GUIDE TO THE GEOLOGY OF THE HENNEPIN AREA, PUTNAM, BUREAU, AND MARSHALL COUNTIES, ILLINOIS

Wayne T. Frankie, Russell J. Jacobson, Ardith K. Hansel, and Myrna M. Killey
ILLINOIS STATE GEOLOGICAL SURVEY

Robert S. Nelson, Dave H. Malone, William E. Shields, and Robert G. Corbett
ILLINOIS STATE UNIVERSITY

Field Trip Guidebook 2002A

April 27, 2002
May 25, 2002

George H. Ryan, Governor

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615 E. Peabody Drive
Champaign, IL 61820-6964

Home page: http://www.isgs.uiuc.edu/

Cover photo: Hennepin Canal, Lock No. 11 (photo by W. T. Frankie).

Geological Science Field Trips The Geoscience Education and Outreach Unit of the Illinois State Geological Survey (ISGS) conducts four free tours each year to acquaint the public with the rocks, mineral resources, and landscapes of various regions of the state and the geological processes that have led to their origin. Each trip is an all-day excursion through one or more Illinois counties. Frequent stops are made to explore interesting phenomena, explain the processes that shape our environment, discuss principles of earth science, and collect rocks and fossils. People of all ages and interests are welcome. The trips are especially helpful to teachers who prepare earth science units. Grade school students are welcome, but each must be accompanied by a parent or guardian. High school science classes should be supervised by at least one adult for each ten students.

A list of guidebooks of earlier field trips for planning class tours and private outings may be obtained by contacting the Illinois State Geological Survey, Natural Resources Building, 615 East Peabody Drive, Champaign, IL 61820-6964. Telephone: 217-244-2427 or 217-333-4747. This information is on the ISGS home page: http://www.isgs.uiuc.edu.

Eight USGS 7.5-Minute Quadrangle maps (Buda, Depue, Florid, Henry, Manlius, Princeton South, Spring Valley, Wyanet) provide coverage for this field trip area.

This field guide is divided into four sections. The first section serves as an introduction to the geology of Illinois and in particular the area surrounding Hennepin. The second section is a road log for the trip, and the third section provides detailed stop descriptions. The final section is an appendix that includes supplementary materials that are important to the field trip area.

ILLINOIS DEPARTMENT OF NATURAL RESOURCES

Illinois State Geological Survey

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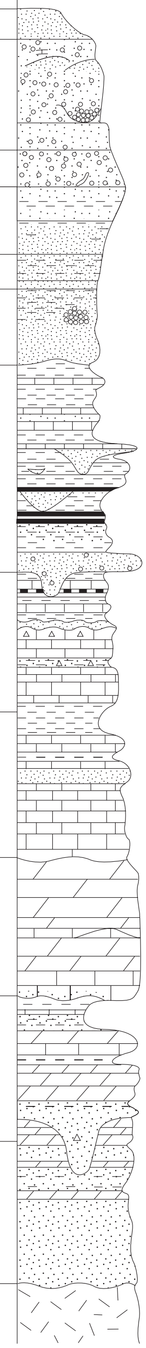
CONTENTS

Era		Period or System and Thickness	Epoch	Age (years ago)	General Types of Rocks
CENOZOIC "Recent Life"	Age of Mammals	Quaternary 0-500'	Holocene	10,000	Recent– alluvium in river valleys
			Pleistocene Glacial Age	1.6 m	Glacial till, glacial outwash, gravel, sand, silt, lake deposits of clay and silt, loess and sand dunes; covers nearly all of state except north-west corner and southern tip
		Tertiary 0-500'	Pliocene	5.3 m – 36.6 m	Chert gravel, present in northern, southern, and western Illinois
			Eocene	57.8 m	Mostly micaceous sand with some silt and clay; presently only in southern Illinois
			Paleocene	66.4 m	Mostly clay, little sand; present only in southern Illinois
MESOZOIC "Middle Life"	Age of Reptiles	Cretaceous 0-300'		144 m – 286 m	Mostly sand, some thin beds of clay, and, locally, gravel, present only in southern Illinois
PALEOZOIC "Ancient Life"	Age of Amphibians and Early Plants	Pennsylvanian 0-3,000' ("Coal Measures")		320 m	Largely shale and sandstone with beds of coal, limestone, and clay
		Mississippian 0-3,500'		360 m	Black and gray shale at base, middle zone of thick limestone that grades to siltstone chert, and shale; upper zone of interbedded sandstone, shale, and limestone
	Age of Fishes	Devonian 0-1,500'		408 m	Thick limestone, minor sandstones and shales; largely chert and cherty limestone in southern Illinois; black shale at top
	Age of Invertebrates	Silurian 0-1,000'		438 m	Principally dolomite and limestone
		Ordovician 500-2,000'		505 m	Largely dolomite and limestone but contains sandstone, shale, and siltstone formations
		Cambrian 1,500-3,000'		570 m	Chiefly sandstones with some dolomite and shale; exposed only in small areas in north-central Illinois
		Precambrian			Igneous and metamorphic rocks; known in Illinois only from deep wells



Generalized geologic column showing succession of rocks in Illinois.

INTRODUCTION

The Hennepin field trip is located along the eastern bank of the Illinois River in an area known as the Big Bend of the Illinois River. This geological science field trip will acquaint you with the *geology*,[1] landscape, and mineral resources for part of Putnam, Bureau, and Marshall Counties, Illinois. The starting point for this excursion will be in Hennepin at the Walter Durley Boyle Community Park, located across from the County Court House. Hennepin is approximately 115 miles southwest of Chicago, 125 miles northeast of Springfield, 220 miles northeast of East St. Louis, and 327 miles north of Cairo. The Putnam County courthouse in Hennepin is the oldest courthouse currently in use in Illinois that has been maintained in its original form. The courthouse was built in 1839 at a cost of $14,000.

Hennepin, population 669, was founded in 1817 and named for the famed French explorer, Father Louis Hennepin. La Salle and Hennepin explored both the Illinois and Mississipi River Valleys in the 1680s. Father Hennepin was the second person to discover coal in Illinois; in 1682 he found several places of "pit coal" along the Illinois River. Illinois is the first place coal was discovered on the North American continent. On a map drawn by Hennepin in 1687, he located a lead (galena) mine in the Galena area. These early discoveries of coal and galena would become the development of vital economic resources hundreds of years later. One could argue that Father Hennepin was one of the first geologists to explore Illinois.

One of Hennepin's most famous citizens was John Wesley Powell. The following is from a monument at the Ernest Bass Municipal Park in front of the village hall at the corner of East High and South Sixth Street.

> Major John Wesley Powell, a Geologist, was a teacher and principal of the Hennepin Schools on this site—1858 to 1861. He lost his right arm in the Battle of Shiloh. He was the famed Explorer of the Colorado River, one of the founders of the National Geographic Society and Director of the U.S. Geological Survey.

A short biography of John Wesley Powell is included in the supplemental reading at the end of this guidebook.

Putnam County, the smallest county in the state of Illinois, encompassing only 166 square miles, was formed on January 13, 1825. It was named for General Israel Putnam (1718–1790), who served in the French and Indian War and Pontiac's War, prior to being a major general in the Continental Army during the Revolutionary War. Western Putnam County was also home to the Pottawtomi Tribe until the early 1830s. Chief Senachwine is buried in Putnam County.

The original Putnam County boundaries were expansive, reaching from the Illinois River to the Wisconsin border, including all of the areas north of the Illinois River and the south fork of the Kankakee River. Once including all of present-day Bureau and eastern Stark Counties and most of Marshall County, a series of changes reduced Putnam County to its present-day boundaries.

Bureau County, originally part of Putnam County, was established on February 28, 1837, and was named for Pierre de Beuro (?–1790), a French Creole. de Buero established a trading post on the Illinois River, near the present-day community of Bureau. de Beuro was killed in an Indian attack

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[1] Words in italics are defined in the glossary at the back of the guidebook. Also please note: although all present localities have only recently appeared within the geologic time frame, we use the present names of places and geologic features because they provide clear reference points for describing the ancient landscape.

in 1790. The southern part of Bureau County was part of the Military Tract. The Military Tract consisted of land that was granted to veterans of the War of 1812.

Marshall County was established on January 19, 1839, and was named for John Marshall, famous as Chief justice of the U.S. Supreme Court.

GEOLOGIC FRAMEWORK

Precambrian Era

Through several billion years of geologic time, the area surrounding Hennepin underwent many changes (see the rock succession column, near the beginning of this guidebook). The oldest rocks beneath the field trip area belong to the ancient Precambrian *basement complex*. We know relatively little about these rocks from direct observations because they are not exposed at the surface anywhere in Illinois. Only about 35 drill holes have reached deep enough for geologists to collect samples from Precambrian rocks of Illinois. From these samples, however, we know that these ancient rocks consist mostly of granitic and rhyolitic *igneous*, and possibly *metamorphic*, crystalline rocks formed about 1.5 to 1.0 billion years ago. From about 1 billion to about 0.6 billion years ago, these Precambrian rocks were exposed at the surface. During this long period, the rocks were deeply weathered and eroded and formed a barren landscape that was probably quite similar to the topography of the present Missouri Ozarks. We have no rock record in Illinois for the long interval of *weathering* and erosion that lasted from the time the Precambrian rocks were formed until the first Cambrian age *sediments* accumulated, but that interval is almost as long as the time from the beginning of the Cambrian *Period* to the present.

Because geologists cannot see the Precambrian basement rocks in Illinois except as cuttings and cores from boreholes, they must use various other techniques, such as measurements of Earth's gravitational and magnetic fields and seismic exploration, to map out the regional characteristics of the basement complex. The evidence collected from these various techniques indicates that in southernmost Illinois, near what is now the historic Kentucky-Illinois Fluorspar Mining District, *rift* valleys, such as those in eastern Africa, formed as movement of crustal plates (plate *tectonics*) began to rip apart the Precambrian North American continent. These rift valleys in the midcontinent region are referred to as the Rough Creek Graben and the Reelfoot Rift (fig. 1).

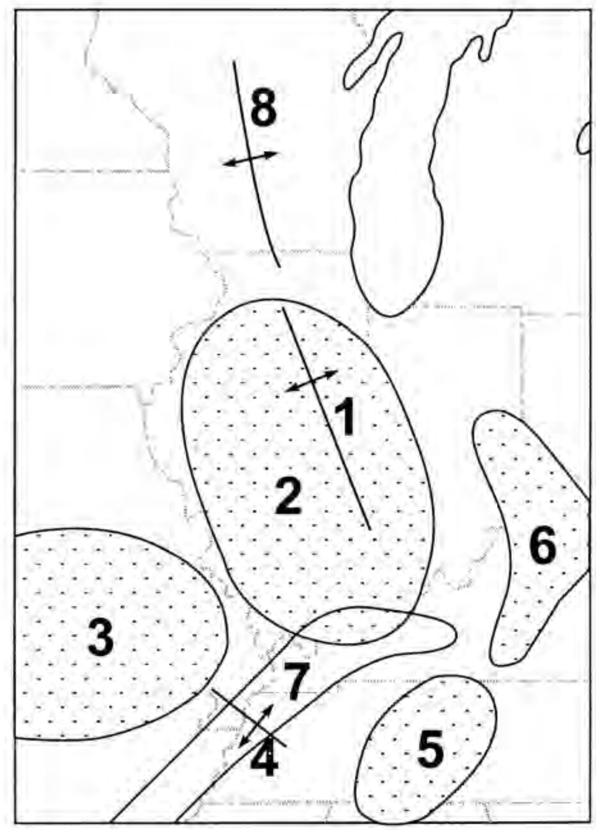


Figure 1 Location of some of the major structures in the Illinois region: (1) La Salle Anticlinorium, (2) Illinois Basin, (3) Ozark Dome, (4) Pascola Arch, (5) Nashville Dome, (6) Cincinnati Arch, (7) Rough Creek Graben–Reelfoot Rift, and (8) Wisconsin Arch.

Paleozoic Era

After the beginning of the Paleozoic *Era*, about 520 million years ago in the late Cambrian Period, the rifting stopped, and the hilly

Precambrian landscape began to sink slowly on a broad regional scale, allowing the invasion of a shallow sea from the south and southwest. During the 280 million years of the Paleozoic Era, the area that is now called the Illinois *Basin* continued to accumulate sediments that were deposited in the shallow seas that repeatedly covered this subsiding basin. The region continued to sink until at least 20,000 feet of sedimentary strata were deposited in the deepest part of the basin, located in the Rough Creek Graben area of southeastern Illinois and western Kentucky. At various times during this era, the seas withdrew, and deposits were weathered and eroded. As a result, there are some gaps in the sedimentary record in Illinois.

In the field trip area, Paleozoic *bedrock* strata range in age from more than 520 million years (the Cambrian Period) to less than 300 million years old (the Pennsylvanian Period). Figure 2 shows the succession of rock strata a drill bit would penetrate in this area if the rock record were complete and if all of the formations were present. The oldest Paleozoic rocks exposed within the field trip area are Pennsylvanian in age. The entire sequence of Pennsylvanian rocks (up to 2,400 feet) found within Illinois formed from sediments that accumulated from about 320 to 286 million years ago. The thickness of the Pennsylvanian rocks in the area ranges from 300 to 400 feet.

Within the field trip area, the depth to the Precambrian basement rocks is approximately 4,500 feet. The elevation of the top of the Precambrian basement rocks ranges from 3,250 feet below sea level in northwestern Bureau County to 4,200 feet below sea level in southeastern Putnam County. The surface of the Precambrian basement rocks in the field trip area dip from the northwest to the southeast toward the center of the Illinois Basin.

DEPOSITIONAL HISTORY

As noted previously, the Rough Creek Graben and the Reelfoot Rift (figs. 1 and 3) were formed by tectonic activity that began in the latter part of the Precambrian Era and continued until the Late Cambrian. Toward the end of the Cambrian, rifting ended, and the whole region began to subside, allowing shallow seas to cover the land.

Paleozoic Era

From the Late Cambrian to the end of the Paleozoic Era, sediments continued to accumulate in the shallow seas that repeatedly covered Illinois and adjacent states. These inland seas connected with the open ocean to the south during much of the Paleozoic, and the area that is now southern Illinois was similar to an embayment. The southern part of Illinois and adjacent parts of Indiana and Kentucky sank more rapidly than the areas to the north, allowing a greater thickness of sediment to accumulate. During the Paleozoic and Mesozoic, the Earth's thin crust was periodically flexed and warped in places as stresses built up in response to the tectonic forces associated with the collision of continental and oceanic plates and the resultant mountain building. These movements caused repeated invasions and withdrawals of the seas across the region. The former sea floors were thus periodically exposed to erosion, which removed some sediments from the rock record.

Many of the sedimentary units, called formations, have conformable contacts; that is, no significant interruption in deposition occurred as one formation was succeeded by another (figs. 2 and 4). In some instances, even though the composition and appearance of the rocks change significantly at the contact between two formations, the *fossils* in the rocks and the relationships between the rocks at the contact indicate that deposition was virtually continuous. In contrast, however, in some other places, the top of the lower formation was at least partially eroded before deposition of the next formation began. In these instances, fossils and/or other evidence within or

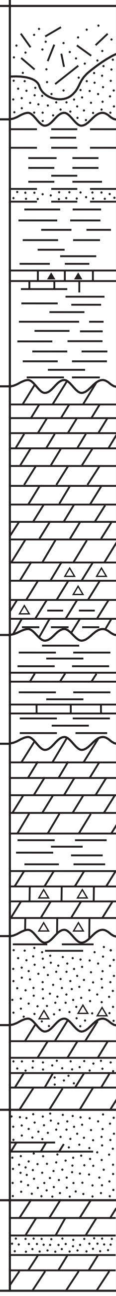
SYSTEM or SERIES	HYDROGEOLOGIC UNITS	GRAPHIC LOG	ROCK TYPE	WATER-YIELDING CHARACTERISTICS
PLEIS-TOCENE	Drift (0–300 feet)		Unconsolidated glacial deposits, loess and alluvium (drift).	Water yields variable, largest from thick basal sand and gravel deposits (Sankoty Sand) in bedrock valleys.
PENNSYLVANIAN	(280–475 feet)		Mainly shale with thin sandstone, limestone, and coal beds.	Generally unfavorable as an aquifer. Locally, domestic and farm supplies obtained from thin limestone and sandstone beds. Casing usually required.
SILURIAN	Niagaran-Alexandrian (410–505 feet)		Dolomite; argillaceous near base, lower part cherty.	Generally yields poor quality water.
ORDOVICIAN	Maquoketa (155–240 feet)		Green to blue shale with limestone and dolomite beds.	Not water yielding at most places. Casing required.
	Galena-Platteville (320–380 feet)		Dolomite, with shaly zone near the middle; some limestone in the lower part.	Not important as an aquifer, Creviced dolomite probably yields some water. Water quality good.
	Glenwood-St. Peter (115–135 feet)		Sandstone, white, clean.	Dependable source of groundwater. Water quality good.
	Shakopee (130–150 feet)		Dolomite, with some shale and sandstone.	Not important as aquifer.
	New Richmond (165 feet ±)		Sandstone, with some dolomite.	May yield some water.
	Oneota (215 feet ±)		Dolomite, with some sandstone beds.	Not important as aquifer.

Figure 2 Generalized stratigraphic column of upper rock formations in the Hennepin field trip area (modified from McComas 1968).

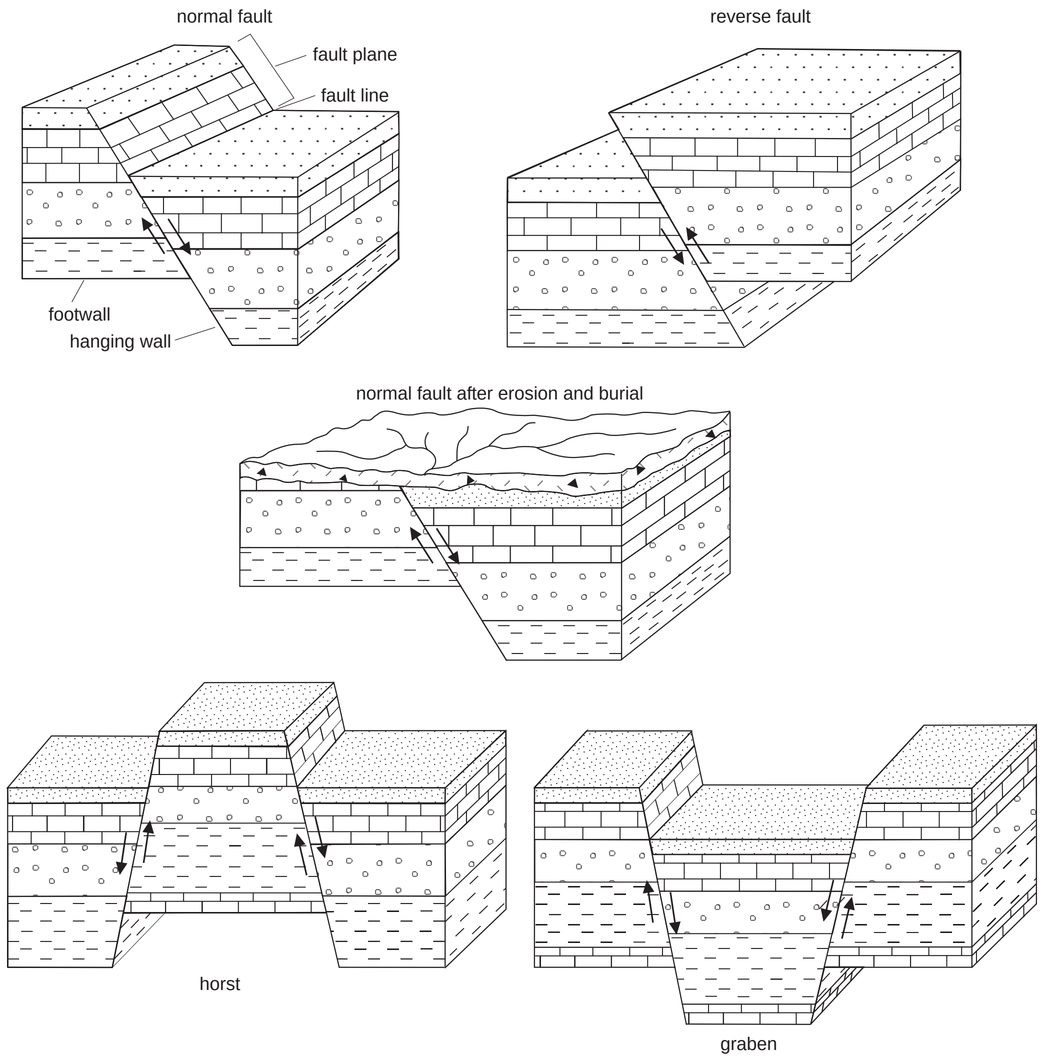


Figure 3 Diagrammatic illustrations of fault types that may be present in the field trip area. A fault is a fracture in the Earth's crust along which there has been relative movement of the opposing blocks. A fault is usually an inclined plane, and when the hanging wall (the block above the plane) has moved up relative to the footwall (the block below the fracture), the fault is a reverse fault. When the hanging wall has moved down relative to the footwall, the fault is a normal fault.

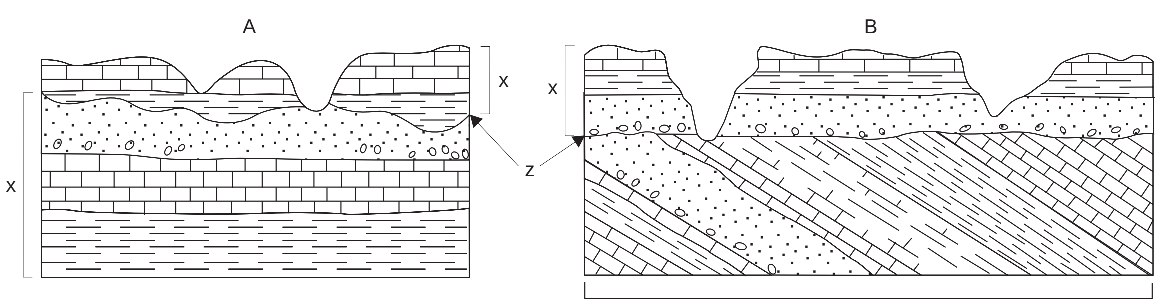


Figure 4 Schematic drawings of (A) a disconformity and (B) an angular unconformity (x represents the conformable rock sequence, and z is the plane of unconformity).

at the boundary between the two formations indicate that there is a significant age difference between the lower unit and the overlying unit. This type of contact is called an *unconformity* (fig. 4). If the *beds* above and below an unconformity are parallel, the unconformity is called a *disconformity*. If, however, the lower beds were tilted and eroded prior to deposition of overlying beds, the contact is called an angular unconformity.

Unconformities occur throughout the Paleozoic rock record and are shown in the generalized stratigraphic column in figure 2 as wavy lines. Each unconformity represents an extended time interval for which there is no rock record.

Near the close of the Mississippian Period, gentle arching of the rocks in eastern Illinois initiated the development of the La Salle Anticlinorium (figs. 1 and 5), a complex structure having smaller structures such as domes, *anticlines*, and *synclines* superimposed on the broad upwarp of the anticlinorium. Further gradual arching continued through the Pennsylvanian Period. Because the youngest Pennsylvanian strata are absent from the area of the anticlinorium (either because they were not deposited or because they were eroded), we cannot determine just when folding ceased—perhaps by the end of the Pennsylvanian or during the Permian Period a little later, near the close of the Paleozoic Era.

Mesozoic Era

During the Mesozoic Era, the rise of the Pascola Arch (figs. 1 and 5) in southeastern Missouri and western Tennessee produced a structural barrier that helped form the current shape of the Illinois Basin by closing off the embayment and separating it from the open sea to the south. The Illinois Basin is a broad, subsided region covering much of Illinois, southwestern Indiana, and western Kentucky (fig. 1). Development of the Pascola Arch, in conjunction with the earlier sinking of the deeper portion of the basin north of the Pascola Arch in southern Illinois, gave the basin its present asymmetrical, spoon-shaped configuration (fig. 6). The geologic map (fig. 7) shows the distribution of the rock *systems* of the various geologic time periods as they would appear if all the glacial, windblown, and surface materials were removed.

Younger rocks of the latest Pennsylvanian and perhaps the Permian (the youngest rock systems of the Paleozoic) may have at one time covered the southern and northern portions of Illinois. It is possible that Mesozoic and Cenozoic rocks (see the generalized geologic column) could also have been present here. Indirect evidence, based on the stage of development (rank) of coal deposits and the generation and maturation of petroleum from source rocks (Damberger 1971), indicates that perhaps as much as 1.5 miles of latest Pennsylvanian and younger rocks once covered southern Illinois. During the more than 240 million years since the end of the Paleozoic Era (and before the onset of *glaciation* 1 to 2 million years ago), however, several thousands of feet of strata may have been eroded. Nearly all traces of any post-Pennsylvanian bedrock that may have been present in Illinois were removed. During this extended period of erosion, deep valleys were carved into the gently tilted bedrock formations (fig. 8). Later, the topographic *relief* was reduced by repeated advances and melting back of continental *glaciers* that scoured and scraped the bedrock surface. This glacial erosion affected all of the formations exposed at the bedrock surface in Illinois. The final melting of the glaciers left behind the nonlithified deposits in which our modern soil has developed.

STRUCTURAL SETTING

The Hennepin field trip area is located within the north-central portion of the Illinois Basin and west of the La Salle Anticlinorium (fig. 5). Paleozoic bedrock strata in the field trip area have a

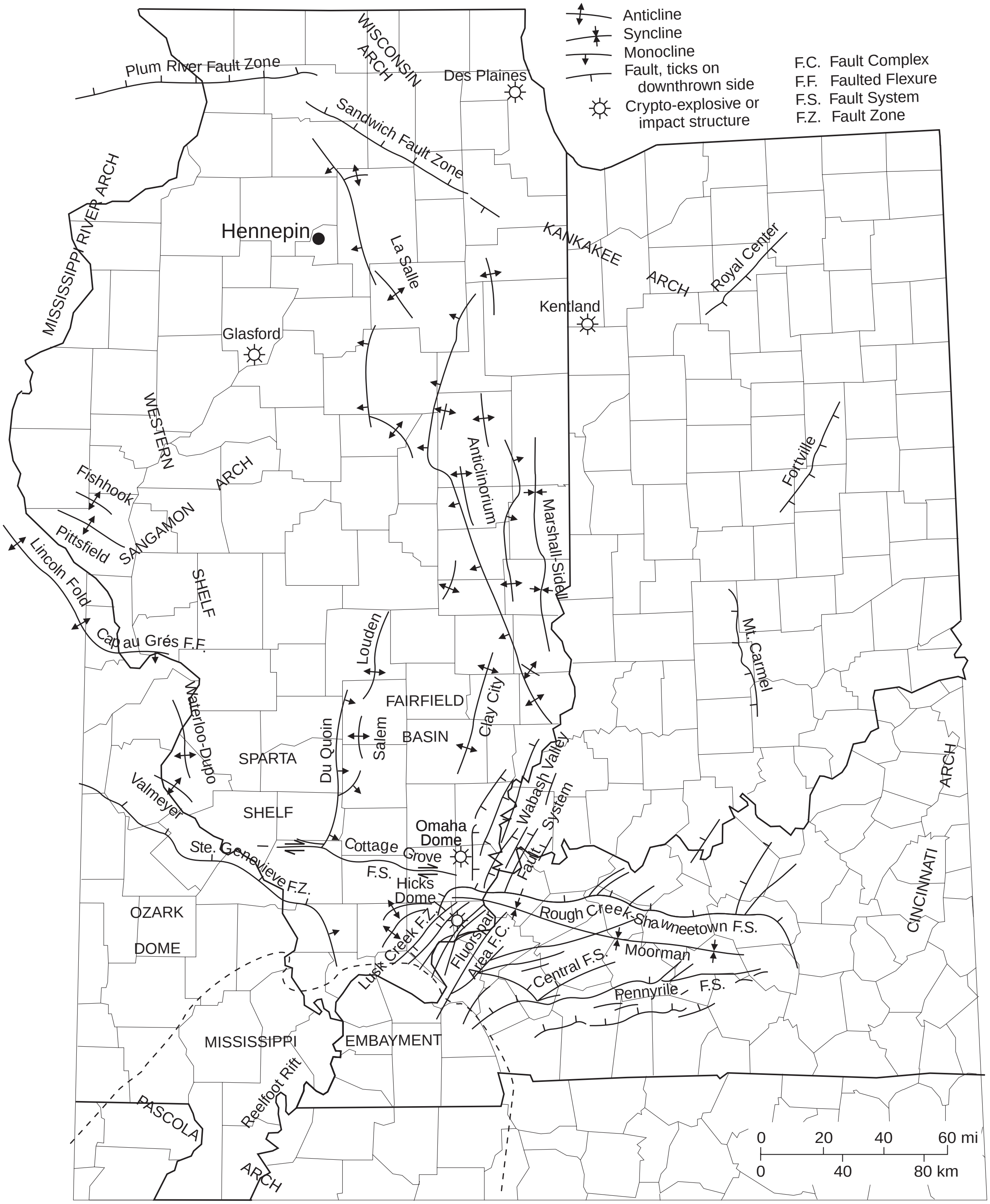


Figure 5 Structural features of Illinois (modified from Buschbach and Kolata 1991).

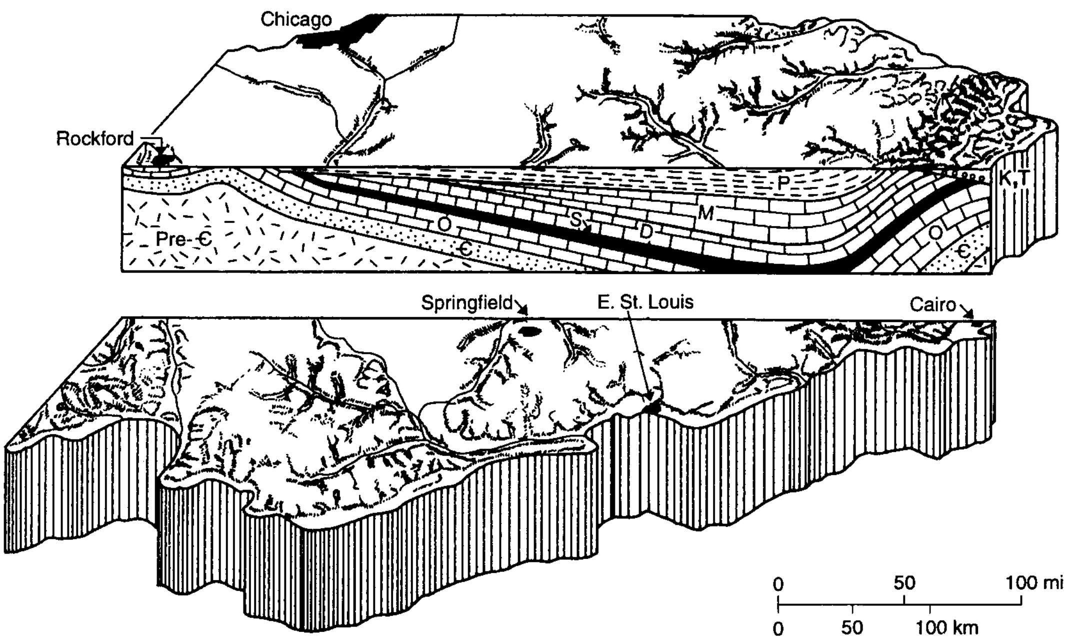


Figure 6 Stylized north-south cross section shows the structure of the Illinois Basin. To show detail, the thickness of the sedimentary rocks has been greatly exaggerated, and younger, unconsolidated surface deposits have been eliminated. The oldest rocks are Precambrian (Pre Є) granites. They form a depression filled with layers of sedimentary rocks of various ages: Cambrian (Є), Ordovician (O), Silurian (S), Devonian (D), Mississippian (M), Pennsylvanian (P), Cretaceous (K), and Tertiary (T). Scale is approximate.

regional dip of approximately 25 feet per mile to the southeast, except where the strata are affected by local structure. The Peru Monocline, a part of the La Salle Anticlinorium, is located approximately 5 miles west of Putnam County. This feature trends northwest-southeast. Rocks located close to the west limb of the monocline dip west about 2000 feet per mile, whereas rocks on the flatter east limb dip east less than 50 feet per mile.

PREGLACIAL HISTORY

Since the last Paleozoic sea withdrew from the midcontinent at the end of the Pennsylvanian Period some 286 million years ago, or possibly as late as the end of the Permian Period nearly 245 million years ago, the region was uplifted, and the strata were subjected to erosion. During this long interval of erosion, many hundreds of feet of Paleozoic strata have been stripped away. During the Pliocene Epoch between 5.3 and 1.6 million years ago, near the end of the Tertiary Period, the topography or relief of the region was further reduced by erosion.

Geologic History of the Illinois River

The development of the present Illinois River valley began during the long period of erosion following the Paleozoic Era. A system of rivers and streams developed on the pre-glacial land surface. Over time, ancient river valleys became deeply entrenched into the bedrock; we call these bedrock valleys (fig. 8). One of these is the Princeton BedrockValley near Hennepin, shown in cross section in figure 9. Entrenchment of this valley started prior to glaciation and was well established by the end of early pre-Illinois glacial episode.

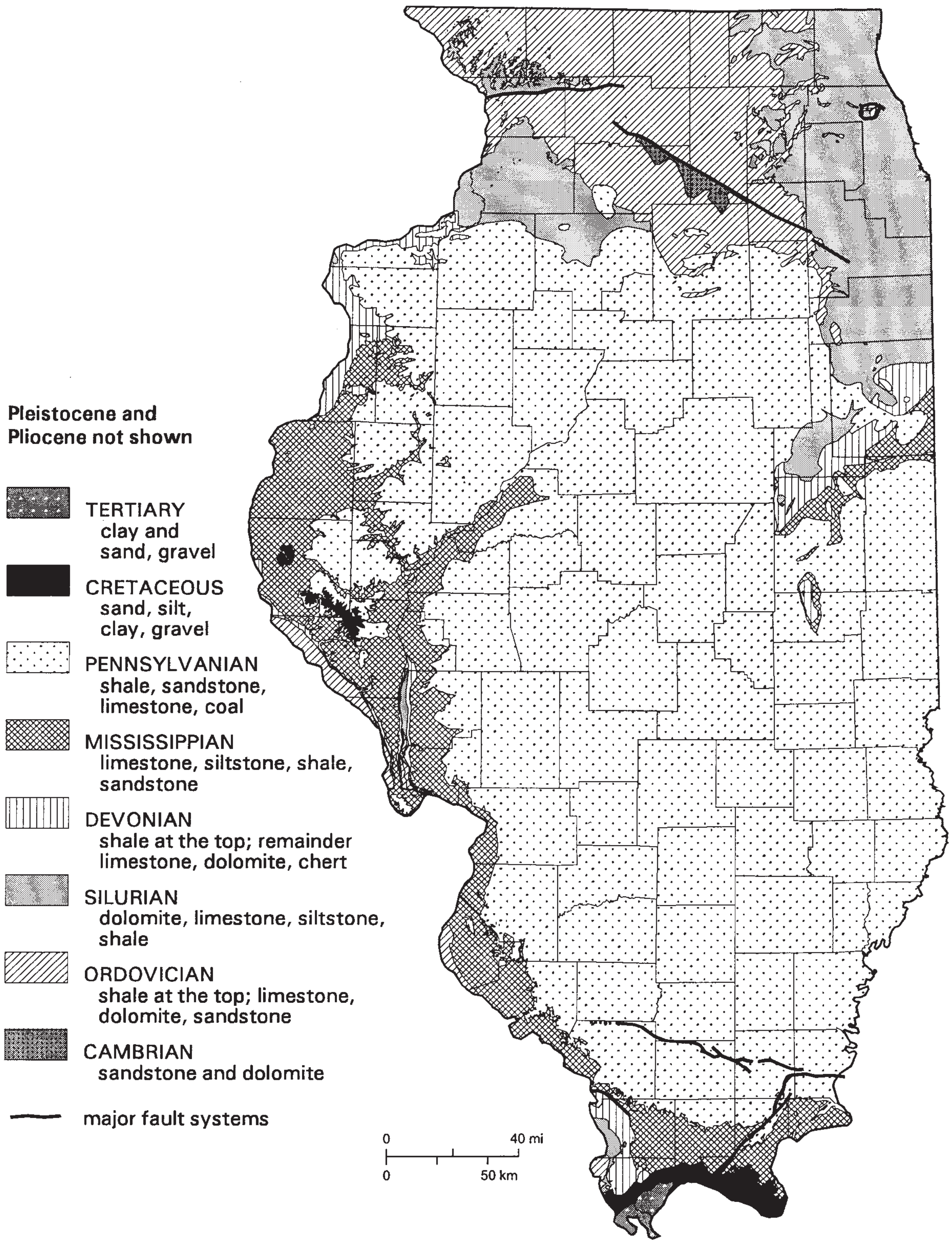


Figure 7 Bedrock geology beneath surficial deposits in Illinois.

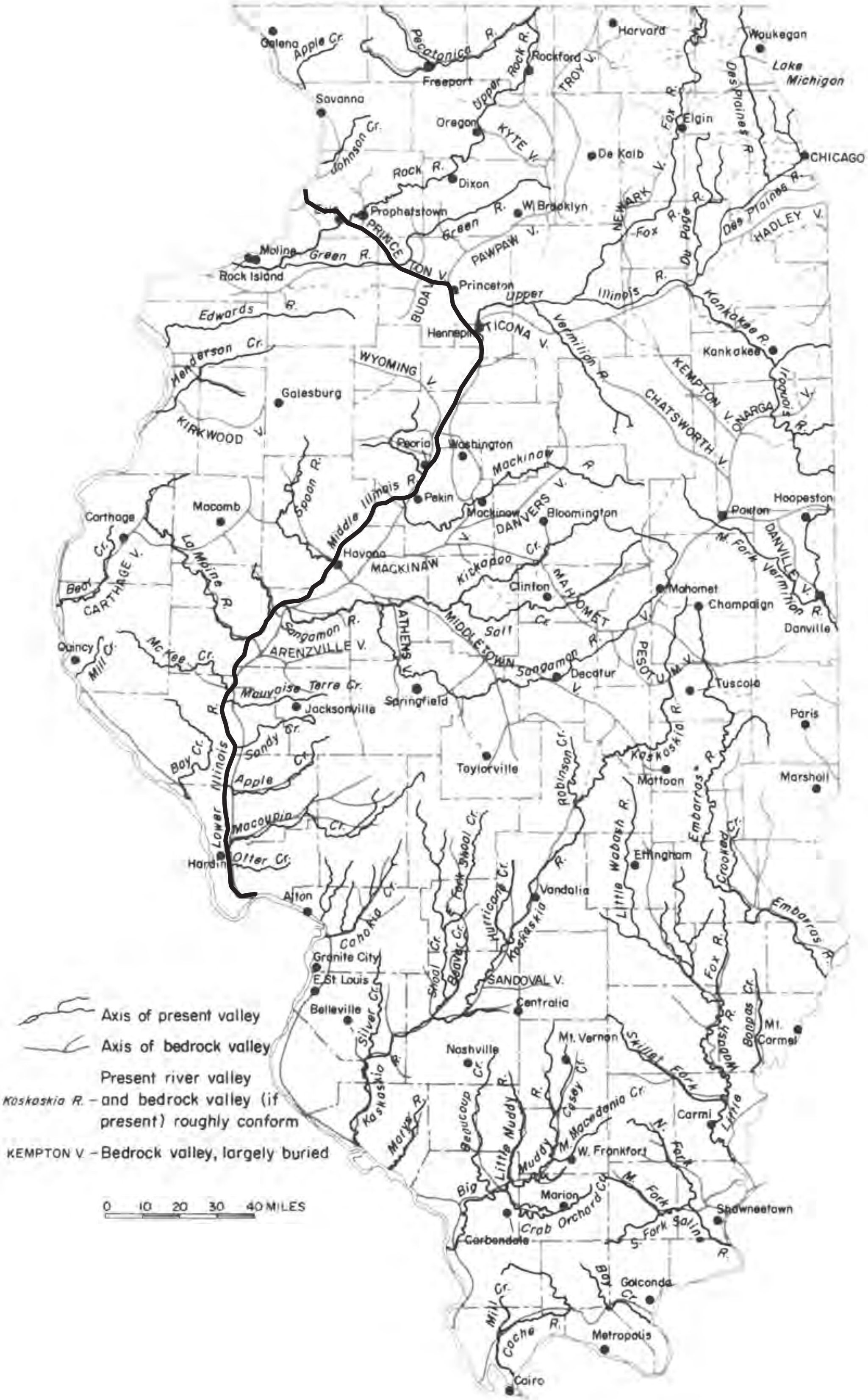


Figure 8 Bedrock valleys of Illinois (modified from Piskin and Bergstrom 1975).

