Institute of Natural Resource Sustainability
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ILLINOIS STATE GEOLOGICAL SURVEY
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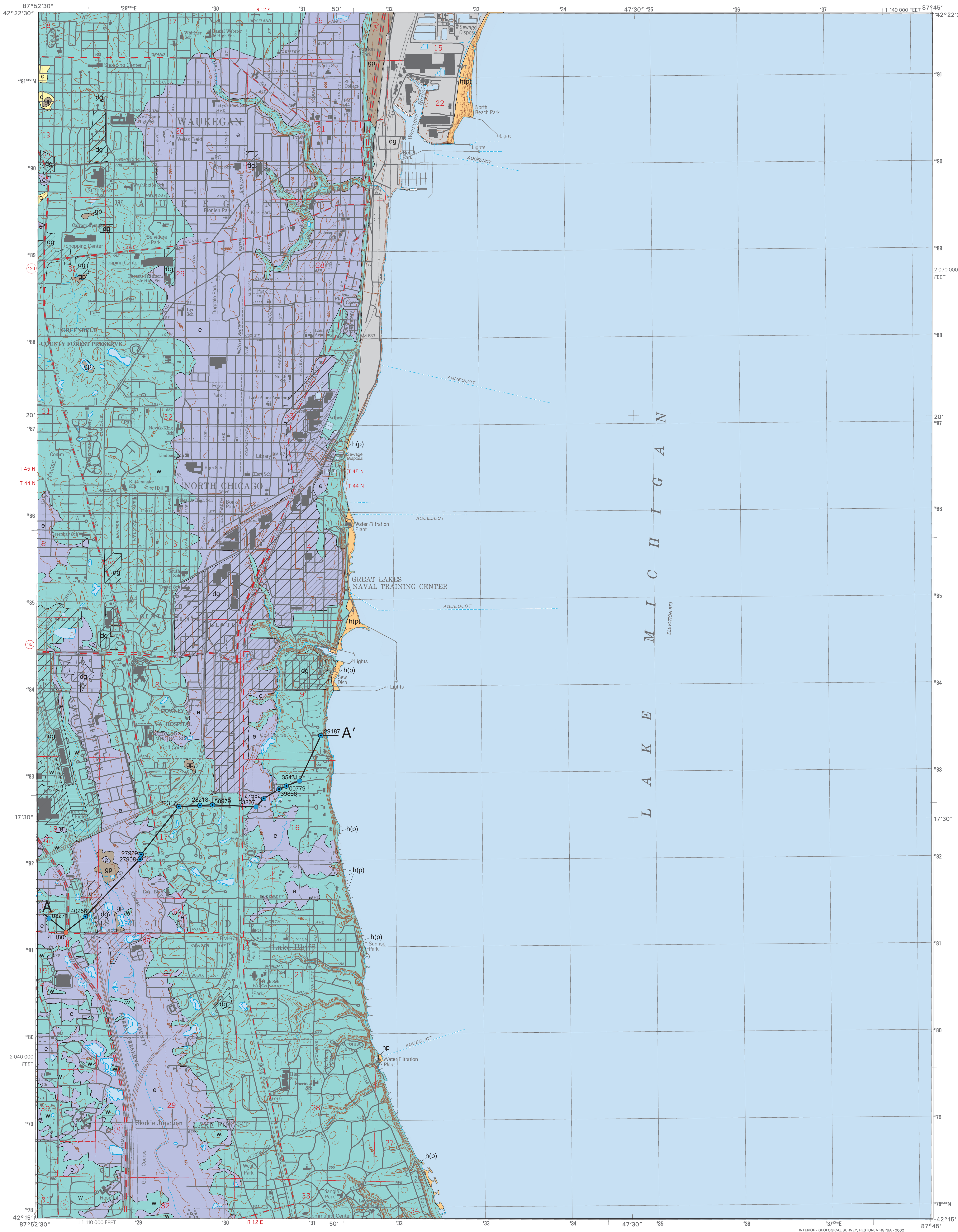
Surficial Geology of Waukegan Quadrangle
Lake County, Illinois

