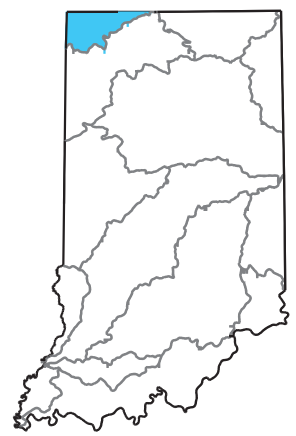


LAKE MICHIGAN BASIN

By Joseph M. Fenelon

General Description

The Lake Michigan basin, located in the far northwestern part of Indiana, encompasses a land area of 604 mi^2 (Hoggatt, 1975) within the northern halves of Lake and Porter Counties and the northern one-third of LaPorte County (fig. 12). In addition, the northern part of the basin includes a 241-mi^2 area beneath Lake Michigan. Within the basin is a major urban and industrial area that includes the cities of Gary, Hammond, East Chicago, and Merrillville.

Previous Studies

The first comprehensive evaluation of the ground-water resources in the Lake Michigan basin was done in a series of reports on the geohydrology and ground-water potential of Lake, Porter, and LaPorte Counties. Rosenshein (1961, 1962a) and Rosenshein and Hunn (1962) did preliminary evaluations of the ground-water resources in the three counties and tabulated well records for about 3,000 wells, including lithologic descriptions for about 1,200 of the wells and water-quality data from about 500 wells. The principal aquifers in Lake, Porter, and LaPorte Counties were described by Rosenshein (1963), Rosenshein and Hunn (1968a, 1968b), and Hunn and Reussow (1968). These authors determined and mapped the geometry and potentiometric surfaces of the aquifers, expected well yields, and general water quality. They also estimated hydraulic properties for the aquifers and associated confining units, and they determined sources and amounts of recharge to and discharge from the aquifers.

Hartke and others (1975) described the aquifers in Lake and Porter Counties, summarized ground-water usage in 1975 and the potential for future use, and qualitatively mapped the potential for aquifer contamination. General descriptions of the aquifers in the Lake Michigan basin have been written by Harrell (1935), the Great Lakes Basin Commission (1975), and Clark (1980). These authors described the major aquifers and the ground-water potential for the area.

A comprehensive study on the water resources of the Lake Michigan basin is being done by the Indiana Department of Natural Resources (J.E. Beaty, 1993, Indiana Department of Natural Resources, oral commun.). The Indiana Department of Natural Resources is characterizing the ground-water availability, use, flow, and quality, and mapping the bedrock elevation, and the geometry and areal extent of the primary aquifers.

Detailed studies have been done on the unconsolidated deposits of most of the Lake Michigan shoreline. Watson and others (1989) and Fenelon and Watson (1993) studied the surficial sand aquifer in most of Lake County north of the Little Calumet River. They mapped the bedrock surface and the geometry of the surficial aquifer, and they described the flow and water quality in the aquifer. Numerous studies have been done along Lake Michigan in the Indiana Dunes National Lakeshore, located between Gary and Michigan City (Meyer and Tucci, 1979; Shedlock and Harkness, 1984; Cohen and Shedlock, 1986; Wilcox and others, 1986; Shedlock and others, 1987; Thompson, 1987; Doss, 1991; Shedlock, Wilcox, Thompson, and Cohen, 1993; Shedlock, Cohen, Imbrigiotta, and Thompson, in press). Many of these studies are site specific, but together they constitute a detailed description of the unconsolidated aquifers and their associated flow paths and water quality within the Indiana Dunes National Lakeshore.

