤ A countywide vulnerability assessment could be undertaken by analyzing current (1990s) and historical (1930s) land-use and land-cover data, and comparing the data with ground- and/or surface-water quality. For example, the percentage of agricultural land could be used as a surrogate for evaluating fertilizer and pesticide usage. Changes in land use from agriculture to residential or commercial could indicate increases or decreases in groundwater contamination or significant changes in runoff regimes and surface water flow rates and quality.

➤ Additional research should focus on the relationship between water quality and the aquifers mapped on our 1:24,000-scale stack-unit maps of the county. This could be accomplished by (a) additional borings, (b) analyses of groundwater quality (including fertilizer and pesticide detections) associated with the map units and their groundwater protection rating, and (c) numerical modeling of groundwater flow. Preferably, an investigation would incorporate all the above.

➤ Finally, future research could build upon work that the Illinois State Water Survey is completing to determine groundwater flow directions for specific aquifers (via a mass water-level measurement of several hundred private wells) and to determine capture zones for specific municipal wells in McHenry County. This additional information should contribute to a greater understanding of the relationships between groundwater flow directions, groundwater quality, aquifer yields, and the lateral and vertical changes in the properties of aquifers and aquitards.

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GLOSSARY

7.5-minute topographic quadrangle maps Published by the U.S. Geological Survey, these maps depict topography with contour lines, natural features (such as lakes and streams), forest vegetation, and cultural features (such as houses, roads, railroads, etc.). Each quadrangle covers 7.5 minutes of longitude and latitude, which in northern Illinois is approximately 58.4 square miles.

Alluvial fans Triangular deposits of sediment (as they appear in map view) form when a stream flowing in a confined, narrow channel changes abruptly to wide and unconfined flow. The velocity and power of the stream to carry sediment decreases rapidly, and sediment is deposited in rapidly shifting channels. The head of the alluvial fan occurs where the change in stream power occurs (Ritter et al. 1995).

Alluvium Stratified sand and gravel or silty clay deposited by rivers and streams.

Anions Negatively charged ions dissolved in water.

Aquifers Earth materials, mostly sand and gravel, sandstone, or fractured carbonate rocks, that contain sufficient volumes of water for human consumption.

Aquitards Earth materials that restrict the movement of groundwater; aquitards are generally diamictons with fine-grained matrices, lake deposits, shales, and other fine-grained, dense, fracture-free sediments.

Arch A region where bedrock layers have been folded upward to form a broad anticline with gently dipping limbs.

Artesian conditions They occur where pressurized water in a confined aquifer causes the water level in a well to rise above the level where the water enters the well (Freeze and Cherry 1979). In some cases, the pressure may be sufficient to cause the water in the well to flow out on the ground surface.

Bedded rocks Layered rocks, usually sedimentary in origin.

Bedrock In northern Illinois, it consists mostly of sedimentary rocks deposited during the Paleozoic Era 570 to 245 million years ago. The bedrock is much older, and generally more lithified (harder) than the overlying sediment deposited by glaciers during the Quaternary Period in the last 1.6 million years or so.

Capture zones The parts of an aquifer affected by pumping during a given time period.

Cation exchange capacity A semiquantitative measurement of the ability of a material to hold cations or exchange cations in reversible reactions (Buol et al. 1980).

Clay loam A soil or geologic material with roughly equal amounts of sand, silt, and clay in the matrix (see textural triangle, fig. 18).

Clay mineralogy In this report, it specifically refers to the results of semiquantitative phase analyses of the minerals in the <.002 mm size fraction. The analyses were performed using oriented, aggregate, glycolated slides of the µm fraction. Clay minerals were separated into three groups. The relative amount of each group was determined using peak height measurements as counts per second measured from an x-ray diffractogram. The three groups are (a) expandable clay minerals—all materials that expand to approximately 17Å (10^{-9} cm) when solvated with ethylene glycol; (b) illite—clay minerals that have a 10Å basal spacing and do not expand when treated with ethylene glycol; and (c) kaolinite plus chlorite—all clay minerals with a 7.2Å basal spacing.

Calcite and dolomite were measured by peak height (counts per second) to obtain relative quantities of these minerals in the <.002 mm fraction. Two additional measurements routinely were made on drift samples for purposes of classification and correlation (Willman et al. 1963, 1966, Wickham et al. 1988): the diffraction intensity ratio (DI) and heterogeneous swelling index (HSI).

Wickham et al. (1988) discusses in greater detail the meaning and use of these indices.

Colluvium Loose material deposited by slope wash and gravity, usually found at the base of slopes, and generally composed of diamicton mixed with loess.

Continental glacial ice Thick ice formed on the continents during "icehouse" events in Earth's history. Continental glacial ice flowed from accumulation centers at high latitudes. In North America during the last Ice Age, two large domes of glacial ice coalesced to form much of the Laurentide Ice Sheet. Tongues of ice extended southward from the main part of the ice sheet, including the Lake Michigan Lobe, which flowed to the south and west across Illinois. Other glacial ice lobes affected Illinois as well (Hansel and Johnson, 1996).

Cross-stratification Structure in sedimentary rocks in which fine layers or beds of sand lie at angles generally less than 30°. The angled strata were deposited by currents of water or wind.

Cuttings The rock fragments and debris generated when drilling a well. Sample sets of cuttings, collected as the well is drilled, can indicate the depth intervals of differing lithologies. Sample sets of several municipal water wells kept at the Illinois State Geological Survey have been studied by several geologists and are the basis for figure 7.

Debris flow deposits They commonly form in the depositional environments in front of glaciers and are composed of diamicton that may have physical characteristics very similar to diamicton deposited in subglacial environments (beneath active glacial ice). Debris flow diamicton is generally less compacted, however, and has a higher moisture content than heavily compacted subglacially deposited diamicton. Debris flow deposits have unique morphologies (such as snouts) and are commonly channelized (Ashley et al. 1985).

Deglaciation An interval of time when glaciers melted and retreated.

Deltaic sediment Sediment deposited by a river or stream as it enters a lake or pond is called "deltaic" because the deposit looks like the Greek letter Delta in map view.