STATEMAP Waukegan-SG

Michael L. Barnhardt
2010



QUATERNARY DEPOSITS

Description	Unit	Interpretation
HUDSON EPISODE (~14,600 years before present [B.P.] to today)[1]		
Fill, compacted land, or other disturbed material; highly variable in grain size (may range from clay to gravel), and may contain construction and mining debris; typical thickness: variable	Disturbed ground (made land) dg; (urban area over unit) dg; (landfill over unit) dg	**Human-disturbed deposits** modified during construction of buildings, roads, and landfills; includes excavations in gravel pits and quarries; urbanized areas and industrial and commercial build-up
Silt and clay; occasional sand lenses; trace gravel; stratified; brown to yellowish brown; loose to compact; may be mottled and gleyed; some bedding; organic-rich in places; typical thickness: 1 to 20 feet	Cahokia Formation (floodplain deposits) c	**Postglacial (modern) stream sediments** deposited on active floodplains; derived mainly from eroded loess and diamicton; may overlie or interfinger with lacustrine silt and clay; includes silty slopewash deposits along footslope and minor drainage-ways on moraines
Sand; fine and medium; well sorted; loose; may be mixed with organics, including layers of peat; some thin lenses of clay; typical thickness: 1 to 12 feet	Henry Formation (Parkland facies) h(p)	**Windblown sand in dunes** and sheet-like deposits between active shoreline of Lake Michigan and wave-eroded bluff; local relief generally less than 12 feet; interdune swales often contain peat, muck, and organic-rich sand; eolian facies of Henry Formation; includes beach sand
Peat, muck, and organic-rich sediment; may contain interbeds of silt, clay, and very fine to fine sand; black to dark brown; sediment may be gleyed and mottled; soft to firm; snail shells common; typical thickness: 1 to 10 feet	Grayslake Peat gp	**Organic-rich sediments** accumulated in low-lying depressions, drainageways, and on floodplains; may include small areas of open water; locally intertongued with modern alluvium, or lake sediment; commonly found around lakes and marshes and channels connecting bodies of water; intermixed with sand dunes along Lake Michigan beach-ridge plain
WISCONSIN EPISODE (~29,900 years–14,600 B.P.)[1]		
Silt, clay, and sand; massive to bedded; dark gray to light gray; calcareous; soft to hard; compact; may be sticky and plastic; very fine and fine sand common along bedding planes; occasional inclusions and lenses of light gray to white silt; some wood fragments; very few clasts; generally abrupt upper and lower contacts; typical thickness: 5 to 25 feet	Equality Formation e	**Postglacial and glacial proglacial lake deposits** that infill low-lying areas, or depressions in drainage channels and where water was impounded behind moraines, such as the Highland Park and Blodgett Moraines; at the surface, these sediments may interfinger with or be overlain by alluvium and organic-rich deposits
Sand and gravel; stratified; occasionally massive; yellowish to grayish brown; calcareous; loose; sand is very fine to very coarse, very well to poorly sorted; gravel is very fine to coarse, very well to very poorly sorted; trace to little amounts of silt and clay, frequently as thin beds; typical thickness: 5 to 120 feet	Henry Formation (Mackinaw facies) (cross section only) h(m)	**Proglacial fluvial (outwash) sediments** exposed along the Lake Michigan bluff; deposited by meltwater originating along the glacier terminus
Diamicton; silty clay loam to silty clay; dark gray to yellowish brown; massive; calcareous; compact; firm to very hard; pebbly with occasional cobbles and boulders; commonly contains beds of silt, clay, sand, and/or gravel; may contain thick, pebble-free, silty and clayey zones with strongly expressed laminations that may be interbedded with the diamicton; lenses of saturated silt and very fine sand are loose and runny in core; typical thickness: 10 to 150 feet	Wadsworth Formation w	**Subglacial and ice-marginal sediments (till)** deposited from Wadsworth glacial ice; sediment that melted out on top of the glacier or along the ice margin was reworked by slope processes and water; laminated sequences may be more than 40 feet thick, but their areal extent is irregular and difficult to delineate; extensive areas and thicknesses of bedded sand, silt, and clay may be intermixed with diamictons of mudflow and meltout origin along the ice margin

PRE-QUATERNARY DEPOSITS

Description	Unit	Interpretation
SILURIAN PERIOD (~443 to 416 million years B.P.)		
Rock; predominantly dolomite overlain locally by shale; upper surface is commonly fractured with crevices and solution cavities; some oil staining	Bedrock (cross section only)	**Bedrock** buried by ~100 to 250 feet of Quaternary sediments

[1]The time periods for the Wisconsin Episode and the Hudson Episode are reported as calibrated radiocarbon years and can be directly compared to calendar years before 1950 (Stuiver et al. 2005).

Data Type

- Engineering boring
- Water well boring
- 26211 Boring label indicates the county number. Dot indicates boring is to bedrock.
- Contact
- A—A′ Line of cross section

Note: The county number is a portion of the 12-digit API number on file at the ISGS Geological Records Unit. Most well and boring records are available online from the ISGS Web site.

Base map compiled by Illinois State Geological Survey from digital data (500 dpi Digital Raster Graphic) provided by the United States Geological Survey. Topography compiled 1988. Planimetry derived from imagery taken 1998 and other sources. Public Land Survey System and survey control current as of 1991. Boundaries current as of 2002.