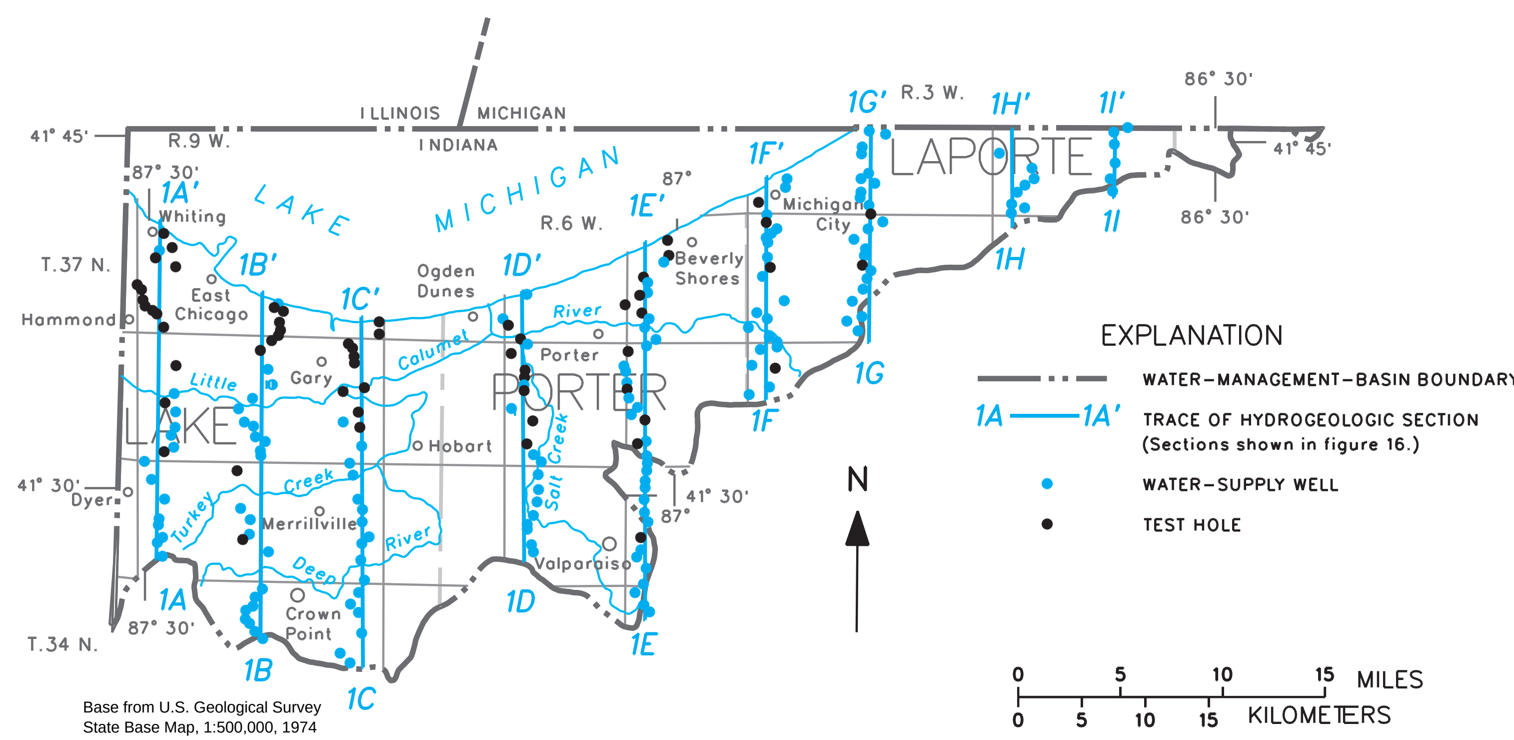


Figure 12. Location of section lines and wells plotted in the Lake Michigan basin.

Physiography

The Lake Michigan basin lies within the Calumet Lacustrine Plain, Valparaiso Morainal Area, and Kankakee Outwash and Lacustrine Plain, which are part of the Northern Moraine and Lake Region. The Kankakee Outwash and Lacustrine Plain, located in the extreme southeastern part of the basin, is discussed in the section on the Kankakee River basin in this report. The Calumet Lacustrine Plain (fig. 13), in the northern part of the Lake Michigan basin, occupies the lake bottom of the former glacial Lake Chicago—an extension of Lake Michigan in late Wisconsinan time (Bretz, 1955, p. 108). The lacustrine plain is not a completely flat area, but is a series of beach ridges, dunes, and interridge marshes. There are three dominant relict shorelines: the Glenwood, Calumet, and Toleston beach complexes, whose elevations are approximately 625, 607, and 600 ft above sea level, respectively (Thompson, 1987, p. 46-64). Relief in the Calumet Lacustrine Plain ranges from elevations greater than 650 ft above sea level in dunal areas associated with ancient beaches to approximately 580 ft above sea level on the present day Lake Michigan shoreline.

South of the Calumet Lacustrine Plain is the Valparaiso Morainal Area (fig. 13), composed of an arc-shaped end moraine complex that parallels the southern shore of Lake Michigan from Illinois, through northwestern Indiana, and into Michigan. The morainal complex is made up of several terminal moraines of Wisconsinan age including the Valparaiso and Tinley Moraines (fig. 13), which mark terminal positions of the Lake Michigan Lobe (Bretz, 1955, p. 106-108). The Valparaiso Morainal complex is about 150 ft higher than the Calumet Lacustrine Plain and forms a major divide that separates drainage to the Mississippi River from drainage to the Saint Lawrence River by way of Lake Michigan. Elevations in the complex generally range from 700 to 800 ft above sea level and are as high as 950 ft above sea level. The western end of the complex is wide and gently undulating, whereas the part of the complex east of Valparaiso, is more hilly and rugged (Schneider, 1966, p. 51-52).

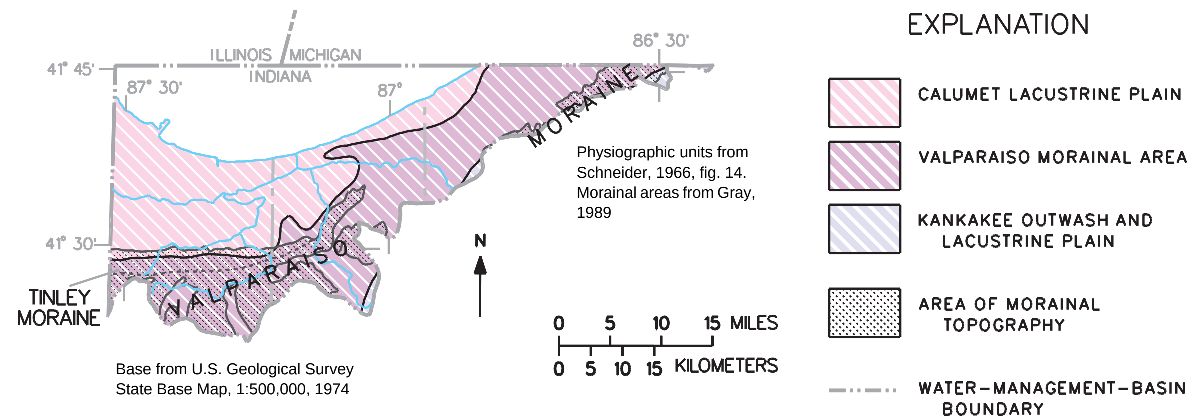


Figure 13. Physiographic units and moraines in the Lake Michigan basin.

Surface-Water Hydrology

The entire drainage area for Lake Michigan is approximately 67,900 mi^2 and includes 44,330 mi^2 of land in Indiana, Illinois, Wisconsin, and Michigan (Great Lakes Basin Commission, 1975, p. 21). Within Indiana, the Lake Michigan basin has an area of 845 mi^2, of which 604 mi^2 is land. The basin is drained in Indiana primarily by the Little Calumet River (fig. 12), which flows approximately parallel to the Lake Michigan shoreline and discharges to Lake Michigan through a ditch on the western side of Porter County. The major tributaries to the Little Calumet River are Turkey Creek, Deep River, and Salt Creek. Each tributary originates on the Valparaiso Moraine and flows north to the Little Calumet River. The eastern part of the Lake Michigan basin in LaPorte County is drained by smaller creeks that flow directly into Lake Michigan.