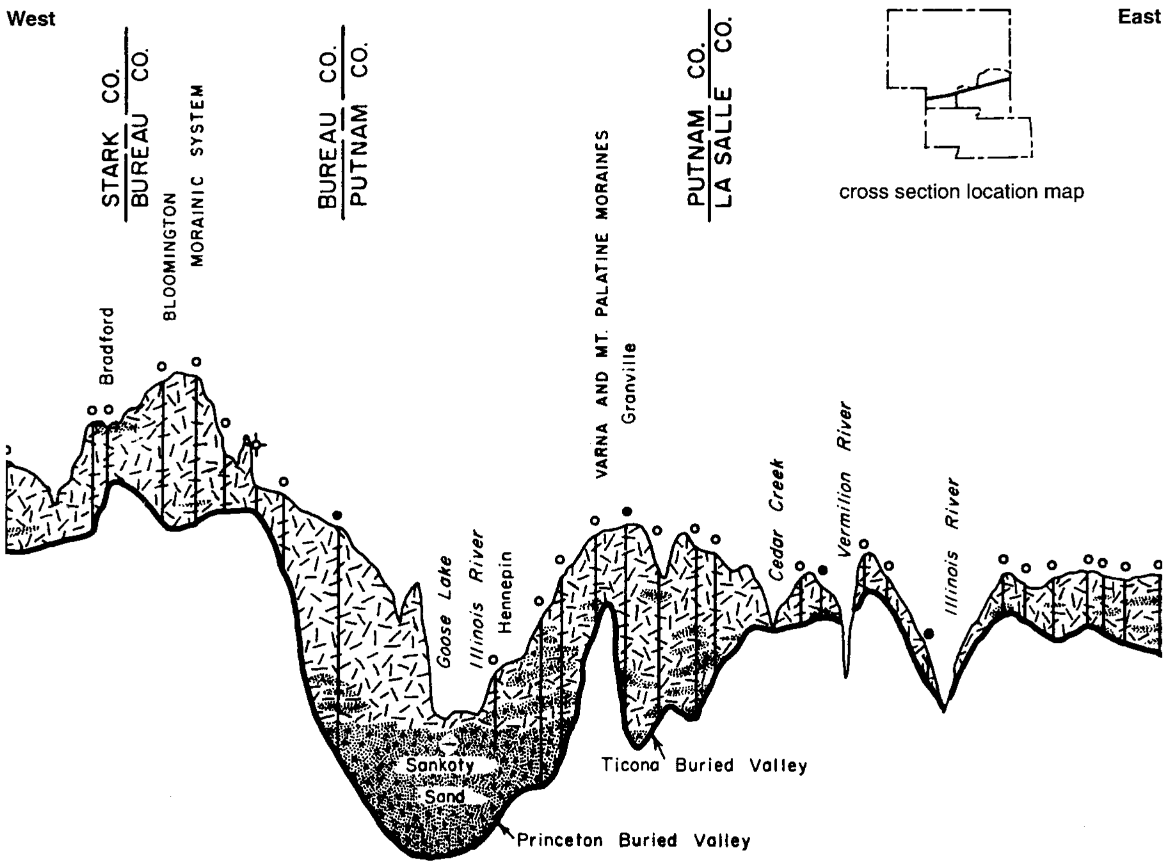


Figure 9 Stratigraphic cross section showing the deposits within the Princeton Bedrock Valley (modified from Piskin and Bergstrom 1975).

The Ancient Mississippi River flowed along the west side of the Driftless Area southward as far as Fulton in Whiteside County. From then it followed the Princeton Bedrock Valley in a southeastward course to the present Big Bend of the Illinois River valley in Bureau County near Hennepin (fig. 8). The Ancient Mississippi River then followed the present course of the Illinois River valley southward to its confluence with the Ancient Iowa River at Grafton in Calhoun County.

Illinois Episode glaciers overrode the Princeton Bedrock Valley at least three times (Willman and Frye 1970), diverting the Ancient Mississippi River to the west each time (see nos. 4–6, fig. 10). During the Sangamon interglacial episode, the interval between the Illinois and Wisconsin Episodes of glaciation, the Ancient Mississippi River again flowed through central Illinois (see no. 7, fig. 10). Large volumes of meltwater flowed through this valley during the early stages of glaciation and deposited the thick Sankoty Sand (fig. 9). Later glaciation covered the bedrock and the sand-filled valleys with drift (fig. 9).

During the Wisconsin Episode glacial advance, the Ancient Mississippi River was again diverted to the west where it remained. This event has been dated about 21,000 years ago (Glass et al. 1964). The Wisconsin glacier (Lake Michigan Lobe) dammed the Ancient Mississippi River to produce a series of lakes in the western part of Illinois near Fulton in Whiteside County. The lakes overflowed from one to another, and a narrow ridge of sandstone (Wyoming Hill) was eventually breached west of Rock Island, and the Mississippi River gorge was cut between Rock Island and Muscatine, Iowa. The Ancient Mississippi River was permanently diverted westward to occupy

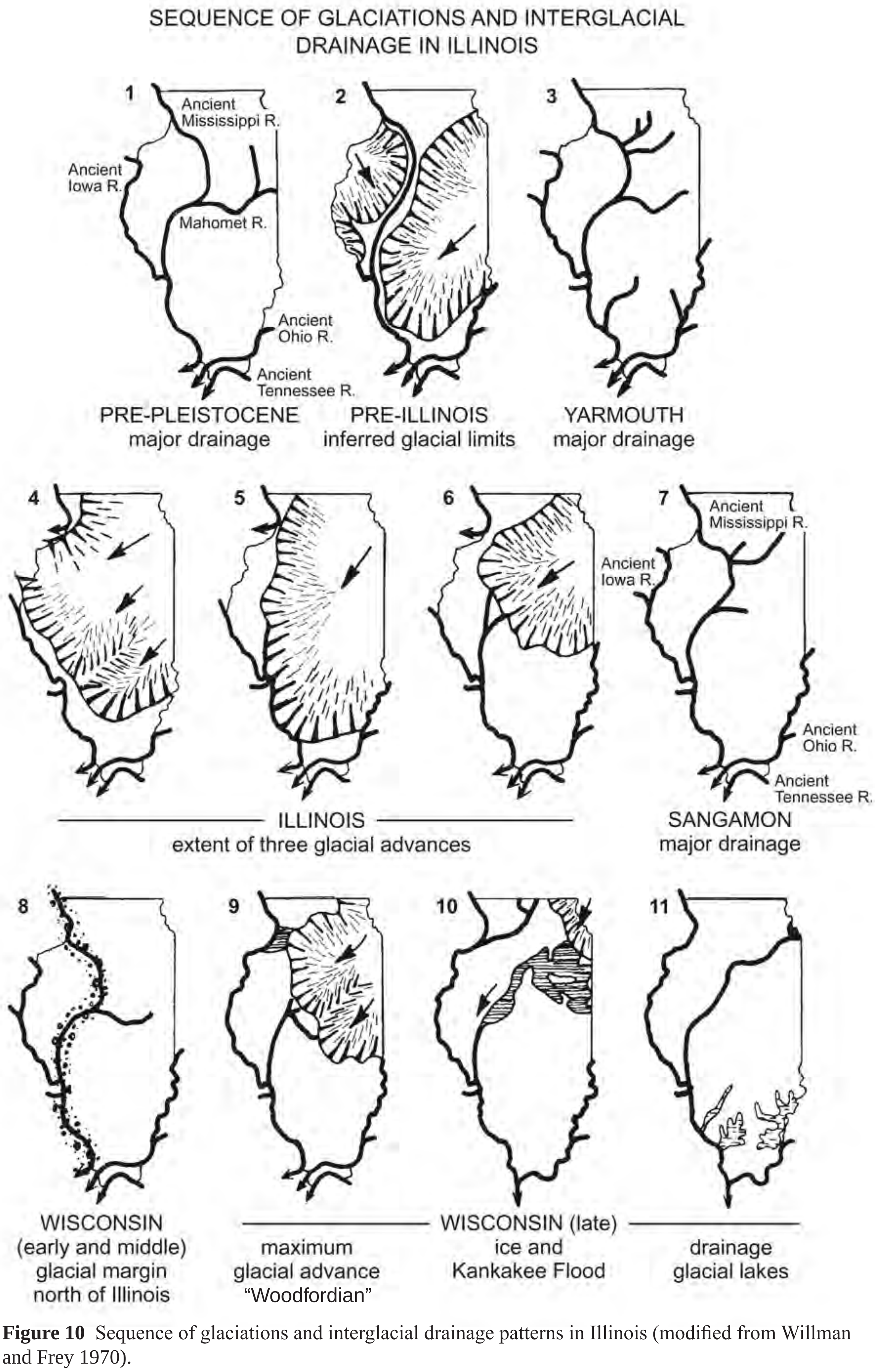


Figure 10 Sequence of glaciations and interglacial drainage patterns in Illinois (modified from Willman and Frey 1970).

the valley of the Ancient Iowa River along the west side of what is now Illinois, a course it still follows. The abandoned Princeton Bedrock Valley was subsequently partially filled with sediments. The Princeton Lowland marks the position of this buried valley.

Development of the Upper Illinois River Valley

As the Lake Michigan Lobe continued to melt back, a series of moraines were formed, and glacial meltwater ponded between the moraines. As the level of the ponded water rose, it would drain through low areas (sags within the moraines). The resultant flow of water would then erode headward into the moraines, providing a drainage way for the ponded water. This flow of released water initiated the cutting of the upper Illinois River valley.

After the Lake Michigan Lobe had melted back to the position of the Woodstock and West Chicago Moraines, large volumes of water accumulated beneath ice and were at times catastrophically released to flood down the Illinois Valley in events refereed to as the Kankakee and Fox River torrents. Additional meltwater from the Saginaw Lobe flowed into the Illinois River valley via the Kankakee River valley.

Once the Lake Michigan Lobe had melted back to the Chicago area, a large proglacial lake called glacial Lake Chicago formed between the Lake Michigan Lobe and the Tinley and Valparaiso Moraines. Glacial Lake Chicago stood 60 feet higher than the present level of Lake Michigan and drained via the Chicago outlet through a sag in the Tinley and Valparaiso Moraines.

This outlet served as an important drainage way at various times when meltwater from the Lake Michigan, Huron, and Erie lobes flowed into the Illinois Valley via Lake Chicago. The entrenchment of Starved Rock and Buffalo Rock on the Illinois River are attributed to these large volumes of glacial meltwater flowing through the Illinois River valley between about 13,000 and 11,000 radiocarbon years ago. Additional flooding occurred between 6,000 and 5,000 years ago as a result of glacial and postglacial events in the Great Lakes region.

When the ice finally retreated from the Midwest, the drainage in the Illinois River was reduced to its present level so that a small river was flowing in a valley cut by much heavier flows of meltwater (fig. 9).

GLACIAL HISTORY OF ILLINOIS

Pleistocene Epoch

Glaciers of the Pleistocene—or "Ice Age" (fig. 11)—have profoundly affected the present topography of the field trip. The landscape we see today is a direct result of sediments deposited during the Pleistocene glaciations and modification of these sediments by postglacial erosion. As already stated, the erosion that took place long before the glaciers advanced across the state left a network of deep valleys carved into the bedrock surface (fig. 8). The present topography of Illinois is significantly different from the topography of the preglacial bedrock surface. The topography of the bedrock surface throughout much of Illinois is largely hidden from view by glacial deposits except along the major streams and in the driftless areas of northwestern and southern Illinois (fig. 12). In many areas, the glacial drift is thick enough to completely mask the underlying bedrock surface. Studies of mine shafts, water-well logs, and other drill-hole information, in addition to scattered bedrock exposures in some stream valleys and road cuts, show that the present land surface of the glaciated areas of Illinois does not reflect the underlying bedrock surface. The topography of the preglacial bedrock surface has been significantly modified by glacial erosion and is subdued by glacial deposits.

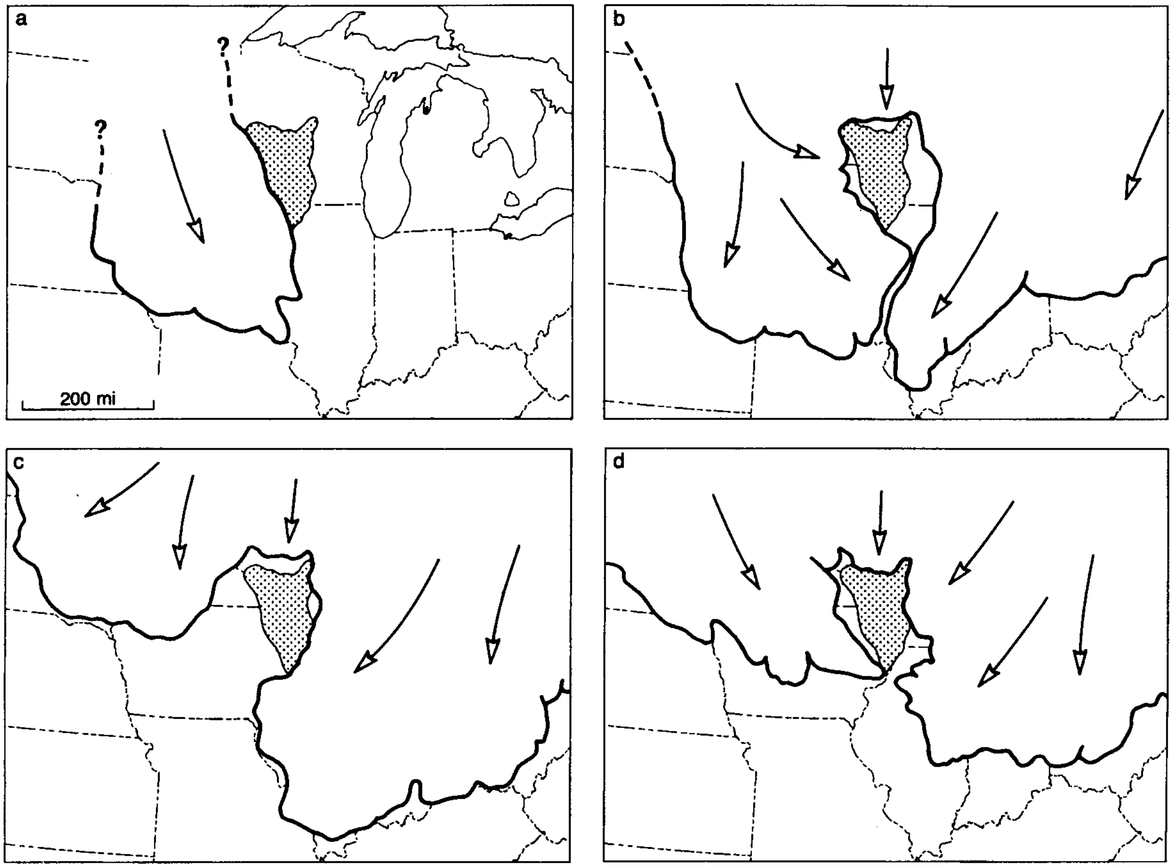


Figure 11 Maximum extent of (a) early Pre-Illinois glacial episode (1,000,000± years ago); Driftless Area shown by stippled pattern; arrow indicates direction of ice movement; (b) late Pre-Illinois glacial episode (600,000± years ago); (c) Illinois Glacial Episode (250,000± years ago); (d) late Wisconsin Glacial Episode (22,000 years ago).

In the past 1.6 million to 2 million years, during the Pleistocene Epoch of the Quaternary Period, much of northern North America was repeatedly covered by huge glaciers (see fig.11). These continent-size masses of ice formed in eastern and central Canada as a result of climate cooling. Their advances into the central lowland of the United States altered the landscape across much of the Midwest.

During an early part of the Pleistocene Epoch, glaciers advanced out of centers of ice accumulation both east and west of the Hudson Bay area in Canada (fig. 11b). These centers are referred to in this guidebook as northeastern and northwestern source areas because Illinois lies to the south of and between these centers of accumulation. Glaciers flowing out of these centers into Illinois carried along rock debris incorporated into the ice as they advanced; the material was dropped out as the ice melted. The number and timing of these early episodes of glaciation are uncertain at present and are therefore unnamed, but, because they precede the first named episode (the Illinois Episode; Hansel and Johnson 1996) of glaciation, they are called simply pre-Illinois glacial episodes (figs. 10 and 13). The pre-Illinois glacial episodes ended about 425,000 years ago.

A long interglacial episode, called the Yarmouth, followed the last of the pre-Illinois glacial advances (figs. 10 and 13). The Yarmouth interglacial episode is estimated to have lasted approximately

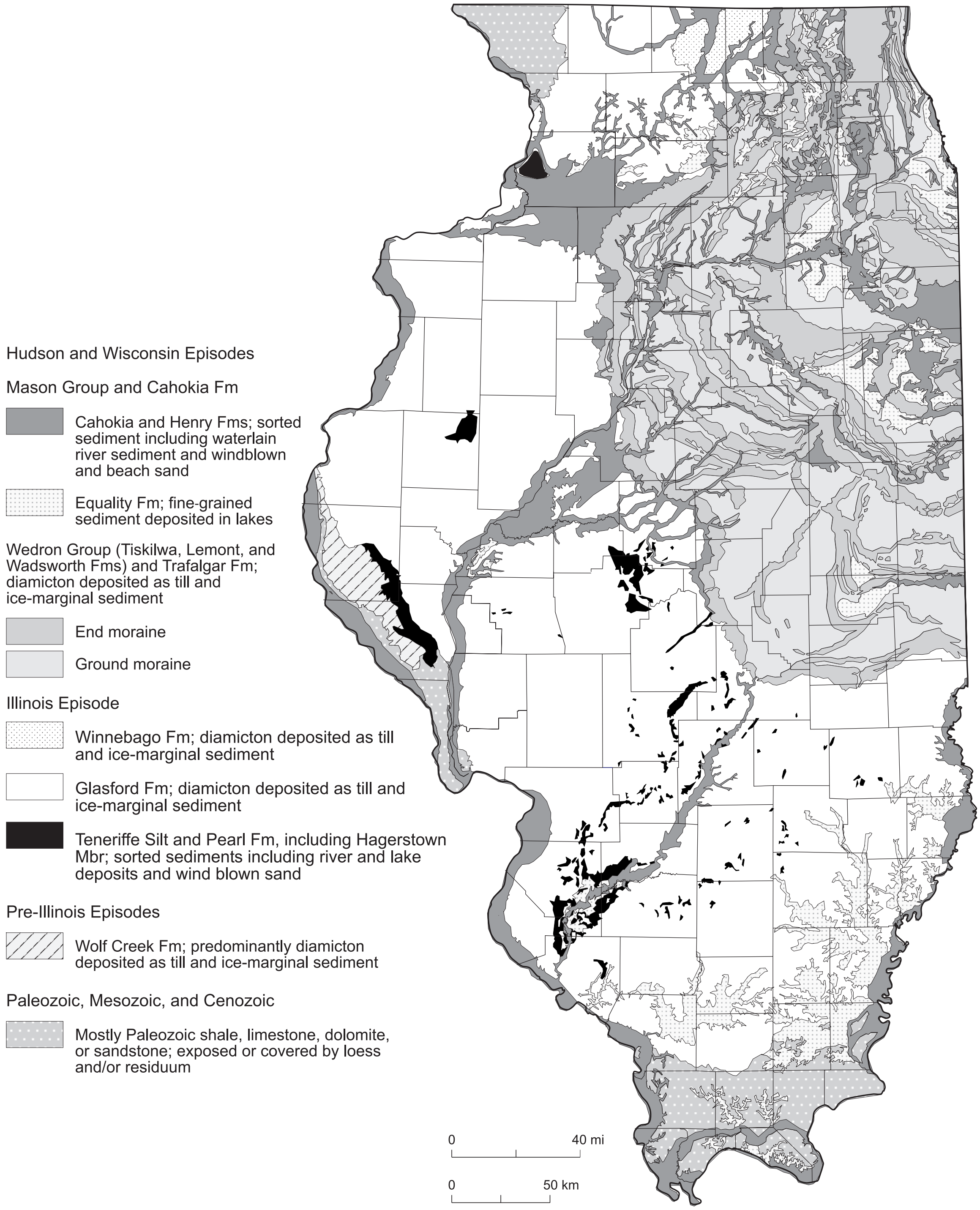


Figure 12 Generalized map of glacial deposits in Illinois (modified from Willman and Frye 1970).

Years before present	Time-distance diagram Interglacial and glacial episodes	Sediment record	Dominant climate conditions Dominant land forming and soil forming events
HOLOCENE	interglacial episode	River, lake, wind, and slope deposits.	Warm; stable landscape conditions. Formation of modern soil; running water, lake, wind, and slope processes.
10,000	WISCONSIN (late) glacial episode; glacial ice	Till and ice-marginal deposits; outwash and glacial lake deposits; loess. **6**	Cold; unstable landscape conditions. Glacial deposition, erosion, and landforming processes (e.g., formation of end moraines, outwash plains, valley trains, proglacial lakes, kettles), plus running water, lake, wind, and slope processes.
25,000	WISCONSIN (early and middle) glacial margin north of Illinois	Loess; river, lake, and slope deposits. **5**	Cool; stable. Weathering, soil formation (Farmdale Soil and minor soils); wind and running water processes.
75,000	SANGAMON interglacial episode	River, lake, wind, and slope deposits. **4**	Warm; stable. Weathering, soil formation (Sangamon Geosol); running water, lake, wind, and slope processes.
125,000	ILLINOIS glacial episode	Till and ice-marginal deposits; outwash and glacial lake deposits; loess. **3**	Cold; unstable. Glacial deposition, erosion, and landforming processes, plus proglacial running water, lake, wind, and slope processes; possible minor soil formation.
300,000	YARMOUTH interglacial episode	River, lake, wind, and slope deposits. **2**	Warm; stable. Long weathering interval with deep soil formation (Yarmouth Geosol); running water, lake, wind, and slope processes.
425,000 – 1,600,000 and older	? PRE-ILLINOIS glacial and interglacial episodes ?	Till and ice-marginal deposits; outwash and glacial lake deposits; loess plus nonglacial river, lake, wind, and slope deposits. **1**	Alternating stable and unstable intervals of uncertain duration. Glacial deposition, erosion, and landforming processes, plus proglacial and interglacial running water, lake, wind, and slope processes; interglacial weathering and soil formation.

(not to scale) PLEISTOCENE EPOCH

Figure 13 Timetable illustrating the glacial and interglacial events, sediment record, and dominant climate conditions of the Ice Age in Illinois (modified from Killey 1998).

125,000 years, and deep soil formation took place during that long interval (Yarmouth Geosol). On the parts of the landscape that were generally poorly drained, fine *silts* and clays slowly accumulated (accreted) in shallow, wet depressions and formed what are called accretion *gleys,* which are characterized by dark gray to black, massive, and dense gleyed clays.

Approximately 300,000 years ago, the Illinois Episode of glaciation began. It lasted for about 175,000 years, and, during this interval, the ice advanced three times out of the northeastern center of accumulation (see nos. 4 through 6, fig. 10; figs. 11c and 13). During the Illinois Episode, North American continental glaciers reached their southernmost position, in the northern part of Johnson County (fig. 12). During the first of these advances, ice of this episode reached westward across Illinois and into Iowa.

Another long interglacial episode, called the Sangamon (see no. 7, fig. 10; fig. 13), followed the Illinois Episode and lasted about 50,000 years. Although shorter than the Yarmouth interglacial episode, this interval's length was sufficient for another major soil, the Sangamon Geosol, to develop. The Sangamon Geosol exhibits both well-drained and poorly drained soil profiles; although accretion gleys are not as pronounced as they are in the Yarmouth Soil, their occurrence is common across the Sangamon landscape, and they are easily identified by the same characteristics as the Yarmouth accretion gleys.

About 75,000 years ago, the Wisconsin Episode of glaciation began (figs. 10, 11d, and 13). Ice from the early and middle parts of this episode did not reach into Illinois. Although late Wisconsin ice did advance across northeastern Illinois beginning about 25,000 years ago, it did not reach southern or western Illinois (figs.10, 11d, and 12). The late Wisconsin glaciation in the field trip area is represented here by moraines, *outwash plains*, *valley trains*, and the windblown silts (*loess*) that blanket the landscape and compose the parent materials for modern soils. The maximum thickness of the later Wisconsin Episode glaciers was about 2,000 feet in the Lake Michigan Basin, but only about 700 feet over most of the Illinois land surface (Clark et al. 1988). The last of these glaciers melted from northeastern Illinois about 13,500 years before the present.

Wisconsin Episode moraines formed in Illinois from approximately 25,000 to 13,500 years ago (fig. 14). The Illinois Episode glaciers may not have built morainic ridges of the size and magnitude of the later moraines of the Wisconsin Episode glaciers, and the Illinois Episode moraines were exposed to weathering and erosion for approximately 280,000 years longer than their younger Wisconsin Episode counterparts. For these reasons, Illinois Episode glacial features generally are not as conspicuous as the younger Wisconsin Episode features.

In general, glacial deposits consist primarily of (1) *till*—pebbly clay, silt, and sand, deposited directly from melting glaciers; (2) *outwash*—mostly sand and gravel, deposited by the rapidly flowing meltwater rivers; (3) *lacustrine deposits*—silt and clay that settled out in quiet-water lakes and ponds; and (4) *loess* (pronounced "luss")—windblown sand and silt.

As glaciers advanced over the field trip area during the major ice advances (fig. 13), outwash deposits of silt, sand, and gravel were dumped along the Ancient Mississippi River valley and the Illinois River valley. When these deposits dried out during the winters, strong prevailing winds from the west (the westerlies) winnowed out the finer materials, such as fine sand and silt, and carried them eastward across the unglaciated terrain.

Lacustrine deposits of the Equality Formation are found in the lower portion of the Big Bureau Creek valley. These quiet slack-water deposits formed a flat topography, which represents long

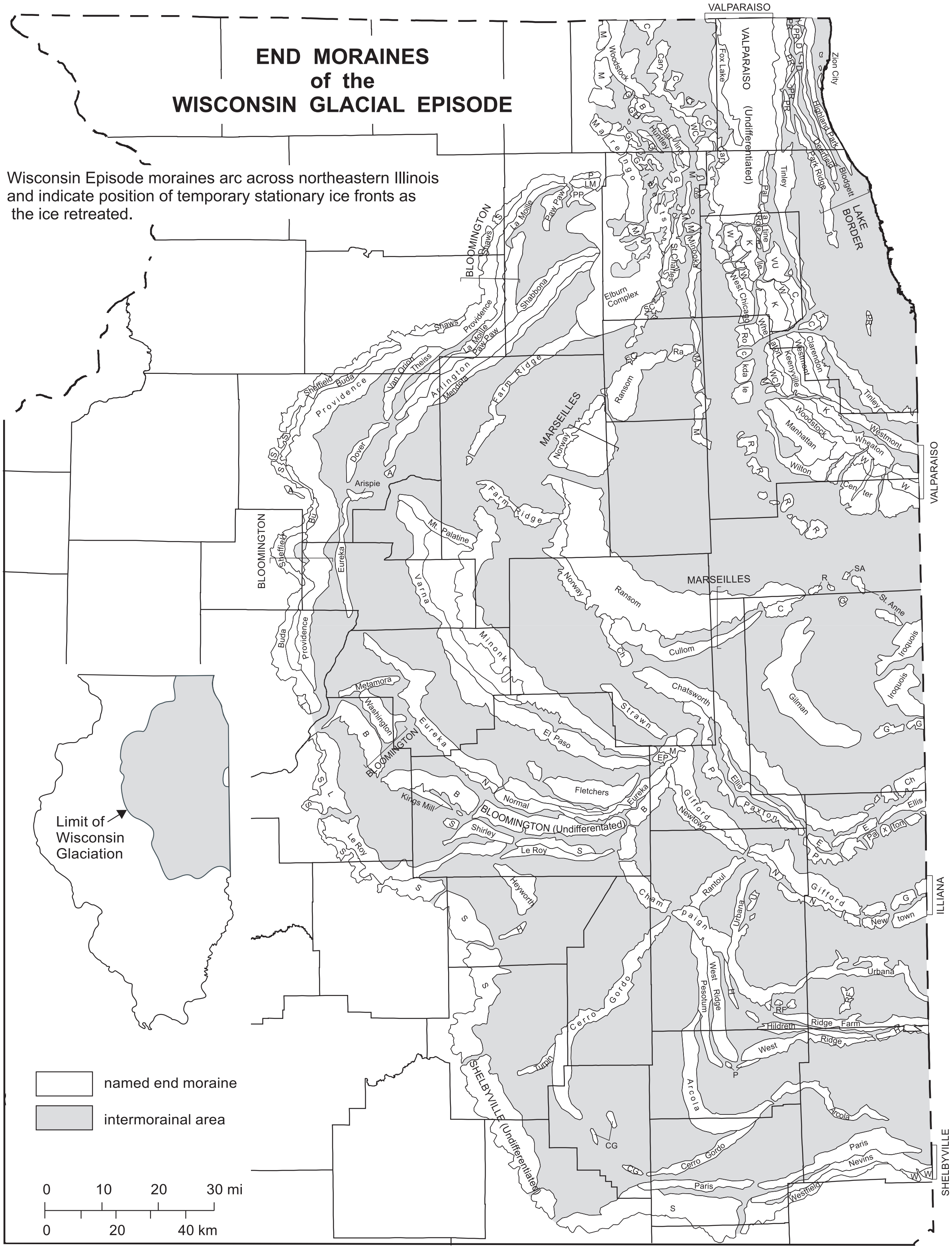


Figure 14 Areal distribution of moraines of the Wedron Group in Illinois (modified from Hansel and Johnson 1996).

periods of flooding during the melting of the last glaciation. Most of these sediments were deposited during the melting of the Wisconsin glacier from about 20,000 to 10,000 years ago. Vast amounts of meltwater poured from the ice front and caused extensive flooding in the Mississippi, Illinois, Wabash, and Ohio Valleys.

Scattered along the Illinois River floodplain are several areas of sand dunes. These areas can usually be recognized by their characteristic topographic form—the random arrangement of small hills or mounds, elongate ridges, and enclosed depressions—and by close visual inspection, which reveals that the dunes are almost made entirely of sand. Dunes are formed by the piling up of sand by the wind and can develop in any region with a readily available source of sand and occasional strong winds. Dunes are common in this region on the valley flats, old terraces, and along the margins of the bluffs bordering the valleys.

The loess that mantles the bedrock and glacial drift throughout the field trip area was laid down by wind during the Wisconsin Episode (approximately 25,000 to 13,500 years ago). This yellowish brown silt occurs on the uplands throughout the field trip area. The loess is generally between 10 to 15 feet thick, but erosion has reduced loess thickness in scattered areas. In general, the thickness of the loess decreases to the east. The loess, which covers most of Illinois, is up to 25 feet thick along the Illinois River valley and is more than 50 feet thick, in some localities, along the east edge of the Mississippi River valley.

GEOMORPHOLOGY

Physiography is a general term used for describing landforms; a physiographic province is a region in which the relief or landforms differ markedly from those in adjacent regions. The field trip area is located in the Bloomington Ridged Plain Section of the Central Lowland Province (fig.15).

Bloomington Ridged Plain

The Bloomington Ridged Plain, according to Leighton et al. (1948), includes most of the Wisconsin moraines and is characterized by low, broad morainic ridges with intervening wide stretches of relatively flat or gently undulatory *ground moraine.* In many places, the major moraines rise with gentle slopes; although they are conspicuous from a distance, the major moraines become less so near at hand, whereas the minor moraines are prominent locally. In this district more than in any other, the grass-covered stretches of rolling prairie and extensive swamps, described by early settlers, were most typically and extensively developed.

The glacial deposits are relatively thick throughout the district and completely conceal the bedrock topography, except locally. Illinoian and older drifts are present below the Wisconsin in most places, so that the level aspect of present drift plains is largely due to the presence of the older drift sheets, which filled in and covered the irregularities of the bedrock surface.

Drainage is generally in the initial stages of development, and most streams follow and are eroding in constructional depressions, many of which cross morainic ridges. The valleys of principal streams are large (owing in part to the greater areal extent of this division and to its somewhat greater age) and have floodplains bordered by valley-train terraces. The Illinois River, the master stream of the district, has a broad, flat-bottomed valley with steep walls and is bordered by numerous narrow steep-walled valleys with steep gradients.

NATURAL DIVISIONS AND GEOLOGY

Glacial history has played an important role in shaping Illinois topography by eroding the preglacial landscape and depositing glacial sediments. Topography influences the diversity of plants and ani-

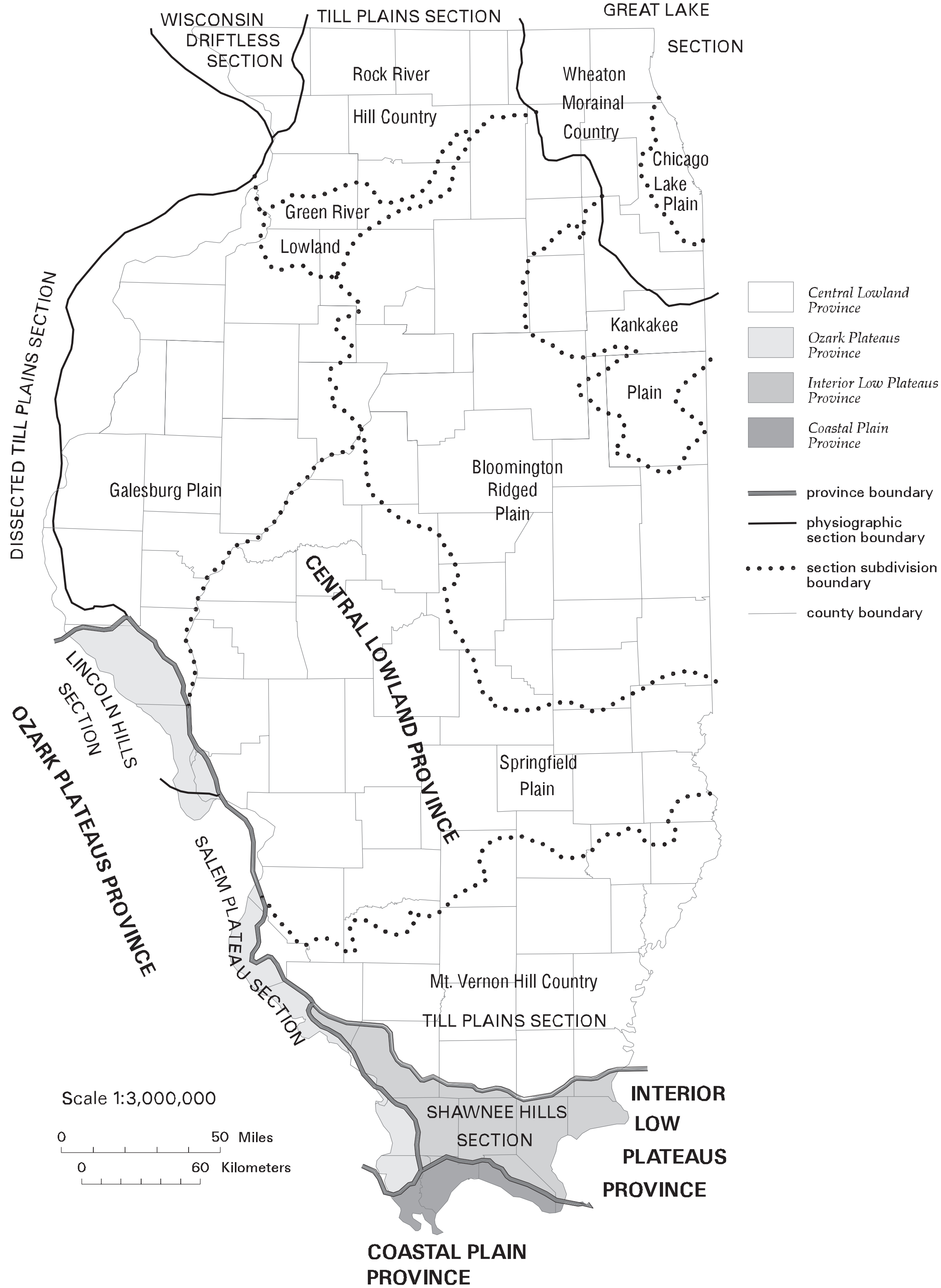


Figure 15 Physiographic divisions of Illinois (modified from Leighton et al. 1948).

mals (*biota*) of Illinois by strongly influencing the diversity of habitats. Geological processes form, shape, and create the topography on all of the Earth's surface. Specifically, geological processes not only determine the composition of the parent material of soils but also form soils through the weathering of parent materials. Thus, the geology of a region is the foundation of its habitats.

Natural Divisions

The state has been divided into fourteen different natural divisions. These divisions are distinguished according to differences in significant aspects of topography, glacial history, bedrock geology, soils, aquatic habitats, and distribution of plants and animals (flora and fauna). A strong relationship exists between the physiographic divisions of Illinois and the natural divisions of Illinois because the geologic factors used to determine the physiographic divisions were important elements used to define the boundaries of the natural divisions. The field trip area is located in three natural divisions: The Grand Prairie Division, the Upper Mississippi River and Illinois River Bottomlands Division, and the Illinois River and Mississippi River Sand Areas Division. The following descriptions of the natural divisions are modified from Schwegman (1973).

Grand Prairie Division The Grand Prairie Division is a vast plain formerly occupied primarily by tall-grass prairie. The soils were developed from recently deposited loess, lakebed sediments, and outwash and are generally very fertile. Natural drainage was poor, resulting in many marshes and prairie potholes. Forest bordered the rivers, and there were occasional groves on moraines and other prominent glacial landforms. The sections of this division are differentiated on the basis of soils, topography, and glacial history.

At one time, bison grazed the prairies, and waterfowl in great numbers occupied the marshes and potholes. The steel plow brought about the rapid destruction of the vast Illinois prairies. Ditches and tile lines drained almost all of the marshes and potholes. The bison were gone by 1814. The abundant waterfowl were displaced. The giant Canada goose was wiped out as a breeding bird, and other characteristic species disappeared or became scarce. The prairie, once seemingly limitless, is now one of the rarest plant communities in Illinois; only pitifully small and often degraded patches remain.

- ***Glacial History*** The Grand Prairie is a rather level, poorly drained plain of glacial drift from the Illinoian and Wisconsin stages of Pleistocene glaciation. Repeated advances and retreats of the Wisconsin glaciers created a series of moraines and morainic systems of which the Shelbyville and Bloomington morainic systems are conspicuous.

- ***Bedrock*** The bedrock, deeply buried by glacial drift, crops out only along the larger rivers. Major outcrops of sandstone are found near Ottawa along the Illinois and Fox Rivers, and dolomite crops out along the Kankakee River west of Kankakee.

- ***Topography*** The topography of the Grand Prairie Division is generally level to rolling, with the major stream valleys and the extensive systems of moraines providing the greatest relief. Large flat expanses of lakebed deposits are found in La Salle, Kendall, Will, Grundy, Livingston, Ford, Iroquois, Kankakee, and Douglas Counties. Extensive outwash plains and sand dunes are found in Kankakee and Iroquois Counties and in the valleys of the Green River and lower Rock River. The major rivers have well-developed floodplains, and in many areas there are ravines in the bluffs.

- ***Soils*** The soils are relatively young and high in organic content, having developed from a thin to moderately thick layer of loess, glacial drift, or lakebed sediments. Soils developed from sand, muck, and peat exist in the Kankakee Sand Area and Green River Lowland sections. Deep loess occurs along the Illinois and the lower Sangamon Rivers.

Upper Mississippi River and Illinois River Bottomlands Division The Upper Mississippi River and Illinois River Bottomlands Division encompasses the rivers and floodplains of the Mississippi River above its confluence with the Missouri River and the bottomlands and associated backwater lakes of the Illinois River and its major tributaries south of La Salle. The division does not include the major sand deposits, which are in a separate division. Much of the division was originally forested, but prairie and marsh also occurred. The more sluggish nature of the Illinois River and its distinctive backwater lakes distinguish the Illinois River Section from the Upper Mississippi River Section.

- ***Bedrock*** The bedrock of the two river valleys is deeply covered by alluvial deposits.

- ***Topography*** The bottomlands of the upper Mississippi River and the Illinois River are characterized by broad floodplains and gravel terraces formed by glacial floodwaters.

- ***Soils*** The soils are from recent *alluvium* and glacial outwash. They are poorly drained, alkaline to slightly acidic, and vary from sandy to clayey. In general, they are lighter than the alluvial soils of the Lower Mississippi River Bottomlands Division.

Illinois River and Mississippi River Sand Areas Division The Illinois River and Mississippi River Sand Areas Division encompasses the sand areas and dunes in the bottomlands of the Illinois and Mississippi Rivers and includes the "perched dunes" atop the bluffs in Carroll and Jo Daviess Counties. Scrub oak forest and dry sand prairie are the natural vegetation of this division. Several plant species found here are more typical of the short-grass prairies to the west of Illinois. Several "relict" western amphibians and reptiles are known only from these sand areas. The two sections are distinguished because of differences in flora and fauna.

- ***Topography*** The topography is generally one of level to rolling plains of sand deposited by glacial meltwaters and blown into widespread areas east of the rivers. In many areas, the sand has migrated onto the bluffs and uplands east of the river terraces. In places, dunes 20 to 40 feet high have formed, and blowouts are common in unstabilized sand.

- ***Soils*** The soils are derived from sand and sandy material. Other soils in depressions surrounded by sand are also in this division. The soils are generally droughty and subject to wind erosion. Low areas are generally wet.

Drainage

The Illinois River (a master stream) is the major drainage way in the field trip area. The largest tributaries in the field trip area are Big Bureau Creek, Clear Creek, and Sandy Creek. Big Bureau Creek, the largest tributary, has developed incised meanders (see route maps). All of the large tributaries have a number of secondary tributaries. These secondary tributaries consist of a series of smaller, relatively short, V-shaped tributaries with steep gradients. All of these tributaries are part of a well-developed drainage network that has grown (eroded) headward into the uplands.

Along the Illinois River, below Hennepin, the slope of the valley floor is extremely low. This low slope was established by the Ancient Mississippi River. Generally, a river the size of the present Illinois River would be expected to have a steeper slope. Because of the low slope, the river water does not have sufficient velocity during normal flow to move sediment carried into the river by tributary streams. Thus, large alluvial fans have formed by the accumulation of sediment at the mouth of these tributary streams. Three of these tributary streams, Big Bureau Creek located across from Hennepin, Clear Creek located south of Hennepin, and Sandy Creek located across from Henry, have developed large alluvial fans at their mouth where they empty into the Illinois River (see route maps). These alluvial fans act as dams, creating behind them the lakes found along the middle Illinois River. Since the Illinois River cannot pick up and transport the sediment in the alluvial fans, it has to flow around them. Thus, the Illinois River is diverted to the opposite side of the valley each time it approaches one of the alluvial fans.