Diamicton A very poorly sorted sediment composed of a wide range of grain sizes. In Illinois, diamictons deposited by glaciers consist of particles ranging in size from boulders as large as houses to grains of the finest clay.

Digitized An adjective to describe lines, polygons, and reference points on a map or illustration that have been assigned x, y, and z coordinates in a computer database. Once a map has been digitized, the map features can be easily retrieved and manipulated with respect to scale, color, etc.

Drift A general term that refers to all sediments associated with glacial environments, including subglacial tills and sorted sediments, and aeolian (windblown), fluvial (river), and lacustrine (lake) materials.

Dolomite A bedrock composed primarily of magnesium calcium carbonate, the mineral dolomite. Dolomite is a common lithology of Paleozoic bedrock in northern Illinois.

Environments of deposition Modern analogs and models of depositional processes that geologists use to explain the distribution of ancient geologic materials, as well as their physical and chemical characteristics. See Ashley et al. (1985) and Andersen and Borns (1994) for good discussions and illustrations of glacial sedimentary environments.

Episode The interval of time during which a set of similar lithostratigraphic units was deposited (Hansel and Johnson 1996).

Facies The specific lithologic characteristics of a stratigraphic unit that distinguishes it from adjacent parts of the unit deposited at the same time, as in a beach facies and an adjacent nearshore facies.

Floodplains Floodplains are where rivers or streams flow during floods when they overflow their channels. For insurance purposes, floodplains are determined by statistical estimates of the frequency and magnitude of flood events for a particular stream.

Fluvial sediments Any sediment deposited by flowing water in a river or stream.

Formations Bodies of rock or sediment composed of a distinctive lithology and thick enough to be mappable at the largest practical scale. Formations are the basic lithostratigraphic unit used by geologists.

Geomorphic floodplain The relatively flat area adjacent to a stream or river channel that often includes terraces and that extends laterally to the edge of adjacent upland areas. The geomorphic floodplain often extends above and beyond the modern floodplain.

Geomorphology The study of the shape, origin, age, and composition of landforms.

Geophysics (electric earth resistivity) An indirect method used in lieu of drilling test wells to determine the physical characteristics of geologic materials without actually sampling the material. It is based on known physical and chemical characteristics of the material.

Geosol A pedostratigraphic unit representing an ancient exposed surface that includes soil horizons developed into a defined suite of lithostratigraphic units (parent materials), as well as a thin accumulation (mantle) of weathered colluvium. Geosols are commonly buried by distinctive lithostratigraphic units or are associated with other geosols, and they may eventually merge with the modern soil.

Glacial deposits (glacial drift) Sediment deposited by glaciers includes diamicton, stratified to massive sand and gravel, and uniform to bedded silt and clay .

Glaciation A period of time when glaciers invade an area.

Glacigenic An adjective to describe sediment deposited by or in close association with continental glaciers.

Glacigenic sequence A succession of sediments and other evidence that reflect the advance, overriding, and retreat of a glacier. An idealized glacigenic sequence might include a basal glaciolacustrine deposit (from deposition of fine sediment carried to a proglacial lake by meltwater streams), coarsening-upward sand and gravel deposits (from the deposition of fast-flowing, sediment-laden glacial meltwater streams), diamicton (from the deposition of basal debris in the glacier), and on top, additional lacustrine sediment (deposited in a low area as the glacier melted), or other diamicton (deposited by debris flow).

Gleyed soil horizon A soil horizon formed under very poorly drained conditions. If soil water movement has been stagnant, the horizon is bluish or green reflecting the presence of reduced iron. Mottled color segregations form if the reduced iron is removed by intermittent movement of soil water.

Granite An igneous intrusive rock composed of crystals of quartz and feldspar and other minerals that crystalized deep below the earth's surface.

Group A lithostratigraphic unit consisting of two or more formations.

Harvard Sublobe A projection of the ice in the Lake Michigan Lobe of the Laurentide Ice Sheet that flowed due west out of the Lake Michigan Basin across eastern and central McHenry County during the Marengo, Livingston, Woodstock and Crown Point Phases.

Hydraulic conductivity The net velocity of water across a specified distance caused by a unit decrease in water pressure (Freeze and Cherry 1983).

Hydrostratigraphy The naming of units based on the hydraulic properties of the rock layers. Aquifers or groups of aquifers are distinguished from confining units and nonaquifers.

Ice contact deposits Sediments deposited adjacent to or on top of glacial ice. Sedimentary layers (bedding) in ice contact deposits often are deformed because of the effects of ice melting away, which removed the lateral and underlying support from the deposits.

Ice-marginal sedimentary environments Depositional environments adjacent to an active glacier, including fluvial and lacustrine settings.

Interbedded Adjective to describe the interlayering in repetitious cycles of beds composed of contrasting lithologies, such as interbeds of silt and sand.

Interglaciation A period of time when glaciers do not affect an area. We include those times when loess is deposited as part of a glaciation, even though the glacier may have been located far from Illinois (Curry and Follmer 1992).

Isopachous maps Maps that show the thickness of a geologic unit. The contour lines of an isopachous map show the thickness intervals in a manner similar to topographic contours.

Kames Isolated hills of sediment deposited in ice-contact sedimentary environments. They are typically composed of chaotically bedded sand and gravel, but may also contain diamicton and deformed beds of silt and clay.

Kame terraces Landforms created where debris-laden streams deposit sediment between glacial ice and valley slopes (ice-contact deposits).

Kamic (topography) Hills, ridges, and depressions composed mostly of sand and gravel. "Kamic" implies that the sediment was deposited mostly in an ice-contact environment.

Kamic moraine In McHenry County, a moraine such as the Fox Lake Moraine that formed adjacent to active glacial ice, unlike the Marengo Moraine that formed beneath the snout of an active glacier. At least some of the sediment in a kamic moraine is water-laid.

Lacustrine sediment Sediment, commonly fine-grained and thinly laminated, that was deposited in the bottom of a lake. Lacustrine sediment that accumulated adjacent to or upon glacial ice is known as glaciolacustrine sediment.

Lake Michigan Lobe The southwardmost projection of the Laurentide Ice Sheet, formed as the glacial ice streamed across the Lake Michigan Basin.