North American Datum of 1983 (NAD 83)
Projection: Transverse Mercator
10,000-foot ticks: Illinois State Plane Coordinate system, east zone (Transverse Mercator)
1,000-meter ticks: Universal Transverse Mercator grid system, zone 16

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SCALE 1:24,000
1 1/2 0 1 MILE
1000 0 1000 2000 3000 4000 5000 6000 7000 FEET
1 .5 0 1 KILOMETER

BASE MAP CONTOUR INTERVAL 10 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

Geology based on field work by Michael L. Barnhardt, 2009–2010.

Digital cartography by Jennifer E. Carrell and Jane E.J. Domier, Illinois State Geological Survey.

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This map has not undergone the formal Illinois Geologic Quadrangle map review process. Whether or when this map will be formally reviewed and published depends on the resources and priorities of the ISGS.

The Illinois State Geological Survey and the University of Illinois make no guarantee, expressed or implied, regarding the correctness of the interpretations presented in this document and accept no liability for the consequences of decisions made by others on the basis of the information presented here. The geologic interpretations are based on data that may vary with respect to accuracy of geographic location, the type and quantity of data available at each location, and the scientific and technical qualifications of the data sources. Maps or cross sections in this document are not meant to be enlarged.

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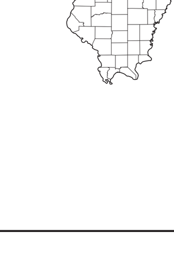
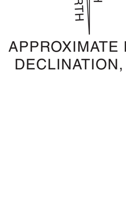


1	2	3
4		5
6	7	8

ADJOINING QUADRANGLES
1 Wadsworth
2 Zion
3 Lake Michigan
4 Libertyville
5 Lake Michigan
6 Wheeling
7 Highland Park
8 Lake Michigan



APPROXIMATE MEAN DECLINATION, 2010

ROAD CLASSIFICATION

- Primary highway, hard surface
- Secondary highway, hard surface
- Light-duty road, hard or improved surface
- Unimproved road
- U.S. Route
- State Route

Introduction

Most of the counties in northeastern Illinois are among the most rapidly growing areas of population in the state and some communities are among the most rapidly growing in the country. Although some communities of this region (including those within the Waukegan Quadrangle) draw the majority of their drinking water from Lake Michigan, a significant portion, including most within the rapidly growing areas, rely upon groundwater from Quaternary sand and gravel deposits or from shallow bedrock.

The Illinois State Geological Survey (ISGS) has implemented a mapping program to develop three-dimensional maps of the glacial geology from land surface to the top of bedrock. Funding for mapping the surficial geology of the Waukegan Quadrangle was provided in part by a grant from the United States Geological Survey (USGS) National Cooperative Geologic Mapping Program, STATEMAP subprogram. These funds were used to develop the detailed map of the surficial geology, the cross section, and the extensive database that is required to accomplish the planned three-dimensional mapping. The 3-D mapping is funded by a separate cooperative agreement with the USGS Great Lakes Geologic Mapping Coalition (GLGMC) and additional funding from the General Revenue Fund of the State of Illinois. Map and digital products that will be developed include three-dimensional models of the material (sediment) and aquifer-bearing units, and maps of the surficial geology, top of bedrock topography, data point distribution, drift thickness, aquifer conductivity, aquifer sensitivity, recharge, aquifer geometry, and susceptibility to contamination. These maps and products can be used by county and municipal agencies and the public to better understand issues related to water utilization, land use, and transportation network planning, and open space and environmental protection.

Regional Setting and Geomorphology

The surficial geology of the Waukegan Quadrangle is primarily the result of continental glaciers and their meltwater during the last glaciation (Wisconsin Episode). While the thickness of glacial sediments in Lake County ranges from about 120 to 350 feet, in the Waukegan Quadrangle they are generally less than 230 feet. These sediments were deposited throughout Lake County during at least three major glacial advances that occurred between about 29,900 and 14,600 years ago (Wisconsin Episode) and a fourth (and possibly more) that occurred between about 200,000 and 130,000 years ago (Illinois Episode). In the Waukegan Quadrangle area, however, the majority of the sediments were most likely deposited during the last 19,000 years the oldest of which directly overlie bedrock and comprise the bulk of the sediments found in the Lake Border Morainic System (see cross section; fig. 1).