Geology

Bedrock Deposits

Overlying Precambrian bedrock in the Lake Michigan basin is more than 4,000 ft of sedimentary bedrock (Rosenshein and Hunn, 1968a, p. 7; Hartke and others, 1975, p. 4) that dips northeast at about 10 to 20 ft/mi. About 3,500 ft of the sedimentary bedrock is of Cambrian or Ordovician age. The Cambrian and Ordovician bedrock consists of about 2,000 ft of fine- to coarse-grained sandstone in the lower part and shale overlying dolomite and sandstone in the upper part (Rosenshein and Hunn, 1968a, p. 9; Hartke and others, 1975, p. 4). Overlying these rocks are Silurian rocks in the western part of the Lake Michigan basin and Silurian, Devonian, and Mississippian rocks further east (figs. 5 and 14).

The rocks of Silurian age, which consist of 400 to 600 ft of dolomite and some limestone (Great Lakes Basin Commission, 1975, p. 37), are divided into the Sexton Creek Limestone, the Salamonie Dolomite, and the Salina Group (Shaver and others, 1986). The Silurian rocks are composed of shaley to pure and fine- to coarse-grained carbonate rocks that include reef facies in the upper part.

The Devonian rocks consist of dolomite and limestone overlain by shale; these rocks contain the Muscatatuck Group and the Antrim and Ellsworth Shales. The Muscatatuck Group overlies the Silurian carbonate rocks; it is absent where Silurian rocks are exposed at the bedrock surface, and it is as much as 200 ft thick elsewhere (Shaver, 1974, p. 5). The Group is composed of a wide variety of impure to pure and dense to coarse-grained dolomite and limestone; in places, it contains anhydrite and gypsum in its lower part (Shaver and others, 1986, p. 99). The Antrim Shale, a brownish-black noncalcareous shale, overlies the Devonian carbonate rocks in the northeastern part of the basin (Shaver and others, 1986, p. 5). The Ellsworth Shale overlies the Antrim Shale and is of Devonian and Mississippian age. It is a grayish-green shale that contains limestone or dolomite lenses in its upper part (Shaver and others, 1986, p. 42).

The bedrock surface is a preglacial erosional feature that has been further modified by glacial erosion. The Silurian and Devonian carbonate rocks exposed at the bedrock surface contain significant fractures and solution features in the upper 100 ft (Rosenshein and Hunn, 1968a, p. 10; Great Lakes Basin Commission, 1975, p. 24; Hartke and others, 1975, p. 4).

Unconsolidated Deposits

The unconsolidated deposits in the Lake Michigan basin are largely the result of glacial, glaciofluvial, shallow-water coastal and lake, wetland, and wind-blown sedimentation. They consist of clay-rich till, sand and gravel outwash, sand beaches and dunes, lake silt and clay, and peat. Thicknesses of unconsolidated deposits range from about 50 ft near the Indiana-Illinois State line to about 350 ft at the basin divide south of Michigan City (fig. 15). The Lake Michigan basin is overlain in most areas by two or more of four general unconsolidated units (Rosenshein, 1962b; Vig, 1962; Hunn and Reussow, 1968; Rosenshein and Hunn, 1968a, 1968b; Hartke and others, 1975).

The lowest unit overlies bedrock and is primarily a dense, clay-loam till that contains zones of intertill sand and gravel. This unit, which ranges in thickness from 0 to more than 100 ft, was formed by Wisconsinan and possibly pre-Wisconsinan glaciers that advanced through the basin. The basal part of the unit contains 0 to 15 ft of sand and gravel that fill the deepest parts of preglacial bedrock valleys.