Laminated sediment Sediments that have a pattern of repeated layering at a millimeter or submillimeter scale and generally composed of fine-grained sand, silt, and clay. The layering may be caused by alterations in particle size of the sediment, the content of organic matter, or other physical and chemical characteristics.

Lenses Discontinuous beds of sediment with a lithology different from the surrounding sediment. For example, lenses of sand and gravel when viewed in cross section within a layer of diamicton.

Limestone Bedrock composed mostly of the mineral calcite (calcium carbonate). Most limestone formed in marine depositional environments and are composed of whole and fragmented fossils of animals and plants.

Lithologic logs Written descriptions of the samples of earth materials brought to the surface when drilling a well. Logs described by drillers are considered to be a less reliable source of geologic information than those described by a geologist.

Lithology The systematic, descriptional classification of a rock in terms of its mineral composition, structure, texture, fossil content, color, and other characteristics.

Lithostratigraphy The formal classification of rock units according to their lithology, relative age, and distribution.

Load-bearing capacity The load or weight a material can withstand without failing or deforming by dewatering, plastic deformation, and/or fracturing.

Loam A soil or other unlithified geologic material consisting of roughly equal amounts of sand and silt, and less clay, in the matrix (see textural triangle).

Marker bed A bed having a lithology, fossil assemblage, or other easily recognizable characteristics distinct from surrounding strata. The most useful marker beds are relatively thin, and traceable over large areas. In this investigation, buried soil horizons, such as the Sangamon Geosol, were marker beds.

Matrix The sand, silt, and clay particles that constitute a sample or layer of diamicton. The matrix does not include the gravel or coarser grained portion of a diamicton.

Moraines Topographic features, generally ridges or linear features with hummocky topography, formed of glacial drift. They are commonly interpreted to indicate the limit of a glacial advance or where a glacial ice margin was stationary because the overall rate of melting was equal to the forward movement of the glacier.

Moulins Locations where a surficial and internal meltwater stream of a glacier abruptly cascades to near the base of the glacier. Cones of sorted sediment commonly accumulate at the base of moulins, and are called moulin kames.

Muck A soft sediment composed of peat in which the fibric material has decomposed. The moisture content of mucks is generally very high, and they have very low load-bearing capacities.

Orthophotographic maps Photographic images that have been corrected to eliminate distortion typical of ordinary aerial photography or remote sensing and to project the corrected photograph onto a standard map projection such as the polyconic or transverse mercator projections (Press and Siever 1982).

Outlets Passes through which glacial meltwater or later streams once flowed. Outlets in Illinois are often cut through moraines.

Outwash Sediment deposited by water flowing away from a glacier. The sediment is commonly composed of sand and gravel, but may also include thin, discontinuous beds of diamicton (deposited by debris flow) or silt and clay (deposited in ponds or small lakes).

Outwash fans Alluvial fans formed adjacent to moraines. They were often deposited concurrently with the moraine.

Paleozoic Era The period of geologic time from about 570 to 245 million years ago (Press and Siever 1982) when most bedrock strata were deposited in Illinois.

Palimpsest landforms Hills, valleys, moraines, and other features buried by a thin cover of younger sediment so that the upper surface of the younger sediment reflects the underlying shape of the old land surface.

Parent material The sediment or rock in which a soil is developed.

Particle-size (grain-size) distribution The composition of a sediment in terms of grain-size classes. In this study, we analyzed the grain size classes of the matrix composed of sand (0.064–2.0 mm), silt (0.004–0.064 mm), and clay (<0.004 mm).

Precambrian Era The geologic time period that includes all of Earth's history prior to the beginning of the Cambrian Period approximately 570 million years ago (Press and Siever 1982).

Proglacial Sediment deposited in front of, or beyond, a glacial margin.

Quaternary Period The interval of geologic time, about 1.6 million years ago to the present, during which Illinois was subjected to repeated episodes of glaciation.

Recharge Water usually in the form of precipitation, but also from lakes and streams, that enters a groundwater system by infiltrating through surficial sediment.

Regional groundwater flow systems A description of the direction and speed of the flow of groundwater at a scale that is county-wide or larger. They generally connote very long flow paths associated with deep groundwater systems (Freeze and Cherry 1983).

Reworked sediment Sedimentary rock or unlithified sediment that has been eroded, transported, and deposited in a new location.

Rhythmically bedded sediment (rhythmites) Repetitive successions of layers composed of sediment with visually contrasting grain sizes. In this study, most rhythmites were composed of either very fine sand, silt, or silt clay deposited in glaciolacustrine environments.

Runoff Water (generally from precipitation) that flows across the land surface instead of infiltrating into the soil.

Sandstone Rock composed of cemented grains of sand (particles with diameters from 64 to 2000 μm across).

Secondary porosity Openings in a sediment or sedimentary rock that formed long after the sediment was deposited. Common forms of secondary porosity in McHenry County resulted from the dissolution of carbonate rocks (such as vug, defined below) or fractures in bedrock and fine-grained diamicton.

Septic systems A means of disposing of household sewage. They generally consist of aeration and settling tanks and shallow drainage fields. Bacteria decompose the waste during treatment.

Setback zones A protective zone surrounding a municipal water well that restricts certain land-use activities (such as application of sludge) in order to protect groundwater from possible contamination.

Silt loam A soil or geologic material with mostly silt, little sand, and very little clay in the matrix (see textural triangle).

Slackwater lake A lake formed in a valley tributary to a flooding stream or river. The abundant sediment carried by the major stream may dam the mouth of the tributary valley; the slackwater lake forms behind the dams. Slackwater lake deposits in Illinois commonly were deposited during glaciations.

Sorted sediment A sediment composed of grains all of roughly the same grain size.

Stratigraphy [stratigraphic, adj.] The study of the description, correlation, and classification of layers of sedimentary rocks, including the interpretation of their environment of deposition (Press and Siever 1982).

Stratigraphic position The order, or succession, of one lithostratigraphic unit relative to other units in the succession.

Structure-contour map A map that shows the buried topography (or elevation) of a distinctive contact between two lithologic units.

Subcrop The occurrence of a particular lithostratigraphic unit beneath overlying units. Commonly used in reference to the distribution of lithologic units at the buried surface of the bedrock covered by a thick mantle of glacial sediment.