Relief

The highest point along the field trip route is at the top of the Providence Moraine at Stop 5, where the elevation is 945 feet above mean sea level (msl). The lowest point is the Illinois River surface near Hennepin, which has a normal pool elevation of 440 feet msl. The regional relief is therefore 505 feet. Local relief is most pronounced along the Illinois River where the tops of the bluffs rise more than 200 feet above the Illinois River valley. The most dramatic manmade relief is the mine dump at Mark (Stop 6), which forms a conical cone 100 feet above the surrounding land surface.

NATURAL RESOURCES

Mineral Production

The total value of all minerals extracted, processed, and manufactured in Illinois during 1998 was $1.95 billion. Minerals extracted accounted for 86.4% of this total. Coal continued to be the leading commodity, followed by construction stone (limestone and dolomite), sand and gravel, and oil. Illinois ranked 5th among coal-producing states, 13th among the 31 oil-producing states, and 16th among the 50 states in total production of nonfuel minerals. Illinois continues to lead all other states in production of industrial sand and tripoli (Ipe 2000).

Of the 102 counties in Illinois, Bureau, Marshall, and Putnam ranked 76th, 80th, and 83rd, respectively, in the total value of minerals produced in 1993, the last year that county by county statistics are available (Samson 1994).

Currently, the only reported mineral production in Putnam, Bureau, and Marshall Counties is limited to deposits of sand and gravel. However, coal has been previously mined in Putnam and Bureau Counties. Cumulative coal production for Putnam County was 10,071,893 tons from underground mines and for Bureau County was 11,094,808 tons from surface mines and 53,823,055 from underground mines.

Historically, additional mineral production in the field trip area includes clays from glacial deposits and Pennsylvanian shales used in the production of bricks and clay tiles, and sand from dunes used as molding sands (McComas 1968).

Groundwater

Groundwater is a mineral resource that is frequently overlooked in assessments of an area's natural resource potential, but groundwater availability is essential for orderly economic and community development. More than 35 percent of the state's 11.5 million citizens and 97 percent of those who live in rural areas depend on groundwater for their water supply. Groundwater is derived from underground formations called *aquifers.* The water-yielding capacity of an aquifer can only be evaluated by constructing wells into it. After construction, the wells are pumped to determine the quality and quantity of groundwater available for use. See figure 2 for general water-yielding characteristics of the rock units in the Hennepin area.

GUIDE TO THE ROUTE

We will start the field trip at the Walter Durley Boyle Community Park in Hennepin. Assemble at the pavilion on the northwest side of the park (SE, SE, NW, SE, Sec. 9, T32N, R2W, 3rd P.M., Depue 7.5-minute Quadrangle, Putnam County). Mileage will start at the corner of Fourth and Court Streets.

You must travel in the caravan. Please drive with headlights on while in the caravan. Drive safely but stay as close as you can to the car in front of you. Please obey all traffic signs. If the road crossing is protected by an Illinois State Geological Survey (ISGS) vehicle with flashing lights and flags, please obey the signals of the ISGS staff directing traffic. When we stop, park as close as possible to the car in front of you and turn off your lights.

Private property Some stops on the field trip are on private property. The owners have graciously given us permission to visit on the day of the field trip only. Please conduct yourselves as guests and obey all instructions from the trip leaders. So that we may be welcome to return on future field trips, follow these simple rules of courtesy:

- Do not litter the area.
- Do not climb on fences.
- Leave all gates as you found them.
- Treat *public* property as if you were the owner—which you are!
- Stay off all mining equipment.
- Parents, closely supervise your children at all times.

When using this booklet for another field trip with your students, a youth group, or family, remember that *you must get permission from property owners or their agents before entering private property.* No trespassing, please.

Eight USGS 7.5-minute Quadrangle maps (Buda, Depue, Florid, Henry, Manlius, Princeton South, Spring Valley, and Wyanet) provide coverage for this field trip area.

Miles to next point	Miles from start	
0.0	0.0	Start at the intersection of East Court Street and North Fourth Street. Set your trip odometer to 0.0 at the corner. TURN onto North Fourth Street. After making the turn, proceed northeast passing by East Mulberry Street and East Locust Street.
0.25	0.25	STOP (two-way). Crossroad intersection (North Fourth Street and 1050N). TURN RIGHT. Located on the northwest corner of the intersection is the

Pulsifer House, built in 1844. It is currently the home of the Putnam County Historic Society and is open to the public.

0.75 | 1.0 | STOP (one-way). T-intersection (Illinois Route 26). TURN LEFT onto four-lane divided highway.

Notice the long, low knolls to the right and left. These are sand dunes that formed when winds from the northwest blew sand across the floodplain and the Hennepin high-level terrace into drifts.

Figure 16 is a generalized profile of the different landforms along the eastern side of the Illinois River valley.

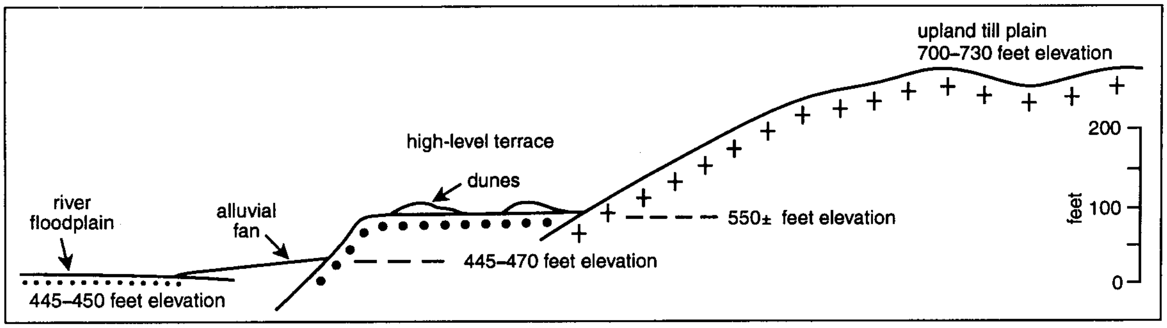


Figure 16 Generalized profile of landforms along the eastern side of the Illinois River valley, south of Hennepin along Illinois Route 26 (modified from Berggren and Hunt 1978).

NOTE: If you want to visit **ALTERNATIVE STOP 8** (go to page 62 and follow the directions)

0.1 | 1.1 | T-intersection from the right. (entrance ramp to Illinois Route 71 east). CONTINUE AHEAD.

0.1 | 1.2 | T-intersection from the left (entrance ramp to Interstate 180 North and Illinois Route 26). TURN LEFT, heading toward Princeton. The large complex to the north of this intersection is the abandoned LTV Steel Plant.

0.9 | 2.1 | Cross the Illinois River. Notice the great view of the Illinois River from the bridge.

0.7 | 2.8 | Prepare to exit Interstate 180, merge to the right. Sign on the right indicating 1/2 mile to exit ramp [Bureau Junction/Illinois 26 North].

0.5 | 3.3 | Exit ramp to the right. Take exit ramp.

0.5 | 3.8 | STOP (one-way). T-intersection (Illinois Route 26). TURN RIGHT.

0.5	4.3	To the right is the Old Channel of Big Bureau Creek. There is a good exposure of overbank deposits and several small slumps along the Old Channel. Big Bureau Creek was diverted and is now located approximately 500 feet to the left. You are passing through the Illinois River floodplain.
0.4	4.7	CAUTION: Cross single-track railroad (signal lights only).
0.1	4.8	STOP (one-way). T-intersection (Illinois Route 26 and Illinois Route 29). TURN LEFT onto Illinois Route 29 (heading south).
0.1	4.9	Cross Big Bureau Creek.
0.1	5.0	T-intersection from the right (2450 East and 910 North). TURN RIGHT. This road is marked as Bureau County Highway 23.
0.1	5.1	Exposure of glacial tills on the left in an old sand and gravel pit. The lower till, near road level, is mapped as the Radner Till Member of the Glasford Formation, deposited during the Illinois Glacial Episode. The overlying till is the Batestown Member of the Lemont Formation of the Wedron Group, deposited during the Wisconsin Glacial Episode. A large slump feature can be seen near the base of the bluff. As you drive along this part of the route, notice the high bluffs to the left. These bluffs form the southern boundary of the valley carved by Big Bureau Creek. We will be roughly paralleling the course of the Big Bureau Creek for the next 5 miles. The flat topography along the road is part of the Big Bureau Creek floodplain.
1.65	6.75	Pass under Interstate 180.
0.05	6.8	T-intersection from the left (2360 East and 1045 North). CONTINUE AHEAD. The sediments that form the base of the very flat topography along the lower portion of Big Bureau Creek are part of the Equality Formation. These sediments consist of well-bedded silts and some clays that were deposited in a slack-water lake within this tributary during flooding of the Illinois River valley during the Pleistocene. The Equality Formation is overlain by recent alluvium from overbank flooding.
1.0	7.8	Cross small unnamed creek. Despite its small size, this creek has carved a series of deep V-shaped valleys into the bluffs on the left.
0.9	8.7	T-intersection from the left (2190 East). CONTINUE AHEAD. There is a great view of Big Bureau Creek and its meanders on the right (see route map).
0.4	9.1	T-intersection from the right (2160 East) is closed. CONTINUE AHEAD. Old truss steel truss bridge across Bureau Creek on the right.
0.7	9.8	Railroad begins to parallel the road on the right.

0.5	10.3	T-intersection from the right (2050 East and 1030 North). TURN RIGHT. CAUTION: Cross single-track railroad (no lights, no guard gates) after making turn. If you continue straight, the road will lead you to Tiskilwa.
0.25	10.55	Cross Big Bureau Creek; notice the meander to your right.
0.1	10.65	Cross Hennepin Canal. The topographic map identifies the canal by its original name—the Illinois and Mississippi Canal. Lock No. 7 is to your right.
1.0	11.65	This road you are traveling on is known locally as Presbyterian Road.
0.7	12.35	T-intersection from the left (1250 North). TURN LEFT.
0.2	12.55	Large abandoned three-story red brick farmhouse on the left.
0.4	12.95	T-intersection from the right (1995 East). CONTINUE AHEAD. This intersection is along the southern crest of the Dover Moraine, which trends north-south at this location. The 700-feet elevation contour on the route map defines the crest of the moraine (see route map). The sediments that constitute the moraine belong to the Batestown Till Member of the Lemont Formation of the Wedron Group.
0.05	13.0	STOP (one-way). Y-intersection (1250 North and 1995 East). CONTINUE AHEAD. The high ridge to your right is the Dover Moraine. The city of Princeton is 2 miles to your right.
2.2	15.2	T-intersection from the left, just before the Hennepin Canal. TURN LEFT, and pull over to the far right side of the road. Park as close together as you can.

STOP 1: Borrow Pit in the Tiskilwa Formation of the Wedron Group and Lock No. 11 of the Hennepin Canal (NE, SW, NE, Sec. 1, T15N, R8E, 4th P.M., Wyanet 7.5-minute Quadrangle, Bureau County).

0.0	15.2	Leave STOP 1 and CONTINUE AHEAD. Road curves to the right.
0.2	15.4	Cross old Iron truss bridge over Hennepin Canal.
0.1	15.5	STOP (two-way). Crossroad intersection (1150 North and 1790 East). CONTINUE AHEAD on 1150 North.
0.3	15.8	Cross Big Bureau Creek. Approximately 3,000 feet to the north are the concrete remains of an aqueduct, a concrete trough that carried the Hennepin Canal over Big Bureau Creek. Although the aqueduct is no longer there, some of the concrete footings and a portion of Lock No. 12 can still be seen. The best access to the aqueduct is to walk along the canal path from Lock No. 11 at STOP 1.

0.35	16.15	CAUTION: Cross single-track railroad. (No lights and No guard gates). Road curves 90 degrees to the left, and then immediately 90 degrees to the right, just before and after the railroad crossing.
0.5	16.65	Y-intersection from the right (1200 North and 1675 East). CONTINUE AHEAD.
0.7	17.35	T-intersection from the left (1625 East, 1200 North). CONTINUE AHEAD.
0.3	17.65	Small manmade pond on the right. Notice that we are beginning to traverse across a landscape topography that is significantly different than what we have previously crossed. This landscape of small hills and basins is typical of what is called knob-and-kettle topography.
0.35	18.0	Exposure of Tiskilwa Till on the right, just before crossing an unnamed creek. This creek is eroding into and dissecting the Providence Moraine (the high ridge) located to the left. The creek is flowing perpendicular to the axis of the moraine.
0.55	18.55	T-intersection from the right (1500 East). CONTINUE AHEAD.
1.05	19.6	STOP (two-way). Crossroad intersection (1200 North and 1400 East). TURN RIGHT. The ridge to the west is the Providence Moraine.
0.8	20.4	Small gravel pit on the left is in an esker (see route map). This sinuous ridge, located in the northeast quarter of Section 32, trends northwest-southeast.
0.7	21.1	Cross-road intersection (1400 East/Wyanet Walnut Road and 1350 North). TURN LEFT. Entering an area where several eskers and kettle lakes have formed. The eskers and kettle lakes trend northwest-southeast (see route maps). The route maps also indicate a number of other kettle depressions, indicated by hachure marks that face inward on enclosed contours. It should be noted that not all kettle depressions contain water.
1.2	22.3	Kettle lake on the left side of the road.
0.05	22.35	Kettle lake on the right side of the road. Pull over to the far right side of the road, and park as close to the car in front of you as possible.

STOP 2: Kettle Lakes and Eskers (middle of the eastern half of Sec. 30, T16N, R8E, 4th P.M., Wyanet 7.5-minute Quadrangle, Bureau County).

0.0	22.35	Leave Stop 2. CONTINUE AHEAD.
0.25	22.6	Road passes through kettle depression; water only on the right side of the road.

0.1	22.7	YIELD: Y-intersection (1250 East and 1375 North). TURN LEFT. Notice the large *erratics* in front of the house on the right.
0.3	23.0	Looking to the southeast (left side of the road) is a sinuous ridge in the middle of the field. This ridge is an esker (see route maps).
0.3	23.3	STOP (one-way). T-intersection (1350 North and 1200 East). TURN RIGHT.
0.1	23.4	CAUTION: Cross dual-railroad tracks. Signal lights and guard gate.
0.2	23.6	Road makes a pair of 90-degree turns, once to the right and then to the left.
0.6	24.2	View of the Providence Moraine (high ridge) straight ahead and to the left.
0.2	24.4	STOP. CAUTION: Cross single-track railroad (no lights, and no guard gates). CONTINUE AHEAD.
0.5	24.9	STOP (two-way). Crossroad intersection (1500 North/U.S. Routes 6 and 34, and 1200 East). TURN LEFT. Small sand and gravel pit located on the left after you make the turn.
0.7	25.6	Passing through an area of large hills and depressions. This area is a good example of knob-and-kettle topography.
1.5	27.1	Crossroad intersection (975 East and 1500 North). CONTINUE AHEAD.
0.7	27.8	Approaching flashing stop light. Intersection of Illinois Route 40 and U.S. Routes 6 and 34. NOTE: Illinois Route 40 on the topographic map is marked as Illinois Route 88.
0.2	28.0	STOP (four-way flashing red light). Crossroad intersection (900 East and 1500 North). TURN RIGHT to go north on Illinois Route 40.
0.5	28.5	Crossroad intersection (900 East and 1550 North). TURN LEFT. Sign for Hennepin Canal Parkway Information Center is at the intersection.
0.1	28.6	CAUTION: Cross single-track railroad (signal lights only, no guard gate).
0.2	28.8	T-intersection from the right. TURN RIGHT. Entrance to Hennepin Canal Parkway State Park.
0.65	29.45	Entrance to parking lot. TURN RIGHT. Sign at entrance denotes visitor center. On the day of the field trip, please park your automobiles in a straight convoy line. We will be using the shelter immediately to the right of the parking lot.

STOP 3: LUNCH at Hennepin Canal Parkway State Park (NE, SW, SE, Sec. 9, T16N, R7E, 4th P.M., Manlius 7.5-minute Quadrangle, Bureau County).

0.0	29.45	Leave Stop 3. Exit the parking lot, and TURN LEFT. Retrace your route back to the main entrance road to the Hennepin Canal Parkway State Park. At the intersection of 1550 North and 900 East/Illinois Route 40), reset your trip odometer to 0.0.
0.0	0.0	STOP (two-way). Crossroad intersection (Illinois Route 40 and 1550 North). TURN RIGHT onto Illinois Route 40 (heading south). After making the turn the road passes through a kettle depression.
0.5	0.5	STOP (four-way with flashing lights). Crossroad intersection (900 East and 1500 North/U.S. Routes 6 and 34). CONTINUE AHEAD south on Illinois Route 40.
0.45	0.95	CAUTION: Cross single-track railroad with signal lights and guard gate; rough crossing. Road begins to make a slight ascent up onto the Buda Moraine.
0.65	1.6	Road descends into a slight depression on the Buda Moraine. The tree-lined ridge to your right marks the crest of the Sheffield Moraine.
0.8	2.4	Crossroad intersection (1310 North and 900 East). CONTINUE AHEAD. The city of Sheffield is 3 miles to the right. The Sheffield, Buda, and Providence Moraines are juxtaposed in this vicinity. These three moraines constitute the Bloomington Morainic System.
0.3	2.7	Entering the community of Buda, population 600. The community of Buda is located on the crest of the Buda Moraine. Buda is reportedly named for the capital of Hungary on the banks of the Danube River.
0.4	3.1	Crossroad intersection. CONTINUE AHEAD. The road to the right leads to the Mautino State Fish and Wildlife Area.
0.4	3.5	Cross bridge over railroad track.
0.15	3.65	T-intersection from the right (1190 North). CONTINUE AHEAD.
0.45	4.1	Road begins descent off of the Bloomington Morainic System and into a low area that separates the Bloomington Morainic System from the Atkinson Moraine to the west. Coal Creek flows through this low divide.
0.25	4.35	CAUTION: Cross single-track railroad (signal lights only, no guard gate).
0.1	4.45	To the right, Coal Creek is parallel to the road. Coal Creek flows to the northwest.

0.25	4.7	Cross Coal Creek.
0.75	5.45	Crossroad intersection (1000 North and 900 East). CONTINUE AHEAD.
0.15	5.6	Bunker Hill Cemetery on the right.
0.2	5.8	Road cuts through middle of a kame on top of the Atkinson Moraine.
0.4	6.2	T-intersection from the right (925 North). CONTINUE AHEAD.
0.25	6.45	T-intersection from the left (900 East and 900 North). TURN LEFT onto 900 North.
0.15	6.6	The wooded area to the left marks the aerial extent of the kame. This northwest-southeast–trending kame is identified as Gravel Hill on the topographic map (see route map). The top of the kame is approximately 60 feet higher than the elevation of the road. This kame is located along the crest of the Atkinson Moraine.
0.8	7.4	Crossroad intersection (1000 East and 900 North). This is a potential stop for the field trip. Pull over to the far right side of the road and park as close to the car in front of you as possible. Following the road to your left, you can walk approximately 1/8 of a mile to see an exposure of the sands and gravels that typically dominate the type of sediments found within kames.

STOP 4: Gravel Hill Kame (Trends from the northwest corner to the southeast corner of Sec. 15, T15N, R7E, 4th P.M., Buda 7.5-minute Quadrangle, Bureau County). Two abandoned sand and gravel pits are located in the SE, SW, NW quarter and the SW, NE, SE quarter of Sec. 15.

0.0	7.4	Leave Stop 4. CONTINUE AHEAD.
0.3	7.7	CAUTION: STOP (two-way). Cross single-track railroad (no lights and no guard gate). The railroad cuts the southeast end of the kame to the left.
0.6	8.3	Note the gentle rolling topography of the landscape. Looking directly to the east, notice that the topography begins to rise slightly. We are heading toward the crest of the Providence Moraine.
0.2	8.5	STOP (two-way). Crossroad intersection (1100 East and 900 North). CONTINUE AHEAD.
0.95	9.45	T-intersection from the left (1200 East). CONTINUE AHEAD. The road jogs slightly to the right, where it changes to a gravel road. Cross Coal Creek after the jog in the road.
0.85	10.3	Road curves slightly the left.

0.15	10.45	T-intersection from the right (1300 East and 905 North). CONTINUE AHEAD. Road jogs slightly to the left and then back to the right. The road begins a gradual ascent to the top of the Providence Moraine.
0.45	10.9	T-intersection from the right (1350 East and 910 North). CONTINUE AHEAD.
0.2	11.1	T-intersection from the left (1365 East). CONTINUE AHEAD. Just past the intersection, on the right, is a glacial erratic marking the site of the Providence Colony and the Providence Congressional Church (established in 1841). Providence was named after the capital of Rhode Island, where the colony that settled it originated. The Providence Colony dates from July 14, 1836, when it was founded by Edward Bayley, Larned Scott, and Simeon G. Wilson. The greater part of the colony for whom this beautiful prairie site was selected, consisting of thirty or forty families, arrived a year later. Other than the erratic marker, there is little evidence that this was once the site of a colony or a church.
0.35	11.45	STOP (two-way). Crossroad intersection (1400 East/Wyanet-Walnut Road and 910 North). CONTINUE AHEAD. CAUTION: View of traffic from the left is obstructed by a rise in the road.
0.15	11.6	STOP and pull over to the right side of the road at the crest of the hill.

STOP 5: Providence Moraine (SW, SW, SW, Sec. 16, T15N, R8E, 4th P.M., Wyanet 7.5-minute Quadrangle, Bureau County). Discussion of the development of the Providence Moraine.

The Providence Moraine in this area trends northwest to southeast. Looking to the southwest, notice that the land slopes off in the direction of the moraine's outwash plain (front slope). Turning 180 degrees and looking to the northeast, imagine a huge glacier in front of you. The land also slopes to the northeast (back slope).

0.0	11.6	Leave Stop 5. CONTINUE AHEAD.
0.3	11.9	Christmas tree farm on the right. A small manmade lake is located on the south side of the road, but, it's obscured from the view by the Christmas trees (see route map). This lake is the first of three manmade lakes constructed by placing a dam across Rocky Run Creek. These dams were built to help prevent flooding in Tiskilwa. Two additional dams were constructed on two separate unnamed creeks to the southwest and south of Tiskilwa. All of these drainage ways have cut deep, high-gradient V-shaped valleys into the Providence Moraine. During a heavy downpour these drainage ways funnel a large volume of water directly toward Tiskilwa.
1.1	13.0	Entrance to the Minlow Church Camp Picnic area to the right. The second manmade lake along Rocky Run Creek is located in the valley to the right (see route map).

0.35	13.35	STOP (one-way). T-intersection (1575 East and 960 North). TURN LEFT.
0.25	13.6	Approaching Y-intersection. BEAR RIGHT, HANG RIGHT, GO RIGHT, and/or TURN RIGHT. (Hope you get the idea.)
0.1	13.7	STOP (one-way). Y-intersection (1000 North and 1575 East). TURN RIGHT onto 1000 North (heading east).
0.3	14.0	View to the northeast, positioned at approximately 10 o'clock on the watch dial. The ridge, marked by the tree line, in the far distance, outlines the bluffs on the northeast side of the Big Bureau Creek and the Hennepin Canal. This view is from a culvert that goes underneath the road at this point.
0.4	14.4	The road begins a gentle descent along the back slope of the Providence Moraine.
0.4	14.8	Road begins gentle curve to the left and back to the right. Notice the deep V-shaped valley along Rocky Run Creek to the right. These deep and narrow V-shaped valleys are indications of a youthful stream downcutting into the ice margin side of the moraine.
0.45	15.25	Mount Bloom Cemetery to the right and left of the road. The road begins a steep descent toward Tiskilwa.
0.15	15.4	Road parallels the course of the very deeply entrenched drainage way eroded by Rocky Run Creek.
0.1	15.5	Looking back and to the right is the third dam that was constructed across Rocky Run Creek helping to protect the town of Tiskilwa from flooding (see route map). Enter the city of Tiskilwa—named after Chief Tiskilwa. This area was a settlement of Potowatomie Indians. It originally sprang up from a small settlement called Indiantown and was renamed Tiskilwa in 1840.
0.5	16.0	STOP (two-way). Cross street intersection (North Galena/1800 East and West Brewster). TURN RIGHT.
0.1	16.1	Cross street intersection, two-way stop from right and left (North Galena/1800 East and Main Street). TURN LEFT onto Main Street. The Tiskilwa Bible Church is located on the southeast corner of the intersection.
0.2	16.3	The Methodist Church, large red brick building on the left, was erected in 1855. Several older large red brick homes are on the right. The clay that was used to make the bricks reportedly came from a local source.
0.15	16.45	T-intersection from the right (State Street and East Main Street). TURN RIGHT onto State Street.
0.1	16.55	Cross street intersection (East First and State Street). TURN LEFT onto East First.

0.15	16.7	Leaving the City of Tiskilwa.
0.05	16.75	T-intersection from the right (South Bound Road). CONTINUE AHEAD.
0.75	17.5	T-intersection from the right (1925 East and 980 North). CONTINUE AHEAD and cross Plow Hollow Creek. Great exposures of valley-fill materials along the banks of the creek to the right. Note the extremely flat topography to the right as you head east. This topography was formed by a combination of slack-water lakes formed in response to flooding along the Illinois River during the melting of the receding glaciers and during modern flooding along Big Bureau Creek. These flat-lying areas form the floodplain along Big Bureau Creek.
0.8	18.3	T-intersection from the right (2000 East). CONTINUE AHEAD.
0.5	18.8	T-intersection from the left (2050 East and 1030 North). CONTINUE AHEAD.
0.5	19.3	Road curves 90 degrees to the right.
1.2	20.5	T-intersection from the left (2160 East). CONTINUE AHEAD. Old steel truss bridge across Bureau Creek on the left.
0.4	20.9	T-intersection from the right (2190 East). CONTINUE AHEAD. Great view of Big Bureau Creek and its meanders on the left (see route map).
0.9	21.8	Cross small unnamed creek.
1.0	22.8	T-intersection from the right (2360 East and 1045 North). CONTINUE AHEAD.
0.05	22.85	Pass under Interstate 180.
1.65	24.5	Exposure of Radner Till Member of the Glasford Formation and the overlying till of the Batestown Member of the Lemont Formation of the Wedron Group on the right.
0.1	24.6	STOP (one-way). T-intersection (2450 East/Illinois Route 29 and 910 North). TURN LEFT onto Illinois Route 29 (heading north).
0.05	24.65	Cross Big Bureau Creek
0.1	24.75	T-intersection from the right (Illinois Route 26 South). TURN RIGHT, heading toward Hennepin.
1.05	25.8	Pass under Interstate 180.
0.1	25.9	Entrance ramp to Interstate 180 to the left. TURN LEFT onto entrance ramp, and merge onto Interstate 180.

0.9	26.8	Enter bridge over the Illinois River.
0.3	27.1	Middle of the Illinois River. Generally there is a great view of barge traffic to the right and left. Hennepin is located to the right along the east side of the Illinois River.
0.75	27.85	Exit ramp on the right (Illinois Route 26 South and Hennepin). CONTINUE AHEAD. A large upper level terrace (the Hennepin Terrace) extends northward from Hennepin for about 5 miles along the eastern inside curve of the Big Bend in the Illinois River. The 550-foot contour line on the topographic map roughly outlines the extent of this terrace. A number of sand dunes are scattered along the top of this terrace (see route map).

NOTE: To visit the ALTERNATE STOP 8, take this exit ramp and follow Illinois Route 26 South. A detailed route description leading to ALTERNATE STOP 8 is included at the end of this Guide to the Route.

0.45	28.3	Interstate 180 ends, and Illinois Route 71 begins.
1.2	29.5	Crossroad intersection (875 East and 1050 North). CONTINUE AHEAD.
0.2	29.7	Road begins ascent onto the Varna/Mt. Palatine Moraines. These two moraines are piggybacked against each other in this area.
0.25	29.95	T-intersection from the right (925 East). CONTINUE AHEAD.
0.55	30.5	T-intersection from the left (975 East). CONTINUE AHEAD.
1.2	31.7	T-intersection from the left (Mennie Drive). CONTINUE AHEAD. Enter the city limits of Mark, population 400.
0.7	32.4	T-intersection from the left (1150 East/Milwaukee Street). CONTINUE AHEAD. The Mark Mine Dump is located on the left. Before this mine dump underwent reclamation by the Illinois Department of Mines and Minerals, the pile was 80 feet higher. The current elevation at the top of the pile is 800 feet above sea level. The top of the pile is approximately 100 feet above the level of the road. On the day of the field trip, this site will be a drive by. A discussion of the history and mining practices is provided in the Stop Descriptions.

STOP 6: Mark Mine Dump Gob Pile (Center of the western half of northeast, Sec. 8, T32N, R1W, 3rd P.M., Spring Valley 7.5-minute Quadrangle, Putnam County).

A small park is located on the north side of the spoil pile. From the top of the pile you can see the mine dumps at Dalzel to the north and at Standard to the east.

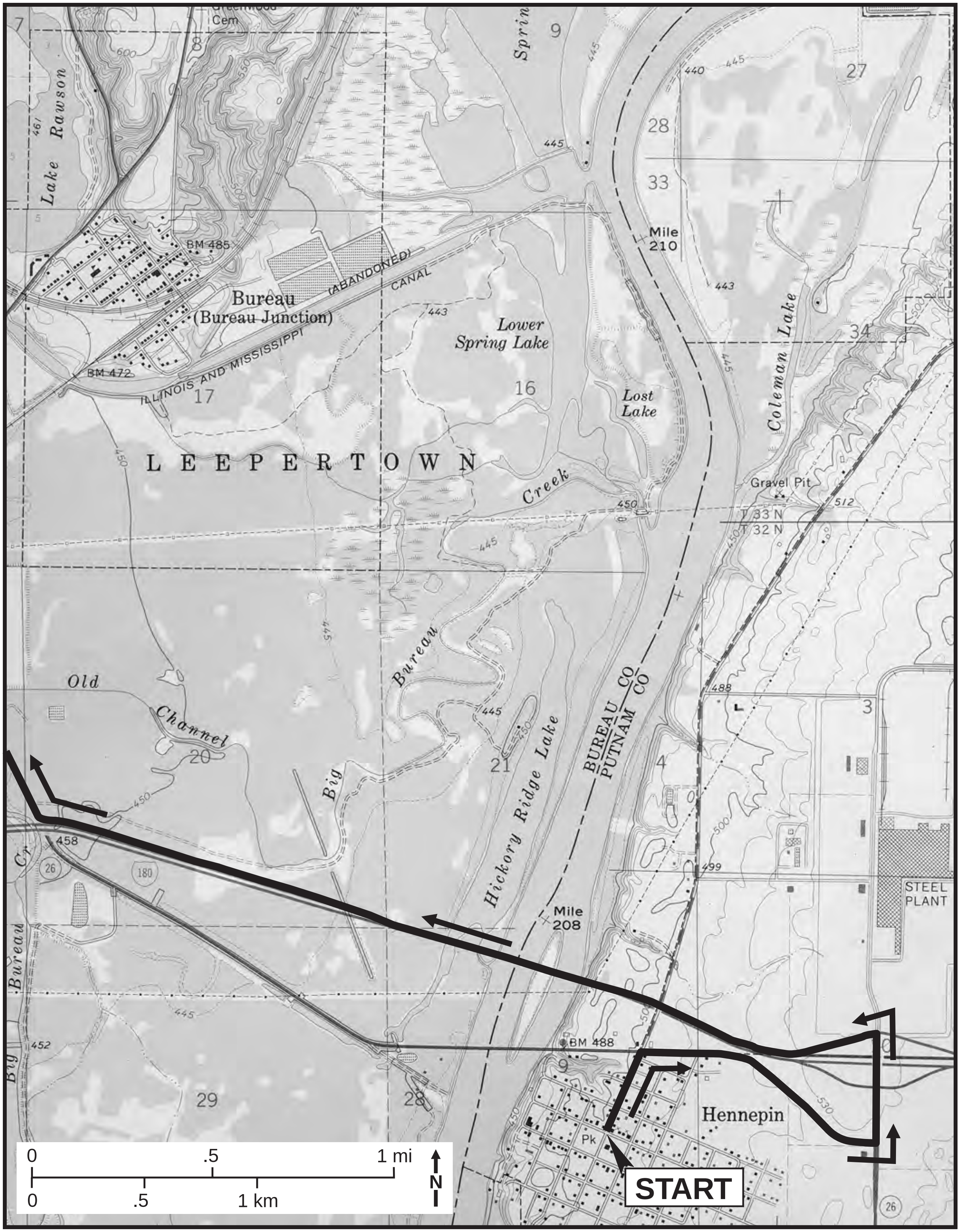
0.0	32.4	Leave Stop 5. CONTINUE AHEAD.
0.25	32.65	T-intersection from the right (1175 East). CONTINUE AHEAD.
0.2	32.85	Enter the community of Granville, population 1,407. T-intersection from the left (1200 East). CONTINUE AHEAD
0.75	33.6	CAUTION: Cross single-track railroad (signal lights only, no guard gate).
0.2	33.8	Crossroad intersection (1300 east). CONTINUE AHEAD.
1.0	34.8	STOP (four-way). Crossroad intersection (Illinois Route 71 and Illinois Route 89). TURN LEFT onto Illinois Route 89 (heading north).
0.5	35.3	Crossroad intersection (Granville Road/1100 North). CONTINUE AHEAD.
1.55	36.85	Crossroad intersection (1250 North). CONTINUE AHEAD.
0.65	37.5	Road begins sharp descent toward the Illinois River valley.
0.3	37.8	CAUTION: Slow down and prepare to turn right at the base of the bluffs.
0.2	38.0	Crossroad intersection (1360 North and 1410 East). TURN RIGHT.
0.1	38.1	Pennsylvanian limestone and shale exposed on a strip bench on the right.
0.1	38.2	T-intersection from the right (entrance to sand and gravel pit). TURN RIGHT into the sand and gravel pit. Stops 7A and 7B. Please follow safety and parking directions from the ISGS staff.

STOP 7A: Bonucci Sand and Gravel Pit - Pearl Formation (NE, NE, SW, Sec. 26, T33N, R1W, 3rd P.M., Spring Valley 7.5-minute Quadrangle, Putnam County).

To visit Stop 7B, follow the road out of the sand and gravel pit and walk along the south edge of the paved road (1360 North) to the left. Stop 7B is located southeast of the junction of 1360 North and 1410 East, on the hillside.

STOP 7B: Pennsylvanian Outcrop (SE, SW, NE, Sec. 26, T33N, R1W, 3rd P.M., Spring Valley 7.5-minute Quadrangle, Putnam County).

END OF FIELD TRIP


Greenwood Cem
Lake Rawson
Bureau
(Bureau Junction)
BM 485
BM 472
ILLINOIS AND MISSISSIPPI CANAL (ABANDONED)
Lower Spring Lake
Lost Lake
LEEPERTOWN
Creek
Coleman Lake
Mile 210
Gravel Pit
T 33 N
T 32 N
Old Channel
Big Bureau
Hickory Ridge Lake
BUREAU CO
PUTNAM CO
Mile 208
STEEL PLANT
BM 488
Hennepin
Pk
Bureau Cr
Big
START
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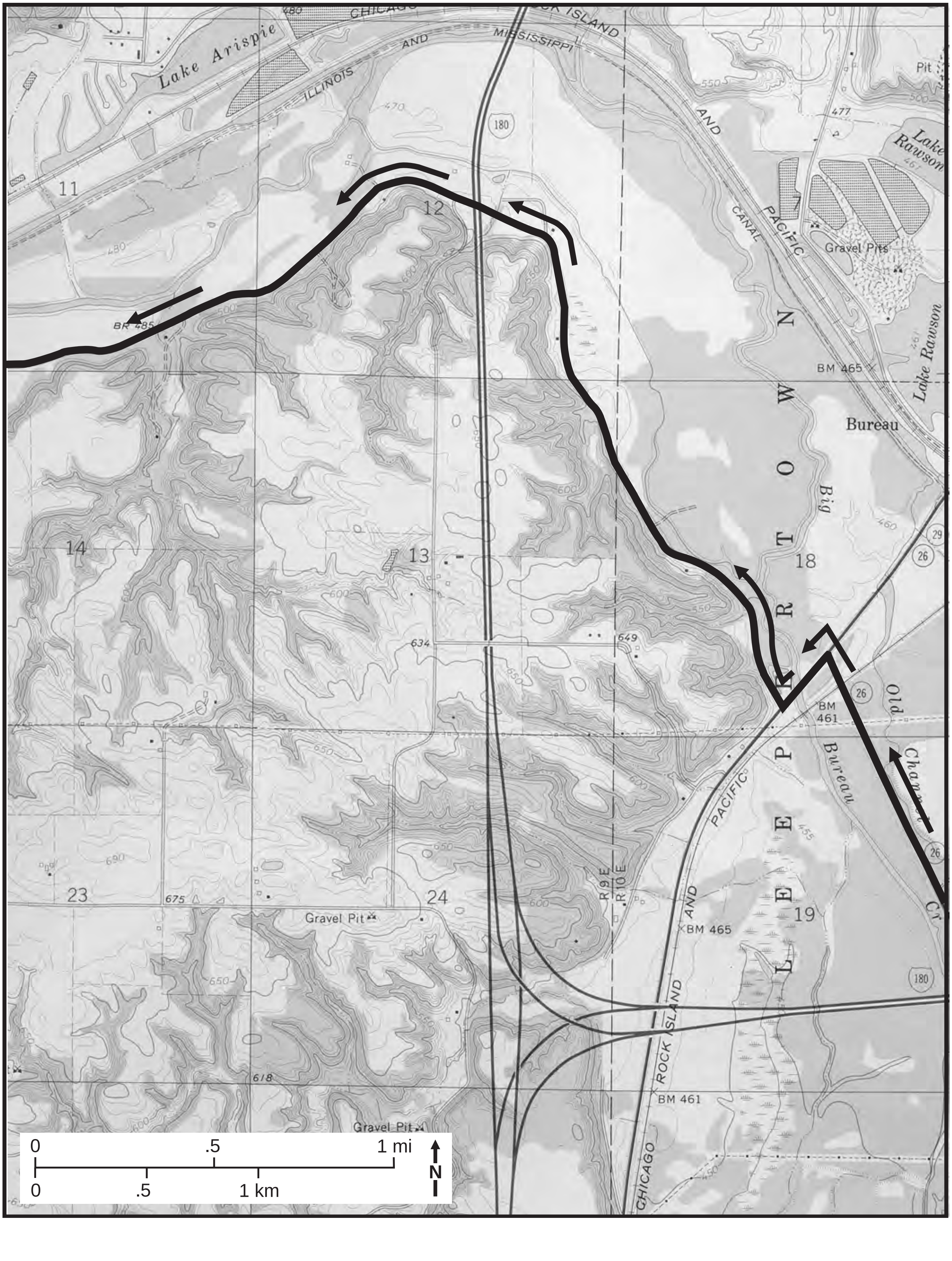
Lake Arispie
CHICAGO
ROCK ISLAND
AND
MISSISSIPPI
ILLINOIS
AND
PACIFIC
CANAL
Lake Rawson
Lake Rawson
Gravel Pits
Pit
Bureau
Big
Bureau
Old
Channel
Cr.
BM 465
BM 461
BM 465
BM 461
BR 485
R9E
R10E
Gravel Pit
Gravel Pit
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12
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14
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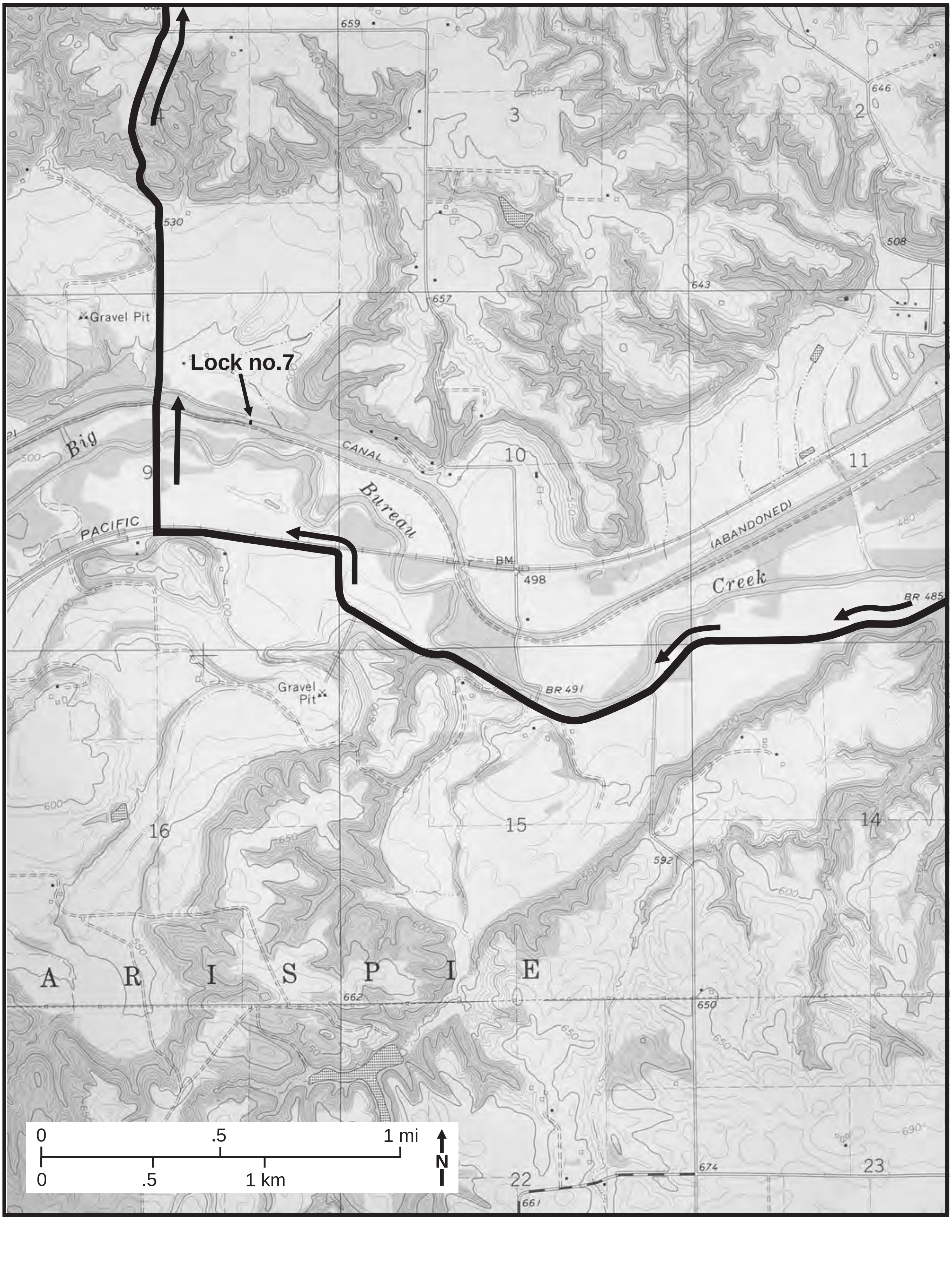