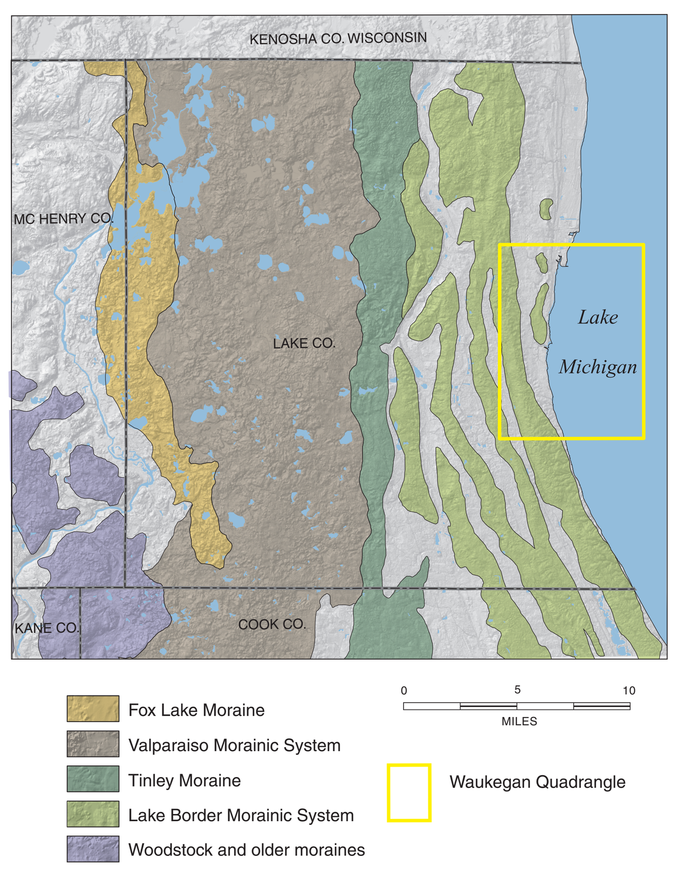


Figure 1 Surface topography and moraines of northeastern Illinois. After Willman and Frye 1970; Willman and Lineback 1970.

The earlier ice advances that originated in the Lake Michigan basin appear to have scoured to bedrock and removed all or most of the previously deposited sediments in the Waukegan area. There is little evidence in the sediment records from boreholes drilled in the study area that suggests the presence of significant amounts of sediment much older than 19,000 years. As each glacier moved westward out of the Lake Michigan basin across Lake County, large amounts of sediment were deposited during both the advance and retreat stages resulting in a complex stratigraphy with a considerable range in age that increases with distance from modern Lake Michigan. In addition, the glacier margin was most likely irregular due to localized minor pulses and surges of ice and variable rates of calving and downwasting. Meltwater that was impounded by ice and sediment drained as outlets opened and closed. These and other factors combined to create significant spatial and vertical differences in sediment thickness, texture, and sequence (Barnhardt 2005, 2008, 2009; Barnhardt et al. 2001; Hansel 2005; Stumpf and Barnhardt 2005; Thomason and Barnhardt 2007, 2008; Stumpf 2004, 2006).

Within the Waukegan Quadrangle, five major landscapes can be identified (see figs. 2 and 3 and the surficial geology map): (1) the Zion beach-ridge plain, which is located in the northeastern corner and roughly parallels the modern Lake Michigan shoreline, is composed of beach sand and small, arcuate sand dunes with occasional intermixed organic-rich sand and peat. Additional small stretches of beach occur along the shoreline to the south but these are generally altered/maintained through extensive shoreline protection structures and are not part of the formal beach-ridge plain; (2) a generally flat to gently eastward sloping lake plain composed of sandy, silty, and clayey sediments, frequently stratified and bedded, deposited in a lake during the Glenwood phase of ancestral Lake Michigan (see additional discussion below). This plain is broad in the northeast part of the quadrangle but narrows southeastward and is deeply incised by gullies that are eroding headward onto the eastern slope of the Highland Park Moraine; (3) the Zion City Moraine is the youngest and smallest of the Lake Border moraines and extends into the northeastern part of the Waukegan Quadrangle from the north. In this area it is likely equally composed of diamicton that is of subglacial, ice marginal, and debris flow origin and sediments deposited in an ice-marginal lake abutting the glacier. The surface expression of this moraine is further muted by extensive urbanization in the city of Waukegan; (4) the Highland Park Moraine, is the dominant northwest-southeast trending ridge that traverses the central part of the quadrangle and, like the Zion City Moraine, is composed of interbedded mixtures of ice-contact diamicton (till) and sediment deposited in bodies of water impounded or dammed ahead of or behind the Highland Park Moraine; (5) the eastern slope of the Blodgett Moraine occurs just west of the Highland Park Moraine along with an intervening linear lowland filled in part with sediments deposited during a high stand of ancestral Lake Michigan. The sedimentology of the Blogdett Moraine is similar to that of the other Lake Border moraines (see cross section).

Post-Glacial Lacustrine Environments

As the last glacier receded from the Waukegan area to the northeast, a huge volume of water was released from the melting ice. Outwash sand and gravel was transported southward toward modern day Chicago and a vast body of water was impounded between the Highland Park and Zion City Moraines and the remaining glacial ice. Silt, sand, and clay deposited in a lacustrine environment and a number of wave-cut terraces document several high stands of water derived from the melting ice (Chrzastowski and Frankie 2000).