Subepisode A subdivision of an episode.

Subglacial sedimentary environment A depositional environment that occurs below active glacial ice (Ashley et al. 1985, Andersen and Borns 1994).

Texture and textural triangle A guide used for textural (matrix grain-size) classification of soils and glacial sediment. Textural terms, such as sandy loam, silty clay loam and silty clay (adopted from the U.S. Department of Agriculture), refer to ranges in the relative proportion of sand, silt, and clay (fig. 18).

Tile systems Open pipes buried about 3 feet below the surface of agricultural fields to provide soil drainage. The tile systems flow into drainage ditches that carry the excess water away to surface streams.

Till A sediment deposited by a glacier; till also refers to a poorly sorted sediment (a diamicton) presumably deposited by a glacier. The terms has both sedimentological and genetic meanings.

Tongue A discontinuous, but regionally important, layer of one formation that extends above or below another formation. The lithology of the tongue is distinct from that of the surrounding formation. The tongues described in this report are composed of either sand and gravel, or of silt and clay, and extend into formations composed of glacially derived diamicton being deposited at the same time elsewhere.

Topography The shape and arrangement of natural and anthropogenic landforms on the earth's surface.

Tunnel valleys Networks of shallow trenches cut into glacial drift by discharge beneath stagnant glacial ice. They are typically found in areas with hummocky topography, including kames, kettles (depressions), and eskers.

Unconformity A surface between layers of sediment or rock that represents the period of time beginning when deposition of the lower layer ceased, and ending when deposition of the upper layer ensued. It may include a period of time during which erosion of the lower layer may have occurred prior to deposition of the upper layer.

Vugs A small, generally rounded, opening in a carbonate rock such as limestone or dolomite. Vugs are a form of secondary porosity.

Appendix
LOCATION OF BORINGS AND ELECTRICAL RESISTIVITY POINTS

Boring no.	Location		Estimated eevation	Quadrangle	Core nos.	County well ID nos.
	McHENRY COUNTY GROUNDWATER PROTECTION					
MC 1	500′NL, 650′WL	Sec. 30-46N-5E	893′	Capron	none	
MC 2	750′NL, 1250′EL	Sec. 5-45N-5E	895′	Capron	C-13990	3386600
MC 3	50′SL, 2350′EL	Sec. 22-46N-5E	907′	Capron	C-13991	3387000
MC 4	500′EL, 650′NL	Sec. 27-45N-7E	910′	Woodstock	C-13992	3386800
MC 5	550′WL, 2350′NL	Sec. 8-44N-8E	788′	McHenry	C-13993	3386500
MC 6	not drilled					
MC 7	1000′NL, 750′WL	Sec. 29-46N-8E	795′	Richmond	C-13994	3387200
MC 8	175′NL, 146′EL	Sec. 6-46N-7E	945′	Hebron	drift C-13995	
					bedrock C-14110	3386900
MC 9	400′NL, 100′EL	Sec. 29-45N-8E	850′	McHenry	drift C-13996	
					bedrock C-14112	3386700
MC 10	215′NL, 10′EL	Sec. 30-45N-5E	840′	Garden Prairie	drift C-13997	
					bedrock C-14107	3386400
MC 11	1500′SL, 1050′EL	Sec. 26-44N-7E	928′	Woodstock	drift C-13998	
					bedrock C-14108	3387100
MC 12	635′E and 400′S of intersection of Seeman and Church Rds.	Sec. 26-43N-6E	895′	Huntley	drift C-13999 bedrock C-14109	3386300
MC 13	2900′SL, 115′WL	Sec. 7-46N-9E	929′	Fox Lake	drift C-14000 bedrock C-14113	3387300
	NORTHEASTERN ILLINOIS PLANNING COMMISSION BORINGS					
NIPC 1	17′N, 2800′W of SE/c	Sec. 7-46N-5E	975′	Capron	C-4515	36100
NIPC 2	2500′N, 2500′W of SE/c	Sec. 8-46N-6E	1160′	Harvard	C-4511	34900
NIPC 3	100′W, 900′N of SE/c	Sec. 12-43N-5E	902′	Marengo South	C-4531	34100
NIPC 4	28′W, 1250′S of NE/c	Sec. 17-43N-8E	895′	Crystal Lake	C-4516	34300
NIPC 5	22′W, 2850′S of NE/c	Sec. 30-43N-8E	900′	Crystal Lake	C-4529	34400
NIPC 6	2500′E, 2100′N of SW/c	Sec. 29-44N-6E	810′	Marengo North	C-4514	34500
NIPC 7	18′N, 1800′W of SE/c	Sec. 29-45N-7E	885′	Woodstock	C-4528	34700
NIPC 8	12′S, 1850′E of NW/c	Sec. 15-45N-6E	910′	Harvard	C-4526	34600
NIPC 9	18′W, 2340′N of SE/c	Sec. 33-46N-6E	875′	Hebron	C-4532	35000
NIPC 10	1300′W, 2200′S of NE/c	Sec. 36-43N-5E	825′	Morengo South	C-4599	34200
NIPC 11	1150′E, 500′N of SW/c	Sec. 32-45N-9E	760′	Wauconda	C-4881	none