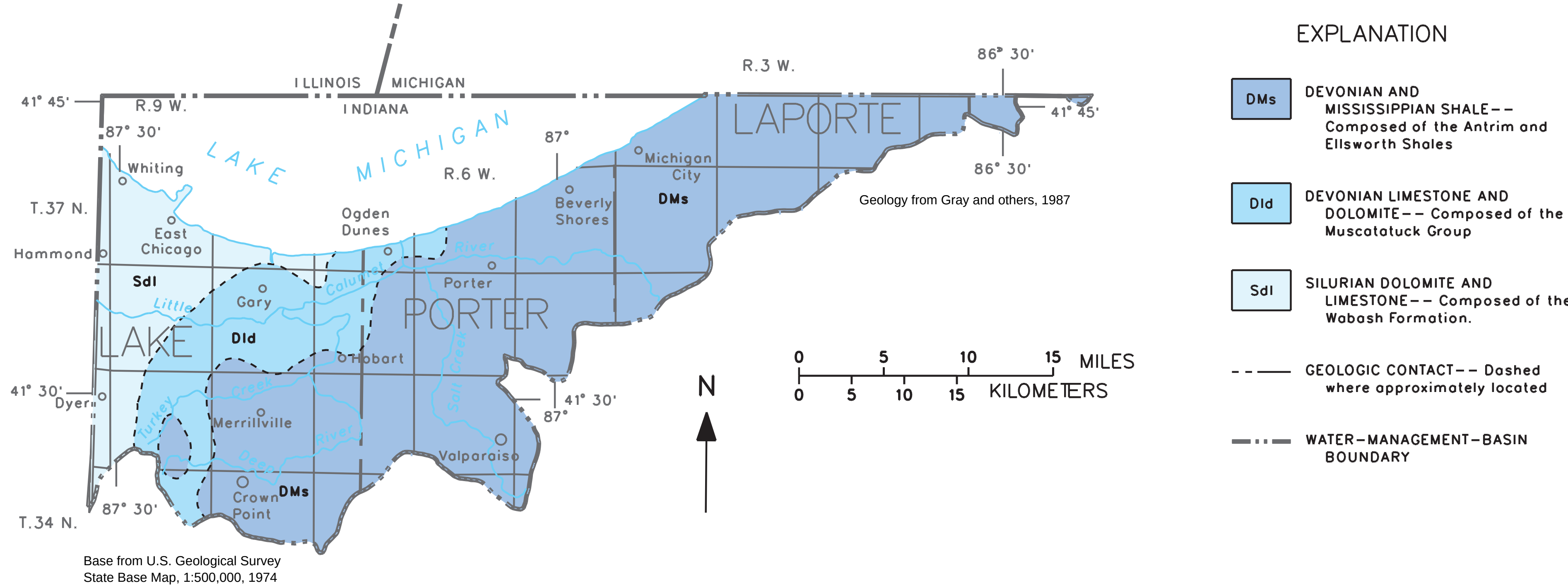
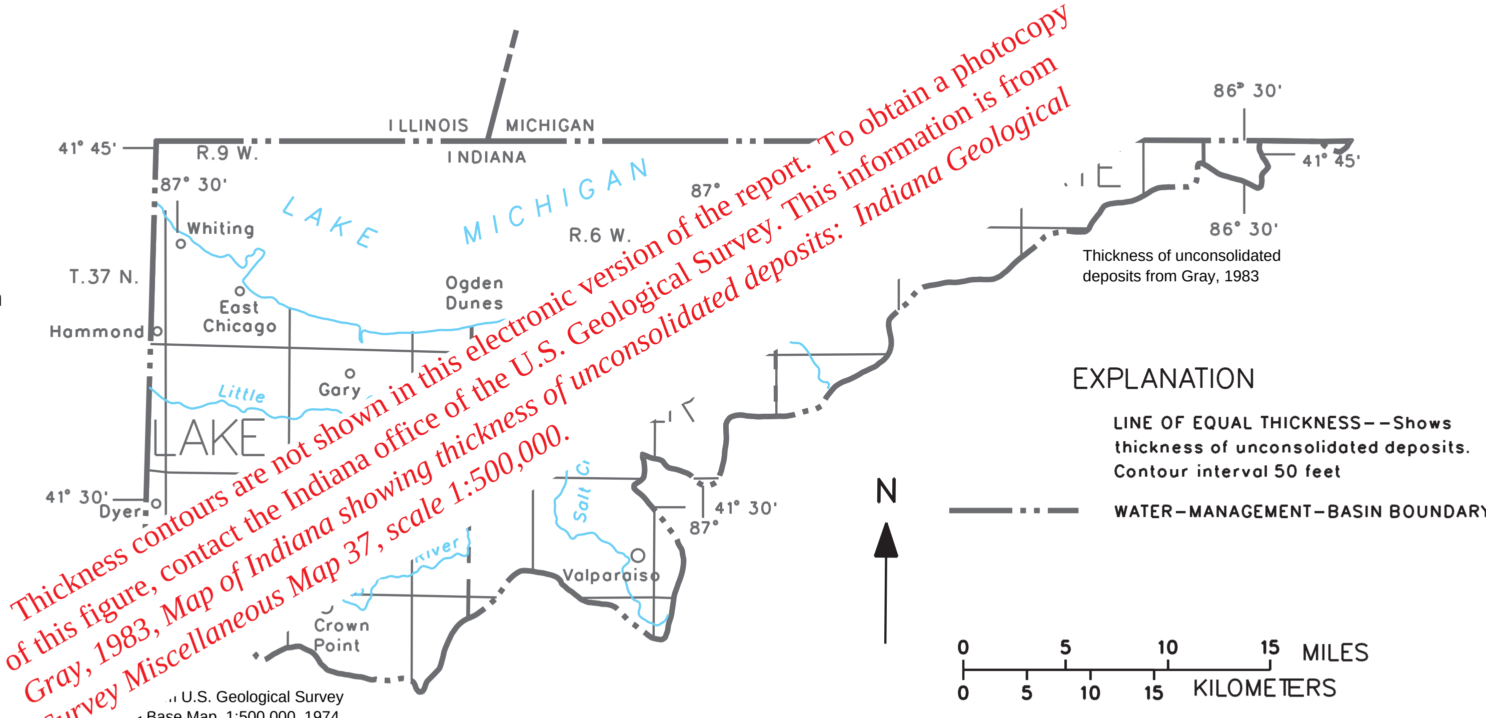


Figure 14. Bedrock geology of the Lake Michigan basin.

Glaciofluvial sand ranging from 0 to 100 ft in thickness overlies the basal till in the southern one-half of the basin. Locally, the sand contains sand and gravel interbeds and clay.

Overlying most of the glaciofluvial sand in the southern one-half of the Lake Michigan basin is a till that extends to the surface. The till ranges from 0 to more than 50 ft in thickness and contains an intertill sand and gravel layer (Rosenshein, 1962b, p. 129). The surficial till is similar lithologically but less dense than the basal till.

Overlying the basal till in the northern one-half of the basin is primarily fine to medium glaciolacustrine and wind-blown sand with some beach gravel, local peat, and lake silt and clay deposits. Most of these deposits were formed in association with glacial Lake Chicago, and they range in thickness from 0 to 70 ft (Rosenshein, 1962b, p. 129; Rosenshein and Hunn, 1968b, p. 17).



Thickness contours are not shown in this electronic version of the report. To obtain a photocopy of this figure, contact the Indiana office of the U.S. Geological Survey. This information is from Gray, 1983, Map of Indiana showing thickness of unconsolidated deposits: Indiana Geological Survey Miscellaneous Map 37, scale 1:500,000.

Figure 15. Thickness of unconsolidated deposits in the Lake Michigan basin.