Lock no.7
Gravel Pit
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CANAL
Bureau
PACIFIC
(ABANDONED)
Creek
Gravel Pit
A R I S P I E
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0 .5 1 km
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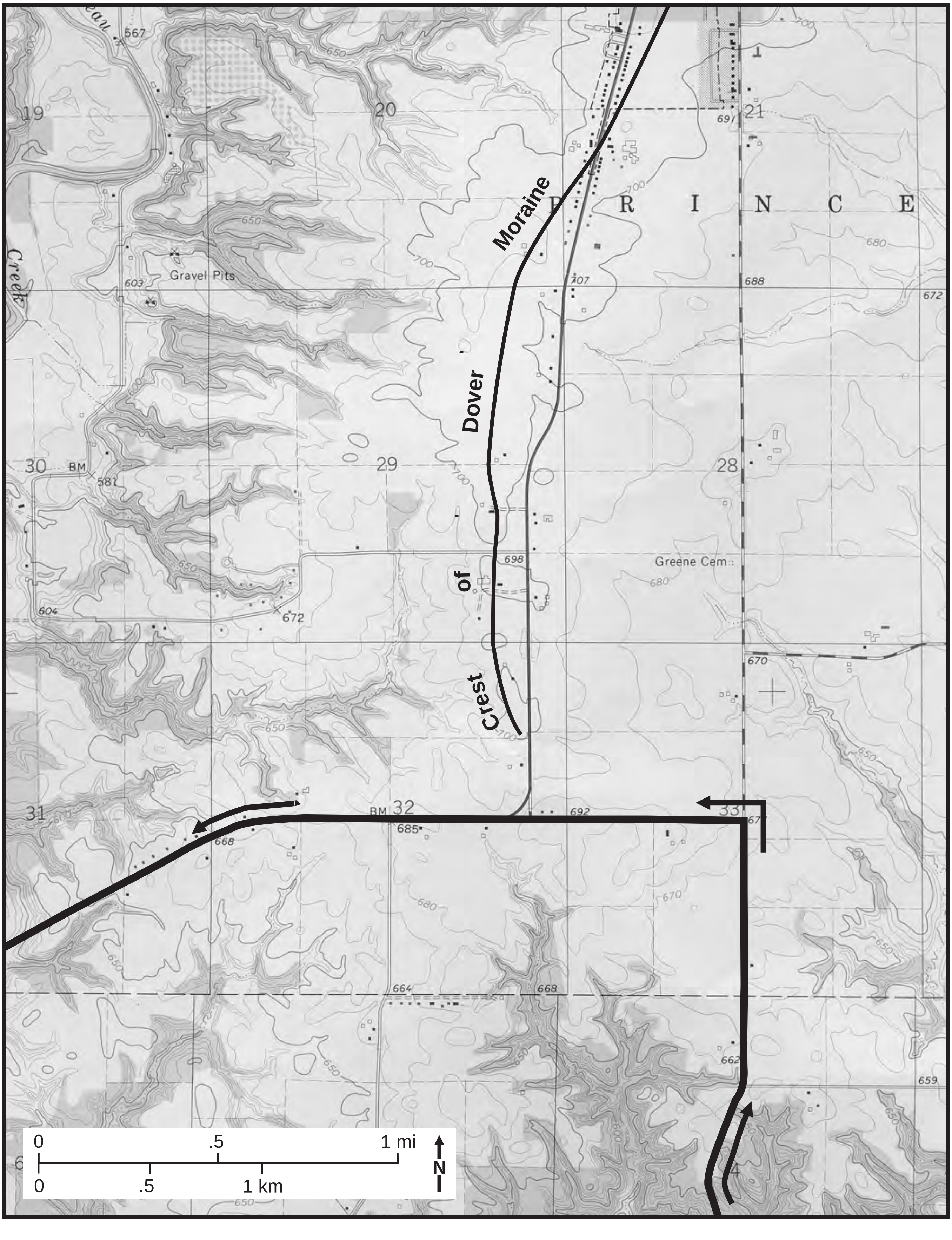

Moraine
Dover
of
Crest
P R I N C E
Gravel Pits
Creek
Greene Cem
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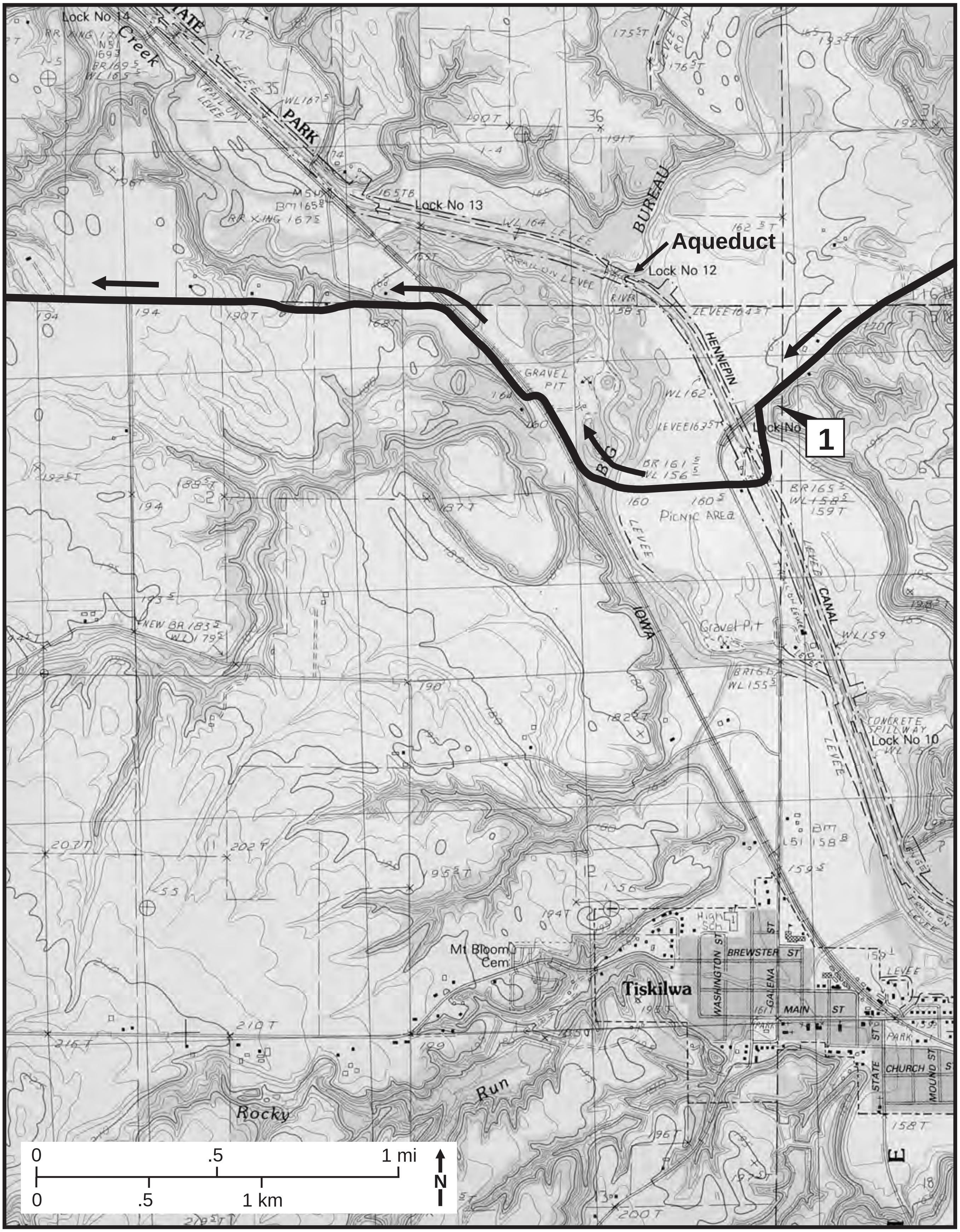
Aqueduct
Lock No 14
Lock No 13
Lock No 12
Lock No 10
1
Creek
PARK
BUREAU
HENNEPIN
CANAL
IOWA
BIG
GRAVEL PIT
Picnic Area
Gravel Pit
CONCRETE SPILLWAY
Mt Bloom Cem
Tiskilwa
High Sch
WASHINGTON ST
BREWSTER ST
GALENA
MAIN ST
STATE ST
CHURCH ST
MOUND ST
PARK
Rocky
Run
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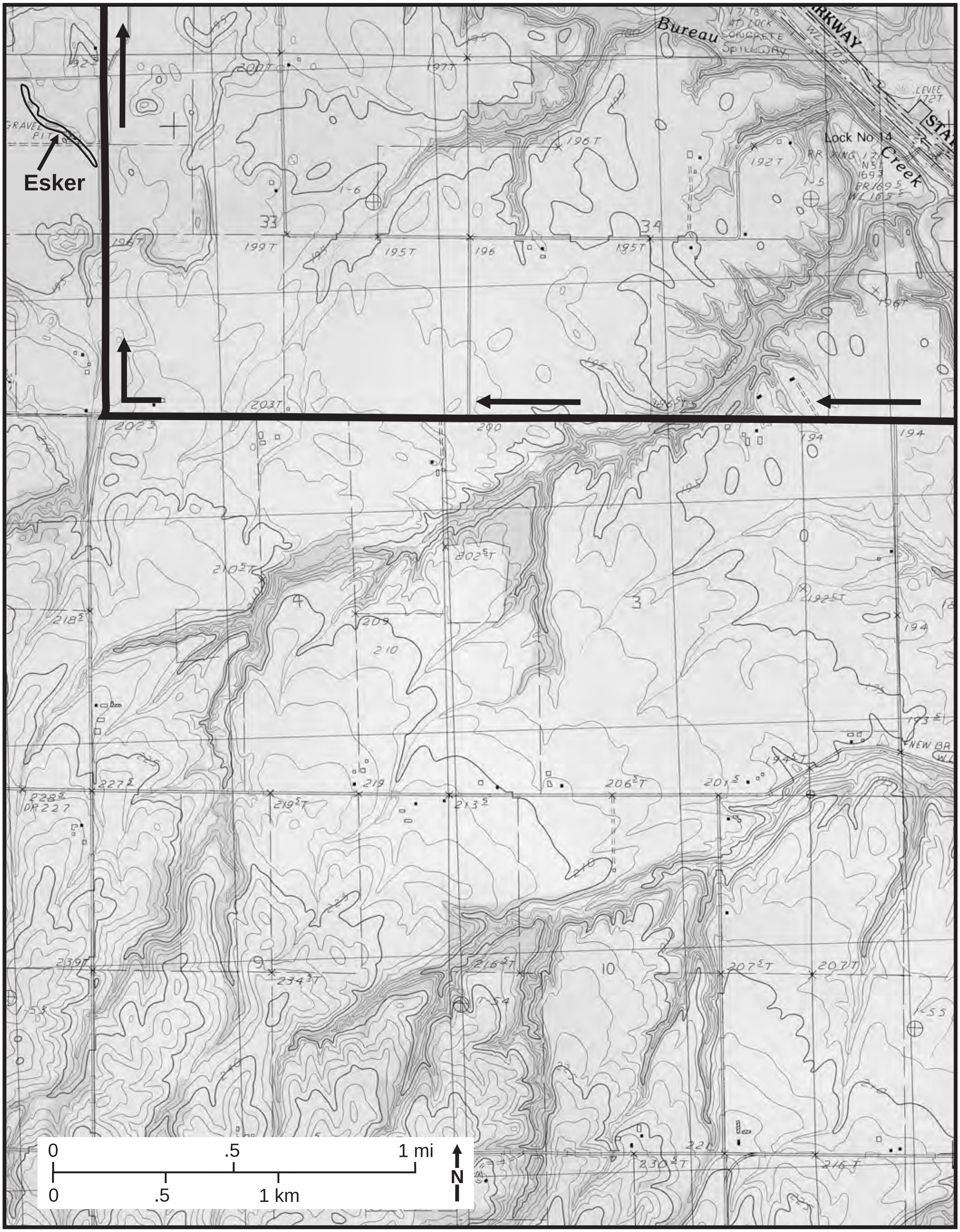
Esker
Bureau
Lock No 14
Creek
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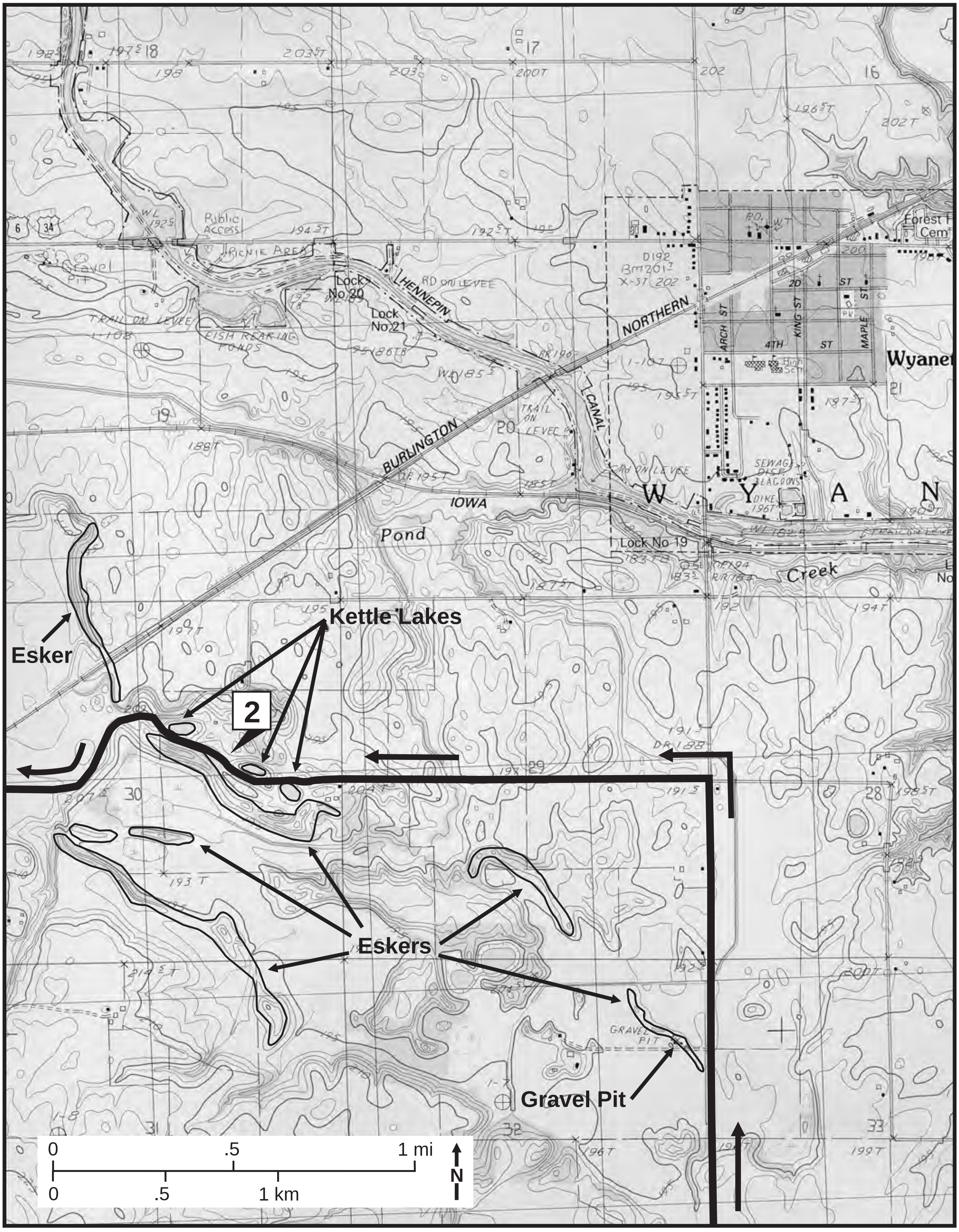
Kettle Lakes
2
Esker
Eskers
Gravel Pit
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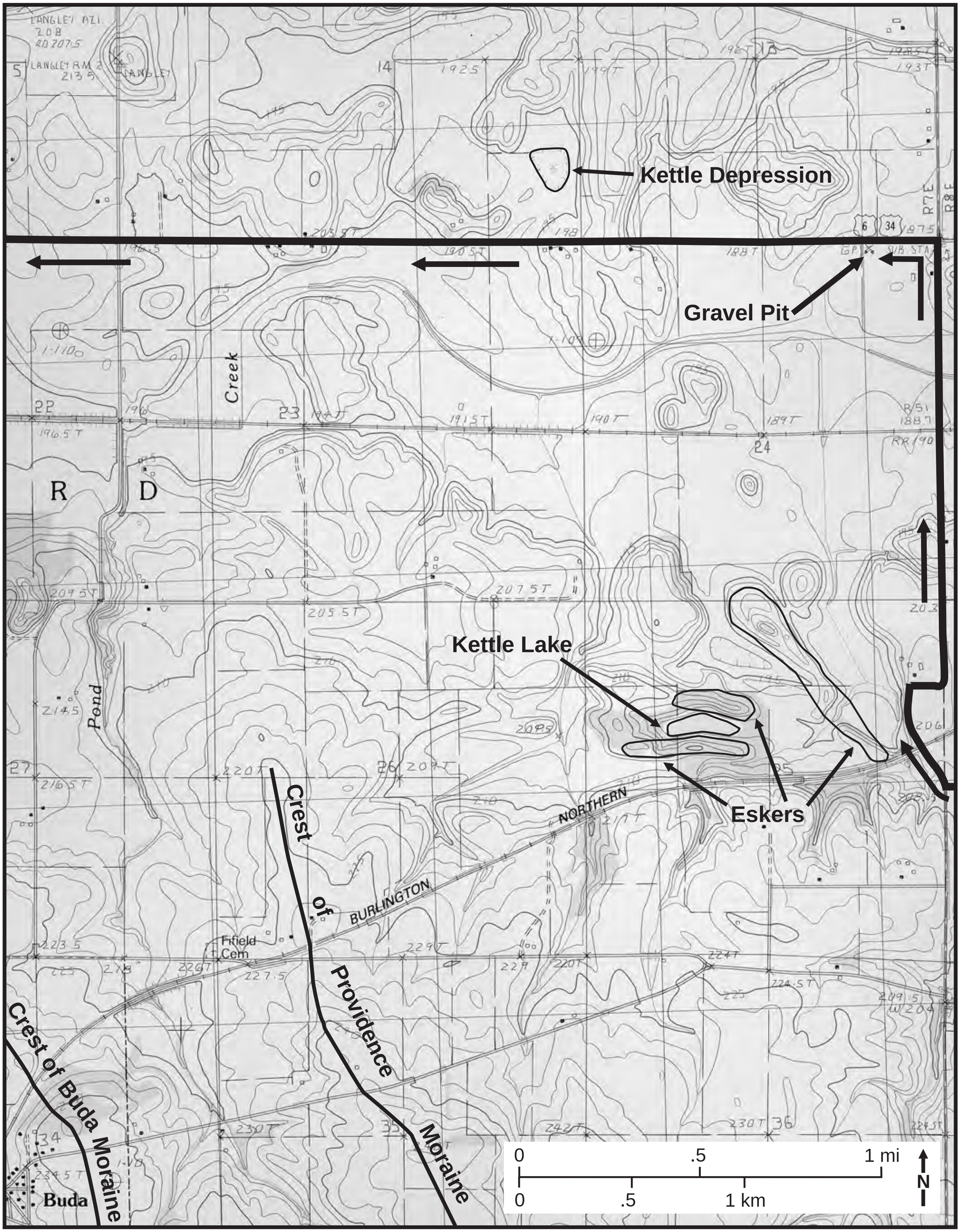
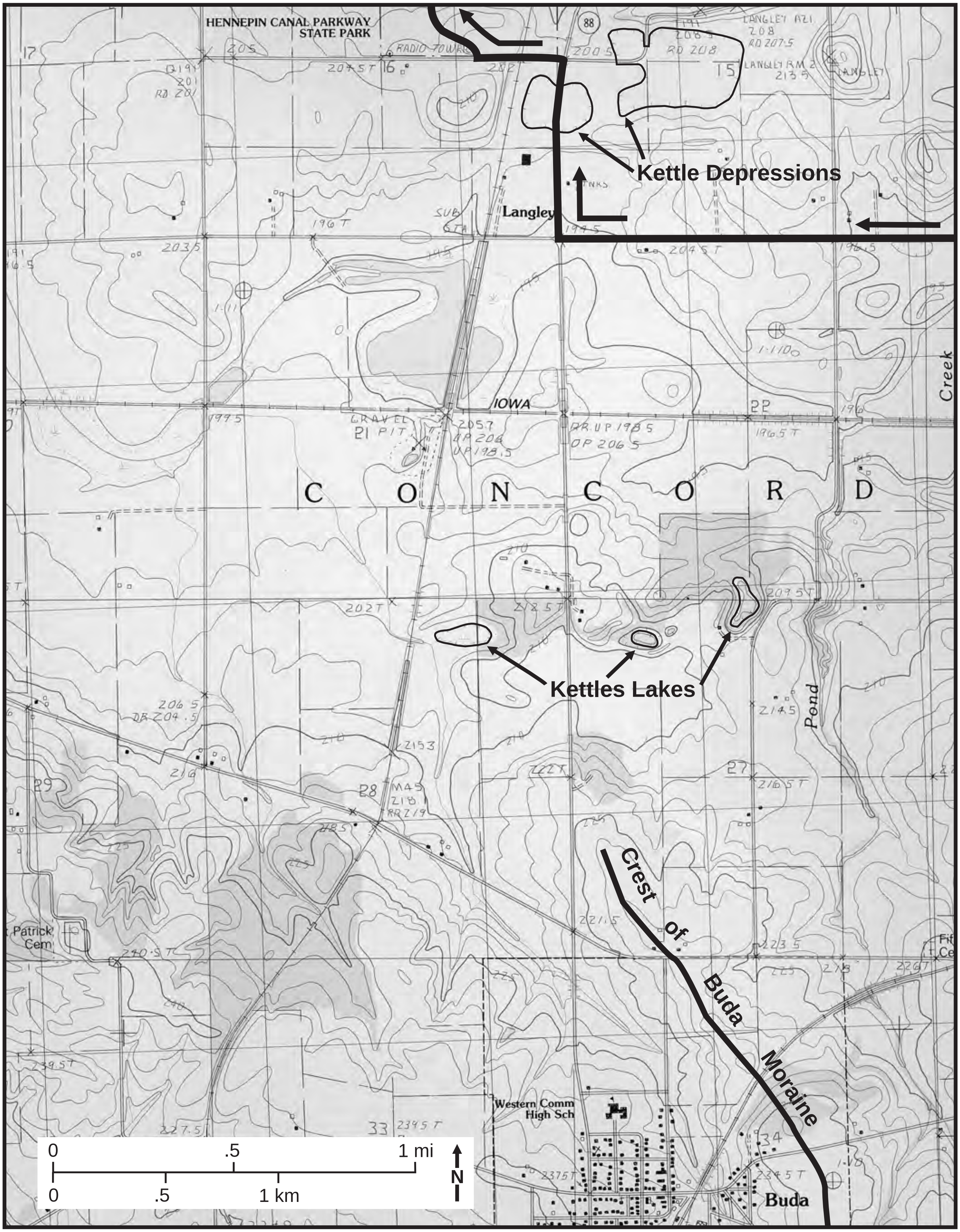
N
Wyanet
Lock No 20
Lock No.21
Lock No 19
HENNEPIN
CANAL
BURLINGTON
NORTHERN
IOWA
Pond
Creek



Kettle Depression
Gravel Pit
Kettle Lake
Eskers
Crest of Providence Moraine
Crest of Buda Moraine
Creek
Pond
NORTHERN
BURLINGTON
Fifield Cem
Buda
R
D
0 .5 1 mi
0 .5 1 km
N


HENNEPIN CANAL PARKWAY
STATE PARK
Kettle Depressions
Langley
IOWA
GRAVEL
PIT
C O N C O R D
Kettles Lakes
Creek
Pond
Crest of Buda Moraine
Western Comm
High Sch
Buda
0
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1 mi
0
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1 km
N


3
LUNCH
HENNEPIN CANAL PARKWAY
STATE PARK
C O N C O R D
HASBROOK
LATERAL
CHICAGO
HENNEPIN
BOAT RAMP
GRAVEL PIT
DITCH
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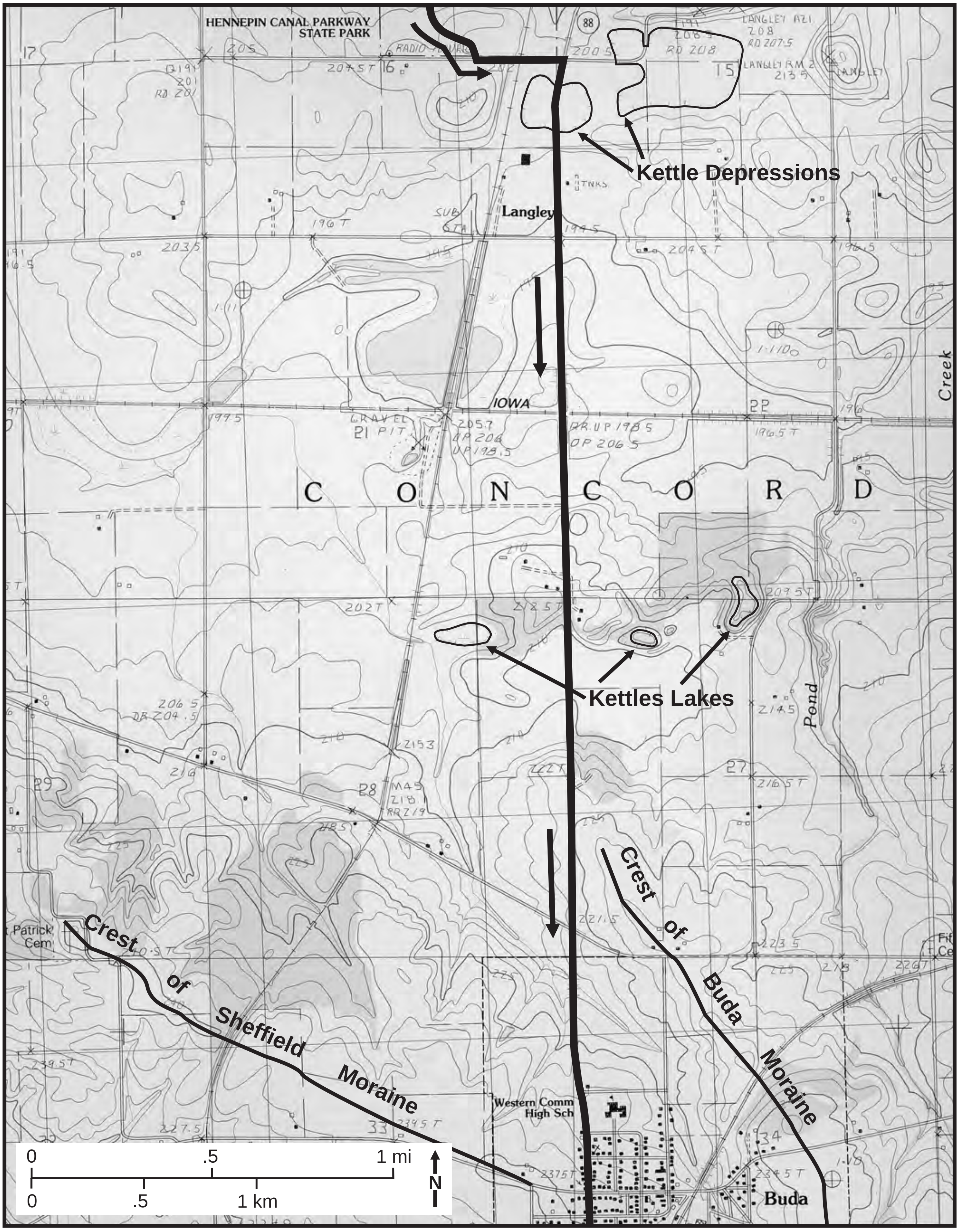
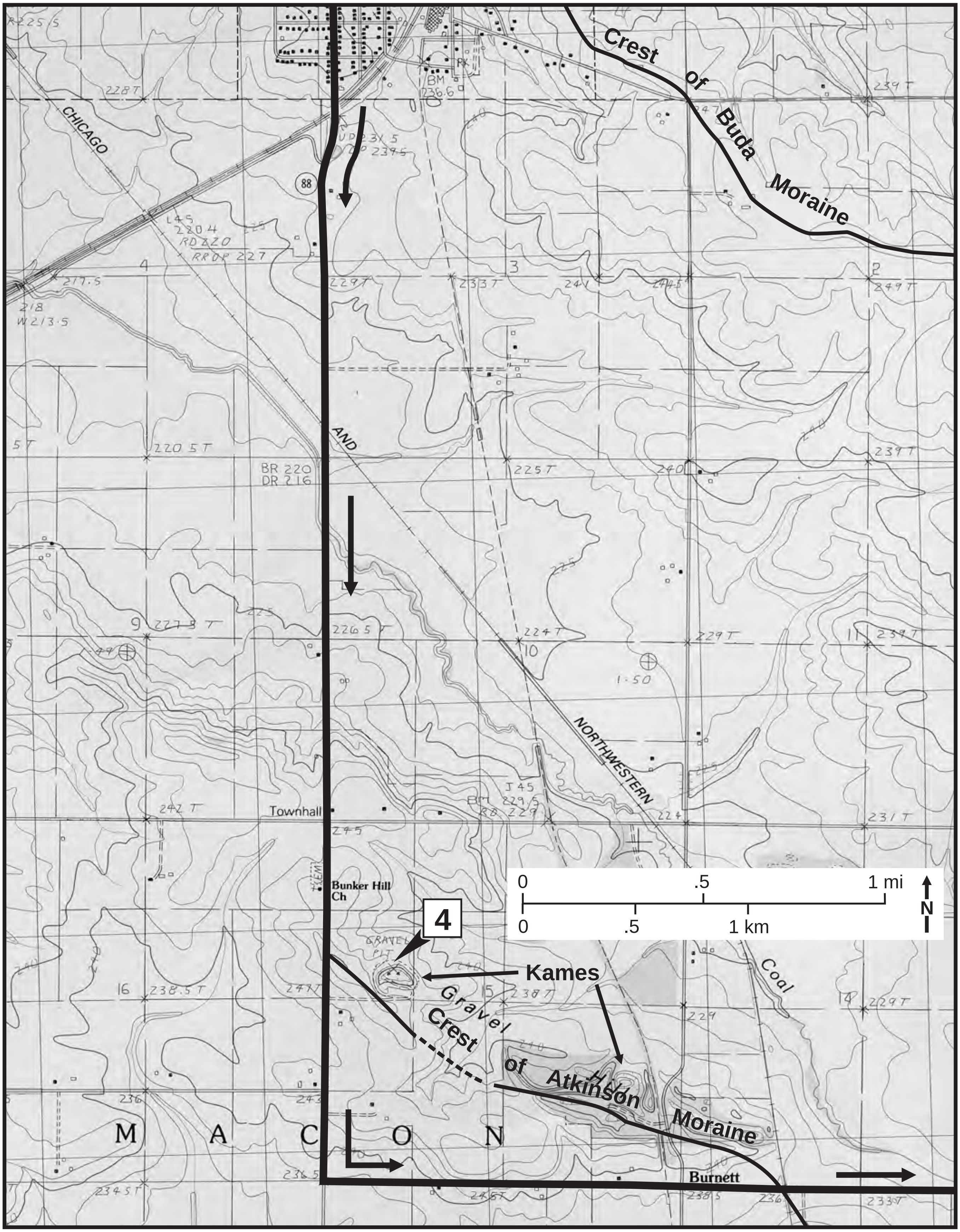
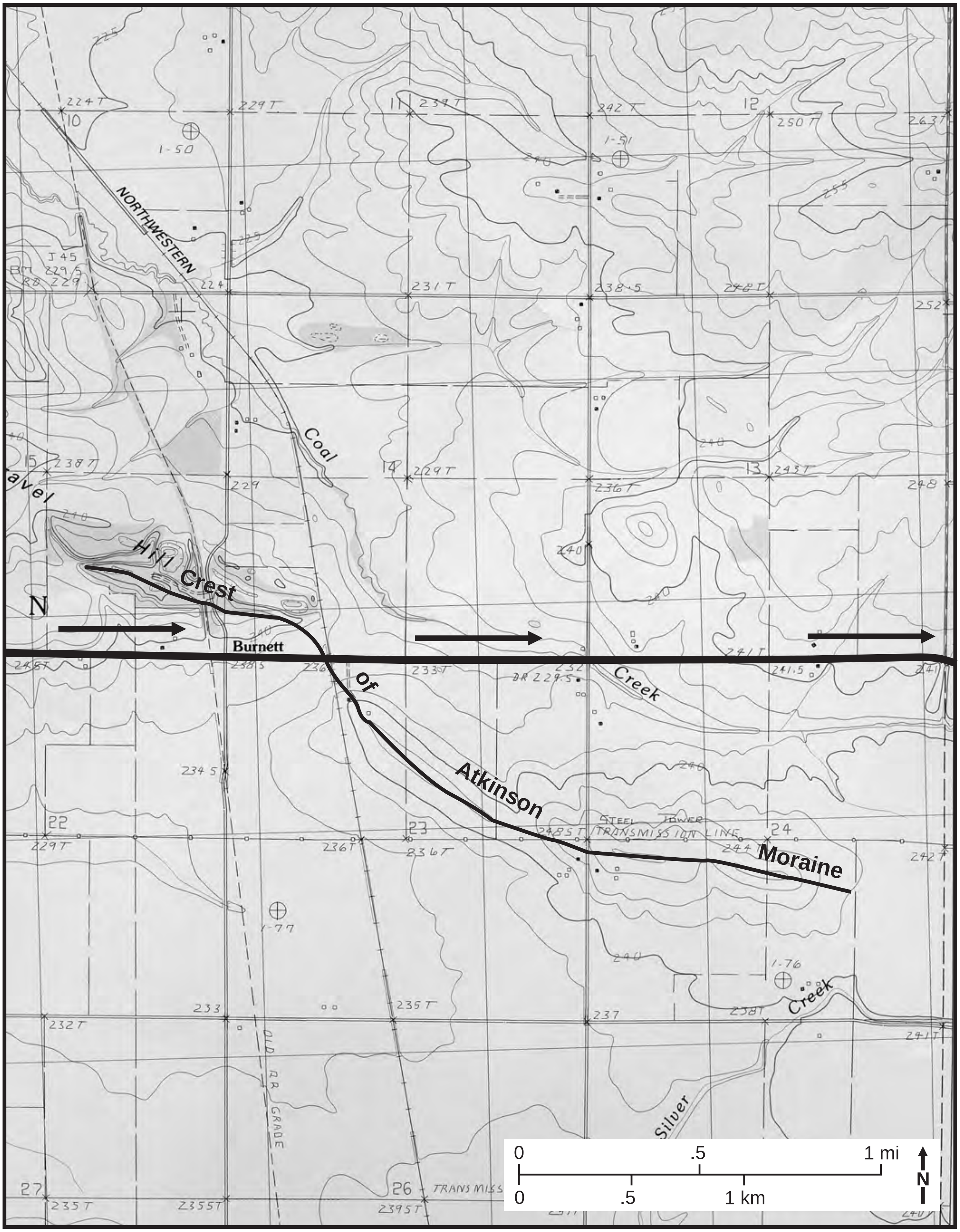
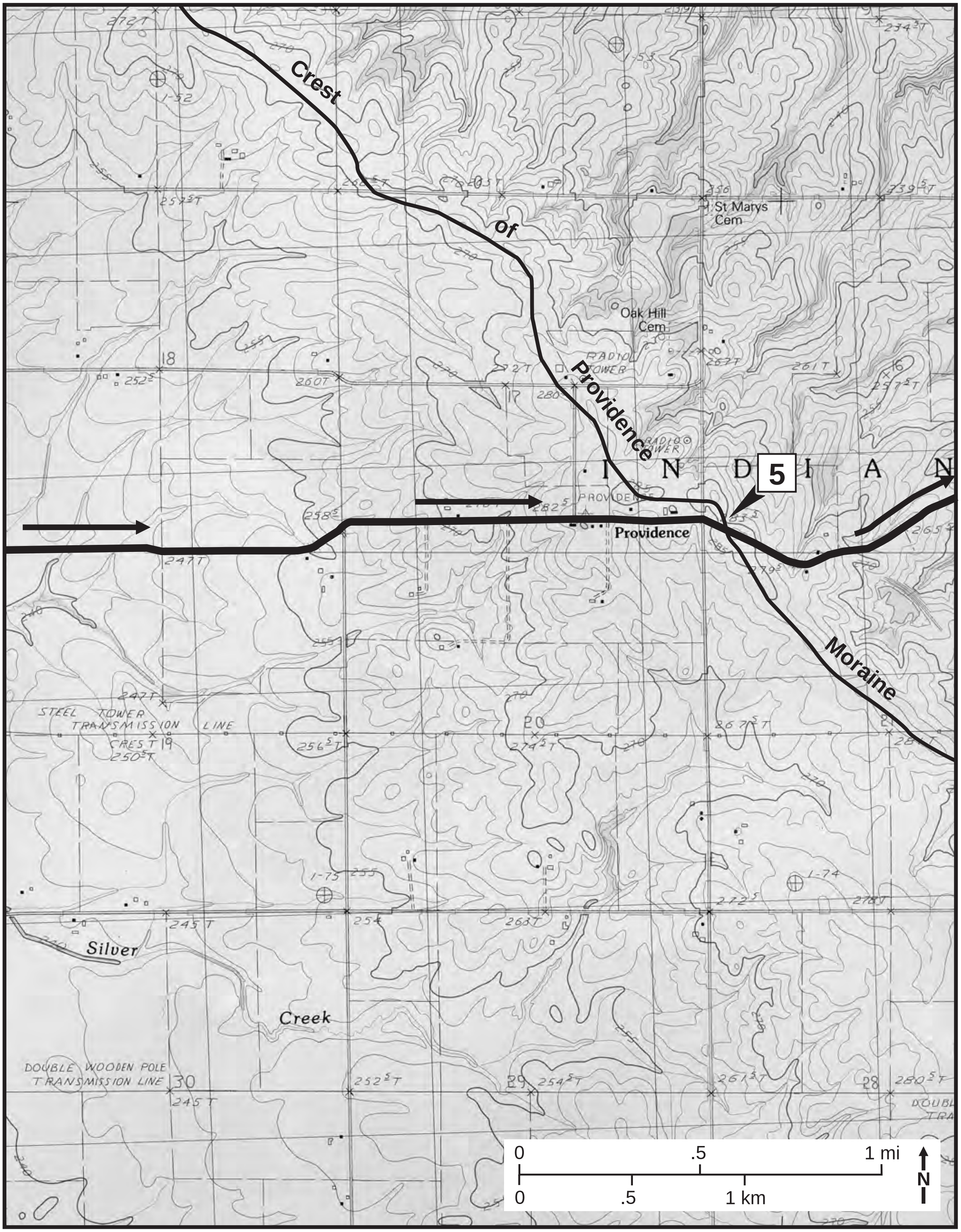
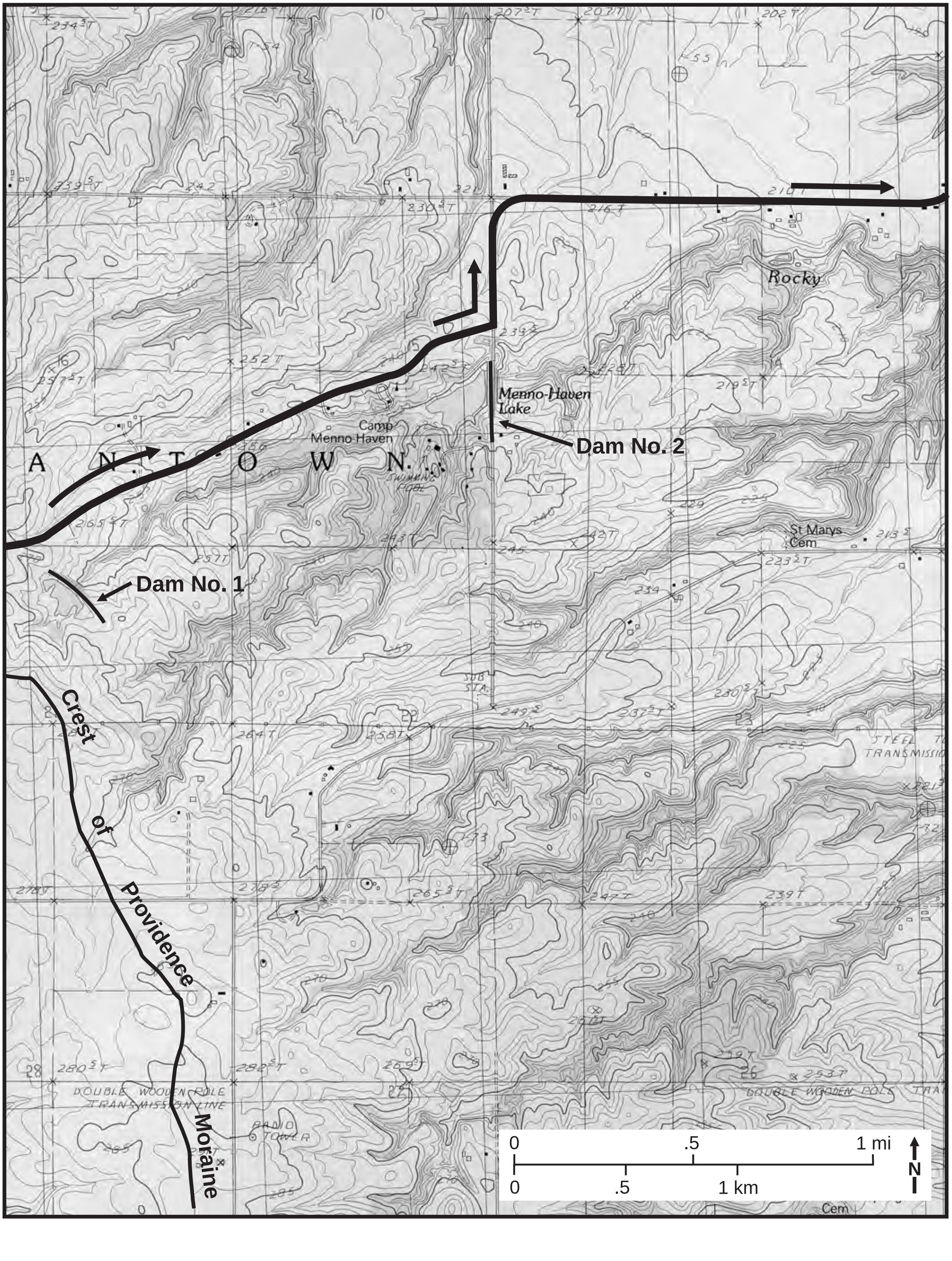
N