Boring no.	Location		Estimated Elevation	quadrangle
	McCUE ROAD LANDFILL (proposed)			
B19	300′NL, 2500′EL	Sec. 35-44N-6E	844′	Marengo North
B 17	600′NL, 1150′EL	Sec. 35-44N-6E	856′	Woodstock
B 15	1900′NL, 1450′EL	Sec. 35-44N-6E	851′	Huntley
B 13	2000′NL, 2600′EL	Sec. 35-44N-6E	854′	Marengo South
	PYOTT ROAD LANDFILL (proposed)			
B 1	1800′SL, 2450′EL	Sec. 21-43N-8E	842′	Crystal Lake
B 7	1380′SL, 1100′EL	Sec. 21-43N-8E	850′	Crystal Lake
G 107	1200′SL, 950′EL	Sec. 21-43N-8E	819′	Crystal Lake
B 9	250′NL, 1800′EL	Sec. 28-43N-8E	851′	Crystal Lake
G 104	280′NL, 2450′EL	Sec. 28-43N-8E	858′	Crystal Lake
B 13	2100′NL, 2600′EL	Sec. 28-43N-8E	785′	Crystal Lake
	DAVIS ROAD LANDFILL (proposed)			
LW 3	1800′NL, 2550′WL	Sec. 17-44N-7E	929′	Woodstock
	VEUGLER LANDFILL (proposed)			
MW 24	2600′EL, 1300′NL	Sec. 16-43N-7E	891′	Huntley
MW 23	1350′EL, 1650′NL	Sec. 16-43N-7E	858′	Huntley
MW 27	1875′NL, 850′EL	Sec. 16-43N-7E	857′	Huntley
B 11	2150′NL, 650′EL	Sec. 16-43N-7E	857′	Huntley
	HARTLAND TOWNSHIP LANDFILL (proposed)			
NW 2	2100′SL, 2100′EL	Sec. 30-45N-6E	940′	Marengo North
NE 2	2100′SL, 500′EL	Sec. 30-45N-6E	902′	Marengo North
SE 4	500′EL, 500′SL	Sec. 30-45N-6E	920′	Marengo North
SW 3	2100′EL, 500′SL	Sec. 30-45N-6E	935′	Marengo North
	ROUTE 47/176 LANDFILL (proposed)			
W-1	2090′SL, 1150′EL	Sec. 29-44N-7E	922′	Woodstock
W-2	2080′SL, 330′EL	Sec. 29-44N-7E	917′	Woodstock
W-5	225′SL, 1160′EL	Sec. 29-44N-7E	908′	Woodstock
W-6	420′SL, 90′EL	Sec. 29-44N-7E	906′	Woodstock
E-1	2570′SL, 340′WL	Sec. 28-44N-7E	919′	Woodstock
E-2	2610′WL, 970′WL	Sec. 28-44N-7E	912′	Woodstock
E-3	2620′SL, 1645′WL	Sec. 28-44N-7E	914′	Woodstock

Station	Location		Estimated elevation	Quadrangle
	ELECTRICAL EARTH RESISTIVITY POINT LOCATIONS			
TU-1	700′EL, 850′SL	Sec. 30-46N-8E	794′	Richmond
TU-2	500′WL, 150′SL	Sec. 29-46N-8E	777′	Richmond
TU-3	2300′WL, 150′SL	Sec. 29-46N-8E	773′	Richmond
TU-4	2250′EL, 200′NL	Sec. 32-46N-8E	785′	Richmond
W-1	300′WL, 150′SL	Sec. 28-45N-8E	793′	McHenry
W-2	15′EL, 2400′NL	Sec. 32-45N-8E	778′	McHenry
W-3	30′EL, 400′SL	Sec. 32-45N-8E	788′	McHenry
W-4	400′EL, 2550′NL	Sec. 5-44N-8E	789′	McHenry
W-5	2600′EL, 1300′SL	Sec. 4-44N-8E	798′	McHenry
W-6	850′WL, 2500′NL	Sec. 3-44N-8E	791′	McHenry
W-7	2600′WL, 2000′SL	Sec. 2-44N-8E	788′	McHenry
TH-1	2600′EL, 500′SL	Sec. 16-44N-8E	787′	McHenry
TH-2	1750′WL, 1400′SL	Sec. 16-44N-8E	793′	McHenry
TH-3	2000′EL, 150′SL	Sec. 20-44N-8E	839′	McHenry
TH-4	950′EL, 700′NL	Sec. 29-44N-8E	835′	McHenry
TH-5	2100′EL, 1700′NL	Sec. 12-44N-7E	808′	McHenry
F-1	900′EL, 20′NL	Sec. 9-45N-5E	912′	Capron
F-2	2000′WL, 2500′SL	Sec. 3-45N-5E	909′	Capron
F-3	1800′WL, 1950′SL	Sec. 2-45N-5E	923′	Harvard
F-4	2450′WL, 450′NL	Sec. 18-45N-6E	1066′	Harvard

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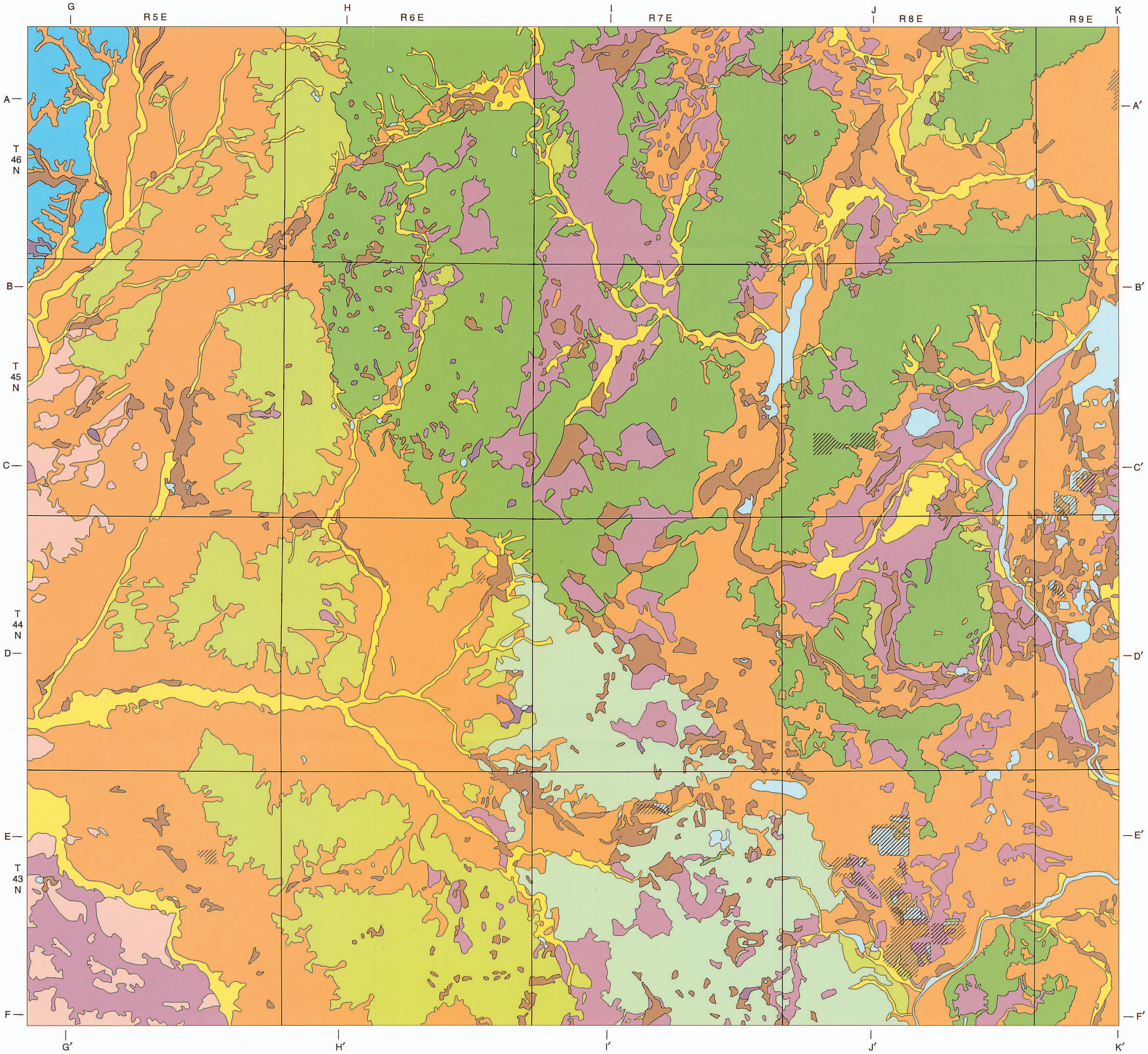
Geologic Materials at Land Surface, McHenry County, Illinois