Aquifer Types

Nine hydrogeologic sections (1A–1A′ to 1I–1I′) were produced for this atlas to show the general hydrostratigraphy of the Lake Michigan basin (fig. 16). All sections are oriented from south to north, approximately perpendicular to the Lake Michigan shoreline (fig. 12). Section lines were drawn at 5- to 7-mi intervals. A total of 212 well logs were used to produce the sections; 58 well logs are from test holes that are unrelated to water use. The average density of plotted wells along the section lines is 2.0 wells per mile.

In general, supplies of ground water throughout the Lake Michigan basin are adequate. Unconsolidated sands and gravels form the most productive aquifers. The primary unconsolidated aquifers are the buried sands and gravels overlying the basal till in the southern one-half of the basin and the surficial sands overlying the basal till in the northern one-half of the basin. Other less significant unconsolidated aquifers are discontinuous buried sands and gravels in the northeastern part of the basin, discontinuous surficial sands and gravels on top of the Valparaiso Morainal complex in the southeastern part of the basin, buried bedrock valley aquifers near Lake Michigan, and intertill sands and gravels throughout the basin. Carbonate bedrock underlies the basin but is used as an aquifer only in the far western part of the basin. The primary aquifers are shown in figure 17. Aquifers beneath Lake Michigan are excluded from the map and from most of the discussion because of insufficient data. Table 3 summarizes the four aquifer units mapped in figure 17. The table lists ranges of thickness and yield and names other authors have used to define the units.

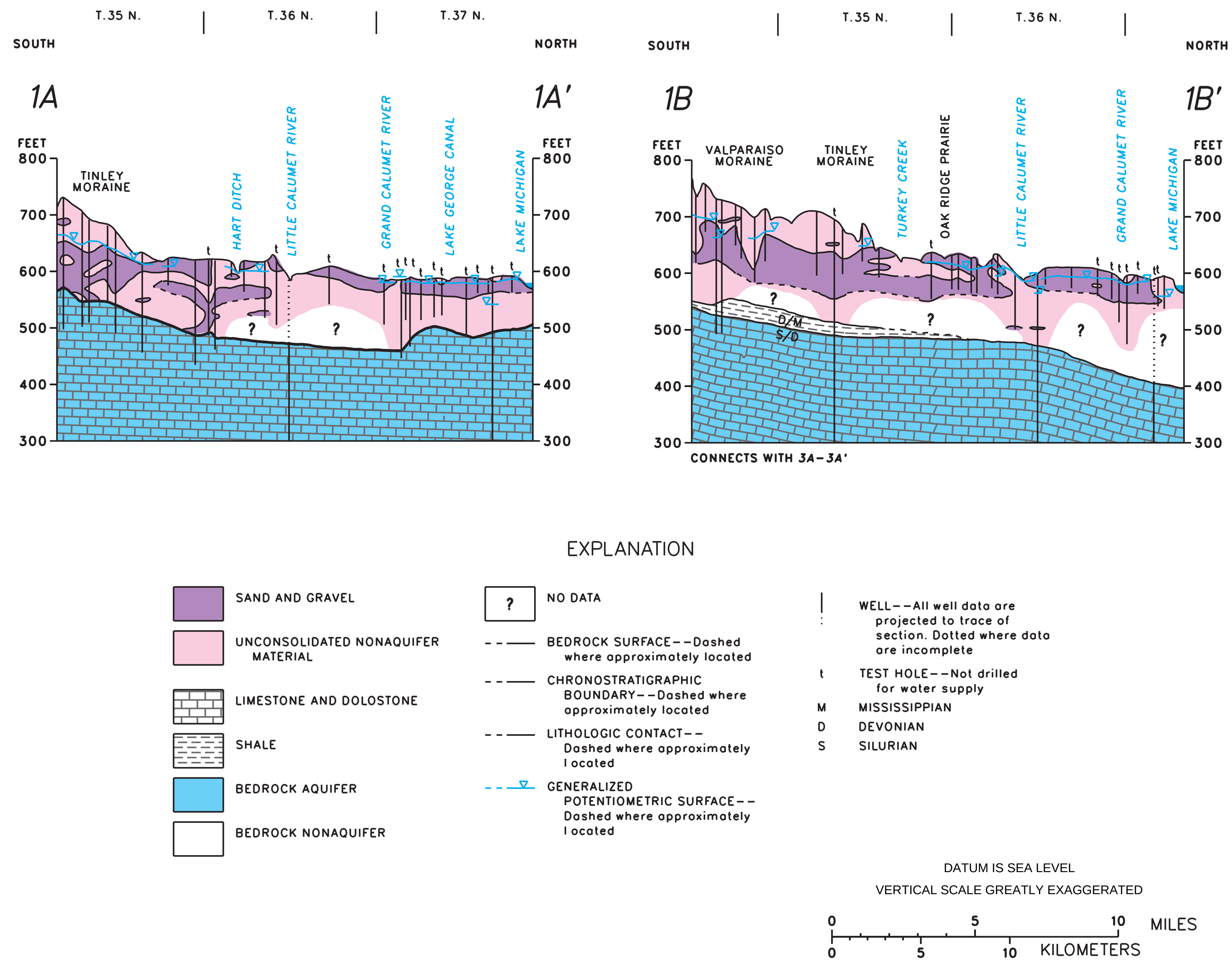
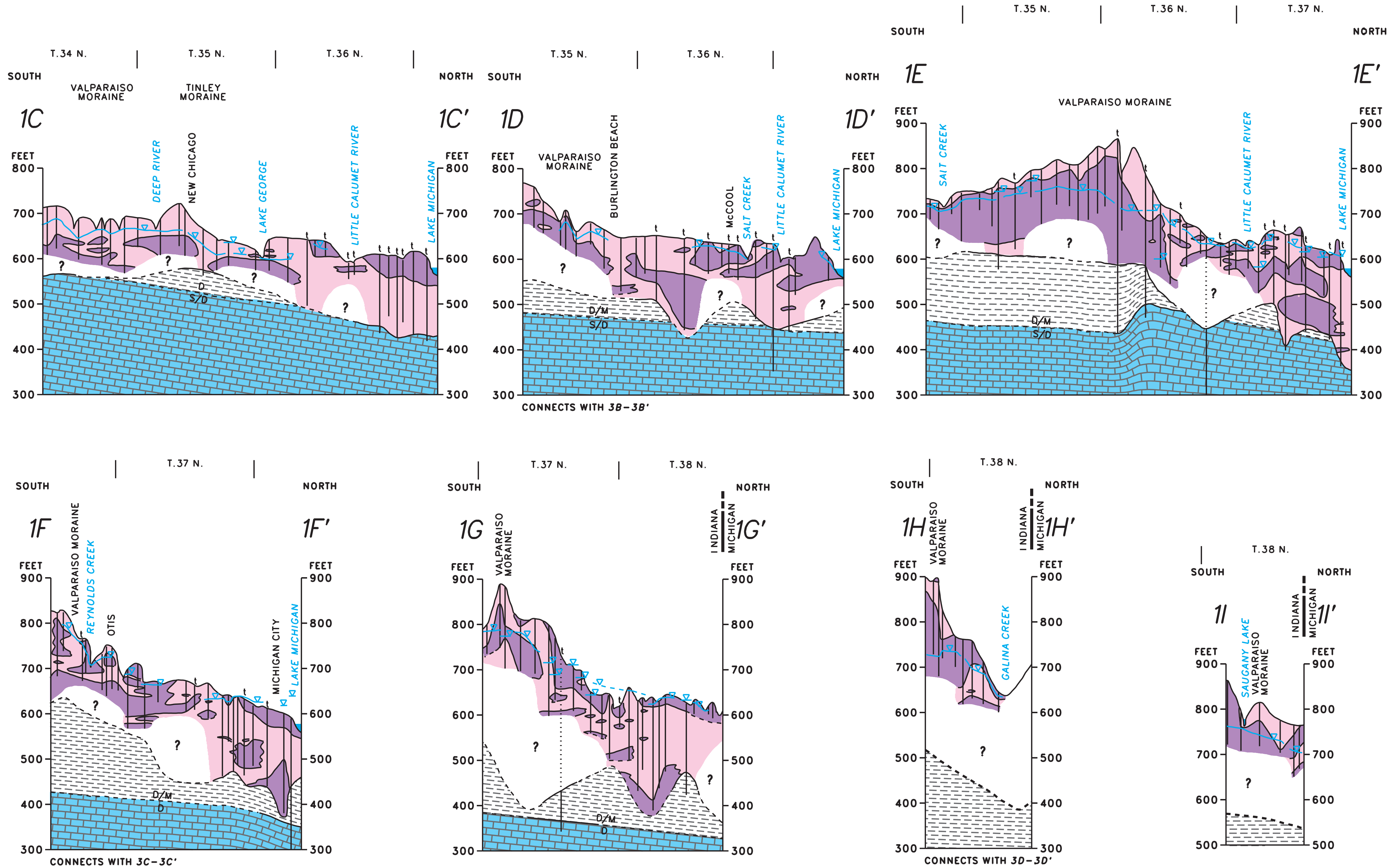