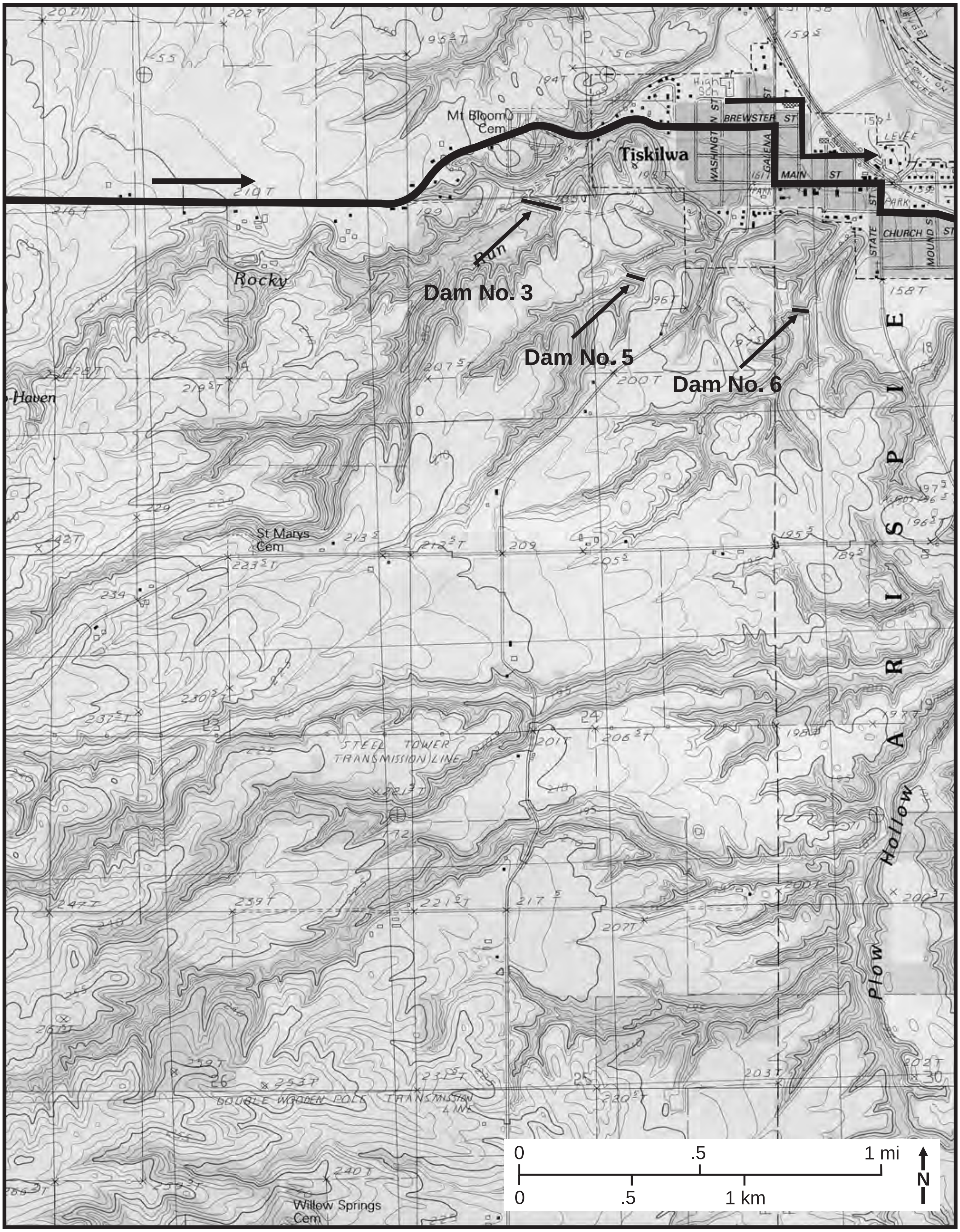

HENNEPIN CANAL PARKWAY STATE PARK
Kettle Depressions
Langley
IOWA
C O N C O R D
Kettles Lakes
Crest of Buda Moraine
Crest of Sheffield Moraine
Western Comm High Sch
Buda
Pond
Creek
0 .5 1 mi
0 .5 1 km
N

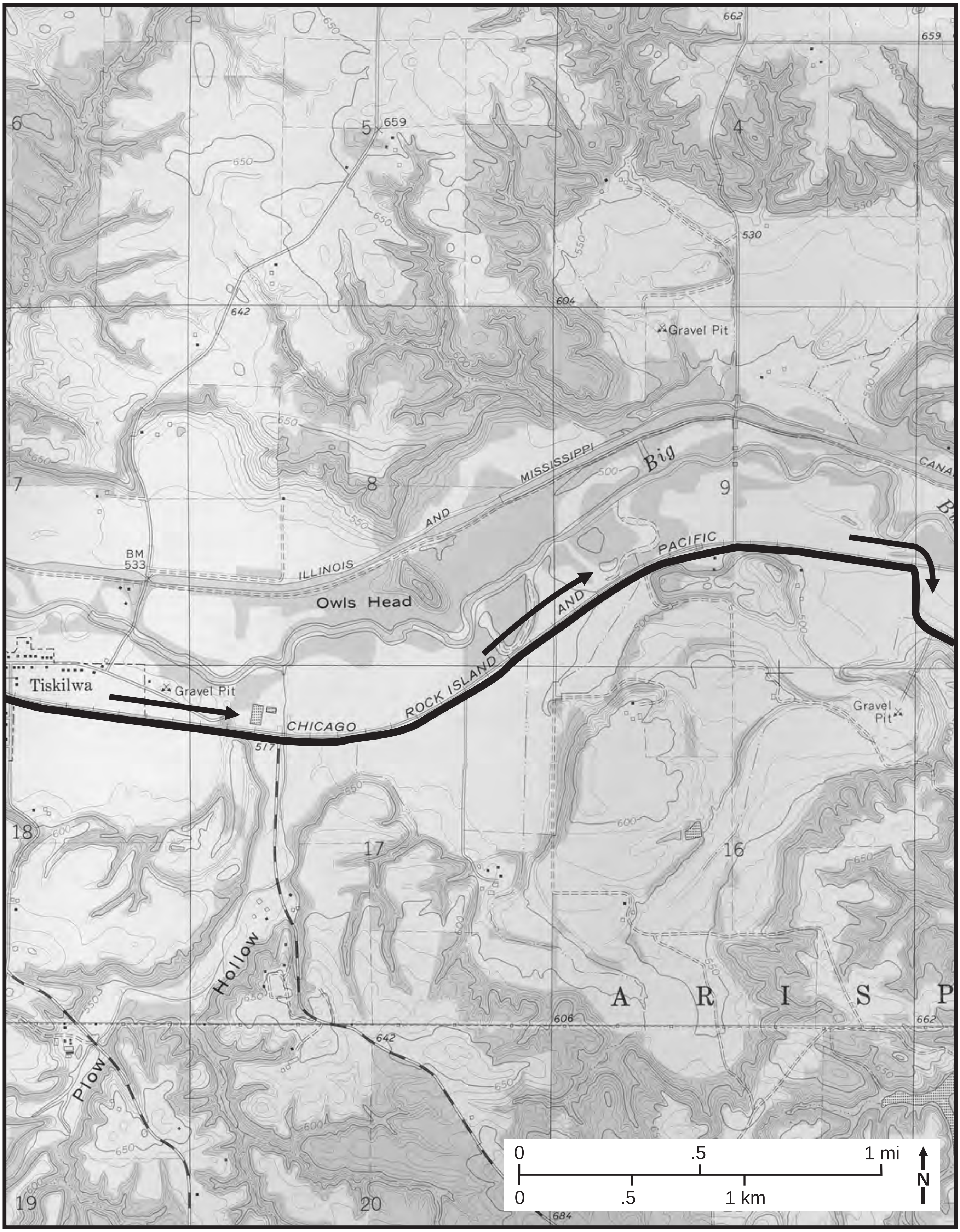

Crest of Buda Moraine
CHICAGO
AND
NORTHWESTERN
Townhall
Bunker Hill Ch
4
GRAVEL PIT
Kames
Gravel Crest of Atkinson Moraine
Hill
Coal
M A C O N
Burnett
0 .5 1 mi
0 .5 1 km
N


NORTHWESTERN
Coal
Hill
Crest
of
Atkinson
Moraine
N
Burnett
Creek
Creek
Silver
STEEL TOWER
TRANSMISSION LINE
OLD RR GRADE
0 .5 1 mi
0 .5 1 km
N

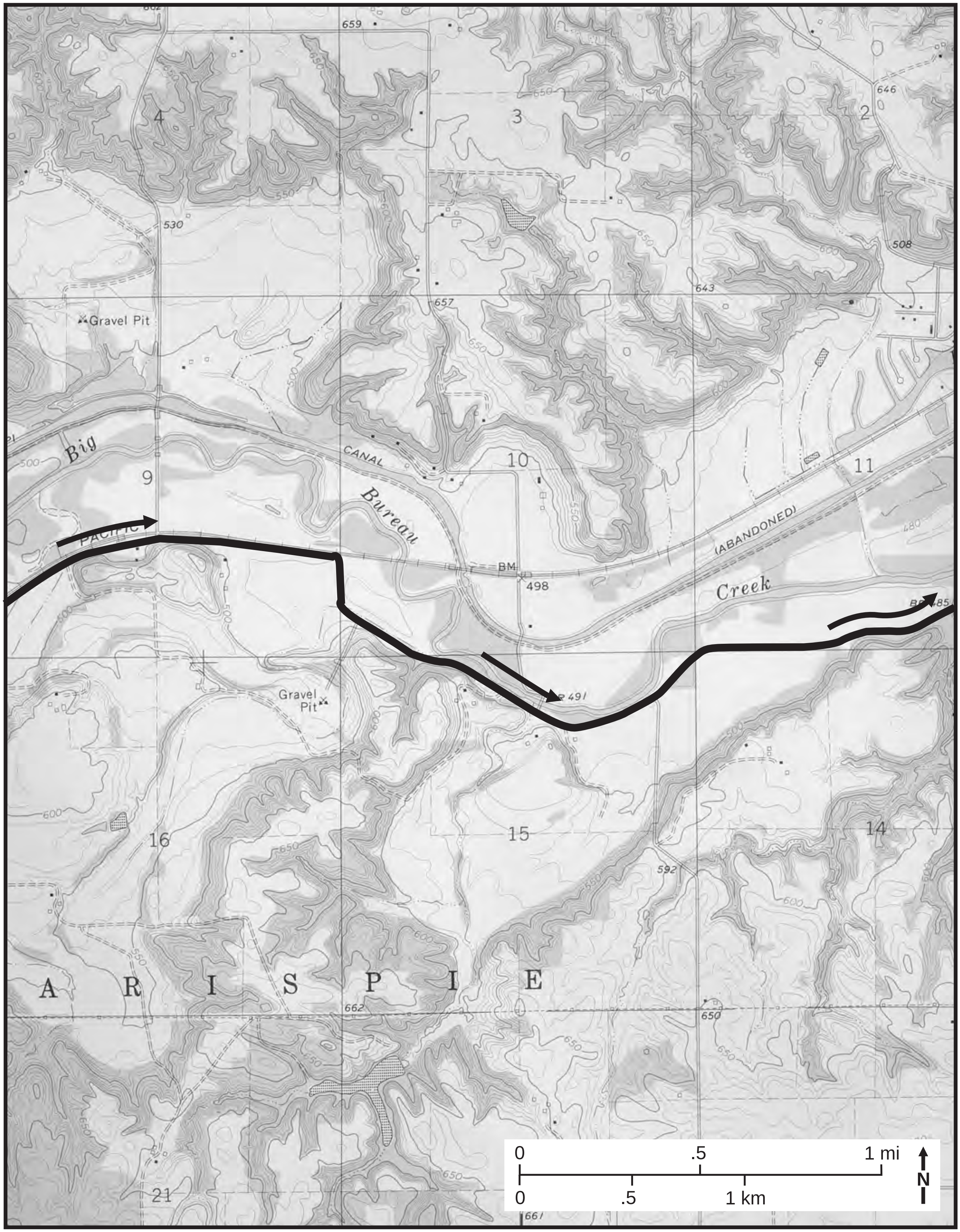

Crest
of
Providence
Moraine
5
I N D I A N
Providence
St Marys Cem
Oak Hill Cem
RADIO TOWER
STEEL TOWER TRANSMISSION LINE
DOUBLE WOODEN POLE TRANSMISSION LINE
Silver
Creek
0 .5 1 mi
0 .5 1 km
N

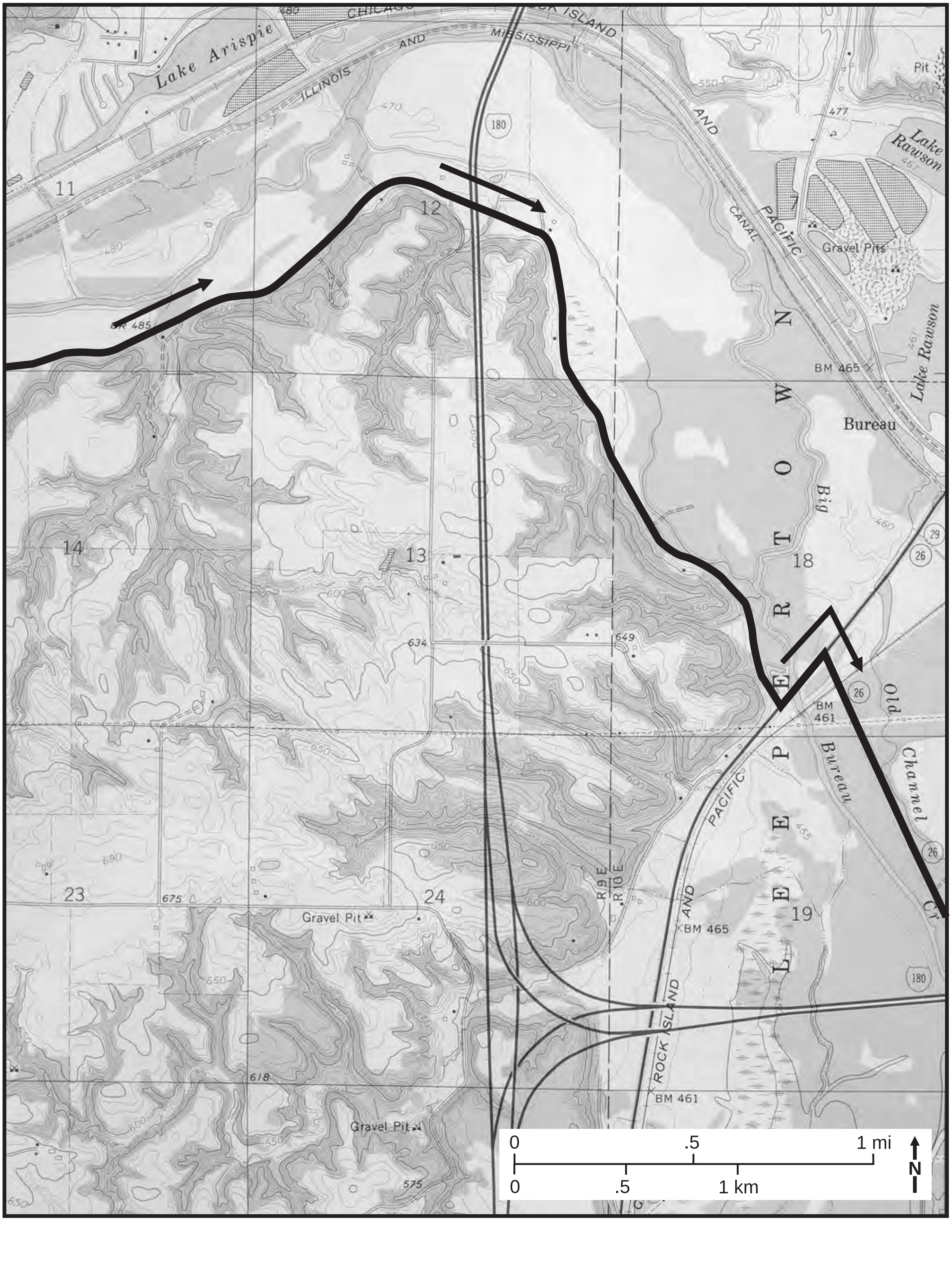

Rocky
Menno-Haven Lake
Camp Menno Haven
Dam No. 2
A N T O W N
Dam No. 1
St Marys Cem
Crest of Providence Moraine
DOUBLE WOODEN POLE TRANSMISSION LINE
RADIO TOWER
0 .5 1 mi
0 .5 1 km
N

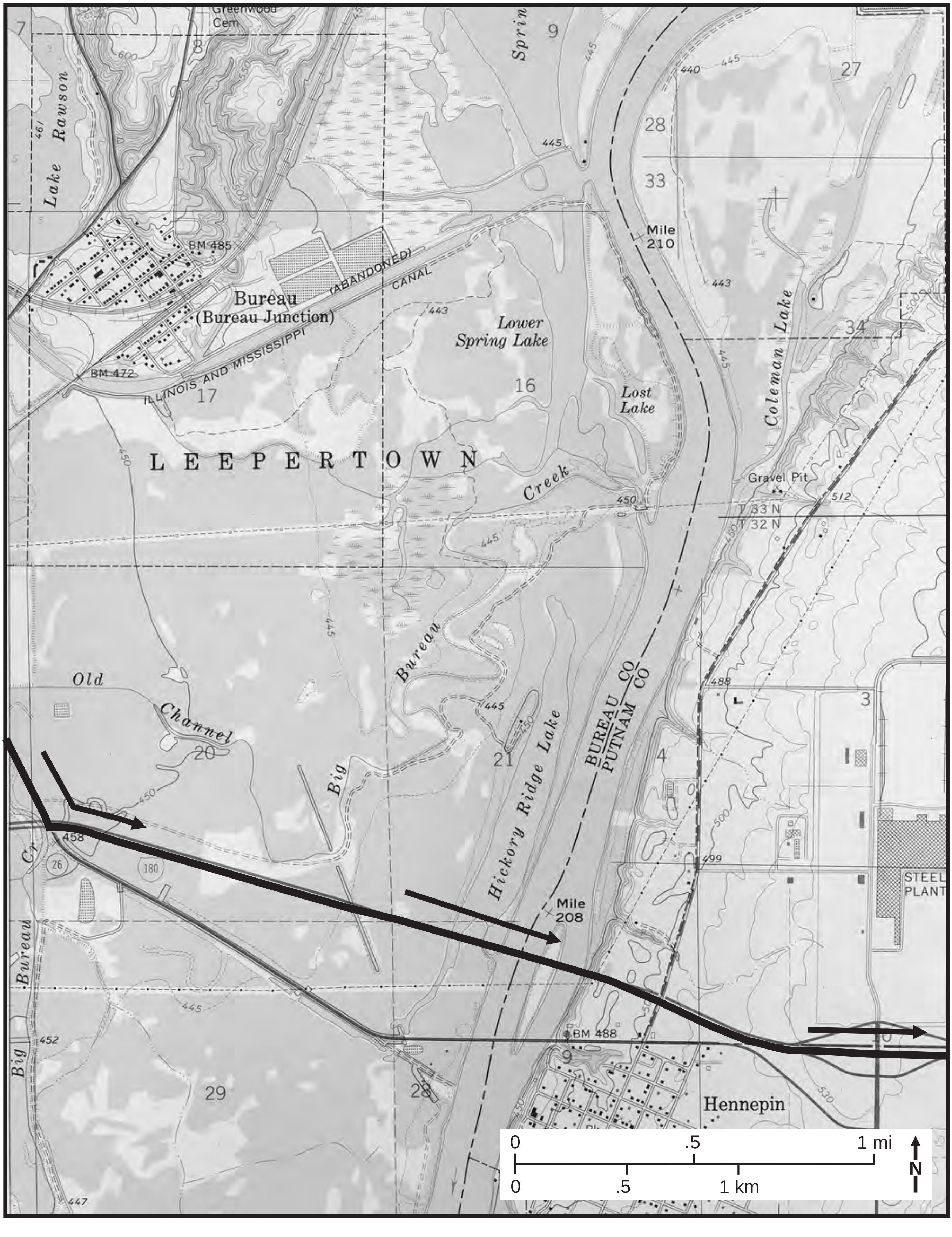

Tiskilwa
Mt Bloom Cem
High Sch
BREWSTER ST
WASHINGTON ST
GALENA ST
MAIN ST
STATE ST
PARK
CHURCH ST
MOUND ST
LEVEE
Rocky
Run
Dam No. 3
Dam No. 5
Dam No. 6
St Marys Cem
STEEL TOWER TRANSMISSION LINE
DOUBLE WOODEN POLE TRANSMISSION LINE
Willow Springs Cem
Plow Hollow
P R A I R I E
0
.5
1 mi
1 km
N



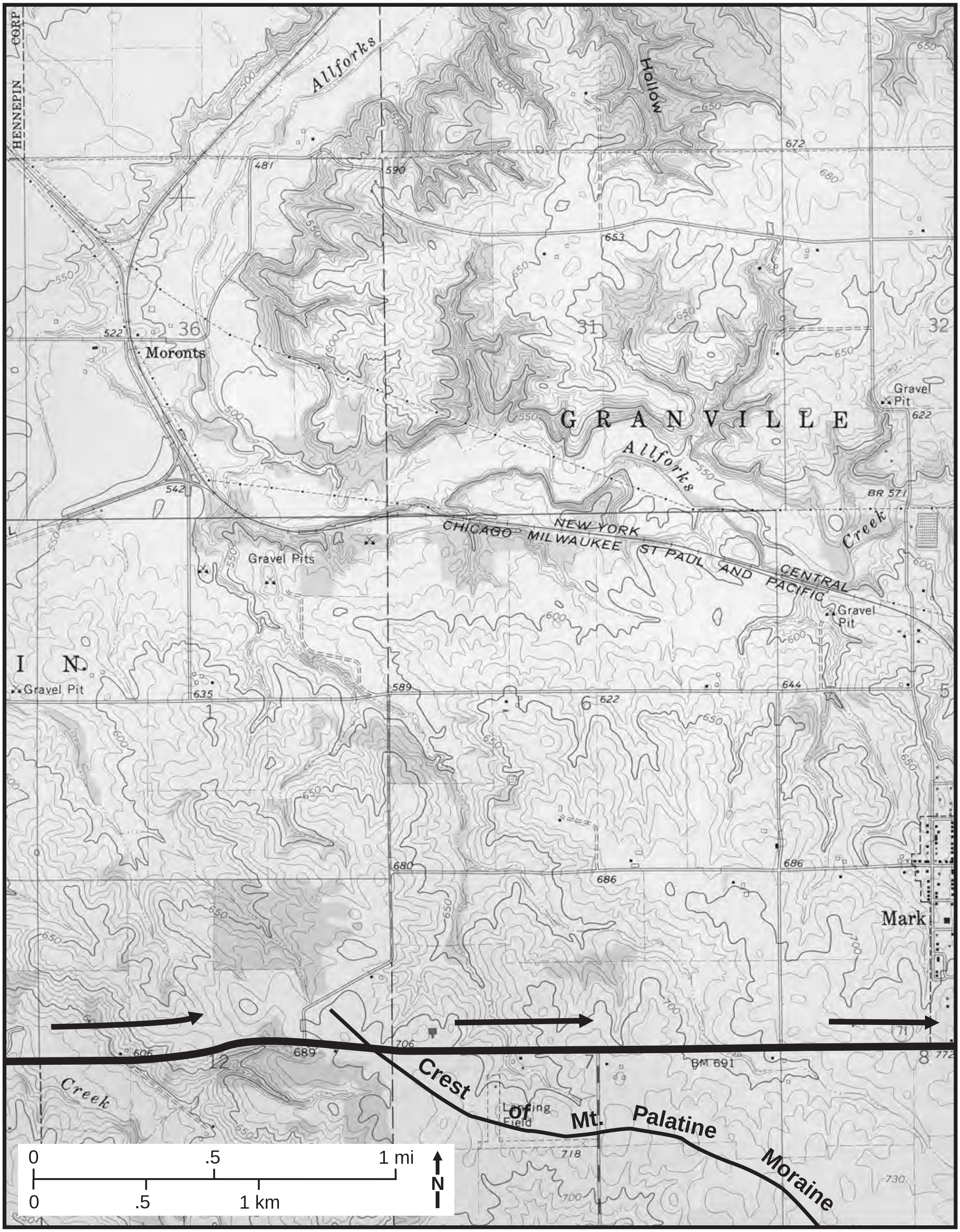
662
659
5
659
4
6
650
550
530
604
642
Gravel Pit
650
MISSISSIPPI
Big
9
8
7
500
550
CANA
AND
BM
533
ILLINOIS
PACIFIC
Owls Head
AND
ROCK ISLAND
Tiskilwa
Gravel Pit
CHICAGO
517
Gravel
Pit
650
18
600
17
16
Hollow
A R I S P
606
662
642
Plow
650
19
20
684
0
.5
1 mi
0
.5
1 km
N


Big
Bureau
Creek
CANAL
(ABANDONED)
PACIFIC
Gravel Pit
Gravel Pit
BM
498
491
A R I S P I E
4
3
2
9
10
11
16
15
14
21
0 .5 1 mi
0 .5 1 km
N


Lake Arispie
CHICAGO
ROCK ISLAND
AND
MISSISSIPPI
ILLINOIS
AND
PACIFIC
CANAL
Lake Rawson
Gravel Pits
Pit
BM 465
Bureau
Big
Bureau
Old
Channel
Cr.
HENNEPIN
TOWN
BM 461
R9E
R10E
ROCK ISLAND
AND
PACIFIC
BM 465
BM 461
Gravel Pit
Gravel Pit
11
12
13
14
18
19
23
24
0
.5
1 mi
0
.5
1 km
N

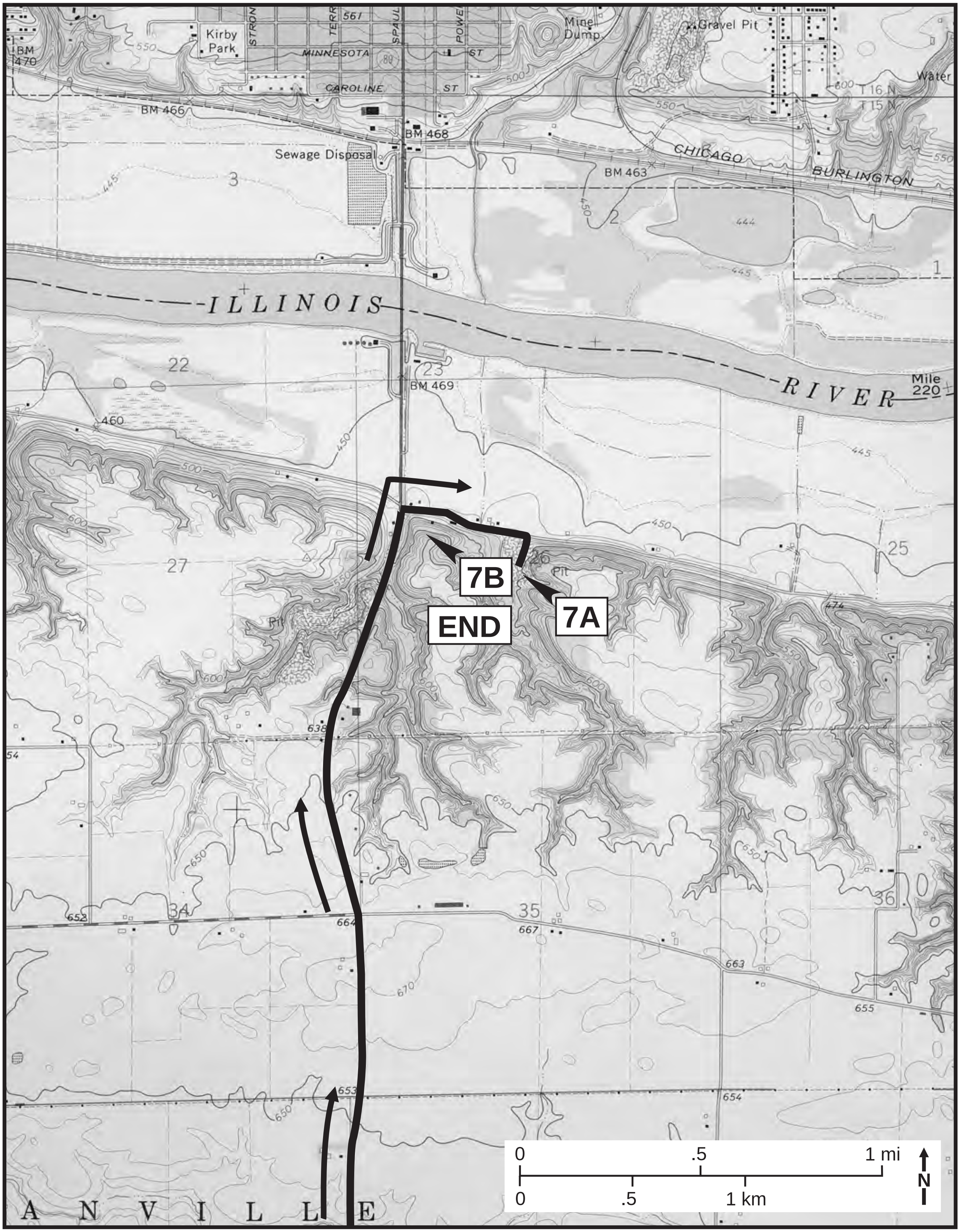

Bureau
(Bureau Junction)
LEEPERTOWN
Lower
Spring Lake
Lost
Lake
Coleman Lake
Hickory Ridge Lake
Lake Rawson
Old
Channel
Big
Bureau
Creek
ILLINOIS AND MISSISSIPPI CANAL (ABANDONED)
BUREAU CO
PUTNAM CO
Mile
210
Mile
208
Gravel Pit
T 33 N
T 32 N
STEEL
PLANT
Hennepin
Greenwood
Cem
BM 485
BM 472
BM 488
0
.5
1 mi
1 km
N

0
.5
1 mi
N
0
.5
1 km
Sand Dunes
Hennepin Terrace
HENNEPIN
Gravel Pit
Gravel Pits
Moronts
NEW YORK
CENTRAL
Substation
STEEL PLANT
Coffee
Creek
Crest of
Varna and Mt. Palatine
Moraines
Sand Dunes



HENNEPIN CORP
Allforks
Hollow
36
31
32
Moronts
GRANVILLE
Allforks
Creek
NEW YORK CENTRAL
CHICAGO MILWAUKEE ST PAUL AND PACIFIC
Gravel Pits
Gravel Pit
I N
1
6
5
Mark
12
7
8
BM 691
Landing Field
Creek
Crest of Mt. Palatine Moraine
0 .5 1 mi
0 .5 1 km
N


GRANVILLE
Granville
Allforks
Creek
Trailer Park
Sacred Heart Cem
Granville Cem
Hopkins High Sch
Mine Dumps
NEW YORK CENTRAL
C M ST P & P
CHICAGO
Pk
BM
6
0 .5 1 mi
0 .5 1 km
N


Kirby Park
MINNESOTA
CAROLINE
ST
Mine Dump
Gravel Pit
Water
T 16 N
T 15 N
BM 470
BM 466
BM 468
Sewage Disposal
CHICAGO
BURLINGTON
BM 463
ILLINOIS
RIVER
Mile 220
BM 469
7B
7A
END
Pit
0
.5
1 mi
1 km
N
ANVILLE

ROUTE GUIDE FOR ALTERNATE STOP 8: SAND AND GRAVEL PIT - HENRY FORMATION

This road log starts at the intersection of Illinois Route 26 and 1050 North (follow dashed line on route map). Reset odometer to 0.0 at the intersection.

0.0	0.0	Heading south on Illinois Route 26. Notice the long, low knolls to the right and left. These are sand dunes that formed when winds from the northwest blew sand across the floodplain and the Hennepin high-level terrace into drifts. Figure 16 is a generalized profile of the different landforms along the eastern side of the Illinois River valley.
0.25	0.25	Crossroad intersection (Illinois Route 26 and Hennepin-Florid Road). CONTINUE AHEAD. Road begins descent into valley cut by Coffee Creek. The road parallels along the base of the high-level terrace to the left and the Illinois River floodplain to the right.
0.7	0.95	Cross Coffee Creek.
1.4	2.35	Road curves to the left and begins ascent to the top of the high-level terrace. The top of the terrace is nearly covered with sheet deposits and dunes of sand. The low hills rising on the left (east of the terrace) form the edge of the till plain, deposited by the last glacier to cover the region.
1.5	3.85	Cross unnamed creek.
0.1	3.95	T-intersection from the left (675 North). CONTINUE AHEAD.
0.25	4.20	Road cuts through a sand dune on the left (see route map).
0.35	4.55	Crossroad intersection (600 North). CONTINUE AHEAD.
1.0	5.55	T-intersection from the left (Illinois Route 26 and McNabb Road/500 North). CONTINUE AHEAD. Road begins to descend to the top of the large alluvial fan that formed at the mouth of the Clear Creek Valley.
1.5	7.05	T-intersection from the left (350 North). CONTINUE AHEAD. An old sand and gravel pit is located to the left in deposits of the high-level terrace at an elevation of 450 feet.
0.7	7.75	Cross Clear Creek. Notice the wide valley to the left, and the deposits of sand and gravel in the bottom of the creek. The broad surface of the alluvial fan is to the right (see route maps). Clear Creek, like the other streams draining the uplands into the Illinois Valley, drops as much as 100 feet in a mile. In contrast, the Illinois River only falls an inch and sometimes less per mile between Hennepin and Chillicothe. Because of the steep gradients (bed slopes) of the creeks, any flooding in these creeks is swift and voluminous; as a result, the creeks move large amounts of silt, sand, and small gravel onto the Illinois Valley floodplain. In contrast, the sluggish Illinois River cannot move much of

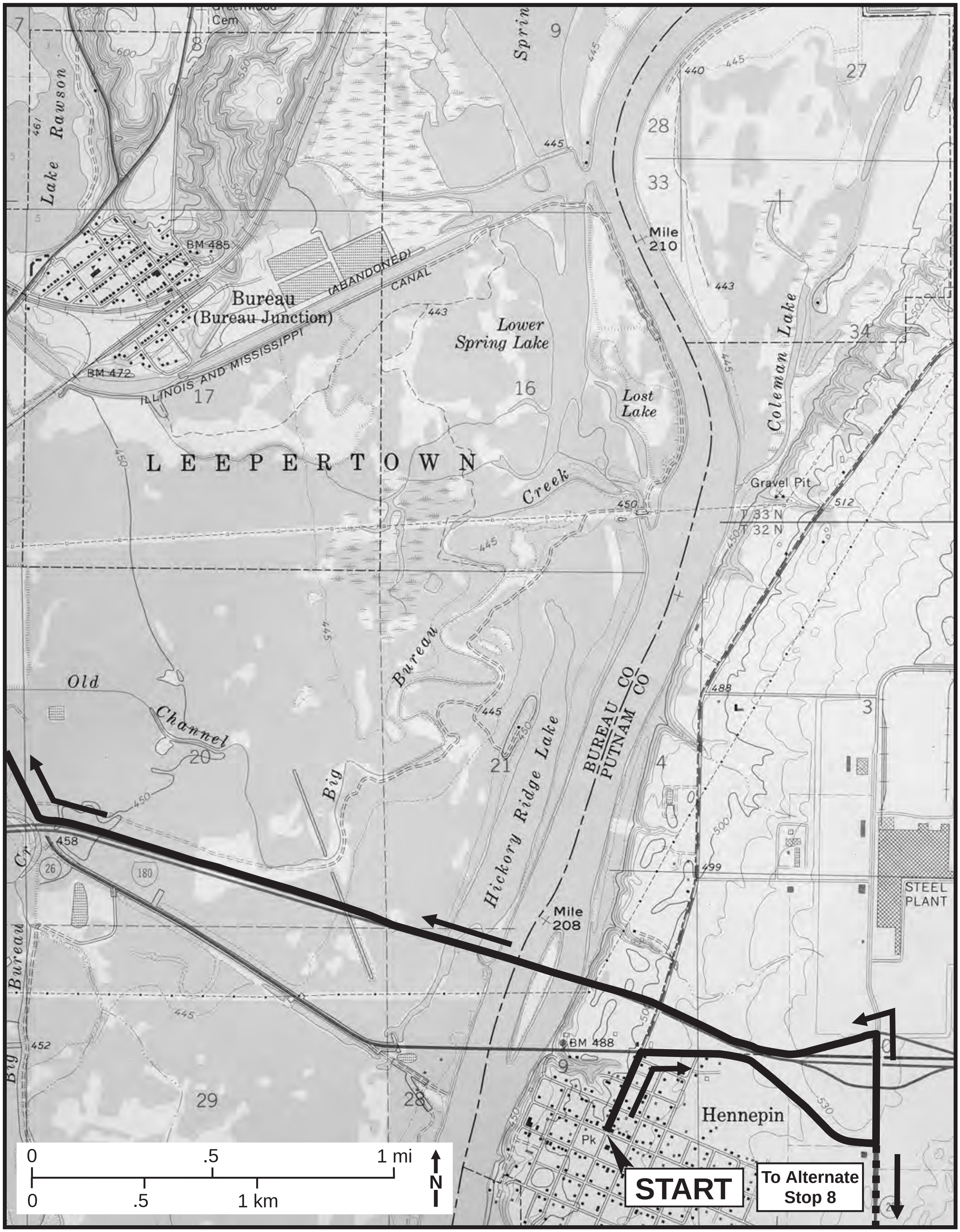
these sediments, so they accumulate at the mouths of the streams in fan-shaped deposits that divert the river's channel to the opposite side of its valley. The alluvial fans partly dam the valley, forming broad, shallow floodplain lakes.

0.6	8.35	T-intersection from the left (unmarked). CONTINUE AHEAD.
1.0	9.35	T-intersection from the left (unmarked). CONTINUE AHEAD.
0.9	10.25	T-intersection from the left (unmarked). CONTINUE AHEAD.
0.65	10.9	STOP (one-way). T-intersection (Illinois Route 26 and Illinois Route 18). TURN RIGHT (west) toward Henry.
0.15	11.05	T-intersection from the left (unmarked). TURN LEFT (east) onto a gravel road just before the highway bridge over Sandy Creek.