William S. Dey, Richard C. Berg, B. Brandon Curry, and Robert C. Vaiden



HUDSON EPISODE DEPOSITS

- Cahokia Formation; loose sand in stream and river channels; silt and clay in floodplains
- Peyton Formation; loose diamicton on some slopes
- Grayslake Peat

WISCONSIN EPISODE DEPOSITS

Nonglacial surficial deposits

- Equality Formation; lake sediments, silt and clay; laminated to massive; some sand layers
- Henry Formation; sand and gravel; stratified; some silt and clay

Glacially derived diamicton units (all units may have discontinuous layers composed of sand and gravel)

Wedron Group

- Wadsworth Formation; gray silty clay to silty clay loam diamicton (rare)

Lemont Formation

- Haeger Member; yellowish brown sandy loam diamicton
- Yorkville Member; gray silty clay to silty clay loam diamicton

- Tiskilwa Formation; brown to pinkish brown clay loam diamicton

ILLINOIS EPISODE DEPOSITS

- Winnebago Formation; brown to pinkish brown loam diamicton
- Glasford Formation; brown loam diamicton

- Water
- Sand and gravel pits
- A - A′ Lines of cross section

Map developed from county soil survey (Ray and Wascher, 1965)

Coverages of water and sand and gravel pits from Illinois Department of Natural Resources, 1996

Scale 1:100,000

0 1 2 3 4 5 6 miles

0 1 2 3 4 5 6 7 8 9 10 kilometers

This map is only a guide to land use and does not eliminate the need for detailed investigations of specific sites for specific purposes.

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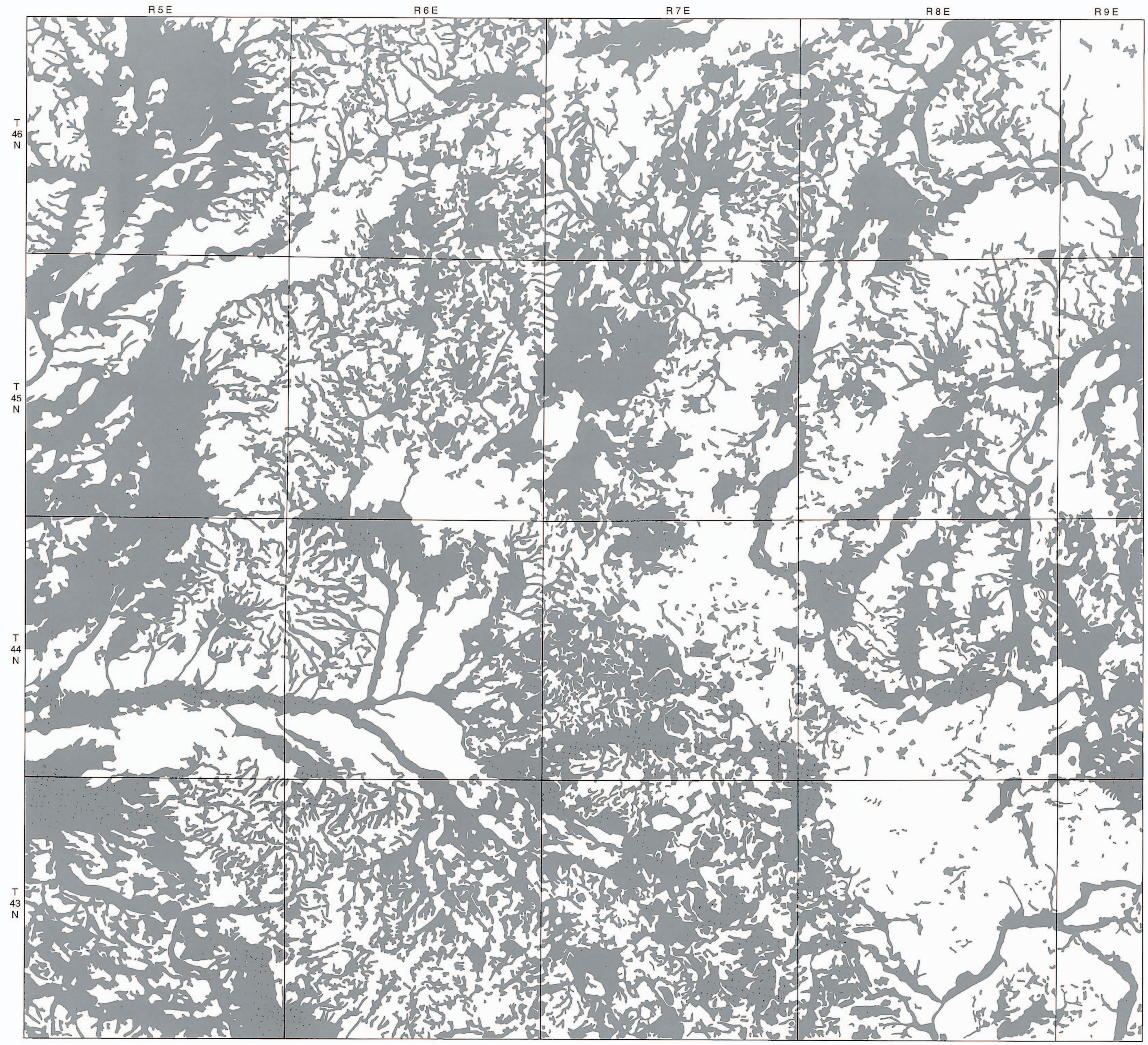
Soil Drainage, McHenry County, Illinois