The Glenwood phase (17,700–14,100 cal yr B.P. (14,500–12,200 ^{14}C yr B.P.)) was a high stand of ancestral Lake Michigan that reached about 630 to 640 feet a.s.l., which is about 40 to 50 feet above modern Lake Michigan (587 feet a.s.l.). The Calumet phase (13,700–13,100 cal yr B.P. (11,800–11,200 ^{14}C yr B.P.)) reached an elevation of about 620 feet or about 30 feet above modern Lake Michigan. The Chippewa phase lasted from about (11,500–6300 cal yr B.P. (10,000–5500 ^{14}C yr B.P.)) and represented an exceptionally low stand of the lake at 319 feet a.s.l., which is about 260 feet below modern Lake Michigan. This low stand initiated significant downcutting by streams and rivers flowing eastward into the lake and is evidenced by the deep ravines that truncate the bluffs that parallel the shoreline. South of the Waukegan Quadrangle, where the Highland Park Moraine forms the lake bluff, numerous ravines provide an important cross sectional view of the sediments that form the moraine. On the Waukegan Quadrangle, similar ravines and several bluff exposures occur near the eastern edge of the cross section (see cross section and figs. 2, 3, 4). They reveal some of the variability in thickness and occurrence of sand and gravel and lake sediments that intermingle with glacial diamicton (till) throughout the length of the cross section. The till is increasingly exposed toward the west and occurs at land surface along the Highland Park Moraine and the Blodgett Moraine (see cross section and surficial geology map). The Nipissing phase (6300–4200 cal yr B.P. (5500–3800 ^{14}C yr B.P.)) represents a time when the lake had again risen to about 20 feet above historical lake levels. This phase represents the early formation of the beach-ridge plain (Chrzastowski and Frankie 2000). During the Algoma and Modern phases (4200 cal yr to present (3800 ^{14}C yr B.P. to present)) the lake was near current levels and represents the early migration of the beach-ridge plain. Erosion and transport of sand from the northern portions of the beach-ridge plain continues today and the gradual southward migration of the plain underscores the ephemeral and transitory nature of the Lake Michigan shoreline.

Interpreting the shape (geomorphology) of the landscape is important to understanding the late Quaternary glacial history of the study area. On numerous occasions, glaciers fluctuated into and out of the Lake Michigan basin. Their former margins are preserved on the landscape commonly as arcuate ridges (moraines) (see figs. 1, 2, 3). These boundaries help delimit the interpretations of the stratigraphy and depositional environments associated with them (Thomason and Barnhardt 2007).

Unit Characterization and Stratigraphy

Several lithologically distinct diamictons, silt and clay beds, and sand and gravel units were deposited by the Lake Michigan lobe as it repeatedly advanced and retreated across northeast Illinois from about 29,900 to 14,600 years ago (fig. 1). The Quaternary deposits in the mapping area overlie directly dolomitic bedrock of Silurian age. The uppermost part of this bedrock may be shaly, highly fractured, vuggy, and, locally, oil-stained. The regional slope dips into the Lake Michigan basin but over small areas may be rather flat.

Recent drilling, core analysis, mapping, and 3-D interpretation of thousands of descriptions from water well, engineering, and stratigraphic boreholes suggests that a large percentage, if not a majority, of the sediment comprising a moraine (e.g, the Highland Park Moraine) may be of lacustrine origin rather than diamicton of subglacial origin (till). (see cross section; figs. 2 and 3). This seems to apply also to moraines developed during earlier glacial advances across Lake County. In western Lake County where glaciers did not erode and/or redeposit as much of the previously deposited sediments like they did in the Waukegan area, multiple diamictons (tills) are found in some of the moraines; however, they are also intermingled with lacustrine sediments. Lakes of various sizes, depths, and longevity seem to have occupied large portions of Lake County during the last 29,900 years and were interacting with the glaciers as they moved through the region.

The Wadsworth diamicton (w on cross section) is the only till exposed at land surface or in cross section on the Waukegan Quadrangle (fig. 3). It is predominantly a dark grayish brown, silty clay to silty clay loam diamicton (a massive to poorly sorted mixture of clay, silt, sand, and gravel), but it also contains lenses and thick beds of sorted sediment, especially silty clay, silt, and fine sand (symbolized on cross section with stippled patterns). Near a moraine front, the Wadsworth diamicton may exhibit a coarser texture and an increase in the number and thickness of lenses and beds of sand and/or gravel. The diamicton is composed of beds of till (that were deposited subglacially) and more variable (bedded and coarser) diamicton that may represent material that melted out near the ice margin, on top of the glacier or was deposited as debris flows in a body of water.