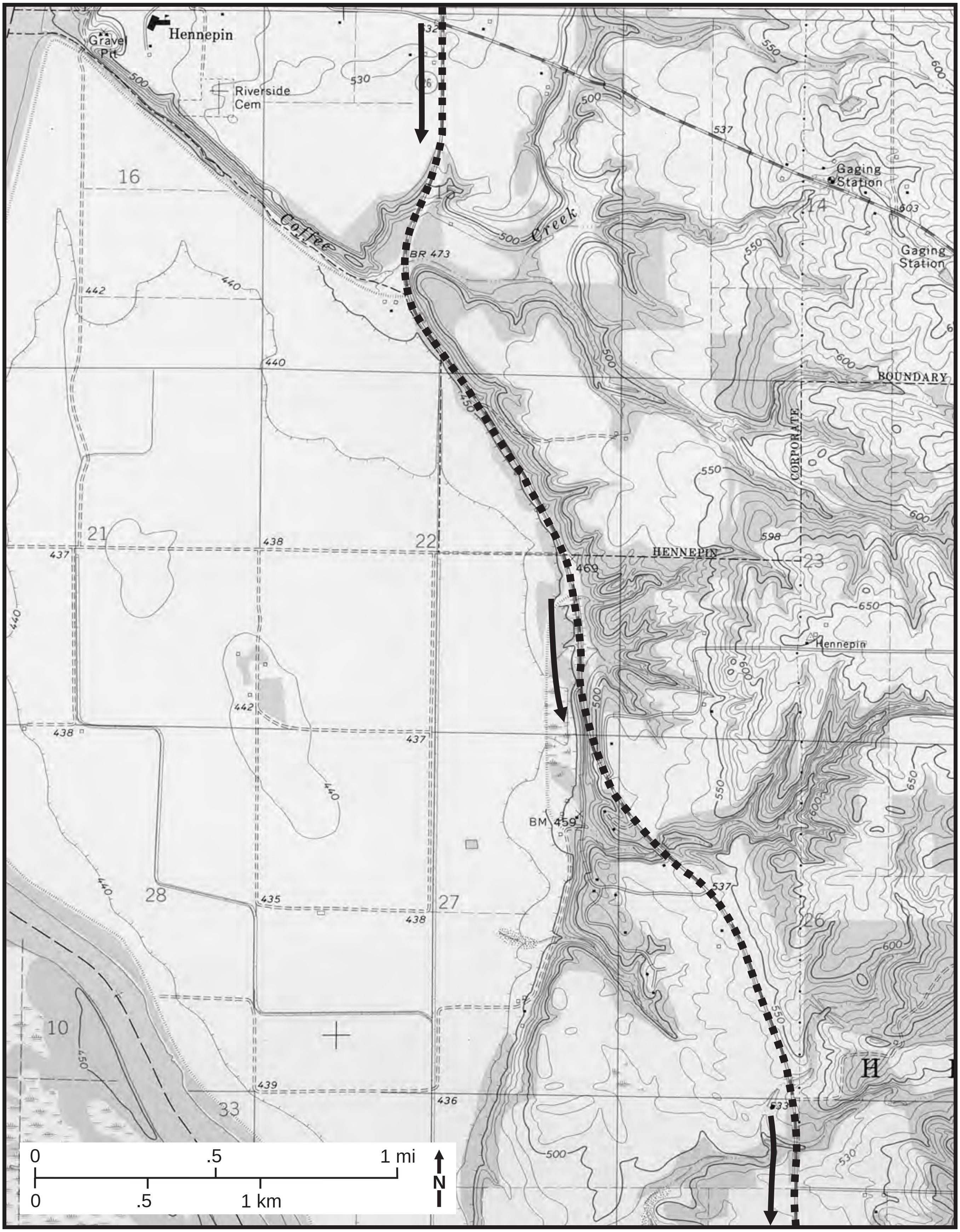
After making the turn, the bluffs are to the left (north), and Sandy Creek is to the right (south). Notice the large alluvial fan deposited by Sandy Creek (see route maps). Follow the road for about 0.5 miles to the exposure and Stop 8. Pull over to the right side of the road.

Alternate STOP 8: Sand and Gravel Pit-Henry Formation (Northwest, Sec. 3, T30N, R2W, 3rd P.M., Henry 7.5-minute Quadrangle, Marshall County). This is an extended section. The exposure is located 800 feet from the north line and 1,400 from the west line of Sec. 3.

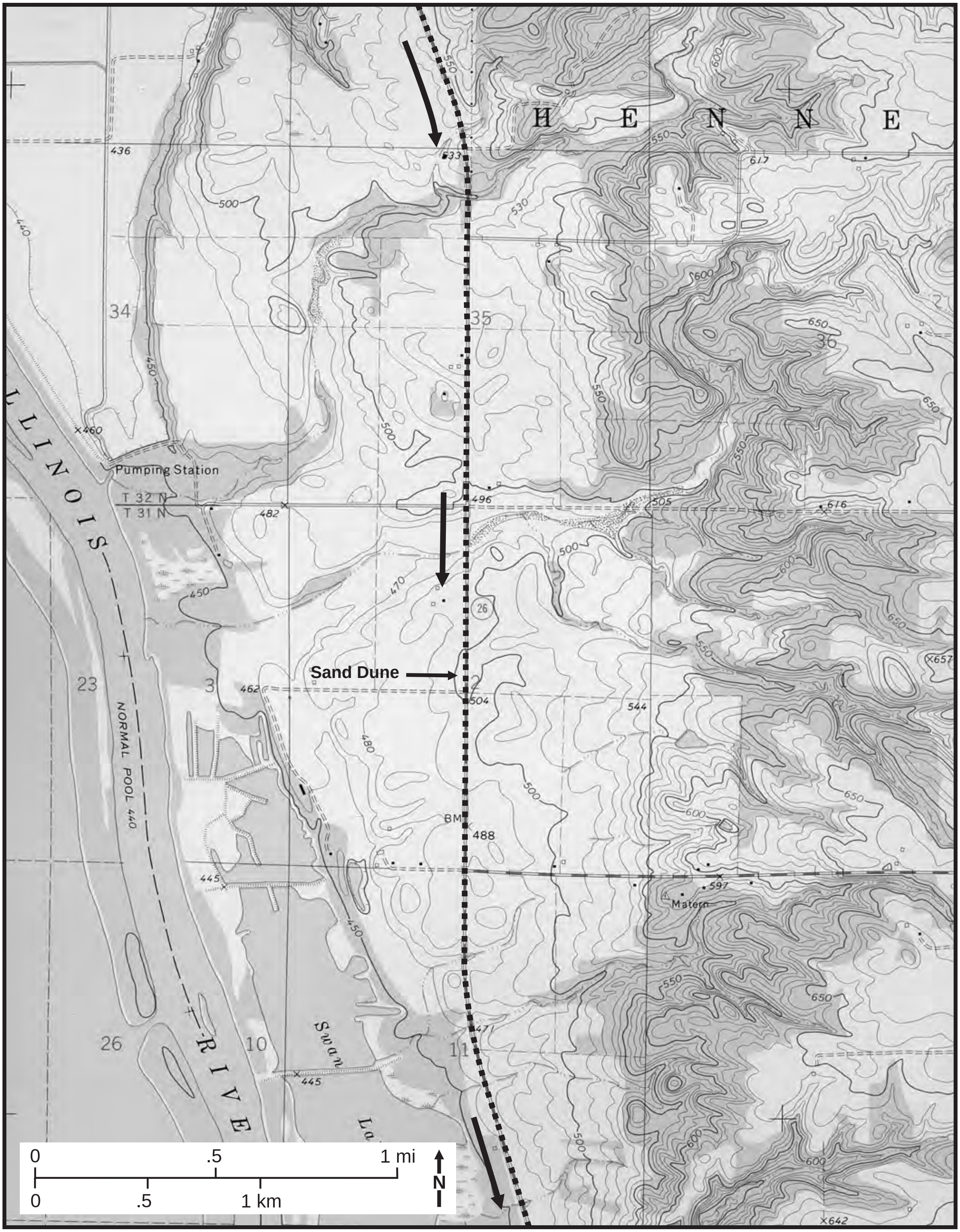
A number of sediment units within the Henry Formation are well exposed in this abandoned gravel pit. Footing is particularly unstable in the upper levels of this exposure. Please be careful.



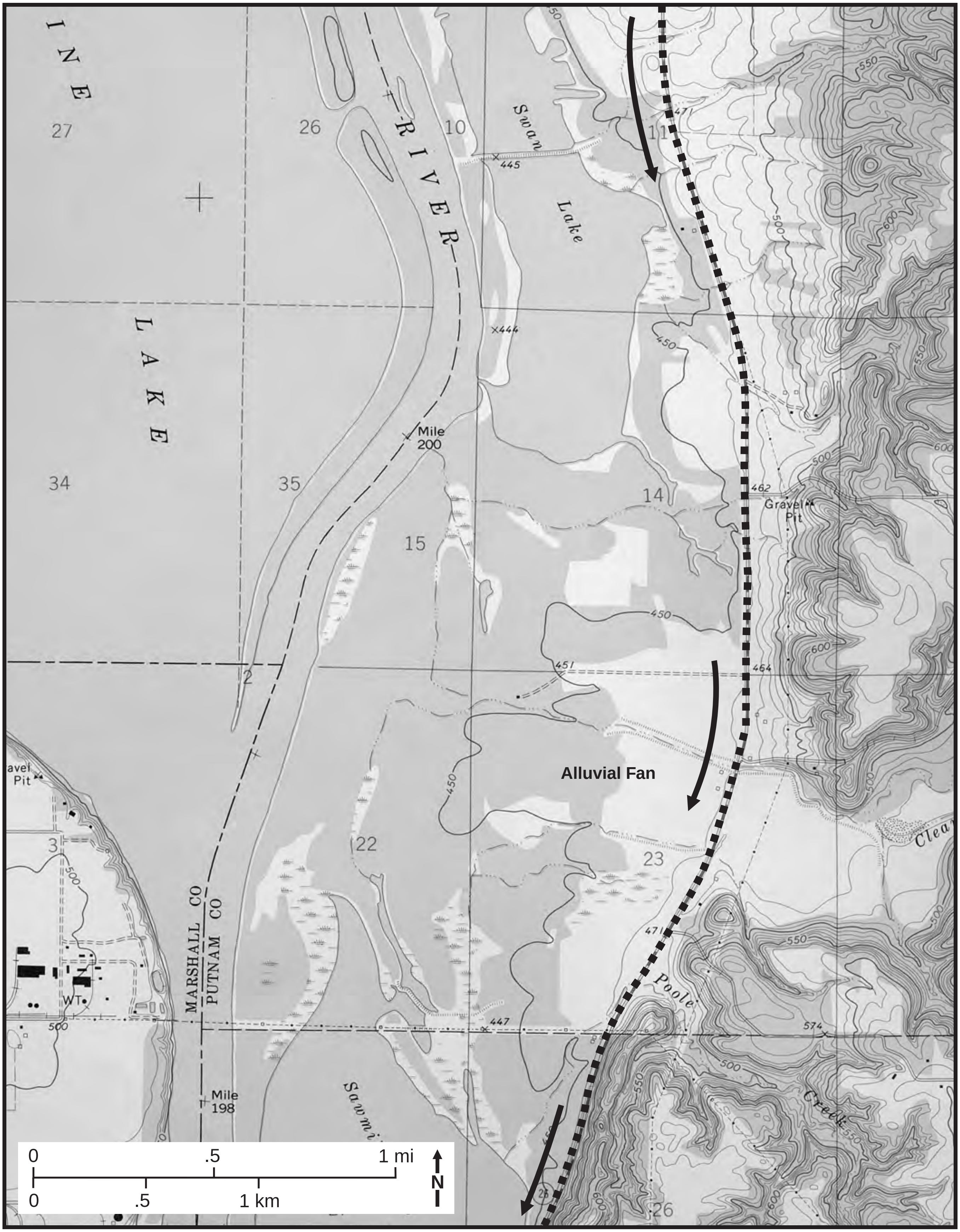
Lake Rawson
Bureau
(Bureau Junction)
BM 485
BM 472
ILLINOIS AND MISSISSIPPI CANAL (ABANDONED)
Lower Spring Lake
Lost Lake
Coleman Lake
LEEPERTOWN
Creek
Gravel Pit
T 33 N
T 32 N
Mile 210
Mile 208
Old Channel
Big Bureau
Hickory Ridge Lake
BUREAU CO
PUTNAM CO
STEEL PLANT
BM 488
Hennepin
Pk
Bureau Cr
START
To Alternate Stop 8
0 .5 1 mi
0 .5 1 km
N



Hennepin
Gravel Pit
Riverside Cem
Coffee Creek
BR 473
Gaging Station
Gaging Station
BOUNDARY
CORPORATE
HENNEPIN
Hennepin
BM 459
16
17
14
21
22
23
28
27
26
33
10
0 .5 1 mi
0 .5 1 km
N



H E N N E
Sand Dune
Pumping Station
T 32 N
T 31 N
ILLINOIS RIVER
NORMAL POOL 440
Matern
BM
0 .5 1 mi
0 .5 1 km
N



Alluvial Fan
RIVER
LAKE
Swan Lake
Mile 200
Mile 198
Gravel Pit
MARSHALL CO
PUTNAM CO
Poole Creek
0 .5 1 mi
0 .5 1 km
N

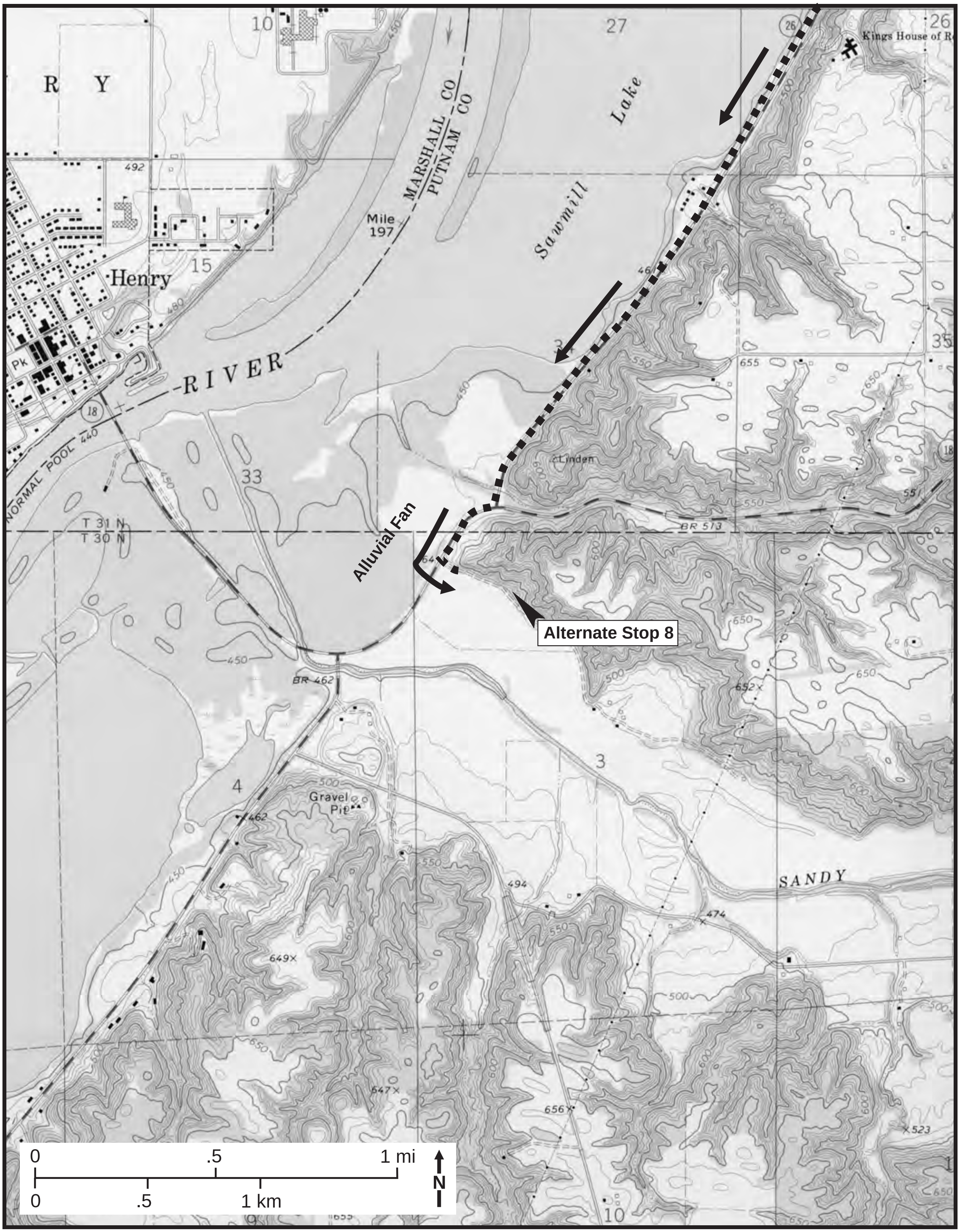

Henry
RIVER
MARSHALL CO
PUTNAM CO
Mile 197
Sawmill Lake
Alluvial Fan
Alternate Stop 8
Linden
Gravel Pit
SANDY
NORMAL POOL 440
T 31 N
T 30 N
BR 513
BR 462
Kings House of R
0 .5 1 mi
0 .5 1 km
N

Figure 17 Exposure of Tiskilwa Formation of the Wedron Group, Wisconsin Glacial Episode at Stop 1 (photo by W. T. Frankie).

STOP DESCRIPTIONS

STOP 1: Borrow Pit in the Tiskilwa Formation of the Wedron Group and Lock No. 11 of the Hennepin Canal (NE, SW, NE, Sec. 1, T15N, R8E, 4th P.M., Wyanet 7.5-minute Quadrangle, Bureau County).

This borrow pit exposes approximately 40 feet of the upper portion of the Tiskilwa Formation of the Wedron Group (fig. 17). This formation is named for the town of Tiskilwa, located in the valley to the south. This deposit is interpreted to be till based on its lack of stratification and the composition of the sediments that consist of a thorough mixture of all kinds and sizes of sediment and rocks. The till was probably deposited as the glacier that formed the Providence Moraine to the west was receding (melting). The Tiskilwa Formation forms the surface unit of the Providence Moraine.

The Tiskilwa Formation consists of calcareous, red gray to gray, medium-textured (clay loam to loam) diamicton that contains lenses of gravel, sand, silt, and clay. Typically, the formation oxidizes to red-brown, brown, or yellowish brown. The Tiskilwa Formation forms a wedge-shaped deposit that pinches out beneath the Lemont Formation to the north and east. In some places, thickness reaches 295 feet (Hansel and Johnson 1996).

Background Information

Within the field trip area, there are numerous opportunities to observe the various types of landforms and deposits left by the glaciers of the most recent Wisconsin Episode. In order to fully understand and appreciate the complexity of continental glaciation and the resultant landforms and deposits created by these glaciers, an introduction to the terminology that geologists use in describing these features and deposits is included along with a simplified discussion of the processes involved in the deposition of glacial sediments and the shaping of the glacial landscape.

Glacial Mechanics

The work produced by a glacier can be divided into four processes:

1. ***Weathering*** As the ice moves over bedrock, it incorporates material by plucking rocks that have become frozen to the moving ice and by gouging into softer sediments.

2. ***Erosion*** First the rocks already incorporated into the ice are scraped along the surface of other rocks, both eroding the rocks they move over and in turn being eroded by the rocks they scrape across. The rocks within the glacier are in contact with one another, which produces additional erosion.

3. ***Transportation*** As the ice advances, it carries all of the incorporated materials toward the front—or what is called the "toe" of the glacier.

4. ***Deposition*** As the glacier starts to melt, it deposits its load of sediment. The deposition of these glacial sediments form a variety of different types and shapes of deposits.

Glacial Deposits

As a glacier melts, it releases from the ice the clay, silt, sand, and rocks of varying size from pebbles to boulders (sediment) it had transported as it advanced. Some of this material, which geologists call drift, is deposited in place as the ice melts. Such material consists of a mixture of all kinds and sizes of rocks and is known as till. Some of the glacial drift is washed out of (transported from) the glacier by the meltwaters. The coarsest of this water-transported material, called outwash, is deposited near the ice front, and the progressively finer material is deposited farther away. Much of the finer material eventually enters into a river and is carried (transported) all the way to the ocean. Where the outwash material is spread widely (deposited) in front of the glacier, it forms an outwash plain, and, where it is restricted to a river valley, it forms elongate stringers of coarser deposits that are called valley trains or braided streams (fig. 18).

At times, especially in the winter when melting of the glacier subsides, the sediments in the outwash plains and valley trains are exposed. With little vegetation to hold it in place, the harsh, dry winter winds pick up the silt and fine-sand–sized particles from these surfaces and distribute the materials across the country. These small-sized sediments are eventually dropped (deposited) onto the landscape. These windblown sediments form the loess deposits that mantle most of Illinois. Near the larger river valleys, the loess may be as much as 60 to 80 feet thick. Far from the valleys, loess is measured in inches, if it can be identified at all.

Moraines

More than 50 successive *end moraines* were formed by the Wisconsin glacier in Illinois alone. An end moraine is formed by the accumulation of drift at the ice margin when the rate of advance and the rate of melting of a glacier are essentially in balance. As more and more material was carried forward (transported) to the edge of the glacier, the material melted out and piled up to form a

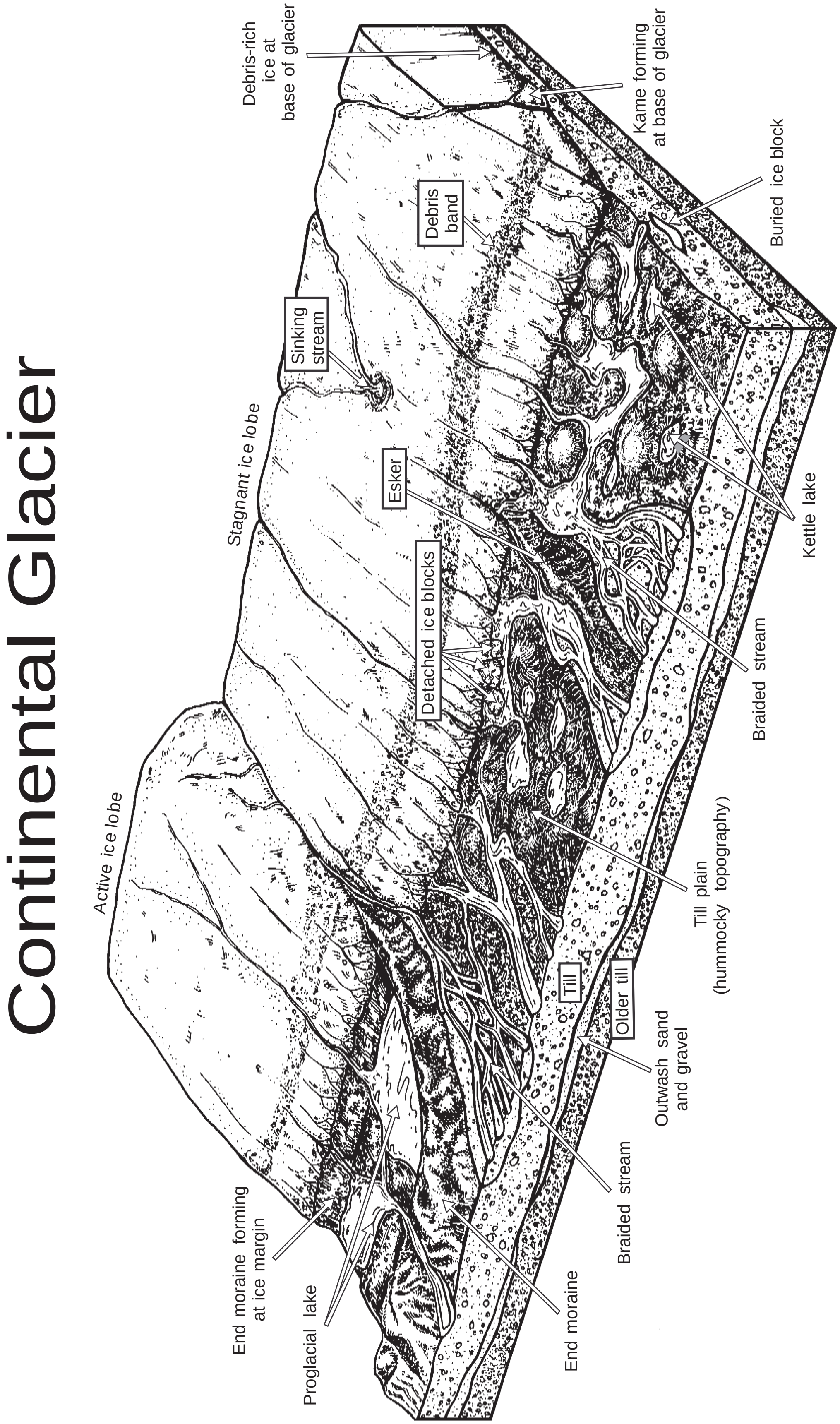


Figure 18 Block diagram of continental glacier showing the relationships of glacial deposits and landforms.

ridge—the end moraine. At some places, there are large gaps in the moraines where subglacial streams presumably carried away most of the drift.

If the rate at which the glacier melted was greater than the rate at which the glacier moved ice and debris forward, the glacier receded. A common misconception is that glaciers flow backwards. The advancement or retreat of a glacier is controlled by the differences between the rates of melting at the margin and the rates of ice accumulation and transport from the centers of ice accumulation located to the north. The Wisconsin glacier advanced and retreated dozens of times across northeastern Illinois. End moraines mark positions where the ice margin stood for hundreds of years.

When melting exceeded the rate of advance, the sediments held within the ice were deposited (dropped) directly onto the landscape. The flatter areas behind (up-ice from) end moraines are called ground moraines or *till plains.* They are underlain by till deposited beneath the glacier.

The surface relief along the top of the end moraines, which is generally greater than that of the till plains, is commonly referred to as swell-and-swale or knob-and-kettle topography depending upon the amount of surface relief. If the relief is gentle rolling surface with small rises and depressions, it is swell-and-swale topography. Surface relief marked by large knobby hills and kettle lakes is knob-and-kettle topography. The Bloomington Morainic System contains both types of topography along its length.

Hennepin Canal

This stop provides an opportunity to visit Lock Number 11 on the Hennepin Canal (fig. 19). See Stop 3 for a description of the history of the Hennepin Canal. The small picnic area on the west side of the canal has three interpretive signs discussing the Canal's development.

Figure 19 Hennepin Canal, Lock No. 11, at Stop 1 (photo by W. T. Frankie).

STOP 2: Kettle Lakes and Eskers (middle of the eastern half of Sec. 30, T16N, R8E, 4th P.M., Wyanet 7.5-minute Quadrangle, Bureau County).

Stop 2 is situated in the midst of a group of kettle lakes and eskers on the back slope of the Providence Moraine, a part of the Bloomington Moranic System (figs. 20 and 21).

Kettle Lakes

The water-filled depressions along the right side of the road are ice block depressions that are referred to as *kettles* by geologists. Kettles often occur in end moraines and contribute to the hummocky topography known as "knob-and-kettle" topography that is also typical of some end moraines. Kettles may also occur on an outwash plain in front of an end moraine or on the till plain behind a moraine. Kettles indicate conditions of stagnant ice and are formed during the late melting stages of a glacier. Kettles form when a large block of ice becomes detached or isolated from the melting ice mass and are subsequently partially or completely buried by outwash from the receding glacier, which filled in around them (fig. 22). At some time after burial, the ice blocks melted away, and the overlying outwash cover slumped into space occupied by the ice, leaving depressions.

There are a number of kettle lakes and kettle holes (depressions without water) within this area. A large number of depressions are present on the topographic map (see route map). The depressions are indicated on topographic maps by enclosed contours with short perpendicular line segments (called hatchures) that point inward.

Eskers

Eskers are long, narrow, sinuous (winding) ridges consisting of stratified sand and gravel that represent channel deposits of meltwater streams that flowed in, on, or under a melting glacier. Their preservation indicates that they formed in areas of relatively stagnant (inactive) ice. The most commonly accepted mode of origin is that eskers formed in subglacial channels or tunnels at the base of a glacier (fig. 23). Meltwater mainly from the surface of the glacier flowed downward through crevasses and other openings to the base of the ice. There under hydrostatic pressure the meltwater enlarged a system of openings to form tunnels that then carried the meltwater flow toward the margin of the melting ice. The tunnels became partially filled with sand and gravel released from the melting glacier, and, when the enclosing ice melted away, the sand and gravel was left standing as elongate ridges. Eskers often exhibit signs of branching and meandering, as modern surface streams do today. Some eskers probably formed, at least in part, in channels cut into the ice surface or in tunnels within the ice as well as in subglacial tunnels. In these cases, the channel deposits were gradually let down onto the ground beneath as the glacier melted.

One esker occurs immediately south of the three kettle lakes. A second esker is located south of this esker (see route maps). Both eskers trend northwest-southeast. The esker to the south is a clearly defined ridge with two branches. The smaller branch is grass-covered and has a cut in it; the main esker ridge extends southeastward and is partially tree covered. This second esker is visible after leaving this stop (see Mile 23.0 of the guide to the route). The eskers have partially been dissected by Pond Creek (see route maps).

The sand and gravel within the subglacial channels was deposited as the meltwater stream gradually slowed and could no longer carry its load of debris. The same principles of stream physics apply to modern rivers.

Figure 20 Kettle Lake, located on the back slope of the Providence Moraine at Stop 2 (photo by W. T. Frankie).

Figure 21 Esker, located on the back slope of the Providence Moraine at Stop 2 (photo by W. T. Frankie).

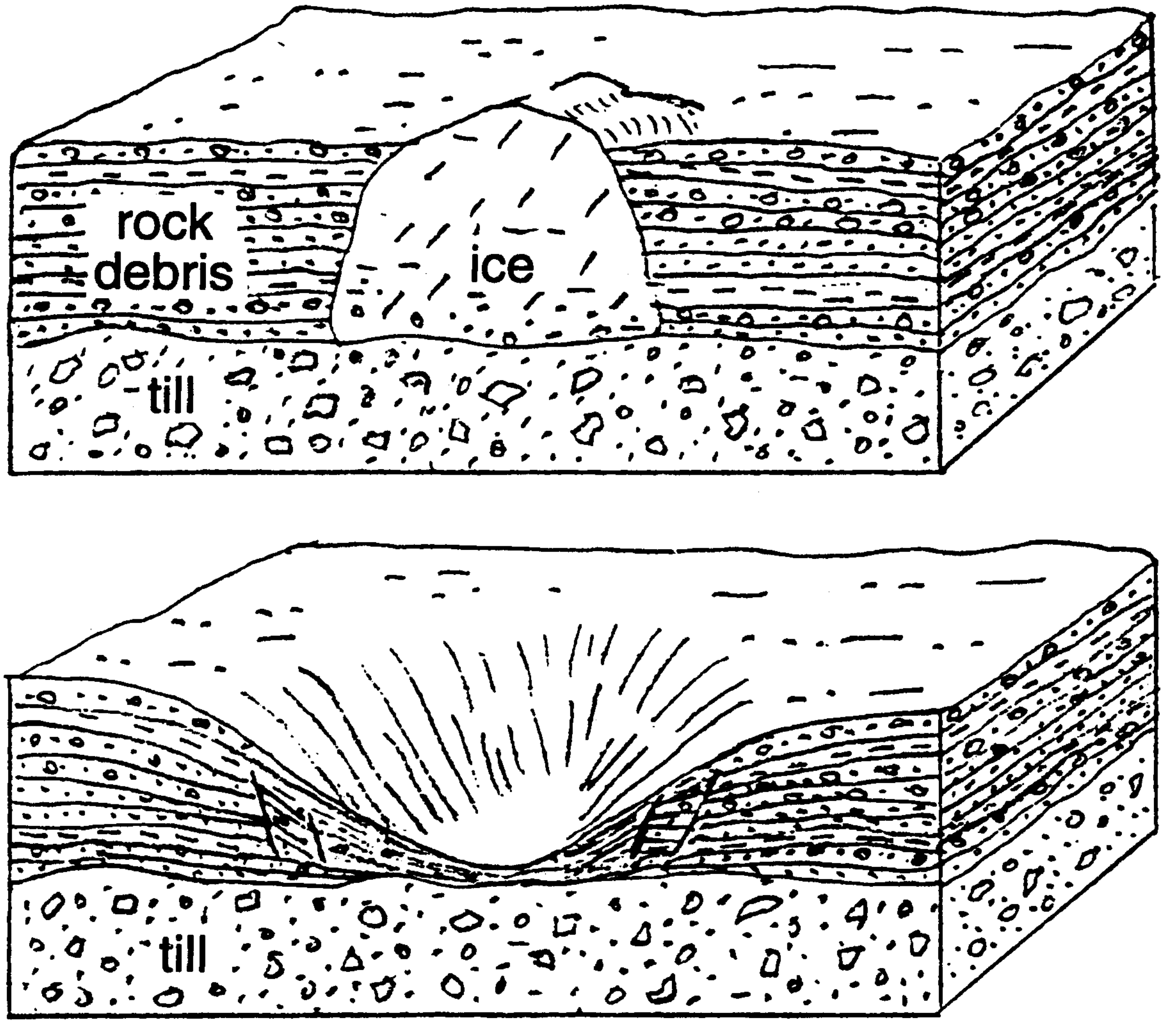


Figure 22 Block diagram of kettle depression. A kettle is formed when a block of ice becomes detached from a glacier and is buried by rock debris deposited by glacial outwash. When the ice block melts, a depression is formed on the landscape.

These eskers, located on the back of the Bloomington Moraine, were formed by subglacial streams that probably flowed northwestward toward the glacier margin, which was located near the vicinity of Sheffield. Within the area from Sheffield northward to the vicinity of Manlius and eastward to Wyanet, including the locality here at Stop 2, the Bloomington Morainic System overlies the Princeton Bedrock Valley (fig. 24). Within this area, the crest of the Bloomington Morainic System has a pronounced sag and is less well-defined than in the areas bordering the valley to the north and south. The sag above the valley, especially near the back of the moraine, includes some of the most distinctive glacial topography in Illinois. Flat, swampy areas among steep-sided morainic hills, numerous kames (gravel hills), kettles (ice block depressions), as well as the esker segments here at Stop 2, form a landscape of glacial features that have been only slightly modified by postglacial erosion. This area affords a unique opportunity to study the effects of glaciation and ice stagnation topography.

The broad sag in the Bloomington Morainic System represents a surface expression of the underlying, deeply buried, Princeton Bedrock Valley. During the Illinois Episode glaciation, the ice was

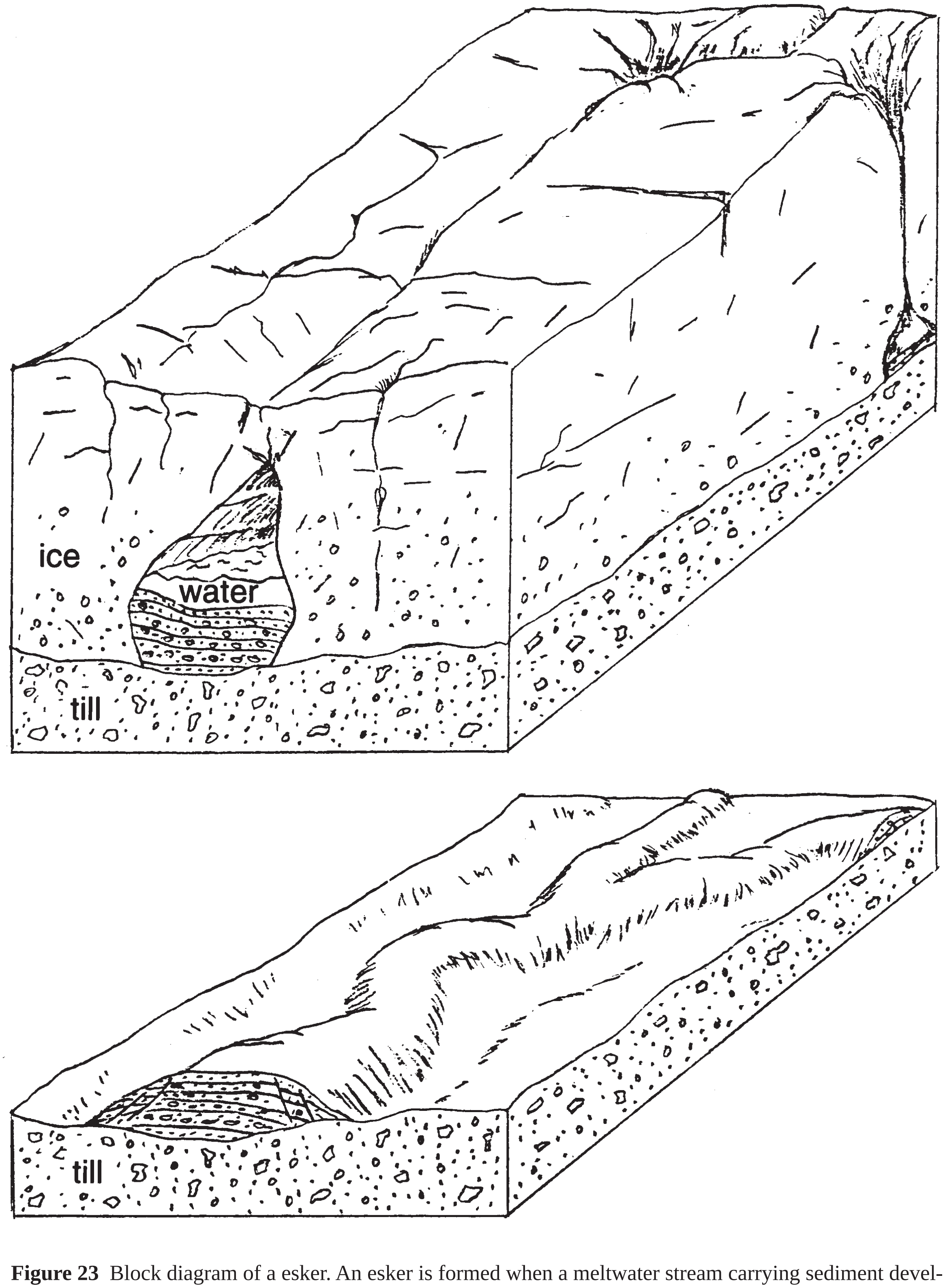


Figure 23 Block diagram of a esker. An esker is formed when a meltwater stream carrying sediment develops beneath a glacier. The stream develops a sinuous pattern as it flows under the ice. When the ice melts, the sediment is left as a long, narrow, winding ridge on the landscape.

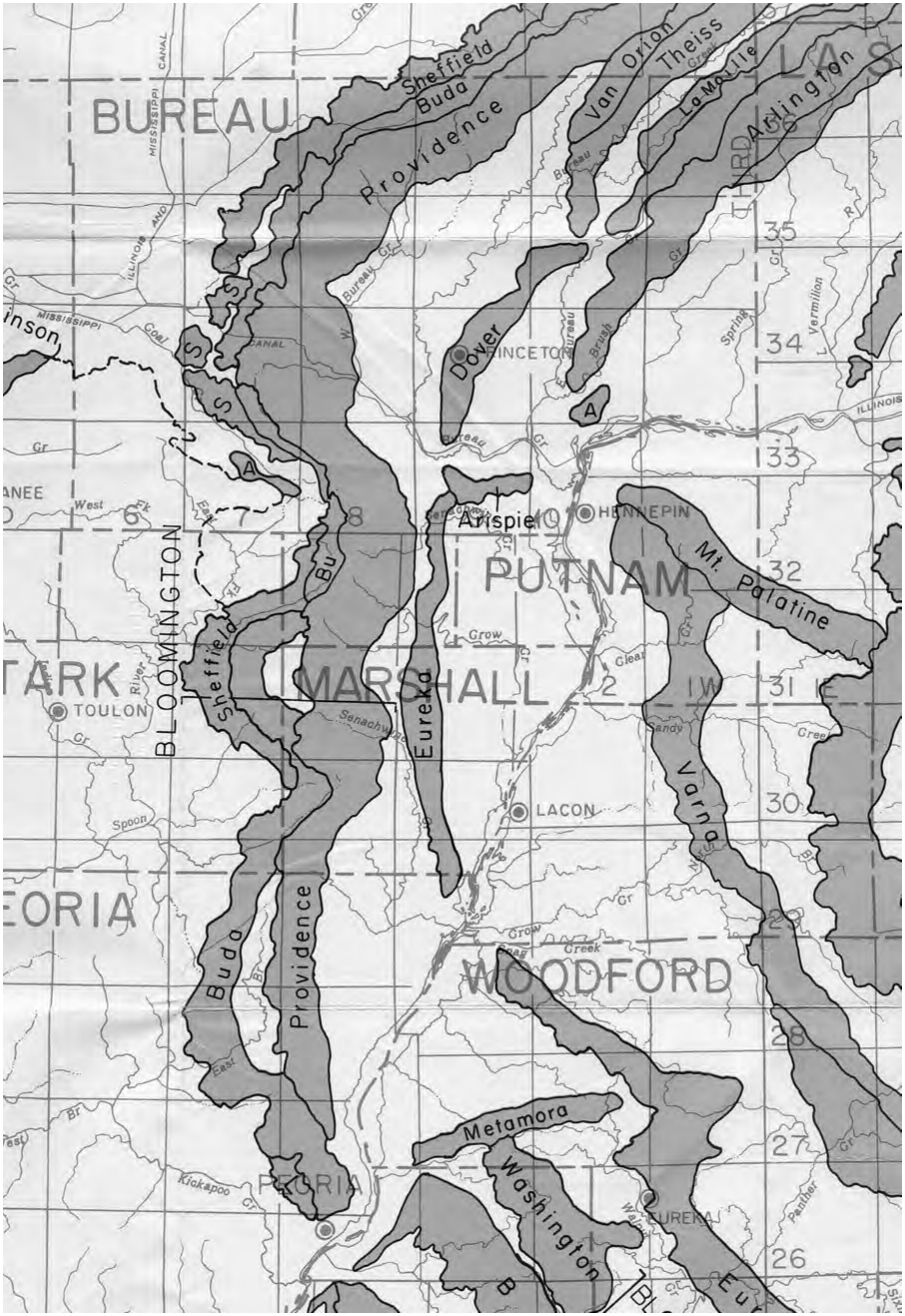


Figure 24 Distribution of Wisconsin Episode moraines in the field trip area (modified from Willman and Frye 1970).

channeled westward along the valley as a tongue-like extension. When the Wisconsin Episode glacier advanced into this area, which hadn't entirely filled with sediment during the Illinois Episode glaciation, the ice once again bulged westward into the valley. Over the valley the ice was probably much thicker than at the sides of the valley, and Survey geologists have suggested that a large mass of this thick ice became isolated when the ice front melted back from the Providence Moraine. This stagnant ice mass persisted within the low area for a considerable time, and as the ice melted away, stagnation features formed. Meltwater was concentrated in the low area, flowing westward through channels in the moraine, and built an extensive outwash plain at the front of the moraine in the Green River Lowland. One of these channels is located immediately north of Sheffield, another is located three miles farther north where the Hennepin Canal crosses the moraine, and a third is located about two miles south of Manlius where Hickory Creek crosses the moraine. The channels are areas where the moraine was breached by erosion.