Richard C. Berg



Very poorly, poorly, and somewhat poorly drained soils

Better drained soils

Compiled from Ray and Wascher, 1965

Scale 1:100,000

0 1 2 3 4 5 6 miles

0 1 2 3 4 5 6 7 8 9 10 kilometers

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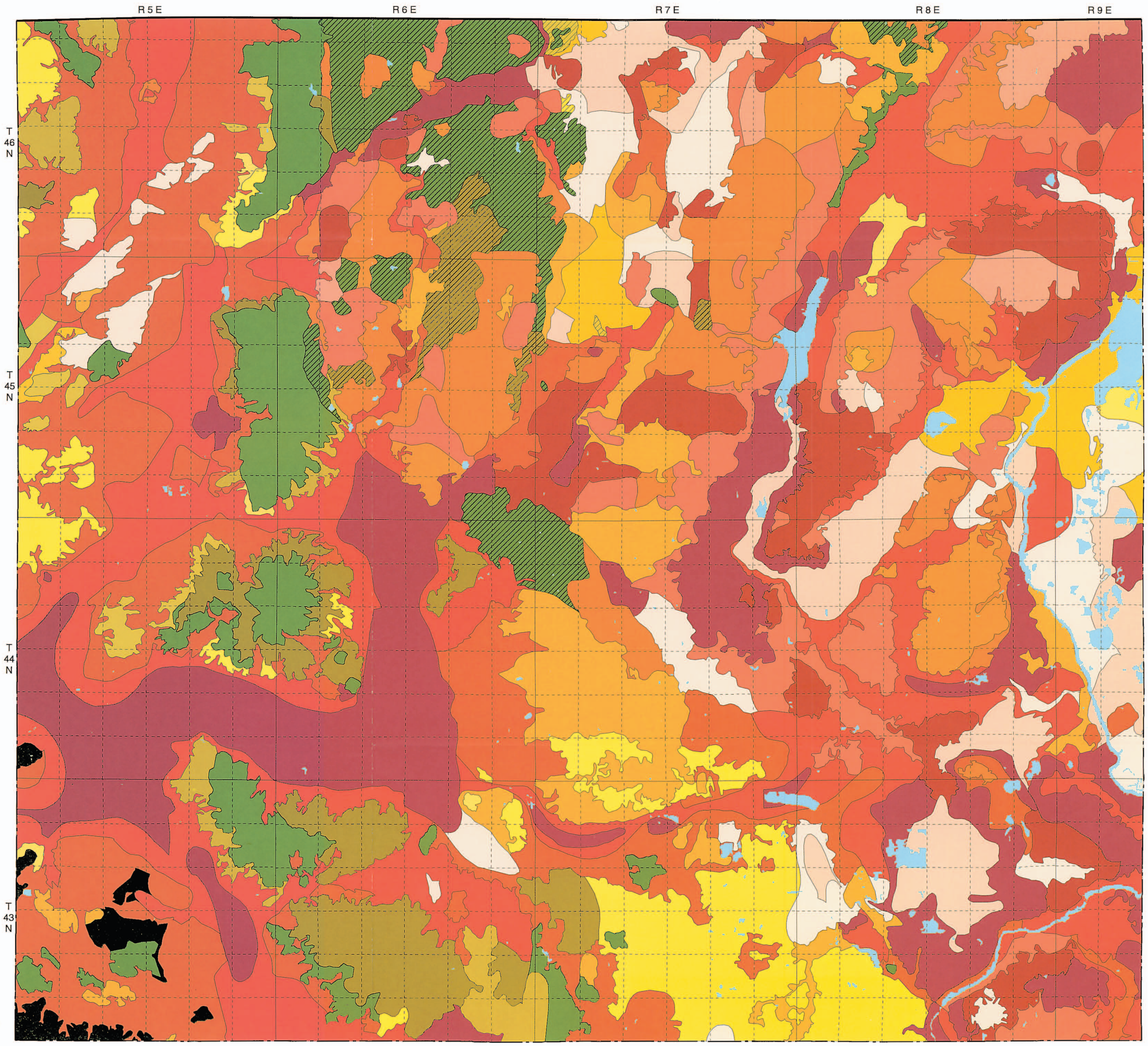
Aquifer Sensitivity, McHenry County, Illinois

Robert C. Vaiden, Richard C. Berg, and B. Brandon Curry



High potential for aquifer contamination

- A1 >50 feet Henry sand and gravel at surface
- A2 <20 feet Haeger sandy diamicton overlying Henry sand and gravel >50 feet thick
- A3 20–50 feet Henry sand and gravel at surface
- A4 <20 feet Haeger sandy diamicton overlying 20–50 feet Henry sand and gravel
- A5 >20 feet Haeger sandy diamicton overlying 20–50 feet Henry sand and gravel
- A6 <20 feet fine-grained materials* overlying >50 feet Henry sand and gravel
- A7 <20 feet fine-grained materials overlying 20–50 feet Henry sand and gravel

Moderately high potential for aquifer contamination

- B1 <20 feet Henry sand and gravel at surface
- B2 <20 feet Haeger sandy diamicton overlying <20 feet Henry sand and gravel
- B3 >20 feet Haeger sandy diamicton overlying <20 feet Henry sand and gravel
- B4 <20 feet fine-grained materials overlying <20 feet Henry sand and gravel