Figure 16. Hydrogeologic sections *1A–1A′* to *1I–1I′* of the Lake Michigan basin.


1C
1C′
SOUTH
NORTH
T.34 N.
T.35 N.
T.36 N.
VALPARAISO MORAINE
TINLEY MORAINE
DEEP RIVER
NEW CHICAGO
LAKE GEORGE
LITTLE CALUMET RIVER
LAKE MICHIGAN
FEET
D
S/D
1D
1D′
VALPARAISO MORAINE
BURLINGTON BEACH
McCOOL
SALT CREEK
D/M
S/D
CONNECTS WITH 3B–3B′
1E
1E′
T.37 N.
VALPARAISO MORAINE
SALT CREEK
1F
1F′
VALPARAISO MORAINE
REYNOLDS CREEK
OTIS
MICHIGAN CITY
D/M
CONNECTS WITH 3C–3C′
1G
1G′
T.38 N.
INDIANA
MICHIGAN
1H
1H′
GALINA CREEK
CONNECTS WITH 3D–3D′
1I
1I′
SAUGANY LAKE

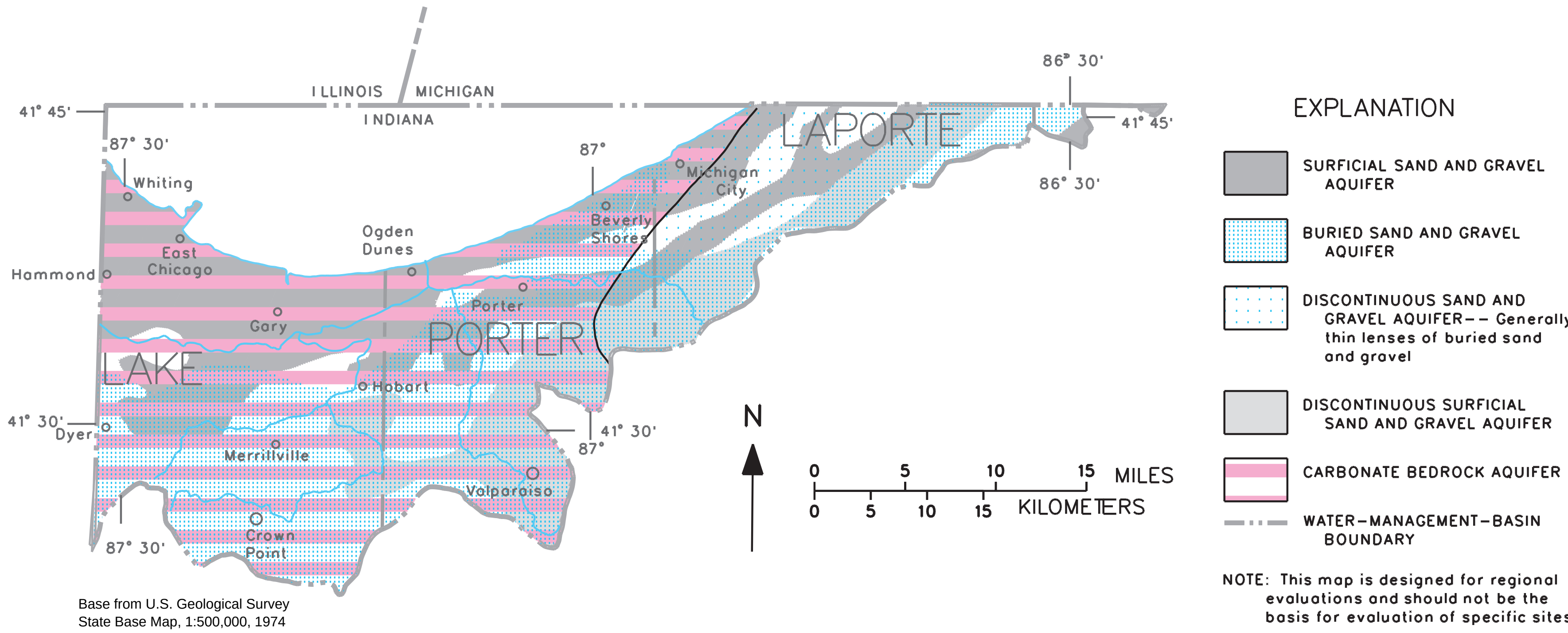


Figure 17. Extent of aquifer types in the Lake Michigan basin.

Unconsolidated Aquifers

Buried Sand and Gravel Aquifers

Buried sand and gravel aquifers are found in more than three-fourths of the basin (fig. 17). Most of the buried aquifers are part of a glaciofluvial sand aquifer, which is shown on the southern one-half to two-thirds of sections 1A–1A′ to 1F–1F′ (fig. 16). The aquifer as shown in the sections consists of sand bodies that are continuous for 3 to 6 mi in a north-south direction. These sand bodies are probably more continuous parallel to Lake Michigan and the Valparaiso Moraine. The buried glaciofluvial aquifer is as much as 200 ft thick (of which 150 ft is saturated) beneath the Valparaiso Moraine in section 1E–1E′ (fig. 16). The typical thickness penetrated by wells is about 50 ft; however, aquifer thicknesses may be greater because most of the wells do not penetrate the full thickness of the aquifer.

The glaciofluvial sand aquifer is overlain by a surficial till in most areas on the Valparaiso Morainal complex. Till thickness ranges from 0 to about 100 ft and is typically 20 to 50 ft. The aquifer is recharged primarily from the overlying till. The aquifer discharges to the land surface through the overlying till and to the bedrock through a basal till (Rosenshein and Hunn, 1968b). In sections 1F–1F′ and 1G–1G′ (fig. 16), north of the Valparaiso Moraine, hydraulic heads in the buried sand and gravel are above land surface; flowing wells can be found in these areas.

Several localized buried aquifers are between sections 1D–1D′ and 1F–1F′ in the northern part of the basin. These aquifers have been studied by a number of investigators (Wilcox and others, 1986; Shedlock and others, 1987; Shedlock, Wilcox, Thompson, and Cohen, 1993; Shedlock, Cohen, Imbrigiotta, and Thompson, in press) and have been named the “subtill” and “basal” aquifers. The “subtill” aquifer, shown on section 1E–1E′ in T. 37 N. (fig. 16), is buried beneath a surficial till and overlies another till. The aquifer extends almost 5 mi and is about 30 ft thick in section 1E–1E′. Beneath the underlying till in places is the “basal” aquifer, which extends about 2 mi in section 1E–1E′ and is about 50 ft thick.

Unmapped intertill sands and gravels in the basal and surficial tills in the southern one-half of the basin also contribute water to wells locally. Yields of some of these aquifers are high, but the aquifers are not extensive (Rosenshein and Hunn, 1968a; 1968b).

Surficial Sand and Gravel Aquifer

The unconsolidated surficial aquifer in the northern one-half of the basin is composed of glaciolacustrine and wind-blown sand. The aquifer extends south about 2 to 5 mi from the Lake Michigan shoreline in the eastern part of the basin and up to 10 mi from the shoreline in the western part of the basin. Thicknesses range from 0 to 70 ft and average about 30 ft. The surficial aquifer is recharged primarily from precipitation and from ground water flowing up from the basal till in the eastern part of the basin. Most discharge goes to streams, ditches, Lake Michigan, and to evapotranspiration (Rosenshein and Hunn, 1968b; Shedlock and others, 1987; Fenelon and Watson, 1993). The aquifer is used very little as a source of water in the western part of the basin because of its proximity to Lake Michigan, the major source of drinking water in the area. The aquifer is also rarely used because of its thin saturated zone (20 to 30 ft) and its susceptibility to contamination (Hartke and others, 1975, p. 25; Fenelon and Watson, 1993). The aquifer is tapped in the eastern part of the basin by households that do not have access to a public water supply or a better source of ground water.

The surficial aquifer extends for an undetermined distance beneath Lake Michigan. Sand or gravel has been found on the lake bottom at widely spaced sampling points within the State boundaries (Schneider and Keller, 1970). The distribution of sand and gravel indicates that the aquifer could extend more than 5 mi into the Lake, although insufficient data are available to map the areal extent or thickness.

Discontinuous Sand and Gravel Aquifers

Discontinuous buried sand and gravel aquifers are present in the northeastern part of the basin and are shown in the central part of section 1G–1G′ (fig. 16). Although the deposits are discontinuous, they are common enough that sources of domestic water supply are easy to find. Some of the discontinuous aquifers are in the deep bedrock valleys in the northeastern part of the basin. Section 1G–1G′ (fig. 16) crosses several of the valleys that are 200 to 300 ft below land surface and have about 100 ft of relief. The bottom of one of the valleys is filled with sand and gravel, which is tapped for a drinking-water supply; however, in general, these deep aquifers are not tapped unless they are the only unconsolidated aquifers in the area.