Outwash sand and gravel of the Henry Formation, Mackinaw facies, h(m), is found along the lake bluffs and was deposited when the ice front was located to the northeast of the study area. These sediments overlie Wadsworth diamicton. Proglacial silt and clay deposits of the Equality Formation (e) are located between the Highland Park Moraine and Zion City Moraine and the lakeshore. These sediments were deposited in water impounded between the moraines and the ice front. These deposits are generally thin and may include some sediment deposited during the Glenwood phase high lake stand.

Grayslake Peat (gp) and sand of the Henry Formation, Parkland facies, h(p), are abundant and intermixed along the beach-ridge plain where peat, muck, and organic-rich sand occur within and between the arcuate ridges of sand dunes. In this area the sediments are very young (<5500 years B.P.) and represent the most dynamic landscape on the map (Chrzastowski and Frankie 2000). Sediments of the Cahokia Formation, (c), are found along larger active floodplains mostly on upland positions. Deposits along smaller channels and drainageways located on uplands are generally not of sufficient extent or thickness to map. Uplands may also contain small isolated depressions in which peat has accumulated.

Mapping Techniques

The map of surficial geology is based largely on digitized soils maps (scale 1:15,840) from the Soil Survey of Lake County, Illinois (Paschke and Alexander 1970; U.S. Department of Agriculture 2004). Initially, individual soil series were grouped by their parent material following (1) the classification key in Soils of Illinois (Fehrenbacher et al. 1984; USDA 2005), (2) profile descriptions in the survey report, (3) NRCS field notes, (4) discussions with NRCS soil mappers, and (5) updated individual Soil Series Description sheets acquired either directly from the USDA-NRCS or downloaded from their web site. These parent material classes then were grouped into more general geologic material classes comprising the mapping units used for this map, following Hansel and Johnson (1996) and Willman and Frye (1970).

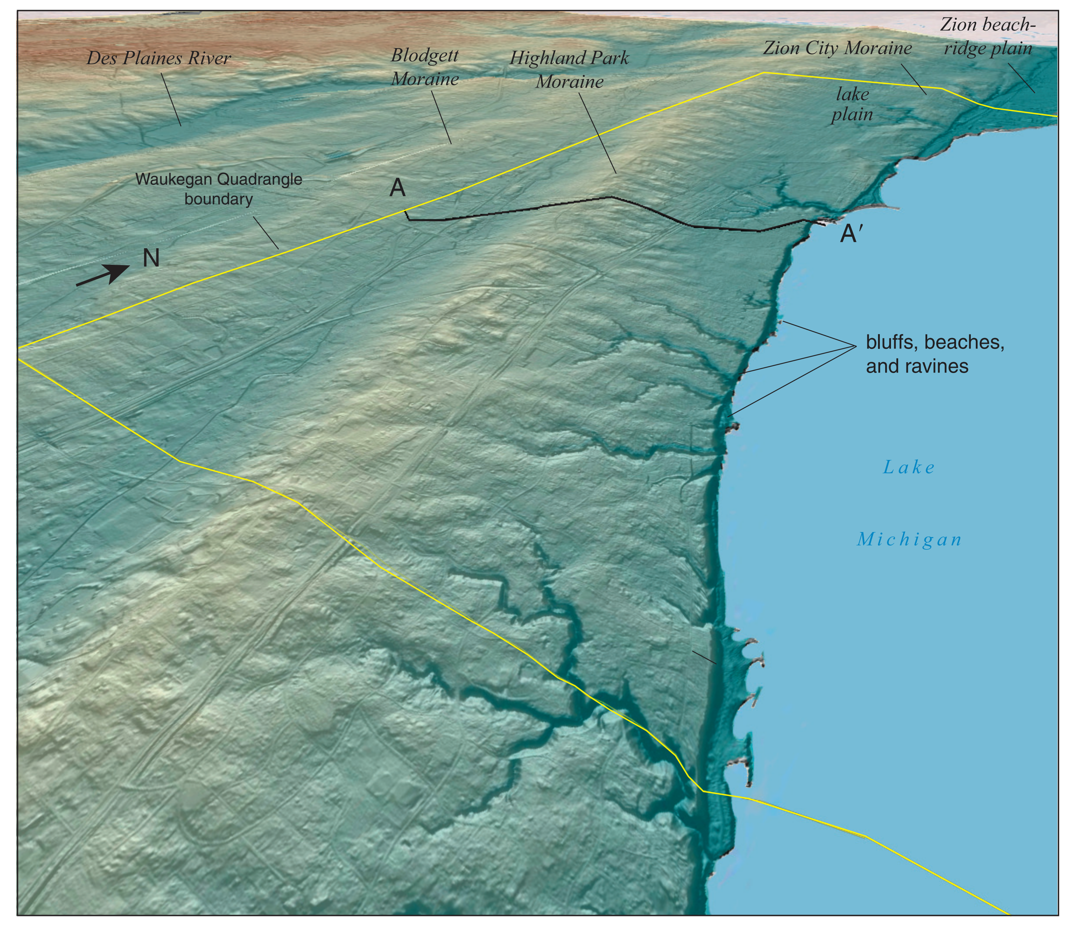


Figure 2 Surface topography of Waukegan Quadrangle with cross section A–A′. Digital elevation model generated from 2004 LiDAR data provided by Lake County. The scene has been vertically exaggerated 10×.