Why was the development of the eskers mostly restricted to this low area? A possible explanation may be theorized based on the possible origin for the development of the crevasses.

As the ice within the glacier started to flow toward the low depression, the tongue of this glacial ice was probably moving faster than the ice to the north and south of this low area. This difference in the rate of ice advancement may have produced stress shearing within the glacier that led to the development of crevasses.

Because kames and eskers are easily accessible sources of sand and gravel, many have been mined, and, in this area, several of the eskers have small sand and gravel pits. We passed by one of these small sand and gravel operations at Mile 20.4.

As you leave this stop and turn left at the Y-intersection, look to the right. In front of the farm house are a number of large glacial boulders along the right side of the road. These boulders are known as "erratics." Erratics are glacially transported rocks that are not indigenous to the areas in which they are found. The erratics seen here are mostly igneous and metamorphic rocks that were carried into Illinois from far to the north in Canada.

STOP 3: LUNCH at Hennepin Canal Parkway State Park (NE, SW, SE, Sec. 9, T16N, R7E, 4th P.M., Manlius 7.5-minute Quadrangle, Bureau County).

The Hennepin Canal Parkway State Park is located about 5 miles southwest of the axis of the buried Princeton Bedrock Valley through which the Ancient Mississippi River flowed. In this area the Princeton Bedrock Valley has an elevation of less than 300 feet msl. Glacial drift thickness in the vicinity of the Visitor Center is just under 300 feet. The Buda Moraine of the Wisconsin Episode Bloomington Morainic System mantles the surface here.

The Hennepin Canal—Its History

Men dreamed of building a canal linking the Illinois and Mississippi Rivers as early as 1834, but both the state and the federal government had financial problems that disrupted many public projects. Railroads were built through the area, but they proved to be too expensive for the early settlements and small industries to use.

Pressure for a transportation short cut that was cheaper than rail continued, though, and the United States Congress finally authorized preliminary surveys of the area for a canal in 1871 and authorized construction of the Illinois and Mississippi (Hennepin) Canal in 1887. Construction on the "Hennepin Canal," as it was commonly known, began in 1892 and was completed in 1907 at a cost of more than seven million dollars. By the 1930s, the canal was used primarily by recreational traffic. The canal was nearly obsolete by the time it was completed because it was too small to handle the larger barges needed to compete with the railroads—which had by this time decreased their shipping costs. The canal was closed to traffic in 1951.

The canal system is shaped like an inverted T. The canal water within the feeder canal flows south from Rock Falls and then splits, flowing east to the Illinois River at Bureau and west to the Mississippi River at Milan. This canal connected the Illinois River just north of Hennepin in Putnam County to the Rock River near Moline in Rock Island County and from there by way of a canal around the Rock River's lower rapids at Milan to the Mississippi River at the city of Rock Island. From Hennepin in Putnam County, the canal passes through Bureau, Henry, and Rock Island Counties. The feeder canal from the Rock River at Rock Falls joined the main canal 29 miles to the south near Mineral.

Although utilization of the Hennepin Canal never reached expected proportions because of its limited size and rapid technological advances in other modes of transportation, it was very important in helping to develop commerce and industry in northwestern Illinois and adjacent states. In conjunction with the Illinois and Michigan Canal, completed almost 60 years earlier, this waterway helped link Chicago and Lake Michigan with the Rock Island and upper Mississippi region. The Hennepin Canal, which was nearly 105 miles long and spanned five counties (Bureau, Henry, Lee, Whiteside, and Rock Island), reduced the waterway distance between Chicago and Rock Island by 419 miles. There was no cost to use the canal. Ice made from the canal's frozen waters was sold during the winters to help pay the canal's maintenance costs. The entire Hennepin Canal is listed on the National Register of Historic Places.

The Hennepin was the first American canal built of concrete without stone cut facings. Although the Hennepin enjoyed limited success as a waterway, engineering innovations used in its construction were a bonus to the construction industry. In fact, construction of the Panama Canal was based on some of the building techniques used for Hennepin.

There are 33 locks on the canal. Thirty-two are still visible. The first one, on the Illinois River, has been under water for half a century. Fourteen of the locks had Marshall gates, which are unique to the Hennepin, and are raised and lowered on a horizontal axis, much like a rural mailbox. Five of the locks have been restored to working condition, although they are not used. All of the gates from the remaining locks have been replaced with concrete walls, creating a series of waterfalls.

The Hennepin originally had nine aqueducts — concrete troughs which carried the canal and its traffic across larger rivers and streams. Today, only six remain.

Hennepin Canal Parkway State Park

(modified from the Department of Natural Resources flyer)

Want a peaceful, relaxing day of picnicking, hiking, fishing, and good old fashioned family fun? Hennepin Canal Parkway State Park is just the place you're looking for. Spend the day and bring a picnic lunch along. There are plenty of picnic tables at the 104.5-mile linear park that spans five counties (Rock Island, Bureau, Henry, Lee, and Whiteside).

Before exploring the wonders at the park, stop in at the Visitor Center near Sheffield. There are several displays that help illustrate the canal's past—including tools used to build and operate it. At the time the canal was built workers often made their own tools by hand. There's also a model of a lock with a boat going through it. Get a peek at the plant and animal life at the park through other displays at the center.

This 96-mile waterway, connecting the Illinois and Mississippi Rivers, provides wonderful opportunities for boating, fishing, biking, hiking, horseback riding, cross-country skiing, and snowmobiling.

The canal opened in 1907, closed in 1951, and was taken over by the state in 1970. The recreational corridor that straddles the 80-foot canal averages a quarter-mile in width.

Canoes, kayaks, and motorboats (motors are limited to 10 hp) must be carried about 300 feet around each of the canal's 33 locks. There are 21 locks within the first 18-mile section of the canal from the Illinois River.

A bike path along the former towpath is currently under construction. When completed in 2003, the bike path will once again provide a route between the Illinois and Mississippi Rivers. Seventeen miles of the former towpath is currently paved with crushed stone and is wheelchair-accessible. Primitive camping is permitted along the canal's towpath at various locations.

Just outside the visitor center is a beautiful half-acre patch of wildflower prairie. Among the plantings are little bluestem and big bluestem—the official state prairie grass. Don't miss the marsh observation area and duck blind located near the Visitor Center. There you will see a variety of marsh type plants and animals including ducks, geese, red-winged blackbirds, muskrat, and cattails.

Hiking An old tow path was originally intended for, but never used by, animals to tow boats along the canal's main line and feeder routes. The tow path provides 155 miles of one-foot-after-the-other fun. Because you're right next to the canal, you'll get a great view of its locks and aqueducts, not to mention the animal life. The going is level and easy at the Hennepin—but be sure to make several stops along the way if you're hiking the canal's entire length.

If you're up to something more challenging, try the 4.5-mile trek in the main complex, which is moderately difficult and gives you a broad taste of landscape from tall timber to grasslands to marsh. Hiking here is particularly satisfying in the fall, when Mother Nature works her wonders on the leaves.

Fishing It's a well-kept secret, but fishing along the Hennepin is well worth the trip. Whether you're angling for bluegill, crappie, walleye, or bass, 70 bridge or lock locations are available, and the pools are stocked regularly.

Directions to the Visitor Center The Hennepin Canal Parkway basically parallels Interstate 80 in Bureau and Henry Counties in west-central Illinois. The Parkway's Visitor Center is one mile south of Interstate 80, just west of Route 40. East or westbound travelers on Interstate 80 should take Exit 45 and turn right (south) on Route 40. Almost immediately, cross the Canal, and in about 1 mile, there will be a brown sign directing visitors to the Parkway Visitors Center. Turn right (west) and proceed to the Visitor Center. For more information on state parks, write to the Illinois Department of Natural Resources, Office of Public Services, 524 S. Second St., Springfield, IL 62701-1787, or call (217) 782-7454.

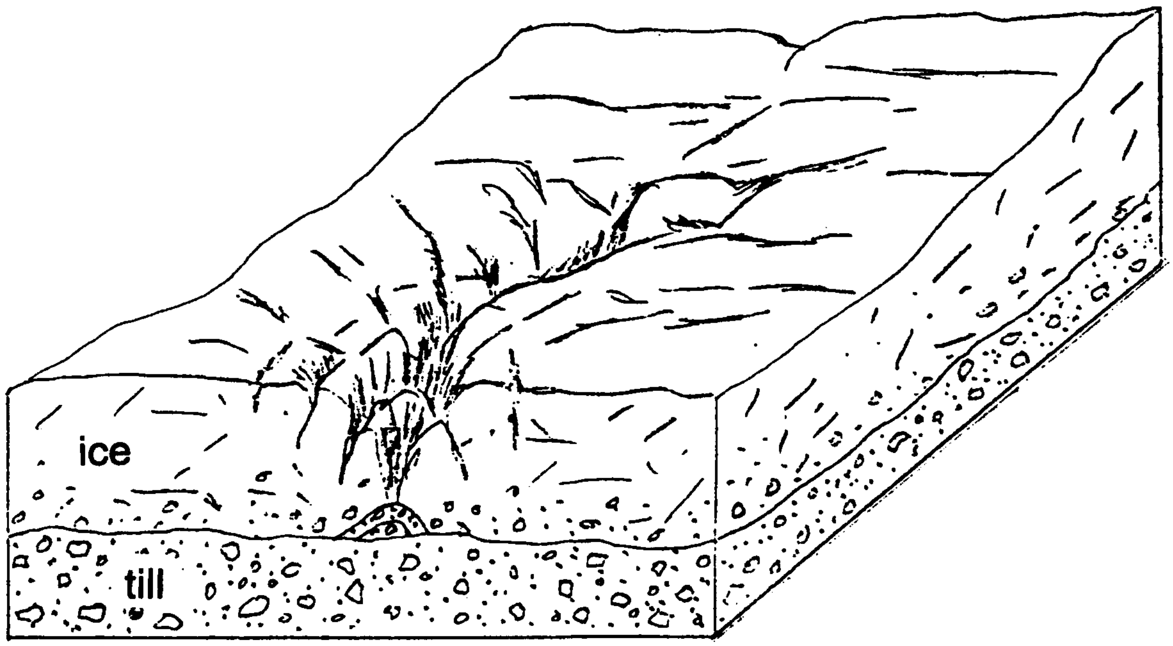
STOP 4: Gravel Hill Kame (Trends from the northwest corner to the southeast corner of Sec. 15, T15N, R7E, 4th P.M., Buda 7.5-minute Quadrangle, Bureau County). Two abandoned sand and gravel pits are located in the SE, SW, NW quarter and the SW, NE, SE quarter of Sec. 15.

The large northwest-southeast–trending ridge to the north is identified on the Buda 7.5-minute Quadrangle as Gravel Hill. This 40-to 60-foot high landform consists mainly of sand and gravel and is what geologists call a kame (fig. 25). Gravel Hill is part of a series of kames that formed in this vicinity. Another large kame occurs south of here in Section 24 (see route maps). These kames sit on top of what has been mapped as the Atkinson Moraine, once considered to be part of the Shelbyville Morainic System but today considered to be older than the last glaciation. Detailed mapping in this area is needed to address age relationships of the landforms and deposits. This type of moraine is called a kame moraine by geologists.

Glaciers from the earlier Illinois Episode passed over the field trip area, advancing from the east and northeast some 250,000 years ago. The view to the west and southwest toward the horizon is across the Illinoian till plain. The large hill in Section 7 to the west is an Illinois Episode kame. Walnut Grove Cemetery is located on top of this kame.

Kames are steep-sided mounds of outwash sand and gravel that were deposited where meltwater plunged through holes in the ice into subglacial pools or where it entered temporary lakes ponded by glacial ice (fig. 26). Whatever the case, the abrupt change in gradient of the meltwater streams caused the sand and gravel to be deposited. The meltwater streams entering lakes ponded by ice

Figure 25 Gravel Hill Kame at Stop 4 (photo by W. T. Frankie).



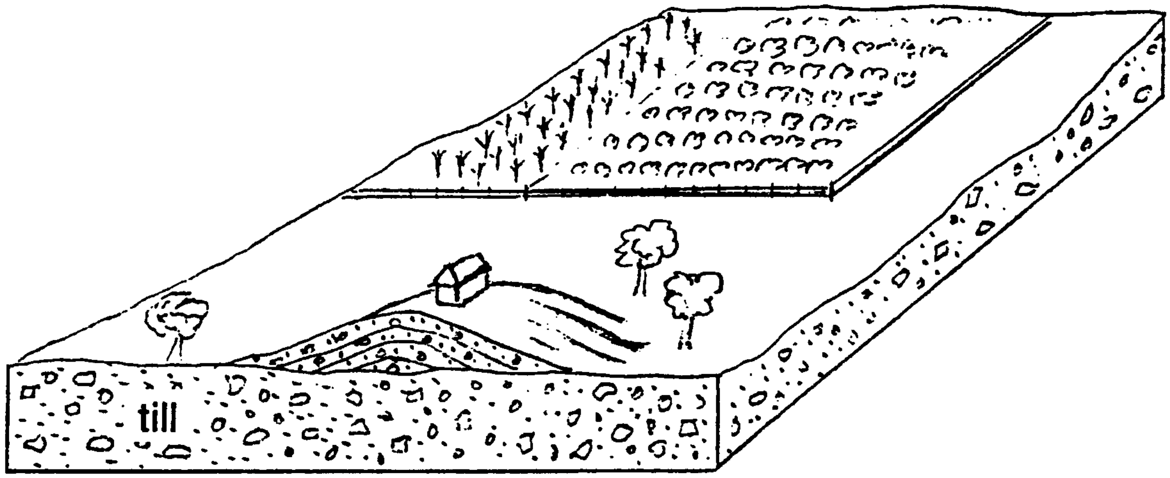


Figure 26 Block diagram of a kame. A kame is formed when meltwater carrying sediment plunges into a crevasse near the ice front and deposits its load of sediment. When the glacier ice finally melts away the result is a mound of unstratified sand and gravel. Kames come in a variety of sizes and shapes but commonly have a conical shape.

formed small deltas, which later were left standing as isolated mounds of sand and gravel after the ice melted away.

This kame was first mined during the early part of the last century. The 1921 edition of the Buda 15-minute Quadrangle map indicated that the Burlington and Quincy Railroad cut through this kame and that two small railroad spurs ran into the middle of the kame. I suspect that this early operation was using the gravel as railroad ballast. The old railroad grade is indicated on the newer Buda 7.5-minute Quadrangle (see route map). Several other small commercial gravel pits have operated in this deposit.

STOP 5: Providence Moraine (SW, SW, SW, Sec. 16, T15N, R8E, 4th P.M., Wyanet 7.5-minute Quadrangle, Bureau County). Discussion of the development of the Province Moraine.

This stop is at the crest of the Providence Moraine, a part of the Bloomington Morainic System. At an elevation of 945 feet above sea level, this crest is the highest elevation on the field trip. Needless to say, this is the most prominent topographic feature in the area and one of the largest and most prominent of the Wisconsin Episode end moraines in Illinois. The view toward the southwest is across the Providence Moraine's outwash plain and the Illinoian till plain, which stretches toward the horizon in the distance.

Along the highest parts of the moraine, the crest stands as much as 150 to 200 feet above the outwash plain to the west and 250 to 300 feet above the till plain behind the moraine. The highest parts of the Bloomington Morainic System occur in the areas north and south of the Princeton Bedrock Valley. As mentioned earlier at Stop 2, there is a pronounced sag in the moraine where it crosses the valley between Buda and Manlius. In Illinois, the Bloomington Morainic System can be traced from the Wisconsin state line in Mc Henry County southward in a great arc as far west as Peoria in Peoria County and then eastward past Danville in Vermilion County to the Indiana state line, a distance of some 280 miles (see fig. 14). In places, as well as here, the moraine has a width of seven to eight miles. This arcuate or lobate regional form exhibited by the Bloomington Morainic System and the other Wisconsin Episode end moraines in northeastern Illinois reflects the influence of the Lake Michigan basin on the shape of the Wisconsin glacier's ice front. The ice advanced southeastward as great tongue-shaped lobes shaped from the deep, round-bottomed lake basin.

The Bloomington Morainic System marks the farthest western extent of the Wisconsin Episode glacier in Illinois, whereas the Shelbyville Moraine marks its southernmost extent. These moraines were formed over an interval of several hundred years about 20,000 radiocarbon years ago by the accumulation of rock debris that was carried forward by the moving ice toward the margin of the glacier. The position of the ice margin remained essentially constant because the rate of forward movement of the ice margin was about equal to the rate at which the ice was melting back. The rock debris released from the melting ice was continually replenished by the moving ice, and it accumulated to form the end moraine. Actually the ice front, most likely, fluctuated back and forth within a narrow zone of several miles as shown by the width of the moraine.

The Providence Moraine in this area trends northwest to southeast. Looking to the southwest, notice that the land slopes off in the direction of the moraines outwash plain (front slope). Turning 180 degrees and looking to the northeast, imagine a huge glacier looming in front of you. Now imagine that the glacier is melting faster than the ice margin is advancing. The flat area beyond the back slope is the area covered by deposits we classify as ground moraine.

Drainage on the back slope (ice margin side of the moraine) is well established. The drainage pattern is perpendicular to the orientation of the moraine. The drainage ways trend from the southwest to the northeast and are generally parallel to each other and equally spaced (see route maps). This pattern of drainage is known as a parallel drainage pattern and is indicative of a region having a pronounced, uniform slope and a homogenous lithology.

Figure 27 St. Paul Coal Company's Mine Dump at Mark, Stop 6 (photo by W. T. Frankie).

STOP 6: Mark Mine Dump Gob Pile (Center of the western half of northeast Sec. 8, T32N, R1W, 3rd P.M., Spring Valley 7.5-minute Quadrangle, Putnam County).

A small park is located on the north side of the *gob pile*. From the top of the pile you can see the mine dumps at Dalzel to the north and the pile at Standard to the east.

The Mark Mine Dump is located on the left (fig. 27). This gob pile was the highest in the state until 1986 when the Illinois Department of Mines and Minerals Abandoned Mined Lands Reclamation Council removed 80 feet from the top of the pile, added cover and lime, and seeded it with grass to prevent further erosion. Unfortunately for geologists, the rocks that once were exposed at the surface are now covered with vegetation. On the day of the field trip, we will drive by this site, but a stop description is included if you want to visit this spoil pile in the future. The current elevation at the top of the pile is 800 feet above sea level. The top of the pile is approximately 100 feet above the level of the road.

The following discussion of the Mining at Mark was modified from the 1978C ISGS Field Trip Guide leaflet, *A Guide to the Geology of the Middle Illinois Valley—Putnam, Marshall, and Peoria Counties, Illinois,* by Dwain Berggren and Cathy S. Hunt.

Mining at Mark

The mine dump (gob pile) at the Village of Mark is a clear indication that coal was mined here more than 60 years ago. The construction of the mine, which was called the St. Paul Coal Company, St. Paul Mine No.1, began when the site was dedicated in June 1903, when St. Paul Coal Company sank a shaft 490 feet to the depth of the Colchester Coal. Immigrants from Italy, Scotland, and Germany settled in company houses. In August 1904, the air and hoisting shafts were completed, and mining began. In 1905, the annual report of the Illinois Department of Mines and Minerals listed the mine for the first time, reporting that it produced 42,964 tons of coal with a labor force averaging 160 miners and 56 other employees. Three years later, the mine's production was 285,220 tons, and it employed 368 miners and 128 other employees. About 97 percent of the coal mined was shipped by rail to Chicago and other distant markets.

The St. Paul Coal Company operated the mine through 1924, closing it in 1925. In its final year, the mine employed 578 men and produced 295,069 tons of coal.

The mine was reopened in 1930 by a new owner who operated it as the Prairie State Coal Company for 9 years, finally closing it for the last time in 1938. Records of the Illinois Department of Mines and Minerals show that during the mine's 29 years of operation it produced a total of 6,824,669 tons of coal, an average yield of 240,000 tons per operating year. During this time, the land around the hoisting shaft, which was located at the northeast side of the largest pile, was undermined a mile to the east and about 3/4 of a mile in the other directions.

The Waste Rock Pile

This pile was created by dumping unwanted rocks that were removed from the mine. The early mining method used at Mark was labor intensive. The coal miners dug, by hand, several inches of underclay out from under the coal seam so they could break the coal down and out of what is called the working face. In addition, along their haulage ways, they dug out about 4 feet of rock above the 3-foot-thick coal to make a 7-foot-high tunnel that mules could walk through when pulling the mine cars. Rock that fell and sagged into the haulage ways had to be removed to keep them open. The waste rock—which could not be stowed in the underground openings left after the coal was mined—was brought to the surface and dumped on the pile.

The composition of the waste rock pile, which is now covered with soil and seeded, is no longer visable. Most of the waste rock is soft gray shale, the rock the miners called "soapstone." This soapstone is the shale above the Colchester (No. 2) Coal that formed the roof of the mine and was "dug down" to heighten the haulage ways. Exposed to weather, the book-sized chunks softened, fell into thick plates, and finally turned to mud. Reacting with the sulfuric acid produced by the oxygen and water that weathers the pyrite in the pile, the shale turned red. When burned by the spontaneous combustion of coal scraps in the waste pile, the shale makes hard brick-like chips that clink underfoot. This red deposit is nicknamed "red dog" by miners. One such unreclaimed pile is still visible on the south side of the Illinois River valley east of where Interstate 39 crosses the river.

Less common are the plates of "blistered" black shale. The miners called this rock "slate," perhaps because it is hard and splits into smooth sheets. As figure 4 shows, the black shale generally lies on top of the gray shale above the Colchester (No. 2) Coal. Sometimes, however, the black shale is close enough to the coal to be taken down when heightening the haulage ways. Strewn over the slopes are dark gray and brown ironstone nodules—heavy for their size—which were formed in the gray shale above the coal. Of course, there are a few pieces of coal on the pile.

The Longwall District and Longwall Mining

From the top of the mine pile, you can see the waste piles of several other longwall mines (see fig. 28). Visible from here is the northwestern quarter of the Illinois coal mining region called the "Third Vein District." The Colchester (No. 2) Coal was called the "Third Vein," because in this region it was usually the third coal seam below two others. The Third Vein District includes the southern half of La Salle County and the bordering portions of Bureau and Putnam Counties to the west and Marshall, Woodford, and Livingston Counties to the south. East of the Third Vein District is a smaller one in the eastern half of Grundy County called the Wilmington District. Together, the Wilmington and Third Vein Districts are generally referred to as the Longwall District. The Longwall District included all the mines that used the longwall mining method to work the Colchester (No. 2) Coal. The Longwall District was the only coal field in the United States that produced large tonnages of coal by longwall mining.

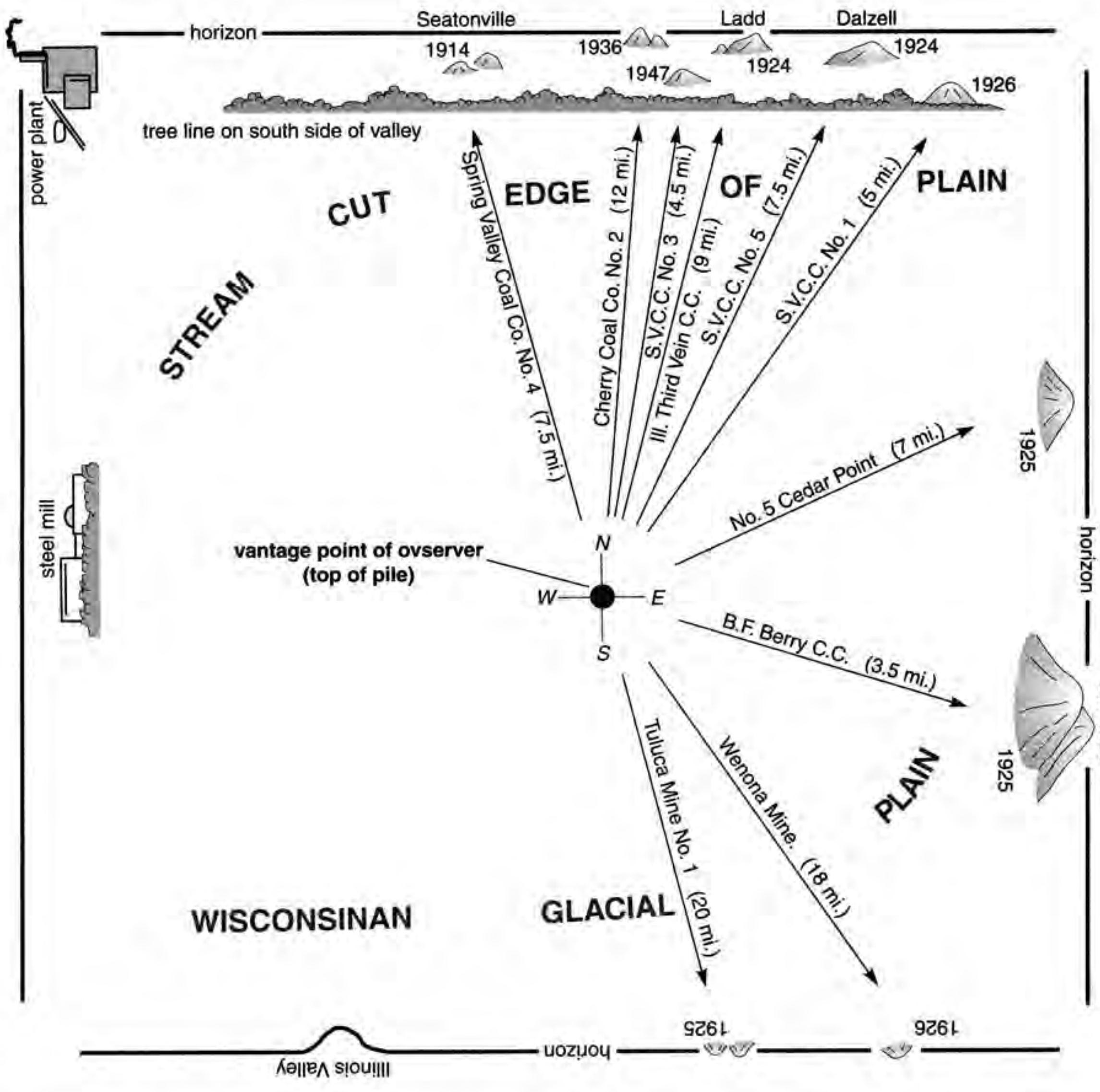


Figure 28 Location of historic longwall coal mines visable from the top of the gob pile located at Mark, Stop 6.

With the longwall mining system, it was possible to mine about 95 percent of the coal in the seam. In contrast, with the more common room-and-pillar mining method, as much as half the coal in a seam must be left as thick walls—pillars—to support the mine roof. The plan of a shaft mine like these using the longwall method can be compared with a wheel (Andros 1914). The shaft pillar, which is analogous to the hub of the wheel, is a polygonal area of coal left unmined under the mine buildings and around the air and the hoisting shafts to support and protect them from the settling caused by coal removal from the mine. Radiating from the shaft pillar—like spokes from the wheel hub—are the main haulage ways out to the working face, the place where the coal is mined. Mining progresses outward in all directions from the shaft pillar at the same time and at the same rate. Therefore, the working face forms a circle expanding outward around the shaft pillar—it forms the rim around the hub and spokes of the longwall "wheel."

Because essentially all of the coal between the shaft pillars and the working face in a longwall mine was removed, the roof rocks settled into the mine openings. Settling was controlled by building "pack walls" with rock from floor to ceiling a few feet behind the working face. The rock was obtained by undercutting the coal and cutting the haulage ways.

A miner dug coal by hand in these mines using pick, wedges, hammer, and shovel. Except when he could work standing in a haulage way, he worked kneeling in the room made by digging out the coal. He loaded coal and any waste rocks that could not be packed and stowed in the mine openings into cars. Mules pulled the loaded cars along narrow gauge tracks to the hoisting shaft where a cage—a simple elevator—drew them to the surface.

In 1882, longwall mines in this region produced 34 percent of the coal mined in the state.This percentage declined steadily until 1924, when the longwall mines produced only one percent of the state's coal—even though for most of this period annual production of these mines exceeded and at times doubled the 1882 amount (Bement 1929). After 1906, the very large, more highly mechanized room-and-pillar mines working in the thicker coals of southern Illinois eclipsed longwall mines. The major reason for this decline is standing before us. Longwall mines required a great deal of effort in mining and hauling rock to make haulage ways and to keep them open under a continually settling roof. On the average, one car in five hoisted out of the mines contained rock instead of coal (Bement 1929). They may not have realized it, but the miners working in the mines of the Longwall District were building their own memorials with the rock hoisted out of the mines.

STOP 7A: Bonucci Sand and Gravel Pit - Pearl Formation (NE, NE, SW, Sec. 26, T33N, R1W, 3rd P.M., Spring Valley 7.5-minute Quadrangle, Putnam County).

This stop reveals significant clues to the geologic history of this part of Illinois. Stop 7A is within Ticona Valley, a buried valley cut into bedrock and subsequently filled with stream and glacial meltwater sediments before it was overridden by glacial ice and buried by glacial sediments. Stop 7B is an exposure of bedrock on the side of the valley that is also buried by glacial sediments. This stop is important because it is one of very few places where you can see the sediment in the buried valley and the bedrock valley wall as well as the overlying glacial sediments.

Sand and Gravel of the Pearl Formation

The Pearl Formation occurs in the buried Ticona Valley (fig. 29). The Ticona Valley is a few miles south of and parallels the Upper Illinois River in La Salle County. This buried valley was first rec-

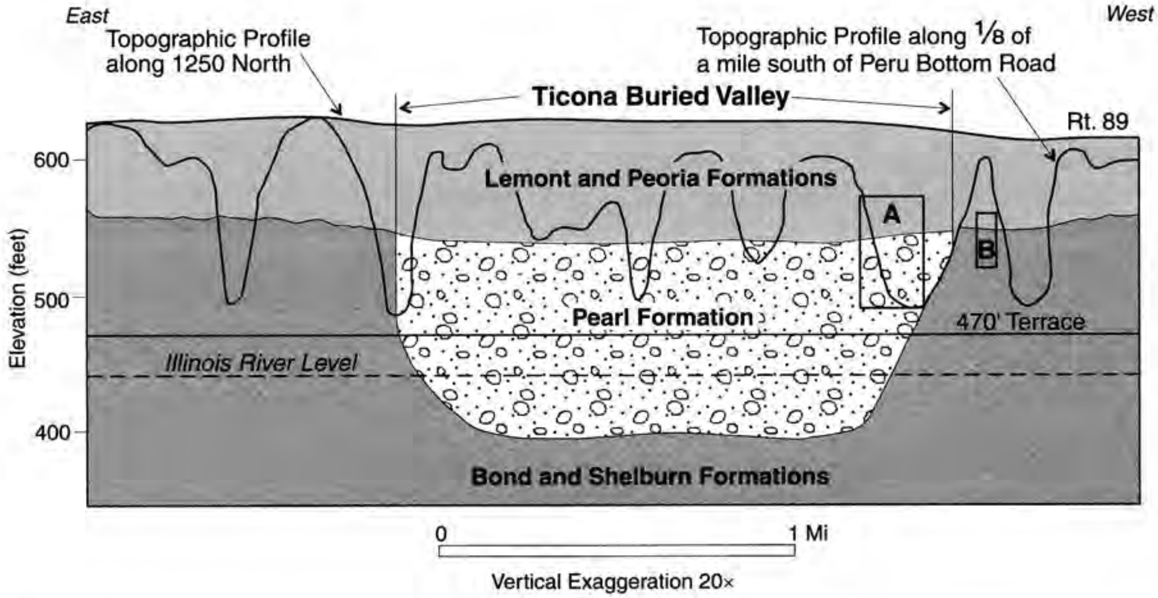


Figure 29 Diagrammatic cross section of Ticona Bedrock Valley at Stop 7A.

ognized in the subsurface in the 1950s by researchers studying unconsolidated sediments in water wells. The sediments that fill this valley are exposed in only two locations: here and where Lone Star Cement (when it was Lehigh Cement) quarrying operations exposed it in the Baily Falls Pit. Two distinct facies are exposed. The lower facies is a distal, low-energy valley train deposit, characterized by upward-fining cycles, relatively fine sediments, thin beds, small-scale cross-beds, and climbing ripple marks. The upper facies was deposited as a proximal, high-energy valley train deposit when glacial ice was closer. This facies is characterized by upward-coarsening cycles, coarse sediments (cobbles), thicker beds, and large-scale cross-beds with dips greater than 25 degrees.

Stratigraphy of Materials within and above the Buried Valley

Quaternary System
- Pleistocene Series
  - Wisconsin Age
    - Richland Silt
      - Loess; gray to red-brown, firm to stiff, clayey silt; wind-transported and deposited loess; 4 feet.
    - Wedron Group
      - Lemont Formation
        - Diamicton; gray to red-brown, stiff to hard, sandy to silty clay with granules, pebbles and cobbles; glacial ice-contact deposit, till; 15 to 25 feet.
      - Tiskilwa Formation
        - Diamicton; gray to red-brown, stiff to hard, sandy to silty clay with granules, pebbles, and cobbles, contains lenses of poorly to well-cemented gravel; glacial ice-contact deposit, till; 25 to 35 feet.
  - Illinois Age
    - Pearl Formation

Grayish tan to medium brown, sand, silt, and gravel; contains numerous gravel beds with cross-beds and several upward-coarsening cycles; top marked by cobble gravel beds, median to proximal valley train outwash, 25 to 35 feet.

Grayish tan to medium brown, sand and silt with some gravel beds; contains several upward-fining cycles; top of cycle marked by silt beds, distal valley train outwash, greater than 30 feet.

Concealed.

STOP 7B: Pennsylvanian Outcrop (SE, SW, NE, Sec. 26, T33N, R1W, 3rd P.M., Spring Valley 7.5-minute Quadrangle, Putnam County).

The La Salle Limestone Member

The La Salle Limestone Member of the Bond Formation only occurs in two areas: the La Salle-Oglesby-Spring Valley and the Pontiac area (fig. 30). The La Salle Limestone is geographically restricted to the crestal region of the La Salle Anticlinorium. The limestone thins and changes nature between Oglesby and here. At Oglesby, the limestone is over 35 feet thick, contains some green shale partings, and is characterized by brecciated beds. Here mudstone beds occur between

Figure 30 Exposure of Pennsylvanian Age La Salle Limestone Member of the Bond Formation at Stop 7B. Geologist Wayne T. Frankie in middle for scale (photo by R. J. Jacobson).

limestone beds (similar to the occurrence at Pontiac), and there is no brecciation. Fossils, mainly brachiopods and crinoids, may occur at any position within the limestone, but the most fossiliferous zones are at the top of the uppermost limestone bed. Individual brachiopods measuring in excess of 4 inches across have been collected from this zone. Several blocks of this fossiliferous limestone have broken away from the ledge and are present near the toe of the slope.

Stratigraphy of the Exposure at Stop 7B, Located Outside of the Buried Valley

Quaternary System

Pleistocene Series

Wisconsin Age

Richland Silt

Loess; gray to red-brown, firm to stiff, clayey silt; wind-transported and deposited loess; 4 feet.

Wedron Group

Lemont Formation

Diamicton; gray to red-brown, stiff to hard, sandy to silty clay, with granules, pebbles, and cobbles; glacial ice-contact deposit, till; 15 to 25 feet.

Tiskilwa Formation

Diamicton; gray to red-brown, stiff to hard, sandy to silty clay with granules, pebbles, and cobbles; contains lenses of poorly to well-cemented gravel; glacial ice-contact deposit, till; 25 to 35 feet.

Pennsylvanian System

Missourian Series

Mattoon Formation

Little Vermillion Limestone Member

Light to medium gray, micrite; some beds may be fossiliferous; unit is discontinuous at this location, less than1 foot.

Dark reddish brown mudstone, 0 to 6 feet.

Black to very dark gray, coal, may have been squeezed and thinned; 0 to 4 inches.

Dark grayish green, mudstone, 4 to 7 feet.

Very dark gray, shale, 0 to 2 feet.

Bond Formation

La Salle Limestone Member

Medium gray, weathers rusty, medium-grained bioclastic limestone with abundant fossils (this is the best fossil collecting horizon, several blocks of this unit are present at the base of the outcrop), 4 to 6 inches.

Medium gray, coarse bioclastic grainstone with some solution openings; 4 to 6 feet.

Medium gray, micrite to medium bioclastic grainstone, some fossils; 4 to 6 inches.

Medium to dark grayish green mudstone; contains brachiopods in vertical and horizontal orientations; 1 to 2 feet.

Light gray to tan, weathers knobby and rusty, micrite; contains fossils and fossil fragments; 6 inches to 1.5 feet.

Medium to dark grayish green mudstone with micrite nodules; 10 to 11 feet.

Medium gray, micrite to medium bioclastic grainstone, some fossils; 4 to 6 inches.

Medium to dark grayish green, mudstone with micrite nodules; greater than 10 feet.

Concealed.

ALTERNATE STOP 8: Sand and Gravel Pit - Henry Formation (Northwest, Sec. 3, T30N, R2W, 3rd P.M., Henry 7.5-minute Quadrangle, Marshall County). This is an extended section; the exposure is located 800 feet from the north line and 1,400 from the west line of Sec. 3 (see fig. 31).

Sandy Creek Section of the Henry Formation

The Henry Formation was originally defined as bedded sand and gravel deposits that occur above the Sangamon Soil and that is either at the surface or overlain by postglacial sediments. The Henry Formation was deposited during the Wisconsin Episode of glaciation. Layers of silt and clay occur within the sand and gravel. The Henry Formation is much younger than the similar gravels present at Stop 7A. The Henry Formation is largely glacial outwash that was deposited as melt-waters from the Wisconsin glaciers that were discharged down larger stream valleys, like the Illinois.

Figure 31 Exposure of Henry Formation at the Sandy Creek Section at Stop 8. Geologist Wayne T. Frankie in upper left for scale (photo by R. J. Jacobson).

There are two educational purposes to this stop. The first is to introduce you to some of the ways geologists go about describing and interpreting sediment units. Geologists think about things much differently than other scientists do. Physics and chemistry are concerned almost exclusively with phenomena controlled by presumably universal natural systems that are non-historical; that is, the discipline is independent of the time in which those systems operate. Geology, astronomy, and biology, on the other hand, are more historical. When a geologist focuses on present processes and characteristics of earth materials, he or she is an applied physicist or chemist. When a geologist interprets a series of past events, he or she becomes a unique historical scientist. While assuming all physical, chemical, and biological theory, the geologist's chief goal is to reconstruct and explain Earth history. The second goal is to provide a thorough discussion of the Henry Formation, which is exposed here, and propose some interpretations as to its origin.

Forensic Geology

Geology is a forensic science. Geologists depict the past by observing the rock record in various parts of the world and by sampling rocks for laboratory analysis. In other words, the history of the Earth comes from the book of rocks that is otherwise known as "the geologic record." In terms of a human life span, the Earth does not appear to change in any significant way. The Earth does indeed change, but the usual pace of change is so slow that it is imperceptible. Furthermore, the nature of the change is gradual, irreversible, cumulative, and evolutionary. This evolutionary change is controlled by a great ecological interaction between the living and nonliving realms of the Earth system.

The principal laws for interpreting the geologic past include the doctrine of uniformitarianism, the laws of cross-cutting relations, superposition, original horizontality, original continuity, inclusions, and the principle of biologic succession. These concepts have existed for almost 200 years and provide the necessary conceptual framework for establishing a relative chronology of events and depicting ancient Earth conditions.

Actualism (the assumption that the present laws of science have always operated) provides the link from present to past through analogical reasoning to allow inference of ancient causes from their historical results.

Thus, the variations in grain size, layer thickness, and sedimentary structures within this exposure reflect different sedimentary environments within these ancient river systems.

Layering and Layer Thickness

Bedding (layering) is the most widespread and most important feature of sediments and sedimentary rocks. Sedimentary bedding forms as a response to variations in local depositional conditions. In other words, the sediments within a given sedimentary rock were deposited under very similar conditions. Contacts between beds represent a variation in these conditions, and the thickness of the layering is dependent on the length of time that these depositional conditions lasted. They can be long-lived or short-lived. A simple analogy would be a rainstorm. The rain may come down lightly or heavily. In addition, the rain may last for only a few moments or for several hours or days. And, of course, any combination is possible, as it is with the deposition of sedimentary rocks.

Grain Size

Grain size is an important clue in determining the overall energy or vigor of sediment transport. In general, running water needs a greater flow velocity to transport coarser materials. Wind can only effectively transport silt and fine sand. Bedded coarse sands and gravels can only have formed in fast-moving streams.

Sedimentary Structures

A sedimentary structure is a geometric feature within sediments or sedimentary rocks that formed at about the time of deposition. Sedimentary structures can occur within beds or along bedding planes, and they can form through erosional or depositional processes. These sedimentary structures are directly related to the process of sediment formation and thus the conditions of the environment of deposition. Thus, sedimentary structures provide important clues about the geologic past.

Description of the Section

The lower 40 feet of the section here is not exposed. This section was measured, described, and interpreted by faculty and students at Illinois State University in 2001. This section was subdivided into ten different units, based on differences in bed thickness, grain size, and sedimentary structures (fig. 32).

Unit 1 At the base of this section about one foot of sand is present. This sand is light yellowish brown. It is well-sorted medium-grained sand and contains mostly quartz with lesser rock dark minerals and rock fragments. The sand is massive, and no sedimentary structures are evident. This unit is interpreted to have been deposited during normal stream flow.