Table 3. Characteristics of aquifer types in the Lake Michigan basin

[>, greater than; <, less than; locations of aquifer types shown in fig. 17]

Aquifer type	Thickness (feet)	Range of yield (gallons per minute)	Common name(s)
Surficial sand	0- 70	[1,2]10- 500	Calumet aquifer[3]; Unit 1[1,2]
Buried sand and gravel	10- 200	[1,2,4]10- >500	Valparaiso aquifer[3]; Unit 3[1, 2]; Subtill and basal aquifers[5]
Discontinuous sand and gravel	0- >100	0- 500	Unit 3[1,2]
Carbonate rock	400- 800	[1]<10- 400	Silurian-Devonian carbonate aquifer

[1]Rosenshein and Hunn, 1968a.
[2]Rosenshein and Hunn, 1968b.
[3]Hartke and others, 1975.
[4]Clark, 1980.
[5]Shedlock, Cohen, Imbrigiotta, and Thompson, in press.

Discontinuous surficial deposits are present throughout the southeastern part of the basin. Most of these deposits are in morainal areas and are a complex mix of ice-contact stratified drift and till. The deposits may contain surficial aquifers, which can be local to extensive and range from a few feet to more than 100 ft in thickness as in T. 37 N. of section 1G–1G′ (fig. 16). The discontinuous surficial aquifers are usually not used as a source of water because sources in the underlying buried aquifers are more reliable.

Bedrock Aquifers

Carbonate Bedrock Aquifer

Silurian and Devonian carbonate bedrock is the principal bedrock aquifer in the Lake Michigan basin. Although the carbonate bedrock aquifer is present throughout the basin (including the part covered by Lake Michigan), it is used mostly in the western part of the basin (sections 1A–1A′ and 1B–1B′ in fig. 16). Generally, wells penetrate only the upper 100 ft of the permeable carbonate bedrock. East of section 1B–1B′ (fig. 16), the aquifer is little used because of the availability of water in the unconsolidated aquifers, the increasing depth to the bedrock aquifer, and the potentially high concentrations of dissolved solids (Rosenshein and Hunn, 1968b, p. 5). The area where the carbonate bedrock aquifer is generally less than 300 ft below land surface is mapped in figure 17; however, the aquifer is not necessarily used in this area. For the same reasons as listed above, the aquifer is generally not used where more than 200 ft of unconsolidated material and(or) shale cover it, and is rarely used where there is more than 300 ft of cover. Depth to the carbonate bedrock ranges from about 100 ft below land surface in section 1A–1A′ to about 500 ft in section 1I–1I′ (fig. 16). Devonian and Mississippian shales, which overlie the carbonate bedrock aquifer in the eastern part of the basin (sections 1B–1B′ to 1I–1I′, fig. 16), are potential sources of small quantities of water (Rosenshein and Hunn, 1968a; 1968b).

Devonian and Mississippian shales and(or) the lower till unit confine the top surface of the carbonate bedrock aquifer throughout most of the basin. The bottom surface of the carbonate bedrock aquifer is underlain at depths of greater than 600 ft by 200 to 250 ft of shale interbedded with some limestone (Gray, 1972). The underlying shale functions as a confining unit for a deeper Ordovician and Cambrian aquifer system (not shown on fig. 17 or in hydrogeologic sections). Although the deeper aquifer is tapped extensively in northeastern Illinois (Schicht and others, 1976; Visocky and others, 1985), it is tapped very little in the Lake Michigan basin of Indiana because of small well yields and high construction and pumping costs (Rosenshein and Hunn, 1968a). An even deeper aquifer, consisting of about 2,000 ft of sandstone of early Cambrian age, is highly saline and is used only for deep waste injection (Hunn and Reussow, 1968; Hartke and others, 1975).

Summary

The Lake Michigan basin includes 604 mi^2 of land within the northern parts of Lake, Porter, and LaPorte Counties and a 241-mi^2 area beneath Lake Michigan in northwestern Indiana. The land is covered by a sandy lake plain overlying a basal till in the northern part of the basin and the till-capped Valparaiso Morainal complex to the south. The till covers a glaciofluvial sand that overlies a basal till. Silurian and Devonian carbonate bedrock is present as subcrop in the western part of the basin but is overlain by Devonian and Mississippian shales further east.

Four aquifer types were delineated in the Lake Michigan basin: (1) surficial sand and gravel, (2) buried sand and gravel, (3) discontinuous sand and gravel, and (4) carbonate bedrock. The primary aquifer, present in the southern one-half of the basin, is a buried glaciofluvial sand aquifer whose average thickness is 50 ft; it can yield more than 500 gal/min. The aquifer, which is covered by 0 to 100 ft of surficial till, overlies a basal till. Other buried sand and gravel aquifers are found in the northeastern part of the basin and in some of the buried bedrock valleys. A thin but extensive surficial sand aquifer in the northern one-half of the basin is little used because of its proximity to Lake Michigan, the major source of drinking water in the area. Discontinuous buried aquifers in the northeastern part of the basin are commonly used as a source of water. Discontinuous surficial aquifers are present throughout the southeastern part of the basin but are rarely tapped because of more reliable buried sources of ground water. The principal bedrock aquifer is a carbonate bedrock aquifer, used only in the far western part of the basin. The aquifer's yields are generally less than those of the unconsolidated aquifer material but can be substantial in some areas.

Regional ground-water discharge from all the aquifers is to Lake Michigan. Locally, however, ground water is commonly discharged through evapotranspiration or by flow to streams, ditches, and pumped wells in the area.

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