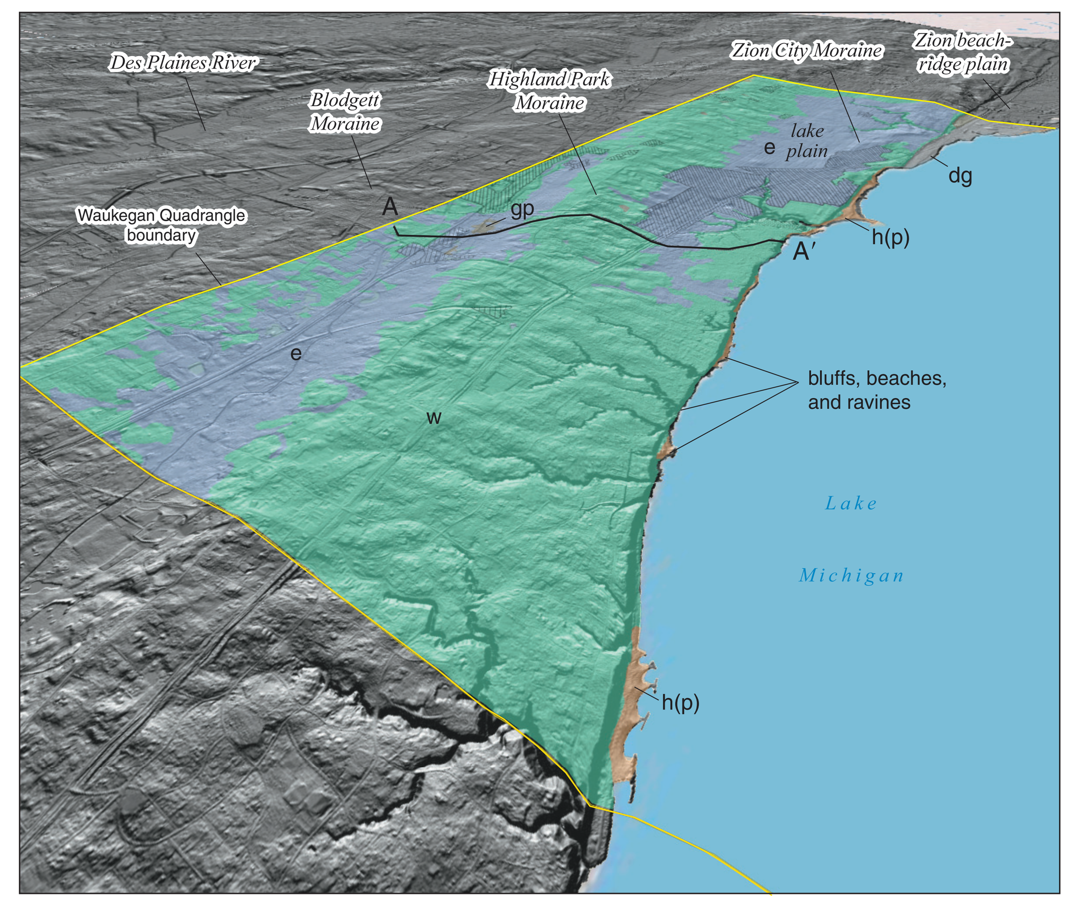


Figure 3 Surficial geology over topography of Waukegan Quadrangle.

The parent material (geologic material) classes were generalized for the surficial geology map because the soil-based data layer created a very complex map with polygons that were too small for incorporation into cross sections. It is assumed the thickness of each soil unit is at least 6 to 10 feet or more based upon the depth to which the soil scientists sample during their mapping. The thickness of specific units was adjusted where our drilling, field observations, or records suggested otherwise. Selected soil series, or in some cases individual polygons in various soil series, were regrouped into different geologic material classes following extensive fieldwork and data analysis for the Waukegan and other quadrangles in Lake County (Barnhardt 2005, 2008, 2009; Barnhardt et al. 2001; Stumpf 2004, 2006; Stumpf and Barnhardt 2005; Hansel 2005; Thomason and Barnhardt 2007, 2008).