Unit 2 This unit is a spectacularly cross-bedded gravel. The cross-beds pervade the entire thickness of the unit. They are about 30 to 35 feet in length and are inclined to the south at about 20 degrees. The orientation of these cross-beds indicate that the current that deposited this unit was flowing down the Illinois River valley rather than along Sandy Creek. Like Unit 1, Unit 2 is yellowish to reddish brown in color, about 8 feet thick, and consists of subequal amounts of sand and gravel. The sand fraction includes medium-coarse–sized grains of quartz, rock fragments, and dark minerals. The gravel fraction includes a variety of sedimentary, igneous, and metamorphic rocks. Sedimentary rock types, which occur upstream along the Illinois River, are the most abundant. Many of the dolomite cobbles have a thin coating of hematite, and the outer foot or so is well cemented by calcite. The hematite and calcite were formed as chemical precipitates from groundwater that was discharged through the unit well after deposition.

Detection of layering in thick gravel units is sometimes a difficult task. In most cases, gravels form massive beds.

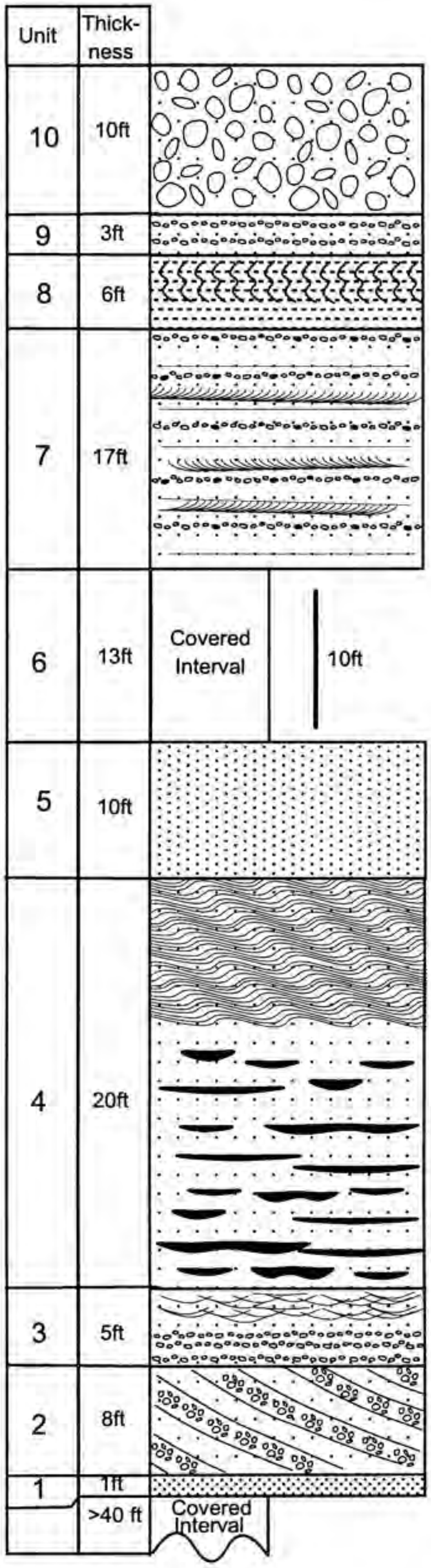


Figure 32 Schematic profile of Henry Formation exposed at Stop 8.

The type of cross-bedding present in this unit probably formed by the migration of large gravel bars during a high-energy torrent event, perhaps as the result of the breaching of a glacial lake upstream along the Illinois River.

Unit 3 About five feet in thickness, Unit 3 is well cemented and makes a prominent bench. The unit consists of interlayered gravels in sands. The gravel layers bear a strong resemblance to Unit 2 in terms of color, texture, and composition. Many layers here are only one clast in thickness. The gravels are more prevalent at the base of the unit. The sand layers occur at the top of the unit. They are brown in color and contain medium-fine grains of mostly quartz sand. Flute casts are abundant. Flute casts (or flute marks, or flutes) (fig. 33) are a very common type of erosional sedimentary structure. They are elongate in shape and are characterized by a rounded nose at one end and a taper at the other. They are as much as 1 foot long and several inches across. Flutes form from small eddies that scour the sediment at the base of a channel.

Unit 3 is interpreted to have formed as the torrent that deposited Unit 3 began to subside. The gravel layers likely represent "lag" deposits. These form when the current is no longer strong enough to transport the coarsest particles, but the surrounding sand is winnowed away. The flute marks at the top of the unit represent a continued reduction in water volume and stream energy where gravel is no longer present. The stream energy, however, is still vigorous enough to erode and transport sand.

Figure 33 Flute casts with hammer for scale (photo by R. J. Jacobson).

Unit 4 Unit 4 is the thickest unit present in this section at about 20 feet. It is dominated by medium to fine sand with small amounts of silt and clay. The sand here is very rich in quartz, with the non-quartz fraction making up less than 5 percent of the unit. The unit is light yellowish brown in color, and is less well exposed than the other units found here. Bedding is difficult to discern on weathered surfaces, but gently scraping the surface reveals many important small-scale features. Bedding is present, and most beds are a few feet thick.

Two distinct types of sedimentary structures are present in this unit, and each is important for the overall interpretation. At the base of the unit, "flaser bedding," a special type of cross-bedding, is common. In flaser bedding, patterns of cross-bedded sands (lighter color) are broken up by small lenses of silt and clay (darker color). In this case, the finer materials drape ripple forms and fill ripple troughs.

The upper layers of the unit contain a special type of sedimentary structure called "climbing ripples." In most cross-bedded sediment, boundaries between cross-bed sets are flat and formed by erosion. In contrast, climbing ripples are inclined and depositional. Climbing ripples form when the sediment supply exceeds the current's ability to erode and transport it.

The presence of flaser bedding and climbing ripples and the lack of gravel indicate that at this time the Illinois River was trying to transport more sediment than its water depth and velocity would allow. Unit 4 likely represents a continuing reduction in stream discharge from the torrent that deposited Unit 2.

Unit 5 Very poorly exposed, Unit 5 bears a strong resemblance to Unit 1 in terms of texture, composition, and structure.

Unit 6 This interval is covered by talus.

Unit 7 This unit is the most heterogeneous of all the units that are exposed here. It is 17 feet in thickness and consists of interbedded sands and gravels. Individual layers range in thickness from less than a foot to more than several feet. The gravel layers are typically massive, several feet in thickness, and similar in texture and composition to those in Units 2 and 3. The sand units are much more variable. The sand units are similar in composition to those of the underlying units, but bedding and cross-bedding are clearly evident here. The grain size is consistent within an individual bed and includes coarse and fine sand layers. The cross-bed patterns are typical for stream-deposited sediments. The orientations of these cross-beds are quite variable and reflect a number of different directions of stream flow. One interesting aspect of some of the sand units is the presence of coal clasts along some of the cross-bed surfaces. This part of the section is the only place where coal clasts were found.

Unit 7 is interpreted to represent a complex variety of sedimentary environments that were related to stream flow down the Illinois River and Sandy Creek. In part, this unit represents an alluvial fan that formed at the mouth of Sandy Creek during normal (rather than torrent) stream flow. It also in part represents sand and gravel bar migration down the Illinois River itself. The coal clasts represent new sediment sources and could have been derived from Colchester Coal exposures upstream along the Illinois River or along Sandy Creek.

Unit 8 This unit consists predominantly of thinly laminated light brown silts. Unit 8 is the only fine-grained unit exposed here and the only unit that did not form in a stream environment. This unit is a windblown loess deposit that formed as the volume of water released down the Illinois River was very low. These dry conditions enabled wind to become an important sediment transport and depositional agent.

Unit 9 Unit 9 is 3 feet in thickness and is identical in texture, composition, and structure to Unit 7. It marks a return to the building of the alluvial fan at the mouth of Sandy Creek and normal stream flow down the Illinois River valley.

Unit 10 This unit is a 10-feet thick boulder gravel that occurs at the top of the exposure. Unlike Unit 2, Unit 10 is massive and has no internal structure. The maximum grain size is much coarser in Unit 10 as well; boulder-sized clasts are common.

Unit 10 is interpreted to represent a second large-scale torrent release down the Illinois River valley.

Discussion

The sediments exposed here were deposited in a variety of sedimentary environments that were present when glacial meltwaters were released down the ancestral Illinois River valley and its tributaries. Two gravel units represent large torrents of water that were released, probably as moraine dams that bounded large glacial lakes upstream episodically failed. One such cycle is preserved here. The lowermost unit consists of cross-bedded gravels that represent the torrent itself. Overlying sediments represent the gradual recession of this torrent to normal stream flow and eventually to low flow, which permitted the deposition of windblown loess.

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Glossary

The following definitions are adapted in total or in part from several sources. The principal source is R.L. Bates and J.A Jackson, eds., 1987, *Glossary of Geology*, 3rd ed.: Alexandria, Virginia, American Geological Institute, 788 p.

ablation Separation and removal of rock material and formation of deposits, especially by wind action or the washing away of loose and soluble materials.

age An interval of geologic time; a division of an epoch.

aggrading stream A stream that is actively depositing sediment in its channel or floodplain because it is being supplied with more load than it can transport.

alluviated valley One that has been at least partially filled with sand, silt, and mud by flowing water.

alluvium A general term for clay, silt, sand, gravel, or similar unconsolidated sorted or semisorted sediment deposited during comparatively recent time by a stream or other body of running water.

anticline A convex-upward rock fold in which strata have been bent into an arch; the strata on either side of the core of the arch are inclined in opposite directions away from the axis or crest; the core contains older rocks than does the perimeter of the structure.

anticlinorium A complex structure having smaller structures, such as domes, anticlines, and synclines superimposed on its broad upwarp.

aquifer A geologic formation that is water-bearing and that transmits water from one point to another.

arenite A relatively clean quartz sandstone that is well sorted and contains less than 10% argillaceous material.

argillaceous Said of rock or sediment that contains, or is composed of, clay-sized particles or clay minerals.

base level Lower limit of erosion of the land's surface by running water. Controlled locally and temporarily by the water level of stream mouths emptying into lakes, or more generally and semipermanently by the level of the ocean (mean sea level).

basement complex The suite of mostly crystalline igneous and/or metamorphic rocks that generally underlies the sedimentary rock sequence.

basin A topographic or structural low area that generally receives thicker deposits of sediments than adjacent areas; the low areas tend to sink more readily, partly because of the weight of the thicker sediments; the term also denotes an area of relatively deep water adjacent to shallow-water shelf areas.

bed A naturally occurring layer of earth material of relatively greater horizontal than vertical extent that is characterized by physical properties different from those of overlying and underlying materials. It also is the ground upon which any body of water rests or has rested, or the land covered by the waters of a stream, lake, or ocean; the bottom of a stream channel.

bedrock The solid rock (sedimentary, igneous, or metamorphic) that underlies the unconsolidated (non-indurated) surface materials (for example, soil, sand, gravel, glacial till).

bedrock valley A drainageway eroded into the solid bedrock beneath the surface materials. It may be completely filled with unconsolidated (non-indurated) materials and hidden from view.

biota All living organisms of an area; plants and animals considered together.

braided stream A low-gradient, low-volume stream flowing through an intricate network of interlacing shallow channels that repeatedly merge and divide and are separated from each other by branch islands or channel bars. Such a stream may be incapable of carrying all of its load. Most streams that receive more sediment load than they can carry become braided.

calcarenite Describes a limestone composed of more or less worn fragments of shells or pieces of older limestone. The particles are generally sand-sized.

calcareous Said of a rock containing some calcium carbonate ($CaCO_3$), but composed mostly of something else (synonym: limey).

calcining The heating of calcite or limestone to its temperature of dissociation so that it loses its carbon dioxide; also applied to the heating of gypsum to drive off its water of crystallization to make plaster of Paris.

calcite A common rock-forming mineral consisting of $CaCO_3$; it may be white, colorless, or pale shades of gray, yellow, and blue; it has perfect rhombohedral cleavage, appears vitreous, and has a hardness of 3 on the Mohs scale; it effervesces (fizzes) readily in cold dilute hydrochloric acid. It is the principal constituent of limestone.

chert Silicon dioxide (SiO_2); a compact, massive rock composed of minute particles of quartz and/or chalcedony; it is similar to flint, but lighter in color.

clastic Said of rocks composed of particles of other rocks or minerals, including broken organic hard parts as well as rock substances of any sort, transported and deposited by wind, water, ice, or gravity.

claypan (soil) A heavy, dense subsurface soil layer that owes its hardness and relative imperviousness to higher clay content than that of the overlying material.

closure The difference in altitude between the crest of a dome or anticline and the lowest structural or elevation contour that completely surrounds it.

columnar section A graphic representation, in the form of one or more vertical columns, of the vertical succession and stratigraphic relations of rock units in a region.

conformable Said of strata deposited one upon another without interruption in accumulation of sediment; beds parallel.

cuesta A ridge with a gentle slope on one side and a steep slope on the other.

delta A low, nearly flat, alluvial land form deposited at or near the mouth of a river where it enters a body of standing water; commonly a triangular or fan-shaped plain extending beyond the general trend of a coastline.

detritus Loose rock and mineral material produced by mechanical disintegration and removed from its place of origin by wind, water, gravity, or ice; also, fine particles of organic matter, such as plant debris.

disconformity An unconformity marked by a distinct erosion-produced irregular, uneven surface of appreciable relief between parallel strata below and above the break; sometimes represents a considerable time interval of nondeposition.

dolomite A mineral, calcium-magnesium carbonate ($Ca,Mg[CO_3]_2$); also the name applied to sedimentary rocks composed largely of the mineral. It is white, colorless, or tinged yellow, brown, pink, or gray; has perfect rhombohedral cleavage; appears pearly to vitreous; and effervesces feebly in cold dilute hydrochloric acid.

drift All rock material transported by a glacier and deposited either directly by the ice or reworked and deposited by meltwater streams and/or the wind.

driftless area A 10,000-square mile area in northeastern Iowa, southwestern Wisconsin, and northwestern Illinois where the absence of glacial drift suggests that the area may not have been glaciated.

earthquake Ground displacement associated with the sudden release of slowly accumulated stress in the lithosphere.

end moraine A ridge or series of ridges formed by accumulations of drift built up along the outer margin of an actively flowing glacier at any given time; a moraine that has been deposited at the lower or outer end of a glacier.

epoch An interval of geologic time; a division of a period (for example, Pleistocene Epoch).

era The unit of geologic time that is next in magnitude beneath an eon; it consists of two or more periods (for example, Paleozoic Era).

erratic A rock fragment carried by glacial ice and deposited far from its point of origin.

escarpment A long, more or less continuous cliff or steep slope facing in one general direction; it generally marks the outcrop of a resistant layer of rocks or the exposed plane of a fault that has moved recently.

esker An elongated ridge of sand and gravel that was deposited by a subglacial or englacial stream flowing between ice walls or in an ice tunnel and left behind by a melting glacier.

fault A fracture surface or zone of fractures in Earth materials along which there has been vertical and/or horizontal displacement or movement of the strata on opposite sides relative to one another.

flaggy Said of rock that tends to split into layers of suitable thickness for use as flagstone.

floodplain The surface or strip of relatively smooth land adjacent to a stream channel produced by the stream's erosion and deposition actions; the area covered with water when the stream overflows its banks at times of high water; it is built of alluvium carried by the stream during floods and deposited in the sluggish water beyond the influence of the swiftest current.

fluvial Of or pertaining to a river or rivers.

flux A substance used to remove impurities from steel. Flux combines with the impurities in the steel to form a compound that has a lower melting point and density than steel. This compound tends to float to the top and can be easily poured off and separated from the molten steel.

formation The basic rock unit, one distinctive enough to be readily recognizable in the field and widespread and thick enough to be plotted on a map. It describes the strata, such as limestone, sandstone, shale, or combinations of these and other rock types. Formations have formal names, such as Joliet Formation or St. Louis Limestone (Formation), generally derived from the geographic localities where the unit was first recognized and described.

fossil Any remains or traces of a once-living plant or animal preserved in rocks (arbitrarily excludes recent remains); any evidence of ancient life. Also used to refer to any object that existed in the geologic past and for which evidence remains (for example, a fossil waterfall)

fragipan A dense subsurface layer of soil whose hardness and relatively slow permeability to water are chiefly due to extreme compactness rather than to high clay content (as in claypan) or cementation (as in hardpan).

friable Said of a rock or mineral that crumbles naturally or is easily broken, pulverized, or reduced to powder, such as a soft and poorly cemented sandstone.

geology The study of the planet Earth that is concerned with its origin, composition, and form, its evolution and history, and the processes that acted (and act) upon the Earth to control its historic and present forms.

geophysics Study of the Earth with quantitative physical methods. Application of the principles of physics to the study of the earth, especially its interior.

glaciation A collective term for the geologic processes of glacial activity, including erosion and deposition, and the resulting effects of such action on the Earth's surface.

glacier A large, slow-moving mass of ice formed on land by the compaction and recrystallization of snow.

gley horizon A soil developed under conditions of poor drainage that reduced iron and other elemental contents and results in gray to black, dense materials.

gob pile A heap of mine refuse left on the surface.

graben An elongate, relatively depressed crustal unit or block that is bounded by faults on its long sides.

gradient A part of a surface feature of the Earth that slopes upward or downward; the angle of slope, as of a stream channel or of a land surface, generally expressed by a ratio of height versus distance, a percentage or an angular measure from the horizontal.

gypsum A widely distributed mineral consisting of hydrous calcium sulfate ($CaSO_4 \cdot 2H_2O$). Gypsum is soft (hardness of 2 on the Mohs scale); white or colorless when pure but commonly has tints of gray, red, yellow, blue or brown. Gypsum is used as a retarder in portland cement and in making plaster of Paris.

horst An elongate, relatively uplifted crustal unit or block that is bounded by faults on its long sides.

igneous Said of a rock or mineral that solidified from molten or partly molten material (that is, from magma).

indurated Said of compact rock or soil hardened by the action of pressure, cementation, and, especially, heat.

joint A fracture or crack in rocks along which there has been no movement of the opposing sides (*see also* fault).

karst Collective term for the land forms and subterranean features found in areas with relatively thin soils underlain by limestone or other soluble rocks; characterized by many sinkholes separated by steep ridges or irregular hills. Tunnels and caves formed by dissolution of the bedrock by groundwater honeycomb the subsurface. Named for the region around Karst in the Dinaric Alps of Croatia where such features were first recognized and described.

lacustrine Produced by or belonging to a lake.

Laurasia A protocontinent of the northern hemisphere, corresponding to Gondwana in the southern hemisphere, from which the present continents of the Northern Hemisphere have been derived by separation and continental displacement. The supercontinent from which both were derived is Pangea. Laurasia included most of North America, Greenland, and most of Eurasia, excluding India. The main zone of separation was in the North Atlantic, with a branch in Hudson Bay; geologic features on opposite sides of these zones are very similar.

lava Molten, fluid rock that is extruded onto the surface of the Earth through a volcano or fissure. Also the solid rock formed when the lava has cooled.

limestone A sedimentary rock consisting primarily of calcium carbonate (the mineral, calcite). Limestone is generally formed by accumulation, mostly in place or with only short transport, of the shells of marine animals, but it may also form by direct chemical precipitation from solution in hot springs or caves and, in some instances, in the ocean.

lithify To change to stone, or to petrify; especially to consolidate from a loose sediment to a solid rock.

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

local relief The vertical difference in elevation between the highest and lowest points of a land surface within a specified horizontal distance or in a limited area.

loess A homogeneous, unstratified accumulation of silt-sized material deposited by the wind.

magma Naturally occurring molten rock material generated within Earth and capable of intrusion into surrounding rocks or extrusion onto the Earth's surface. When extruded on the surface it is called lava. The material from which igneous rocks form through cooling, crystallization, and related processes.

meander One of a series of somewhat regular, sharp, sinuous curves, bends, loops, or turns produced by a stream, particularly in its lower course where it swings from side to side across its valley bottom.

meander scars Crescent-shaped swales and gentle ridges along a river's floodplain that mark the positions of abandoned parts of a meandering river's channel. They are generally filled in with sediments and vegetation and are most easily seen in aerial photographs.

metamorphic rock Any rock derived from pre-existing rocks by mineralogical, chemical, and structural changes, essentially in the solid state, in response to marked changes in temperature, pressure, shearing stress, and chemical environment at depth in Earth's crust (for example, gneisses, schists, marbles, and quartzites)

mineral A naturally formed chemical element or compound having a definite chemical composition, an ordered internal arrangement of its atoms, and characteristic crystal form and physical properties.

monolith (a) A piece of unfractured bedrock, generally more than a few meters across. (b) A large upstanding mass of rock.

moraine A mound, ridge, or other distinct accumulation of glacial drift, predominantly till, deposited in a variety of topographic land forms that are independent of control by the surface on which the drift lies (*see also* end moraine).

morphology The scientific study of form and of the structures and development that influence form; term used in most sciences.

natural gamma log One of several kinds of measurements of rock characteristics taken by lowering instruments into cased or uncased, air- or water-filled boreholes. Elevated natural gamma radiation levels in a rock generally indicate the presence of clay minerals.

nickpoint A place with an abrupt inflection in a stream profile, generally formed by the presence of a rock layer resistant to erosion; also, a sharp angle cut by currents at base of a cliff.

nonconformity An unconformity resulting from deposition of sedimentary strata on massive crystalline rock.

nonlithified Said of unconsolidated materials.

normal fault A fault in which the hanging wall appears to have moved downward relative to the footwall.

outwash Stratified glacially derived sediment (clay, silt, sand, and gravel) deposited by meltwater streams in channels, deltas, outwash plains, glacial lakes, and on floodplains.

outwash plain The surface of a broad body of outwash formed in front of a glacier.

oxbow lake A crescent-shaped lake in an abandoned bend of a river channel. A precursor of a meander scar.

palisades A picturesque extended rock cliff or line of bold cliffs, rising precipitously from the margin of a stream or lake.

Pangea The supercontinent that existed from 300 to 200 million years ago. It combined most of the continental crust of the Earth, from which the present continents were derived by fragmentation and movement away from each other by means of plate tectonics. During an intermediate stage of the fragmentation, between the existence of Pangea and that of the present widely separated continents, Pangea was split into two large fragments, Laurasia on the north and Gondwana in the southern hemisphere.

ped Any naturally formed unit of soil structure (for example, granule, block, crumb, or aggregate).

peneplain A land surface of regional scope worn down by erosion to a nearly flat or broadly undulating plain.

Pentamarus An articulate brachiopod.

period An interval of geologic time; a division of an era (for example, Cambrian, Jurassic, and Tertiary).

physiographic province (or division) (a) A region, all parts of which are similar in geologic structure and climate and which has consequently had a unified geologic history. (b) A region whose pattern of relief features or landforms differs significantly from that of adjacent regions.

physiography The study and classification of the surface features of Earth on the basis of similarities in geologic structure and the history of geologic changes.

point bar A low arcuate ridge of sand and gravel developed on the inside of a stream meander by accumulation of sediment as the stream channel migrates toward the outer bank.

radioactivity logs Any of several types of geophysical measurements taken in boreholes using either the natural radioactivity in the rocks, or the effects of radiation on the rocks to determine the lithology or other characteristics of the rocks in the walls of the borehole (for example, natural gamma radiation log; neutron density log).

relief (a) A term used loosely for the actual physical shape, configuration, or general uneveness of a part of Earth's surface, considered with reference to variations of height and slope or to irregularities of the land surface; the elevations or differences in elevation, considered collectively, of a land surface (frequently confused with topography). (b) The vertical difference in elevation between the hilltops or mountain summits and the lowlands or valleys of a given regional extent. Formed in places where the forces of plate tectonics are beginning to split a continent (for example, East African Rift Valley).

rift (a) A narrow cleft, fissure, or other opening in rock made by cracking or splitting; (b) a long, narrow continental trough that is bounded by normal faults—a graben of regional extent.

sediment Solid fragmental matter, either inorganic or organic, that originates from weathering of rocks and is transported and deposited by air, water, or ice or that is accumulated by other natural agents, such as chemical precipitation from solution or secretion from organisms. When deposited, sediment generally forms layers of loose, unconsolidated material (for example, sand, gravel, silt, mud, till, loess, and alluvium).

sedimentary rock A rock resulting from the consolidation of loose sediment that has accumulated in layers (for example, sandstone, siltstone, mudstone, and limestone).

shoaling Said of an ocean or lake bottom that becomes progressively shallower as a shoreline is approached. The shoaling of the ocean bottom causes waves to rise in height and break as they approach the shore.

silt A rock fragment or detrital particle smaller than a very fine sand grain and larger than coarse clay, having a diameter in the range of 4 to 62 microns; the upper size limit is approximately the smallest size that can be distinguished with the unaided eye.

sinkhole Any closed depression in the land surface formed as a result of the collapse of the underlying soil or bedrock into a cavity. Sinkholes are common in areas where bedrock is near the surface and susceptible to dissolution by infiltrating surface water. Sinkhole is synonymous with "doline," a term used extensively in Europe. The essential component of a hydrologically active sinkhole is a drain that allows any water that flows into the sinkhole to flow out the bottom into an underground conduit.

slip-off slope Long, low, gentle slope on the inside of a stream meander. The slope on which the sand that forms point bars is deposited.

stage, substage Geologic time-rock units; the strata formed during an age or subage, respectively. Generally applied to glacial episodes (for example, Woodfordian Substage of the Wisconsinan Stage.

stratigraphic unit A stratum or body of strata recognized as a unit in the classification of the rocks of Earth's crust with respect to any specific rock character, property, or attribute or for any purpose such as description, mapping, and correlation.

stratigraphy The study, definition, and description of major and minor natural divisions of rocks, particularly the study of their form, arrangement, geographic distribution, chronologic succession, naming or classification, correlation, and mutual relationships of rock strata.

stratum A tabular or sheet-like mass, or a single, distinct layer of material of any thickness, separable from other layers above and below by a discrete change in character of the material, a sharp physical break, or both. The term is generally applied to sedimentary rocks but could be applied to any tabular body of rock (*see also* bed).

subage A small interval of geologic time; a division of an age.

syncline A convex-downward fold in which the strata have been bent to form a trough; the strata on either side of the core of the trough are inclined in opposite directions toward the axis of the fold; the core area of the fold contains the youngest rocks (*see also* anticline).

system A fundamental geologic time–rock unit of worldwide significance; the strata of a system are those deposited during a period of geologic time (for example, rocks formed during the Pennsylvanian Period are included in the Pennsylvanian System).

tectonic Pertaining to the global forces that cause folding and faulting of the Earth's crust; also used to classify or describe features or structures formed by the action of those forces.

tectonics The branch of geology dealing with the broad architecture of the upper (outer) part of Earth; that is, the major structural or deformational features, their origins, historical evolution, and relations to each other. It is similar to structural geology, but generally deals with larger features such as whole mountain ranges or continents.

temperature-resistance log A borehole log, run only in water-filled boreholes, that measures the water temperature and the quality of groundwater in the well.

terrace An abandoned floodplain formed when a stream flowed at a level above the level of its present channel and floodplain.

till Nonlithified, nonsorted, unstratified drift deposited by and underneath a glacier and consisting of a heterogenous mixture of different sizes and kinds of rock fragments.

till plain The undulating surface of low relief in an area underlain by ground moraine.

topography The natural or physical surface features of a region, considered collectively as to form; the features revealed by the contour lines of a map.

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

unconformity A substantial break or gap in the geologic record where a rock unit is overlain by another that is not next in stratigraphic successsion.

underfit stream A misfit stream that appears to be too small to have eroded the valley in which it flows. It is a common result of drainage changes effected by stream capture, by glaciers, or by climate variations.

valley train The accumulation of outwash deposited by rivers in their valleys downstream from a glacier.

water table The point in a well or opening in the Earth where groundwater begins. It generally marks the top of the zone where the pores in the surrounding rocks are fully saturated with water.

weathering The group of processes, both chemical and physical, whereby rocks on exposure to the weather change in character and decay and finally crumble into soil.

John Wesley Powell in Illinois

By Robert G. Corbett
Professor Emeritus, Illinois State University

Geologist G. K. Gilbert prepared the following tribute to Powell after his death in 1902. It was published in the October 10, 1902 issue of *Science:*

> To the nation he was known as an intrepid explorer; to the wide public as a conspicuous and cogent advocate of reforming the laws affecting the development of the arid West; to geologists as a pioneer in a new province of interpretation and the chief organizer of a great engine of research; to anthropologists as a leader in philosophic thought and the founder in America of a new regime.

Misinformation or incomplete information about John Wesley Powell and his time in Illinois is widespread. A goal of this brief biography is to set the record straight.

Before Illinois

John Wesley Powell was born in 1834 at Mount Morris, New York, to Joseph and Mary Dean Powell, immigrants from England. His father was a licensed exhorter in the Methodist Episcopal Church, and the family was outspoken in the cause of abolition. They moved to Jackson, Ohio, a town along the Ohio River, in 1838. Life for young John at the local school involved torment, resulting from the anti-slavery views. For a while, he and several others were educated on a farm by George Crookham, who awoke in his students an interest in natural history through observation of nature in the field. The family moved to a farm in southern Wisconsin in 1846, and young John took on the new responsibilities of farming and marketing of produce that allowed his father to ride the circuit. John was an avid reader, and his mother provided tutelage. John attended classes in the winter of 1850 twenty miles from the farm in Janesville.

Illinois Years, Pre-Civil War

The family moved to a larger farm in Boone County, Illinois, in 1851. The next year, farming responsibilities were passed on to a younger brother, and John then devoted himself to preparation as a schoolteacher, reading extensively in grammar, arithmetic, and geography. He found employment in a one-room school in Jefferson Prairie, Wisconsin. He taught and studied for the year, and returned to the family farm in 1853. His father helped found the Illinois Institute (now Wheaton College), and the family moved to Wheaton in the fall of 1853. Apparently young John attended some courses.

Young John moved to near Decatur in the fall and taught school. He also joined the Illinois Natural History Society, and this affiliation would become more important over the years. At the end of the school year, John and his brother-in-law tried to establish a sheep farm and nursery, but the operation failed. He spent the summer of 1855 studying, and in the fall formally entered Illinois College. After one term, he left for a teaching position in Clinton during the winter and spring. He returned to Wheaton, and finding that he was already advanced beyond the available classes, again studied on his own. With a goal of preparing for the ministry, he entered the sophomore class at Oberlin College (Ohio), and there reinforced his interest in natural history, particularly botany.

After leaving Oberlin, Powell roamed the Midwest largely by rowboat, collecting plant and animal specimens. He was involved with the Natural History Society, emphasizing mollusks of the state. He viewed these efforts as a part of the broader study of geology.

Powell taught at Hennepin during the school year of 1859–1960. In the summer, he resumed exploring and collecting in northern Illinois and eastern Iowa. He also had visited the South, giving lectures, and he became convinced that war was inevitable over the issue of slavery. He returned to Hennepin for another year of teaching. He found time to teach himself some engineering and something about military tactics. At the end of the school year and in response to President Lincoln's call for volunteers, John enlisted at Hennepin as the Civil War had begun.

Civil War Years

His rapid rise through the ranks (entering as a private, with promotions to sergeant-major, second lieutenant, captain, major, and lieutenant colonel) reflected both his distinction to duty, skills as a planner and leader in the artillery, and fortunate opportunities. He met General Ulysses S. Grant and served under the command of Generals McPherson, Sherman, and Thomas. During this time, he also studied books, collected specimens, and took notes on the local geology and military tactics of the opponents. He lost his right arm to a large musket ball at the battle of Shiloh. Much of his time in the military is well documented.

Illinois Years after the Civil War

Powell had married Emma Dean during the war, and now he looked for a way to support the two of them. Among several opportunities was an offer from Illinois Wesleyan University to join the faculty as Professor of Natural Science and curator of the university's museum of natural history. The Major (his preferred appellation) gladly accepted the appointment. Records show that Powell taught mineralogy, botany, and zoology. In his 2 years at Wesleyan, he created the museum, had students study specimens in the laboratory and in the field, some of which students collected, and remained active in the Illinois Natural History Society. The collections of the society were housed in Old Main on the campus of Illinois State Normal University (now Illinois State University). Powell presented several lectures on geology at Normal and became good friends with Normal's President Edwards and a number of faculty. Powell, with the encouragement of President Edwards, sought funding from the state legislature to improve the museum of the Society. The bill passed. Within a month of this passage (on March 26, 1867), Professor Powell was appointed Museum Curator and Professor of Geology by Normal's governing board, in concurrence with the Directors of the Natural History Society. Powell continued as Curator and Professor of Geology at Illinois State until he resigned in the spring of 1872.

During his tenure at Normal, Powell planned and led four scientific explorations and collecting trips to the West. During this time, the Major maintained his good relations with Wesleyan, and some members of three of the four expeditions had ties to Wesleyan. The third expedition is the one that brought him national prominence as he defied all odds with his team of hardened Civil War veterans. In riverboats, they went from Green River, Wyoming, to the Virgin River—in 100 days over a distance of about 1,000 miles, through the unexplored region now named the Grand Canyon. Seven of the ten survived the trip. The somewhat embellished tale is exciting reading, originally published in 1895 as *Canyons of the Colorado* and reprinted in 1961 as *The Exploration of the River and Its Canyons.* Last summer, *Canyons* was named by the National Geographic Society as one of the five greatest adventure books of all time. A popular movie reports the adventure under the title, *Ten Who Dared.*

Powell's time in higher education is a shared legacy between Illinois Wesleyan University (2 years) and Illinois State University (5 years). Each university has honored Powell in several ways. Most recently, Wesleyan has commissioned a sculpture of Powell for display in the entryway to their newly opened Ames Library.

After Illinois

The Major had a lasting impact in our nation's capitol. Powell accepted a commission from the Indian Bureau to return to the West. He published several major reports. He founded the Cosmos Club in Washington, which commemorated him by a large portrait of the Major. He became Director of the Bureau of Ethnology at the Smithsonian Institution. Powell was a co-founder of the National Geographic Society. He worked to help establish the U.S. Geological Survey (USGS), becoming its second director in 1881 and building it into the pride of American research. He was honored during his life with honorary degrees and since then with various commemorations, such as the naming of a building at the USGS, establishment of Powell museums at Green River and Page, Utah, and designation of Powell Point in the Grand Canyon. Books about Powell continue to be written.

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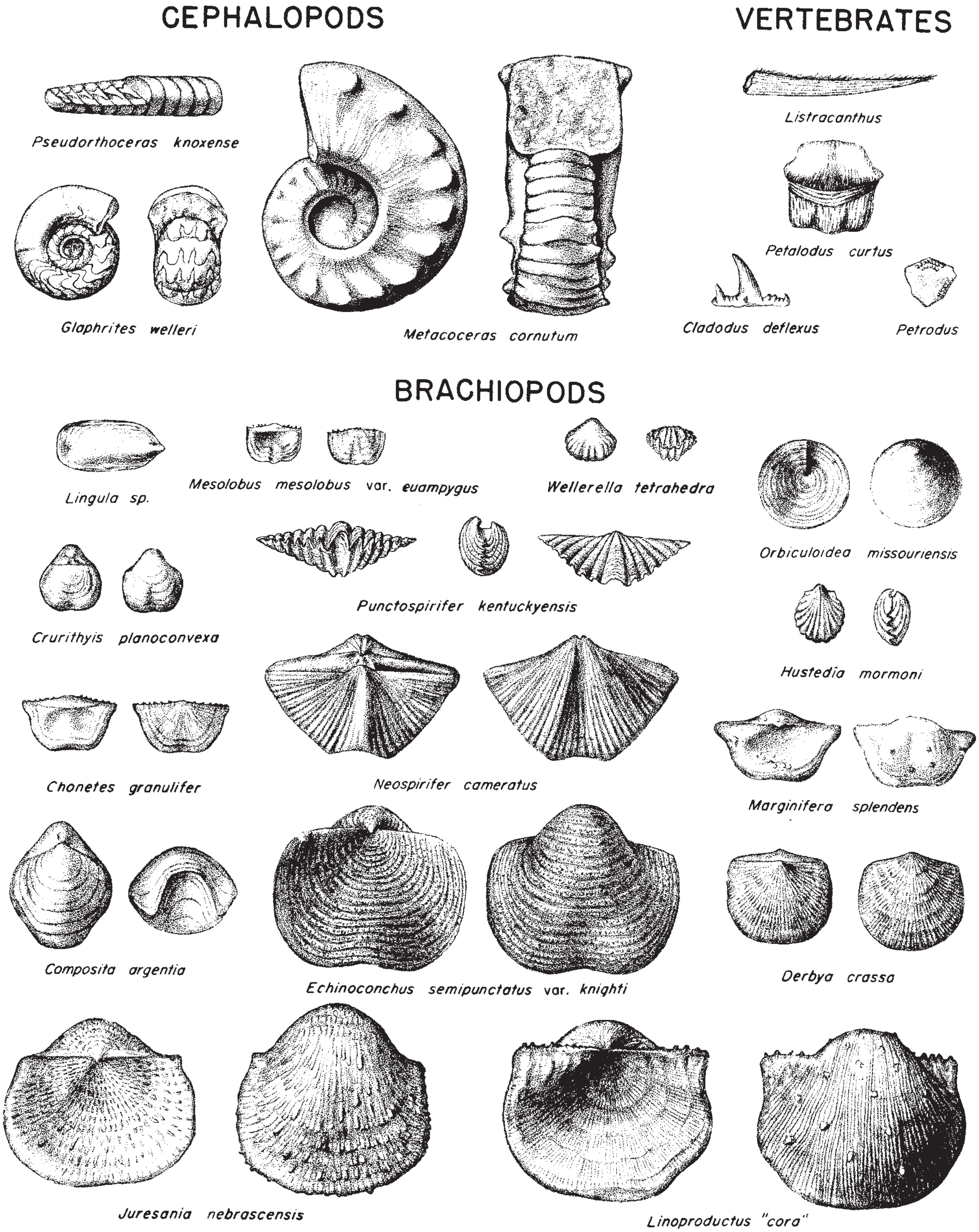
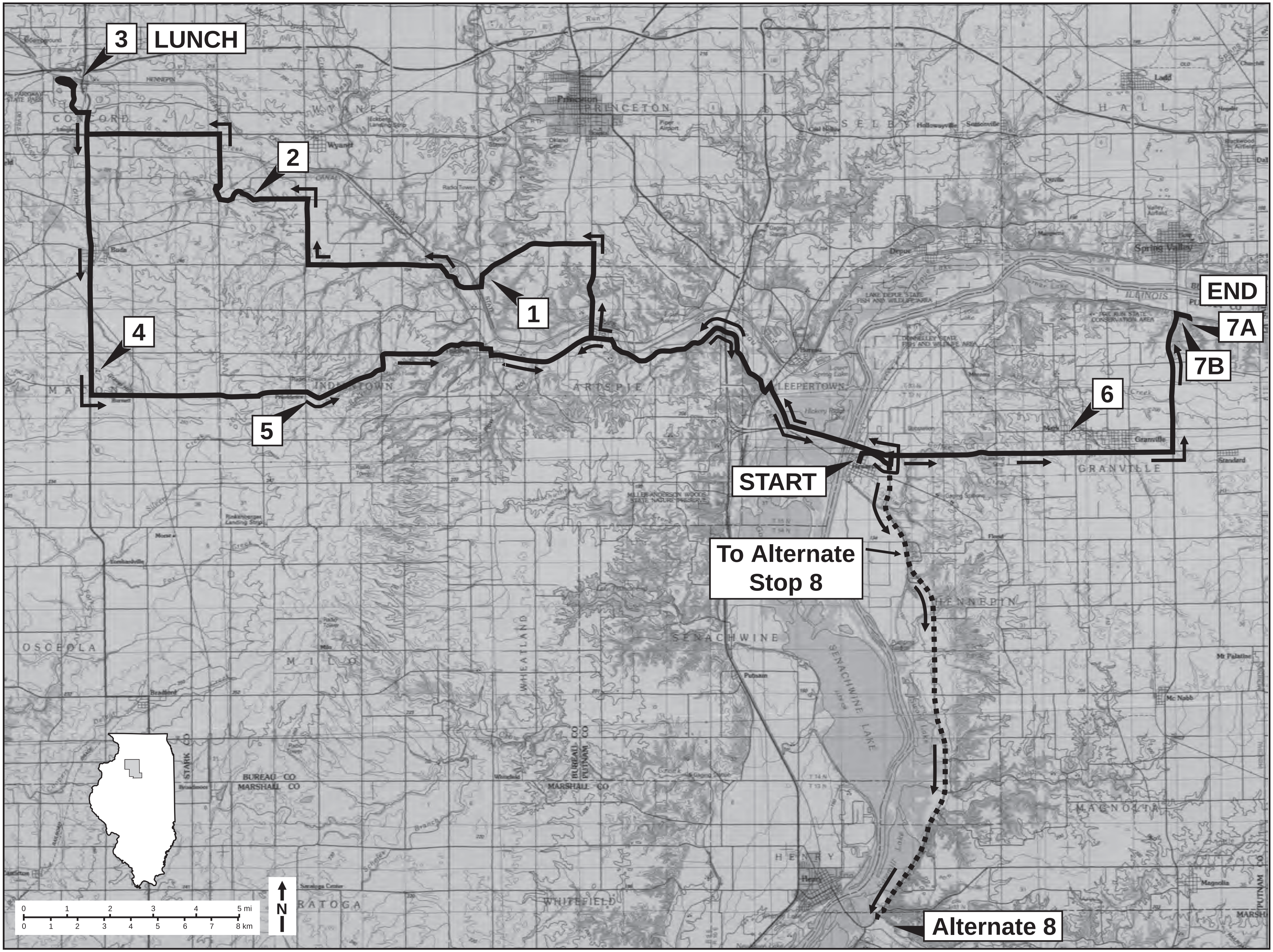
COMMON PENNSYLVANIAN FOSSILS

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