Moderate potential for aquifer contamination

- C1 20–50 feet fine-grained materials overlying >50 feet sand and gravel
- C2 20–50 feet fine-grained materials overlying 20–50 feet sand and gravel
- C3 20–50 feet fine-grained materials overlying generally <20 feet sand and gravel
- C3' <20 feet Haeger sandy diamicton overlying 20–50 feet fine-grained materials overlying <20 feet sand and gravel

Moderately low potential for aquifer contamination

- D1 50–100 feet fine-grained materials overlying >50 feet sand and gravel, or Silurian carbonate rocks
- D1' <20 feet Haeger sandy diamicton overlying 50–100 feet fine-grained materials overlying >50 feet sand and gravel
- D2 50–100 feet fine-grained materials overlying 20–50 feet sand and gravel
- D3 50–100 feet fine-grained materials overlying generally <20 feet sand and gravel
- D3' <20 feet discontinuous Haeger diamicton (possibly overlain by Equality silt and clay) overlying 50–100 feet fine-grained materials overlying generally <20 feet sand and gravel

Low potential for aquifer contamination

- E >100 feet fine-grained materials that may contain discontinuous lenses of sand and gravel
- E' <20 feet discontinuous Haeger diamicton overlying >100 feet of fine-grained materials that may contain discontinuous lenses of sand and gravel
- F >100 feet fine-grained materials that may contain discontinuous lenses of sand and gravel overlying Ordovician shale

Water

* Fine-grained materials, including Yorkville Member and Tiskilwa and Glasford Formation diamictons and Equality Formation silt and clay

Derived from 1:24,000-scale stack unit maps (Vaiden et al., ISGS, unpublished)

Scale 1:100,000

0 1 2 3 4 5 6 miles

0 1 2 3 4 5 6 7 8 9 10 kilometers

This map is only a guide to land use and does not eliminate the need for detailed investigations of specific sites for specific purposes.

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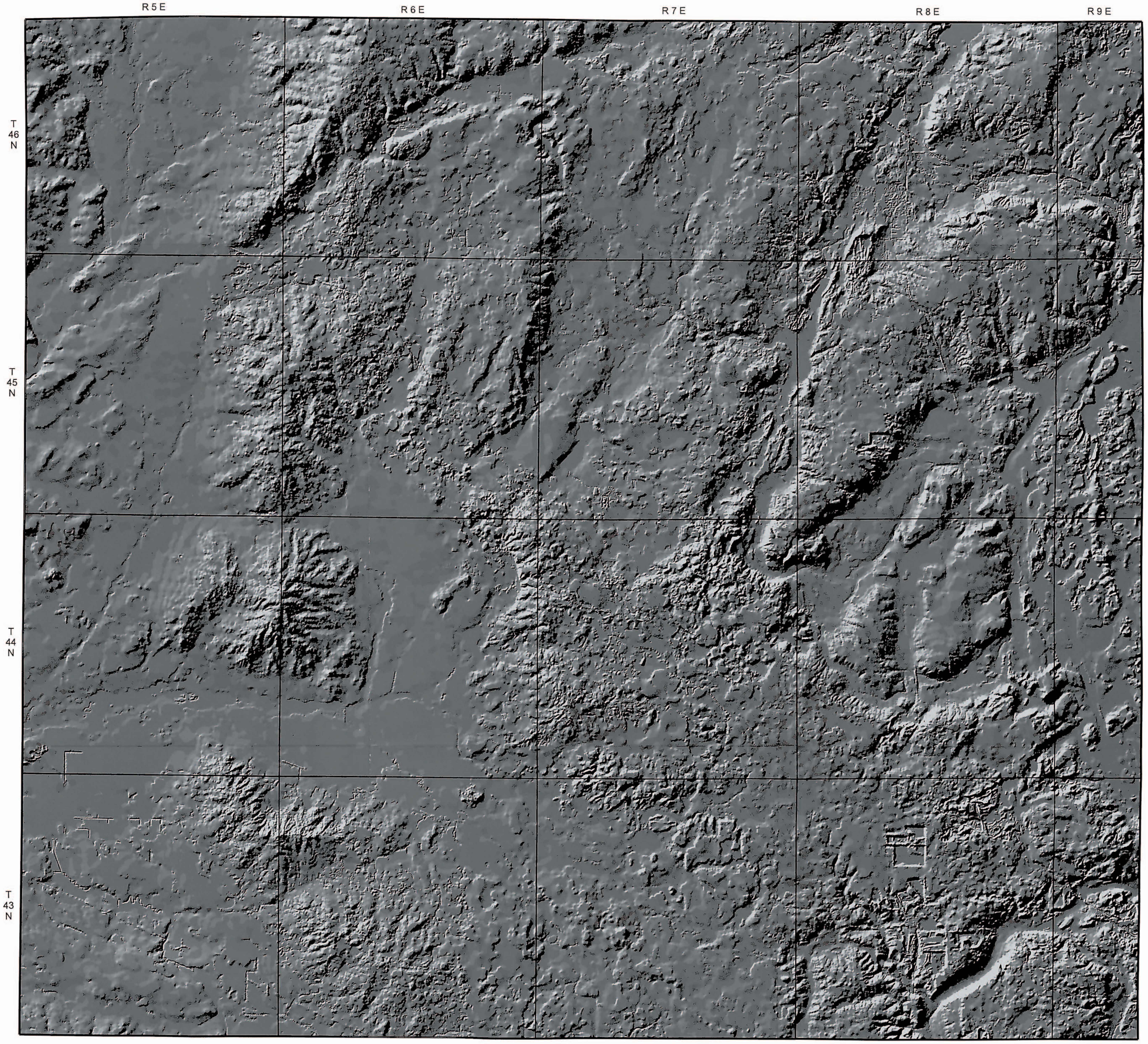
Shaded Relief, McHenry County, Illinois

Christopher S. McGarry



Scale 1:100,000

0 1 2 3 4 5 6 miles

0 1 2 3 4 5 6 7 8 9 10 kilometers

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