The sediment at land surface (parent material for the soils) was examined and correlated with its geomorphic (landscape) position to develop a sediment-landscape model. This was accomplished within ArcGIS by draping the sediment (parent material/surficial geology) layer over a digital elevation model (DEM) with a 2-foot resolution (figs. 2 and 3). In addition, the original, high-complexity soil series layer was added to increase the degree of detail available for analysis. Variations of this model were combined with records of water-well and stratigraphic and engineering borings and analyzed in ArcScene to better understand the subtle sediment-landscape relationships and the changes in subsurface stratigraphy as depicted in the cross section. This model was used to interpret the sediment description for every water-well, stratigraphic, or engineering boring used in the mapping.

The ISGS has drilled fourteen boreholes to bedrock within the area delineated as the Lake Border Morainic System (see fig. 1). Each was drilled and continuously sampled using either a CME-75 or Mobile B-57 drill rig, which are equipped with a wireline sampler. Downhole natural gamma-ray logs were also collected for each and observation wells were installed where appropriate to monitor long term water levels in sand and gravel aquifers. Subsamples were taken for particle-size analysis. Each of the high-quality sediment cores from these boreholes was described in great detail and analyzed in conjunction with their gamma logs and, then, reviewed and discussed by ISGS geologists to better understand and interpret the depositional environment in which this sediment was deposited. This information was used to develop a framework of depositional environments within which considerably less detailed descriptive records from adjacent water wells could be examined. Geologic information for subsurface units depicted on the cross section was obtained from core descriptions for the ISGS boreholes and other sample sets and drilling logs obtained from water wells and engineering boreholes, which are available in databases at the ISGS. A total of 653 location-verified water well and engineering boreholes are located on the Waukegan Quadrangle most of which are verified to tax parcel size and repositioned as needed (fig. 4). The quality of the geologic information for each borehole was evaluated as they were selected for developing and validating the surficial geology map and cross section. The legend of map units provides additional discussion on the variability of sediments and their occurrence on the landscape.

The ages reported herein are calibrated calendar years before 1950 as calculated following Stuiver et al. (2005). The equivalent ^{14}C age is presented parenthetically for information cited from Chrzastowski and Frankie (2000) because the calibrated years given in this report are those of this author and not theirs, which were reported as carbon-14 years in their report.

Acknowledgments

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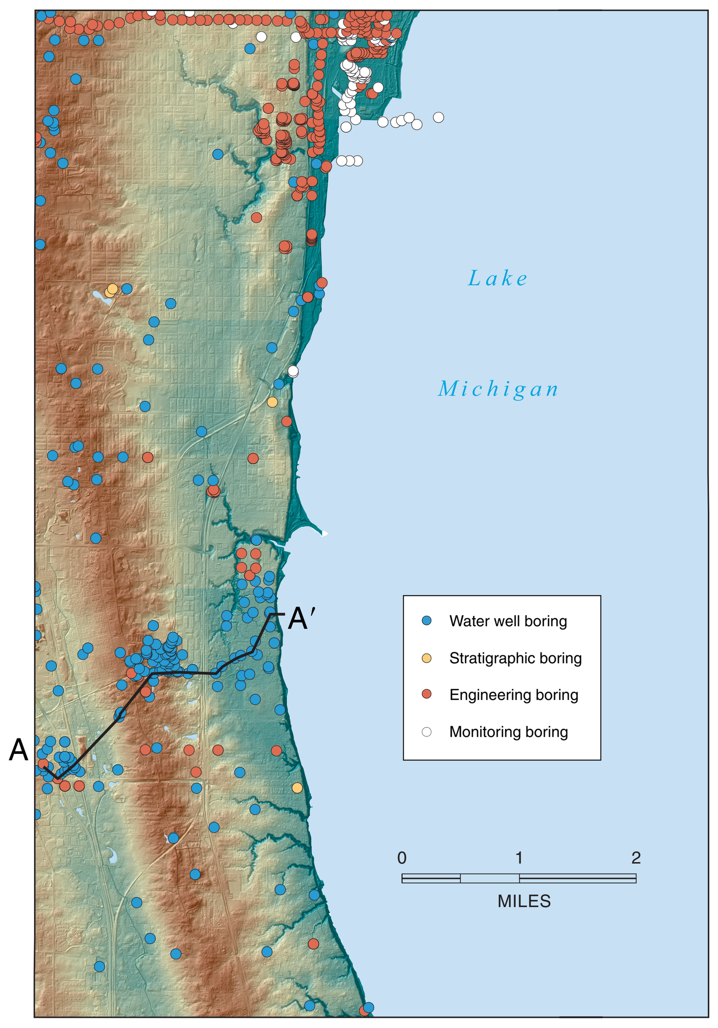

Figure 4 Locations of boreholes and cross section.

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